ALTERNATIVE FUELS TASK FORCE REPORT

Purpose

In 2009, former Governor Butch Otter established the Idaho Strategic Energy Alliance (ISEA) to enable the development of a sound energy portfolio that emphasizes the importance of an affordable, reliable, and secure energy supply. In October 2020, Governor Brad Little, through Executive Order 2020-18,[1] continued the group's operation.

The ISEA is led by a board of directors that are selected by and serve on behalf of the governor. This group and its task forces create opportunities for a variety of in-state energy experts to assist with the development of achievable and effective recommendations for improving Idaho's energy future.

The ISEA Board of Directors identified the topic of alternative transportation fuels as an area where experts and policymakers can further develop their understanding of consumer and manufacturing trends. As the nation's power and transportation systems are becoming increasingly integrated and new technologies are being deployed at a rapid pace, it is important to understand how Idaho will be impacted.

With the nationwide transportation market experiencing unprecedented production and adoption of alternative-fuel vehicles, there is much discussion about the potential for alternative-fuel transportation to reduce harmful emissions, increase energy efficiency, and be more cost-effective long term for vehicle owners. The purpose of this report is to provide detailed information about different alternative transportation fuels, including current manufacturing and technology adoption trends, specific to the State of Idaho. This will allow readers to determine if policies supporting alternative fuels for transportation can improve Idaho's economy and provide other benefits.

Executive Summary

Nationwide, in 2019, the U.S. Energy Information Administration identified the transportation sector as being responsible for 29.9% of total end-use energy consumption. About 26% of total U.S. energy consumption in 2020 was for transporting people and goods from one place to another.[2] The Idaho Strategic Energy Alliance (ISEA) created the Alternative Transportation Fuels Task Force and tasked this group with preparing a report that provided thorough data-driven information on vehicles, fuels, and fuel infrastructure in Idaho. This report introduces readers to a comparison of the established petroleum-based transportation fuels with five different alternative fuels used for transportation:

- Biofuels
- Natural gas
- Propane
- Electricity
- Hydrogen.

The report discusses the availability, economics, regulations, tax policy, and vehicle efficiencies with each alternative fuel, while acknowledging the barriers and recognizing the benefits associated with each alternative fuel type. The goal of this report is to provide information that allows readers to draw their own conclusions about areas where Idaho could improve its transportation sector and economy by incentivizing the adoption of alternative-fuel vehicles and the growth of alternative-fuel production capacity. The following are some important facts to consider while reading this report:

While petroleum-based fuels provided 95.5% of transportation energy in Idaho, the use of alternative fuels such as compressed natural gas, liquefied natural gas, propane, and electricity continues to increase.

Over 1.82 million vehicles are registered in Idaho. This number has grown 8.3% increase in just 4 years. As of July 2022, there were 4,508 EV's registered in Idaho.[3] Gas and electric hybrid vehicles remain the most popular form of electric vehicle among Idaho residents.

Demand for Transportation in Idaho

Idaho has experienced rapid population growth within the past few years. Idaho has been identified as the second-fastest growing state within the past decade.[4] Not only are more individuals moving to the state, but tourism in Idaho has grown as well. As the number of people traveling on Idaho's roads increases, so does demand for affordable and accessible transportation fuels. In fact, as of 2021, the transportation sector accounts for 29% of the state's total energy use.[5] The question is often posed whether adoption of alternative fuels, such as biofuels, electricity, and hydrogen, to support Idaho's growing transportation sector will improve accessibility and affordability of energy.

This report identifies the available forms of alternative transportation fuels, benefits and barriers associated with each, and some factors influencing the likelihood that alternative fuels will improve Idaho's energy future.

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Acronyms

AC	Alternating Current
ASME	American Society of Mechanical Engineers
AVMT	Annual Vehicle Miles Traveled
BEV	Battery Electric Vehicle
BPA	Bonneville Power Administration
CAFE	Corporate Average Fuel Economy
CO	Carbon Monoxide
CCS	Combined Charging System, a standard fast charging connector design
CETP	Certified Employee Training Program
CHAdeMO	A trade association that has standardized a fast charging connector design; "CHAdeMO" is an abbreviation of "CHArge de MOve," equivalent to "charge for moving,"
CNG	Compressed Natural Gas
CPI	Consumer Price Index
DC	Direct Current
DCFC	Direct Current Fast Charger
DEQ	Idaho Department of Environmental Quality
DERA	Diesel Emissions Reduction Act
DOE	United States Department of Energy
DOT	United States Department of Transportation
EIA	Energy Information Administration
EISA	Energy Independence and Security Act
EPA	United States Environmental Protection Agency
EREV	Extended Range Electric Vehicle
EV	Electric Vehicle
EVSE	Electric Vehicle Supply Equipment
FCEV	Fuel Cell Electric Vehicle
FCV	Fuel Cell Vehicle
FFV	Flexible Fuel Vehicle
FY	Fiscal Year
GGE	Gasoline-Gallon Equivalent

GHG	Greenhouse Gas
HEV	Hybrid Electric Vehicle
ICE	Internal Combustion Engine
IGC	Intermountain Gas Company
INL	Idaho National Laboratory
IPUC	Idaho Public Utilities Commission
IRP	Integrated Resource Planning
ISEA	Idaho Strategic Energy Alliance
ITD	Idaho Transportation Department
LCA	Life-Cycle Analysis
LDC	Local Distribution Company
LNG	Liquefied Natural Gas
LPG	Liquefied Petroleum Gas
MY	Model Year
NAAQS	National Ambient Air Quality Standards
NEMA	National Electrical Manufacturers Association
NERC	North American Electric Reliability Corporation
NG	Natural Gas
NGL	Natural Gas Liquids
NGV	Natural Gas Vehicle
NHTSA	National Highway Traffic Administration
NREL	National Renewable Energy Laboratory
OBC	Onboard charger
OEM	Original Equipment Manufacturer
PADD	Petroleum Administration for Defense District
PERC	Propane Education and Research Council
PEV	Plug-in Electric Vehicle
PGA	Purchase Gas Adjustment
PHEV	Plug-in Hybrid Electric Vehicle
RFS	Renewable Fuel Standard
RFS2	Amended Renewable Fuel Standard

RIN	Renewable Identification Number
RNG	Renewable Natural Gas
RVO	Renewable Volume Obligations
SAE	Society of Automotive Engineers
WCSB	Western Canadian Sedimentary Basin
ZEV	Zero-emissions vehicles

1. PETROLEUM-BASED FUELS AND VEHICLES

1.1 Introduction

Petroleum-based fuels continue to be the most dominant fuel used in Idaho and in the United States across all vehicle segments; therefore, they are recognized as the baseline against which alternative fuels are compared. Petroleum, which consists of crude oil and refined products, such as gasoline, diesel, and propane, accounted for more than 36% of total energy consumed in the United States in 2018.[6] Gasoline and diesel have become fuels of choice due to their high energy density. One gallon of gasoline equates to 120,286 Btu, and 1 gallon of diesel fuel equates to 137,381 Btu. Although both fuels are losing popularity, given the recent steep increase in prices, petroleum-based fuels remain the most familiar fueling option for Idahoans.

1.2 Availability and Economics

Most gasoline and diesel fuel enters Idaho via the Marathon Northwest Pipeline, which originates in Salt Lake City, Utah. This 760-mile pipeline runs across Idaho, up Eastern Oregon, through Pasco, Washington, and Spokane, Washington. Along this route there are fuel storage terminals in Burley, Pocatello, and Boise. The Yellowstone Pipeline, operated by Phillips 66, runs from Billings, Montana, to Spokane. Northern Idaho receives petroleum products from terminals in Pasco, Spokane, and occasionally Missoula, Montana.

Both pipelines generally operate at capacity during the late spring and summer months, when demand is at its highest. The operators of these pipelines are regulated as common carriers, such as the public utilities. Some gasoline and diesel fuel is shipped into Idaho by truck and some diesel is shipped into the state by railcar. Gasoline is never shipped by railcar due to its volatility. Trucks are also used to ship fuels from storage terminals to fuel stations.[7]

As of the third of January 2023, diesel and gasoline in the Mountain West costs approximately $3.04 per gallon in gasoline and $4.73 per gallon for diesel. Factors that have influenced gas price magnitude and volatility nationwide and in Idaho include distribution, marketing, refining costs and profits, federal and state taxes, and global market prices for crude oil.[8] Today's high price of petroleum-based fuels directly translates to high transportation cost to both individual consumers and businesses.

1.3 Regulations and Tax Policy

Federal fuel economy regulations include Corporate Average Fuel Economy (CAFE), which is administered by the Department of Transportation's National Highway Traffic Safety Administration (NHTSA). CAFE regulations establish requirements for the average fuel economy of vehicles produced by a single vehicle manufacturer in the United States, separated by vehicle size (e.g., car versus light truck and sport utility vehicle).[9] The Environmental Protection Agency (EPA) regulates carbon dioxide (CO_2) emissions on a national level in addition to measuring light, medium, and heavy-duty fleets average fuel economy and toxic emissions from individual vehicles. Additional regulations define requirements for oxygenation of gasoline, use of diesel exhaust fluid, and the make-up of dyed diesel. Currently, the federal tax rate for gasoline is $0.184

per gallon and the diesel federal tax rate is $0.244. The state gas and diesel tax rate is $0.32.[10] High demand for petroleum-based fuels and relatively fixed supply leads to increased prices when supply is reduced due to geopolitical conflicts, extreme weather, or other disruptions to the global supply chain. Price fluctuations have secondary effects, as the resulting changes in the cost of transportation affects nearly all sectors of the economy. To hedge against this uncertainty, it is common practice for vehicle fleet operators, such as trucking companies and farmers, to negotiate fixed-price contracts with fuel suppliers.

Measures have been established that speak to consumer awareness of environmental issues and improving alternative fuel technologies, such as the Diesel Emissions Reduction Act (DERA)[11] and its predecessor, the Energy Policy Act of 2005.[12] This act gave the EPA new grant and loan authority for promoting diesel emission reductions and authorized appropriations to the agency of up to $200 million per year through fiscal year (FY) 2011. Congress appropriated funds for the first time under this program in FY 2008. The program was reauthorized in the Diesel Emission Reduction Act of 2010 and in the Consolidated Appropriations Act, 2021, and has continued to award DERA grants and rebates each fiscal year.[13]

1.4 Vehicle Efficiency

Fuel efficiency varies among petroleum-fueled vehicles. Figure 1 depicts average fuel economy by major vehicle category and conveys the wide variation between vehicle segments. Light-duty automobiles (i.e., cars) and motorcycles are the most efficient vehicle types, irrespective of vehicle mission. Heavy-duty class 8 trucks and transit buses remain the vehicles that are recognized as being least efficient, averaging less than 5 miles per gasoline gallon.

