Department of Commerce

2019 Biennial Energy Report

Issues, Analysis and Updates

December 2018
Report to the Legislature
Brian Bonlender, Director

Acknowledgements

Washington State Department of Commerce

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Executive Summary

The 2019 Biennial Energy Report provides the governor and legislature an analysis of energy issues affecting Washington citizens and businesses, along with an update on recommendations made in the last state energy strategy. At this point, the most recent state energy strategy is from 2011. The report also includes a review of statistical indicators the Department of Commerce has tracked in monitoring this sector of the state's economy.

For the 2019 biennial report, Commerce provides analysis in the following areas:

- **Deep decarbonization and electrification**. Policy makers are focusing ever more attention on the feasibility and effectiveness of making significant reductions in the amount of fossil fuels used to operate the economy and meet the energy needs of people in Washington.
- **Energy efficiency and renewable energy.** The state's electric utilities are consistently meeting targets for energy conservation and renewable energy. A substantially higher clean energy standard appears feasible if it includes flexibility to accommodate variations in the state's hydroelectric generation.
- **Updated fuel mix disclosure mechanism.** The electric power disclosure law enacted almost 20 years ago can be updated to give customers more timely and accurate information about power sources used by their utility. This change would bring the disclosure law in line with more recent statutes concerning renewable electricity.
- **Equity considerations in the clean energy transition.** The clean energy transition must directly address equity and access concerns, engaging those who face excessive energy cost burdens or live in vulnerable communities.
- **Energy resilience.** Planners and policy makers recognize the need to prepare for emergencies and invest in systems that improve the resilience of the state's energy delivery systems.
- **Investment.** Washington has developed a robust portfolio of public investment to transform the state's economy, demonstrate leadership by public agencies and address equity and access issues.
- **Regional energy issues**. Washington has always made energy policy in a multi-state setting, and regional issues continue to grow in importance.

In addition to these topics, the report provides a high-level update on recommendations made in the last state energy strategy and a detailed status report on key indicators in the energy sector.

Introduction

The Department of Commerce will every two years "prepare and transmit to the governor and the appropriate committees of the legislature a report on the implementation of the state energy strategy and other important energy issues, as appropriate." RCW 43.21F.045(2)(h)

This report is submitted to the governor and legislature to fulfill the requirements quoted above. The statute provides Commerce with flexibility to prioritize and frame the biennial energy report. A review of past reports would find a variety of approaches, in some cycles focusing on a recently issued state energy strategy and at other times concentrating on a matter of great policy interest. In all cases, Commerce has included a review of key statistical indicators of the energy sector in Washington.

If this report were focused on a single topic, it would be the transformation of Washington's energy systems to achieve the state's climate goals and strengthen its clean energy industries. The report examines the options for Washington to achieve "deep decarbonization" and the economic and health benefits that can result. All the decarbonization pathways lead through the electric power industry, requiring new sources of non-emitting electricity and a more flexible power grid to accommodate additional renewable resources. The report reviews electric industry achievement under existing clean energy standards and outlines a potential new standard for 100 percent clean electricity.

However, the issues before policy makers are broader than decarbonization and electrification. The scope of the report reflects the complexity of the clean energy transformation with chapters reviewing equity and access issues, efforts to improve energy resilience, the state's clean energy investment actions and the multistate regional issues that affect Washington.

It is worth noting that significant areas of energy-related work by state agencies fall outside the scope of this report. Some of these are reported under separate statutory provisions and include analysis of renewable natural gas potential, electric utility resource planning, updates to the Washington State Energy Code, development of policy and programs to encourage deployment of electric vehicles and public agency efforts to increase energy efficiency and environmental protection.

List of Abbreviations

aMW	average megawatt
ARRA	American Recovery and Reinvestment Act
BPA	Bonneville Power Administration
Btu	British thermal unit
CAFE	corporate average fuel economy
CEEP	Community Energy Efficiency Program
CEF	Clean Energy Fund
DDP	deep decarbonization pathways
DOE	Washington Department of Ecology
DR	demand response
EIA	Energy Independence Act (Chapter 6)
EIA	U.S. Energy Information Administration (Chapter 8)
EIM	Energy Imbalance Market
EPA	Environmental Protection Agency
ESF12	Emergency Support Function 12
EV	electric vehicle
FEMA	Federal Emergency Management Agency
FPL	Federal Poverty Level
GHG	greenhouse gases
GSP	gross state product
ICS	incident command structure
IPR	Integrated Program Review
LBNL	Lawrence Berkeley National Laboratory
LIHEAP	Low-Income Home Energy Assistance Program
LMI	Low and moderate income
mpg	Miles per gallon
MW	megawatt
NAICS	North American Industrial Classification System
NIMS	National Incident Management System
NWPCC	Northwest Power and Conservation Council
PNNL	Pacific Northwest National Laboratory
PSCCU	Puget Sound Cooperative Credit Union
PUD	public utility district
RCW	Revised Code of Washington
RECIP	Renewable Energy System Incentive Program
RMI	Rocky Mountain Institute
SEDS	State Energy Data System
SEEP	State Efficiency and Environmental Performance
SIC	Standard Industrial Classification System
SSS	Self Sufficiency Standard
TBtu	trillion British thermal units

WSEC	Washington State Energy Code
WSEDTS	Washington State Energy Disruption Tracking System
WSHFC	Washington State Housing Finance Commission

Chapter 1 – Deep Decarbonization Pathways and Beneficial Electrification

Framing Health and Economic Benefits

Deep Decarbonization and Electrification

> *"The guiding principle for reduction of [greenhouse gas] emissions by 2050 must be to limit global warming to less than 2°C. For Parties to this [Memorandum of Understanding] this means pursuing emission reductions consistent with a trajectory of 80 to 95 percent below 1990 levels by 2050 and/or achieving a per capita annual emission goal of less than 2 metric tons by 2050."* Subnational Global Climate Leadership Memorandum of Understanding[1]

In 2015, at the United Nations' Conference of the Parties, Washington Gov. Jay Inslee signed the *Subnational Global Climate Leadership Memorandum of Understanding* (Under2MOU). The Under2MOU represents a commitment by state and local governments (subnationals) to maintain global average temperature increases due to human-caused greenhouse gas (GHG) emissions to below 2 degrees centigrade (3.6 degrees Fahrenheit). To meet that commitment Washington must dramatically reduce its overall greenhouse emissions from current levels of more than 90 million tons per year to well below 20 million tons by mid-century.

Making the transition from a relatively GHG-intensive economy to a thriving but very low-carbon future represents both daunting challenges and significant opportunities – opportunities to improve the quality of the environment, to enhance individuals' health and to create new jobs and new business possibilities.

To understand better the details of how Washington could build toward such a low-carbon future, the state of Washington commissioned a high-level Deep Decarbonization Pathways Analysis for Washington State (DDPs)[2]. The study focused on the technical characteristics and economic implications of several different approaches to a mid-century state emissions profile 80 percent below the 1990 emissions levels.[3]

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[1] www.under2coalition.org/under2-mou

[2] Deep Decarbonization Pathways Analysis for Washington State, Evolved Energy Research and Deep Decarbonization Pathways Project December 2016.

[3] The study developed scenarios that reduce emissions from 88.4 million metric tons in 1990 to 17.7 million metric tons in 2050. More specifically the modeling produced an 86% reduction in energy-related emissions and a 50% reduction in all non-energy emissions.

What Is Deep Decarbonization?

National and state jurisdictions across the world have undertaken a variety of deep decarbonization pathways studies.[4] These studies begin with establishing mid-century reduction goals of 80 to 95 percent below current levels, coupled with one or more intermediate reduction goals. The analysis then works backward in time to identify the technologies, infrastructure and investments that will be required to achieve the reduction goals, as well as the costs. It also analyzes the risks and trade-offs associated with different policy approaches.

These analyses help policymakers identify intermediate targets that must be achieved, potential "forks in the road" and "dead ends." A fork in the road would be mutually exclusive technology options and a dead end is a short-term solution that makes it impossible to achieve long-term goals.[5] Most DDP modeling is based on characterization of both a jurisdiction's energy-producing infrastructure (e.g., electricity generation, natural gas distribution, petroleum refining, other energy supply systems) and its energy using systems (e.g., buildings, transportation equipment, industrial processes) coupled with current and future usage trends.

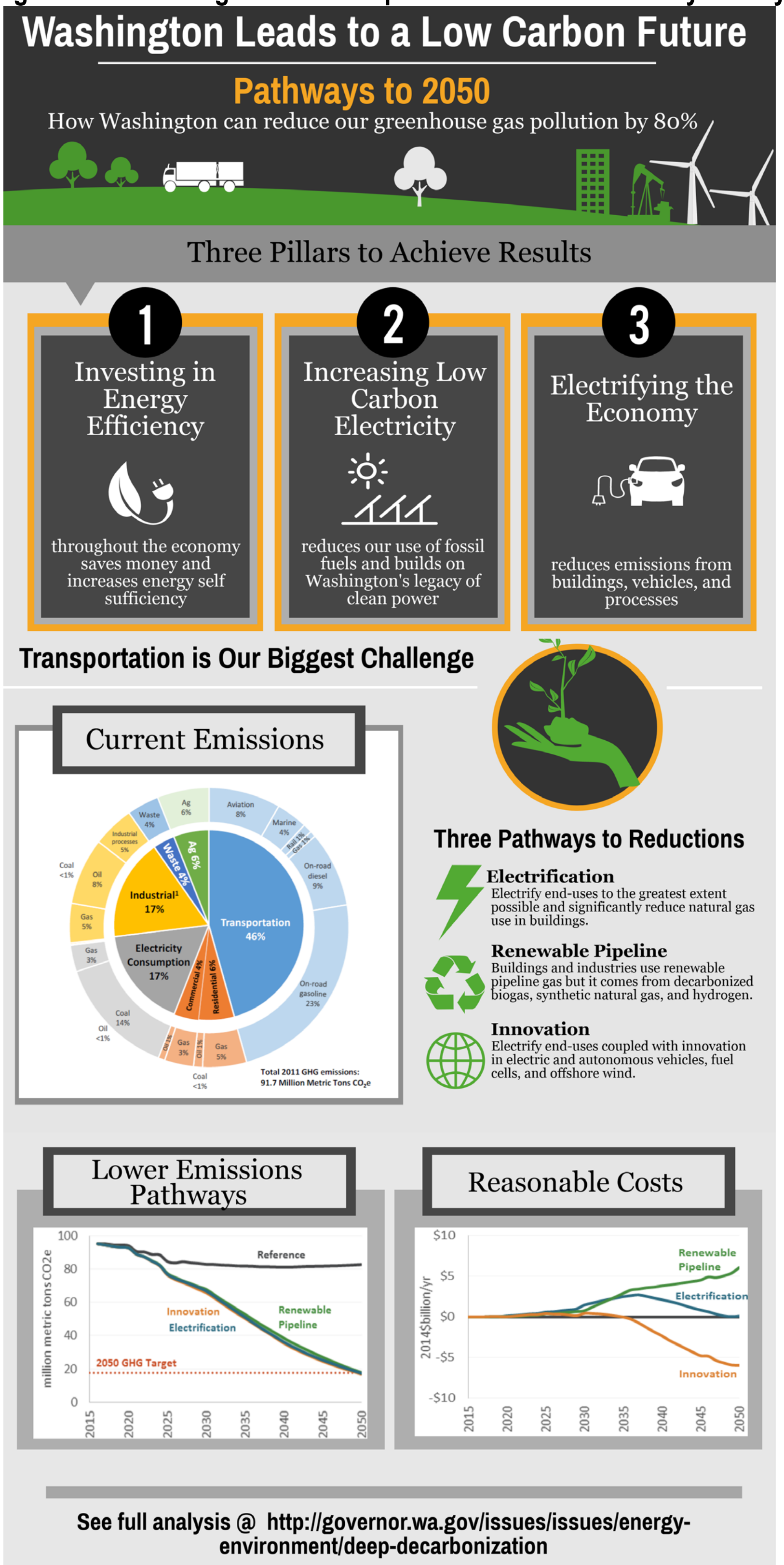
Table 1.1 illustrates Washington state's current statutory reduction requirements and recommendations for the Dept. of Ecology based on legislative direction to review and update current law. The update is intended to reflect current scientific understanding of the amount of emission reduction required to stabilize levels of carbon dioxide in the atmosphere and slow the rate of warming. Washington's DDP study examined pathways to meet the more aggressive recommended limits.

Table 1.1: Current and Proposed Greenhouse Gas Reduction Limits for the State of Washington

	2020	2035	2050	Source
Current GHG Limits	Return to 1990 levels	25% below 1990 levels	50% below 1990 levels	RCW 70.235.020
Recommended GHG Limits (December 2016)	Return to 1990 levels	40% below 1990 levels	80% below 1990 levels	WA GHG Emissions Reduction Limits report (RCW 70.235.040)[6]

[4] See the Deep Decarbonization Pathways Project for other studies.
[5] Under2MOU 2050 Pathways
[6] WA Dept. of Ecology, *Washington Greenhouse Gas Emission Reduction Limits*, Dec. 2016, Publication No. 16-01-010.

Figure 1.1: Washington State Deep Decarbonization Pathways Study



As illustrated in Figure 1.1, Washington's study examined three different pathways or scenarios that would be likely to yield 80 percent reductions by mid-century:

1. A pathway emphasizing major increases in the use of very low or non-carbon electricity to meet energy needs for heating and cooling (high-efficiency heat pumps), transportation (electric vehicles) and some industrial applications;
2. A pathway that includes greater electrification but also emphasizes the substitution of biogas, synthetic natural gas and some hydrogen for fossil natural gas especially in buildings and industry; and
3. An innovation pathway that contains emerging technologies, including autonomous vehicles, fuel cells and offshore wind development.

What did the Washington DDP study conclude?

The Washington DDP study concluded that there are feasible pathways available to us that could realistically achieve an 80 percent reduction in GHG emissions by 2050 using technology that is largely available today and at reasonable overall costs. However, the study also made clear that Washington needs to begin now to make strong and sustained commitments in four major areas if it is to achieve those reductions with minimal disruption and at the least costs possible. Those four areas are:

1. Investing in vastly improving the energy efficiency of all energy-using systems;
2. Ensuring that the state meet its electricity needs by developing new supply sources that emit little or no greenhouse gases, while also making best use of its existing supplies of clean energy;
3. Expanding the use of electricity throughout the economy; and
4. Making capital asset investment decisions today that support the first three directions and don't lock us into a high energy use or high carbon future.

The remainder of this chapter briefly provides more details on the first three of these areas with a particular emphasis on the potential benefits of greater electrification. It also includes high-level recommended actions.

Energy Efficiency

To gain an overall sense of why energy efficiency is a critical foundation for all work toward a low carbon future, one need look no further than the energy flow diagram in Chapter 6, Energy Indicators - Sources and Consumers of Energy in Washington in Calendar Year 2014. Of the nearly 1,600 trillion BTUs of energy that go into powering the state, about half do not produce any useful work, ending up simply as waste heat. In the transportation sector alone, near three of every four units of fuel used to power vehicles are wasted. Thermodynamic laws prevent the complete elimination of that waste, but using existing and new technologies and practices would allow the state to accomplish as much while using less energy.

The best example of the potential of energy efficiency is in the electric sector. Washington and other Pacific Northwest states have a long and highly successful record in using cost-effective energy efficiency investment to meet electricity needs. The Northwest Power and Conservation Council's (NWPCC) assessment of the region's electricity system notes that energy efficiency is second only to hydropower as a supply resource. Since 1978, the Northwest has saved more than 50 million megawatt hours of electricity – equivalent to five times the annual electricity use of Seattle.[7]

Future efficiency efforts need to:

1. Continue to sustain and expand investments in new electricity efficiency[8] through meeting electric utility Energy Independence Act conservation obligations (RCW 19.285.040), investing in public-sector efficiency projects, strengthening building energy codes and deploying new approaches such as pay-for-performance contracting.
2. Expand current programs and set ambitious goals for improving the efficiency of natural gas use, especially in heating buildings and serving industrial processes.
3. Vastly increase the number of electric vehicles through the state, as well as improve the overall efficiency of the transportation system.[9]
4. Support industry in its efforts to reduce operating costs, reduce its carbon footprint and improve its competitiveness through investment in energy efficiency.
5. Expand programs that save energy while providing health, costs savings and comfort benefits, especially as they relate to low-income and vulnerable populations.

Low or No Carbon Electricity Production

Washington has the lowest carbon emitting and cleanest large electricity grid in the U.S. primarily because of its extensive hydroelectric-based system.[10] In 2001, Washington had no commercial wind energy facilities. Today it has more than 3,000 megawatts in operation, the ninth largest wind fleet in the U.S.[11]

To expand on this clean production base, Washington needs to:

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[7] NWPCC, Energy Efficiency in the Northwest.

[8] The NWPPC's Seventh Northwest Power Plan concludes that "cost-effective efficiency [can] meet all electricity load growth through 2030 and in more than half of the futures all load growth for the next 20 years." Chapter 1, page 1.

9 See the 2012 Washington State Energy Strategy, Chapter 3- Advancing Transportation Efficiency for further discussion of transportation efficiency and policy recommendations.

10 In 2016, nearly 64% of the electricity used in Washington came from hydroelectric facilities. See WA Dept. of Commerce Fuel Mix Disclosure web page.

11 American Wind Energy Association, Wind Facts at a Glance.

1. Continue to meet the renewable portfolio requirements of the Energy Independence Act (RCW 19.285.040)
2. Develop policies and legislation that drive Washington to 100 percent zero carbon electricity system while maintaining reliable and affordable electricity service.
3. Support streamlined siting requirements for development of new renewable and no carbon generating projects.
4. Expand state government's investment in carbon-free electricity sources for facilities.
5. Develop policies that support clean on-site and renewable energy production.

Electrification and its Benefits

A core strategy in any deeply decarbonized future, and particularly one in Washington state, is to significantly expand the use of cleanly produced electricity economy-wide. In all three DDP scenarios, greater electrification is a part of the pathway. The extent of electrification varied by scenario, but all three recognized that the Washington economy is becoming increasingly electrified as we add new electronic devices, develop new industrial technologies and deploy more electricity producing systems. From a deep decarbonization perspective, the question is: What is the optimal technological and economic mix of electricity deployment that yields deep carbon benefits?

Many organizations including the Electric Power Research Institute, the Regulatory Assistance Project and the Lawrence Berkeley National Laboratory (LBNL) have enumerated potential benefits for greater electrification. A recent study by LBNL[12] identified a wide range of potential benefits of electrification for buildings and industrial applications, including:

- Opportunities for local economic development and greater use of indigenous resources, especially if the electricity is supplied by renewable resources. One of Washington's policy principles calls for "leveraging the indigenous resources for the state for the production of clean energy" in order to "reduce dependence on fossil fuel resources."[13]
- Potential to provide process improvement to industry through "better process control and potentially yields higher quality products in some applications."
- Improved air quality. "Electrically powered end uses do not rely on combustion of fuels onsite, eliminating emission at the point of customer usage compared to end uses that require onsite combustion of natural gas, heating oil and other fuels."

Benefits of Electric Vehicles

Washington is a strong supporter of efforts to increase vehicle electrification. Gov. Inslee has

[12] *Electrification of Buildings and Industry in the U.S.,* Lawrence Berkely National Lab, March 2018. ipu.msu.edu/wp-content/uploads/2018/04/LBNL-Electrification-of-Buildings-2018.pdf
[13] RCW 43.21F.088 (1) (d)

set forth five specific electric vehicle (EV) action items to expand use of electric vehicles:

1. Make electric vehicles more accessible and affordable to everyone through incentives such as sales tax exemptions.
2. Reduce range anxiety, by increasing the number of charging stations.
3. Reduce the so-called "garage orphan" problem by providing charging places for people who cannot install chargers at their homes.
4. Make sure that 50 percent of all new passenger vehicles in the state fleet are electric.
5. Increase education and public awareness about EVs.[14]

Environmental and public health benefits of electric vehicles[15]

- EVs do not emit toxic air pollution. Gasoline cars emit fine particles and air toxics (hazardous air pollutants such as benzene, acetaldehyde and 1,3-butadiene) that are unhealthy to breathe.
- EVs do not directly emit greenhouse gas and indirect emissions are eliminated if electric vehicles are supplied with 100 percent carbon-free electricity from hydro, wind or solar power.
- EVs protect Puget Sound waterways. They do not contribute as many contaminants to stormwater runoff as gasoline cars, which means less pollution in waterways and Puget Sound, reduced highway runoff mitigation construction costs and reduced annual fish kill-off due to toxic pollutants dripped onto non-mitigated roadways.
- According to the Puget Sound Clean Air Agency, more than 100 premature deaths can be attributed each year to pollution from motor vehicles, along with many more cases of asthma, respiratory disease and hospitalization. In the Puget Sound region alone, more than 200,000 people live within 200 meters of a major highway and are exposed to elevated pollution from vehicles. Reduced rates of respiratory diseases resulting from cars without tailpipe emissions would help reduce state health care costs, reduce lost work and school time and improve quality of life.

Economic benefits of EVs

Electric cars strengthen Washington's economy by keeping more money circulating locally. More than $10 billion in fuel spending leaves the state each year. According to the U.S. Energy Information Administration, two-thirds to three-quarters of the price of fossil fuels pays for the raw resources: crude oil, coal and natural gas. Since Washington doesn't produce any fossil fuels, all that money goes elsewhere.

[14] *Leading the charge; Inslee promotes an electric transportation future,* July 11, 2018.
[15] Many of the benefits enumerated here are from the WA State Dept. of Transportation publication, *Washington State Electric Vehicle Action Plan 2015-2020*, February 2015.

For a Washington resident, having the choice to drive an electric vehicle means an opportunity to save money on gasoline and maintenance. Although the purchase price is higher, the cost to drive an electric vehicle in Washington is significantly less than the cost to drive a gasoline- or diesel-powered car.

Conclusion

For deep decarbonization efforts via electrification, the key question is: What is the optimal technological and economic mix of electricity deployment that yields carbon reduction benefits?

To further electrification, Washington should:

1. Continue to analyze different pathways toward electrification in the state with a particular emphasis on better understanding the economic, technological and environmental cost and benefits for different approaches. For example, how can utilities mitigate the peak electricity impacts of increased use of electric heat pumps to replace natural gas space heating in the winter?
2. Where low- and no-carbon electricity is already available, consider investing in energy systems that use electricity rather than fossil fuels
3. Support policies that encourage electric utilities to help their customers electrify transportation.

Chapter 2 – The Energy Independence Act and a Potential New Clean Energy Standard

The vision in Chapter 1 of a vibrant economy fueled by clean, carbon-free energy resources is realized only through the decisions and actions of policy makers, energy suppliers and energy consumers. While no single policy or investment ensures success, the electricity sector is expected to play a central role in this transformation. This chapter reviews the primary existing clean energy policy for electric utilities – the Energy Independence Act (EIA) – and provides an analysis of options to build on the state's successful implementation of existing policy.

The EIA requires that electric utilities both increase the efficiency of electric use by Washington homes, businesses and industry and increase the amount of renewable energy used to serve Washington customers. The EIA applies to all electric utilities, whether investor-owned, public or consumer-owned, that serve at least 25,000 customers.[16]

Energy conservation: Saving Washington customers $750 million per year

According to the annual performance reports that utilities submit to Commerce, every utility exceeded its energy conservation target in all of the two-year performance periods since the law took effect in 2010. In the most recent period covering 2016-2017, overall achievement exceeded targets by an average of 36 percent (See Table 2.1 for details). Reported results are subject to review by the Utilities and Transportation Commission for investor-owned utilities, the Washington State Auditor for municipal utilities and public utility districts or an independent auditor for cooperative utilities.

The conservation savings represent a significant resource for Washington utilities, especially as most conservation measures save electricity over multiple years. Without these measures, electricity consumption would be about 13 percent higher in 2020 than actual consumption. The cumulative savings vary significantly among utilities, from 15 percent at Puget Sound Energy and Seattle City Light to 7 percent at Grant PUD.

The cumulative bill savings to Washington consumers and businesses are about $750 million per year. This amount represents gross electricity bill savings to Washington customers – the additional amount they would have paid for electricity absent energy efficiency savings. Net savings are smaller since utilities and customers incur costs to achieve energy efficiency savings.

[16] Chapter 19.285 RCW.

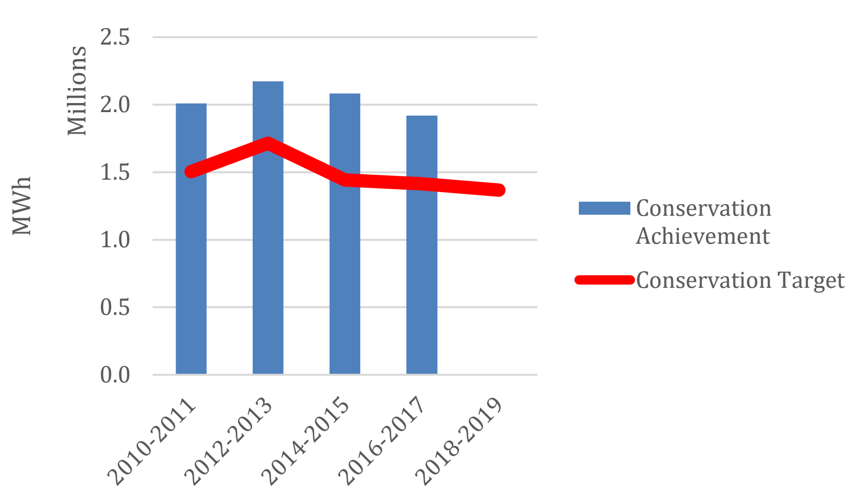
Table 2.1: Conservation Targets and Acquisitions

	2016-2017 Conservation Targets and Acquisitions				2018-2019	
Utility	2016-17 Conservation Target (MWh)	2016 Conservation Acquired (MWh)	2017 Conservation Acquired (MWh)	2016-17 Conservation as a Percent of 2016-17 Target	2018-19 Conservation Target (MWh)	Change from 2016-17 Target
Avista	82,477	80,343	68,258	180%	94,260	14%
Benton PUD	17,257	11,734	9,344	122%	19,710	14%
Chelan PUD	15,593	18,103	17,116	226%	21,199	36%
Clallam PUD	7,008	5,199	5,827	157%	9,198	31%
Clark Public Utilities	67,802	48,792	114,998	242%	85,760	26%
Cowlitz PUD	41,260	121,668	27,249	361%	61,145	48%
Grant PUD	27,418	24,590	7,183	116%	32,149	17%
Grays Harbor PUD	6,482	8,979	5,525	224%	12,790	97%
Inland Power	6,658	7,307	6,088	201%	9,811	47%
Lewis PUD	5,519	5,350	7,671	236%	10,337	87%
Mason PUD #3	3,428	5,977	1,682	223%	5,050	47%
Pacific Power	93,059	54,960	43,730	106%	79,509	-15%
Peninsula Light	4,767	4,462	3,551	168%	7,884	65%
Puget Sound Energy	605,194	314,525	318,629	105%	520,456	-14%
Seattle City Light	224,431	125,725	145,336	121%	214,620	-4%
Snohomish PUD	122,990	96,571	100,693	160%	127,984	4%
Tacoma Power	81,993	50,049	50,418	123%	55,538	-32%
Total	1,413,335	984,335	933,299	136%	1,367,400	-3%

Note: Conservation acquired excludes any excess claimed from prior periods.
Source: Utility reports submitted June 2018. Available at: www.commerce.wa.gov/EIA

The *2017 Biennial Energy Report* noted a downward trend in the conservation targets utilities are establishing for themselves. Figure 2.1 shows the trend continues in targets set for 2018-2019. The overall conservation target for 2018-2019 is 3 percent lower than 2016-2017, with a wide range among the 17 utilities. Grays

Figure 2.1. Statewide Totals - Conservation Targets and Achievement



Harbor PUD has almost doubled its conservation target compared to 2016-2017, and Tacoma Power has reduced its target by 32 percent.

Possible expansion of the energy efficiency mandate

The EIA's conservation mechanism is effective in reducing energy consumption and greenhouse gas emissions in the electricity sector, and Commerce recommends that policy makers consider extensions of this mechanism:

- Demand response - The energy conservation mandate of the EIA is narrow in concept, reflecting the traditional regional focus on meeting annual energy requirements rather than seasonal peak requirements. Measures that shift consumption from the seasonal peak period to an off-peak period, without reducing total electricity consumed, are not energy conservation measures. However, these "demand response" measures are increasingly valuable to the power system as renewable energy replaces fossil fuel sources. Demand response measures reduce the need for more expensive energy storage investments and greenhouse gas emissions from natural gas-fired peaking generation. An expanded mandate could include cost-effective demand response resources.
- Electrification of transportation and heating - Conservation today is evaluated within a single form of energy, such as electricity, natural gas or gasoline. For the EIA, electric utilities are required to identify ways to use electricity more efficiently. A broader view of energy efficiency would look for opportunities to reduce energy use and carbon emissions by switching from one form of energy to another form. Converting from gasoline-powered vehicles to electric vehicles would increase electricity consumption, but it could improve overall energy efficiency. The efficiency mandate of the EIA could be expanded and adapted to require that electric utilities identify and pursue these broader energy efficiency opportunities.
- Natural gas utilities - The EIA's efficiency standard, if applied to natural gas distribution companies, could reduce energy consumption and greenhouse gas emissions. The state Utilities and Transportation Commission regulates natural gas distribution companies and could oversee this requirement if adopted by the legislature.

Renewable Energy

The renewable energy provisions of the EIA require that utilities serve their customers using a resource portfolio that includes renewable energy. The renewable portfolio standard started in 2012 at 3 percent of retail electricity sales, and it increased in 2016 to 9 percent of sales. The third and final standard of 15 percent takes effect in 2020. The eligible renewable energy sources are limited to certain fuel types and, in most cases, eligibility requires the electricity be generated at a plant that started operation after 1999. While hydro power is defined as a renewable resource, only incremental generation due to efficiency improvements made after 1999 may be counted toward the EIA requirement.

As with the conservation standard, utilities have consistently reported compliance with the renewable energy requirements. In 2018, the 9 percent renewable target was 6.6 million MWh, and the 17 utilities covered by the EIA reported plans to use 7.9 million MWh.[17] Wind energy accounts for 71 percent of the resources used to meet the renewable requirement, with incremental hydro generation the second most common resource at 12 percent.

Table 2.2: 2018 Renewable Energy for Washington Qualifying Utilities

2018 Renewable Energy for Washington Qualifying Utilities					
Utility	Average Load 2016-2017 (MWh)	9% Renewable Target for 2018 (MWh)	Qualifying Renewables for 2018 (MWh)	Qualifying Renewables for 2018 (% of load)	Incremental Cost of Renewable Energy and RECs (% of revenue requirement)
Avista	5,697,837	512,805	899,199	15.8%	-1.0%
Benton PUD	1,739,588	156,563	156,563	9.0%	2.7%
Chelan PUD	1,658,102	149,229	149,229	9.0%	0.1%
Clallam PUD	621,705	55,953	55,954	9.0%	0.9%
Clark Public Utilities	4,483,340	403,501	39,301	0.9%	1.0%
Cowlitz PUD	4,980,982	448,288	448,289	9.0%	3.4%
Grant PUD	4,525,315	407,278	868,757	19.2%	0.0%
Grays Harbor PUD	938,242	84,442	96,630	10.3%	1.1%
Inland Power	893,078	80,377	80,377	9.0%	1.4%
Lewis PUD	927,808	83,503	83,503	9.0%	2.0%
Mason PUD #3	623,844	56,146	56,146	9.0%	2.3%
Pacific Power	4,101,476	369,133	369,133	9.0%	0.7%
Peninsula Light	585,586	52,703	52,703	9.0%	0.4%
Puget Sound Energy	20,882,410	1,879,417	2,112,182	10.1%	1.4%
Seattle City Light	9,294,549	836,509	836,671	9.0%	3.5%
Snohomish PUD	6,439,941	579,595	1,169,222	18.2%	5.8%
Tacoma Power	4,689,907	422,092	422,092	9.0%	0.7%
Total	73,083,706	6,577,534	7,895,950	10.8%	1.9%

Note: Incremental cost amounts are as reported by utilities and are not calculated using consistent methods. Some utilities note in their reports that they are using cost calculation methods other than the ones they would use if complying with the incremental cost cap provision.

Note: Clark Public Utilities intends to comply under the 1 percent no-growth cost cap provision.

Source: Utility reports submitted June 1, 2018. Available at: www.commerce.wa.gov/EIA

However, not every utility is meeting the 9 percent target. The EIA provides exceptions to the percentage standard based on costs of renewable energy. Clark Public Utilities is using a cost-based compliance method, which in 2018 resulted in it procuring 0.9 percent renewable energy

[17] The actual renewable percentage is likely less than the amount reported. Snohomish PUD reported renewable energy equal to 18.2% of its load and is unlikely to use the entire amount for EIA compliance.

instead of using 9 percent renewable energy.

The renewable energy achievements of the EIA are also reduced by the use of two multiplier provisions in the law. The apprentice labor multiplier gives utilities extra credit for renewable energy from a generating facility that was constructed under an approved apprentice labor plan. The distributed generation multiplier provides extra credit if the generating unit is smaller than 5 MW in capacity. In 2018 renewable energy achievement is lower by about 5 percent as a result of these multipliers.

Beyond 2020: Moving to a clean electricity standard

The renewable targets established by Washington voters in 2006 were, at that time, among the most aggressive in the nation. Most states had no renewable requirement at all, and Washington set its standard at 15 percent by 2020.

Today electric utilities are subject to renewable energy standards in 29 states, the District of Columbia and three U.S. territories.[18] At 15 percent, Washington's 2020 renewable standard would no longer be considered aggressive. Most states in New England have substantially higher targets and in the West, the states with higher standards include California, Oregon, Hawaii, New Mexico, Colorado and Nevada.

Many stakeholders in Washington have called for a substantial increase in the state's renewable requirements. In some cases, stakeholders advocate not for a higher renewable standard but for a lower ceiling on the use of fossil fuels to generate electricity for Washington consumers and businesses. Two examples from the 2018 legislative session are House Bill 2997 and Senate Bill 6253. These bills differed in details but generally would have required that electric utilities reduce their use of fossil fuel-fired electricity by 100 percent by 2045, with intermediate targets starting earlier.

