Subject Matter Study Report

**Present Energy Consumption and**

**Future Energy Consumption Issues**

May 2022

By

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**Executive Summary**

The Federal government of the United States believes that global warming is caused by fossil fuels used primarily for transportation. The Federal government believes that electric cars are the key to reducing fossil fuel emissions and reduce global warming.

This is a major misconception, because 65% of the electric energy is lost with electric generation and transportation system. Only 35% of the generated electric power reaches end-users of electricity.

Two studies published by the United States Energy Information Administration (EIA) in the Department of Energy to analyze the potential effects of electrification of cars on the total sources of energy used within the United States. Because of the very significant energy losses within the electric power section and lack of alternative fuel sources such as nuclear electric generation, the net effect will be to increase the use of fossil fuels, primarily natural gas for electric power generation for cars.

The study does not include the probable electric energy losses within the equipment to charge batteries for electric cars and the ineffectiveness in use of electricity within the electric cars, because this data has apparently not been published.

In summary, electric cars will increase the amount of natural gas consumed in the United States and may increase emissions and global warming unless emissions from electric power plants consuming natural gas have a high level of control over emissions that is much higher than cars using petroleum.

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**Introduction**

The United States Energy Information Administration (EIA) in the Department of Energy publishes data on energy issues. The report entitled “U.S. Energy Facts Explained” contained substantial information and data on U.S. energy consumption in 2020. The EIA has also published a paper on energy consumption by the transportation sector through 2050.

**2020 Energy Consumption by Energy Sources**

The five primary sources of energy consumed in the U.S.A. are:

1. Petroleum,
2. Natural gas,
3. Renewable energy,
4. Coal, and
5. Nuclear.

The breakdown on sources of energy consumed in the U.S.A. during 2020 from the EIA publications was as follows.

1. Petroleum: 35%
2. Natural Gas: 34%
3. Nuclear: 9%
4. Coal: 10%
5. Hydroelectric: 2.64%
6. Wind: 3.12%
7. Wood: 2.16%
8. Solar: 1.32%
9. Geothermal: 0.24%
10. Biofuels: 2.04%
11. Biomass Waste: 0.48%

Hydrostatic, wind, solar, wood, Geothermal, biofuels, and biomass waste make up the renewable energy sector of energy sources.

Electricity is not considered to be a basic energy source, because electricity is made from the above primary energy sources. Produced alternating current electricity is also a very inefficient form of energy for transportation and consumption purposes. Direct electric current forms of electricity such as from batteries do not suffer from the inefficient forms of electric current. However, electricity produced as direct current is a very small part of produced and used electricity. However, batteries must be recharged by electricity that is inefficiently produced and transported. The electric transportation grid is based on transmission of alternating electric current and is very inefficient.

Of the five primary sources, coal has generally been considered the worst energy source on degradation of the atmospheric environment. Some coal contains mercury which is a deadly element when breathed. Technology is available to clean emissions from coal burning power plants; however, this technology has apparently been grandfathered in older coal burning power plants. Coal mines are dangerous places to work and surface mining of coal destroys the surface land environment.

Sources of energy such as hydroelectric, wind, and solar are unlikely to provide significant increases in energy sources for future use such as for electrification of the transportation sector. In 2020, the sources of energy for the transportation sector were:

1. Petroleum: 90%;
2. Natural gas: 4%;
3. Renewable energy: 5%; and
4. Electric: less than 1% (0.04%).

**Domestic Energy Consumption Since 1950**

Energy consumption in the U.S.A. has increased from about 35 quadrillion British Thermal Units (BTUs) in 1950 to about 95 quadrillion BTUs in 2020. In 1950, the primary energy consumption sources were as follow.

|  |  |  |
| --- | --- | --- |
| Source | Quadrillion BTUs | % of Total |
| Petroleum | 14.5 |  40.8 |
| Natural Gas |  5.5 |  15.5 |
| Coal | 12.5 |  35.2 |
| Renewables |  3.0 |  8.5 |
| Nuclear |  0.0 |  0.0 |
| Total | 35.5 | 100.0 |

In 2020, the primary energy consumption sources were as follow.

|  |  |  |
| --- | --- | --- |
| Source | Quadrillion BTUs | % of Total |
| Petroleum | 32.0 |  34.4 |
| Natural Gas | 34.0 |  35.5 |
| Coal |  9.0 |  9.7 |
| Renewables | 11.0 |  11.8 |
| Nuclear |  8.0 |  8.6 |
| Total | 94.0 | 100.0 |