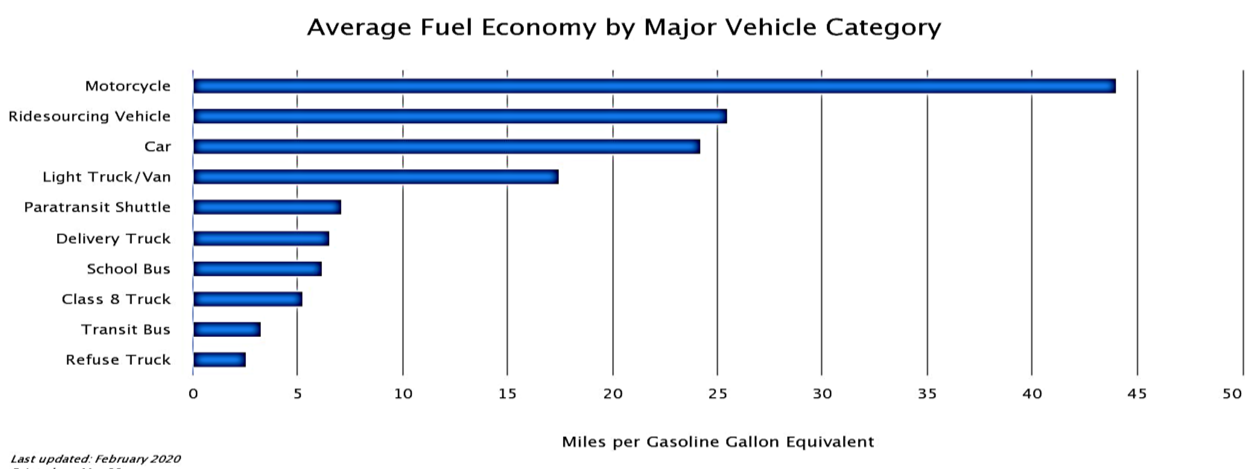

Figure 1. Average fuel economy by major vehicle category.[14]

Argonne National Laboratory completed a study in 2021 that compared fuel economy and cost of ownership for light-duty, medium-, and heavy-duty trucks and buses and off-highway agriculture equipment. Some results from this study are shown in
Table 1. Although tempting to directly compare the fuel economy of light-duty vehicles to medium and heavy-duty vehicles and off-highway equipment, the distinctly different vocations of these vehicles makes such a comparison unwise. When measured in terms of ton-miles per gallon (i.e., the amount of fuel required to transport 1 ton of goods 1 mile) or passenger-miles per gallon (i.e.,

the amount of fuel required to transport 1 passenger 1 mile), fully laden heavy-duty trucks and buses are exceedingly more efficient than light-duty vehicles. The Argonne study shows heavy-duty class 8 tractor-trailer trucks can achieve over 160 ton-miles per gallon.

Table 1. Vehicle efficiency and cost.[15]

Type of Vehicle	Typical Fuel Economy	Separate Cost and Ownership Length
Light-Duty Vehicle	17.5–35.16 mpg	$25,000–$30,000
Medium- and Heavy-duty Trucks and Buses	7.08–15.79–23.42 mpg	$60,000–$100,000
Off-highway Ag Equipment	6.66–8.27 mpg	$120,000–$149,000

1.5 Conclusion

Petroleum-based fuels have been the main source of transportation fuel in Idaho for many years; however, with the recent increase of gasoline prices, consumers may be considering researching alternative fuels. Experts forecast the national average price in the next year would mark the highest retail gasoline and diesel prices since 2014. Nevertheless, consumers of petroleum-based fuels remain optimistic that costs will decrease overtime.

The rationale behind the increase in cost of gasoline and diesel fuel is rising demand and constrained supply. The combination of domestic supply interruptions and trouble in energy markets overseas have made crude oil more expensive.[16] Given the conflict overseas with Ukraine, at the time of this writing, analysts believe the price of crude oil is likely to rise as European countries consider a ban on Russian oil imports.[17] Despite the increase in cost, petroleum remains the most common transportation fuel source today. A fuel source that once was recognized as affordable remains the most convenient currently for many vehicle owners and may return to being the most affordable overtime.

2. BIOFUELS

2.1 Introduction

Biofuel usually refers to alternative liquid fuel primarily used in engines derived from biological sources. Biofuels are currently the only direct replacement for liquid petroleum fuel. Liquid fuel plays a unique and critical role in powering the transportation sector. In 2020, liquid petroleum accounted for about 90% of the total U.S. transportation energy use. Biofuel accounted for only 5%, with ethanol's share at about 4%. Biodiesel and renewable diesel combined for about 1%. Unlike other forms of energy, liquid fuels are hard to replace because of their relatively high energy density and existing infrastructure to produce and distribute the fuel. Many people view electricity as a potential replacement for liquid fuel, but even today's most advanced battery has only about 2% of the energy density of liquid petroleum fuel by weight. Less than 1% of the energy used in transportation in 2020 came from electricity.

The most common biofuels are ethanol and biodiesel. Ethanol is usually blended with gasoline at up to 10% and biodiesel is blended with diesel fuel at up to 5%.[18] Despite the increase in cost, petroleum remains the most common transportation fuel source today and at time of publication continues to decrease in cost.

2.2 Motivations and Benefits (Economic, Environmental, Public Health)

Replacing petroleum fuel with renewable fuel, like biofuel, is perhaps becoming more appealing as petroleum-based fuel price volatility is at the forefront in global politics. If petroleum fuel supply dwindles in the future, there will likely be further price increases due to petroleum dependence. The United States used 97.3 quads of energy in 2021.[19] Becoming energy independent or, more specifically, a fuel-independent nation increases economic stability and national security.

In addition to becoming fuel independent, biofuel has other economic, environmental, and public health benefits. Ethanol is cheaper than gasoline on a volume basis. In May 2022, the rack price of ethanol was $2.82 in Nebraska versus $3.73 for unleaded 87-octane gasoline.[20] It should also be noted that the energy density of ethanol is only 2/3 of the gasoline and on an energy basis, ethanol is more expensive than gasoline at these per-gallon prices. Biodiesel is typically slightly more expensive than diesel fuel on a per-gallon basis. The increased price has been a major drawback in consumer demand.

The price of biofuel at the pump is only a part of the equation. Biofuel is primarily domestically produced and brings the economic benefits back to farming communities. The biofuel industry provides local jobs and a market for agricultural commodities. According to the Renewable Fuels Association, ethanol production in 2020 accounted for more than 62,000 direct jobs across the country, $35 billion in the gross domestic product, and $19 billion in household income.[21] Similarly, the biodiesel industry has provided 47,000 jobs with $2 billion in paid wages.[22]

Biofuel is considered an environmentally friendly fuel compared to its petroleum counterparts. Environmental impacts of fuel are determined by Environmental Life-Cycle Analysis (LCA). This approach considers the whole life cycle from agricultural production to final fuel use. Life-cycle analysis, which includes the global ripple effect from making biofuel, known as the indirect effect, is called consequential LCA. The Energy Independent and Security Act of 2007 (EISA) stipulates that any significant indirect impact from making biofuel is to be included in the analysis.[23] Unfortunately, however, experts have a split opinion on the ability to reliably estimate the indirect impacts because of the lack of critical data, unknown relations, and the ability to isolate causes.

The EPA based the Renewable Fuel Standard (RFS2) on findings from its own study in 2010 that found corn-based ethanol reduce greenhouse gas emissions by 21%.[24] Since then, many studies have challenged or supported this result. Because of the uncertainty in data and unknown relations, the studies rely on assumptions and model predictions and are only as good as those assumptions. Consequently, many studies claim biofuel, in particular corn-based ethanol, to be beneficial to the environment;[25-31] while others argued it is detrimental to the environment.[32] Unfortunately, due to uncertainty in the model, this debate probably will remain unsettled for the foreseeable future.

An additional benefit of using biofuel to replace petroleum fuel is public health. Petroleum fuel contains a certain percentage of aromatic compounds, which are considered carcinogenic. Biofuel contains no aromatic compounds. A 2019 study on the health impacts of blending ethanol into gasoline in five global cities estimates that a 10% blend of ethanol will save several thousand years of potential life lost in each city and additional tens of millions of dollars of direct healthcare costs for cancer treatment.[20]

Biodiesel provided substantially lower particulate matter emissions, carbon monoxide, and unburned hydrocarbons in older diesel engines. New regulations have required new diesel engines to have much lower emissions, and engine manufacturers have made technological improvements to the engine to meet these requirements that make the effect of the fuel less important. Modern diesel engines use a combination of in-cylinder controls and after-treatment to reduce emissions to extremely low levels. Reductions in carbon monoxide (CO), unburned hydrocarbons, and particulates still occur when using biodiesel, but they are of less significance because the particulate filter and the oxidation catalyst would remove them anyway.[33] Even though biodiesel may not have a significant emission advantage with newer engines, it does provide higher lubricity or a smooth texture to the fuel that reduces engine wear and tear.

2.3 Availability and Economics

Following the Renewable Fuel Standard (RFS2), the EPA mandates that certain volume of renewable fuel be mixed into gasoline as an oxygenator. The obligated parties, who are mainly fuel producers and distributors, are required to mix the mandated volume of the biofuel. The EPA revises and updates these volume mandates based on the availability of different biofuel categories. Due to this mandate, most gasoline sold in the United States is blended with 10% ethanol and diesel fuel, with up to 5% biodiesel.

Pumps selling higher blend levels of ethanol or biodiesel is less common. The United States Department of Energy's Alternative Fuels Data Center provides a map of fuel stations that sell B20 (20% biodiesel mixed with petroleum diesel) or above[34] or E85 (85% ethanol).[35] The map shows Idaho has three E85 pumps and no higher-blend biodiesel pumps at this time of writing. Pumps such as these can service older cars that tend to rely on biodiesel fuel, as well as some current models by brands such as Ford, BMW, Jeep, Volkswagen, and Audi.[36]

An interesting academic study compared electric vehicles powered by electricity produce by burning biofuels to vehicles with internal combustion engines powered directly by biofuels. The study found that bioelectricity-powered light-duty vehicles are more efficient overall when limited to short-range driving. For light-duty vehicles driven over longer ranges and heavy-duty trucks such as long-haul tractor-trailers, burning biofuels in the vehicle's engine is more efficient, especially assuming advanced technology.[37]

2.4 Supply Limitations

A major portion of ethanol is made from corn, whereas biodiesel is made from soybean or corn oil. A limited supply of these feedstock commodities is the main limitation in increasing the biofuel supply. Ethanol made from corn is called Conventional Biofuel and its production is capped at 15 billion gallons. In 2021, the United States produced 15.015 billion gallons of ethanol.[18] Virtually all ethanol was corn ethanol. The total ethanol production capacity is 17.5 billion gallons/year, and most plants are concentrated in the Midwest.

The industry uses about 40% of the corn produced in the United States to produce 15 billion gallons of corn ethanol. As discussed earlier, many experts have raised concerns about increasing food prices because of biofuel. However, a study found that the consumer price index (CPI) for food indicates no significant food price change due to biofuels.[38] Corn and soybean are used in animal feed and other food products; therefore, consumer price index for food correlates well with corn and soybean prices. Figure 2 shows a cumulative increase in the average consumer price index since 1973. The slope of each line segment in Figure 2 shows the average inflation rate for that period.

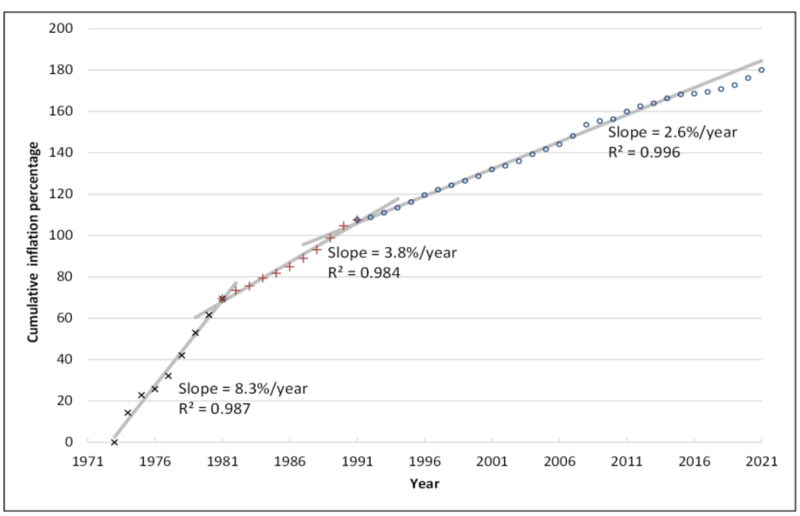

Figure 2. Cumulative consumer price index for food with 1973 as base line. The slope of each segment shows the average inflation rate during those years.[38]

There is a natural equilibrium influencing how much agricultural commodity can go to making biofuel. The equilibrium is not only an artifact of supply and demand but also from policy and regulations. Due to Renewable Fuel Standards (RFS2) limitations, the ethanol volume will only grow slowly to provide a market for surplus agricultural production. Surplus agricultural production is expected to grow due to an increase in agricultural productivity (currently 2.8% globally) and population growth (currently 1.0% in 2020).