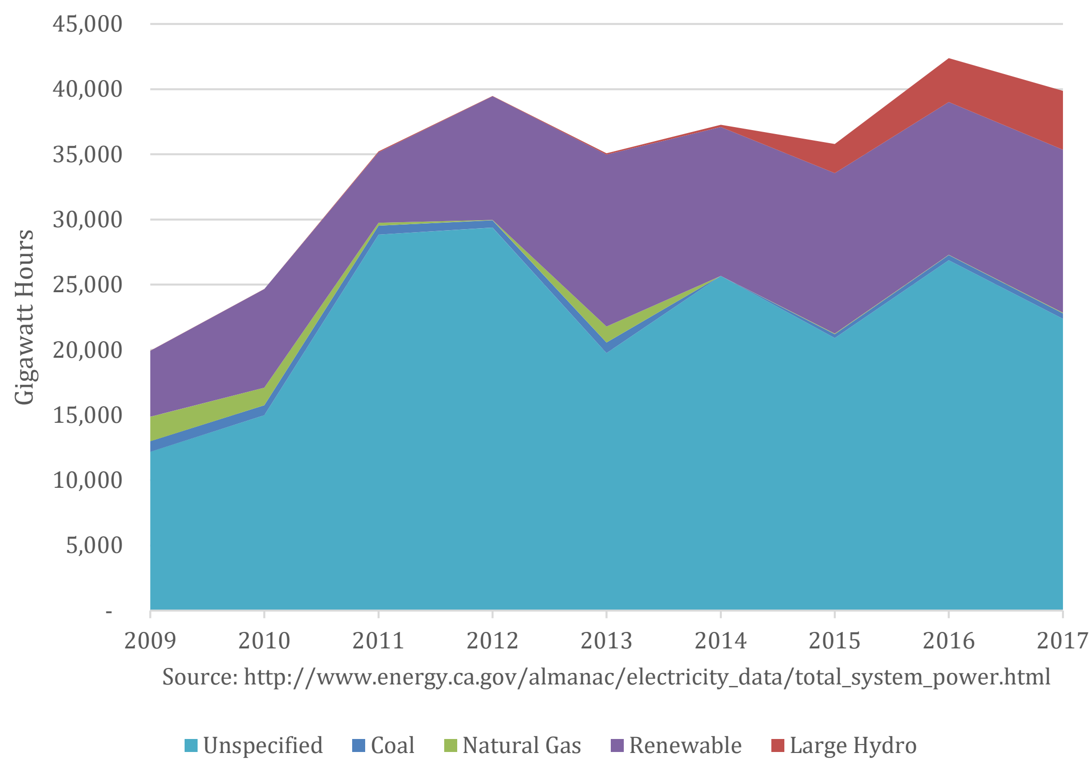
After the 2018 session stakeholder and policymaker interest in this concept remains high as a topic for action in 2019. Interest accelerated after California enacted SB 100 in September 2018,[19] which establishes a planning standard of 100 percent renewable and zero-carbon electricity by 2045. It directs the state's energy agencies to incorporate this policy into all relevant planning for retail load. It also increases the renewable portfolio standard (similar to Washington's Energy Independence Act) from 50 percent by 2030 to 60 percent.

Some observers have questioned the benefits of higher renewable standards for Washington and other Northwest states. They observe that with legacy hydro resources and an existing nuclear power plant, Washington's electricity supply is already among the least carbon-intense in the nation. However, this analysis misses two important points regarding the state's future electricity sources:

[18] http://ncsolarcen-prod.s3.amazonaws.com/wp-content/uploads/2017/03/Renewable-Portfolio-Standards.pdf
[19] leginfo.legislature.ca.gov/faces/billNavClient.xhtml?bill_id=201720180SB100

- First, without explicit policy support, the electrification of the state's economy - in particular, the conversion of various transportation uses from gasoline and diesel - will likely not be served entirely with renewable energy. Hydro is the main source of power in the existing mix, but Washington cannot add new large hydro projects to meet growth in electricity demand. A likely scenario is that utilities would meet growing demand with a combination of natural gas generation and enough new renewables to comply with the 15 percent standard under the EIA.
- Second, absent policy change, there is no assurance that even the existing zero-carbon resources that produce Washington's low carbon emissions profile today will be available to Washington customers in the future. As customers and utilities in other states seek to increase their supplies of zero-carbon resources, Northwest hydro is likely to be an attractive option. As Figure 2.2 shows, entities in California have increased their use of large hydro from the Northwest. This recent experience may not prove to be a trend, but it remains a possibility if Washington policy continues not to recognize the zero-carbon benefits of its legacy hydro resources.

Figure 2.2. Northwest Imports in California's Power Mix



Source: http://www.energy.ca.gov/almanac/electricity_data/total_system_power.html

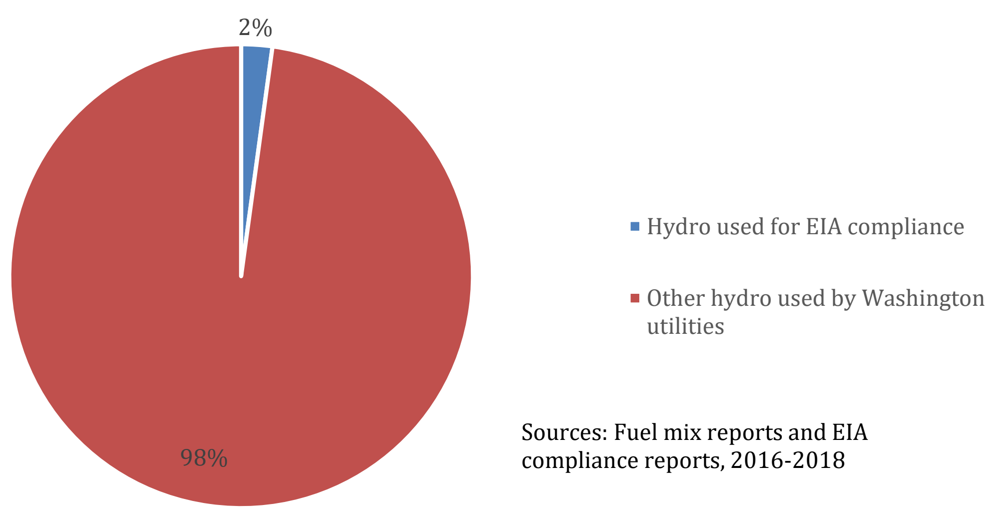
Specific provisions of a post-2020 clean electricity standard are not resolved. In broad outline, the standard would include both a much higher renewable requirement than the existing EIA and a broader set of renewable resources that could be used to meet that standard. Where the current renewable standard of 15 percent must be met for years 2020 and beyond using new renewables (in most cases defined as commencing operation after 1999), a new clean electricity standard could allow compliance using any renewable resource, regardless of project vintage or ownership.

This potential change in eligible resources is most significant for hydroelectric resources because the existing law excludes use of most hydro generation for compliance. The EIA allows use of incremental generation due to efficiency improvements at the hydroelectric projects that are owned by any of the 18 utilities that are covered by the EIA. In doing so, the EIA excludes many other hydro resources, including:

- the pre-upgrade amount of generation at the projects owned by EIA utilities,
- all generation at hydro facilities owned by utilities that are below the EIA threshold, such as the Wells Project owned by Douglas PUD,
- all hydro generation at hydro facilities of non-utility owners, such as the Electron Hydro project, and
- all hydro generation at hydro facilities owned by the federal government, such as Grand Coulee Dam and other projects on the Columbia and Snake rivers.

These non-EIA eligible hydro resources are being used today, in whole or in part, to provide electricity to Washington customers, and they contribute to the low-carbon nature of the state's existing electricity supply discussed above. As illustrated in Figure 2.3, about 2 percent of the hydro generation provided to Washington customers is also used to comply with EIA requirements.

Figure 2.3. Hydro generation used for EIA compliance and other hydro used by WA utilities

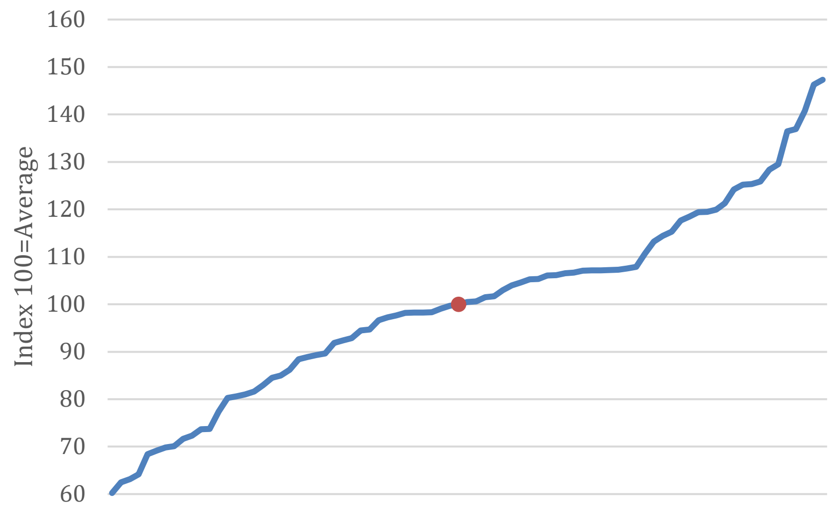


Sources: Fuel mix reports and EIA compliance reports, 2016-2018

Developing a clean electricity standard that works with hydroelectric resources

With such a large portion of Washington's electric supply coming from hydro, it is likely that Washington's clean electricity standard will require a different structure than any standard that might be adopted in another state. In some ways, Washington has an easier road to a 100 percent clean electricity supply since it starts with 74 percent of its electricity supplied from renewable or zero-carbon sources.[20] The challenge, however, is that the region's hydro resources experience substantial variation from year to year in their production. This is illustrated in Figure 2.4, which depicts the historical range of annual streamflow amounts in the Columbia River at the Bonneville Dam. The highest annual flow is about 2.5 times the lowest annual flow. The amount of electricity available from regional hydro resource could vary from 6,613 aMW to 10,970 aMW, depending on streamflows.[21]

Figure 2.4. Average Annual Streamflows at Bonneville Dam Ranked from Lowest to Highest 1929-2008



Source: https://www.bpa.gov/p/Power-Products/Historical-Streamflow-Data/Pages/Monthly-Data.aspx
BON5M_monthly.xls

Other renewable sources also experience variation in output, but neither wind nor solar varies in the way that Pacific Northwest hydro does. While wind and solar vary from hour to hour and day to day, hydro generation is characterized by large year-to-year changes in output due to a complex set of weather-related factors. Within any given year, however, the hydro system provides some flexibility to schedule the use of the resource. This flexibility allows hydro operations to absorb some of the hourly or daily variation in wind and solar output, making it easier to accommodate high levels of these forms of renewable energy.

While hydro can help balance wind and solar variations, the converse currently is not true. The year-to-year variations in hydro output would not easily be balanced by varying the output of the region's wind and solar resources. Projects built solely to serve as backup to the hydro

[20] Calculated from 2016 fuel mix disclosure reports, available at www.commerce.wa.gov/fmd.
[21] *2017 Pacific Northwest Loads and Resources Study*, Bonneville Power Administration, December 2017, Table 2-4. www.bpa.gov/p/Generation/White-Book/wb/2017-WBK-Loads-and-Resources-Summary-20171218.pdf

system would produce excess generation under all but the lowest hydro conditions.

A promising approach, at least for a near-term clean electricity standard, would be to provide for some use of fossil fuels during years when hydro output is low, as long as it is offset in higher hydro years by generating more renewable electricity than the state's customers consume. This can be achieved through a provision to allow banking of renewable energy certificates.

This approach is used in the existing RPS and is consistent in concept with approaches that are widely adopted in evaluating the energy consumption of individual residential and commercial buildings and for many corporate sustainability goals.[22] A net-zero building is built with enough on-site renewable generation to provide as much electricity as the building consumes. While the building generates an amount of electricity equal to 100 percent of its electricity consumption, it typically uses electricity from the grid during times when its on-site production is low and returns at least as much electricity to the grid during times when on-site production is high. For example, a net-zero building with solar would use grid electricity at night and return solar electricity to the grid during the day. Net-zero buildings are widely considered to have zero greenhouse gas emissions from their electricity consumption.

Under a clean electricity standard with banking, during years of average or high hydro conditions Washington's power system would produce more renewable and carbon-free electricity than the state's customers use. The extra clean electricity would be exported to other states, where it would displace generation that would otherwise use natural gas or coal. There would also be occasional years where hydro availability is low, and in those years the total amount of renewable and carbon-free electricity would be less than the amount consumed in the state. This difference would be met with power generated using the most efficient natural gas turbines available, with no impacts to grid reliability.

It is possible that, in the long term, the banking component of this clean electricity standard could be reduced, moving to a standard that eliminates fossil fuel generation entirely. For example, excess hydro generation might be used to produce hydrogen that would replace natural gas. Other technological breakthroughs could occur in the areas of renewable natural gas or long-term energy storage. In the meantime, the state would be able to achieve a 100 percent renewable and carbon-free electricity supply that takes full advantage of its hydroelectric resources.

This standard would require adjustments to the existing system of tracking and verifying use of renewable energy. The existing renewable standard under the EIA uses renewable energy certificates to validate claims on all renewable resources other than hydro. Some hydro is already tracked using these certificates. This system could easily be expanded to track all clean energy resources used to meet the standard. Doing so would ensure that when Washington

[22] For example, Google announced that in 2017 it achieved 100 percent renewable electricity on an annual basis and described this as a "first step" that does result in an hour-by-hour matching of generation and consumption. sustainability.google/projects/announcement-100/

utilities export hydro to other states, the utilities in those states are not also counting the hydro energy toward their own renewable or clean energy requirements.

Chapter 3 – Recommended Changes to Fuel Mix Disclosure

Since 2000 Washington law has required that electric utilities disclose to customers the fuel sources of their electricity. The purpose of fuel source disclosure is to help residential and business customers know what they are getting in their electricity purchases. Business customers are increasingly interested in data about the carbon emissions associated with their electricity purchases. While consumers in Washington cannot choose their retail electricity supplier, every customer has the choice to use a green power product in place of the standard utility electricity product. Fuel source disclosure helps customers make an informed choice.

This chapter provides an overview of recommended changes to the disclosure law. Commerce publishes a detailed fuel mix report each year[23] and the details provided there are not repeated in this chapter.

Heightened policy interest in fuel mix disclosure

Fuel mix disclosure has operated as a straightforward, data-driven process for most of its existence. Each utility identified the generating resources and contracts used to serve retail customers. In some cases the utility used power without a specified source, and Commerce performed calculations to impute a fuel mix to be applied to those sources. For many smaller utilities, the fuel mix was simply the resource mix of the Bonneville Power Administration.

Fuel mix disclosure became a more prominent policy issue as concern increased about the harmful effect of fossil fuel combustion. Stakeholders and policy makers have used fuel mix data as an approximate measure of how much coal and natural gas utilities are using to generate electricity. In 2016, a carbon tax initiative submitted to the legislature proposed to use fuel mix reports to calculate tax liability for electric utilities.[24]

The carbon tax initiative was not approved by the legislature or by voters in the November 2016 general election, but the prospect of a tax based on the carbon intensity of the fuel mix prompted a much closer examination of the methods and data sources prescribed in the 2000 legislation. Commerce concluded that the law should be updated to reflect changes in industry practice – in particular to incorporate the electric industry's system of accounting for renewable energy generation – and to remove a number of obsolete or overly prescriptive provisions.

Commerce began a stakeholder process in 2017 to develop legislation to update the fuel mix statute. While the carbon tax proposal helped prompt this review, Commerce has not sought to develop a fuel mix disclosure that could be used for carbon taxes. Instead, the objective has been to provide consumers with general information about the fuels used to generate their

[23] Current and historical reports are available on Commerce's fuel mix web site: commerce.wa.gov/fmd

[24] Section 7, Initiative 732. sos.wa.gov/_assets/elections/initiatives/finaltext_779.pdf

electricity without requiring the level of detail or oversight that would be required to support tax computation. Commerce has also advised stakeholders and legislators seeking to develop appropriate methods of assessing carbon taxes on electricity without affecting fuel mix disclosure reports.

Commerce's proposed approach to update and streamline fuel mix disclosure

Commerce's stakeholder work during 2017 and 2018 resulted in an agency recommendation to make statutory changes in three broad areas:

- **Improve timeliness and accuracy by eliminating the net system mix calculation.** Most utilities make some power purchases without knowing the generating unit that produced the electricity. For these unspecified sources, existing law requires that Commerce calculate and apply a residual or "net system" fuel mix. The statute prescribes a calculation that requires data from hundreds of power plants across the West, data not available to Commerce until about 10 months after a year ends. Once the residual mix is calculated, Commerce uses it to impute a fuel mix to the unspecified sources.

  Commerce believes that a better approach is for utilities to report unspecified power sources as a separate category. Figures 3.1 and 3.2 provide an example, at the statewide level, illustrating the two approaches. While a category of "unspecified" appears to be less accurate than the current method, it actually enhances accuracy by replacing assumptions and calculations with a straightforward statement that the source is unknown. Moreover, by eliminating the need for regional data, the change will allow utilities to make more timely disclosure to their customers.

- **Require disclosure of all known sources of power supply used to serve retail customers.** While current law requires that utilities disclose a fuel mix to their customers, it does not explicitly require that all known sources be disclosed. In some cases utilities have opted to use a statewide average result in place of disclosing their actual power sources. To increase accountability, Commerce recommends that each utility be required to report any power source used to serve retail customers. This would not eliminate the result where some power sources are unspecified, because the existing business practices of utilities include transactions where electricity is sold without identifying its source.

- **Incorporate existing industry practice in accounting for renewable energy claims to guard against double-counting.** The electric power industry has developed a rigorous system of accounting for renewable energy claims by utilities and customers. This system uses renewable energy certificates to ensure that no two entities claim the same unit of renewable energy. The fuel mix statute enacted in 2000 did not include a reference to renewable energy certificates, but two laws enacted later incorporate this accountability mechanism.[25] The requested statute would clarify that a utility may not claim to its customers that their electricity is from a renewable source if anyone else owns the renewable energy certificates from that electricity. Electricity separated from its certificates is an unspecified source and would be included in that category on the disclosure label.

This provision would not be a change from existing practice, but this clarification would remove the potential that renewable resources are double-counted. It also would establish a single, consistent method of verifying renewable energy claims made by utilities in their EIA compliance filings, by corporate customers making voluntary green power claims and by utilities in their disclosures to retail customers.

The proposed legislation includes a number of other provisions to eliminate outdated or unnecessary provisions and to reflect current utility practice in communicating with customers.

[25] The legislature included use of renewable energy certificates when it enacted the voluntary green power statute in 2001 (RCW 19.29A.090). The Energy Independence Act, approved by voters in 2006, allowed for use of renewable energy certificates to meet renewable energy targets and directed Commerce to select a tracking system for these certificates (RCW 19.285.040).

Figure 3.1: Washington State Electric Utilities Aggregate 2017 Fuel Mix: Using Net System Mix

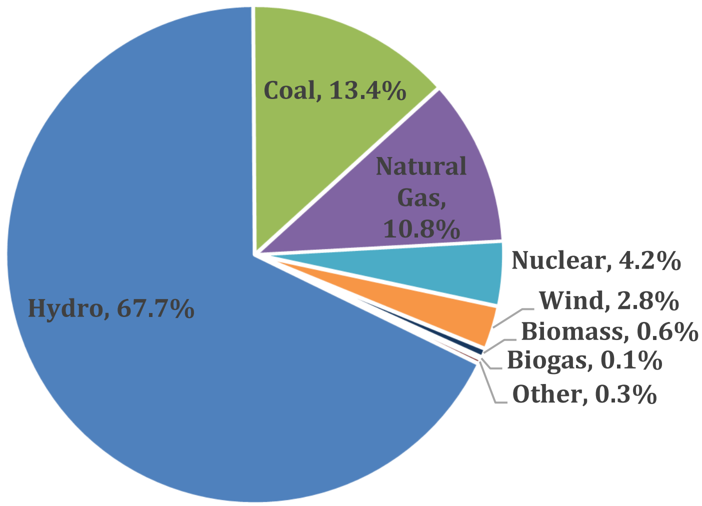
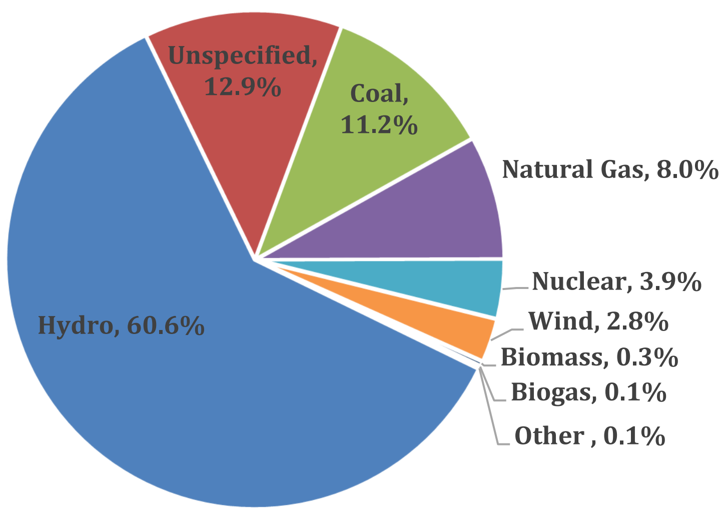


Figure 3.2: Washington State Electric Utilities Aggregate 2017 Fuel Mix: Including Unspecified Source Category



Chapter 4 – Addressing the Energy Burden of Low-Income Washington Households

The transition to a clean energy future that is described earlier in this report holds the potential to provide greater access for Washington consumers to affordable clean energy. However, the transition also poses challenges for low-income households and communities across the state, and the Dept. of Commerce seeks to improve its understanding of these issues. This includes a better understanding of current programs that provide assistance to those populations and new programs and policy ideas, emerging alongside long-standing ones, to expand access to clean affordable energy. This understanding will better position the state to bring benefits of the clean energy transition to all communities in Washington.

The chapter begins with a discussion of standards used to define a household as low-income and an overview of the current state of programs administered by Commerce that address low-income energy issues. These are the Low-Income Home Energy Assistance Program (LIHEAP) and Weatherization Plus Health program. A review of these programs provides insights into opportunities for evolving this work to serve unmet need. The chapter next explores three issues in these policy areas that are influencing access for and participation by low-income and other disadvantaged communities in the state of Washington: availability of resources and benefits, structural access to resources, and program design. In doing this review, Commerce acknowledges that income is only one measure of the extent to which an individual or community is disadvantaged.

Major shifts in the energy equity conversation have emerged along a number of fronts, both in the Pacific Northwest and across the country. The second part of this chapter presents highlights of energy policy with equity and access considerations from across the region. The chapter concludes with a list of takeaways and directions for future work taking into account our past programmatic experiences and the emerging conversation on accessibility for disadvantaged communities.

How Washington Defines Low-income

The state of Washington makes significant investment in services to low-income households, which are usually defined as being at or below 200 percent of Federal Poverty Level (FPL). There is emerging research to suggest that the 200 percent FPL definition of low-income is not sufficient to address the needs of those living in the state. Ongoing research from the Workforce Development Council of Seattle-King County suggests Federal Poverty Level measures are inadequate and suggest an alternative measure of need.[26] Its Self Sufficiency Standard (SSS) states:

> *The official poverty measure, developed half a century ago, is now methodologically out of date and no longer accurately measures poverty, and at best measures "deprivation." Throughout Washington State, the Self-Sufficiency Standard shows that incomes well above the official federal poverty thresholds are nevertheless far below what is necessary to meet families' basic needs.*
>
> *The Self-Sufficiency Standard for Washington State 2017 defines the minimum income needed to realistically support a family, meeting basic needs without aid from government, community or personal aid. Note that these budgets are "bare bones," with just enough allotted to meet basic needs, but no extras. Thus the food budget is only for groceries. It does not allow for any takeout or restaurant food, not even a pizza or a latte.*

The SSS exceeds 200 percent of FPL in 38 of the 39 Washington state counties, and it exceeds 250 percent of FPL in Washington's urban counties. The SSS is greater than 300 percent of FPL of King County and Seattle. When looking at this metric, combined with energy costs, these households need help offsetting the cost of their utility bills. Households at or below 50 percent of Federal Poverty Level ($12,550/year) are severely cost burdened by energy bills, spending 64 percent of their annual income on home energy bills.

Therefore, it becomes clear that low-income households typically bear a disproportionate energy and housing cost burden relative to non-low-income households. Low-income households pay up to three times as much as the average household on their energy bills.[27] A growing body of research by the Human Impact Partners[28] has enumerated how energy equity is a critical public health concern:

- Families who cannot pay energy bills often struggle to cover other basic needs such as housing, food, and medication. High energy bills in the winter can trap people in a "heat or eat" dynamic; in one study, adults and children in low-income households did what

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[26] Pierce D. 2017. The Self-Sufficiency Standard for Washington State 2017. The Workforce Development Council of Seattle-King County. Seattle, WA September 2017. selfsufficiencystandard.org/sites/default/files/selfsuff/docs/WA2017_SSS.pdf

[27] Drehobl, A., and L. Ross. 2016. Lifting the High Energy Burden in America's Largest Cities: How Energy Efficiency Can Improve Low-Income and Underserved Communities. Washington, DC: ACEEE. aceee.org/research-report/u1602. Berg, W., and Drehobl, A., 2018. State-Level Strategies for Tackling High Energy Burdens: A Review of Policies Extending State- and Ratepayer-Funded Energy Efficiency to Low-Income Households. Washington, DC: ACEEE. aceee.org/files/proceedings/2018/#/paper/event-data/p390

[28] humanimpact.org

wealthier households did not -- reduced their calories by 10 percent during the winter, resulting in lower weight.[29]

- Families are forced to forgo buying adequate food so they can pay for heat or air conditioning — a particularly serious "choice" for families with young children, who experience extraordinary brain and body growth from birth to age 3.[30]
- Difficulty paying energy bills contributes to chronic stress, which harms mental and physical well-being and is linked to greater risk of illness.[31]
- General health suffers when people go into debt to pay energy bills — it is associated with conditions like stress, anxiety, severe depression, ulcers, and heart attacks.[32]

Benefits resulting from energy efficiency programs historically focused on energy and cost savings. This growing body of research linking weatherization, and other energy efficiency upgrades, to positive health impacts must be taken into consideration. These health impacts are long term and actualized in fewer days of missed school and work, reduced visits to the emergency room and urgent care, and reduced medication utilization.[33] There is also an increasing awareness that energy efficiency work provides other important benefits such as preservation of affordable housing and improved household economic resilience. These benefits, while likely to be much greater than energy benefits, can be difficult to quantify with precision.

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[29] Bhattacharya J, DeLeire T, Haider S, & Currie J. (2003). Heat or eat? Cold-weather shocks and nutrition in poor American families. *American Journal of Public Health*, 93(7), 1149–1154. doi.org/10.2105/AJPH.93.7.1149

[30] Children's Sentinel Nutrition Assessment Program, 2007. Balancing Acts: Energy insecurity among low-income babies and toddlers of color increases food insecurity and harmful health effects. www.childrenshealthwatch.org/wp-content/uploads/SEDC_energy_report_2007.pdf

[31] Hernández D, Phillips D, & Siegel EL. (2016). Exploring the Housing and Household Energy Pathways to Stress: A Mixed Methods Study. *International Journal of Environmental Research and Public Health*, 13(9), 916. doi.org/10.3390/ijerph13090916

[32] Sweet E, Nandi A, Adam EK, & McDade TW. (2013). The high price of debt: Household financial debt and its impacton mental and physical health. *Soc Sci Med*, *91*, 94-100. www.ncbi.nlm.nih.gov/pubmed/23849243. Disney R, & Bridges S. (2002). Debt and Depression. University of Nottingham, Centre for Finance, Credit and Macroeconomics. ideas.repec.org/p/not/notcfc/06-02.html

[33] E4TheFuture 2016. Occupant Health Benefits of Residential Energy Efficiency. Energy For the Future November. e4thefuture.org/wp-content/uploads/2016/11/Occupant-Health-Benefits-Residential. Wilson J, Jacobs D, Reddy A, Tohn E, Cohen J, & Jacobsohn E. 2016 Home Rx: The health benefits of home performance – A review of current evidence, US Department of Energy, Office of Energy Efficiency and Renewable Energy, DOE/EE -1505. December. energy.gov/eere/buildings/downloads/home-rx-health-benefitshome-performance-review-current-evidence

Low-Income Home Energy Assistance and Weatherization Program

The Low-Income Weatherization Program makes homes safe, healthy and efficient for households at or below 200 percent of federal poverty level. The program has a national savings-to-investment ratio of 1.4, meaning the savings resulting from the investment are paid back over the life of the measure. However, when the cost of health and safety benefits are included, the program has a 4.1 savings-to-investment ratio.[34] The most recently completed benefit/cost analysis for Washington, which excludes most health, safety and housing benefits, conservatively estimated a savings to investment ratio at 1.5.[35]

Adequate funding is one significant barrier in being able to help more Washington families in need of benefits. Financial resources in the energy sector for low-income communities have been available for decades. While these programs have been available, the funding appropriated at the state and federal level has not been sufficient to meet the need that exists in the state of Washington, nor to meet the need of every state in our nation.

Various sources contribute funding for energy assistance and weatherization in Washington.

- Congress authorized the U.S. Health and Human Services' Low-Income Home Energy Assistance Program (LIHEAP) in 1981. LIHEAP funding for Washington is an average of $56 million annually, distributed to offset the cost of utility operating costs for both owner-occupied and rental units at or below 125 percent of FPL. LIHEAP benefits are distributed to 76,000 households each year, which is 18-20 percent of the 389,970 current eligible households. LIHEAP prioritizes benefits to households with young children, households with elderly persons, and households with high home energy burdens. Families and individuals receiving LIHEAP benefit are referred to the state Low-Income Weatherization Program.
- Washington's Low-Income Weatherization Program started in 1978 with funding from the federal government. State funds have also been appropriated to the Weatherization Program since the mid-1990s. On average, Washington State has received $20 million per year, combined state and federal funds, since 2013 after the conclusion of the American Recovery and Reinvestment Act (ARRA). The program also benefits from approximately $5 million from utilities through the Energy Matchmaker Program each year. This funding level weatherizes 2,500 to 4,000 house on average annually and has helped approximately 40,000 units in the past decade. At current investment and production levels, Washington will meet only a small portion of the 300,000 households

[34] Department of Energy, Weatherization Assistance Program 2015 National Evaluations, Summary of Results. Washington DC US DOE Efficiency and Renewable Resources. weatherization.ornl.gov/wpcontent/uploads/2018/06/WAPNationalEvaluationWxWorksv14blue8515.pdf

[35] Washington State University Energy Program 2018. Washington Weatherization Program FY 2017 Cost Benefit Analysis.

that are likely eligible to receive weatherization services in the state. Table 4.1 summarizes the funding sources to support low-income weatherization.

Table 4.1 Low-Income Weatherization Assistance Program Funding
(annual estimates)

Department of Energy, Weatherization Assistance Program	$5 million
Health & Human Services, Low-Income Home Energy Assistance Program-Weatherization Assistance Program	$11 million
Bonneville Power Administration, Low-Income Weatherization Assistance Program	$2.5 million
Washington State Energy Matchmaker Program	$5 million

- The Legislature funded the Community Energy Efficiency Program (CEEP) in 2009 with the specific charge of serving households that were difficult for utilities to serve, such as manufactured housing, renters, houses using fuels other than electricity or natural gas, and households between 125 percent and 250 percent of FPL. CEEP has funded efficiency measures in over 35,000 households, about 30 percent of whom are in the near low-income segments. Current funding for CEEP is $2.5 million per year, and CEEP-funded initiatives provide service to about 1,000 households per year in about one-quarter of Washington counties.

Washington households participating in the state's Low-Income Weatherization Program and Energy Assistance Programs represent only a small fraction of the households that are eligible for services. In 2017, there were 784,290 households in the state living at or below 200 percent of FPL (Energy Affordability Gap, 2017 Washington data). Their FPL makes them eligible for weatherization, yet in 2015 an estimated 300,000 households had not received services from the state's weatherization program. Many of these homes are not in adequate physical condition to receive such services.[36] These homes are in need of health, safety and energy upgrades to ensure that families and individuals can stay stably housed with affordable living expenses into the future. Moderate-income households (between 125 percent and 250 percent of FPL and up to 300 percent of FPL in high cost areas) are a particular concern, as these households do not have sufficient minimum income to meet basic needs including energy costs.

[36] Schueler V. and Kunkle R 2017. 2016 Washington State Low Income Weatherization Potential Assessment: Summary of Results. Washington State University Energy Program. Olympia. Schueler V. 2018. The Washington State Weatherization Plus Health Pilot: Implementation and Lessons Learned. WSU Energy Program Olympia WA May. www.energy.wsu.edu/documents/WxHSummaryReport.pdf

Broadening Access to Renewable Energy Systems

The number of households installing solar photovoltaic systems – often with financial support from taxpayers – has increased rapidly, and this change prompts questions about the access of low-income households and communities to this technology. National studies indicate that higher income households are more likely than average to install solar projects.[37] This raises the question about the extent to which households of all income levels have access to the benefits of solar such as reduced energy bills, increased resiliency, and added protection from rate changes.

In 2017 the Washington Legislature revamped the solar incentive program and created the Renewable Energy System Incentive Program (RECIP). This change broadened access by including renter-occupied houses as eligible sites. Most low-income households live in multifamily or rental housing, which was not eligible before RECIP began. However, high initial costs and the complexity of these projects continue to be barriers for participation.

RECIP also offers incentives for community solar projects, which could be more accessible to low-income households. However, fewer than 15 community solar projects have received certification for RECIP funding, and none was specifically targeted to serve lower-income households. The RECIP legislation requires that the program administrator report on barriers to low-income communities to inform future policy, but the incentive program does not include specific elements to ensure the equitable distribution of incentives.

The Low-income Weatherization Program is actively seeking approaches to address unequal access to renewable energy incentives and benefits. There may be opportunities with current and potential funders to incorporate solar projects into the portfolio of measures applied through weatherization. Upcoming pilots created through partnerships with Commerce, city governments, local agencies, and landlords will target multi-family buildings serving LMI households.

Other Challenges

In addition to insufficient resources available to serve disadvantaged communities, there has also been an increase in the cost to deliver weatherization and other housing improvement services.

Construction costs, both labor and materials, have been on the rise since the economy has improved in 2013. After the conclusion of federal Recovery Act programs, public funding for efficiency programs decreased, and many construction workers left the trades to find work elsewhere. Labor shortages have resulted in increased labor costs. The increase in new

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[37] Moezzi, Mithra, Ingle, Aaron, and Luzenhiser, Loren, 2017. *A Non-Modeling Exploration of Residential Solar Photovoltaic (PV) Adoption and Non-Adoption.* National Renewable Energy Laboratory. www.nrel.govhttps://www.nrel.gov/docs/fy17osti/67727.pdf

construction building activity has strained the already reduced pool of construction workers. There are additional challenges in recruiting workers and companies to do work in existing homes. Construction material costs have also increased. Between 2011 and 2016 national materials costs for most common weatherization measures increased by 15 percent to 50 percent.[38]

Prevailing wage has been a state requirement in the Weatherization Program and the Community Energy Efficiency Program since 2009. The administrative processes required to comply with the prevailing wage system in Washington have driven up the cost to deliver services. Intent and affidavit filing fees, in addition to the increased administrative time needed to track work by labor classifications, have increased the cost of weatherization projects between 6 percent and 12 percent.[39]

Also affecting the cost to deliver services are increased regulations at the federal and state level. One such example is that the U.S. Dept. of Energy implemented a requirement that all projects completed with its funds have a certified Quality Control Inspector physically inspect each unit. The inspector may not be the same individual who audited and completed the scope of work for the weatherized home, unless the state administrator increases the percentage of homes that the state must monitor and inspect. While this requirement has yielded some improvement in work quality, it has come at a significant increased cost to the Weatherization Program.