In 1950, the primary energy production sources were as follow.

|  |  |  |
| --- | --- | --- |
| Source | Quadrillion BTUs | % of Total |
| Crude Oil | 14.5 |  39.2 |
| Natural Gas |  5.5 |  14.9 |
| Natural Gas Liquids |  0.5 |  1.4 |
| Coal | 13.5 |  36.4 |
| Renewables |  3.0 |  8.1 |
| Nuclear |  0.0 |  0.0 |
| Total | 37.0 | 100.0 |

In 2020, the primary energy production sources were as follow.

|  |  |  |
| --- | --- | --- |
| Source | Quadrillion BTUs | % of Total |
| Crude Oil | 23.0 |  24.0 |
| Natural Gas | 35.0 |  36.5 |
| Natural Gas Liquids |  8.0 |  8.3 |
| Coal | 11.0 |  11.5 |
| Renewables | 11.0 |  11.5 |
| Nuclear |  8.0 |  8.2 |
| Total | 96.0 | 100.0 |

Comments on energy consumption between 1950 and 2020 include:

1. Petroleum included crude oil and natural gas liquids.
2. Fossil fuels, petroleum, natural gas, and coal accounted for 87% of the energy consumption in 1950 and about 79% in 2020.
3. Nuclear power energy consumption began in 1957 and leveled off in 2000 at about the consumption of renewables at 10 quadrillion BTUs.
4. Renewable energy consumption sources in 2020 consisted of the following.

|  |  |  |
| --- | --- | --- |
| Source | % of Total | Quadrillion BTUs |
| Geothermal |  2  |  0.22 |
| Solar |  11 |  1.21 |
| Hydroelectric |  22  |  2.42 |
| Wind |  26  |  2.86 |
| Biomass waste |  4 |  0.44 |
| Biofuels |  17  |  1.87 |
| Wood |  18 |  1.98 |
| Total | 100 | 11.00 |

1. Coal consumption in the U.S.A. peaked out in 2007 at 1.13 short tons and coal production peaked out at 1.17 short tons in 2008.
2. Natural gas production in the U.S.A. reached a record high of 33.97 billion cubic feet or 93.06 billion cubic feet a day in 2019. Natural gas production was about 2% lower in 2020.
3. Natural gas consumption in 2020 was 83.28 billion cubic feet a day and 34% of the U.S.A. energy consumption.
4. Annual crude oil production generally decreased between 1970 and 2008. In 2009, the trend reversed and production began to rise. In 2019, U.S.A. crude oil production reached a record high of 12.25 million barrels per day. However, U.S.A. crude oil production declined to 11.31 million barrels per day in 2020 and has continued to decline creating the need to import crude oil.
5. Natural gas liquids production has generally increased since 2005, coinciding with increases in dry natural gas production until 2020 when dry natural gas production began to decline.
6. Renewable energy production and consumption reached a high of about 11.8 quadrillion BTUs in 2019 and declined to 11.6 quadrillion BTUs in 2020.
7. Consumption and production of renewables have increased until 2000 and have remained somewhat level since 2000 until 2020.
8. Hydroelectric power production in 2020 was about 9% lower than the previous 50-year average.
9. Biomass production and consumption in 2020 were both 10% lower than the highest levels recorded in 2018.
10. Geothermal energy use has remained somewhat consistent since the highest levels recorded in 2014.

**Pipeline Capacity Issues**

Pipelines are used to transport the vast majority of petroleum (crude oil, natural gas liquids, and refined products) and natural gas. However, there is little spare capacity in these pipelines. The vast majority of these petroleum and natural gas pipelines are over 60 years old and have experienced considerable deterioration over time. Pipelines are essential for transporting petroleum and natural gas to end users including electric power plants that use these fuels to produce electricity.

The new infrastructure bill passed by Congress and signed by President Biden does not address these old, overpressured transmission pipelines. The present administration believes that eliminating the use of petroleum and natural gas is essential to combat global warming; however, these fuels as essential to address the “hunger” for energy on our planet and production of electricity. Natural gas will be essential for producing inefficient alternating current electricity for future transportation purposes.