The main hurdle in biofuel is the limited feedstock supply and enormous volume of liquid fuel use. Forty percent of corn converted to ethanol can replace only 10% of gasoline used in the country. Similarly, excess vegetable oil from food market and waste cooking oil can supply only about 6% of the diesel fuel.[39] There are known and viable pathways to produce ethanol from woody plant biomass, but the technology has not been economically viable in comparison to prevailing petroleum fuel prices. More research is needed to convert non-traditional feedstock to make biofuel.

2.5 How Energy Source is Distributed to End-Use Customer

Generally, biofuel is blended with petroleum fuel to distribute through the pipeline. No upgrade to the existing infrastructure is needed to blend the fuels. Up to a 10% blend of ethanol and a 5% blend of biodiesel in distillate fuel is used. However, at a higher blend level, there may be material compatibility issues. Ethanol and biodiesel have different solubility properties than the petroleum counterpart, and both fuels tend to erode sealing material traditionally used in the vehicle fuel line. This technical hurdle of mixing a higher percentage of ethanol into the fuel line is known as a blend wall. The blend wall is the point at which fuel supply infrastructure and all vehicle engines would need to be updated to be compatible.[40]

Due to the blend wall, a higher blend of ethanol and biodiesel are transported and handled separately with upgraded compatible sealing material. The number of stations that sell higher blends of ethanol and biodiesel is limited. Someone wanting to use a higher blend of biofuel would need to know if their vehicle's fuel line seals are compatible. Most new vehicles are compatible with a higher blend of biofuel. BiodieselEducation.org[41] published the compatible sealing material for anyone wanting to make their vehicle compatible with higher biodiesel blends.

2.6 Historical E85, Biodiesel Prices

Historically biodiesel has been slightly more expensive than regular No. 2 diesel, and ethanol had been cheaper than gasoline on a volume basis. However, a better comparison is based on their energy content basis. Gasoline-gallon equivalent (GGE) is used for fair fuel price comparison. GGE is the amount of an alternative fuel that equals the energy content of one gallon of gasoline. The average retail price of gasoline, diesel, E85, B99, or B100 per GGE is shown in

Table 1. In general, biofuel is more expensive than its petroleum counterpart on a GGE basis.

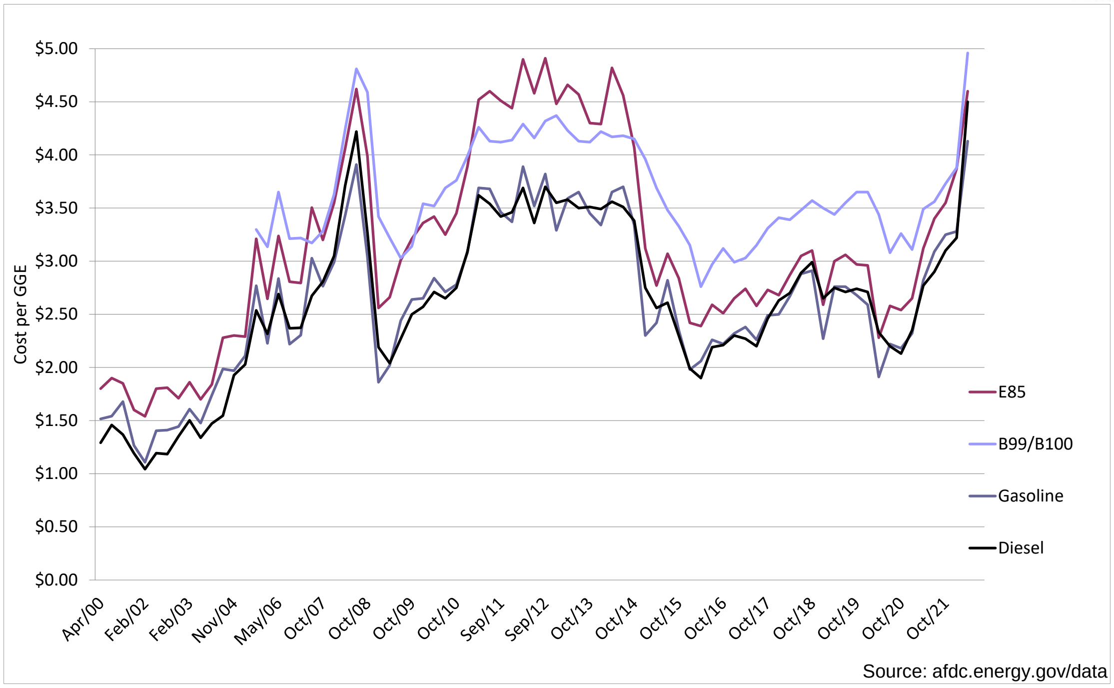

Figure 3. Average retail fuel prices in the United States in GGE.[42]

2.7 Factors Influencing Price Nationwide and in Idaho

The price of different fuels is highly correlated. As can be seen in Figure 3, the fuel prices go up and down in tandem since gasoline and diesel prices are based on an international market of supply and demand. Biofuel increases the supply of fuel, hence lowering the overall fuel prices. Even though the volume of biofuel may be small, the price benefit it provides may be significant due to nonlinear supply and demand relations.

Critics argue that Renewable Fuel Standards (RFS2) mandate for a certain volume percentage of biofuel in petroleum fuel creates a guaranteed market demand that may artificially increase the price for biofuel if there is not enough supply. This, in turn, raises the overall price of gasoline and diesel blended with biofuels. This is a valid concern. The United States EPA has been careful to adjust the volume mandate in Renewable Fuel Standards (RFS2) commensurate with supply to avoid artificial price hike.

For high-volume users of fuel like farmers and fleet operators, volatility in the fuel market may present a management nightmare. To protect against this, many farmers have opted to produce their own biodiesel for a farm tractor by dedicating a portion of land to grow oil seed. In Idaho, a biodiesel producer that produces up to 5,000 gallons of biodiesel fuel in a calendar year for personal consumption is exempt from the requirement to obtain an Idaho motor fuel distributor's license.

Although this may be desirable for a fuel-security standpoint and to hedge against price volatility, there is a potential that farmers and fleet operators may still see an increase in cost. When biofuel is produced on-farm, usually for farm use, the overhead cost of maintaining fuel quality, process safety and logistics can take a significant amount of the farmer's time and resources. Many small biodiesel plants have closed because of the economics associated with the operation. The National Biodiesel Education Program has more information for those interested in making biodiesel themselves.[43]

2.8 Regulations and Tax Policy

To help the infant biodiesel industry become price competitive, the United States established the biodiesel tax credit under the American Jobs Creation Act of 2004. This allowed a blender of biodiesel and renewable diesel to claim a credit of $1 per gallon against their United States federal tax liability. The United States Congress let the biodiesel tax credit expire a few times; however, in each of these years the tax credit was reinstated retroactively. The current tax credit was last approved by Congress in 2019 to extend it through 2022.[44]

In addition to the federal tax credit, there are grants and guaranteed loans available for renewable fuel. Many states also provide incentives to use alternative fuel or low carbon intensity fuels. An example of such a program is California's Low Carbon Fuel Standard[45] that puts a policy in place to incentivize low-carbon-intensity energy sources, such as biofuel. Idaho currently does not have such a program at the state level.

One of the selling points of biofuel is its low emissions. LCA is used to assess the environmental impacts of biofuel considering agricultural production, transportation, processing, manufacturing, distribution, and use. A 2020 analysis by Argonne National Laboratory found that using corn-based ethanol in place of gasoline reduces life-cycle greenhouse gas (GHG) emissions on average by 40%.[46] Biodiesel reduces GHG emissions by about 78% compared to regular diesel.[46] A biofuel that reduces GHG emissions by over 50%, such as renewable diesel and cellulosic ethanol, is categorized as advanced biofuel under the Renewable Fuel Standards (RFS2).

2.9 Federal and State Gas Taxes

Both petroleum and biofuel are taxed at the same rate.[47]As stated earlier, Idaho's current tax is 32 cents per gallon for ethanol and biodiesel. The United States federal excise tax on gasoline is 18.4 cents per gallon and 24.4 cents per gallon for diesel fuel.

2.10 Other Regulations and Incentives

A significant federal incentive currently in place is the Renewable Fuel Standard (RFS) program created under the Energy Policy Act of 2005. The RFS program established the first mandatory blend levels for renewable fuel in the United States. The Renewable Fuel Standard program (RFS) was amended in 2007, now known as Renewable Fuel Standard (RFS2), to include renewable fuel replacements for diesel. The incentive requires obligated parties to blend a certain volume of biofuel called Renewable Volume Obligations (RVO) into petroleum fuel. To track compliance, the EPA created a system of tradable credits know as Renewable Identification

Numbers (RIN). Each gallon of biofuel has a unique RIN attached to it. The total number of RINs that can be generated is determined from both the volume of fuel and its GHG equivalence value. For biodiesel, the equivalence value is 1.5 and represents the number of gallons that can be claimed for compliance purposes for every gallon of biodiesel.[24] The RFS2 provides a guaranteed market for biofuel.

2.11 Conclusion: Summary of Trends, Barriers, and Opportunities

Supply of petroleum fuel is subject to geopolitics and from many factors that are not in direct control of the United States or State of Idaho, making the price of petroleum-based fuel volatile. Petroleum fuel's energy density is over 50 times higher than most advanced battery technology and is not likely to replace liquid fuel powered heavy-duty vehicles, such as agricultural tractors or semi-trucks in the foreseeable future.

Biofuels are a renewable alternative to petroleum fuels. Ethanol and biodiesel are two major types of biofuels, with ethanol substituting for gasoline and biodiesel substituting for diesel fuel. The biofuel industry has provided a market for excess agricultural production after use for food and feed. Since 2000, the CPI for food has not changed. This indicates that biofuel did not have a significant impact on the CPI for food.

Biofuel is a better alternative to petroleum fuel for GHG emissions. Despite its advantages, the supply is limited due to feedstock limitations. More research is needed to expand the feedstock for biofuel production from other non-food sources such as algae, forest residues, and even synthesizing liquid fuel.

3. NATURAL GAS

3.1 Introduction

Natural gas has been recognized as a transportation fuel since the twentieth century.[48] Natural gas is an odorless, gaseous mixture of hydrocarbons that account for about 30% of the energy used in the United States. There are three forms of natural gas; renewable natural gas (RNG), compressed natural gas (CNG), and liquid natural gas (LNG). Approximately 40% of the fuel goes to electric power production and the remainder is split between residential and commercial uses. Only about 2/10 of 1% is used for transportation fuel.[49] As the transportation sector shifts to a more diverse fuel market, natural gas continues to receive more recognition and consideration among consumers.

3.2 Availability and Economics

Residential and commercial customers typically are not subjected to price volatility due to regulation and gas utilities' ability to work with gas suppliers to lock in gas prices for a given year. A major regulated gas utility in Idaho, Intermountain Gas Company (IGC), maintains stable pricing throughout the year through the Purchase Gas Adjustment (PGA) filed with the Idaho Public Utilities Commission each October. The filing limits price increases or decreases to only once per year, thus influencing pricing in a positive manner towards Idaho customers.[50]

Natural gas is viable as a transportation fuel. For vehicles that travel long distances, liquified natural gas offers a greater energy density than compressed natural gas, and a vehicle's range on a single tank of liquified natural gas is comparable to conventional vehicles powered by petroleum fuels. The advantages of natural gas as a transportation fuel include the ability of natural gas to be produced domestically, distributed using widespread, existing distribution infrastructure, and reduced GHG emissions over conventional gasoline and diesel fuel.[51] Many medium-duty and heavy-duty vehicles operate using natural gas and are available from various manufacturers. Many fleet operators have adopted CNG, including transit agencies and refuse truck fleets. LNG-powered class 8 tractor-trailers are also common. Manufacturers include but are not limited to Freightliner, Volvo Trucks, Peterbilt, New Flyer, Ford Motor Company, Battle Motors, Elgin, and Autocar.[52]

Considering the growth of the electric vehicle (EV) market, natural-gas-powered generators could be placed at CNG or LNG vehicle fueling stations to power EV charging equipment. These fueling stations would offer multi-fuel options to customers, providing both natural gas and electricity for commuters, municipalities, and fleets even during times of extreme weather, natural disasters, or scheduled electric grid outages.