Structural Access to Resources

In addition to the financial barriers discussed earlier, there are barriers to access by low-income households in the structure of the programs intended to serve them. A 2018 evaluation of Washington's Weatherization Plus Health Program found that for many low-income households, the application process was a major barrier to access.[40] Clients may need to travel long distances or provide extensive and sometimes notarized documentation of ownership, citizenship, and income. Once clients navigate the application process it may take up to a year to receive completed services. Over that year, a typical project may involve 10 or more visits for installations, inspections, quality control and education, which may require time away from work or schools.

This approach of "you come to us" is in part a response to great demand for scarce funding and the complexity of federal and state requirements. The unintended consequence is that

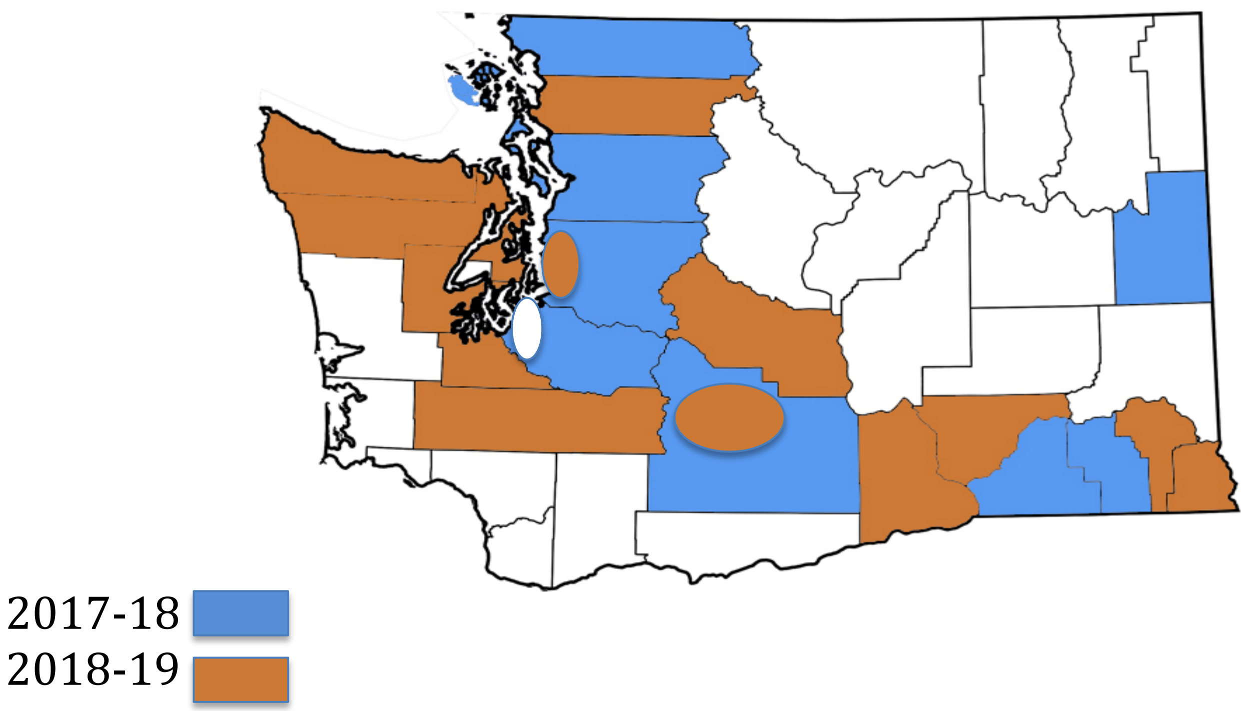
[38] Washington State University Energy Progam 2017. Analysis of RS Means Residential Construction Materials Costs for Common Low Income Weatherization Measures.
[39] Schueler V. 2018. The Washington State Weatherization Plus Health Pilot: Implementation and Lessons Learned. WSU Energy Program. www.energy.wsu.edu/documents/WxHSummaryReport.pdf
[40] Schueler V. 2018. The Washington State Weatherization Plus Health Pilot: Implementation and Lessons Learned. WSU Energy Program. www.energy.wsu.edu/documents/WxHSummaryReport.pdf

sometimes the clients in most need of help are not served due to significant barriers when navigating the process.

A wide variation in the tools and approaches to underserved communities exists among local agencies providing energy services. For example, most application and education tools for the Low-income Weatherization Program or RECIP are not available in languages other than English, nor are there systemic strategies or resources for addressing cultural barriers or establishing relationships with ethnic or other diverse communities.

The challenge of delivering services in rural areas also contributes to disparity in access to clean energy services. The lower population density of rural areas results in higher service costs, lack of broadband and other infrastructure, and a limited supply of contractors. The utilities serving rural areas may have lower capacity and resources to deliver services.[41] The disparity in access is illustrated in Figure 4.1, which shows the counties where agencies offer Weatherization Plus Health measures.

Figure 4.1. Areas of Washington State served by agencies providing Weatherization Plus Health Services



In addition to a concern that existing programs and services are not available to all state residents, there is increasing attention paid to ensure that resources are targeted to

[41] Shoemaker M. Gilleo A and L Ferguson 2018. Reaching Rural Communities with Energy Efficiency Programs, American Council for an Energy Efficient Economy. https://aceee.org/research-report/u1807

communities experiencing the greatest need or with the greatest vulnerability. Funding for Low-Income Weatherization and allied programs is awarded statewide based on estimates of low-income populations by county. However little work has been done to assure that local agencies are delivering targeted services to specific communities and geographic areas of greatest need.

Program Design

Program design and requirements, many of which are driven by rules governing federal funding, drive how disadvantaged communities are served, and who benefits. These also create inequities in access and services within disadvantaged communities and poor alignment with the areas of greatest need.

Of the roughly $20 million in weatherization funds that the department administers each year, 75 percent is federal. Federal law generally prohibits a home from receiving funding more than once. As a result, once a home is weatherized with federal funds, the program typically will never go into the home again. Virtually all low-income weatherization projects managed through the state program are comprehensive, “whole house” upgrades, with measure costs between $10,000 and $15,000. Compared to a less comprehensive approach to weatherization, a smaller number of households get a great deal of benefit and many go without help. The smaller number of higher-cost projects further drive up costs because of greater needs for quality assurance, income verification and documentation, as these are higher-risk projects. Participation is skewed toward home ownership, not renters, because of the need for assurance that these projects remain in the low-income housing stock and requirements for property owner approval and contributions. Current requirements for comprehensive installations do not allow for phased investments for large multi-family projects, thus making them less attractive and a harder sell.

Table 4.2. Comparison of Household Characteristics

	Low-Income Households Under 200% of FPL (American Community Survey 2006-2011)	Households Served in Weatherization Program (FY 2018)
Tenure		
Renter	62%	41%
Owner	38%	59%
Building Type		
Single-family Site Built	46%	33%
Manufactured Housing	11%	24%
Multi-family 2-4 units	12%	11%
Multi-family 5+ units	31%	32%
Household Income		
Under 125% of FPL	57%	82%
125% - 200% of FPL	43%	18%

The result of these issues is that existing state-managed low-income services are not well aligned with need, and some segments are not well served. Even where there is close alignment (for example with multi-family units), a closer examination suggests that the key segments are missed. For example, most of the large multi-family units are public or subsidized housing with very few market rate large multi-family units serving low-income households. Table 4.2 provides a high-level comparison of the target population and the households that receive services through the weatherization program.

Washington's low-income programs often prioritize households under 125 percent of FPL, and households at the higher end of low-income are much less likely to receive services. There are almost no resources available for near low-income and working poor (between 200 percent and 300 percent of FPL). Much of what is offered to these households has been access to financing – as one of the working hypotheses of federal Recovery Act funding was that access to financing and information would move markets. Testing financing models revealed that the true barrier was not access to financing but the willingness or ability of low-income households to take on any debt. While there has been modest uptake on some efficiency loan products, these services are expensive to operate and generally have very low uptake rates for the near low-income.

Extensive testing of incentive models by Washington's CEEP grantees has established that for the near low-income, incentives for major efficiency upgrades must exceed 75 percent of measure costs to assure uptake. The Self-Sufficiency Index supports this finding as it suggests that few households under 250 percent of FPL have room in their budgets to take on debt. If the near low-income segments are going to be addressed in an equitable manner that allows for meaningful participation, costs of entry need to be reduced or funding must be significantly increased.

Energy Equity and the West Coast

Emergent energy equity issues include a number of programmatic shifts and policy discussions in the state and the West Coast region.

California

California has taken the most aggressive action to address equity in its energy planning. It was one of the first states to codify an official definition of "environmental justice" in statute.[42] In 2005 the California Environmental Protection Agency has implemented the Environmental Justice Small Grants Program with funding opportunities to "assist eligible non-profit

[42] codes.findlaw.com/ca/government-code/gov-sect-65040-12.html

community organizations and federally recognized Tribal governments address environmental justice issues in areas disproportionately affected by environmental pollution and hazards."[43]

The California Environmental Protection Agency also manages the CalEnviroScreen 3.0, which is a mapping tool that can be used to identify "communities most affected by many sources of pollution, and where people are often especially vulnerable to pollution's effects."[44] The tool uses a wide range of environmental, health and socioeconomic information to create scores for census tracks and use that information to compare communities and identify need.

California also has passed legislation that requires a specific portion of funds be directed to low-income communities. The cap and trade system, which took effect in 2012, reserves at least 35 percent of carbon allowance auction proceeds for communities that are disproportionately impacted by climate change.[45] The Clean Energy and Pollution Reduction Act (SB 350), passed in 2015, established higher targets for greenhouse gas emissions reductions and directed state agencies to identify barriers and opportunities for low-income customers and local small businesses in disadvantaged communities to renewable energy, energy efficiency, weatherization and clean transportation.[46]

Oregon

The Oregon Public Utility Commission expanded community engagement as a result of SB 978, enacted in 2017. The legislation required that the agency investigate how changing trends in the energy market affect the role of regulation. From this research, it created a road map that would expand its regulatory abilities and address issues of climate change, equity and environmental justice, among other recommendations.[47] Specific recommendations include a clear mandate to address GHG emissions beyond just the economics and pushing the Legislature to find ways to improve access to the clean energy transition and energy services. There was also a call for greater public engagement and inclusion in the decision making process.

On Nov. 6, 2018, voters in Portland overwhelming approved Measure 26-201, or the Portland Clean Energy Community Benefits Initiatives. The work on this measure was largely done by communities of color, such as APANO. The initiative adds a 1 percent tax on businesses that make over $1 billion in gross revenues nationally (and $500,000 locally), with groceries, medicine and health care services being exempt. Proponents have said the measure will raise

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43 calepa.ca.gov/envjustice/funding/
44 oehha.ca.gov/calenviroscreen
45 www.arb.ca.gov/cc/capandtrade/auctionproceeds/communityinvestments.htm
46 www.energy.ca.gov/sb350/
47 pamplinmedia.com/sl/406649-305241-puc-report-evaluates-how-to-expand-consideration-of-climate-change-and-equity

roughly $30 million a year for Portland's Climate Action Plan, which has a significant equity component.[48]

Washington

In Washington, several attempts have been made to push for equity and inclusion in energy policy. The biggest effort was the recent Initiative 1631, which was not enacted by voters in November 2018. The initiative was designed and supported by a diverse set of groups representing labor, tribal nations, communities of color, environmental justice, health, faith and businesses. It would have established a fee on carbon dioxide emissions, and at least 35 percent of the investments would have benefitted communities hardest hit by pollution and poverty. Also, it would have required that at least 15 percent of all clean-energy investments funded by the fee would help low-income residents gain access and transition assistance to the clean energy economy. Likewise, carbon tax legislation considered in 2018 would have directed some revenue to a transition assistance account and would "provide a financially equitable transition to a clean energy economy by providing economic, financial, and public health supports, programs, services, and assistance to low-income households."[49]

Washington also has taken steps to include opportunities for equitable access to the clean energy economy. In the 2017-2018 Clean Energy Fund appropriation, a $4 million program to encourage solar project deployment required that at least 25 percent of the total go to projects with a direct benefit to low-income residents and communities. This appropriation also included $11 million for electrification of transportation with a provision for electric vehicle sharing in low-income, multi-unit housing communities in urban areas.

Future Directions

As a first step, with the assistance of federal Department of Energy funding through the Solar Plus competitive grant award, a group from Washington participated in an eLab Forge event in June 2018. The eLab Forge is a multi-day deep-dive workshop hosted by Rocky Mountain Institute (RMI) for teams to critically advance the delivery of clean energy benefits at scale to people with lower incomes. The eLab Forge brought together seven people with different perspectives, experiences, and needs related to the Washington's clean energy transition. Commerce sponsored Washington's participation through the DOE Solar Plus grant, using the Transition Assistance Account proposed in 2018 legislation as a frame of reference for the opportunity to ensure that LMI communities benefit from the transition.

After three intense days supported by RMI's strategic facilitation, the team developed a cross-agency understanding of these issues supplemented by the perspective of utility, environmental, and environmental justice stakeholders. A picture of obstacles that prevent LMI communities in Washington from benefitting from the transition emerged, along with the

[48] www.portlandoregon.gov/bps/article/583501
[49] lawfilesext.leg.wa.gov/biennium/2017-18/Pdf/Bills/Senate%20Bills/6203-S2.pdf

acknowledgement that a set of fixed options does not exist for a challenge this complex. The Forge team's next steps are continuing the discussion and taking advantage of emergent opportunities.

Assessing the Barriers

Identifying barriers to participation in the clean energy economy is key to understanding where to put money and resources. There is significant work ahead as Washington moves forward, including choosing metrics to identify and measure in clean energy policies and programs, and recommending adjustments to or creation of policy with data-driven feedback from stakeholders and households.

In the past year there has been a dramatic improvement in mapping tools to assess how well program services geographically align with the needs of low-income and disadvantaged communities. These tools can also be used to assess how well programs are directing resources to where the impacts of clean energy transition and climate pollution are greatest.

In February 2018, the Washington Environmental Justice Mapping Symposium convened a workshop to identify and illustrate the communities most affected by pollution and climate change. The goal was to refine a mapping tool for the state to identify at a fairly granular (census tract) level which areas have the greatest social vulnerability, economic vulnerability, and exposure to climate and environmental hazards.[50] The Washington Tracking Network provides a powerful tool for assessing whether funding and projects are being located in the areas of greatest vulnerability.

Potential Directions in Commerce's Existing Programs

Existing clean energy programs and services are not equally available across all geographical regions. Rural areas of the country and in Washington are less likely to benefit from clean energy service programs because the low population density makes them harder to serve due to higher service costs and lack of infrastructure. Further, structural barriers to these programs and the clean energy economy more broadly are deeply ingrained and require engagement with communities to understand.

Including equity considerations in policy and program design represents a change to the economic and engineering framework of the State Energy Office. Considerations for future dialogue include equitable access to these services, unintended structural barriers and impacts across incomes, housing types, race and ethnicity and, geography (rural and urban and among socially and economically vulnerable communities). Some takeaways and future directions include:

[50] frontandcentered.org/putting-environmental-justice-on-the-map

- Create more expansive definitions of poverty to address the needs in Washington. Allow for flexibility in assessing economic need and income eligibility, as current poverty definitions are inadequate for some higher cost cities and counties.
- Lean on data-driven analysis and tools to map out regional needs for energy and use more comprehensive metrics, like energy burden, to capture the many layers of how poverty and energy intersect.
- Identify options to reduce barriers to participation by vulnerable and underserved populations in program design and applications. Mitigation strategies could include additional resources for outreach and application support, simplifying applications and eligibility verification and documentation, and requirements where doing so does not compromise public trust.
- Increase investments in coordinating services and applications processes to increase accessibility and impact of these services. For example, it is common practice to refer LIHEAP energy assistance clients to weatherization services. The next step may be to coordinate more closely to identify the highest energy burden households for targeted assistance.
- Understand how emerging conversations on equity, access and environmental justice can be included in program design for programs like Weatherization.
- Explore options to expand the scope of funding for programs, like the Low-Income Weatherization Program, to include funding for solar and other renewable energy projects.

Chapter 5 – Improving Energy Resilience

The resilience of Washington's energy systems is a fundamental concern for consumers, energy providers and policy makers. By preparing for natural and human-caused disasters, Commerce helps the state's energy system operators and supporting entities improve their ability to recover when disruptions occur.

Preparing for improved energy resilience centers on the work done through Emergency Support Function (ESF) 12 – Energy, with Commerce designated as the lead agency by both state statute and the State Comprehensive Emergency Management Plan (CEMP). Specifically, Chapter 43.21F RCW directs Commerce to plan for and respond to energy shortages and emergencies. This responsibility is further promulgated by the Governor through the state's CEMP and its ESFs. This work focuses on emergency planning, response and coordination activities before, during and after an event to enable timely restoration of service from the energy sector.

Emergency Planning Initiatives

ESF12 is currently focused on catastrophic planning efforts. Lessons learned from the 2016 Cascadia Rising Exercise and other events are incorporated into plans during the regular cyclical updates and during new plan development. One new planning effort is the development of the Statewide Catastrophic Incident Planning Framework. Catastrophic planning and response is fundamentally different from that previously identified and conceptualized in terms of both complexity and the need for increased coordination. It considers the response and recovery planning for the most extreme catastrophic events in response and recovery planning. ESF12's contribution to this planning effort centers around developing the impacts for extreme events on the electrical grid, petroleum and natural gas sectors. This framework gives local jurisdictions a planning tool to answer questions needed by the state to complete a statewide catastrophic plan. The electricity portion of this framework was completed in Summer 2018 with input provided by stakeholders from local jurisdictions, utilities, state agencies and federal partners. Additional frameworks focused on petroleum and natural gas are in development.

In addition to this planning function, ESF12 has begun actively engaging other state and federal agencies in an effort to develop a comprehensive approach to catastrophic incident fuel allocation planning. This planning is in its early phases and will integrate federal resource allocation capabilities with the anticipated needs of local communities. The state of Oregon has identified dependency on Washington petroleum resources, with approximately 90 percent of its refined fuels imported from Washington. Because of this dependency, additional consideration must be given to coordinating fuel supply chain restoration in a catastrophic event in order to ensure equity in resource distribution.

Several new planning initiatives are queued for development in the coming years in addition to updating existing plans:

- Fuel Allocation Plan

- Regional Fuel Allocation Framework
- Catastrophic Energy Annex
- Cybersecurity Plan

Exercises, Lessons Learned and Recommendations for Improvement

The State Energy Office provides training to agency staff and utilities about the Washington State Energy Disruption Tracking System (WSEDTS) annually. This activity has expanded the number of fully trained staff available to provide response support in the event of an emergency or natural disaster. A single ESF12 training event for Emergency Operations Center staff included 60 attendees. This training provided basic information on the electrical grid and how it works. Basic information on grid design and operation addresses the misperception that individual facilities can be restored to service after an event without addressing issues within the distribution and transmission system.

The State Energy Office staff have participated in several notable exercises and workshops:

- Fueling Anxiety – The tabletop exercise was sponsored by the Portland Regional Disaster Preparedness Organization in close coordination with the Oregon Department of Energy. It helped identify the needs of both states and provided an opportunity to identify specific interdependencies between the states for incorporation into the fuel allocation planning process.
- Energy Resiliency Retreat – The tabletop exercise and symposium was sponsored by the Western Governors' Association. The purpose was to explore opportunities for Oregon and Washington to coordinate with one another, the private sector and local and federal governments to improve energy resiliency and better prepare for a prolonged power outage. The discussion focused on stockpiling emergency and backup electricity equipment to expedite power restoration and developing resiliency for liquid fuels during a prolonged power outage.
- FEMA Region X Power Grid Project Workshop – The Federal Emergency Management Agency (FEMA) Region X National Preparedness partnered with the Critical Infrastructure Resilience Institute, University of Illinois at Urbana-Champaign on a power grid risk profile project. When complete, this project will improve the region's power grid threat and hazard risk profile. This workshop was held to discuss threats to the Region X power grid, societal and economic impacts of extended grid outages and it will identify mitigation and response measures and recovery strategies.
- Columbia Generating Station Dress Rehearsal and Graded Exercises – This exercise simulated the response of states and the station operators to an emergency at the Columbia Generating Station nuclear power plant near Richland. A dry run was completed in February with the FEMA graded exercise completed in March. The exercise scenario posed the question of how response and recovery occurs in a worst case scenario, in this case, what happens in an event in which a SCRAM (the procedure used to shut down a nuclear power plant) fails. Emergency Support Function 12 actions were

according to plan and no major issues were identified for continuous improvement within existing plans.
- Blue Cascades VII Earthquake Recovery – The Blue Cascades Earthquake Recovery Tabletop Exercise was a follow-on exercise to the June 2016 Cascadia Rising Subduction Zone Earthquake Exercise. The tabletop exercise used the Cascadia Rising Exercise Scenario but focused only on the disaster recovery and critical infrastructure interdependencies. It was sponsored by the Pacific Northwest Economic Region.
- Washington State Cyber Summit 4 – This event was the fourth in a series of technical and policy discussions, building on past cyber summits that brought industry together with policy makers to determine what is being done in Washington state and how can we work together to protect grid systems from cyber attacks.

It is critical to update emergency plans by incorporating lessons learned from exercises, including the ones identified above. Existing emergency operations plans and procedures for ESF12 are being reviewed, enhanced and designed to use federal support that will be provided during catastrophic events from the U.S. Department of Energy, FEMA and the Defense Logistics Agency.

Several priorities have been identified through the exercises noted above and previous after-action reports. These priorities provide a lens through which planning efforts are focused. Specifically:

- Increasing coordination among ESF12 leads and their counterparts in other affected states for situational awareness and resource coordination.
- Development of pre-disaster agreements with Oregon and Idaho to provide updates and collaborate on resources relevant to ESF12.
- Continued development of strong relationships with energy utilities, increased access to information critical to situational awareness and operational coordination.
- Increased planning for catastrophic events including devolution of operations to a non-impacted location or governmental entity.
- Increased incorporation of the Incident Command System into Commerce's existing plans and training activities.
- Increased frequency of ICS training and exercises.
- Clarification of federal, state and local roles in energy supply and infrastructure restoration.
- Development of a fuel allocation plan.

Commerce's Future State for ESF12

Exercises are critical to inform the work of ESF12. They identify both weaknesses and strengths within the current ESF planning framework and training. Catastrophic planning and response are fundamentally different from what was previously identified and conceptualized. Creating frameworks and plans for these types of events is labor-intensive and requires stakeholder engagement to a level not previously used in statewide planning. Planning is primarily focused on catastrophic and fuel allocation planning during the next revision cycle.

Situational awareness is the core of the support that ESF12 can provide to the state Emergency Operations Center. To further expand ESF12's capabilities to engage utilities during events, Commerce is currently working with the U.S. Department of Energy and Oakridge National Laboratory on a small-scale project called the outage data initiative. This project seeks to understand the technical capacity of utilities' outage data systems to identify the barriers that prevent greater integration of WSEDTS into the utilities' event reporting.

This work will support the development and ramp up for the next major catastrophic earthquake exercise in 2022. The exercise will be the second iteration of Cascadia Rising, testing how local, state and federal agencies would respond if a 9.0 magnitude earthquake occurs along the Cascadia Subduction Zone.

Chapter 6 – Clean Energy and Energy Efficiency Investment

Washington invests in developing, demonstrating and deploying technologies that save energy, reduce energy costs and generate energy that are essential to the state's clean energy future. Commerce has a portfolio of programs investing directly in clean energy and energy efficiency. The primary programs are the Clean Energy Fund and Energy Efficiency and Solar Grants. These state-funded programs are matched at least 1:1 by non-state funds, effectively doubling the state's investment.

Clean Energy Fund

The Legislature has invested in clean energy development through three appropriations to the Clean Energy Fund (CEF) from 2013 to 2017. The CEF enables a mix of projects to support development, demonstration and deployment of clean energy technologies. These technologies save energy, reduce energy costs, reduce harmful air emissions and increase energy independence for the state. CEF investments help strengthen communities all across the state.

Through 2017, the Legislature has appropriated nearly $103 million for competitive award through the CEF and an additional $9.8 million for directed funding to support clean energy goals.

2013-2015 Clean Energy Fund 1 – $36 million

Energy Revolving Loan Fund/Grants to Non-Profit Lenders Program ($15 million) – It finances use of proven building energy efficiency and renewable energy technologies that currently lack access to capital, serving residential and commercial sectors.

Status: Fully awarded $14.5 million to two grantees.

Commerce competitively awarded $14.5 million to two non-profit lenders, Craft3 and Puget Sound Cooperative Credit Union (PSCCU). Each lender operates a lending programs consistent with its customer requirements and business approach, resulting in a range of loan terms and underwriting standards. The program requires a 1:1 match at a minimum from the lenders. By using CEF funds as loan loss reserves, the lenders are able to offer loans at rates between 4.0 percent and 4.29 percent for qualified residential borrowers and 8.0 percent for qualified commercial borrowers. Craft3 has experienced no defaults and PSCCU's portfolio default rate is 0.012 percent.

- Craft3 – Commercial and residential loan programs, $11.6 million grant
- PSCCU – Residential loan program, $2.9 million grant

Smart Grid Grants to Utilities ($15 million) – The program demonstrates improved integration of renewables through energy storage and information technologies, improves reliability and reduces the costs of intermittent renewable or distributed energy.

Status: Fully awarded $14.5 million to four grantees.

These initial investments in grid modernization focused on demonstrating different batteries and energy storage systems. Projects were selected to compare a wide range of use cases at diverse locations within utility distribution systems. Multiple battery and software control technology providers worked to deploy both lithium ion and vanadium redox flow systems. All systems are now operational and undergoing extensive technical and economic evaluation by Pacific Northwest National Labs (PNNL).

PNNL collects data from the energy storage projects and researchers produce detailed analyses of these real-world use cases. PNNL's work is revealing broad valuation of energy storage on multiple levels: technology, economics, resilience and optimization of energy storage resources. The focus of the analysis is to identify approaches that make sense for the state's hydro-heavy power systems. The diversity of technologies in play is unmatched in the nation, commanding interest from energy research, planning, business and policy leaders worldwide.

- Snohomish County PUD MESA1 – multiple lithium-ion battery manufacturers within a single substation; $2.4 million grant
- Snohomish County PUD MESA2 – Vanadium flow battery within an urban substation; $4.4 million grant
- Avista Pullman – Vanadium flow battery deployed at the Schweitzer Engineering manufacturing facility; $3.2 million grant
- PSE Glacier – lithium-ion battery storage deployed in a remote community; $3.8 million grant

Federal Grant Matching Funds ($6 million) – Washington research institutions develop or demonstrate clean energy technologies that have been demonstrated as viable in prior published work, yet are not commercially available.

Status: Fully awarded $5.8 million to seven projects.

This program awarded funding to Washington research institutions for testing of demand response initiatives between transmission and distribution grid operations, transactive campus energy systems and distribution grid operations, battery optimizer software and use case analysis for battery systems that build on the smart grid to utilities and energy revolving loan grants for smart appliances and batteries. Additionally, investments were made in marine kinetics laboratory and composite recycling technology center equipment.

- Pacific Northwest National Lab (PNNL) Battelle – Develop transactive technology allowing building owners to dynamically control energy use with the University of Washington and Washington State University; $2.25 million
- PNNL Battelle – Use Case Analysis Project; $695,000
- PNNL Battelle – Joint project with Avista to develop energy storage control strategies; $145,000

- PNNL Battelle – Advanced research project supporting battery research to analyze the technical and economic attributes of several Federal Funds Matching projects; $162,000
- Composite Research Technical Center – Renovate an industrial and workforce training facility used to recycle composite materials; $1 million
- Snohomish County PUD – Joint project with Bonneville Power Administration to support use of distribution level energy assets to help optimize regional transmission systems; $1 million
- University of Washington National Marine Renewable Energy Center – Next-generation array development and demonstration through the Advance Laboratory and Field Arrays project; $518,000

2015-2017 Clean Energy Fund 2 – $40 million

Energy Revolving Loan Fund/Grants to Non-Profit Lenders Program ($10 million) – Commerce awards matching grants for loan loss reserves or interest rate buy-downs for proven building energy efficiency and renewable energy technologies that currently lack access to capital, generating opportunities within the residential and commercial sectors.

Status: Fully awarded $9.7 million to three grantees. An additional $3.2 million was reappropriated under SSB 6090, Section 1012. A 2018 competitive process awarded $3.1 million in reappropriated funds to Craft3, PSCCU and WSHFC.

Commerce has competitively awarded $12.8 million to three non-profit lenders under the second cycle of this program: Craft3, Puget Sound Cooperative Credit Union (PSCCU) and the Washington State Housing Finance Commission. Each lender operates different lending programs, which results in variability in the actual products provided and loan terms. The Grants to Non-Profit Lenders Program requires a 1:1 match at a minimum from lenders.

Craft3 and PSCCU use these CEF funds as a loan loss reserve, allowing them to provide average rates between 4.0 percent and 4.29 percent for qualified residential borrowers and between 3 percent and 11 percent for qualified commercial loans to borrowers. Only PSCCU has experienced default within their portfolio with a 0.0015 percent default rate for this round of funding.

WSHFC provides commercial lending products. Specifically, the commission uses these funds for loan products to businesses and nonprofits to deploy proven building energy efficiency and renewable energy technologies. These loans are focused on energy efficiency upgrades for multifamily housing and nonprofit facilities and community solar projects. The CEF funds are used as part of WSHFC’s loan capital.

- Craft3 – Commercial and residential loan programs; $5.63 million grant
- PSCCU – Commercial and residential and loan program; $5.3 million grant
- WSHFC – Commercial loan program; $1.87 million grant

Grid Modernization Grants to Utilities ($13 million) – It awards matching grants to advance integration of renewables through energy storage and information technology, improved reliability and reduced costs of intermittent renewable or distributed energy.

Status: Fully awarded $12.6 million to five grantees.

Grid modernization grants have encouraged public-private partnerships on a diverse range of projects, leading the way in electrical grid modernization. From different battery chemistries to energy storage to microgrids and solar, CEF project data and business case analyses are transforming how utilities and communities view energy systems and resiliency.

Most of the projects focus on microgrids combining solar with storage, load controls, etc., to provide resiliency benefits in addition to many of use cases for battery energy storage that were demonstrated in CEF1. All projects are currently in the early stages of design with deployments anticipated in 2019 and 2020.

- Snohomish County PUD – Arlington Microgrid; $3.5 million grant
- Avista Utilities – Spokane Urbanova, multiple microgrids; $3.5 million grant
- Energy Northwest – Horn Rapids solar and storage; $3.0 million grant
- Seattle City Light – Miller Community Center solar and storage microgrid pilot; $1.5 million grant
- Orcas Power And Light Co. – Decatur Island solar and storage microgrid; $1.0 million grant

Research Matching Fund Grants ($10 million) – Matching grants support clean energy research and development awarded from competitive solicitations.

Status: Fully awarded $9.13 million to eleven grantees. Two grant agreements remain in negotiation, totaling $566,316.

This program expands upon the federal funds matching grant program created under CEF1. The approving proviso language allowed the use of funding as match not only for federally provided research dollars but for entities with other fund sources, such as internal research funding, as well. As a result, the grants executed display a broader scope of work with investments targeted toward creating an ecology within Washington that encourages clean energy technology research and development. Commerce received 52 grant applications with $41.5 million in funding requests for the $9.7 million in funds available.

- Composite Recycling Technology Center – Demonstrate viable commercial processes for recycling carbon fiber; $1.726 million
- Edaleen Cow Power – Demonstrate an advanced solids and nutrient recovery system converting manure into fertilizer and cow bedding; $273,000
- Impact Bioenergy – Demonstrate conversion of food waste into biogas; $550,000
- PolyDrop – Conductive polymer additives to improve the fuel efficiency of vehicles and planes; $449,000

- Microsoft – Fuel cells in a data center environment; $675,000
- Oscilla Power – Build and test community scale wave energy conversion; $1 million
- Dresser-Rand – Test HydroAir™, a variable radius turbine system that generates electric power from ocean waves; $870,000
- Demand Energy (Next Watts) – Develop a platform that will help evaluate new battery technologies and optimize renewables and energy storage; $630,000
- Battery Informatics – Demonstrate next generation lithium ion battery management systems to maximize battery efficiency; $135,000
- Zunum Aero – Develop the first commercial-class hybrid aircraft; $800,000
- PNNL Battelle – Further develop transactive technology allowing building owners to dynamically control energy use; $2 million

Credit Enhancement Grants ($200,000) – It provides matching grants for loan loss reserves, interest rate buy-downs and other credit support for the development of new or expansion of existing in-state renewable energy manufacturing. Funding for this program was originally appropriated at $6.6 million. The funding was reduced to $200,000 under Section 1012 of SSB 6090, with the remaining funds being split between the Revolving Loan Fund/Grants to Non-Profit Lenders Program ($3.2 million) and a joint project between the Washington State Department of Corrections and PNNL ($3.2 million) to study potential demand response savings at Corrections facilities.

Status: Fully awarded $194,000 to Itek Energy.

The Washington Economic Development Finance Authority pre-qualified applicants for this program. Commerce awarded funds to Itek Energy to reimburse interest paid on eligible loans taken to expand manufacturing capacity.

- Itek Energy – Credit enhancement for advanced manufacturing expansion; $194,000

Department of Corrections & PNNL Demand Use Project ($3.2 million) – These funds were reappropriated in 2018 under Section 1012 of SSB 6090 from Credit Enhancement Grants. PNNL will use demand side management and analyze electricity use by the Department of Corrections. Remaining funds may be used for reducing energy use of Corrections.

Status: Fully awarded $600,000 to PNNL. Grant agreement negotiations underway with Corrections for remaining $2.5 million.

PNNL and Corrections worked collaboratively to identify two facilities to be evaluated, the cost to complete that work and the methodology to collect the data. Once PNNL completes its analysis and provides a strategic plan, Corrections will use that information to deploy efficiency measures in selected locations.

- PNNL – Demand response evaluation and analysis, $600,000

2018-2019 Clean Energy Fund 3 – $46.1 million authorized

Grid Modernization ($11 million)

Funds will be available to public and private electric utilities serving Washington consumers and must advance clean, renewable energy technologies and transmission and distribution control systems; support integration of renewable energy sources, deployment of distributed energy resources and sustainable microgrids; or increase utility customer choice in energy sources, efficiency, equipment and utility services. A competitive grant round opened in September 2018. The program is anticipated to select projects in February 2019.

Research, Development & Demonstration (RD&D) ($7.85 million)

RD&D provides matching funds to federal and non-state funds for strategic research and development projects focused on new and emerging technologies. Potential projects include solar technology, advanced bioenergy and biofuels, development of new earth-abundant or lightweight materials, advanced energy storage, battery component recycling, new renewable-energy technology and new energy-efficiency technologies. A competitive grant round opened in August 2018. During the Phase 1 application stage (of a two-phase process), Commerce received 64 applications totaling more than $59 million in funding requests. The program is anticipated to announce selected projects in February 2019.

Electrification of Transportation ($9 million)

This new program will offer grants to Washington state local governments and public or private electric utilities that may partner with research entities and businesses to transform transportation systems. A competitive grant round anticipated early 2019. The program is anticipated to announce selected projects in spring of 2019.