**Nuclear Energy**

Nuclear energy produces about 9% of the energy in this country and is produced in the form of alternating current electricity. Unfortunately, over 65% of the alternating current electricity is lost within the electrical sector during transportation from the electrical lower source to the end-users. Therefore, the nuclear electric energy source only provides 3.15% (0.35 x 9%) of the energy consumed energy by end-users in the United States, because 5.85% of the electric energy produced by nuclear sources is lost between the electric generation source before it reaches the end-user.

Additions to our nuclear energy electrical source is very expensive and very time consuming to construct and begin operation. The amount of electricity produced by nuclear power in the U.S.A. in 2020 is about the same as in 2001. The time to construct a nuclear reactor to make electricity since 1980 has varied from five (5) years to ten (10) years. Nuclear power cannot accommodate any rapid demand increases. The recent infrastructure bill does not address nuclear power electrical facilities, but it should.

There are 445 nuclear reactors in 32 countries plus Taiwan. These facilities produce about 10% of the electricity on our planet and amount 3.5% of the energy consumed on our planet. Between 1999 and 2021, 103 nuclear reactors were retired and shut down in the U.S.A. due to integrity and safety concerns. A total of 104 new nuclear reactors were constructed in the U.S.A. and connected to the inefficient electrical transmission grids. Many more nuclear reactors will be retired in the U.S.A. in the future.

Currently, 50 additional nuclear reactors are under construction in 19 countries on our planet. However, only one of these new nuclear reactors is located in the U.S.A. With nuclear retirements, the nuclear energy producing capacity in the U.S.A. is dropping at a time when energy consumption is rising. Between 1999 and 2021, an average of over five (5) nuclear reactors were retired each year in the U.S.A. China is constructing 18 new nuclear reactors and India is constructing seven (7) new nuclear reactors.

**U.S.A. 2020 Energy Consumption by Source and Sector**

The energy consumption sectors and their energy use in the U.S.A., including electricity, during 2020 in quadrillion BTU’s were:

1. Industrial: 22.18 units;
2. Transportation: 24.10 units;
3. Residential: 6.56 units;
4. Commercial: 4.35 units;
5. Electric power plants: 35.70 units; and
6. Total: 92.9 units.

As shown above, electricity is by far the highest consumer of energy in the U.S.A.

The end-users consumed the following amount of electric energy during 2020 were:

1. Industrial: 3.12 units;
2. Transportation: 0.04 units;
3. Residential: 5.00 units;
4. Commercial: 4.34 units; and
5. Total: 12.5 units.

The difference between electric power plant consumption of 35.7 units and electricity used by end-users of 12.5 units was 23.2 units, which is electric energy loss within the electric power system. Electric power system losses were 25% of the total energy consumed in the U.S.A. during 2020.

**Sources of Energy for the Electric Power Sector**

The sources of energy and percent of energy sources consumed by the electric power sector in 2020 included:

1. Petroleum: 1% - 0.2 units;
2. Natural gas: 33% - 12.0 units;
3. Renewable energy: 19% - 7.0 units;
4. Coal: 23% - 8.3 units;
5. Nuclear: 23% - 8.2 units; and
6. Total: 100% - 35.7 units.

The electrical energy consumed by each of the end-use sectors during 2020 was:

1. Industrial: 25% - 3.12 units;
2. Transportation: < 1% - 0.04 units;
3. Residential: 40% - 5.00 units;
4. Commercial: 35% - 4.34 units; and
5. Total: 100% - 12.50 units.

The difference between energy consumed by the electric power sector, 35.7 units, and electricity consumed by end-users, 12.5 units, was electrical system losses of 23.2 units. Electrical system losses were comparable to the total consumption of energy of the industrial sector. Electrical system losses are comparable to the total consumption of energy by the transportation sector.

**Effects of Electrical Conversion in Transportation**

The present sources and amounts of energy consumed by the transportation sector in 2020 were:

1. Petroleum: 90%;
2. Natural gas: 4%;
3. Renewable: 5%; and
4. Electric: Less than 1% (0.04%).

The primary sources for transportation have little spare capacity and the U.S. Department of Energy has done little, if anything, to encourage or require spare energy transportation capacity. The same is essentially true for the pipeline and other transportation energy sectors. Spare capacity increases investment costs, unless provisions are made to pay for spare capacity, and reduces profits. Energy and transportation companies are highly profit conscious as are most companies. The Federal government has grossly failed to address these energy and transportation issues which have been major issues when pipeline ruptures occur and long-term outages occur. There will become major energy infrastructure issues in the future, because of the lack of action by the U.S.A. Department of Energy.