3.3 Renewable Natural Gas

RNG, also called biogas, is typically produced from organic waste, such as cow manure, wastewater treatment facilities, landfills, and food production facilities. It is a pipeline-quality vehicle fuel that qualifies as an advanced biofuel under the Renewable Fuel Standard.[53] RNG can use the existing natural gas distribution system and must be compressed or liquefied for use in vehicles.[52]

RNG is the only alternative fuel that, when produced according to best practices, is a carbon-negative fuel.[54] As a raw biogas, RNG has a methane content between 45% to 65% and must go through a series of steps to be converted to RNG. Once upgraded, the gas has a methane content of 90% or greater. RNG has the lowest LCA carbon footprint of any alternative fuel available today, even surpassing EVs charged by renewable electricity.

RNG in Idaho is currently produced by three dairy farms in south-central Idaho. The dairy farms process cow manure into pipeline-quality natural gas. Using typical production processes, the farms treat the raw gas to remove moisture, carbon dioxide (CO_2), trace level contaminants, and to reduce the nitrogen and oxygen content.[55] Once processed and the RNG meets all gas quality specifications, the gas is injected into IGC distribution systems. Current RNG production in Idaho ranges from as low as 2,000 therms per day to as high as 8,000 therms per day. It should be noted that IGC's ability to receive the RNG into its distribution system is dependent on the flow rate, time of year, operating pressure and demand within the distribution system. IGC is under no obligation to take or inject the RNG into its distribution system.

Two additional RNG facilities in Idaho have been announced and are expected to inject into IGC's distribution systems. A third RNG facility is being planned and is currently in a design and feasibility review.[56]

3.4 Compressed Natural Gas

CNG is produced by compressing natural gas to less than 1% of its volume at standard atmospheric pressure. It is necessary to compress natural gas for storage onboard vehicles to increase energy density and provide adequate driving range. CNG is also stored in tanks or tubes for storage at filling stations or for transport to the station in trailers such as the one shown in Figure 4.

Figure 4. CNG tube trailer for transporting compressed natural gas.[59]

There are three types of CNG stations: time-fill, fast-fill, and combination-fill. Time-fill stations are primarily used by fleets that fuel vehicles at a central location when they are parked for long periods of time, such as overnight. Vehicles at time-fill stations are generally filled directly from the compressor, not from fuel stored in high-pressure vessels. Fast-fill stations are best suited for retail situations where vehicles arrive randomly and need to fill up quickly. Fast-fill stations receive fuel from a local utility line at a low pressure and then use a compressor onsite to compress the gas to a high pressure and store it in gas tubes and/or tanks, such as those at an IGC CNG station shown in Figure 5.

Figure 5. CNG station at Intermountain Gas Company.[60]

Drivers fueling light-duty vehicles at a fast-fill station experience similar fill times to a conventional gasoline fueling station. Lastly, combination-fill stations include both fast-fill and time-fill components in one system. Vehicles connected to the time-fill dispensers are filled directly from the compressor, usually overnight, whereas fast-fill dispensers are filled from the storage vessels or from the compressor. Combination-fill stations can garner revenue from fleets and private customers if fast-fill dispensers are made available to the public.[57]

Non-renewable natural gas in Idaho is sourced from the Williams Northwest Pipeline, which is a transmission pipeline generally running along the Snake River Plain in southern Idaho. Williams receives gas into its pipeline from other pipeline interconnects, including Sumas at the Washington/Canadian border, GTN Transmission, and various domestic gas sources in Wyoming, New Mexico, Colorado, and Utah.[58] It should be noted that Williams is basically considered a transporter of natural gas and does not actually own the gas in its pipeline.

3.5 Liquid Natural Gas

The only LNG production facility in Idaho is the IGC's Nampa LNG plant. There, un-odorized natural gas is received from the Williams Northwest Pipeline. It is cooled and liquefied to -260°F through a liquefaction process and then stored in a 7.35-million-gallon tank. LNG is typically liquefied at a rate of 50,000–55,000 gallons per day, depending on ambient temperature. IGC has a truck loading station at its Nampa LNG plant and is authorized to sell LNG via a tariff approved by the Idaho Public Utilities Commission. The truck loading station is equipped to fill the 10,000-gallon LNG trailers used to transport LNG to fueling stations. LNG has substantially less volume than gaseous natural gas, allowing for LNG distribution to destinations beyond the reach of pipelines. It takes 1.7 gallons of LNG to equal the energy equivalent of 1.0 gallon of diesel.

3.6 Regulations and Tax Policy

Natural gas fueling stations are becoming more readily available around the States. For example, a LNG fueling station in Idaho is shown in Figure 6.

Figure 6. LNG fueling station.[61]

Fueling natural gas vehicles (NGVs) at home can be possible with a small fueling appliance.[62] The State of Idaho subjects CNG used as a special motor fuel to the state fuel excise tax rate of \$0.32 per GGE. LNG is subject to the excise tax rate of \$0.349 per diesel gallon equivalent.[63] However, state excise tax paid on special fuels used in-state or for federal government vehicles is subject to a refund, if the tax was originally paid directly to a special fuel vendor. The tax refund is not available for special fuels used while idling. The Idaho Fuels Taxes and Fees website provides additional information regarding this subject.[64]

3.7 Efficiency, Emissions, Performance, and Durability of Natural-Gas-Powered Vehicles

When used as a vehicle fuel, natural gas can offer life-cycle GHG emissions benefits over conventional fuels, depending on vehicle type, duty cycle, and engine calibration. Argonne National Laboratory's GREET model estimates that NGVs emit 6% to 11% lower levels of greenhouse gas (GHGs) than gasoline throughout the fuel life cycle. Argonne National Laboratory also found that all RNG production methods produce significantly less greenhouse gas (GHG) emissions than conventional fossil natural gas and gasoline."[65]

Natural gas also has lower tailpipe emissions than petroleum-based fuels. Tailpipe emissions result from fuel combustion in a vehicle's engine. The emissions of primary concern include the regulated emissions of unburned hydrocarbons, oxides of nitrogen (NOx), carbon monoxide (CO), as well as carbon dioxide (CO_2). The U.S. EPA requires all fuels and vehicle types to meet increasingly lower, near-zero thresholds for tailpipe emissions of air pollutants and particulate matter.[65] One advantage to NGVs is their ability to meet these stringent standards with less complicated emissions controls.

Driving range of NGV is generally less than a comparable gasoline- or diesel-powered vehicle, due to lower energy density of CNG and LNG. Extra storage tanks can be added to increase range but at the expense of space for passengers or cargo. NGVs have similar driving performance characteristics to gasoline and diesel vehicles under most conditions. NGV performance suffers in extreme cold temperature because of reduced fuel pressure and the temperature of engine intake air. Engine maintenance requirements are comparable between NGVs and conventional vehicles.

3.8 Conclusion

There are many identified advantages of natural gas as an alternative fuel, such as domestic availability, an established distribution network, stable fuel prices, and emission benefits. Using natural gas as an alternative transportation fuel also could lessen our dependence on other nations to support the transportation sector needs, thus having a potential to increase national security and economic stability. The United States is the one of largest producers of natural gas in the world. The affordability, accessibility, and existing regulatory and infrastructure frameworks of this energy resource are compelling benefits.

There are also significant barriers to utilizing this energy source, including very sparse fueling station availability, poor performance in extremely cold weather, and unfamiliarity of the vehicle service industry with NGVs. Also, the potential for natural gas as a transportation fuel is largely unknown to the average consumer.

4. PROPANE

4.1 Introduction

Propane, also known as liquefied petroleum gas or propane autogas, is a popular alternative to gasoline and diesel. It is considered an alternative fuel under the Energy Policy Act of 1992.[66] Propane accounts for about 2% of the energy used in the United States. Less than 3% of propane consumption is for transportation. There are now over 27 million propane-powered vehicles used around the world.[67] A growing number of governments are encouraging the use of the fuel, recognizing its emission reduction, low cost, and practicality benefits compared to some other alternative fuels. Today in the U.S., about 60,000 on-road vehicles, including school buses, run on propane.[68]

4.2 Availability and Economics

Propane is often used for medium-duty vehicles like airport shuttles, mass transit vehicles, and delivery trucks. For this type of vehicle, propane has a low cost of ownership because the fuel is readily available, relatively affordable, and vehicles that use it have low maintenance costs.

Propane has a lower energy density. One gallon of propane has 73% of the energy in 1 gallon of gasoline.[69] As for emissions, there is a 97% reduction in oxides of nitrogen (NOx) and a 10% reduction in carbon dioxide (CO_2) compared to diesel-powered medium-duty vehicles.[70]

There are two types of propane vehicles: dedicated and bi-fuel. Dedicated propane vehicles are designed to run only on propane. Bi-fuel vehicles have two separate fueling systems, allowing the vehicle to run on propane or gasoline. Bi-fuel vehicles have a greater range than dedicated propane or gasoline vehicles. A gallon of propane has 27% less energy than a gallon of gasoline, making the fuel economy of propane vehicles slightly lower.[51]

Propane is an energy sourced from natural gas liquids (NGL). This gas is a byproduct of the massive amount of natural gas we consume for electric production and heat. In 2018, Idaho consumed 67 million gallons of propane.[70] With coal-powered electric power plants being replaced by natural-gas-fired plants, propane production in the U.S. has doubled. This has driven producers to start exporting their product. Idaho employed 186 people and paid $9.3 million in direct wages associated with propane production.[71]

A barrier that comes with propane is the need for training services and repair centers to safely repair a propane engine. The Propane Education and Research Council has developed online training. The Certified Employee Training Program (CETP) is a training resource for refueling, repairing, and providing emergency response.[72] The Rocky Mountain Propane Association provides hands-on training for dispensing propane safely and addresses propane emergencies for first responders as well.[73]

Propane is typically stored in a retail container of 1,000 gallons or less. Locations like truck stops or travel plazas have multi-purpose stations that can fill small cylinders for cooking and filling propane. The public is not allowed to fill their own vehicles in Idaho. There are hundreds of propane refueling stations in Idaho.[74]

Considering the growth of the EV market, propane-powered generators could be placed at propane vehicle fueling station to power EV charging equipment. These fueling stations would offer multi-fuel options to customers, providing both propane and electricity for commuters, municipalities, and fleets even during times of extreme weather, natural disasters, or scheduled electric grid outages.

4.3 Regulations and Tax Policy

Currently, state gas taxes for propane are set at $0.232. Because it is considered a special fuel like natural gas in Idaho tax code, state excise tax does not apply to propane when it is used in-state or for federal government-owned vehicles, except consumption during idling.

The Idaho Department of Environmental Quality (DEQ) offers rebates for the replacement of qualified medium- and heavy-duty vehicles.[75]

4.4 Efficiency, Emissions, Performance and Durability of Propane-Powered Vehicles

Propane has a lower energy density than gasoline, so vehicles powered solely by propane have shorter range. Today's high-compression engines see an increase in power when using propane as a fuel. Also, propane burns cleaner. As for maintenance, most medium- and heavy-duty trucks and buses that run off propane can go double the distance of petroleum-powered fleets without an oil change being required.[67]

In the 1970's, propane was the alternative fuel of choice for farmers. Propane vehicle conversions and factory installed systems peaked in the early 1990's. In the mid-1990's the EPA cracked down on after-market installations of natural gas and propane conversions by establishing rules that required the vehicle conversion companies to receive the same emissions certifications as original equipment manufacturer (OEMs).[76] These rules brought propane conversions to a halt.