Solar Deployment ($4 million)

This new program in the CEF portfolio will focus on solar projects with 500 kilowatts or greater capacity. Priority will be given to projects interconnected in the distribution and reducing peak demand and to projects that provide a direct benefit to low-income customers and communities. A competitive grant round is anticipated in October 2018 and should announce selected projects in spring of 2019.

Greenhouse Gas Reduction ($2.4 million)

This new program focuses on projects to reduce greenhouse gas emissions by a minimum 750,000 tons per year. Projects must increase energy efficiency and protect or create jobs in counties under 300,000 population. A competitive grant round is anticipated early 2019 and should announce selected projects in spring of 2019.

State Efficiency and Environmental Performance ($750,000)

These funds were appropriated to support the State Efficiency and Environmental Performance (SEEP) program. SEEP is authorized by Executive Order 18-01. SEEP works with state agency partners to achieve reductions in greenhouse gas emissions and eliminate toxic materials from state agency operations.

SEEP was recently migrated to Commerce from the Department of Enterprise Services; Commerce has hired a program director. The funding for this program has been fully appropriated to Commerce and the Department of Enterprise Services.

PNNL Scientific Instruments ($8 million)

Funds are provided solely for scientific instruments to help accelerated research in advance materials at PNNL. These funds were contingent on securing federal funds for a new facility in which to house the instruments and are provided as match to the federal funding. The instruments will support researchers at the bioproducts sciences and engineering laboratory, a joint center for deployment research in earth-abundant materials and clean energy technology and other energy and materials collaborations with the University of Washington and Washington State University.

Status: Fully awarded $7.76 million to PNNL

PNNL is using the funds to position Washington state for global leadership in energy and materials science and technology by enhancing its scientific capability. Funds will be used for procurement, installation and commissioning of cutting-edge scientific instrumentation (mass spectrometer and electron scanning microscope) that will accelerate research in advanced materials. Advances in new materials development will transform society with new energy and transportation technology and will be an important engine for a next-generation manufacturing workforce in Washington state and the U.S. These unique tools, which will be located at and operated by PNNL, will serve researchers from Washington State University, the University of Washington, PNNL and industry partners. They will foster state economic, environmental and security goals.

Klickitat Public Utility District No. 1 ($1.1 million)

Funds are provided solely for a grant to the Public Utility District No. 1 of Klickitat County for the remediation, survey and evaluation of a closed-loop pump storage hydropower project at the John Day pool.

Status: Fully awarded $1.07 million to Klickitat PUD No. 1

Klickitat PUD No. 1 will use funds to support studies associated with environmental, cultural resources and preliminary engineering studies for a proposed 1,200 MW pumped storage hydroelectric project at the site of the former Goldendale aluminum site. These studies are required for a draft license to be submitted and processed by the Federal Energy Regulatory Commission.

Energy Efficiency and Solar

The Energy Efficiency and Solar Program provides competitive grant funds for projects that result in energy and operational cost savings at state public higher education institutions, local government facilities, state agencies and kindergarten through 12th grade (K-12) public school districts. This program will provide $7.1 million in energy efficiency grants and $1.69 million in solar grants. A minimum of $1.42 million is dedicated for energy efficiency grants to small cities and towns with populations of 5,000 or less.

The energy efficiency funding is a combination of $1.79 million in funding in state funds and $5.33 million in funding from repurposed American Recovery and Reinvestment Act (ARRA) funds from the U.S. Department of Energy. The repurposed ARRA funding is subject to federal requirements and awards that include ARRA funds will be subject to the more stringent of local, state, or federal requirements. The maximum grant award is $500,000 for energy efficiency and $350,000 for solar.

The program is anticipated to announce selected projects in January 2019. This funding is anticipated to generate at least 25 energy efficiency and solar projects.

Chapter 7 – The Western Regional Context for Energy Policy in Washington

Washington energy policy operates in a regional environment, where numerous organizations conduct analyses, influence regional electricity rates and conduct energy efficiency activities affecting consumers and businesses in Washington. This chapter summarizes some of the activities of two organizations whose operations directly influence Washington energy policy issues: the Northwest Power and Conservation Council (Council) and the Bonneville Power Administration (BPA). The Council develops regional power plans and sets conservation targets tied to Washington's electric utilities' energy efficiency efforts through Energy Independence Act and BPA's investments in energy efficiency, transmission capacity and other resources in the region affect regional power prices.

NW Power and Conservation Council

In early 2016, the Northwest Power and Conservation Council (Council) published the Seventh Regional Power Plan. The Pacific Northwest region is still operating under that plan and in 2018 the Council began assessing progress toward the Seventh Plan targets and recommendations. The Council plans to release the Seventh Plan Mid-term Assessment in the first quarter of 2019 and has already reviewed some of the major elements of the plan, including progress toward the six-year conservation target and development of the demand response resources recommended in the plan.

Energy Efficiency – The Seventh Plan set a conservation target of 1,400 average megawatts (aMW) by 2021 and created interim two-year milestones of 370 aMW in 2016 and 2017, 460 aMW in 2018 and 2019 and 570 aMW in 2020 and 2021. The region exceeded the first milestone, achieving 408 aMW in the first two-year period. An important outcome of the region's progress toward the Seventh Plan target is that 408 aMW of energy savings represent 865 megawatts (MW) winter capacity and 500 MW summer capacity contributions.

The Council identified challenges that the region may face in reaching the full target by 2021. Planned budgets for utility conservation programs are flat or declining, while the Seventh Plan interim milestones ramp up in the next two biennia. In addition, federal efficiency standards have slowed or stalled, leaving additional cost-effective savings available in the region. Finally, the contribution of energy savings outside utility programs are uncertain in the current assessment of regional progress toward the Seventh Plan target.

Demand Response – A demand response (DR) resource is an electric device, such as a water heater or vehicle charger, that may be controlled by a utility and provide flexibility to match electricity supply and demand over short time intervals. The Seventh Plan recommended that the region pursue development of approximately 600 MW of DR resources by 2021 to help meet capacity needs as older generating resources retire. Relative to the Seventh Plan baseline, the region has developed or contracted for very little new demand response. Utilities are encountering barriers to implementing more DR yet are also identifying through their planning work longer-term value for DR resources. The technical potential for DR remains high in end uses such as electric water heating.

The Council also updated cost assumptions for generating resources and updated the regional demand forecast and wholesale price forecast for the Seventh Plan Mid-term Assessment. The analysis found that costs for natural gas generating resources have declined slightly but remain within the ranges used in the Seventh Plan. The exception is frame generating turbines,[51] which declined approximately 35 percent. Costs for wind and solar photovoltaics have decreased 30 to 40 percent and 25 to 60 percent respectively. The regional demand forecast updated for the Mid-term Assessment reflects higher population growth than anticipated and therefore more residential units are being built. Overall energy demand and winter peak demand fell within the ranges forecast in the Seventh Plan, but summer peaks are growing slightly faster than anticipated.

Looking forward, the Council recently drafted a timeline for developing the Eighth Power Plan and the different analytical inputs that will be needed along the way. The Council tentatively plans to release the Eighth Plan in early- to mid-2021.

Bonneville Power Administration

Since the last Biennial Energy Update, the BPA released the 2018-2023 Strategic Plan and conducted studies under the auspices of its Resource Program, assessing the potential for energy efficiency and demand response for public power entities in the region. BPA also conducted a biennial public budget review process in preparation for the next rate case affecting rates in 2020-2021. In this Integrated Program Review (IPR), BPA proposed budgets for energy efficiency and grid modernization investments for that biennium.

2018-2023 Strategic Plan – Key objectives identified in BPA's Strategic Plan were modernizing the federal power and transmission system operation and supporting updated technologies. BPA stated that a more rigorous approach to asset management will lead to more efficient use of its resources and prepare the agency to operate "in evolving markets to preserve reliability and take advantage of new opportunities for maximizing sales of surplus power." BPA cited increases in variable renewable energy in the region and the expansion of the Western Energy Imbalance Market (EIM) as drivers.[52]

Strategic asset management plans for each asset category – power, transmission, facilities, information technology and fish and wildlife – include risk-based performance objectives and prioritized maintenance activities and capital investments.[53] A related strategic objective was to update business processes and operating systems to be compatible with emerging markets

[51] https://www.energy.gov/fe/how-gas-turbine-power-plants-work
[52] Bonneville Power Administration, "BPA Strategic Plan2018-2023," January 2018 (at 25). https://www.bpa.gov/StrategicPlan/StrategicPlan/2018-Strategic-Plan.pdf
[53] Id. at 26

and technologies. BPA developed a grid modernization roadmap with projects designed to achieve greater automation of use of data and analysis to support faster intra-hour dispatch and enable it to better determine system obligations and monitor operating conditions. These actions "will also help BPA to preserve reliability, optimize reserve levels and operate the transmission system closer to its physical limits." [54] Many of the actions outlined under these strategic plan objectives would prepare BPA to join the EIM. Stakeholder meetings are ongoing and Bonneville projects a potential implementation date of April 2022.[55]

Resource Program – In the draft results of the conservation potential assessment, BPA found 1,812 aMW of conservation savings potential cumulatively between 2020 and 2035. It also found an achievable potential in the base case of 1,551 MW of demand response in the winter and 1,602 MW of achievable DR potential in the summer over that time period.[56]

Integrated Program Review – BPA then conducted analyses to determine the amount of cost-effective potential available and how much of each to pursue in the 2020-2021 timeframe. The mix of energy efficiency measures BPA proposed to pursue shifted in this year's budget review process to some higher-cost measures that will better match BPA's system needs, such as more heating, ventilation and air-conditioning measures that save electricity during peaks. BPA proposed in the IPR to pursue 74 to 101 aMW of energy efficiency in the 2020-2021 biennium.[57] It also identified cost-effective demand response acquisitions ranging from 40 to 131 MW in the summer months in the lowest cost portfolios analyzed in this year's IPR.[58]

[54] Id. at 28. See BPA Integrated Program Review, Appendix Grid Mod Projects for Grid Modernization Roadmap. https://www.bpa.gov/Finance/FinancialPublicProcesses/IPR/2018IPR/IPR%202018%20Grid%20Mod%20Final%20Appendix.pdf

[55] Bonneville Power Administration website. https://www.bpa.gov/Projects/Initiatives/EIM/Pages/Energy-Imbalance-Market.aspx. Accessed September 28, 2018.

[56] Bonneville Power Administration, "BPA Resource Program Draft Results," May 10, 2018. https://www.bpa.gov/p/Power-Contracts/Resource-Program/mm/20180510%20-%20Resource%20Program%20Workshop%20Presentation.pdf

[57] Bonneville Power Administration, "Rate Period 2020-2021 EE Goal and IPR Budget Proposal," June 2018. https://www.bpa.gov/Finance/FinancialPublicProcesses/IPR/2018IPR/2020_21%20EE%20Goal%20Proposal.pdf

[58] Bonneville Power Administration, presentation to the NW Power and Conservation Council, "BPA 2018 Resource Program and 2020-21 Energy Efficiency Goal and Budget," June 12, 2018. https://www.nwcouncil.org/sites/default/files/2018_0612_3.pdf

Chapter 8 – Status of State Energy Strategy Recommendations

This chapter provides an update on the status of recommendations made in the most recent state energy strategy, the *2012 State Energy Strategy,*[59] which was submitted to the Legislature and Governor in December 2011. The 2012 strategy included both near-term and long-term recommendations and envisioned a process in which the strategy itself would be updated on a four-year cycle. In the absence of funding to support energy strategy development, the recommendations from 2012 become increasingly less salient in the state's current and future energy and policy environment.

Nonetheless, the fundamental principles that underlie the state energy strategy process continue to provide a solid foundation for policy makers. These are:

> … [A] successful state energy strategy must balance three goals to:
>
> (a) Maintain competitive energy prices that are fair and reasonable for consumers and businesses and support our state's continued economic success;
>
> (b) Increase competitiveness by fostering a clean energy economy and jobs through business and workforce development; and
>
> (c) Meet the state's obligations to reduce greenhouse gas emissions.[60]

Transportation

The primary focus of the *2012 Washington State Energy Strategy* was transportation efficiency. Transportation was and is, the state's largest energy user by sector and is also its least efficient sector.[61] Experience over the past six years shows that transportation is also the most dynamic sector, in many cases exceeding the scope of recommendations from 2012. Recent developments are highlighted here.

Support for electric vehicles – In 2015, the Washington Department of Transportation adopted a Washington State Electric Vehicle Action Plan,[62] which was developed with input from more than 50 private and public sector partners. It includes actions to stimulate electric vehicle sales, extend the network of electric vehicle charging facilities and improve regional coordination. The objective of these recommendations is to increase the number of plug-in electric vehicles in the state from about 10,000 in 2014 to Governor Inslee's state target of 50,000 by 2020.

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[59] 2012 Washington State Energy Strategy
[60] RCW 43.21F.010(4).
[61] 2012 Strategy, page viii.
[62] www.wsdot.wa.gov/NR/rdonlyres/28559EF4-CD9D-4CFA-9886-105A30FD58C4/0/WAEVActionPlan2014.pdf

Electric utility roles in vehicle charging – In 2017, the Utilities and Transportation Commission (UTC) provided guidance to regulated utilities and stakeholders in a detailed policy statement. It stated:

> The Commission adopts policies supporting transformation of the electric vehicle (EV) market through utility provision of electric vehicle charging services and a framework for regulating these services. Utilities may offer a portfolio of electric vehicle charging services on a regulated basis, consistent with Commission interests and policies promoting load management and system benefits, consumer protection, service quality, direct benefits to low-income customers, interoperability, stakeholder engagement, regular reporting and education and outreach. The portfolio approach is also meant to support consumer choice and allow a competitive market for these services to continue to develop. Finally, the Commission recognizes that utilities have access to information that will help align transportation electrification goals with electric system grid needs. The Commission stands ready to work with statewide and regional planning organizations to facilitate efficient electrification of the transportation system to meet state policy goals.[63]

Following the adoption of this policy statement, all three regulated electric utilities proposed programs to encourage individual customers to purchase electric vehicles or support businesses establishing direct current fast charging stations. Coordination between the UTC, regulated utilities, state agencies and relevant stakeholders regarding further transportation electrification continues.

The UTC policy statement does not apply to consumer-owned utilities, including municipal utilities and public utility districts and legislation to clarify their authority to support electric vehicles has not yet been enacted. However, some consumer-owned utilities are already designing and implementing programs to support electric vehicle charging. For example, Seattle City Light plans to install 20 DC fast chargers within its service area.[64]

Tax incentives for electric and alternative fuel vehicles – In May 2018, Washington ceased providing a sales tax exemption for the purchase of alternative fuel and hybrid-electric vehicles. The Legislature had capped the number of qualifying vehicles at 7,500 and the state reached this limit.[65] However, the sales tax exemption for charging infrastructure and batteries separate from vehicles is in place until 2020.

Mitigation programs funded by the Volkswagen settlement – The Department of Ecology is administering a $112.7 million fund resulting from Volkswagen's settlement with the US

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[63] Policy and Interpretive Statement Concerning Commission Regulation of Electric Vehicle Charging Services, Docket UE-160799, June 14, 2017. www.utc.wa.gov/_layouts/15/CasesPublicWebsite/GetDocument.ashx?docID=147&year=2016&docketNumber=160799

[64] www.seattle.gov/light/electric-Vehicles/

[65] www.dol.wa.gov/vehicleregistration/altfuelexemptions.html

Environmental Protection Agency of federal Clean Air Act violations associated with diesel vehicle emissions. The settlement requires mitigation funds be used to reduce air pollution, specifically nitrous oxide, from transportation modalities.[66] Currently, Ecology is planning to expend funds across three transportation categories: 1) light-duty vehicle charging infrastructure; 2) on-road vehicles, including transit and school buses; and 3) marine vessels and related port charging infrastructure. Ecology will also ensure that communities disproportionately impacted from diesel emissions receive targeted benefits from the funds.

Ecology is also managing distribution of $28.4 million in settlement funds from Volkswagen for violating the state's Clean Air Act. Funds will be spent to replace old school buses, electrify transit buses and state vehicles fleets and help public ports purchase cleaner trucks.[67]

Legislative efforts – As a result of legislation passed in 2007 and amended in 2011, alternative fuel vehicle procurement rules developed by the Department of Commerce for approximately 1,100 Washington local governments went into effect in October 2015. Due to lack of implementation funds and compliance authority, Commerce has prioritized supportive, interactive dialogue with the top 65 local governments as determined by petroleum-based fuel usage.

The Legislature in 2017 awarded funding to the Puget Sound Clean Air Agency to study the feasibility of electric vehicle car sharing programs for multi-family dwellings with the intent to extend benefits of zero-emission vehicles to low-income residents.

The Legislature in 2018 allocated approximately $9 million dollars to Commerce as part of the agency's larger Clean Energy Fund program. The money is intended to assist local governments and retail electric utilities with procurement of electric vehicle charging infrastructure while also meeting goals such as peak load management, enabling access and benefits to underserved communities and fleet electrification.

Distributed Energy

The 2012 Washington State Energy Strategy included three near-term recommendations to encourage the development of small-scale renewable energy systems. The strategy did not address the potential roles of distributed resources to improve grid resilience, to meet peak electricity demand, or to store renewable generation for use during peak demand hours.

The distributed energy policy that has received the most attention since the 2012 strategy concerns the compensation that renewable generation systems receive for the electricity they produce. The 2012 strategy recommended that Washington expand the existing compensation mechanism using net energy metering. Under net energy metering, the utility provides a balancing service to customers who self-generate. During times when generation exceeds the customer's consumption, the excess generation is delivered to the grid. The customer

[66] ecology.wa.gov/Air-Climate/Air-quality/Vehicle-emissions/VW-federal-enforcement-action
[67] ecology.wa.gov/Air-Climate/Air-quality/Vehicle-emissions/VW-state-enforcement-action

consumes an equal amount of grid electricity in other time periods without being charged for that electricity.

The legal requirement to offer net energy metering is limited. Utilities are not required to net-meter systems larger than 100 kW and credits for excess generation expire each year.[68] Each utility may adopt an alternative to net energy metering once the aggregate capacity of interconnected generating systems exceeds 0.5 percent of the utility's peak demand in 1996.

Since 2012, when no utility had reached this net metering threshold, Washington has experienced significant growth in distributed generation, mostly solar. The state's largest utilities have all reached the threshold and today most residential and business customers are served by a utility that is no longer legally bound to offer net energy metering to new distributed generation systems.

All of the state's largest utilities nonetheless have continued to offer net energy metering to new systems. In a few cases, small utilities have adopted replacement mechanisms. These fall into two basic structures:

Buy all, sell all – This arrangement requires that customers sell the entire output of their generation system to the utility. The purchase rate is prescribed by the utility and typically reflects short term wholesale electricity market prices. The customer is required to purchase all of the electricity that it consumes from the utility at the utility's general retail rates.

Buy some, sell some – Under this arrangement, which is sometimes called "net billing," customers sell to the utility only the electricity that is generated in excess of the customer's consumption. The purchase rate could be based on wholesale market prices, the avoided cost of new generating resources, or other measures of value. Self-generation that is consumed by the customer reduces the amount that the customer purchases from the utility at its general retail rates.

There are many other compensation arrangements that have been proposed or adopted in other states, many of which have faced this issue earlier than Washington.

Energy Efficiency in Buildings

The *2012 Washington State Energy Strategy* included recommendations to increase the disclosure of information about the energy efficiency of buildings, explore innovative methods of financing energy efficiency projects, improve the quality of rental housing stock and increase public investment in low-income weatherization.

Public agency energy efficiency - Washington continues to push for greater efficiency in the building sector. The state has increased funding for high-efficiency public buildings and in 2018

[68] RCW 80.60.020.

Gov. Inslee created the Office of State Efficiency and Environmental Performance (SEEP),[69] which Commerce manages and coordinates the work of executive agencies to reduce the environmental impact and cost of state buildings and lead by example.

Washington State Energy Code (WSEC) - The State Building Code Council adopted a stronger state energy code in 2015 and is currently developing further amendments to become effective in 2020. RCW 19.27A.160 directs the State Building Code Council to achieve a 70 percent reduction in annual net energy consumption, using the adopted 2006 WSEC as a baseline. The 2015 edition of the WSEC has reduced energy use in most new buildings by more 30 percent, compared to the baseline. The State Building Code Council is considering new provisions for the 2019 edition of the WSEC.

Ultra-high energy efficiency demonstrations – Washington is investing in several pilot projects demonstrating net zero energy construction in low-income housing projects. The Housing Trust fund provided $1.9 million for Ultra-High Energy Efficiency Affordable Housing Demonstrations. Three projects are currently under construction that will result in 145 units of new housing. When completed, the projects will provide detailed reporting on cost, benefits and process outcomes. These serve to provide examples for future projects and programs.

Expanded weatherization – The state has expanded the objectives of the weatherization program to reflect the health benefits of housing improvements by enacting House Bill 1720 in 2015.[70] The state has launched the Weatherization Plus Health program as a result. Lead remediation and reducing asthma triggers in homes are included in this effort. In 2018, the Legislature created and funded a revolving loan program to rehabilitate owner-occupied homes in rural areas. This program will increase the number of homes that are suitable for weatherization, but the funding is not yet sufficient for long-term sustainability.[71]

Prevailing wage for weatherization – The weatherization program values living wage jobs for contractors working in the program and has complied with state prevailing wage law since these were applied under the American Recovery and Reinvestment Act. In 2018 the state Department of Labor and Industries established prevailing wage rates that significantly affect the cost-effectiveness of weatherization projects. The L&I decision implemented 2018 legislation that sets prevailing wage rates based on collective bargaining agreements or other methods when agreements have not been negotiated.

The 2018 update in prevailing wage rates resulted in substantial increases – up to 400 percent – in the wage rates for trades commonly employed in the weatherization program. This increases the cost of any particular weatherization project, but it also reduces the measures that the program may fund. The weatherization program applies a cost-effectiveness screen to

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[69] Executive Order 18-01. www.governor.wa.gov/sites/default/files/exe_order/18-01%20SEEP%20Executive%20Order%20%28tmp%29.pdf

[70] www.commerce.wa.gov/growing-the-economy/energy/weatherization-and-energy-efficiency/matchmaker/weatherization-plus-health-wxh/

[71] Commerce published proposed rules in June 2018. lawfilesext.leg.wa.gov/law/wsr/2018/13/18-13-097.htm

measures and packages of measures. When costs to install measures increase for any reason, this affects the program's ability to pay for this work and reduces the number of low-income families served in the state. The department estimates that the wage rate changes will increase direct installed measure cost by 25-35 percent.

Carbon Policy for Washington State

The *2012 Washington State Energy Strategy* briefly discussed policies to reduce greenhouse gas emissions – often referred to as carbon policy – without making any near-term or long-term recommendations to policy makers. It described an economic model developed by Commerce to estimate the effect of carbon emissions taxes on emissions levels and analyzed a "revenue-neutral" policy in which other taxes are reduced as carbon taxes are imposed.[72]

Since then, the state's policy leaders and citizens have been engaged in a nearly continuous discussion of legislation and administrative proposals that are much more comprehensive than the policies envisioned in the state energy strategy. These include:

Cap and Trade Legislation – In 2015, Gov. Inslee proposed the Carbon Pollution Accountability Act (House Bill 1314) to establish a market-based program to limit carbon pollution by major polluters.[73] The bill received a favorable vote in the House Environment Committee but did not receive a vote in either full legislative chamber.

Clean Fuel Standard – The Dept. of Ecology in 2015 initiated a rulemaking process to consider a low-carbon or clean standard for motor fuels such as gasoline. A low-carbon fuel standard reduces emissions of greenhouse gases in the transportation sector by substituting renewable or lower-emitting fuels for petroleum products.[74] [75] In July 2015, the Legislature enacted a transportation budget with a provision that effectively prevented agency action to adopt a clean fuels standard.

Initiative 732 – In 2015, more than 360,000 voters signed an initiative to the Legislature proposing a carbon tax of $15 per metric ton starting in 2017. It was characterized as a revenue-neutral tax shift, because it would decrease sales taxes and business taxes. The Legislature did not act on it during the 2016 session and it was placed on the general election ballot in November 2016. The proposal was opposed by some business and environmental groups and failed by a vote of 59 percent to 41 percent.[76]

Clean Power Plan – In August 2015 the U.S. Environmental Protection Administration adopted a comprehensive, nationwide rule to reduce greenhouse gas emissions within the electric power sector. The Clean Power Plan provided states multiple options to achieve ambitious

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[72] Chapter 6, *2012 Washington State Energy Strategy*.

[73] www.governor.wa.gov/issues/issues/energy-and-climate/2015-carbon-pollution-reduction-legislative-proposals

[74] www.ofm.wa.gov/sites/default/files/public/legacy/reports/Carbon_Fuel_Standard_evaluation_2014_final.pdf

[75] fortress.wa.gov/ecy/publications/documents/1501001.pdf

[76] ballotpedia.org/Washington_Carbon_Emission_Tax_and_Sales_Tax_Reduction,_Initiative_732_(2016)

emissions reduction targets. The Washington Dept. of Ecology began stakeholder discussions to develop a state implementation plan,[77] but in 2016 the U.S. Supreme Court issued a stay of the EPA rule. The subsequent administration has proposed a replacement rule that would result in little or no reduction in electric sector greenhouse gas emissions.[78]

Clean Air Rule – At the direction of Gov. Inslee, the Dept. of Ecology in 2016 enacted rules to reduce greenhouse gas emissions by large polluters in the state.[79] In addition to regulating large single sources, such as an oil refinery or a power plant, the rule required that motor fuel and natural gas distributors reduce the emissions from the combustion of these fuels by individual consumers. Natural gas distributors and other firms affected by the rule challenged the rule and the Thurston Superior Court issued a stay in March 2018. This decision was on appeal before the state Supreme Court at the time this report was prepared.

Carbon Tax Legislation – In 2018 Gov. Inslee proposed Senate Bill 6203 to establish a tax on carbon dioxide emissions that would start at $20 per metric ton in 2019. Tax revenues would be used to fund programs to reduce greenhouse gas emissions and provide assistance to adversely affected communities and workers. Amended versions of SB 6203 received favorable votes in two Senate committees but did not receive a vote in either full legislative chamber.

Initiative 1631 – A diverse coalition of groups sponsored a voter initiative in 2018 to establish programs to increase supplies of fossil-free energy and energy efficiency, improve water and forest quality and invest in local communities. These programs would be funded by a fee on carbon dioxide emissions that would start at $15 per metric ton in 2020. The initiative appeared on the November 2018 ballot and failed by a vote of 57 percent to 43 percent.[93]

100 Percent Clean Electricity Standard – During 2018 Governor Inslee, along with many legislators and environmental advocates, developed plans to introduce legislation in 2019 to establish a clean electricity standard. It would ultimately result in a requirement that Washington produce enough renewable or carbon-free electricity to meet 100 percent of its electricity needs.[80] This standard is discussed further in Chapter 2.

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[77] ecology.wa.gov/Air-Climate/Air-quality/Business-industry-requirements/Clean-Power-Plan

[78] www.governor.wa.gov/news-media/joint-statement-regarding-clean-power-plan-governors-washington-oregon-and-california-and

[79] ecology.wa.gov/Air-Climate/Climate-change/Carbon-reduction-targets/Clean-Air-Rule

[93] https://ballotpedia.org/Washington_Initiative_1631,_Carbon_Emissions_Fee_Measure_(2018)

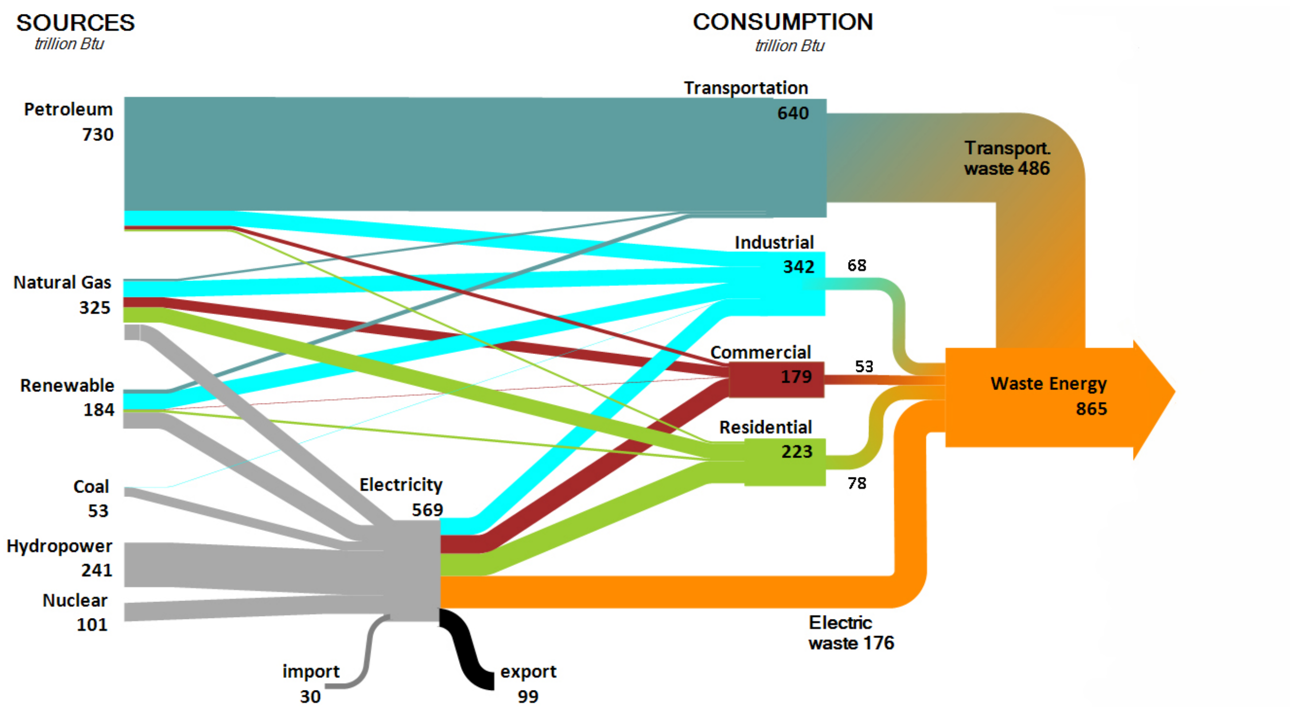
[80] One analysis of the 100 percent clean electricity standard was prepared by Climate Solutions and is available here: www.climatesolutions.org/article/1530911734-100-clean-electricity-within-reach-says-new-research

Chapter 9 – Energy Indicators

Washington's Energy System

When compared to other states, Washington's energy system is characterized by relatively clean and low-cost electricity dominated by hydroelectric generators, as well as thermal energy with a larger-than-typical contribution from biomass. Washington state has fairly typical residential, commercial, industrial and transportation energy consumption rates. The state's greenhouse gas footprint is dominated by transportation energy, thanks to the relatively low greenhouse gas emissions from electricity generation.

Figure 9.1: Sources and Consumers of Energy in Washington in Calendar Year 2016



Note: The state consumed 1,634 TBtu of energy. Sums may not equal totals due to rounding error.

Energy input, flows and end-use consumption in Washington state are presented in the figure above, using data obtained from the U.S. Energy Information Administration's State Energy Data System.[81] Data is for calendar year 2016, the most recent year for which data are available on all sources and consumption of energy. In the figure, the thickness of each line, or pipe, is proportional to the quantity of energy being delivered, consumed, or rejected as waste energy; these quantities appear as numeric values on or adjacent to each line, in trillion British thermal units (TBtu). The values to the left in the figure represent the six primary energy sources by fuel type: petroleum, natural gas, renewable energy (includes a number of renewable energy

[81] https://www.eia.gov/state/seds/seds-data-complete.php?sid=WA

resources and or technologies), coal, hydropower and nuclear fuel. The four end-use sectors, transportation, industrial, residential and commercial, are located in the middle and are connected to the six energy sources by pipes of various sizes. The electricity sector is not an end-use sector, as it is where various primary energy sources are converted into electricity and are then transmitted to and consumed in the four end-use sectors. The values at the right of the figure represent estimates of the amount of energy that ends up being wasted – primarily rejected to the environment in the form of heat.

The state consumed 1,634 TBtu of primary energy in 2016 with petroleum fuels representing 730 TBtu or 45 percent of total energy input. The largest end-use sector was transportation, which consumed 640 TBtu of energy, primarily in the form of refined petroleum products. The transportation sector is the least efficient user of primary energy, delivering only 25 percent of the primary energy as useful energy services and losing the remainder as waste heat.[82] The electric sector had 569 Tbtu of energy inputs and delivered 303 TBtu of electricity to the Washington end-use sectors and exporting 99 TBtu to consumers in other states. In total the four end-use sectors – transportation, industrial, residential and commercial – consumed 1,384 Tbtu of energy.[83]

History of the Energy Indicators: In the early 1990s, Commerce developed 23 energy indicators. We have since consolidated them to 17 to illustrate important long-term energy trends in Washington state. Commerce does not collect a large amount of primary energy data, but rather depends on regional and national sources. The energy indicators are grounded in the best available information and can be updated on a regular basis. They are based as much as possible on regularly published data from sources in the public domain. The principal source for the indicators is the U.S. Energy Information Administration's (EIA) Combined State Energy Data System (SEDS). Other sources include the U.S. Bureau of Economic Analysis, the U.S. Census Bureau, the President's Council of Economic Advisors, the Washington State Office of Financial Management, Federal Highway Administration, Oak Ridge National Laboratory Center for Transportation Analysis and the Washington State Fuel Mix Database.

Collecting and publishing detailed statistics on energy consumption, price and expenditures for 50 states and the District of Columbia is a large task involving analysis, verification and compilation of fuel and sector-specific data. As a result, comprehensive state information from EIA lags by more than two years and therefore the Energy Indicators are better suited to the analysis of long-term energy trends. Although EIA data does suffer from a significant time delay, it does provide for comparisons of Washington energy data to that of other states. [84]

Data for most of the indicators runs from 1960 or 1970 to 2016; a few indicators are one-year snapshots. For each indicator there is a chart, figure, or table illustrating the trend and narrative giving additional perspective or describing further aspects of the data. Data sources and links to

[82] Sectors are from the Lawrence Livermore National Lab: flowcharts.llnl.gov/commodities/energy
[83] The four-sector total includes energy from the electric sector, which itself is not an end-use sector.
[84] For example the EIA maintains an on-line state to state comparison web site at www.eia.gov/state/

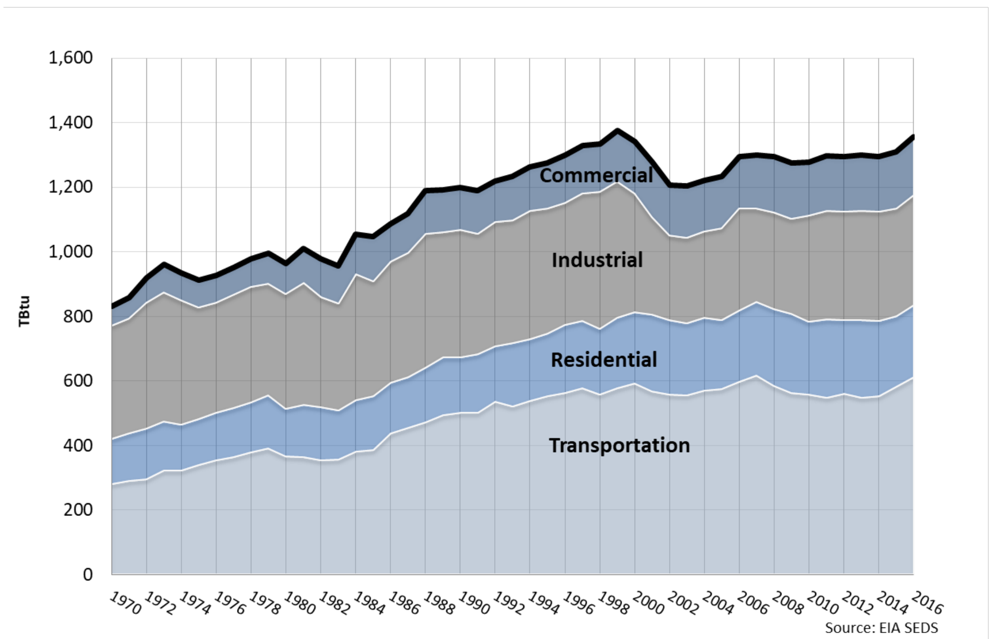
related data are included for those indicators where the information is available.