**Energy Consumption of Transportation Sector in 2021 and 2050**

The Transportation Sector Consumption according to another study by the EIA are expected to be as follows.

 Consumption, Quadrillion BTUs

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| Mode | 2021 | 2050 | Overall Change | Annual Change |
| Light Duty Vehicles\* | 14.1 | 14.8 | 0.7 | 0.023 |
| Medium & Heavy-Duty Vehicles |  5.7 |  5.8 | 0.1 | 0.003 |
| Air |  2.5 |  3.9 | 1.4 | 0.047 |
| Commercial Light Trucks |  0.8 |  0.9 | 0.1 | 0.003 |
| Rail |  0.6 |  0.6 | - | - |
| Marine |  1.0 |  1.0 | - | - |
| Other Transportation Modes |  1.6 |  1.6 | -  | - |
| Total | 26.3 | 28.6 | 2.3 | 0.077 |

\* Includes cars, vans, and light trucks

The percent changes in energy consumption for 2021 to 2050 estimated by the EIA are as follow.

 Consumption Change,

|  |  |  |
| --- | --- | --- |
| Mode | Overall Change | Annual Change |
| Light Duty Vehicles |  +5.0% | +0.18% |
| Medium and Heavy-Duty Vehicles |  +1.8% | +0.06% |
| Air |  +56% | +2.00% |
| Commercial Light Trucks | +12.5% | +0.45% |
| Rail | - | - |
| Marine | - | - |
| Other Transportation Modes | - | - |
| Total |  +8.75% | +0.31% |

Energy consumption by the types of fuel in the transportation sector between 2021 and 2050 are predicted to be as follow.

 Consumption, Quadrillion BTUs

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| Fuel | 2021 | 2050 | Total Change | Annual Change |
| Motor Gasoline | 15.1 | 15.9 | +0.8 | +0.027 |
| Distillate Fuel Oil |  6.7 |  6.0 | -0.7 | -0.023 |
| Jet Fuel |  2.6 |  4.5 | +1.9 | +0.063 |
| Electricity |  0.04 |  0.5 |  +0.46 | +0.015 |
| Other |  1.6 |  2.3 | +0.7 | +0.023 |
| Total | 26.04 | 29.0 |  +3.16 | +0.105 |

Motor gasoline, distillate fuel oil, and jet fuel are petroleums. The above table does not include the additional fuel to produce electricity due to the 65% loss in energy to produce and transport electricity. The above table on transportation sector consumption will be modified as follows.

 Consumption, Quadrillion BTUs

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| Fuel | 2021 | 2050 | Total Change | Average Annual Change |
| Petroleum | 24.4 | 26.4 | +2.0 |  +0.069 |
| Electricity |  0.04 |  0.5 |  +0.46 | +0.0159 |
| Extra fuel to produce electricity |  0.11 |  1.43 | +1.32 | +0.046 |
| Other |  1.6  | 2.3 | +0.07 | +0.024 |
| Total | 26.15 |  29.2  | +4.48 | +0.154 |

The above table will be modified in terms of percent change as follows.

 Consumption Change, Percent

|  |  |  |
| --- | --- | --- |
| Fuel | Total Change 29 Years | Average Annual Change |
| Petroleum |  +8.2% |  +0.028% |
| Electricity | +1150% | +39.7% |
| Extra fuel to produce electricity | +1200% | +41.4% |
| Other |  +43.81% |  +1.56% |
| Total |  +17.13% |  +0.59% |

The primary source of extra fuel to produce electricity will likely be natural gas, because coal and nuclear energy has been on the decline in the U.S.A. and sources of renewable energy are limited. Wind driven electrical sources will likely be a primary future source of additional energy; however, electrical transmission losses will be higher, because of the long transmission distances than strategically located electric generation plants using fossil fuels.