In the early 2000s, companies trying to get EPA certification often used computer modules and chips that were not of the best quality, and consumers and fleets were not happy with the ensuing products. From 2010 to 2020, Roush partnered with Ford to develop a liquid propane fuel injection system that proved to have high quality.[77] Prins, the largest propane conversion kit in Europe, partnered with the American company Alliance Autogas to provide high-quality, EPA-certified products for vehicle conversions.[78] Blue Bird, IH, and Thomas all have successfully implemented propane engines in their buses. The Freightliner SG2 propane-powered chassis has also been successful in the marketplace.[79]

Currently, organizations are working to address future needs by developing propane engines with higher displacement. For example, Cummins is developing a 6.7-liter propane engine, scheduled to reach production in 2024.[80] An additional benefit to propane engines is that they can be easily rebuilt, repaired, and recycled.

Propane also provides safety benefits. It is a low-pressure fuel, stored at 100 psi (at 60°F), whereas CNG is stored onboard vehicles at 3,000 psi or greater.[81] Also, crash tests have shown propane tanks to be stronger than gasoline tanks in rear end collisions. On the other hand, because propane tanks are pressurized, they are more expensive to manufacturer and are less space-efficient than conventional vehicle fuel tanks.

4.5 Conclusion

Propane as a transportation fuel is affordable and readily available for the nation's alternative fuel corridors. Propane's simple, affordable, currently available fueling equipment significantly reduces a major barrier to adoption that other alternative transportation fuels face. Propane has the potential to be an effective transportation fuel that could be relied upon by many consumers. With the recent passage of the Infrastructure and Investment Jobs Act, funding is expected to become available for propane fueling stations and potentially could also be used for propane-powered generators connected to EV chargers for added resilience.

5. ELECTRICITY

5.1 Introduction

EVs are an older technology that has been gaining popularity in the past several years. EVs were first created in the 1800s. In the early 1900s, 30% of cars were fueled on electricity.[82] Today, there are three types of EVs: battery-EVs (BEVs, also referred to as all-electric vehicles), plug-in hybrid EVs (PHEVs), and hybrid EVs (HEVs). BEVs run on electricity only and are charged from an external power source. They are propelled by one or more electric motors powered by rechargeable battery packs. Most BEVs introduced to the market in the past 5 years can travel at least 200 miles on a charge, with some vehicles having range of over 400 miles on a single charge. Plug-in Hybrid Electric vehicles (PHEVS) have both an electric motor and an internal combustion engine. PHEVs can usually drive 20 to 50 miles in EV mode using only the battery, at which point they automatically shift to gasoline-powered propulsion. HEVs are powered by a combination of an internal combustion engine with electric motors running off a battery pack for greater efficiency, but the batteries cannot be charged from an external source.[83]

5.2 Current Vehicle Availability

There are many applications for EVs, from passenger vehicles to heavy-duty trucks and buses. The national and global EV markets are currently growing quickly. According to the International Energy Agency, more than 10 million EVs were on the road in 2020, globally.[84] In the United States, nearly 1.8 million EVs have been registered.[85] As of June 2022, there are 3,500 BEVs registered in Idaho.[86] As of 2021, Idaho has 104 public EV charging station locations with 262 charging ports.[87] As prices for some EVs decrease and vehicle range increases, transitioning to an electric vehicle is becoming more realistic and feasible for a larger number of consumers and fleets.

The first quarter of 2022 saw an increase in consumers purchasing EVs and automakers committing to manufacture more EV models and in higher quanitities.[88] At the time of this writing, mainstream automakers have collectively committed to sell over 40 million EVs worldwide per year by 2030.[89] Given the scientific consensus and growing number of policymakers considering climate risk as a serious threat, policy supporting significant emission reductions is being enacted, such as the Infrastructure and Investment Jobs Act that was recently passed in November 2021. This trend is expected to increase over time, especially targeting the transportation sector and its various forms of transporting goods and people.

According to Bloomberg New Energy Finance, roughly 41% of U.S. passenger car sales will be electric by 2030.[90] To charge these vehicles, the capacity of the electric grid will need to increase, given the expected trend in EV adoption. Figure 7 shows the United States energy consumption historically and provides future predictions.[91] According to the figure, the transportation sector will become significantly more dependent on electricity to meet transportation needs.

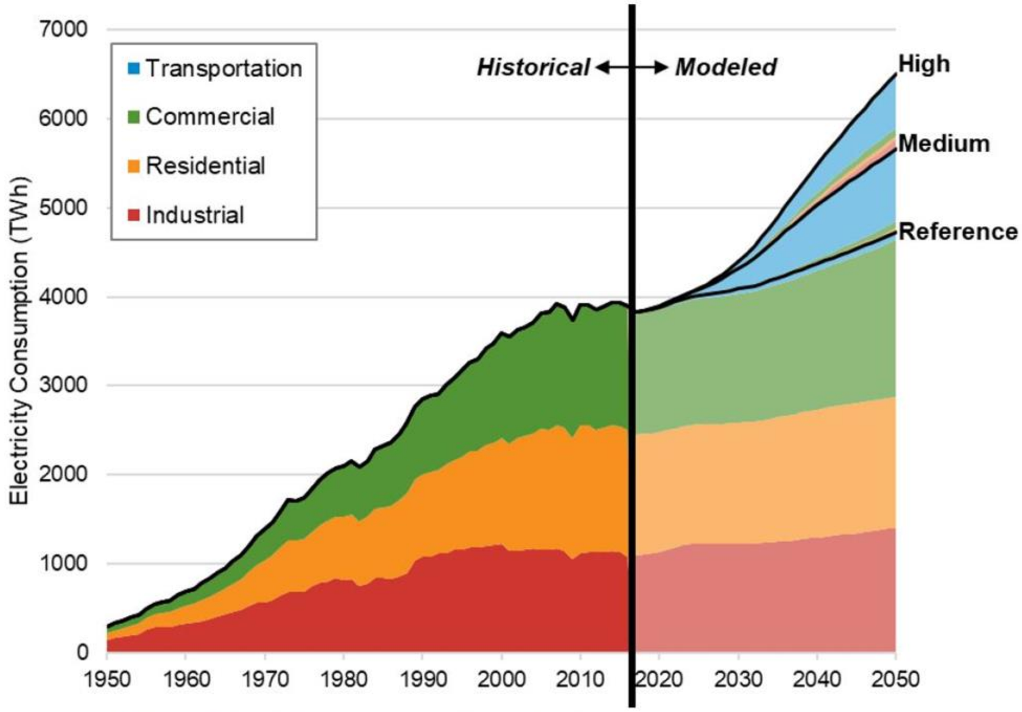

Figure ES-3. Historical and projected annual electricity consumption

Figure 7. Explores demand-side impacts of a highly electrified future.[92]

Charging infrastructure is also expected to grow in response to consumer demand for EVs. Direct current (DC) fast charging station locations in Idaho are shown in Figure 8. As of Spring 2022, 13 public DC fast charging stations that are open to most vehicle makes/models are located in Idaho. Tesla has an additional six DC fast charging stations in Idaho that serve only Tesla vehicles.[93] For additional EV charging station locations out of state, the U.S. Department of Energy offers a site to search for specific locations nationwide.[94]

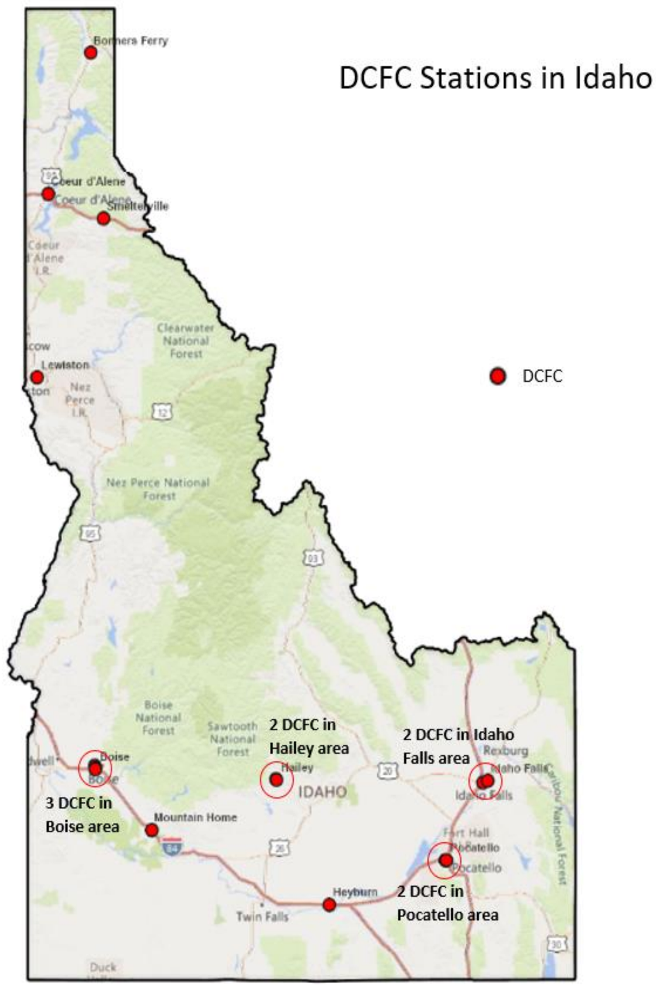

Figure 8. DC fast charger station locations in Idaho, as of Spring 2022.[87]

5.3 Efficiency, Emissions, Performance, and Durability of Electric Vehicles

EVs provide both economic and health benefits to the consumer and the State. Economically, the estimated scheduled maintenance cost for a light-duty BEV is $0.06 per mile, while a conventional internal combustion engine vehicle costs $0.10 to maintain per mile.[95] From a public health and environmental standpoint, BEVs have no tailpipe emissions. Fleet operators may realize added environmental benefits by reducing the need to store and manage combustible fuels and lubricants onsite for fueling and maintenance. This also reduces operational costs and regulatory burdens.

Table 2. Vehicle type and grams of CO_2 emissions per mile.[96]

Vehicle Type	Grams CO_2e/mile
Internal Combustion Engine (ICE)	381
Plug-In Hybrid Electric Vehicle (PHEV) (national)	200
Battery Electric Vehicle (BEV-national)	113
Battery Electric Vehicle (BEV-Idaho)	107

Although EVs do not omit carbon dioxide (CO_2) when in use, the production of EVs and batteries generates CO_2 emissions. Table 2 above speaks to the vehicle type and grams of CO_2 emissions per mile, considering overall lifecycle emissions. Figure 9 displays the high amount of CO_2 emissions during production of EVs. According to Argonne National Laboratory, despite this large amount of CO_2 emissions that goes into producing an EV, after 15,000 miles of driving an internal combustion engine vehicle, the conventional vehicle's CO_2 tailpipe emissions exceed the carbon footprint of EV manufacturing.[97]