See Appendix A for more information on the methodology used to develop and update the indicators.

Indicator 1: End-Use Energy Consumption by Sector

State and national energy consumption is often presented on a four-sector basis: the sectors being transportation, residential, commercial and industrial. Electricity is not an end-use sector and is part of the four primary sectors. Washington's end-use energy consumption grew at an average rate of 1.8 percent per year between 1970 and 1999. Consumption reached an all-time high of 1,388 trillion Btu (TBtu) in 1999, 67 percent higher than in 1970, before declining 13 percent by 2002 primarily due to a sharp drop in industrial energy consumption. Energy use began to climb again and reached another peak in 2007 before declining about 2 percent during the recession of 2007-09. By 2016, as the economy recovered, state energy consumption is approaching the level seen during the previous peak in 1999, though with a population that is 23 percent larger.

Figure 9.2: End-use Energy Consumption by Sector 1970-2016



Source: EIA State Energy Data System www.eia.doe.gov/emeu/states/seds.html

From the late 1970s through early 1980s, growth in energy consumption was dampened by higher energy prices and changes in the state's economy. Energy consumption grew steadily from 1984 to 1999, due to population growth and relatively modest energy prices. The transportation sector accounted for the largest share of growth in energy consumption during this period, growing at an annual rate of 3.3 percent. Since the mid-1990s, transportation sector energy consumption has been relatively constant. Energy consumption in the commercial sector, which includes service industries such as software, finances and insurance, grew at a 3.3 percent rate between 1970 and 2000 and has grown at a lower rate of about 0.6 percent since 2000. Residential sector energy use grew steadily at a 1.5 percent rate from 1970 to 2000, but is virtually unchanged over the past dozen years, in part due to significant improvements in building and equipment energy efficiency. Although there is some year-to-year variation due to economic activity, industrial sector energy consumption is actually lower in 2016 than it was in 1970. Some of this is due to energy efficiency improvements, but it also reflects structural changes in the state's economy, such as the decline of the aluminum industry.[85]

Indicator 2: Primary Energy Consumption by Source

Another way to present energy consumption is by fuel or generation source. The figure below shows the extent of Washington's reliance on seven major primary[86] energy sources: petroleum, hydroelectricity, natural gas, biomass, coal, other renewables (wind, geothermal and solar) and uranium (nuclear).[87]

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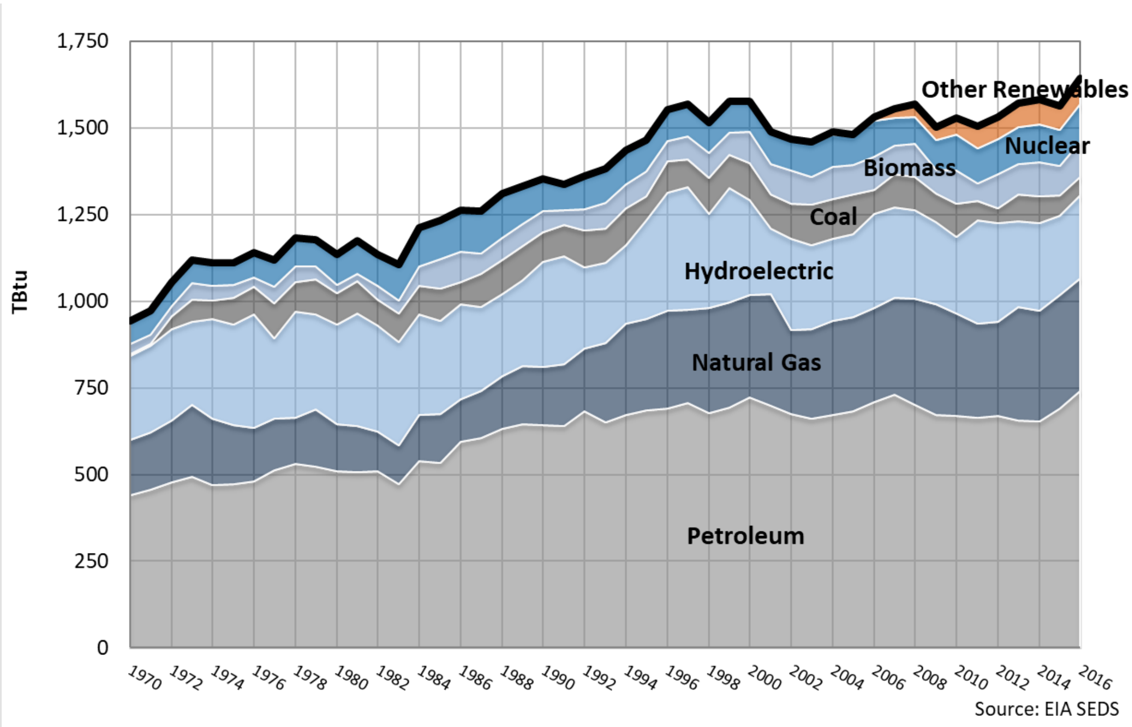
[85] During 1999-2002, high electricity prices, combined with a recession, shut down much of the Northwest aluminum industry and consequently industrial sector energy consumption declined by 38 percent.

[86] The main difference between primary and end-use energy consumption is the treatment of electricity. Electricity must be generated using energy sources such as coal, natural gas, uranium or falling water. These inputs to the power plant are counted as primary energy; the output of the power plant that is consumed by homes and businesses is end-use electricity. Since over half of the energy inputs to thermal power plants are typically lost as waste heat, primary energy consumption is larger than end-use. Note that some of the primary energy used to produce electricity in Washington may be for electricity used in other states. Washington typically generates more electricity than is consumed in the state (see Indicator #3).

[87] The "other renewable" energy sources – geothermal, wind and solar – provide about 5 percent of primary energy.

Figure 9.3: Total Primary Energy Consumption by Source, 1970-2016



Sources: EIA State Energy Data System http://www.eia.doe.gov/emeu/states/_seds.html

Washington relies on petroleum, much of which is delivered from Alaska and Canada, to meet the largest share of its energy needs – 45.6 percent of its primary energy needs in 2016. The petroleum share of primary energy use declined slowly from about 50 percent around 1990, but has increased sharply during the last two years of the time series. Most of the recent increase appears to be due to an abnormally high residual fuel oil consumption level reported in the transportation sector. This fuel is generally not used directly by Washington residents or businesses, but is frequently used to refuel large vessels used in international trade.

Natural gas is the next most frequently consumed primary energy source at 20 percent -- only a modest increase from 1970 when its share was just under 17 percent. Natural gas is used for heating, electricity generation and industrial processes. Consumption is variable, depending in particular on the winter heating and electricity demand.

Coal, chiefly imported from Wyoming, is consumed almost exclusively at the TransAlta Centralia Generation facility, while uranium is used only at Energy Northwest’s Columbia Generating Station in Richland. Together, fuel used for electricity generation at coal and nuclear generation plants accounted for 9.5 percent of Washington’s primary energy consumption.

Total fossil fuel consumption (petroleum, coal and natural gas) accounted for 67.7 percent of primary energy use in 2016, slightly more than in 1970, but down from the peak of 74.3 percent in 2001. Fossil fuel consumption depends somewhat on the severity of winter weather and the output of the hydroelectric system.

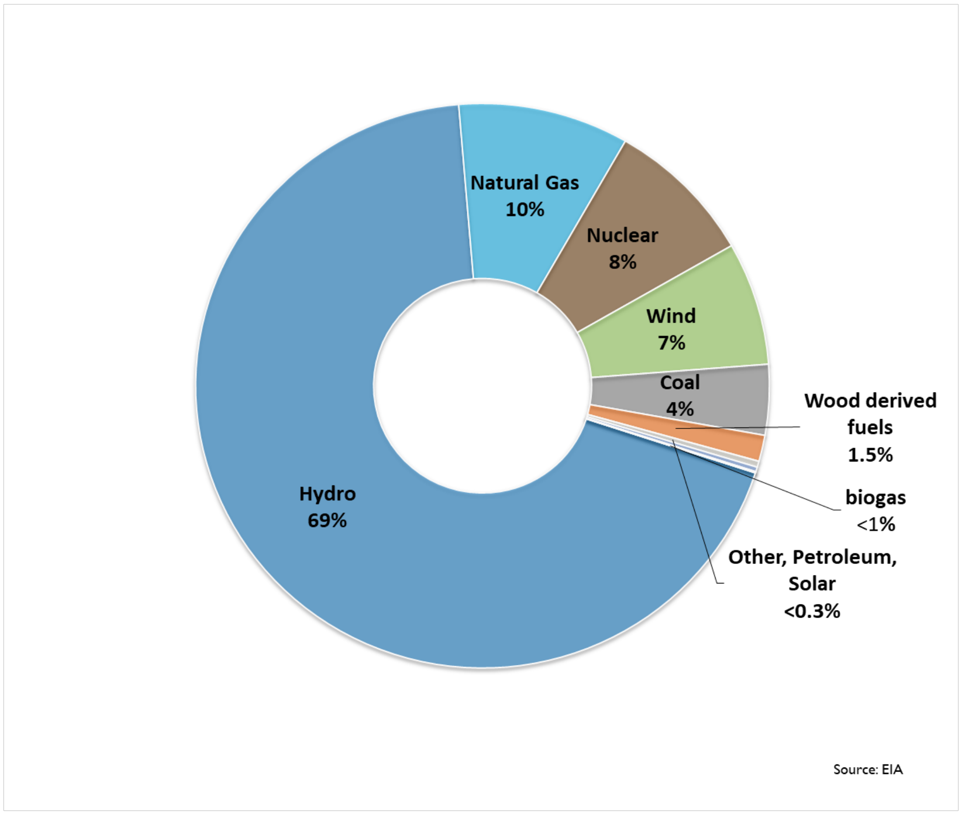
Hydroelectricity has been a key energy source in Washington for many years. It is important to recognize that total annual generation from hydroelectric dams varies widely depending on snowpack and river flow patterns. Generation in 2001 dropped to its lowest level in 35 years, 32 percent lower than the average for the last 30 years. This compares to the peak year in 1997 when generation was 29 percent greater than the average. Hydropower generation in 2016 was 14.8 percent of total energy or about 16 percent below the 20-year average.

Biomass, mainly wood and wood waste products, accounted for about 6.6 percent of primary energy consumption in 2016. The biomass share has declined slightly from the 1980s, but is up significantly since the 1990s. Biomass is primarily burned for electricity and process steam at pulp and paper mills, but is also used for residential heating.

Indicator 3: Fuels Consumed for Electricity in Washington

There are two ways to look at the energy sources for electricity in Washington. One way is to consider the sources for electricity generated in Washington: shown in the next figure. Electricity generated from hydroelectric dams accounted for 69 percent of the electricity generated in the state in 2016. Natural gas and nuclear are the next most common sources of electricity generation at 9.6 and 8.4 percent respectively. Coal had a share of about 4 percent. The remaining percentage is a mix of fossil and renewable fuel sources. The total for non-hydro renewable fuel sources, which includes biomass (wood and wood derived fuels), wind, waste and landfill gas, is about 8.8 percent of the total generation. Wind has grown from a nearly zero share in 2000 to 7.1 percent in 2016 (Washington ranks 10th in the nation for installed wind capacity according to the American Wind Energy Association). In 2016, power plants in Washington generated 25 percent more electricity than was consumed in the state.

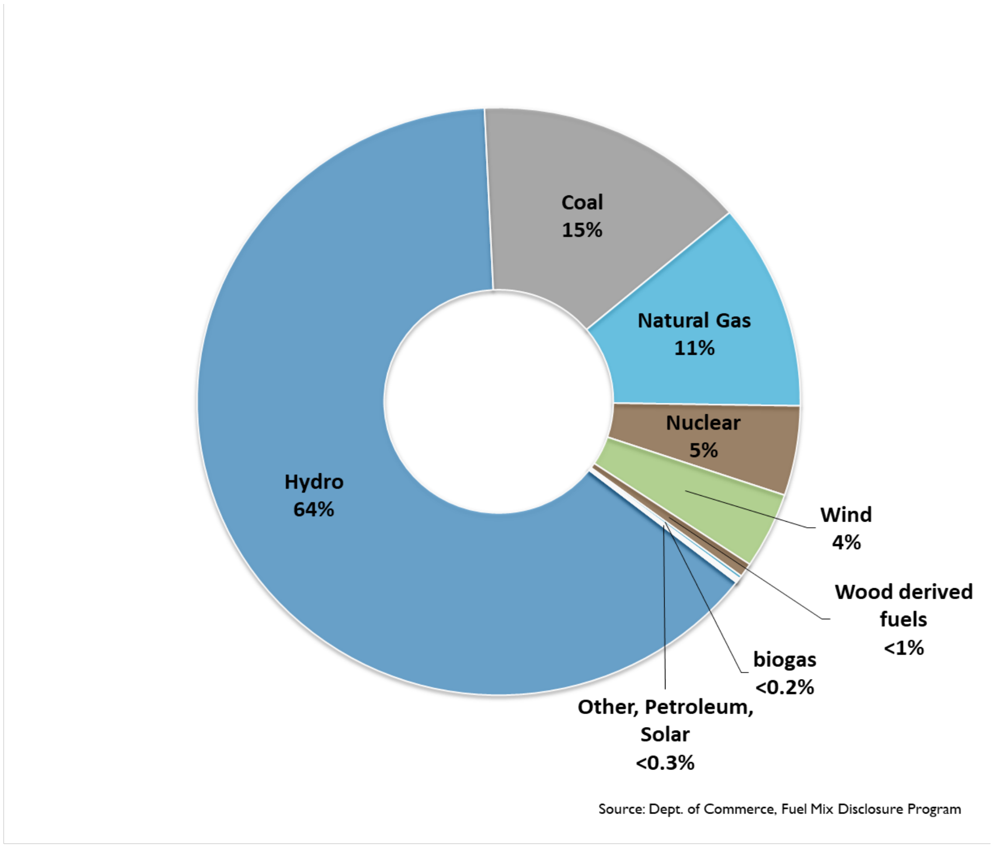
Figure 9.4: Fuels Consumed for Electricity Generated in Washington During Calendar Year 2016



Another and perhaps better approach to analyzing the electricity sector, is to focus on the mix of resources used by utilities to serve customers in the state (Figure 9.4 and Table 9.1). This approach is often referred to as **consumption-**based accounting, in contrast to the **generation-**based accounting described above. Washington is part of an interconnected, multi-state, regional bulk power system, and utilities purchase electricity generated from a variety of sources throughout the region. Many of the large hydroelectric dams on the Columbia and Snake rivers were constructed and are owned and operated by the federal government. Through the Bonneville Power Administration (BPA) the output of these dams is sold to more than 130 utilities throughout the Pacific Northwest. The data for estimating the sources of electricity consumed in Washington is collected for the Washington State Fuel Mix Disclosure process[88] and includes utility market (unspecified) power purchases.

[88] Fuel Mix Disclosure reporting is conducted annually and includes electricity consumption data reported by utility. Each utility reports resource category and fuel type for its electricity sales in Washington.

Figure 9.5: Fuels Consumed for Electricity Delivered in Washington During Calendar Year 2016 (see Table 9.2).



In 2016 hydroelectricity was the dominant source, accounting for 64.6 percent of the electricity consumed in the state. Electricity generated from coal accounted for 14.6 percent of the electricity used by Washington consumers, which is larger than the in-state generation share in Figure 9.4. This reflects the electricity purchased by some utilities from coal-fired power plants in other states, such as Montana and Wyoming. On a consumption basis, natural gas accounted for 11.4 percent of Washington's electricity, while nuclear was responsible for 4.9 percent. Renewable sources, excluding hydro, accounted for approximately 5.1 percent of the electricity purchased by utilities for use by Washington consumers. This was less than the generation share, indicating that some of the renewable energy generated in Washington, notably wind, was sold to customers outside the state.

Table 9.1: Fuels Associated with Electricity Generated in Washington, 2016

Fuel	Megawatt Hours	Share of Mix
Hydroelectric Conventional	78,345,809	68.7%
Natural Gas	10,982,195	9.6%
Nuclear	9,625,622	8.4%
Wind	8,041,847	7.0%
Coal	4,601,726	4.0%
Wood and Wood Derived Fuels	1,708,240	1.5%
Other Gases	401,642	0.4%
Other Biomass	299,322	0.3%
Other	59,751	0.052%
Petroleum	22,018	0.019%
Solar Thermal and Photovoltaic	727	0.001%
Pumped Storage	-2,318	0.00%
Total	114,086,582	100.0%

This table lists fuels used by electric generators physically located in the state.

Table 9.2: Fuels Associated with Electricity Delivered to Customers in Washington, 2016

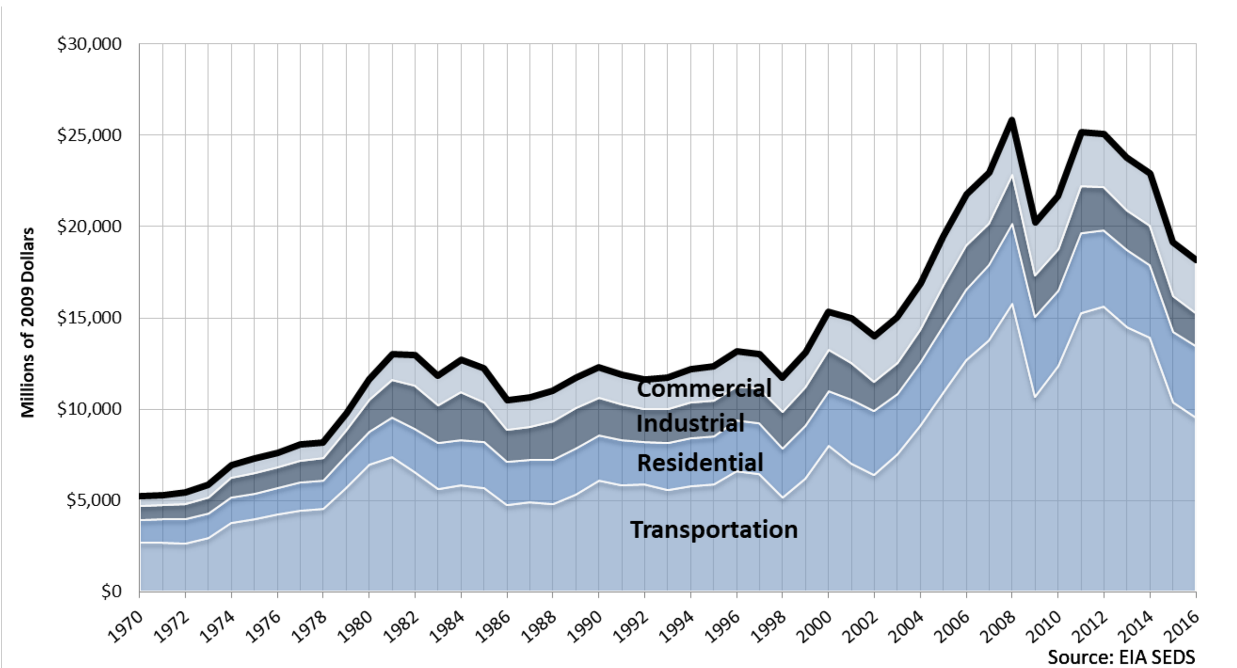
Fuel	Megawatt Hours	Share of Mix
Hydro	55,697,796	63.69%
Coal	12,799,782	14.64%
Natural Gas	9,937,111	11.36%
Nuclear	4,308,647	4.93%
Wind	3,661,267	4.19%
Biomass	675,649	0.77%
Biogas	148,177	0.17%
Other Non-Biogenic	73,976	0.08%
Petroleum	61,888	0.07%
Other Biogenic	48,095	0.05%
Waste	36,723	0.04%
Solar	3,491	0.00%
Geothermal	0	0.00%
Total	87,452,602	100.0%

This table lists fuels used to generate the electricity purchased by Washington energy consumers, regardless of where the electricity was generated. www.commerce.wa.gov/Programs/Energy/Office/Utilities/Pages/FuelMix.aspx. Does not include electricity provided by power marketers.

Indicator 4: End-Use Energy Expenditures by Sector

Washington state energy expenditures grew rapidly during the 1970s, as population and per capita consumption grew. During much of the 1980s and 1990s, inflation-adjusted[89] expenditures declined or grew modestly despite significant growth in population and energy consumption. This period of stagnation in energy expenditures was at first due to increasing energy efficiency and later due to declining energy prices. This trend changed around year 2000 as inflation-adjusted energy prices began to rise. By 2008, state energy expenditures reached a peak of just under $26 billion, an increase of over 100 percent relative to the low expenditure year of 1998. Energy prices and consequently expenditures, declined during the recession of 2008-09 then rebounded to near-record levels in 2011 and 2012. Expenditures have declined 28 percent since 2012.

Figure 9.6: End-use Energy Expenditures by Sector, 1970-2016



Sources: EIA State Energy Data System, President's Council of Economic Advisors-2005 Annual Economic Report of the President. www.eia.doe.gov/emeu/states/_seds.html

The transportation sector accounted for the largest share of state energy expenditures: 54 percent in 2016, down from 61 percent in 2008. This transportation portion has declined over the last four years, reflecting a decline in the real price of petroleum fuels. Industrial energy expenditures have declined sharply from a peak in 2008, due to a significant decrease in natural

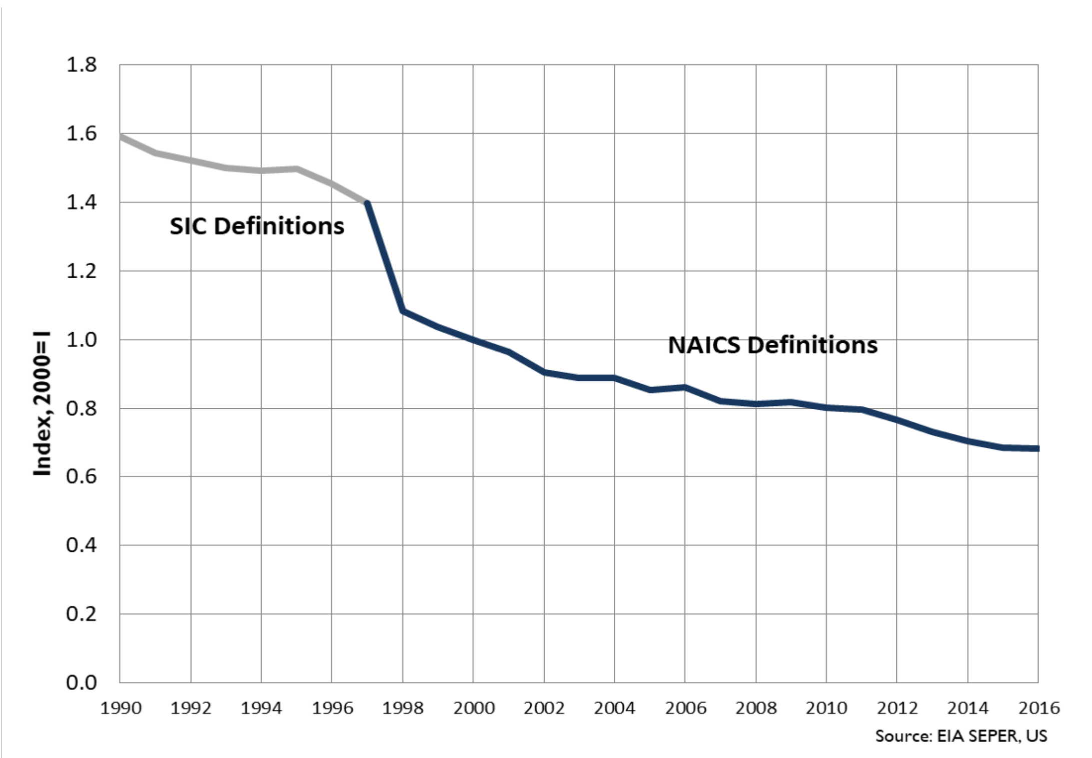
[89] Fuel prices and energy expenditures throughout this document are referred to as "inflation-adjusted" or constant dollars and include energy taxes. This adjusts for the effects of inflation and allows prices for different years to be directly compared. Prices or expenditures are in 2005 and 2009 dollars: See Appendix A: Methodology for details.

gas prices, Over the past 10 years, the industrial share of state energy expenditures has remained the same at about 10 percent, while the residential and commercial shares have increased.

Indicator 5: Energy Consumption per Dollar of Gross State Product

Washington's economy is becoming less energy intensive – the amount of energy required per dollar of gross state product (GSP) is declining.[90] Key reasons are a shift in the state's economy from manufacturing to high-value businesses that are less energy-intensive and improved energy efficiency across all sectors. The next figure depicts an indicator of the overall energy intensity. In the last 20 years, energy consumption per dollar of GSP[91] declined approximately 50 percent.

Figure 9.7: Energy Consumption per Dollar of Gross State Product, 1990-2016



The message from the above chart is that Washington's economy is growing faster than its energy consumption. This is due to a number of factors; chief among them is growth in the state's economic output and a shift from resource and manufacturing industries to commercial activity based on software, biotech and other less energy-intensive businesses. This trend will

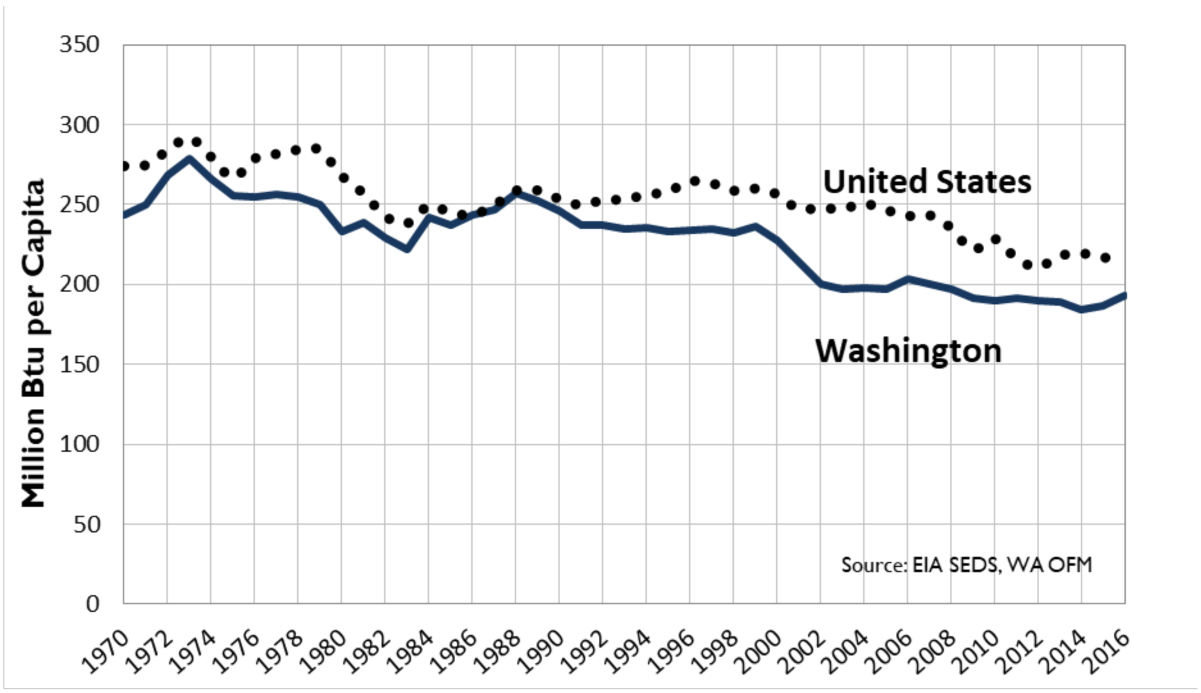
[90] Economic output (GSP) is in real dollars (millions of chained 2009 dollars). This adjusts for the effects of inflation and allows values for different years to be compared.

[91] Because there was a change in definitions for industry classifications used in the definition of GSP in 1997 (from SIC to NAICS), an exact comparison of energy intensity from 1990 to 2005 is not possible. However, at a state level the change does not appear to have a significant impact.

likely continue with the decline in production at the energy intensive industries. Gains in energy efficiency have also contributed to the reduction in Washington's energy intensity. We have not tried to determine the relative contribution of these various factors to the overall decline in energy use per unit of GSP.

Another way to look at Washington's energy intensity is energy consumption per capita. Energy consumption per capita in Washington was relatively constant between 1970 and 1999 with growth in overall state energy use being driven by growth in population. However, since 1999 energy consumption per capita has declined by 15 to 20 percent below historical levels. This was the result of several factors: the decline in industrial energy consumption, particularly in the energy-intensive aluminum industry; generally higher energy prices from 2002 through 2014 and more aggressive federal and state energy efficiency codes, standards and programs.

Figure 9.8: Energy Consumption per Capita, 1970-2016

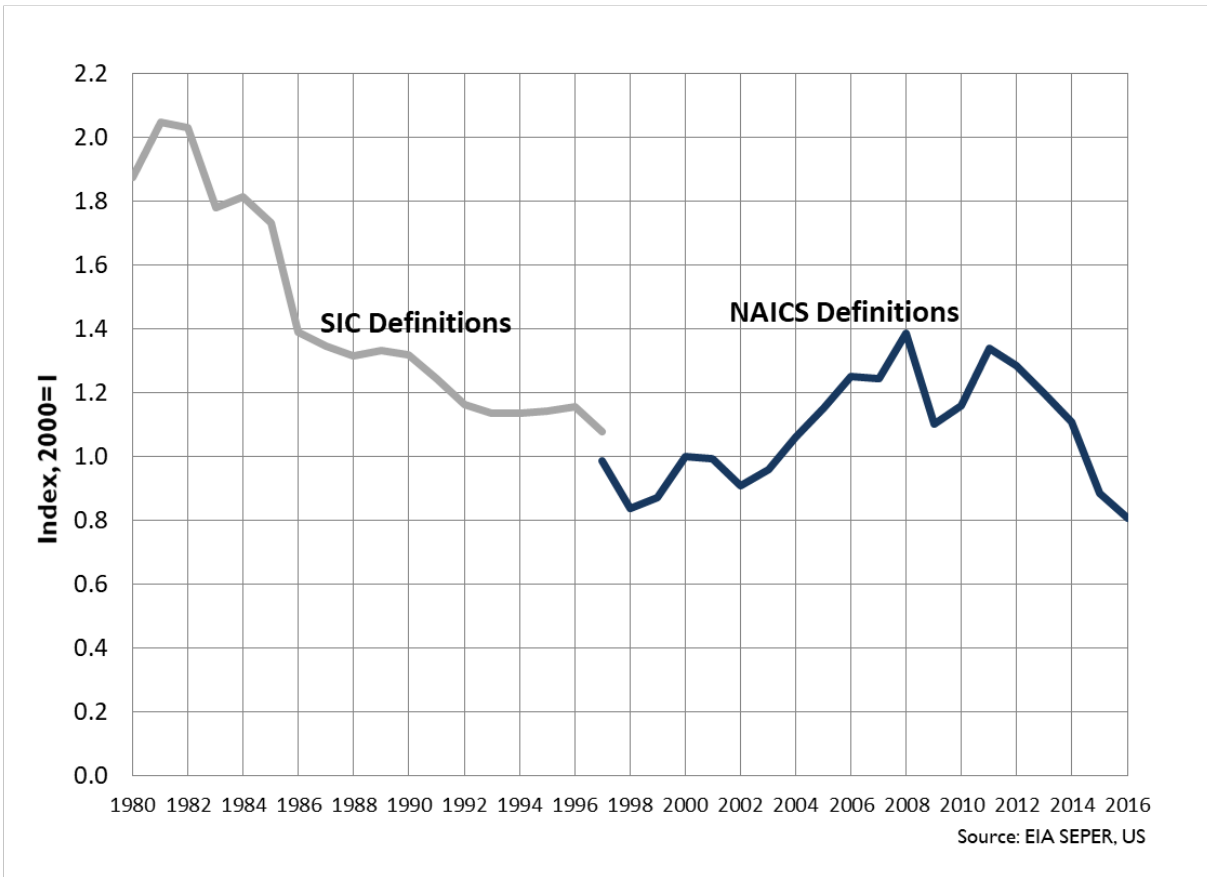


Washington's annual per capita energy consumption averaged about 250 million Btu from 1970 to 1999, the energy equivalent of about 2,300 gallons of gasoline per person per year. There were periodic dips in per capita energy consumption during this period, which were usually the result of high energy prices or economic downturns. Washington's trend was similar to the national average from 1970 through 1999.

More recently the state's annual per capita energy consumption, which has averaged about 10 percent below the national rate, has moved to a lower level of around 190 million Btu per capita, or about 15 percent below the historical trend. However, in 2016 per capita energy consumption jumped 7 Btu per capita to 193 Btu per capita, almost entirely because of a more than doubling of the EIA's reported residual fuel consumption for Washington state. [92]

The indicator below divides statewide energy expenditures by economic output, in the form of GSP, which in the figure below is indexed to the value in year 2000. The result is an estimate of the significance of energy in Washington's economy.

Figure 9.9: Energy Expenditures per Dollar of GSP, 1980-2016



Sources: EIA State Energy Data System, U.S. Department of Commerce, Bureau of Economic Analysis www.eia.doe.gov/emeu/states/_seds.html. GSP data at Bureau of Economic Analysis, www.bea.gov/regional/gsp/

After peaking at nearly 11 cents per dollar of GSP in 1981,[93] this value declined through the 1980s and 1990s. In 2000, approximately 5.2 cents was spent on energy in Washington for every dollar of GSP. Two trends contributed to this decline. Washington's economy was becoming less energy-intensive and real energy prices were declining. However, energy prices

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[92] This fuel is generally not used directly by Washington residents or businesses. Residual fuel can be stored for long periods of time. It is most often used to refuel large vessels used in international trade and sales volumes vary considerably from year to year.