The percent changes in energy consumption between 2021 and 2050 by type of fuel used in the transportation sector are estimated as follow.

|  |  |
| --- | --- |
| Type of Fuel | % Change, 2021 to 2050 |
| Motor Gasoline |  +5.3% |
| Distillate Fuel Oil | -10.4% |
| Jet Fuel | +73.0% |
| Electricity |  +1150% |
| Other | +43.8% |
| Total | +11.4% |

The predicted amounts of electrical energy consumed by the transportation sector are as follow.

|  |  |
| --- | --- |
| Year | Consumption, Quadrillion BTUs |
| 2021 | 0.04 |
| 2025 | 0.10 |
| 2030 | 0.18 |
| 2035 | 0.25 |
| 2040 | 0.35 |
| 2045 | 0.41 |
| 2050 | 0.50 |

The amount of electricity consumed by passenger rail service in 2020 is estimated by the EIA to be about 0.03 quadrillion BTUs and is estimated to rise to 0.07 quadrillion BTUs in 2050.

Vehicle travel in the U.S.A. including cars and trucks is expected to increase from 2.7 trillion miles in 2021 to 3.6 trillion miles in 2050. The average annual percent increase in vehicle travel in the 29 years is 0.012%. Passenger travel by air is estimated by the EIA to increase from 0.6 trillion miles in 2021 to 2.0 trillion miles in 2050, an average annual percent increase of 8% is estimated by the EIA.

Railroad freight is expected to increase from 1.6 trillion ton-miles in 2021 to 1.8 trillion ton-miles in 2050. Domestic marine transportation within the U.S.A. is expected to be reduced from 0.30 trillion ton-miles in 2021 to 0.25 trillion ton-miles in 2050 according to the EIA.

The changes in direct energy consumption of light duty vehicles, including cars, between 2021 and 2050 are expected to be as follow.

 Fuel Consumption, Quadrillion BTUs

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| Type of Fuel | 2021 | 2050 | Overall Change | Annual Change |
| Gasoline | 13.3 | 11.7 |  -1.6 | -0.05 |
| Flex Fuel |  0.6 | 0.6 | - | - |
| Diesel |  0.07 |  0.07 | - | - |
| Electric Battery |  0.35 | 1.5 |  +1.15 | +0.04 |
| Plug-in Electric Hybrid |  0.14 |  0.45 |  +0.31 | +0.01 |
| Electric Hybrid |  0.7 | 1.3 | +0.6 | +0.02 |
| Total | 15.16 | 15.62 |  +0.46 |  +0.015 |

However, the above estimates do not include the electrical system losses of at least 65% to make and transmit electricity for use in electrical applications, including light vehicles. When the inefficiency in electricity production and transmission are added to the above electricity estimates, the estimates on energy consumption of light duty vehicles become as follow.

 Fuel Consumption, Quadrillion BTUs

|  |  |  |  |
| --- | --- | --- | --- |
| Type of Fuel | 2021 | 2050 | Change |
| Gasoline | 13.3 | 11.7 | -1.6 |
| Flex Fuel |  0.6 |  0.6 | - |
| Diesel |  0.07 |  0.07 | - |
| Electric Battery |  1.0 |  4.3 | +3.3 |
| Plug-in Electric Hybrid |  0.4 |  1.3 | +0.9 |
| Electric Hybrid |  2.0 |  3.7 | +1.7 |
| Total | 17.37 |  21.67 | +4.3 |

**Conclusions**

1. Because of the 65% loss of energy associated with the creation and transportation of electricity, energy from other sources will be needed to make electricity.
2. The energy sources to compensate for electricity losses will likely be fossil fuels, because nuclear, solar, and wind are not likely to be used due to the high cost and time to implement.
3. There are no plans for extensive increases in energy in the U.S.A. from nuclear sources that would take five to ten years to implement.
4. China and India are far ahead of the U.S.A. in use of nuclear energy to provide long term electrical energy.
5. Energy use by cars and trucks are likely to remain high, because the average speed on highways appears to be 10 to 15 miles per hour higher than the speed limits.
6. Excessive speeds will cause excessive use of fuel, because kinetic energy is proportional to the velocity of an object.
	1. Energy consumption at 85 mph will be about 50% higher than 70 mph and
	2. Energy consumption at 85 mph will be about 100% higher than 60 mph.
7. Excessive speed on highways is due to the sparse police enforcement of highway speed due to the lack of police funding and the growing amount of crime within the U.S.A.
8. Railroads are the most efficient and inexpensive form of passenger and freight transportation.
9. Railroads are the only form of transportation that has to pay for its roadways and that has little financial support from government entities and is among the most efficient use of energy of the transportation entities.
10. The Federal government has selected to financially support other modes of transportation than railroads.

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