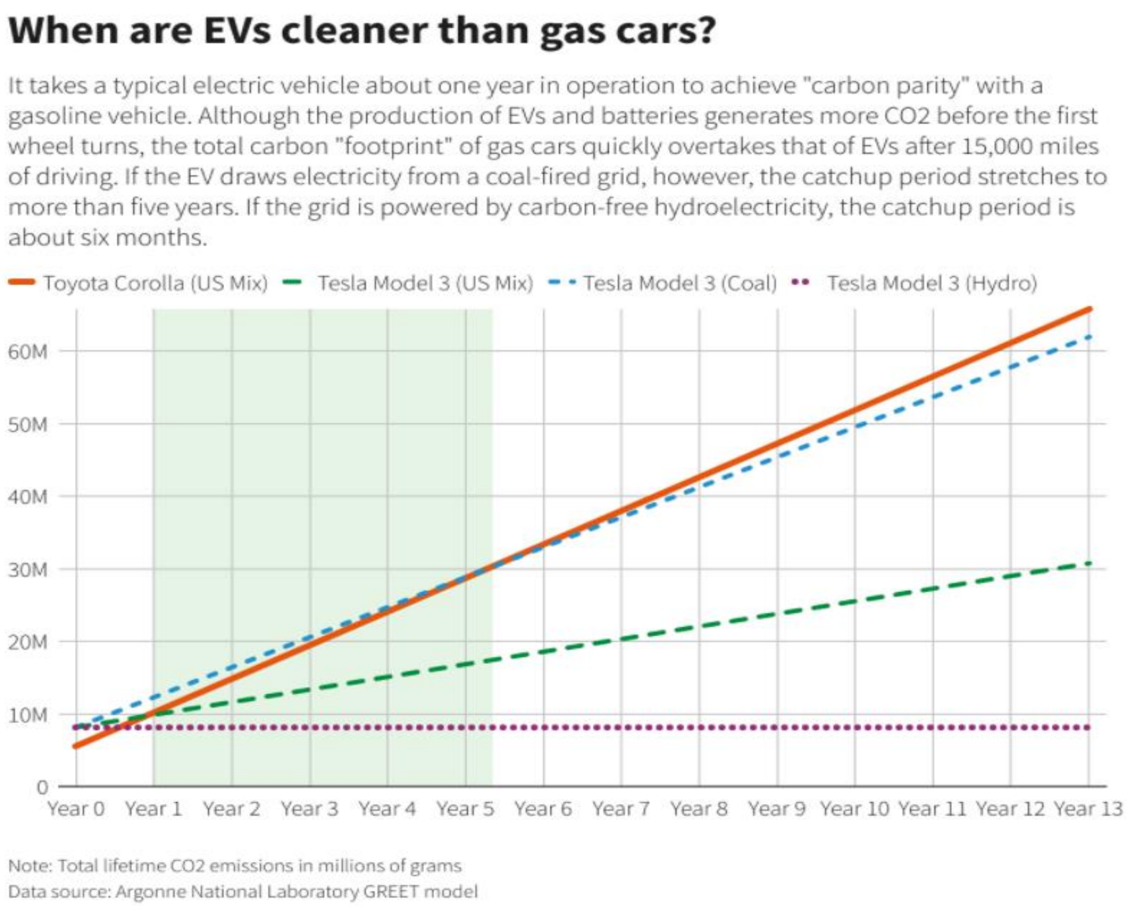

Figure 9. Total emissions over a 13-year period.[97]

According to a United States Department of Energy report focusing on impacts of high EV adoption on the Western U.S. Power Grid, grid capacity already planned for in 2028 is likely to be sufficient to support charging of a large number of EVs, so long as charging is mostly done during off-peak hours.[98]

A variety of types of EV chargers are available, specific to different uses. Generally, three charging categories are used to describe EV charging, as follows:

1. **Alternating Current (AC) Level 1:** AC Level 1 chargers use 120-volt AC power and can be plugged into a standard wall outlet. Unlike other chargers, Level 1 chargers do not require the installation of any additional equipment, although a dedicated electrical circuit is recommended. These chargers typically deliver 2 to 5 miles of range per hour of charging. Level 1 chargers are the least expensive charging station option, but they also take the most time to charge the car's battery. Because they require many hours to fully charge most EV batteries, Level 1 chargers are best suited for residential and workplace charging.
2. **AC Level 2:** AC Level 2 chargers are used for both residential and commercial charging stations. They require a 240-volt circuit, so they cannot be plugged into a standard wall outlet. Instead, they are usually installed by an electrician. When installing a Level 2 charger, drivers will need to take into consideration local and state laws for inspection and permitting. Level 2 chargers deliver 10 to 60 miles of range per hour of charging, but often will require multiple hours to fully charge most EV batteries. Therefore, Level 2 chargers are best suited for residential and workplaces, where drivers have hours to fill their tanks. Level 2 can also be used for public charging at retail or short-term parking opportunities where drivers may wish to "top off" their battery. Level 2 chargers are also good for overnight charging for fleets.
3. **DC Fast Charger:** DC Fast Chargers convert AC power received from the grid to DC power before delivering it to the vehicle. DC Fast Chargers typically require three-phase, 480-volt AC power from the grid and are therefore only used in commercial and industrial applications. These chargers are more costly to install than Level 2 chargers, so public DC fast charging stations usually have a fee for us. For example, one brand of charging station charges $0.35/kWh, equivalent to approximately $3/gallon in average driving range (assuming 3.3 miles/kWh on average, which is typical of most light-duty passenger car EVs). By comparison, Level 2 chargers installed in an Idaho residence (where electricity costs are often less than $0.10/kWh) can charge for less than $1/gallon of gasoline equivalent. Most DC Fast Chargers for passenger vehicles deliver 50 kW to 180 kW output power. This equates to roughly 60 to 200 miles of driving range replenished in about 20 minutes. Industry trends are moving toward higher-power DC fast chargers, up to 350 kW, resulting in close to 400 miles of range replenished in 20 minutes. Not all EVs can be charged with DC Fast Chargers. Table 3 summarizes and compares the different chargers for an EV.

Table 3. Differences between various chargers for electric vehicles.[99]

	Level 1 Charger	Level 2 Charger	DC Fast Chargers
AC Voltage	120 volts	208/240 volts	480 Volts
AC Input Current and Power	12–16 amps 1.4–1.9 kW	16–80 amps 3.8-19.2 kW	50 kW to 350 kW
Estimated Charge Time (when charging from 20% state of charge to 100% state of charge)	~17 hrs. depending on vehicle	3.3-kW onboard charger: 7 hrs. 7.0-kW onboard charger: 3.5 hrs. 20.0-kW onboard charger: 1.2 hrs.	150 kW: 100+ miles of range in 15 min 350 kW: 200+ miles of range in 10 min
Wall Plug Types	Standard wall receptacle	Typically hard wired, NEMA 14–50 (RV plug) or NEMA 6–50 Electric Vehicle	N/A
Connector (i.e., Plug) Type	SAE J1772 or Tesla	SAE J1772 or Tesla	CHAdeMO (Nissan, Mitsubishi) CCS (all others except Tesla) Tesla
Typical Level Charger Cost	$0 – Typically comes with the vehicle	$400–$6,500	$10,000–$40,000
Typical Installation Cost	$0 – No installation required	$600–$12,700	$4,000–$51,000

On average, car owners in the United States drive about 30 miles per day, a range that newer EVs can meet several times on a single charge. According to the United States Department of Energy, over 80% of EV charging happens at home.[100] With EVs becoming more common in the transportation industry, discussions are taking place that focus on installing chargers in public spaces to reduce range anxiety, provide charging solutions for trips beyond the vehicles' range and accommodate those drivers who do not have access to a dedicated parking space, such as multifamily units. Figure 10 provides which charger types should be chosen for different location types and use cases.

Medium- and heavy-duty vehicles that return to base operations can more easily adopt EV technologies today; however, long-term public charging for longer haul medium-to-heavy-duty vehicles face additional challenges, such as those listed below:

- Heavy-duty vehicles needing en-route opportunity charging will benefit from higher capacity charging (e.g., 350 kW or higher).
- Turn radius/maneuverability requirements are different for medium-to-heavy-duty EVs. These uses may require pull-through charging islands, but most charging stations today require EVs to park headlong into a parking stall.

- The industry is working on very high-powered charging (>1 MW) for heavy-duty trucks and buses with large batteries.

5.4 Regulations and Tax Policy

In 2015, Idaho state law changed to allow companies to buy electricity from a public utility and resell it to charge electric car batteries.[101] Additional regulations centered around EVs consist of safety standards, fuel economy and emission regulations, EPA calculated miles per gallon equivalent (MPGe), CAFE and other states' Zero-Emission Vehicle regulations. Federal and state gas taxes apply as well. Passenger BEVs and PHEVs are subject to additional registration fees in Idaho to collect taxes for road maintenance that would typically be captured through taxes on gasoline and diesel. The BEV registration fee in the State of Idaho is an additional $140, whereas PHEVs have an additional $75 registration fee.

The Volkswagen Settlement Funding provided funding for public fast charging through July 2022 and funding for replacement of heavy-duty diesel vehicles with clean alternatives. On November 15, 2021, Congress passed the Infrastructure and Investment Jobs Act.[102] This act has several provisions to advance transportation electrification including:

- *National EV Infrastructure Formal Program:* Approximately $30 million for Idaho Transportation Department (ITD) to use over 5 years to deploy EV charging infrastructure.
- *Alternative Fuels Competitive Program:* An additional opportunity for Idaho state and local governments or transit authorities to apply for funding to support alternative fuels including electricity, CNG, LNG, and propane.
- Competitive grants for electric school buses and transit buses.
- *Energy Efficiency and Conservation Block Grant:* ~$1.9 million that can be used to supplement state EV programs.

The Inflation Reduction Act was passed in August 2022. This act provides several additional EV and/or charging incentive opportunities including:

- Inflation Reduction Act Qualified Commercial Clean Vehicles (Section 13403): Beginning January 1, 2023, the Inflation Reduction Act's Commercial EV Tax Credit will provide a 30% vehicle purchase credit for electric and other non-gasoline/diesel trucks and a 15% credit for combustion engine vehicles with at least a 15-kWh battery. The credit should not exceed $40,000 or the incremental cost of the vehicle and is valid until 2032. For vehicles that weigh no more than 14,000 pounds, a rebate of up to $7,500 is available.[103]
- Inflation Reduction Act: Alternative Fuel Refueling Property Credit (Section 13404): The section 30C(g) term to receive credit is extended to December 31, 2032. Each property cannot receive more than $100,000 in rebates.[104]
- Clean Heavy-Duty Vehicles (Section 60101): Funding has been set aside to support an incentive program that replaces Class 6 or Class 7 heavy-duty vehicles with zero-emission vehicles and infrastructure to support charging zero-emission vehicles, encouraging the adoption of zero-emission vehicles.[105]

Commercially available EVs must meet the Federal Motor Vehicle Safety standards [106] and undergo the same safety testing as conventional vehicles with internal combustion engines. Many

EVs have received 5-star safety ratings from the National Highway Safety Administration.[107] Emergency response procedures differ, given the makeup of the vehicles. To prepare Idaho for the transition to EVs, the Treasure Valley Clean Cities Coalition [108] has sponsored first-responder trainings to educate Idaho firefighters on how to identify EVs and manage incidents. Trainings have been held in Canyon County, Ada County, Boise County, Twin Falls County, and Bannock County.

5.5 Conclusion: Summary of Trends, Barriers, and Opportunities

With the recent increase in gasoline costs, demand among consumers for EVs is growing and manufacturers are responding by increasing investment in EV production. Through the third quarter of 2022, sales of light-duty passenger vehicles with a plug (BEVs plus PHEVs) comprised 6% of all new-car sales in the United States. Table 4 provides the names of auto manufacturers that have announced major milestones or goals for EV production.

Table 4. Auto manufacturers who have announced major milestones to expand their EV product offerings.[113]

Bentley	Mercedes-Benz
BMW	Mitsubishi
Ford	Nissan
General Motors	Rolls-Royce
Honda	Stellantis
Hyundai-Kia	Toyota
Jaguar Land Rover	Volkswagen
Mazda	Volvo

High demand for EVs and supply chain constraints due to the worldwide COVID-19 pandemic have created a new barrier to EV adoption: insufficient vehicle supply. It is currently very difficult to find EVs to purchase from auto dealerships in Idaho; however, as manufacturers work to overcome supply chain challenges and ramp up production to meet demand, accessibility of EVs is expected to increase.

6. HYDROGEN

6.1 Introduction

Hydrogen is an alternative fuel that is recognized under the Energy Policy Act of 1992. Hydrogen (H) is the first element in the periodic table because it is the lightest element, with one proton and an atomic weight of approximately 1.[114] Hydrogen is the most abundant element in the universe and hydrogen reactions are what powers the sun and stars. On earth, hydrogen is plentiful, but since it is so reactive, it has an affinity for other atoms and is not available in elemental form. Hydrogen always comes chemically bonded to other atoms and exists as part of molecules, such as water (H_2O), or gasoline (C_8H_{18}).

When we refer to hydrogen as a transportation fuel, two hydrogen atoms are bonded together to make the hydrogen molecule, H_2, as seen in Figure 10.[115] Since there is no practical pure source of H_2, it must be made from other molecules. Thus, H_2 is not a primary energy source but an energy carrier in the form of chemical energy that is made utilizing other primary energy resources, such as fossil fuels, renewable energy, or nuclear power.