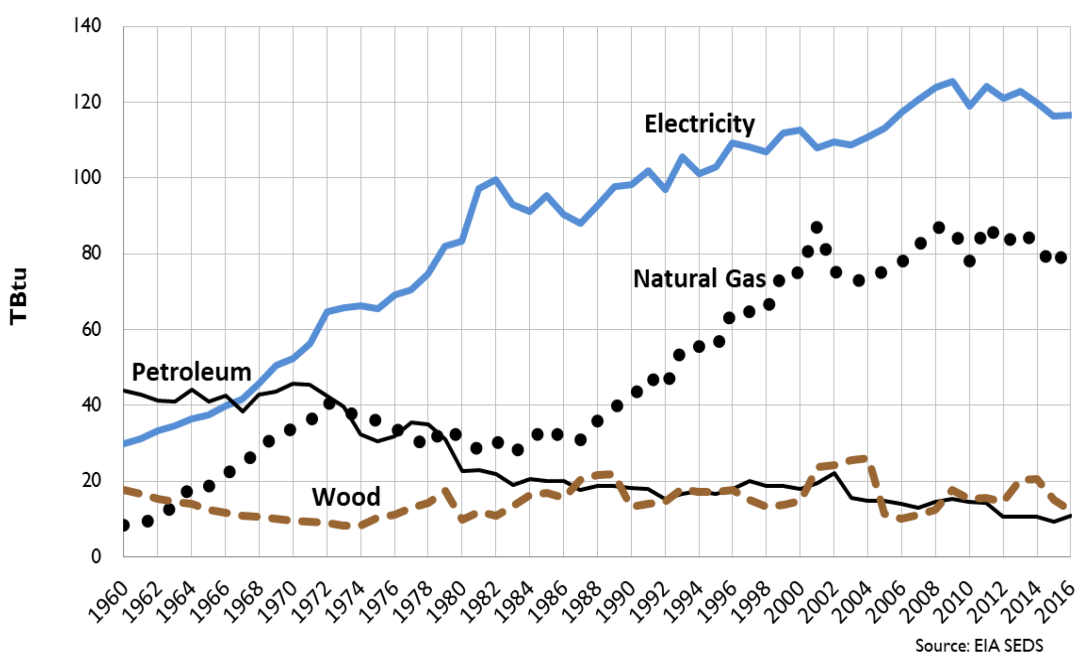
[93] Because there was a change in definitions for industry classifications used in the definition of GSP in 1997 (from SIC to NAICS), an exact comparison of energy intensity from 1990 to 2005 is not possible. However, at a state level the change does not appear to have a significant impact.

began to rise in 1999, increasing Washington's energy expenditures per dollar of GSP from the low of 4.6 cents in 1998 to 7.2 cents in 2008. The trend sharply reversed itself again in 2009 when energy prices and consumption plummeted during the recession in 2007-2009. The trend then resumed its upward course as energy prices sharply rebounded during 2010-12. Over the last several years, energy prices have once again dropped, and the trend line in the chart above is again declining.

Indicator 6: Residential End-Use Energy Consumption by Fuel and Household Energy Intensity – Excluding Transportation

Electricity and natural gas account for the majority of household energy use. Growth in total household electricity consumption has slowed in the last 25 years, while growth in the use of natural gas for space and water heating rose rapidly through 2001. Heating oil consumption has declined significantly since the early 1970s, while biomass (wood) use has remained relatively constant for the last 35 years.

Figure 9.10: Residential End-use Energy Consumption by Fuel, 1960-2016



Electricity share of residential energy consumption has grown steadily over the decades and accounted for 52 percent of residential energy consumption in 2016, even though average electricity use per household has declined 25 percent since 1982. Petroleum use (heating oil and liquefied petroleum gas) fell from more than 43 percent of household consumption in 1960 to 4.9 percent in 2016.[94]

Growth in natural gas consumption accelerated through 2001: residential sector gas use grew at 1.9 percent per year between 1980 and 1985, 3.9 percent per year between 1985 and 1990, 5.8 percent per year between 1990 and 1995 and 8.0 percent from 1995 to 2001. From 1980 to 2001, the natural gas share of residential energy consumption rose from 21 percent to 37 percent. This reflects increased use of natural gas for space and water heating, as well as increased overall availability of natural gas as a residential fuel source. Natural gas displaced both electricity and petroleum-derived fuels. However, the natural gas share has remained steady since 2001 in part due to higher natural gas prices and more efficient new buildings, but also because electricity-driven heat pumps have recently become competitive with natural gas.

Consumption of wood has varied in response to higher heating fuel and electricity prices. It increased in the late 1970s due to higher fuel prices, but remained stable or declined during much of the 1990s, when energy prices were relatively low. However, when energy prices jumped in 2001, so did wood use as people cut back on their use of natural gas, electricity and petroleum for heating. Since 2005, wood use has declined, possibly due to higher prices for this fuel and because of air quality fuel-switching programs pursued by the more densely populated counties.

By another measure the energy intensity[95] of Washington households declined by over one-third between 1970 and 1987. From the late 1980s through the early 2000s, household energy intensity remained essentially the same as new home size steadily increased. Over the last decade or so, household energy intensity has begun a gradual decline.

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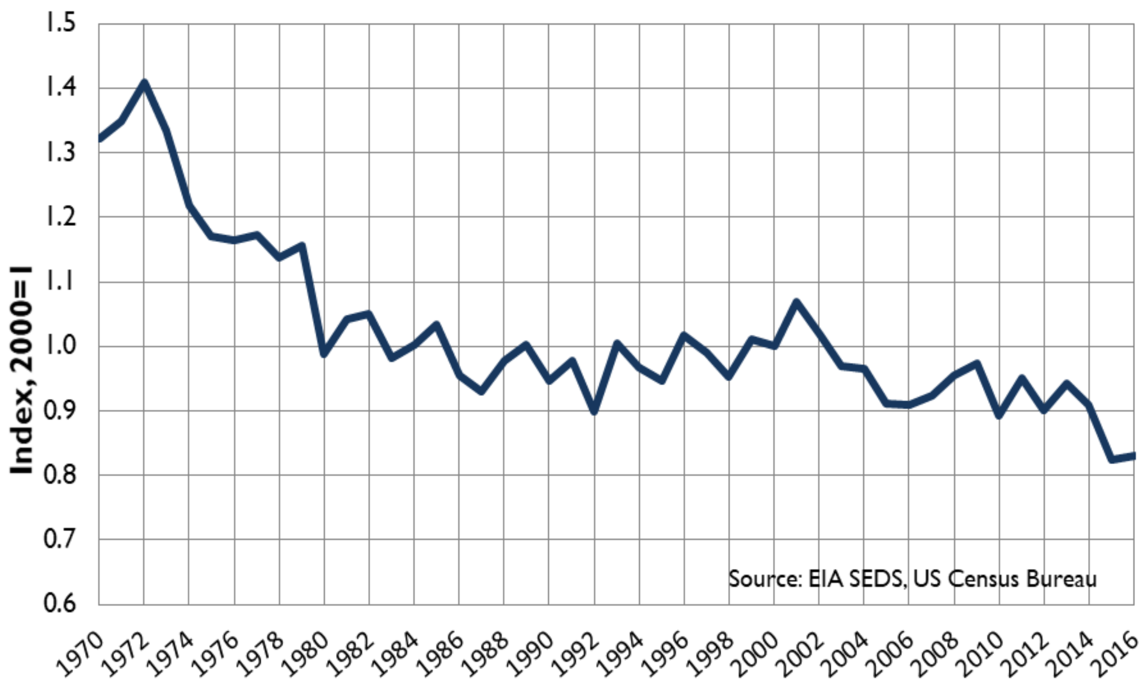
[94] The primary petroleum products consumed in households are heating oil (No. 2 distillate oil) and LPG. Both are mainly consumed for space heating, although LPG can also be used for cooking and water heating. Residential sector energy use does not include energy consumption for personal transportation.

[95] Energy intensity is calculated by dividing total residential sector energy consumption by number of households (excludes transportation fuel unless otherwise noted).

Figure 9.11: Residential Energy Consumption per Household, 1970-2016



Sources: EIA State Energy Data System, U.S. Bureau of the Census. www.eia.doe.gov/emeu/states/seds.html

Much of the decline in residential household energy consumption is due to more stringent building and appliance standards. Concerted efforts to improve residential energy efficiency through building standards and codes began in the mid-1980s. Some studies suggest that gains in energy efficiency due to building standards and codes were being mostly offset by construction of larger homes[96], more widespread use of air conditioning and the proliferation of electricity-using appliances, computers and entertainment systems. Starting around 1975 national appliance standards were developed. National and state appliance standards have been periodically updated.

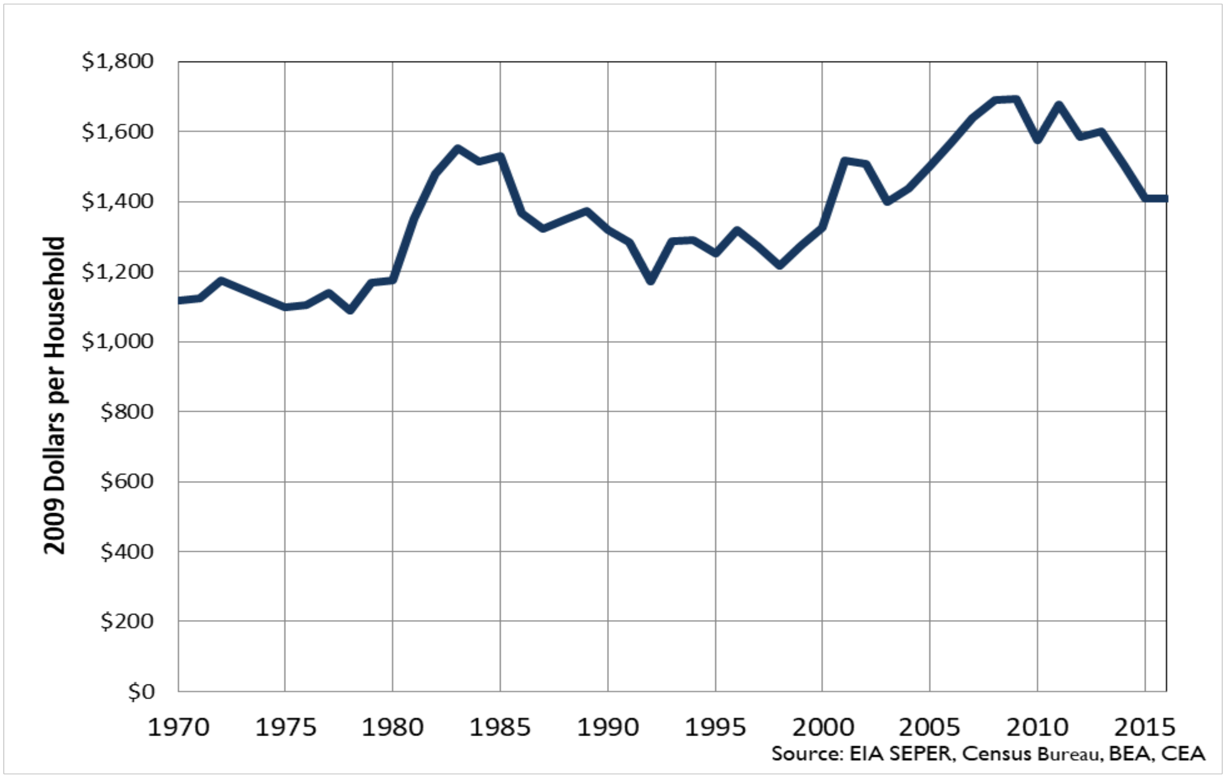
Indicator 7: Residential Household Energy Bill With and Without Transportation

Annual household energy expenditures is influenced by type of fuel used, fuel price, the efficiency of the equipment and the efficiency of the building shell. It is also strongly impacted

[96] See tables 43 and 44 of the September 2012 report by the Northwest Energy Efficiency Alliance (neea.org/docs/reports/residential-building-stock-assessment-single-family-characteristics-and-energy-use.pdf?sfvrsn=8), which indicates newer homes have half the heat loss of older vintage homes.

by temperature variations – either a cold winter or a hot summer. Adjusted for inflation, the average Washington household spent 23 percent more for home energy in 2014 compared to the low expenditure year of 1998. Household expenditures peaked in 2008/09 due to a cold winter and higher natural gas, electricity and petroleum prices.

Figure 9.12: Residential Energy Expenditures Without Transportation per Household, 1970-2016



When household energy bills spiked in the mid-1980s, increased emphasis on energy conservation and fuel switching from heating oil to natural gas and wood helped mitigate the impact of the price shocks. However, there was no immediate substitute for electricity, so when average residential electricity prices increased by 65 percent between 1979 and 1983, due largely to the inclusion in rates of the Washington Public Power Supply System bond default, the average household electricity bill increased by a similar amount.

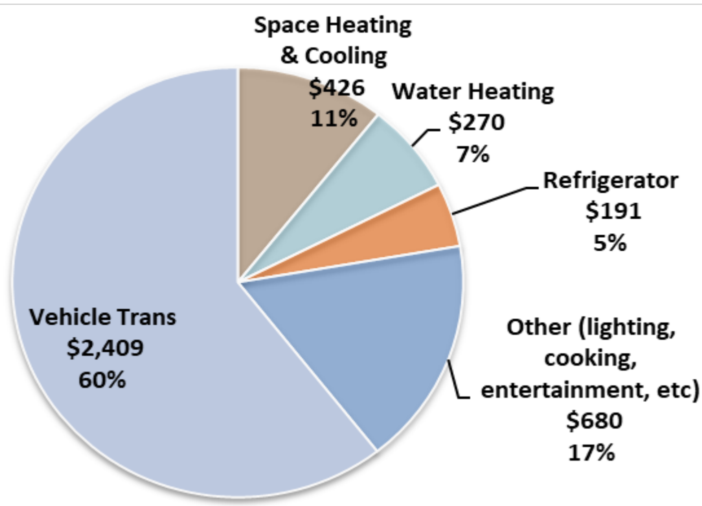
During the mid-1980s and through most of the 1990s household energy bills declined due to declining energy prices and fuel switching from expensive electricity and oil to natural gas for heating. Most new homes were being built with natural gas space heat and water heating (78 percent in 1998) and numerous existing households switched to natural gas as well. Electricity usage per household fell 18 percent between 1985 and 2001, while natural gas usage increased 83 percent.

The 2000-2001 West Coast electricity crisis led to another increase in residential electricity prices. Independently natural gas and petroleum prices increased, which also contributed to higher overall residential energy expenditures. The recent trend towards lower natural gas prices and the state's emphasis on energy efficiency should help lower household energy bills in the future. In 2016, the average Washington household spent the inflation-adjusted sum of $1,407 (using constant 2009 dollars) for electricity, natural gas, heating oil and propane delivered to the home. This is $190 more than households spent in 1998, but $286 less than was spent in 2009.

Most presentations depicting residential energy expenditures do not include the major component of household energy expenditures – fuel for vehicles. The vehicle share grew rapidly during the previous decade, declined in 2009-10 during the recession, then rebounded in 2011 and 2012 as gasoline prices increased. Household energy expenditures started to decline in 2013 as petroleum and natural gas prices declined. Over the long-term, increasing vehicle efficiency is forecast to slowly drive down household energy expenditures.

Adding energy used for personal transportation triples the annual energy bill for the average Washington household to $3,975 in 2016 (Figure 9.13 and Table 9.3).

Figure 9.13: Household Energy Bill by End Use, nominal 2016 Dollars



Source: EIA SEDS and Residential Energy Consumption Survey

Table 9.3: Household Energy Bill with Transportation, nominal 2016 Dollars

Average Retail Gas Price Methodology		
Space Heating and Cooling	$	426
Water Heating	$	270
Refrigeration	$	191
Other (lighting, cooking, entertainment, etc.)	$	680
Vehicle Trans	$	2,409
Total per household	$	3,975

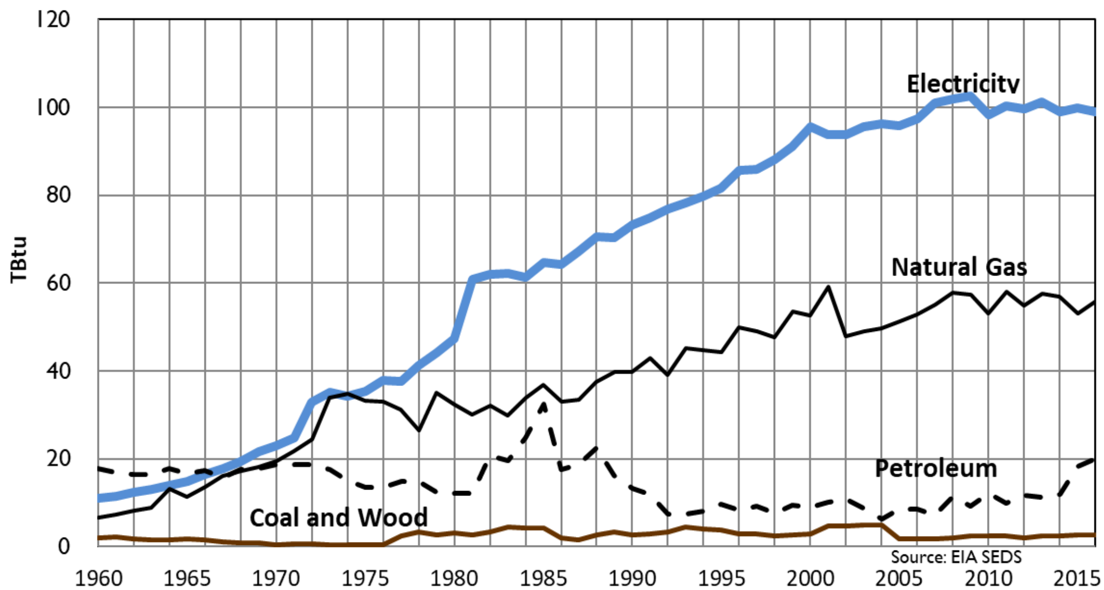
Sources: EIA State Energy Data System; Residential Energy Consumption Survey; Residential Transportation Energy Consumption Survey www.eia.doe.gov/emeu/states/seds.html

After personal transportation, the major categories of household energy expenditures include other uses (lighting, household appliances and electronic equipment), space conditioning (heating, cooling and ventilation), water heating and refrigeration. The "other" uses category has been growing, largely due to the proliferation of computers and electronic equipment. It is now larger than the space conditioning expenditures.

Indicator 8: Commercial End-Use Energy Consumption by Fuel

Electricity and natural gas are the dominant fuels in Washington's commercial sector. Their use in the commercial sector grew at an average annual rate of more than 5 percent from 1960 to 2000 and at a slower annual rate of about 1 percent after that. In 2016, electricity was 55 percent of commercial sector end-use energy consumption, while natural gas and petroleum were 31 percent and 11 percent respectively.

Figure 9.14: Commercial Energy Consumption by Fuel, 1960-2016

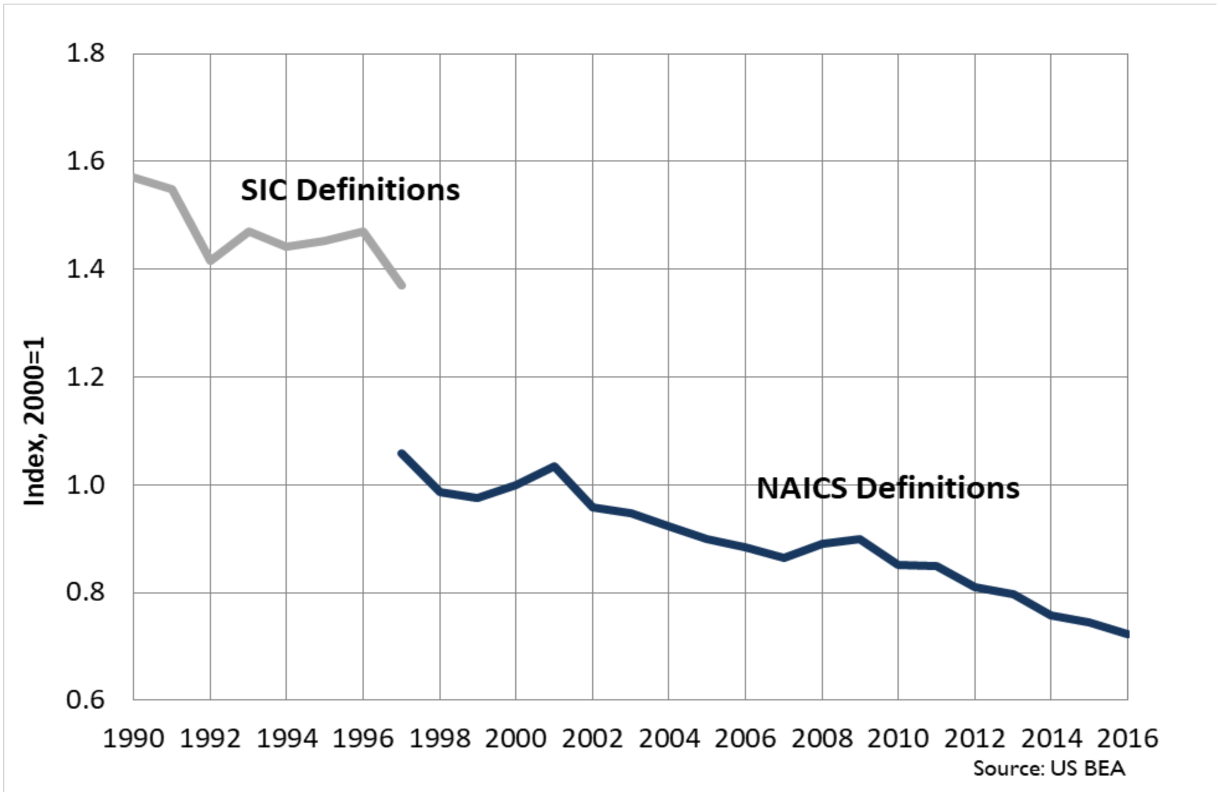


With a rising use of electricity-consuming equipment, such as computers, printers and copiers, the commercial sector became increasingly reliant on electricity during the 1970s through the 1990s. Sector electricity consumption increased more than four times from 1970 to 2016.

Growth in commercial natural gas use stagnated in the late 1970s and early 1980s because of high prices, but has grown since then. Natural gas use in 2001 was three times the amount in 1970, but dropped to a 20 percent share of total commercial energy consumption in 2002 and has increased only slowly since. Petroleum consumption, primarily for space heating, increased the last two years of the chart and in 2016 was approximately the same as the 1970 level. However, petroleum's energy share declined from 30 percent in 1970 to 11 percent in 2016. Coal and wood represent under 2 percent of commercial energy use.

After declining about 15 percent during the 1990s, commercial energy use relative to economic output increased in 2000 and 2001, before resuming a downward trend. Note that in 1997, federal economic reporting moved from the Standard Industrial Classification System (SIC) to the North American Industrial Classification System (NAICS). Energy intensities after 1997 should not be compared to intensities before it, or vice versa. A downward trend can be seen in both data sets.

Figure 9.15: Commercial Sector Energy Consumption per Real Dollar of Sector GSP, 1990-2016



Sources: EIA State Energy Data System; U.S. Department of Commerce, Bureau of Economic Analysis www.eia.doe.gov/emeu/states/seds.html

Washington's commercial sector has become less energy intensive over the last 15 years.[97] From 1990 to 1997, commercial energy consumption in dollars grew only 13 percent, while the value of all goods and services produced by the commercial sector grew 30 percent. This decline in commercial energy intensity can be attributed to growth in the economy, shifts to less energy-intensive businesses, increased productivity and improvements in the efficiency of buildings, lighting and equipment.

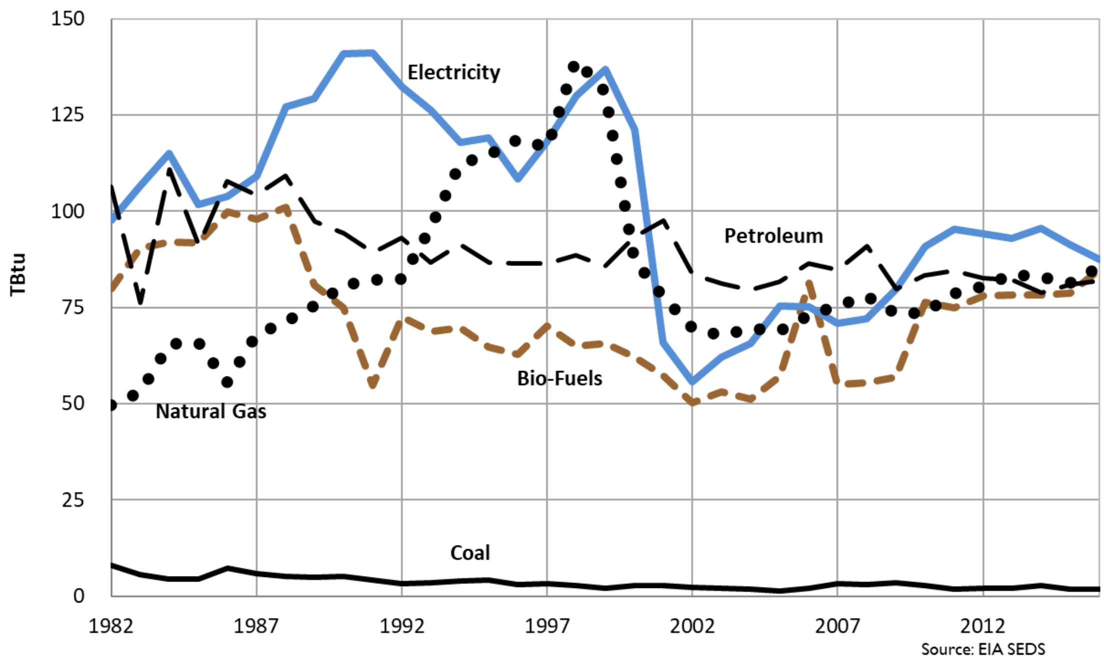
The trend appears to have briefly reversed in 2000, with growth in energy use exceeding growth in commercial sector GSP from 2000 to 2001. The change is likely due to an economic downturn at the time. However, the downward trend in energy intensity returned in 2002 as the economy picked up with little or no increase in commercial energy use. Commercial energy intensity ticked upward during the 2007-09 recession, but has since resumed its downward trend.

[97] Because there was a change in definitions for industry classifications used in the definition of GSP in 1997 (from SIC to NAICS), an exact comparison of values before and after 1997 is not possible.

Indicator 9: Industrial End-Use Energy Consumption by Fuel

Industrial energy consumption in Washington is more diversified among the different fuels than the other sectors and has varied more over time. As the chart below indicates, total industrial consumption declined rapidly between 1998 and 2002. Industrial natural gas and electricity consumption has rebounded moderately over the last 15 years.

Figure 9.16: Industrial Energy Consumption by Fuel, 1960-2016



Energy consumption in Washington's industrial sector is quite diversified, unlike the residential and commercial sectors, which rely primarily on electricity and natural gas, or the transportation sector that consumes almost exclusively petroleum fuels. Petroleum accounted for 24 percent of industrial consumption in 2016, much of which occurs at five oil refineries, while electricity and natural gas accounted for 26 and 25 percent respectively. Biofuels[98] share is sensitive to activity in the timber industry and accounted for 25 percent in 2016, but only 19 percent during the recession year of 2008 when demand for wood products was low. Coal use accounted for less than 1 percent of industrial consumption in 2016, declining from a high of 14 TBtu in 1976 to 1.9 TBtu in 2016.

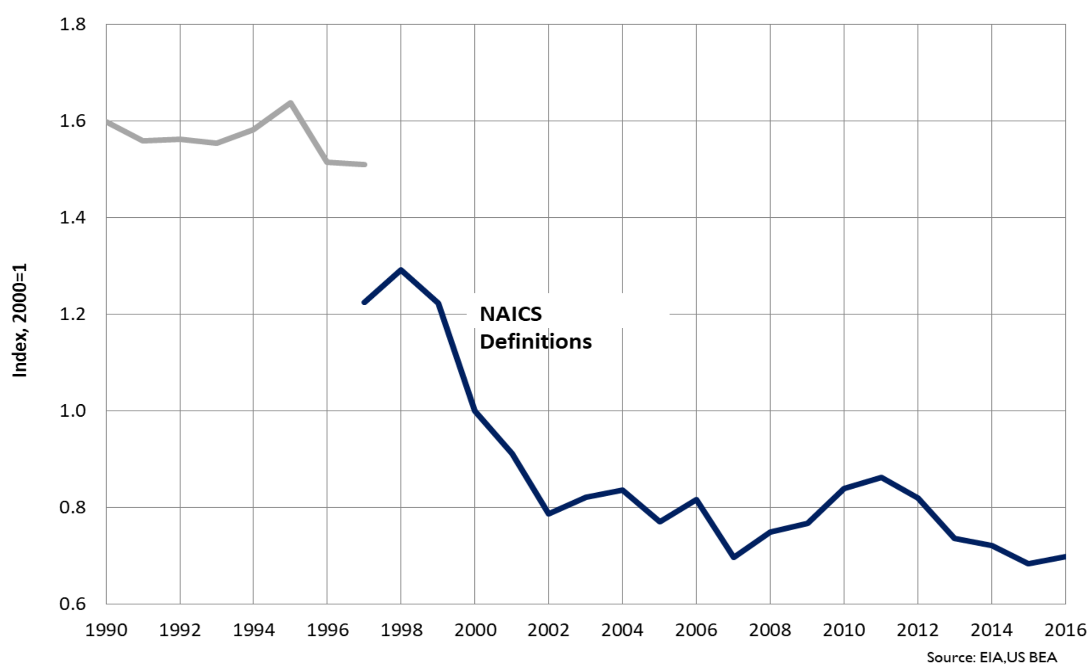
Energy consumption in the industrial sector also varies more over time than the other sectors, with peaks and valleys that mirror economic activity. When industrial production declines,

[98] Biofuels consumed in the industrial sector comprise mainly wood and wood waste products such as black liquor or hog fuel. These fuels are primarily burned in industrial boilers to make steam, which can be used directly for industrial processes or to generate electricity for on-site use.

energy use declines. High energy prices can also contribute to lower production, particularly in energy intensive industries. Peaks in industrial energy use have occurred in 1973, 1988 and 1998. Between the 1998 consumption peak and 2002, industrial electricity use declined almost 60 percent and natural gas use declined 50 percent. This reflected the decline in aluminum production due to high electricity prices (and low aluminum prices) during 2000-02 and cuts in production for industries relying on natural gas due to high natural gas prices. Industrial energy use has since rebounded – in 2016 it was 130 percent higher than in 2002, the recent low point.

Washington's industrial sector is less energy intensive than it was two decades ago when comparing industrial energy use to the industrial share of state GSP. [99] Energy intensity in Washington's industrial sector was relatively constant during the 1990s, but declined significantly from 1998 to 2002, but has only slowly declined since.

Figure 9.17: Industrial Sector Energy Consumption per Real Dollar of Sector GSP, 1990-2016



Sources: EIA State Energy Data System; U.S. Department of Commerce, Bureau of Economic Analysis
www.eia.doe.gov/emeu/states/seds.html

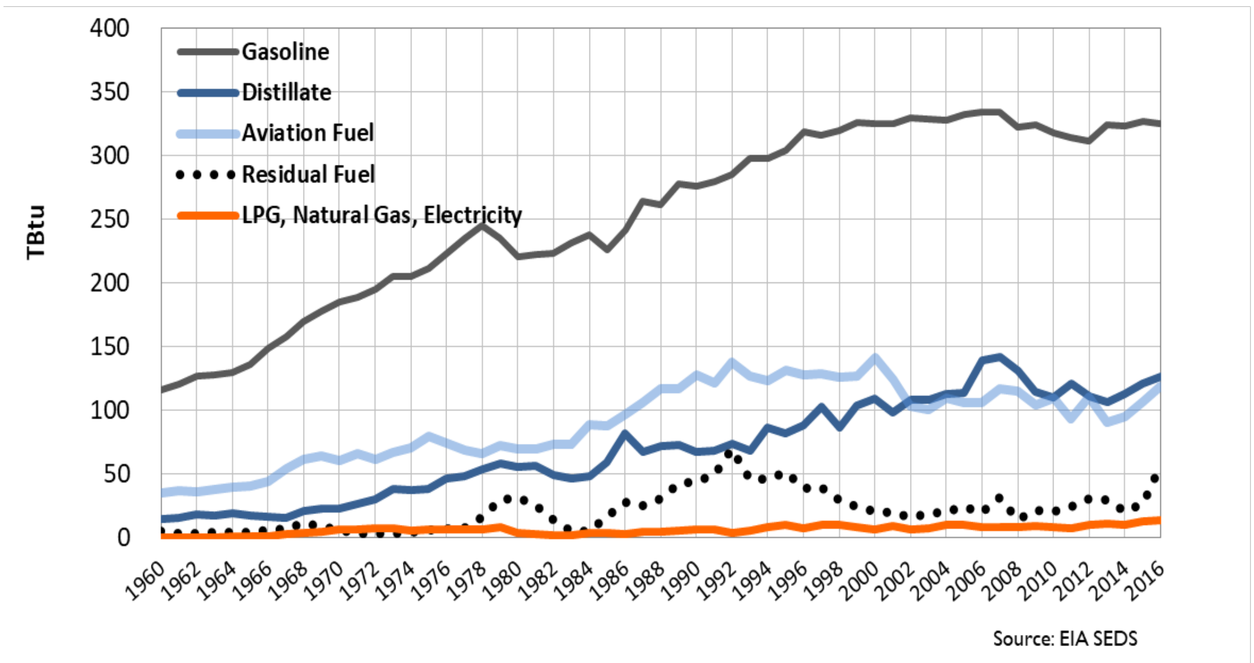
[99] Because there was a change in definitions for industry classifications used in the definition of GSP in 1997 (from SIC to NAICS), an exact comparison of values before and after 1997 is not possible.

Indicator 10: Transportation End-Use Energy Consumption by Fuel

Gasoline[100] accounts for just under half of transportation sector energy use in Washington. Petroleum fuels accounted for 98 percent of transportation energy use in 2016. Washington's status as a major international seaport and aviation hub means significant quantities of aviation and marine fuels are consumed.

Except for the periods between 1978 and 1981 and after 2007-08 (when prices rose significantly), gasoline consumption has generally increased as population grew and demand for travel outstripped gains in vehicle fuel efficiency. Overall, gasoline consumption roughly tracked population growth until 2005. In 2016, consumption was 76 percent greater than in 1970, whereas the state population has increased by 111 percent.

Figure 9.18: Transportation Sector Consumption by Fuel, 1960-2016



Sources: EIA State Energy Data System www.eia.doe.gov/emeu/states/seds.html
For price trends see the EIA weekly Gasoline and Diesel Fuel price update at www.eia.gov/petroleum/gasdiesel/

Consumption of distillate fuels by heavy duty trucks, ships and railroads grew at a much faster rate than other transportation fuels, reaching levels in 2016 that were over five times greater than 1970. However, due to a low base level of diesel use in 1970, the magnitude of this

[100] Motor gasoline figures include some consumption for off-road uses such as recreational vehicles and agricultural uses. No. 2 distillate, also known as diesel fuel, is used by large trucks, ships and railroads. The only transportation use for residual fuel is by very large ships. Aviation fuel includes kerosene-based jet fuel used by major airlines and military jets, as well as aviation gasoline consumed by smaller airplanes.