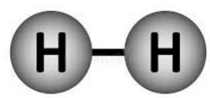

Figure 10. Hydrogen molecule.[115]

6.2 Availability and Economics

Annually, over 10 million tonnes[116] of hydrogen fuel is produced for industrial and chemical applications in the United States. Of the hydrogen produced today, very little is used as a transportation fuel. Hydrogen is primarily produced from natural gas and water electrolysis. Because there is currently no major industrial hydrogen production in Idaho, hydrogen for transportation would likely be produced in the future by water electrolysis. According to the U.S. Hydrogen Study, co-authored by representatives from 20 private companies in the automotive, electric utility, gas supply, and other industries, hydrogen will cost between $2/kg and $3.50/kg in 2030, assuming continued progress is made in reducing the cost and improving the efficiency of electrolysis.[123] This is less than Idaho's average gasoline price, even after subtracting state tax of approximately $0.33 per gallon and federal excise tax of $0.184 per gallon.[124] (Recall that the energy content of 1 kilogram of hydrogen is equivalent to 1 gallon of gasoline.)

For vehicle applications, hydrogen fuel is commonly stored in the gaseous or liquid form. The energy density of hydrogen is one of the lowest of any fuel when measured by volume. Figure 11 below depicts that gasoline has more than three times the energy density compared to liquid hydrogen, which can limit vehicle range. Hydrogen gas is stored in vehicles at very high pressure – up to 700 bar or 10,000 psi – to increase energy density, but its energy density even at this pressure is still very low relative to combustible liquid fuels.

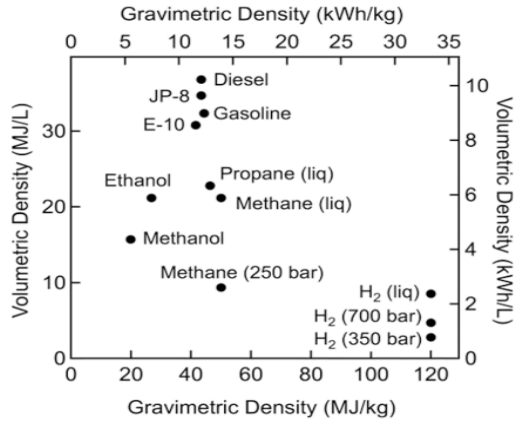

Figure 11. Volumetric versus gravimetric energy densities of common transportation fuels.[117]

Despite the low energy density of hydrogen, fuel cell vehicle (FCV) manufacturers have been able to achieve 350 to 400-mile range on a single tank for compact and mid-size cars with compressed hydrogen, because a hydrogen FCV is much more efficient than a conventional vehicle with internal combustion engine.[118] For a 300-mile driving range, a light-duty FCV will need about 5 kilograms of hydrogen.[118] Of note, 1 kilogram of hydrogen has approximately the same amount of energy as a gallon of gasoline.

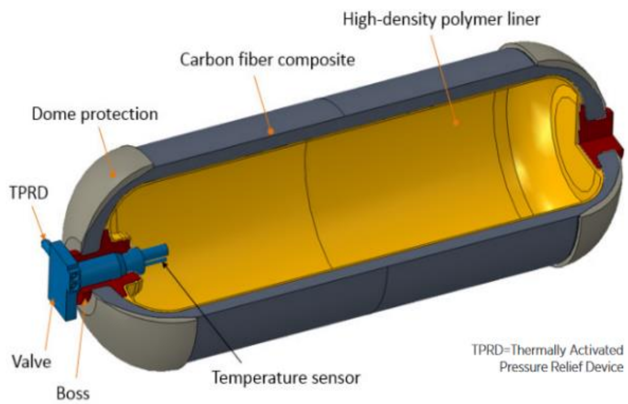

Figure 12. Type IV composite pressure vessel for storing hydrogen at 10,000 psig.[119]

Figure 12 shows a typical hydrogen-storage tank used in FCVs. The tank is made of carbon fiber composites instead of steel to save weight. The fueling time for hydrogen is similar to the fueling time for gasoline vehicles.

Hydrogen can be combusted in an ICE like gasoline, but the vast majority of investment in developing hydrogen-powered vehicles is focused on FCVs. The fuel cell stack in a FCV electrochemically converts hydrogen and oxygen from the air into electricity to power an electric motor. This is why FCVs are sometimes referred to as EVs or FCEVs. The only byproduct is water. Hydrogen converted electrochemically produces no nitrogen oxides. FCVs are classified as zero-emissions vehicles (ZEVs) like BEVs. FCVs are approximately two times more efficient than today’s gasoline vehicles. Today, FCVs are manufactured at low production volumes and are still under development; thus, these vehicles are more costly than internal combustion engine-powered vehicles produced at high volumes. A depiction of the major components in a FCV is shown in Figure 13.

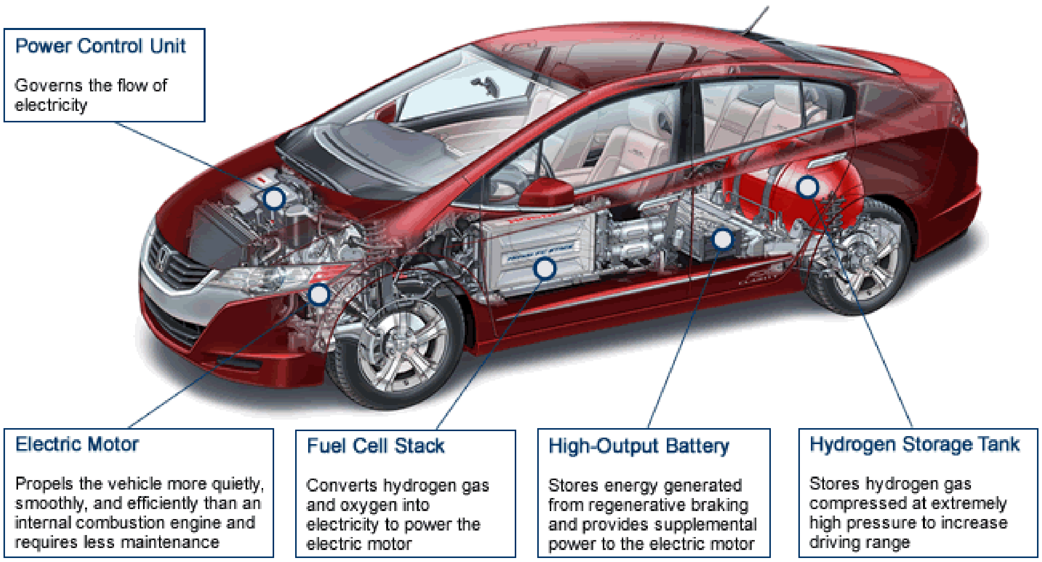

Figure 13. Major components of a FCV.[120]

Because hydrogen can be produced without emissions and then be converted to produce heat and electricity without emissions, there has been significant public and private investment to research, develop, demonstrate, and deploy hydrogen as a transportation fuel, along with FCVs that consume it. The United States has over 7,600 FCVs on the road today, more than any other country.[123] Figure 14 shows the FCVs available today, along with the fuel economy and driving range of each vehicle make/model.[128] However, the vehicles in this figure are not yet for sale in Idaho. A group called H2USA studied several scenarios for increased vehicles sales. The most optimistic scenario shows 8 million FCVs being sold nationwide by 2050.[129]

According to the Alternative Fuels Data Center, there were about 48 public hydrogen fueling stations nationwide in 2021, with 60 more under construction.[125] There are no public or private hydrogen fueling stations in Idaho,[126] which is undoubtedly the reason no FCVs are available for sale in Idaho. In contrast, the United States has about 120,000 gasoline retail fueling stations.[127] The lack of convenient hydrogen fueling is a major barrier to widespread deployment of FCVs.

It is well documented that gasoline and diesel combustion by mobile sources causes air pollution. Emissions of air pollutants such as fine particulate matter and ozone are the largest contributors to premature mortalities.[121] An American Lung Association report found that if the United States shifted to ZEVs, such as BEVs and FCVs by 2050, then over $72 billion in health benefits would be realized, including 6,300 premature deaths avoided and 416,000 lost-work days avoided.[121]

	2021 Honda Clarity	2021 Toyota Mirai Limited	2021 Toyota Mirai XLE
			
	Fuel Economy		
Mi/Kg	66 comb, 67 city, 66 hwy	64 comb, 65 city, 63 hwy	72 comb, 74 city, 70 hwy
MPGE	68 comb, 68 city, 67 hwy	65 comb, 67 city, 64 hwy	74 comb, 76 city, 71 hwy
	Other Estimates		
Range (miles)	360	357	402
	Vehicle Characteristics		
Vehicle Class	Midsize Car	Compact Car	Compact Car
Motor	AC Permanent Magnet Synchronous (130 kW)	AC Synchronous (134 kW)	AC Synchronous (134 kW)
Battery	346 V Lithium Ion	311 V Lithium Ion	311 V Lithium Ion
Availability	Select dealers in California	Dealers in California & Hawaii	Dealers in California & Hawaii

kW = kilowatt; V = volt; kg = kilogram; NiMH = nickel metal hydride

Updated 1/7/2021

Figure 14. Available FCVs in the United States.[128]

Considering the growth of the EV market, hydrogen-powered generators could be placed at FCV fueling stations to power EV charging equipment. These fueling stations would offer multi-fuel options to customers, providing both hydrogen and electricity for commuters, municipalities, and fleets even during times of extreme weather, natural disasters, or scheduled electric grid outages.

6.3 Regulation and Tax Policy

According to NHTSA as of April 1, 2022, the new CAFE standards require an industry-wide fleet average of 49 mpg for passenger cars and light trucks in model year 2026. NHTSA plans to increase the estimated fleetwide average by nearly 10 miles per gallon for model year 2026, relative to model year 2021.[130] Producing a greater number of FCVs will increase automaker's average fleet fuel economy and contribute toward reaching federal CAFE requirements. Naturally, this applies to any type of alternative fuel vehicle whose average fuel economy exceeds that of conventional vehicles.

Because the Environmental Policy Act classifies FCVs as ZEVs, they meet federal and Idaho criteria pollutant emissions requirements. A tax credit of up to $8,000 is available for light-duty FCVs, depending on the fuel economy.[131,132] This tax credit expired December 31, 2021; however, the Inflation Reduction Act extends tax credits for clean vehicles of up to $7,500 that appear to apply to FCVs.[133]

For gasoline, the federal government currently taxes \$0.184/gallon.[134] The State of Idaho taxes \$0.33/gallon for a total of \$0.514/gallon.[123] According to the National Conference of State Legislatures, Idaho is one state that taxes alternative fuels such as hydrogen at the same rate per gallon gasoline equivalent. In addition, Idaho is one of four states that provides the option of purchasing an annual decal in lieu of paying the excise tax. This tax does not apply to state or federal vehicles. Farming vehicles that would use hydrogen have an alternative fuel federal tax exemption. For other vehicles, the federal government offers a \$0.50/gallon Alternative Fuel Excise Tax Credit, which can be taken as a credit against the entity's alternative fuel tax liability.

As part of the Volkswagen Clean Air Act Civil Settlement, the Idaho DEQ set up a competitive rebate program for replacing medium- and heavy-duty diesel vehicles with new cleaner diesels or alternative fuels. There are also federal tax credits available for fuel cell vehicle medium- and heavy-duty vehicles based on their weight.

The federal government offered a tax credit of 30% (not to exceed \$30,000) for hydrogen fueling equipment by station owners.[135] This tax credit has been extended through December 31, 2024.

6.4 Efficiency, Emissions, Performance, and Durability of Fuel Cell Vehicles

Over the last 15 years, the Department of Energy's National Renewable Energy Laboratory (NREL) has tested more than 230 light-duty FCVs with over 7 million cumulative miles.[136] Since testing began, there has been a 32% increase in "on-road" fuel economy with latest data showing nearly 60 miles/kg or gallon gasoline equivalent.[137] On-road fuel economy better simulates real-world driving versus controlled driving cycles on dynamometers used to measure fuel economy.