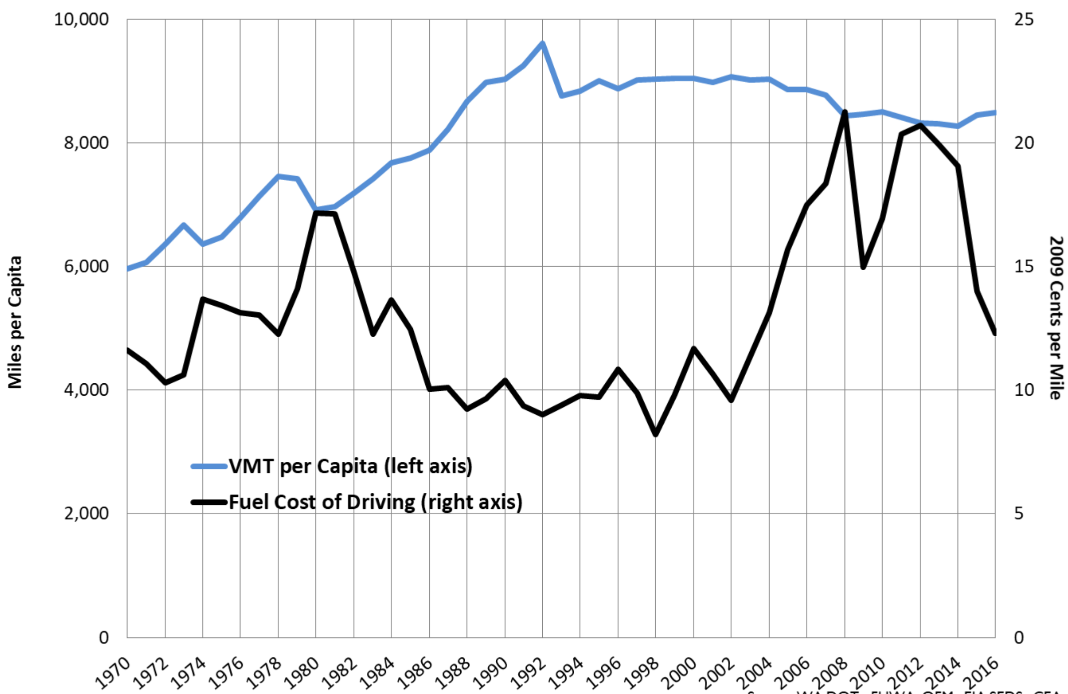
consumption increase (in Btu) was three-quarters the increase for motor gasoline. Aviation fuel consumption more than doubled between 1970 and 2000, but is now about 10 percent lower due to fuller flights and more efficient aircraft entering the commercial aviation fleet.

Residual fuel consumption is subject to price-induced volatility because it can be stored for long periods of time without degrading. Purchases of this fuel dropped when local prices were high, but grew when prices were relatively low. It also correlates with marine traffic at Washington ports and where large ocean going ships choose to purchase their fuel. The volatility of residual fuel use in Washington may indicate tracking and accounting problems with this fuel.

Indicator 11: Miles Driven and Transportation Fuel Cost of Driving

Vehicle miles per capita increased during the 1980s, stabilized during the mid-1990s and began to decline around 2004. Washingtonians drove 42 percent more miles per capita in 2016 than in 1970. During the same period the fuel cost of driving rose, declined and then rose again. The fuel cost of driving began to decline in 2013 and continued to fall through 2016.

Figure 9.19: Fuel Cost of Driving and Miles Driven per Capita, 1970-2016



Sources: EIA State Energy Data System; President's Council of Economic Advisors; Federal Highway Administration, Washington State Department of Transportation, Washington State Office of Financial Management

This indicator contrasts the fuel cost of driving with miles driven per capita in Washington. These two series exhibit a weak inverse relationship. The fuel cost of driving, calculated as real dollar highway energy expenditures divided by vehicle-miles traveled (VMT), increased in 1974, 1979-1980 and 2007-2008 and 2011-2012, as a result of high oil price or refinery mishaps. Each time, vehicle miles traveled per capita dropped slightly in response to higher prices. Other factors, such as the state of the economy, congestion, availability of transit options and an aging population, influence per capita VMT as well.

The spikes in fuel cost of driving frequently coincided with the beginning of economic downturns, which also explains the small declines in per capita VMT. Long-term factors such as land-use patterns, commuting habits, increasing congestion and the long lifetimes of vehicles (limiting the ability to switch to fuel-efficient vehicles) mean that large swings in fuel prices lead to only small changes in miles driven and fuel consumed in the short run.

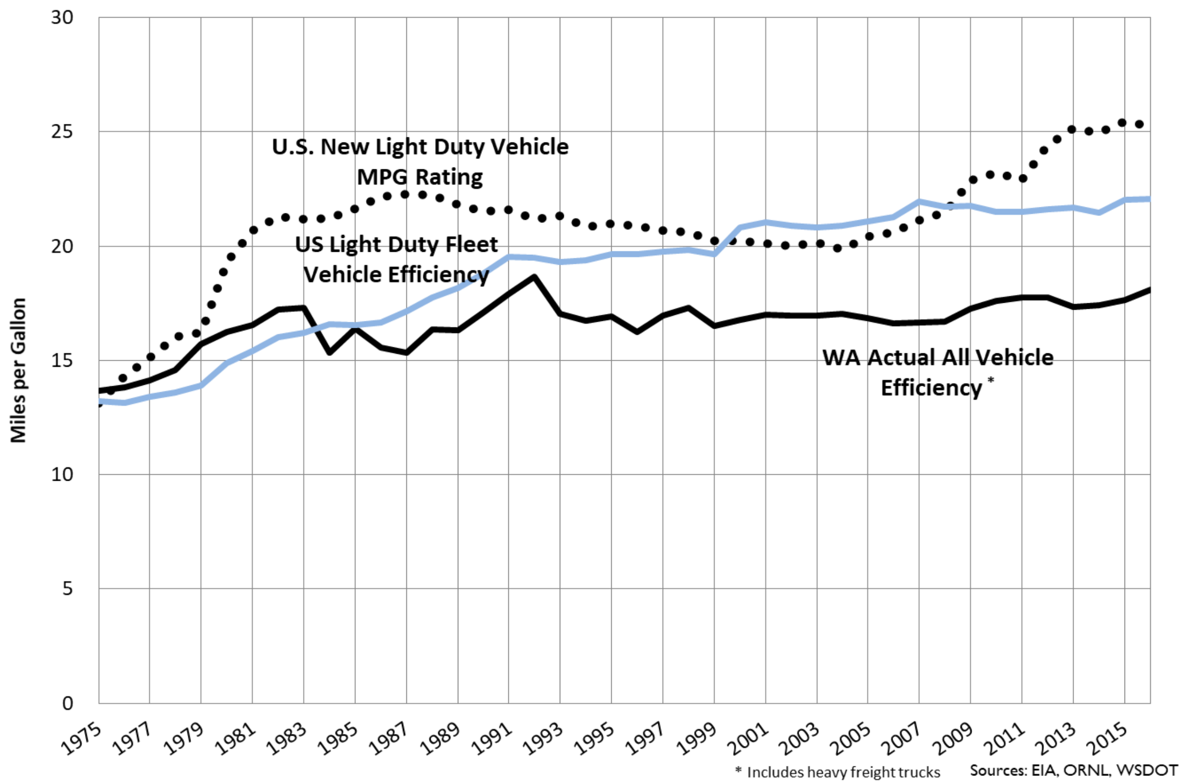
Increasing sales of more fuel-efficient vehicles in the early 1980s, combined with declines in the price of highway fuels, caused a rapid drop in the fuel cost of driving, from a high of 17.3 cents per mile in 1981 to 8.2 cents in 1988 (in 2009 dollars). As the fuel cost of driving declined per capita, VMT increased rapidly. In the 1990s per capita VMT stabilized, possibly the result of growing traffic congestion and an aging population.

The real price of gasoline changed little over the next 12 years and, as a consequence, new vehicle fuel efficiency held steady and then declined slightly. Low gasoline prices helped push the fuel cost of driving to an historic low in 1998, but the eventual return of higher fuel prices around 2002 reversed this trend. In 2008 and 2012, the fuel cost of driving had risen almost 150 percent relative to 1998. Per capita vehicle travel, which had remained relatively stable from 1993 through 2004, then slowly declined during 2006-2013 because of higher fuel prices and a severe recession. The fuel cost of driving reached a peak high of 21.3 cents per mile in 2008, with 2012 a close second at 20.7 cents per mile. During the last three years the fuel cost of driving declined rapidly and a small uptick in per capita VMT can be observed in Figure 9.19 above.

Indicator 12: Ground Transportation Sector Fuel Efficiency

Like other sectors, Washington's transportation sector has become more energy efficient over the years. The average efficiency of Washington's total vehicle fleet is shown in the next figure. This metric includes both light and heavy-duty vehicles (freight) and is based on estimated total miles driven, divided by total gasoline and road diesel fuel consumption. It is not directly comparable to the U.S. light-duty fleet efficiency line. It is also important to note that due to factors such as driving behavior and congestion, the actual on-road fuel efficiency of new vehicles is often less than the new vehicle EPA-rated fuel efficiency.

Figure 9.20: Washington State New Vehicle and Existing Vehicle Miles per Gallon, 1970-2016



Sources: EIA State Energy Data System; Federal Highway Administration; Washington State Department of Transportation; Oak Ridge National Laboratories Center for Transportation Analysis

Spurred by high gasoline prices and new vehicle efficiency standards, the fuel efficiency of Washington's existing vehicle fleet increased by more than 45 percent between 1975 and 1992. The increasing popularity of less fuel-efficient vehicles, such as vans, trucks and sport utility vehicles, through the 1990s and into the 2000s temporarily put an end to this upward trend. A steady increase in the amount of freight being moved through the state by heavy-duty trucks and increasing congestion on roadways, may also have contributed to the stagnation in the existing fleet fuel economy.

Washington's total vehicle fleet efficiency increased from 12.6 miles per gallon (mpg) in 1975 to 18.7 mpg in 1992. However, this came to an end in the 1990s when Washington's vehicle fleet efficiency declined by 2.0 miles per gallon. The last several years suggest that the total vehicle fleet fuel efficiency is improving again.

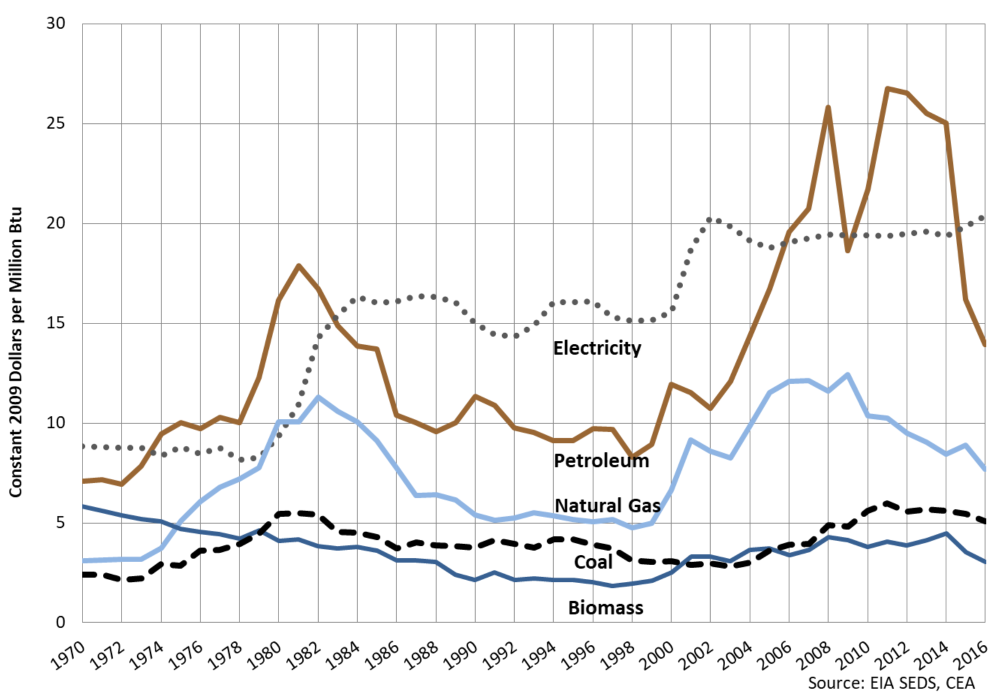
Gains in the efficiency of the U.S. and Washington light-duty vehicle fleets through the 1980s were due to the replacement of old vehicles with more efficient new models. However, new light-duty vehicle fuel efficiency standards did not change after the mid-1980s. The Corporate Average Fuel Economy (CAFE) standards required automakers to maintain the average fuel efficiency of new vehicles at 27.5 mpg for cars and 20.5 mpg for light trucks (which includes minivans, pickups and sport-utility vehicles). CAFE had no mandates about how many vehicles could be sold in each vehicle category and it did not apply to the largest pickup trucks. As trucks and SUVs made up a larger fraction of the vehicle fleet, overall fuel economy declined. By 2005, higher fuel prices helped reverse the downward new vehicle mpg trend. In addition the recent adoption of higher national CAFE standards (2007, 2010 and 2012 updates) have contributed to increasing new vehicle fuel efficiency over the past 10 years.

In 2012 the Environmental Protection Agency (EPA) and the National Highway Traffic Safety Administration developed standards to improve the fuel economy of medium- and heavy-duty freight trucks. In fall 2016, the EPA issued Phase-2 standards for heavy-duty trucks. These efforts will deliver significant and long-term fuel savings, as heavy trucks travel a large number of miles every year and have long service lifespans.

Indicator 13: Average Energy Prices by Fuel

After a long period of stability from 1985 to 2000, Washington's real energy prices (expressed in 2009 dollars) began to rise during the previous decade, as shown in this figure.

Figure 9.21: Average Energy Prices by Fuel, 1970-2016



Sources: EIA State Energy Data System; President's Council of Economic Advisors www.eia.doe.gov/emeu/states/_seds.html

The effect of the first oil shocks of the 1970s and early 1980s on Washington petroleum and natural gas prices was dramatic, but not permanent. Real petroleum prices more than doubled from 1972 to 1981, then returned to 1974 levels by 1986, where they remained for nearly 15 years. Around the year 2000 petroleum and natural gas prices began rising, reaching record levels by 2007-2008. Petroleum fuel prices declined during the 2007-09 recession, but continued their upward trend in 2010 as strong global demand for this source of fuel resumed. Petroleum fuel prices reached new record levels in 2012, but have since declined for several years because of lower crude oil prices, in part due to increasing U.S. shale oil production.

Real natural gas prices followed a similar trend, rising steeply during the 1970s, falling during the 1980s and staying relatively stable in the 1990s. Natural gas prices increased significantly during the previous decade, peaking in 2009. They declined since, as the shale gas boom delivered new supplies of gas, causing wholesale natural prices to drop sharply.

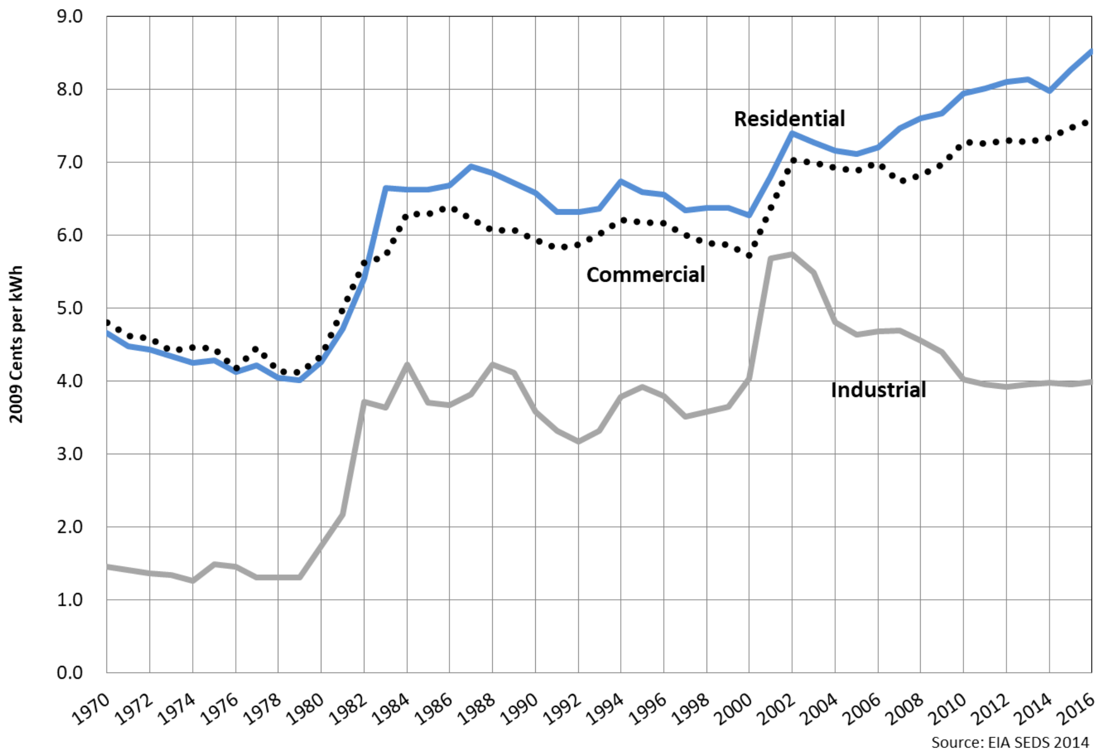
The average price of electricity, which had been low and stable for years, almost doubled between 1978 and 1984 as the costs of nuclear power plant projects in Washington, most of which were never completed, were incorporated into electric utility rates. In contrast to oil and natural gas prices, real electricity prices did not decline from the level they reached during the early 1980s. Even though electricity prices in Washington tend to be lower than in other parts of the country, until 2005 electricity was the most expensive primary energy source in Washington (on a Btu basis). Real electricity prices rose in 2000 and 2001 after 15 years of relative stability and have continued to rise at a very slow rate over the past decade.

The price trend for coal is similar to the other fossil fuels, but the price swings have been less dramatic and the difference between coal and the more expensive energy sources on a Btu basis has grown. Biofuel prices have been slowly rising since 1988, but are still less expensive than other sources of energy.

Indicator 14: Electricity Prices by Sector

Electricity prices in Washington state have tended to be less volatile than natural gas or petroleum product prices. This is in part due to the large amount of low cost hydroelectric generating capacity that was developed from the early 20th century until about 1970. Many of the dams were developed by the federal government. Despite the price stability of the hydroelectric base, there have been two periods over the past 50 years when retail electric prices increased rapidly. Even so, Washington state still has some of the lowest electricity rates in the nation.

Figure 9.22: Electricity Prices by Sector, 1970-2016



Sources: EIA State Energy Data System; President's Council of Economic Advisors. EIA Electric Sales, Revenue and Average Pricereport.www.eia.gov/electricity/sales_revenue_price/.EIAStateEnergy Data System www.eia.doe.gov/emeu/states/_seds.html

The most notable time periods for real electricity prices were the steady or declining prices in the 1970s, a rapid increase between 1979 and 1984 and the period after 1984 when prices stayed relatively constant (with some up and down variation). The second period of stable prices ended in 2001 when prices began to go up again, particularly for the residential and commercial sectors. In contrast, industrial sector electricity prices peaked in 2002, declined for several years, then stabilized near 4 cents per kWh. The price increases during the early 1980s were due to the costs associated with the bond default on several partially constructed nuclear power plants, while increases in 2001 and 2002 reflect the impacts of the West Coast electricity crisis and higher natural gas prices. Increasing spill requirements at dams and higher fish and wildlife expenditures over the past 20 years may also be contributing to the upward trend in electricity prices.

Electricity price trends for the residential and commercial sectors from 1970 to 2016 were nearly identical. Industrial sector prices have increased more and have been more volatile than residential and commercial electricity prices. Industrial electricity prices in 2016 were 275 percent greater than 1970, versus increases of 183 percent and 158 percent for the residential and commercial sectors.[101] On a per-unit basis, the average price increase from 1970 through 2016 also varied by sector: 3.8 cents per kWh for residential, 2.8 cents per kWh for commercial and 2.5 cents per kWh for industrial. Note that the trends in Figure 9.22 are average costs and Washington exhibits significant variation in price from utility to utility.

Indicator 15: Natural Gas Prices by Sector

Real natural gas prices have followed a cyclical pattern over the last 35 years. Prices increased rapidly for all sectors between 1974 and 1982, as U.S. suppliers struggled to meet demand and declined just as rapidly from 1982 to 1991, as new gas supplies were developed.[102] After remaining relatively stable during the 1990s, natural gas prices began to rise around 2000, again reflecting supply constraints and increasing demand. Regional utility natural gas prices spiked during 2000 and 2001 due to market manipulation and shortages in hydroelectricity, which created a need to operate natural gas power plants.

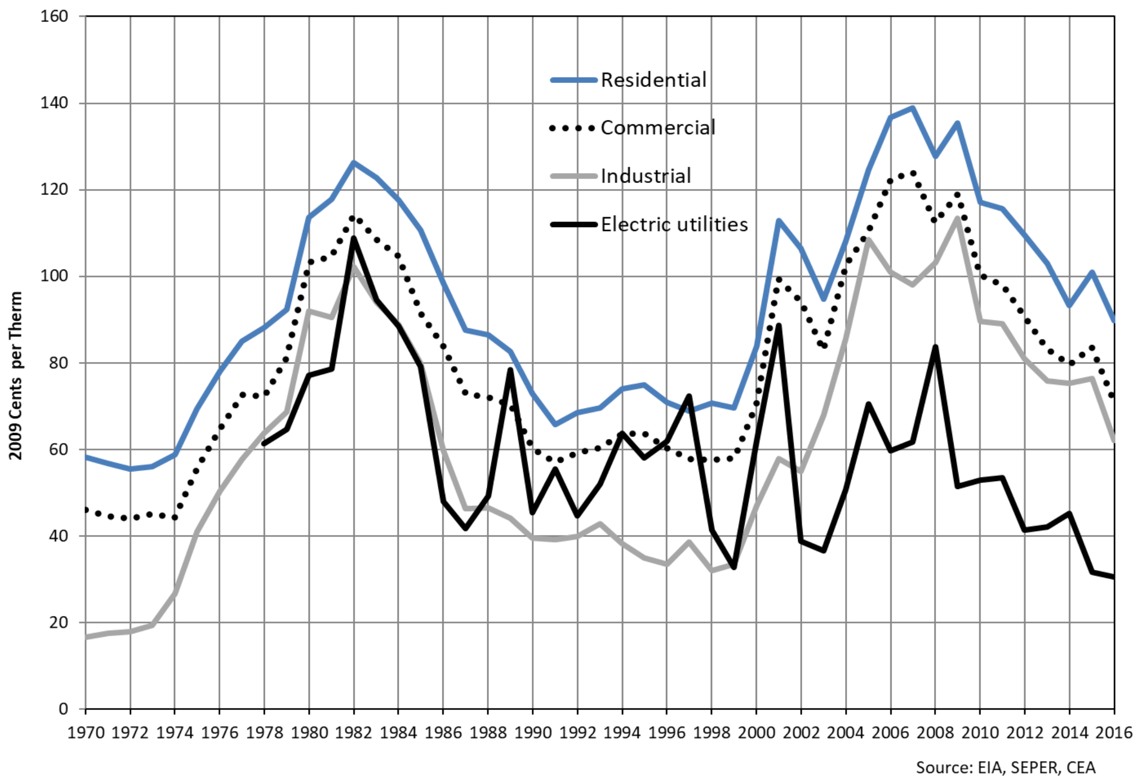
By 2006 and 2007, prices had exceeded the historic highs of 1982 for the residential, commercial and industrial sectors. This reflects supply constraints and growing demand, in part due to the increasing use of natural gas by the utility sector for electricity generation.

Figure 9.23 also shows a decline for 2008, which not only was a recession year, but reflects the first year that natural gas from shale resources began to enter the market in large quantities. This new natural gas resource is expected to keep natural gas price lower for several decades. The trend toward lower natural gas prices for all sectors has continued through 2016.

[101] Industrial electricity prices include the aluminum industry and other Direct Service Industries (DSI) that have historically had access to relatively low-cost electricity from the Bonneville Power Administration. As production in these electricity price sensitive industries (such as aluminum smelters) varies, it can have an impact on average industrial electricity prices. For example, in 2001 when aluminum smelters curtailed production, non-DSI industries paying higher electricity prices made up a larger share of industrial electricity consumption, contributing to the increase in average industrial electricity prices.

[102] Natural gas prices were partially regulated until the early 1970s. This regulation is generally credited with creating a disincentive to develop new natural gas fields, which resulted in a supply shortfall that lasted from 1974-82.

Figure 9.23: Natural Gas Prices by Sector, 1970-2016



Sources: EIA State Energy Data System; President's Council of Economic Advisors www.eia.doe.gov/emeu/states/_seds.html.

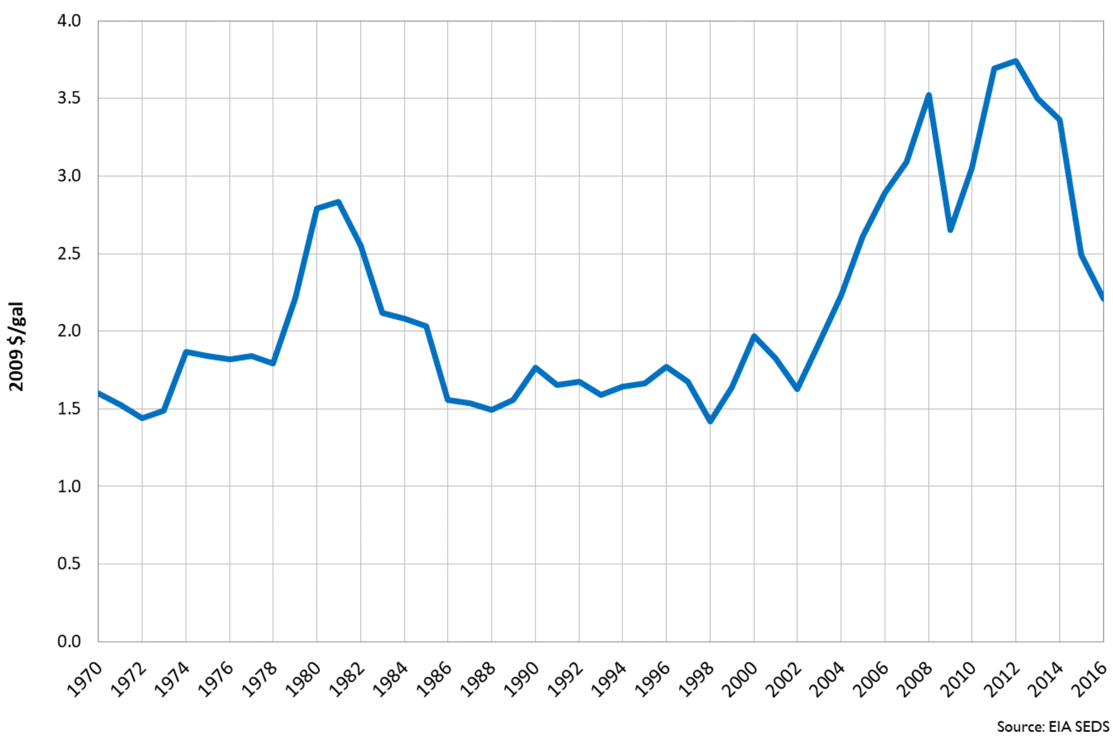
Over the long-term average industrial natural gas prices have been significantly lower than the other sectors, but by 2016 that relative difference had narrowed. Many large industrial customers began to make bulk purchases of commodity gas from suppliers other than their local utilities during the 1990s, helping to keep industrial prices down. However, when prices began to climb in late 1999, the increase was more dramatic for the industrial sector than the other sectors.

During the 1970s and 1980s electric utilities used natural gas to fire relatively small power plants for "peaking," or seasonal purposes. Consumption was typically low and weather dependent, with natural gas often being purchased on the spot market when needed. Over the past 25 years, utilities have shifted to larger more efficient combined cycle natural gas turbine plants to provide electricity, which require a larger and more secure supply of natural gas.

Indicator 16: Gasoline Prices

Washington state retail gasoline prices, expressed in constant dollars[103] , first peaked in 1981 and then declined to a historic low in 1998. Prices first exceeded the 1981 peak in 2006 and reached an all-time high in 2012 of about 3.74 dollars per gallon. Since 2012, gasoline prices have steadily declined with annual constant dollar of 2.21 per gallon for 2016.

Figure 9.24: Washington State Retail Gasoline Prices, 1970-2016



Sources: EIA State Energy Data System; President's Council of Economic Advisors. For fuel-price trends see EIA's weekly Gasoline and Diesel Fuel price update, www.eia.gov/petroleum/gasdiesel/.

For much of the 30 years from 1970 to 2000, the equilibrium price of gasoline in Washington hovered around $1.70 per gallon (all prices are expressed in 2009 dollars). There were periods when prices exceeded this value, such as during the Arab oil embargo of 1973-74 and during the period from 1979-1985 when the Iranian revolution and Iran-Iraq war occurred. The first spike in gasoline price occurred in 1981 when it reached $2.83 per gallon. Around the year 2000 gasoline prices became more volatile and started to increase again, though the growing tightness in the petroleum markets was masked by the 2000-01 recession. After 2002 gasoline rose rapidly and reached $3.52 per gallon in 2008, before falling during the subsequent deep

[103] Gasoline prices from EIA include state and federal gasoline taxes but they do not include local sales tax.

recession. With post-recession economic recovery in the U.S. and the world, gasoline prices began increasing again in 2010 and reached a new peak in 2012 of $3.74 per gallon.[104] Gasoline prices began to decline in late 2014 due to a combination of slow demand and production growth of new petroleum resources such as shale oil in the U.S., reaching an annual average price of $2.21 per gallon in 2016.

A large share of crude oil for Washington refineries comes from Alaska, but increasing amounts are arriving from the Canada (conventional and oil sands) and by rail from the Bakken region of North Dakota. In 2015, 36 percent of crude oil came from Alaska, 33 percent from Canada and 25 percent North Dakota. Gasoline prices in Washington, even excluding taxes, tend to be higher than the national average, reflecting the isolation of the west coast petroleum supply system.

Indicator 17: Energy-Related Carbon Dioxide Emissions

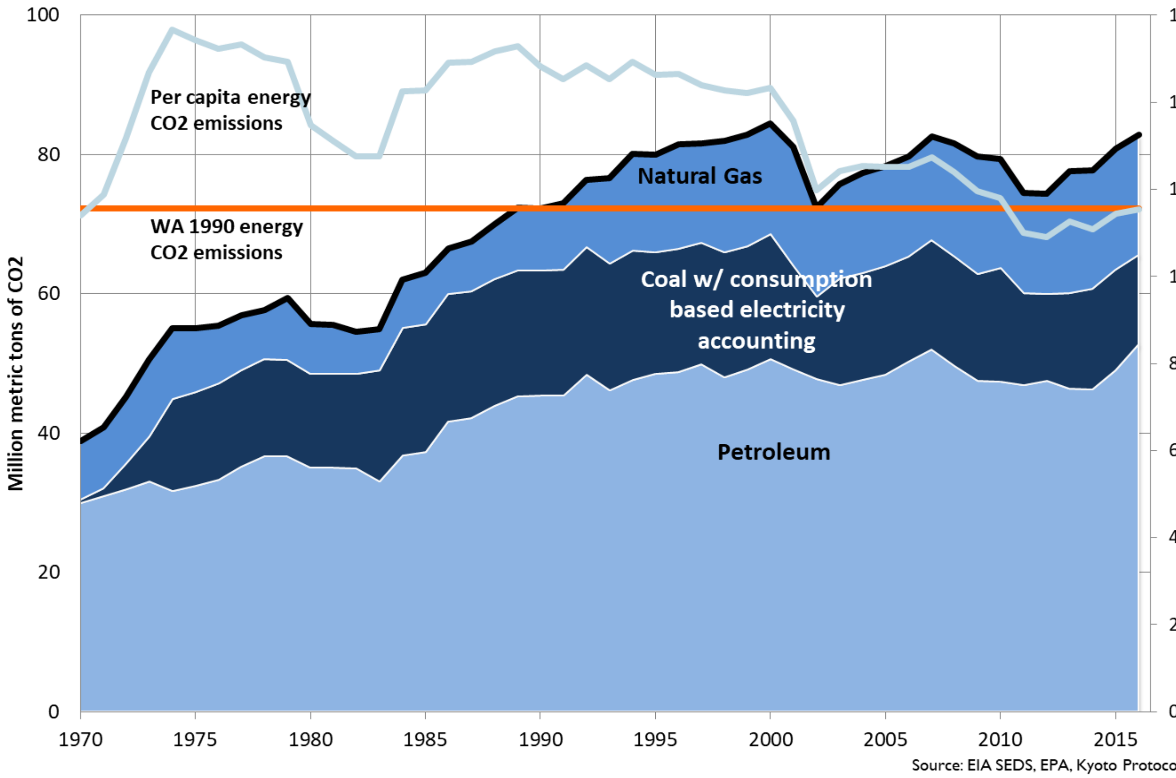
Statewide energy-related carbon dioxide emissions from 1990 through 2016 are determined using EIA data and are show in the figure below.[105] The data behind the figure are based on sector specific EIA SEDS data and Washington Dept. of Ecology (DOE) estimate of emissions from the electric sector calculated on a consumption basis.[106] We have also approximated the DOE methodology for marine fuel emissions. Since 1970, Washington's continued population growth and reliance on fossil fuels has led to steady growth in emissions of carbon dioxide, the principal human-caused greenhouse gas. Petroleum use, primarily for transportation, accounted for 72 percent of CO_2 emissions from energy use in Washington in 2016. In 1970, the share for petroleum related CO_2 emissions was 78 percent.

[104] Note that state gasoline and diesel taxes have been increased several times over the past 15 years.

[105] Independently, the Dept. of Ecology also produces a GHG emission inventory that differs from the Commerce/EIA estimates shown above in the following ways: the state GHG inventory includes gases other than carbon dioxide, including methane, nitrous oxide, HFCs, CFCs and SF6. The state GHG inventory also includes other sectors of the economy such as agriculture and forestry. In 2016 energy related CO2 emissions comprised about 84 percent of Washington state's GHG emissions.

[106] Ecology consumption based electric sector emissions cover 1990-2016. We have estimated the 1970-1989 emissions. Because of the estimations we have made, the data behind this figure should be used for only for illustrative purposes.