For Model Year 2005–2012 FCVs tested, performance data showed that the technology would need to continue to improve to meet the Department of Energy's 2020 targets of 65% peak energy efficiency at 25% rated power.[138] This same testing reported approximately 57% efficiency at 25% rated power.[138] Based on this data and the rate of development progress, it is probable that Model Year 2020 fuel cell vehicles would approach the 65% energy efficiency target at part-load.

The NREL has also tested for durability against the U.S. Department of Energy's Model Year 2020 target of 5,000 hours. As shown in Figure 15,[138] the maximum fleet average durability for FCVs tested during 2012 to 2015 achieved 4,000 hours durability. The maximum operation of any vehicles exceeded the target at 5,500 hours. Based on this data and the rate of development progress, it is highly probable that Model Year 2020 FCVs would exceed the 2020 target of 5,000 hours and approach the ultimate Department of Energy's target of 8,000 hours.

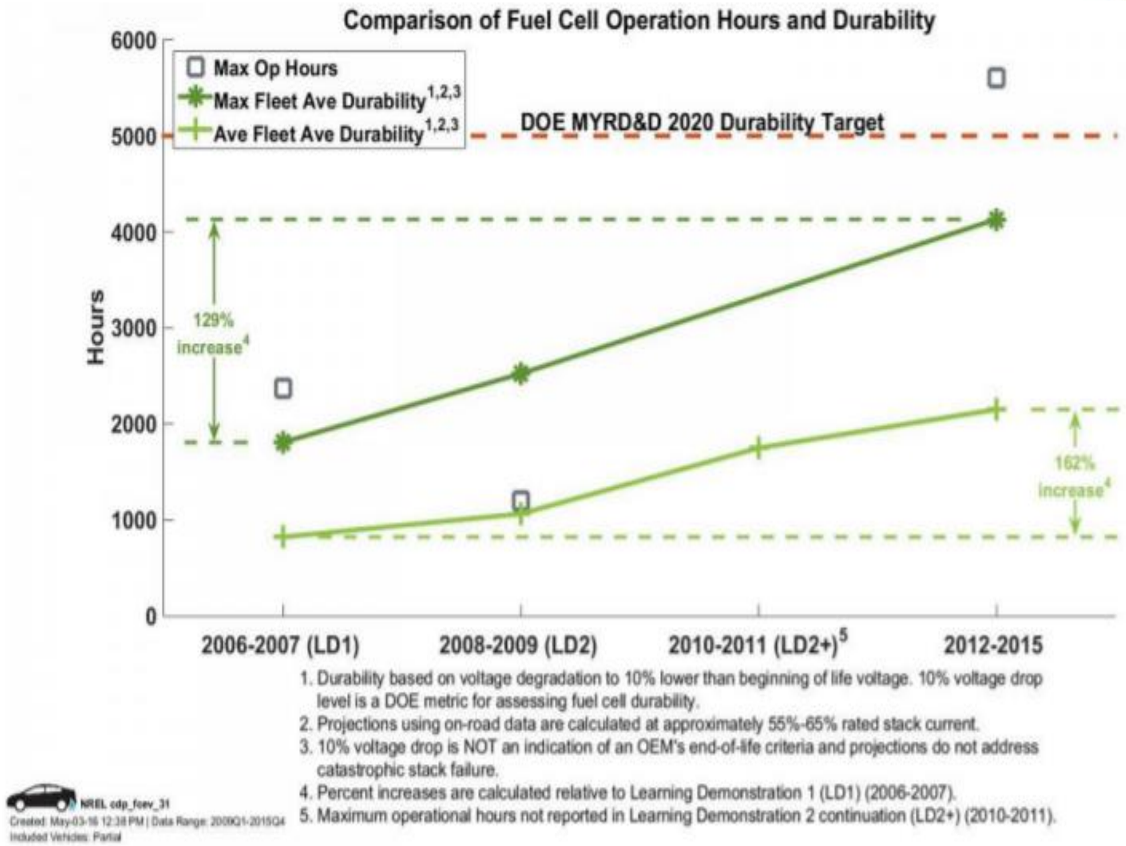

Figure 15. Comparison of fuel cell operation hours and durability.[139]

6.5 Fueling Infrastructure Needs

For greater deployment of FCVs, barriers need to be addressed to make hydrogen infrastructure more economically competitive with existing transportation fueling infrastructure.[140] Table 5 identifies some barriers recognized with hydrogen.

Table 5. Hydrogen infrastructure barriers.

Hydrogen Infrastructure Area	Barriers/Needs
Production	Lower-cost, more-efficient, and more-durable polymer-based electrolyzers. Higher-temperature electrolyzers capable of using nuclear heat and electricity. Advanced and innovative hydrogen production techniques from renewable, fossil, and nuclear energy resources, including hybrid and fuel-flexible approaches. Low-cost and environmentally sound carbon capture, utilization, and storage technologies for hydrogen production from natural gas.
Delivery	Lower-cost and more-reliable systems for distributing and dispensing hydrogen. Advanced technologies and concepts for hydrogen distribution including liquefaction and material-based chemical carriers. Rights-of-way, permitting, and reduced investment risk of deploying delivery infrastructure.
Storage	Lower-cost hydrogen-storage systems with higher storage capacity having reduced weight and volume. Large-scale storage, including onsite bulk emergency supply and in geologic formation.

In the recently passed Infrastructure Investment and Jobs Act, provisions in Section 40314 provides over $9.5 billion in research, development, and demonstration (RD&D) programs.[141] The Regional Clean Hydrogen Hubs are an unprecedented opportunity for public-private partnerships to demonstrate and deploy hydrogen fuel cells for transportation with investment totaling $8 billion over 5 years. In addition, this infrastructure bill provides $1 billion to lower the cost and improve performance of electrolyzers. Finally, there is $500 million for RD&D of new manufacturing and end-of-life recycling technologies. Currently, there are no industrial scale, polymer-based fuel cell, and electrolyzer end-of-life recycling capabilities.

In addition to the recently passed Infrastructure bill, the Department of Energy funds hydrogen research, development, and demonstration from its annual appropriations across several offices. In FY 2022, the Department of Energy requested approximately $400 million for hydrogen compared to the FY 2021 appropriations of approximately $285 million.[142] Therefore, additional funding opportunities may arise with continued robust budgets.

Creation of hydrogen-related codes, standards, and safety regulations at the federal and state level may incentivize private investments to support hydrogen implementation. These actions will provide the basis for the safe and consistent deployment and commercialization of hydrogen and related technologies. In 2015, the Department of Energy, Pacific Northwest National Laboratory, and the California Fuel Cell Partnership launched an online national hydrogen safety training resource for emergency responders.[143] The Department of Energy has also issued an online introductory hydrogen course for code officials and developed codes and standards permitting tools.[144]

A highly skilled workforce is needed to manufacture, operate, and maintain hydrogen fuel systems and fuel cell engines. The Center for Advanced Energy Studies, a research, education, and innovation consortium with Idaho public universities and Idaho National Laboratory offers multiple educational opportunities for students in clean energy research and policy.[145]

6.6 Conclusion: Summary of Trends, Barriers, and Opportunities

Hydrogen fuel costs need to be further reduced through electrolyzer cost reductions. In terms of total cost of ownership, FCVs are expected to be cost competitive with conventional vehicles and BEVs. An increase of hydrogen fueling stations could help achieve economies of scale and reduce hydrogen fuel costs. With passage of the Infrastructure Investment and Jobs Act, there will be future opportunities for Idaho universities and research institutions, Idaho National Laboratory, and industries to research and demonstrate hydrogen and fuel cells in transportation applications. As Idaho National Laboratory transitions to a carbon-neutral research campus, there may be additional opportunities to demonstrate hydrogen FCVs and fueling stations within the state.

7. CLOSING SUMMARY

The objective of this report is to inform Idaho readers of the alternative fuels that are currently available and that are foreseeable to become more popular among consumers.

The existing baseline against which the fuel alternatives are compared is petroleum-based fuels. Idaho is a fast-growing state with a rising need for transportation fuel. To varying degrees, the existing petroleum-based transportation fueling system meets desired goals by being affordable, reliable, and accessible. All gasoline and diesel fuel consumed in Idaho is imported, primarily via pipelines running from Utah and Montana. The fuel is subsequently distributed by truck to fuel stations throughout the state. Gasoline and diesel fuel are widely accessible and reliably distributed via fuel stations. Gasoline and diesel fuel provide the overwhelming majority (about 95%) of transportation fuel used in Idaho.[146] Gasoline and diesel fuel prices are affected by variations in the global price for petroleum as well as changes in refining capacity. Concerns remain regarding emissions resulting from gasoline and diesel combustion both within the traditional toxic "criteria" pollutants, as well as more recently concerning GHG emissions.

The full range of existing light, medium- and heavy-duty highway and off-highway (such as agricultural equipment) vehicles are designed to use gasoline or diesel with or without a small amount of biofuel mixed into the fuel. Over the past century, the vehicles have been developed to operate durably and efficiently using petroleum-based fuels. The high-energy density of petroleum-based fuels allows for rapid vehicle fueling. Overall, petroleum fuels remain the most convenient and commonly used transportation fuel within Idaho.

This report discussed five alternative transportation fuels. Table 6 summarizes the trends, barriers and opportunities associated with these fuels.

Table 6. Summary of alternative transportation fuels.

Type of Fuel	Trends	Barriers	Opportunities
Biofuels	Usage relatively stable with ethanol used for about 4% of U.S. transportation fuels and biodiesel about 1%. High-energy density makes potential for large vehicles, including off-highway farm equipment. Research on woody-biomass is ongoing.	Large production price. Limited supply of feedstock commodities to produce this energy source. No state incentives are provided.	Only direct replacement for liquid petroleum fuel. Domestically produced. Low toxic emissions due to no aromatic compounds.
Natural Gas	RNG being produced by several dairy farms in south central Idaho. Rising U.S. exports of LNG raise exposure to global price pressures.	Only one LNG production facility in Idaho. Driving range of NGVs is less than gasoline and diesel vehicles. Lack of awareness among consumer.	Low price volatility. Good choice for high-mileage vehicles. Domestic availability and widespread existing distribution infrastructure. Reduced GHG emissions. Could be used for generating electricity at EV charging sites.
Propane	Relatively stable level of usage: approximately 60,000 on-road vehicles. Blue Bird, IH and Thomas have propane engines, largely for school buses.	Public is not allowed to fill their own vehicle. Less efficient by volume. Lack of training centers and repair services.	Low emissions, cost, and maintenance. Bi-fuel provides a greater range for transportation. Could be used for generating electricity at EV charging sites.
Electricity	As of 2022, 6% of all U.S. light-duty vehicle sales were EVs. EV sales constrained by battery availability. Substantial federal funding support available.	Battery production cost is high and supply chain expansion is needed. Battery energy density remains a challenge for high load, long-haul applications for medium- and heavy-duty vehicles	Vehicle range has increased. Lower estimated maintenance costs. Lower cost than other fuel alternatives. Cost of electricity is more stable than other fuel types.
Hydrogen	Very low sales to date (7,600), primarily in California and Hawaii.	More costly to manufacture than ICEs.	2x more efficient than internal combustion engine vehicles.

	Opportunities for research at INL and Idaho universities.	Lack of hydrogen fueling stations. Lack of clean hydrogen production centers.	Additional funding becoming available for research and development Could be used for generating electricity at EV charging sites.

The different fuel types share similar barriers, such as limited supply, lack of infrastructure to support fueling, and large costs associated with the introduction of the energy resource or establishing infrastructure to support the energy resource. Alternative fuels discussed in this report also share similar and compelling benefits, such as lower toxic and GHG emissions, reduced vehicle maintenance, and increased economic stability.

This report was produced for Idahoans to acknowledge current technologies that have the potential to evolve and strengthen Idaho's transportation economy. Having recognized the barriers and benefits associated with each type of fuel, Idaho can continue to work towards providing affordable and reliable fuels to consumers in Idaho, in step with new innovations in the transportation sector.

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