Figure 9.25: Washington Carbon Dioxide Emissions from Energy Use by Fuel Source, 1970-2016



Sources: EIA, CO2 Energy Emissions by State. For more information on CO2 emissions see EIA State Level Energy Related Carbon Dioxide Emissions, www.eia.gov/environment/emissions/state/analysis/

To address climate change, Washington state has set several greenhouse gas (GHG) emission targets for the next several decades. The first is a 2020 GHG emission target of returning to the 1990 emission level (or lower). The orange line in Figure 9.25 illustrates the 1990 level of energy-related CO_2 emissions. This is not the same as the state 2020 target of returning to the 1990 level of GHG emissions, which includes CO_2, methane, nitrous oxide and other gases. However, as CO_2 represents more than 80 percent of state GHG emissions, the figure above is indicative of the size of the reduction that must be realized for the state to meet the 2020 GHG emission limit. The time series suggests that energy-related CO_2 emissions peaked in the last decade, then declined following the 2008-09 recession. Since 2012 state emissions have been rising, likely the result of lower fuel prices and a growing population.

State CO_2 emissions grew rapidly during the 1960s as the population grew and per capita petroleum consumption increased. Emissions continued to increase during the 1970s primarily due to the construction of coal-fired power plants to provide electricity to state residents and businesses. After dipping in the early 1980s, growth in CO_2 emissions resumed after 1983 as the economy recovered from a protracted recession and as oil and fuel prices began to decline. Washington's CO_2 emissions from energy use grew more than 70 percent between 1983 and 2001. Emissions dropped in 2002 as a result of lower energy use due to a recession and the partial shutdown of the Northwest aluminum industry. In addition, the Sept. 11, 2001 terrorist attacks briefly curtailed emissions associated with airline travel. Emissions returned to a slow growth pattern from 2002 through 2007, then declined during the 2008-09 recession. Emissions appear to have increased during 2013-16 as the economy and population grew rapidly and petroleum and natural gas prices declined.[107]

Examining the figure on a fuel basis, we see that the consumption of petroleum products, the vast majority used for transportation, has accounted for majority of the growth in Washington's energy-related CO_2 emissions since 1970. Emissions from coal exhibit the largest relative increase since 1970 due to a series of regional coal-fired electric power plants that were built between 1972 and 1986 by Northwest utilities. Natural gas contains less carbon per unit of energy than other fossil fuels, but because of higher levels of consumption now accounts for a larger share of Washington's CO_2 emissions than coal.

Figure 9.25 also contains a time series for per capita energy CO_2 emissions with a secondary axis on the right of the chart. This time series indicates per capita energy CO_2 emissions hovered between 14 and 15 metric tons per year. In the early 2000s per capita emissions dropped as industrial energy use declined and energy prices began to increase. More recently per capita emissions have hovered around 11 metric tons per year.

Methodology

Introduction

Most publicly available comprehensive energy data at the state level originate with surveys and estimates developed by the Energy Information Administration (EIA), an independent branch of the U.S. Department of Energy. We rely heavily on the EIA's State Energy Data System (SEDS) to produce Energy Indicators and other products. However, we modify data from the EIA, based on years of experience with their components, to more accurately portray energy use in Washington. This includes the exclusion of non-energy uses of petroleum and the calculation of primary energy use for hydroelectricity generation.

Excluded Petroleum Products

We exclude the consumption of petroleum products used for non-energy purposes. We identified and removed the following products and this exclusion has been made through all of the energy indicators: asphalt and road oil, petrochemical feedstock, lubricants, petroleum

[107] As noted for Indicator 2, year 2016 saw and unusually large increase in residual fuel consumption in the transportation sector. Residual fuel is a low grade fuel and is used in large oceangoing vessels. In general Washington citizens and businesses are not purchasing residual fuel.

coke, special naphtha, unfinished oils, unfractionated stream, waxes and aggregated items in ”miscellaneous petroleum.” These petroleum items are primarily used in the industrial sector, such as petroleum used as feedstock for paints and solvents or to make waxes to coat packaging. The focus of this analysis is energy consumption in Washington, rather than the supply of and demand for, petroleum products or other fossil fuels. Excluding these non-energy uses provides the most accurate picture of the consumption of energy in the state.

Hydroelectric Conversion

One last methodological note regards the differences readers may notice here compared to other tallies of state primary energy use. In a steam-powered generator, as much as two-thirds of the energy in the fuel that is consumed is not converted to electricity, but is lost as waste heat due to thermal inefficiencies. Hydroelectric power generation does not experience thermal losses, but for comparative purposes the EIA assigns losses to it equivalent to an average loss rate for fossil fuel-powered generation, in an effort to enable comparison of primary energy consumption among individual states. We remove those imputed losses from the primary energy totals. This difference does not affect depictions of sector end-use consumption of energy, as these do not reflect primary energy inputs in the electric generation sector.

Methodology Summary

In summary, non-energy petroleum products used in the industrial sector and the calculation of primary energy use for hydroelectricity generation require modifications to standard views of energy consumption to accurately portray the trends depicted in these Indicators.

Fuel Prices

Fuel prices are shown in real dollars and are also referred to as inflation-adjusted dollars. The actual (or nominal) prices in each year have been adjusted to real or constant dollars reflecting the value of a dollar in the year 2009 (the constant year). This is done by multiplying the nominal prices by a gross domestic purchases index for the U.S. for each year (where the value in 2009 equals 1.0). This adjusts for the effects of inflation and allows prices for different years to be compared.

Sector Definitions

Residential sector: An energy-consuming sector that consists of living quarters for private households. Common uses of energy associated with this sector include space heating, water heating, air conditioning, lighting, refrigeration, cooking and running a variety of other appliances. The residential sector excludes institutional living quarters. Note that various EIA programs differ in sectoral coverage.

Commercial sector: An energy-consuming sector that consists of service-providing facilities and equipment of businesses; federal, state and local governments; and other private and public organizations, such as religious, social or fraternal groups. The commercial sector includes institutional living quarters and sewage treatment facilities. Common uses of energy associated with this sector include space heating, water heating, air conditioning, lighting, refrigeration, cooking and running a wide variety of other equipment. Note: This sector includes generators that produce electricity and/or useful thermal output primarily to support the activities of the above-mentioned commercial establishments.

Industrial sector: An energy-consuming sector that consists of all facilities and equipment used for producing, processing, or assembling goods. The industrial sector encompasses the following types of activity manufacturing (NAICS codes 31-33); agriculture, forestry, fishing and hunting (NAICS code 11); mining, including oil and gas extraction (NAICS code 21); and construction (NAICS code 23). Overall energy use in this sector is largely for process heat and cooling and powering machinery, with lesser amounts used for facility heating, air conditioning and lighting. Fossil fuels are also used as raw material inputs to manufactured products. Note: This sector includes generators that produce electricity and/or useful thermal output primarily to support the above-mentioned industrial activities.

Transportation sector: An energy-consuming sector that consists of all vehicles whose primary purpose is transporting people and/or goods from one physical location to another. Included are automobiles; trucks; buses; motorcycles; trains, subways and other rail vehicles; aircraft; and ships, barges and other waterborne vehicles. Vehicles whose primary purpose is not transportation (e.g., construction cranes and bulldozers, farming vehicles and warehouse tractors and forklifts) are classified in the sector of their primary use.

Electric power sector: An energy-consuming sector that consists of electricity generators and combined heat and power plants whose primary business is to sell electricity, or electricity and heat, to the public, i.e., NAICS code 22 plants.

Appendix A: Energy Indicator Data

A-1

Indicators **1** end use energy consumption by sector, **2** primary energy consumption by source.

	indicator 1, trillion Btu					indicator 2, trillion Btu							
year	**res.**	**comm.**	**ind.**	**trans.**	**total**	**biomass**	**coal**	**hydro**	**nuclear**	**NG**	**petrol.**	**renew. oth.**	**year**
1970	142	61.7	349	282	835	66.5	5.9	243	28.7	158	441	0	**1970**
1971	147	65.9	355	292	860	67.2	6.4	250	27.7	165	455	0	**1971**
1972	157	76.7	390	297	921	67.0	36.6	262	31.5	180	477	0	**1972**
1973	152	87.2	400	323	962	66.2	65.0	239	48.3	208	493	0	**1973**
1974	144	84.6	385	323	936	65.2	54.2	287	43.4	191	470	0	**1974**
1975	142	82.8	347	343	915	64.3	76.2	290	36.4	171	472	0	**1975**
1976	146	84.6	342	358	931	71.4	81.2	326	26.6	155	480	0	**1976**
1977	151	86.3	351	367	956	78.3	102.4	231	46.5	149	511	0	**1977**
1978	154	85.9	358	387	985	81.0	84.7	307	45.3	133	530	0	**1978**
1979	165	94.1	347	404	1,011	77.5	99.0	274	39.3	166	523	0	**1979**
1980	148	94.9	356	381	980	88.3	91.0	287	22.3	135	509	0	**1980**
1981	161	105.6	378	377	1,022	94.9	90.9	326	22.5	131	508	0	**1981**
1982	164	118.2	342	362	986	91.1	74.1	305	40.2	114	510	0	**1982**
1983	153	116.2	332	358	960	104.4	80.2	300	38.1	112	471	0	**1983**
1984	160	124.3	389	384	1,057	110.3	82.3	290	57.6	132	539	0	**1984**
1985	168	138.4	355	394	1,055	112.0	93.7	268	85.4	140	535	0	**1985**
1986	157	116.6	375	452	1,100	117.7	63.3	275	89.3	122	595	0	**1986**
1987	157	120.9	386	468	1,131	122.5	95.7	242	57.7	136	605	0	**1987**
1988	169	133.6	415	486	1,204	127.4	99.1	236	63.6	151	633	0	**1988**
1989	179	130.3	388	515	1,212	108.2	96.7	248	64.7	168	644	0	**1989**
1990	172	130.1	396	522	1,221	93.4	85.6	303	60.8	168	643	0	**1990**
1991	182	133.7	372	526	1,214	73.9	89.1	310	44.3	179	640	0	**1991**
1992	172	127.3	384	570	1,253	95.4	106.1	235	59.6	181	683	0	**1992**
1993	196	136.3	381	544	1,258	96.5	97.8	231	74.9	230	650	1	**1993**
1994	192	137.3	395	561	1,286	96.3	106.9	225	70.4	263	672	1	**1994**
1995	192	140.4	390	579	1,301	90.1	69.8	283	72.9	264	684	1	**1995**
1996	210	148.1	380	581	1,320	89.7	90.9	339	58.7	284	689	1	**1996**
1997	209	148.2	395	596	1,348	94.2	80.5	354	65.5	268	706	1	**1997**
1998	204	147.3	426	571	1,349	87.1	103.5	271	72.6	303	677	1	**1998**
1999	220	157.7	422	588	1,388	89.1	96.9	330	63.6	302	694	1	**1999**
2000	220	161.1	367	603	1,351	89.2	106.2	273	89.7	298	721	1	**2000**
2001	239	168.7	301	577	1,286	92.7	99.4	188	86.2	322	698	1	**2001**
2002	232	157.6	262	565	1,216	87.6	100.8	265	94.5	240	675	5	**2002**
2003	223	159.6	266	564	1,212	95.7	118.2	242	79.4	256	662	7	**2003**
2004	225	158.6	268	581	1,232	92.6	112.5	239	93.7	270	672	8	**2004**

2005	216	158.6	284	586	1,244	81.3	112.3	240	86.0	272	682	6	**2005**
2006	220	161.8	318	606	1,305	103.7	69.2	271	97.3	271	709	11	**2006**
2007	227	166.2	289	633	1,316	79.1	95.7	259	85.1	279	730	25	**2007**
2008	238	174.5	299	591	1,303	77.3	94.6	255	96.9	307	701	37	**2008**
2009	245	172.9	293	574	1,285	84.3	84.0	237	69.4	320	670	36	**2009**
2010	227	167.4	327	567	1,288	104.1	94.9	222	96.6	295	669	47	**2010**
2011	243	171.2	335	561	1,310	101.9	57.0	297	50.3	272	662	62	**2011**
2012	229	169.2	337	574	1,310	100.7	42.7	283	97.8	272	669	64	**2012**
2013	240	173.3	339	562	1,314	108.3	75.0	248	88.4	328	655	68	**2013**
2014	234	171.4	338	562	1,305	108.9	76.5	252	99.3	320	653	71	**2014**
2015	218	174.9	334	595	1,322	104.7	58.3	228	85.3	328	691	68	**2015**
2016	223	178.5	342	640	1,383	108.0	53.3	241	100.7	325	740	76	**2016**

A-2

Indicators **4** end use energy expenditures by sector, **5** energy consumption per GSP (index) **6** energy consumption per capita, **7** energy expenditures per GSP (index)

	indicator 4, billion 2005$				**ind. 5** 2000=1	**indicator 6** mmBtu/person		**ind. 7** 2000=1	
year	**res.**	**comm.**	**ind.**	**trans.**		**WA**	**US**		**year**
1970	1,237	512	771	2,714		245	274		**1970**
1971	1,267	534	783	2,688		250	275		**1971**
1972	1,350	644	844	2,618		269	284		**1972**
1973	1,348	709	884	2,927		279	292		**1973**
1974	1,369	724	1,066	3,786		267	280		**1974**
1975	1,375	772	1,149	3,998		256	267		**1975**
1976	1,427	802	1,151	4,226		256	279		**1976**
1977	1,519	868	1,214	4,452		257	282		**1977**
1978	1,516	838	1,263	4,563		257	285		**1978**
1979	1,722	976	1,405	5,695		254	284		**1979**
1980	1,808	1,135	1,746	6,962		237	268	1.88	**1980**
1981	2,146	1,409	2,057	7,389		242	257	2.05	**1981**
1982	2,370	1,720	2,354	6,543		231	243	2.03	**1982**
1983	2,495	1,643	2,057	5,633		223	238	1.78	**1983**
1984	2,481	1,765	2,647	5,814		243	249	1.82	**1984**
1985	2,558	1,891	2,149	5,668		239	245	1.73	**1985**
1986	2,322	1,600	1,774	4,776		247	244	1.39	**1986**
1987	2,293	1,621	1,816	4,909		250	249	1.35	**1987**
1988	2,409	1,693	2,112	4,812		261	259	1.32	**1988**
1989	2,515	1,673	2,186	5,340		256	259	1.33	**1989**
1990	2,469	1,645	2,061	6,115	1.61	251	254	1.32	**1990**
1991	2,466	1,631	1,933	5,851	1.56	242	250	1.24	**1991**
1992	2,317	1,624	1,813	5,867	1.55	244	253	1.16	**1992**

1993	2,589	1,727	1,854	5,575	1.52	239	253	1.14	**1993**
1994	2,633	1,804	1,959	5,775	1.51	240	256	1.14	**1994**
1995	2,613	1,842	1,981	5,897	1.52	238	258	1.14	**1995**
1996	2,812	1,929	1,837	6,581	1.46	237	265	1.16	**1996**
1997	2,758	1,889	1,905	6,451	1.41 [a]	238	264	0.99 [b]	**1997**
1998	2,691	1,861	2,007	5,175	1.09	235	259	0.84	**1998**
1999	2,859	1,965	2,109	6,198	1.04	238	260	0.87	**1999**
2000	3,012	2,089	2,219	7,994	1.00	229	257	1.00	**2000**
2001	3,496	2,461	1,997	7,009	0.97	215	247	0.99	**2001**
2002	3,526	2,501	1,568	6,387	0.90	201	248	0.91	**2002**
2003	3,314	2,476	1,714	7,521	0.89	199	247	0.96	**2003**
2004	3,450	2,566	1,810	9,077	0.89	200	251	1.06	**2004**
2005	3,663	2,646	2,190	10,942	0.86	199	247	1.15	**2005**
2006	3,904	2,818	2,402	12,666	0.86	205	243	1.25	**2006**
2007	4,145	2,832	2,265	13,740	0.83	203	244	1.25	**2007**
2008	4,339	2,992	2,700	15,787	0.81	198	236	1.39	**2008**
2009	4,395	2,937	2,223	10,679	0.82	193	222	1.10	**2009**
2010	4,129	2,878	2,298	12,353	0.80	192	229	1.16	**2010**
2011	4,414	2,962	2,550	15,234	0.80	194	216	1.34	**2011**
2012	4,153	2,906	2,378	15,613	0.77	192	211	1.29	**2012**
2013	4,209	2,902	2,168	14,507	0.73	191	218	1.20	**2013**
2014	3,979	2,854	2,154	13,896	0.70	186	219	1.11	**2014**
2015	3,840	2,932	1,991	10,372	0.69	188	217	0.89	**2015**
2016	3,895	2,892	1,822	9,549	0.69	197	215	0.81	**2016**

[a] Based on NAICS 1997 & after, SIC 1996 & before; SIC-based index in 1997 (the transition year) is 1.23

[b] Based on NAICS 1997 & after, SIC 1996 & before; SIC-based index in 1997 (the transition year) is 1.04

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Indicators **8** residential end use by fuel, **9** residential energy intensity (index), **10** residential energy bill excl. transportation

	indicator 8, trillion Btu				**ind. 9** 2000=1	**ind. 10** $/hhld	
year	**elec.**	**NG**	**petrol.**	**wood**		(2005 $)	**year**
1970	52.4	33.7	45.7	9.58	1.32	1,119	**1970**
1971	56.4	35.8	45.5	9.22	1.35	1,125	**1971**
1972	64.6	40.8	42.5	8.94	1.41	1,176	**1972**
1973	65.7	38.3	39.6	8.20	1.34	1,149	**1973**
1974	66.2	37.2	32.2	8.27	1.22	1,125	**1974**
1975	65.5	35.8	30.6	10.25	1.17	1,098	**1975**
1976	69.3	33.7	31.9	11.23	1.17	1,104	**1976**
1977	70.4	31.9	35.5	12.85	1.17	1,141	**1977**

1978	74.8	28.7	35.1	14.28	1.14	1,089	**1978**
1979	81.9	34.4	31.0	17.37	1.16	1,169	**1979**
1980	83.4	31.3	22.5	9.74	0.99	1,174	**1980**
1981	97.2	28.2	22.9	12.02	1.04	1,351	**1981**
1982	99.5	30.7	21.8	10.93	1.05	1,479	**1982**
1983	93.0	27.1	18.9	13.35	0.98	1,552	**1983**
1984	91.2	30.6	20.5	16.48	1.00	1,513	**1984**
1985	95.3	34.3	20.0	16.98	1.03	1,531	**1985**
1986	90.4	31.1	20.0	15.46	0.95	1,366	**1986**
1987	87.9	30.8	17.6	20.19	0.93	1,321	**1987**
1988	92.8	35.9	18.6	21.54	0.98	1,348	**1988**
1989	97.8	39.6	18.6	21.78	1.00	1,372	**1989**
1990	98.3	41.6	18.2	13.30	0.95	1,318	**1990**
1991	102.0	47.7	17.8	13.94	0.98	1,284	**1991**
1992	97.0	44.5	15.4	14.63	0.90	1,173	**1992**
1993	105.5	55.3	16.6	17.99	1.00	1,286	**1993**
1994	101.2	55.4	17.4	17.07	0.97	1,290	**1994**
1995	102.9	55.0	16.6	17.07	0.95	1,250	**1995**
1996	109.2	65.1	17.9	17.73	1.02	1,318	**1996**
1997	108.3	64.8	20.1	14.99	0.99	1,270	**1997**
1998	107.0	64.8	18.7	13.32	0.95	1,217	**1998**
1999	112.0	75.6	18.6	13.67	1.01	1,274	**1999**
2000	112.7	74.8	17.8	14.72	1.00	1,326	**2000**
2001	107.8	87.4	19.6	23.79	1.07	1,519	**2001**
2002	109.4	75.5	22.2	24.15	1.02	1,507	**2002**
2003	108.7	73.0	15.5	25.42	0.97	1,400	**2003**
2004	110.7	72.9	14.8	26.05	0.96	1,437	**2004**
2005	113.3	75.8	14.9	11.34	0.91	1,503	**2005**
2006	117.5	77.8	14.1	10.06	0.91	1,569	**2006**
2007	120.7	82.2	12.9	11.12	0.92	1,638	**2007**
2008	124.0	87.1	14.5	12.44	0.96	1,690	**2008**
2009	125.5	86.7	15.3	17.55	0.97	1,693	**2009**
2010	119.1	78.0	14.6	15.32	0.89	1,576	**2010**
2011	124.1	87.9	14.2	15.67	0.95	1,677	**2011**
2012	121.2	82.2	10.6	14.62	0.90	1,585	**2012**
2013	122.8	86.1	10.5	20.19	0.94	1,601	**2013**
2014	119.7	82.2	10.5	20.43	0.91	1,504	**2014**
2015	116.3	76.5	9.4	15.16	0.82	1,407	**2015**
2016	116.7	82.3	10.9	12.16	0.83	1,407	**2016**

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Indicators **12** commercial end use by fuel, **13** commercial energy intensity (index), **14** industrial end use by fuel, **15** industrial energy intensity (index)

	indicator 12, trillion Btu				**ind. 13** 2000=1	**indicator 14**, trillion Btu					**ind. 15** 2000=1	
year	**elec.**	**NG**	**petrol.**	**coal,wd**		**elec.**	**NG**	**petrol.**	**biomass**	**coal**	(2005 $)	**year**
1970	22.9	19.5	18.75	0.52		88.5	98.3	100.5	56.8	5.09		**1970**
1971	24.7	21.7	18.74	0.71		84.7	101.3	105.4	57.8	5.33		**1971**
1972	33.0	24.5	18.61	0.57		97.1	106.7	124.7	57.9	3.44		**1972**
1973	35.2	34.0	17.65	0.40		93.1	127.9	117.2	57.9	3.92		**1973**
1974	34.3	34.8	15.16	0.35		103.3	113.6	105.0	56.7	6.48		**1974**
1975	35.4	33.3	13.58	0.47		95.4	96.0	90.5	53.9	10.91		**1975**
1976	37.8	33.0	13.39	0.52		102.8	82.0	82.9	59.9	14.24		**1976**
1977	37.7	31.3	14.88	2.38		94.0	79.4	99.9	65.2	12.41		**1977**
1978	41.2	26.5	14.90	3.33		108.5	71.4	99.4	66.5	12.18		**1978**
1979	44.1	34.9	12.46	2.60		109.2	86.8	79.0	59.8	12.48		**1979**
1980	47.2	32.4	12.14	3.14		108.4	67.0	95.8	78.3	7.09		**1980**
1981	60.9	30.1	12.14	2.57		119.8	70.0	98.3	82.6	7.67		**1981**
1982	61.9	32.2	20.62	3.44		97.7	49.6	106.5	79.9	7.95		**1982**
1983	62.3	30.0	19.52	4.51		106.5	53.1	76.2	90.3	5.58		**1983**
1984	61.4	33.8	24.86	4.23		115.1	65.6	111.0	92.1	4.52		**1984**
1985	64.7	36.9	32.47	4.35		101.8	65.7	91.1	91.7	4.49		**1985**
1986	64.2	33.0	17.51	1.97		103.8	55.6	107.7	99.8	7.38		**1986**
1987	67.2	33.4	18.70	1.59		109.2	67.9	104.3	98.0	5.89		**1987**
1988	70.7	37.6	22.61	2.75		127.3	71.2	109.3	101.1	5.27		**1988**
1989	70.4	39.7	16.14	3.34		129.2	75.6	97.5	80.8	4.95		**1989**
1990	73.4	39.8	13.38	2.60	1.57	140.9	80.8	94.2	75.0	5.20	1.60	**1990**
1991	75.0	43.0	11.91	2.99	1.55	141.3	82.2	89.4	54.7	4.28	1.56	**1991**
1992	76.9	39.0	7.36	3.26	1.42	132.4	82.4	93.2	72.6	3.37	1.56	**1992**
1993	78.3	45.3	7.41	4.52	1.47	126.2	95.8	86.7	68.9	3.51	1.55	**1993**
1994	79.8	44.8	8.03	3.96	1.44	117.9	112.2	91.5	69.6	3.88	1.58	**1994**
1995	81.6	44.4	9.61	3.88	1.45	119.0	114.6	86.7	64.8	4.23	1.64	**1995**
1996	85.8	50.0	8.37	2.91	1.47	108.5	118.6	86.5	63.0	2.98	1.51	**1996**
1997	86.0	49.0	9.29	2.94	1.06 [a]	118.1	116.6	86.5	70.1	3.22	1.23 [b]	**1997**
1998	88.3	47.7	7.73	2.51	0.99	130.0	139.3	88.7	64.9	2.69	1.29	**1998**
1999	91.1	53.5	9.36	2.68	0.97	137.0	131.0	85.7	65.7	2.18	1.22	**1999**
2000	95.7	52.6	8.89	2.92	1.00	121.1	87.3	93.2	62.2	2.82	1.00	**2000**
2001	93.9	59.1	10.08	4.65	1.04	66.0	77.6	97.6	57.3	2.89	0.91	**2001**
2002	93.9	47.8	10.78	4.76	0.96	55.7	69.7	83.7	50.2	2.28	0.79	**2002**
2003	95.7	49.1	8.86	5.00	0.95	62.0	67.6	81.1	53.1	2.09	0.82	**2003**
2004	96.3	49.8	6.37	4.85	0.92	65.7	69.7	79.5	51.2	1.85	0.84	**2004**
2005	95.9	51.2	8.56	1.82	0.90	75.5	68.9	81.7	57.1	1.48	0.77	**2005**
2006	97.5	52.8	8.55	1.69	0.88	75.1	72.9	86.4	81.3	2.01	0.82	**2006**
2007	101.0	55.1	7.28	1.80	0.86	70.8	75.4	84.9	55.1	3.19	0.70	**2007**
2008	101.9	57.9	11.55	1.89	0.89	72.1	78.0	91.0	55.5	2.95	0.75	**2008**

2009	102.6	57.4	9.22	2.48	0.90	79.8	73.4	79.9	56.8	3.51	0.77	**2009**
2010	98.4	53.0	12.11	2.45	0.85	90.9	73.6	83.4	76.3	2.73	0.84	**2010**
2011	100.3	58.1	9.92	2.36	0.85	95.3	78.5	84.6	75.0	1.83	0.86	**2011**
2012	99.8	55.0	11.59	2.06	0.81	94.1	80.5	82.7	78.0	2.10	0.82	**2012**
2013	101.2	57.7	11.17	2.39	0.80	92.9	83.6	82.2	78.3	2.01	0.74	**2013**
2014	99.1	56.9	11.96	2.49	0.76	95.6	83.0	78.8	78.3	2.71	0.72	**2014**
2015	99.9	53.1	18.33	2.61	0.74	91.3	81.4	80.9	78.8	1.92	0.68	**2015**
2016	98.9	55.7	20.09	2.74	0.72	87.6	85.5	82.0	84.9	1.88	0.70	**2016**

[a] Based on NAICS definitions from 1997 forward; SIC definitions 1996 and earlier. SIC-based index in 1997 is 1.19.
[b] Based on NAICS definitions from 1997 forward; SIC definitions 1996 and earlier. SIC-based index in 1997 is 1.21.

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Indicators **16** transportation end use by fuel, **17a** travel per capita, **17b** fuel cost of driving, **18** transportation energy intensity

	indicator 16, trillion Btu				**ind.17a** mi/person	**ind.17b** ¢/mi	**indicator 18**, mi/gal			
year	**gasoline**	**distillate**	**av. fuel**	**resid.**		(2005 $)	**WA[a]**	**US[b]**	**US[c]**	**year**
1970	185	23.0	61.1	6.4	5,968	11.61	13.8		13.0	**1970**
1971	189	26.2	66.6	3.8	6,066	11.08	13.8		13.0	**1971**
1972	195	29.9	61.1	3.0	6,365	10.29	14.0		12.9	**1972**
1973	205	38.9	67.4	3.6	6,671	10.62	14.0		12.8	**1973**
1974	205	37.6	70.5	4.0	6,360	13.69	13.6		13.1	**1974**
1975	211	38.5	80.1	6.6	6,476	13.42	13.7	13.1	13.2	**1975**
1976	223	46.6	74.2	7.3	6,791	13.15	13.8	14.3	13.1	**1976**
1977	235	48.5	69.2	8.2	7,128	13.03	14.1	15.1	13.4	**1977**
1978	245	53.6	65.8	15.9	7,457	12.27	14.6	16.0	13.6	**1978**
1979	235	58.7	72.7	29.7	7,416	14.09	15.7	16.2	13.9	**1979**
1980	220	55.9	69.3	31.8	6,920	17.16	16.3	19.3	14.9	**1980**
1981	222	56.2	69.4	25.7	6,962	17.13	16.6	20.7	15.4	**1981**
1982	223	49.1	73.0	14.8	7,189	14.78	17.2	21.3	16.0	**1982**
1983	231	46.5	73.1	5.2	7,421	12.25	17.3	21.2	16.2	**1983**
1984	238	48.7	88.8	5.2	7,674	13.64	15.3	21.2	16.6	**1984**
1985	226	59.1	87.6	17.3	7,759	12.47	16.4	21.6	16.6	**1985**
1986	241	82.0	97.2	28.1	7,878	10.05	15.6	22.2	16.7	**1986**
1987	264	67.9	106.1	25.6	8,219	10.12	15.4	22.3	17.2	**1987**
1988	261	71.9	117.4	30.5	8,674	9.23	16.4	22.2	17.8	**1988**
1989	278	72.9	117.0	42.2	8,975	9.67	16.3	21.8	18.2	**1989**
1990	276	67.6	127.6	44.7	9,028	10.41	17.1	21.5	18.8	**1990**
1991	280	68.5	121.6	49.9	9,250	9.36	17.9	21.6	19.5	**1991**
1992	285	73.6	137.4	69.6	9,606	9.01	18.7	21.2	19.5	**1992**
1993	297	68.0	126.6	46.6	8,761	9.40	17.1	21.3	19.3	**1993**

1994	297	86.7	123.3	45.9	8,841	9.78	16.7	20.8	19.4	**1994**
1995	304	82.0	131.5	52.0	9,003	9.73	16.9	21.0	19.6	**1995**
1996	318	88.7	128.0	38.6	8,873	10.83	16.2	20.9	19.6	**1996**
1997	316	102.8	128.4	39.5	9,017	9.87	17.0	20.7	19.8	**1997**
1998	320	86.5	125.9	29.4	9,031	8.20	17.3	20.6	19.8	**1998**
1999	325	103.4	127.1	23.9	9,041	9.81	16.5	20.2	19.6	**1999**
2000	325	109.1	141.9	20.9	9,048	11.69	16.8	20.2	20.8	**2000**
2001	325	98.5	124.4	19.7	8,982	10.67	17.0	20.1	21.0	**2001**
2002	330	107.9	103.8	16.6	9,066	9.60	17.0	20.0	20.9	**2002**
2003	328	108.6	100.3	18.8	9,021	11.35	17.0	20.1	20.8	**2003**
2004	327	113.0	110.0	20.5	9,026	13.13	17.0	19.8	20.9	**2004**
2005	332	113.7	106.1	24.4	8,867	15.66	16.8	20.4	21.1	**2005**
2006	334	138.8	106.3	19.5	8,865	17.47	16.6	20.6	21.3	**2006**
2007	334	142.2	116.8	31.4	8,776	18.36	16.7	21.2	22.0	**2007**
2008	322	130.9	114.7	14.2	8,434	21.26	16.7	21.5	21.7	**2008**
2009	324	114.2	104.3	22.0	8,461	14.97	17.3	22.9	21.8	**2009**
2010	318	110.5	110.0	20.3	8,505	16.93	17.6	23.2	21.5	**2010**
2011	314	120.8	93.8	24.4	8,415	20.36	17.8	22.9	21.5	**2011**
2012	311	111.1	110.7	31.1	8,326	20.70	17.8	24.4	21.6	**2012**
2013	324	106.5	90.5	30.1	8,313	19.92	17.3	25.2	21.7	**2013**
2014	323	113.3	95.4	20.4	8,273	19.06	17.4	25.0	21.5	**2014**
2015	326	121.2	106.8	27.5	8,448	14.01	17.6	25.5	22.0	**2015**
2016	325	126.6	118.6	56.3	8,494	12.31	18.1	25.3	22.1	**2016**

[a] All Washington on-road vehicles, regardless of class
[b] (for reference) Registered U.S. light duty vehicles
[c] (for reference) U.S. new light duty vehicle fuel efficiency rating

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Indicators **20** energy prices by fuel, **21** electricity prices by sector, **22** natural gas prices by sector

	indicator 20, 2005$/mmBtu					**indicator 21**, ¢/kWh			**indicator 22**, ¢/therm[a]				
year	**petrol.**	**elec.**	**NG**	**biomass**	**coal**	**res.**	**comm.**	**ind'l.**	**res.**	**comm.**	**ind'l**	**utility**	**year**
1970	7.08	8.85	3.11	5.82	2.41	4.66	4.80	1.45	58.2	46.0	16.6		**1970**
1971	7.18	8.79	3.13	5.58	2.42	4.48	4.62	1.41	56.7	44.6	17.5		**1971**
1972	6.94	8.75	3.20	5.39	2.16	4.43	4.58	1.36	55.5	43.9	18.0		**1972**
1973	7.85	8.75	3.18	5.19	2.24	4.34	4.41	1.34	56.1	45.1	19.3		**1973**
1974	9.45	8.34	3.76	5.08	2.92	4.25	4.46	1.26	58.8	44.2	26.8		**1974**
1975	10.00	8.81	5.09	4.71	2.86	4.28	4.45	1.49	69.4	55.7	41.0		**1975**
1976	9.72	8.47	6.06	4.55	3.62	4.13	4.17	1.45	78.1	64.5	50.4		**1976**
1977	10.28	8.75	6.79	4.43	3.66	4.22	4.46	1.31	84.9	72.7	57.7		**1977**
1978	10.00	8.17	7.19	4.22	3.95	4.05	4.13	1.30	88.1	72.2	63.7	61.3	**1978**

1979	12.26	8.29	7.75	4.61	4.46	4.01	4.12	1.30	92.4	81.1	68.6	64.7	**1979**
1980	16.15	9.35	10.07	4.11	5.44	4.27	4.35	1.73	113.5	103.2	92.0	77.1	**1980**
1981	17.88	10.91	10.07	4.17	5.49	4.72	4.96	2.17	117.8	104.6	90.4	78.5	**1981**
1982	16.70	14.24	11.29	3.84	5.40	5.41	5.62	3.71	126.3	114.3	102.3	108.9	**1982**
1983	14.87	15.39	10.59	3.71	4.55	6.65	5.71	3.63	122.8	108.7	93.9	94.5	**1983**
1984	13.84	16.31	10.06	3.78	4.50	6.63	6.29	4.22	117.7	104.7	88.9	88.5	**1984**
1985	13.72	16.01	9.12	3.63	4.29	6.63	6.29	3.71	110.7	91.4	79.9	79.2	**1985**
1986	10.41	16.08	7.76	3.11	3.71	6.68	6.39	3.67	98.5	83.9	59.7	48.0	**1986**
1987	10.01	16.35	6.36	3.14	4.00	6.95	6.22	3.82	87.6	72.7	46.4	41.7	**1987**
1988	9.58	16.33	6.40	3.06	3.88	6.85	6.06	4.22	86.4	72.1	46.6	49.2	**1988**
1989	10.00	16.04	6.14	2.41	3.82	6.72	6.07	4.11	82.5	70.3	44.1	78.4	**1989**
1990	11.32	15.01	5.39	2.12	3.76	6.58	5.94	3.57	72.9	60.1	39.5	45.3	**1990**
1991	10.88	14.42	5.14	2.52	4.13	6.32	5.82	3.32	65.7	57.1	39.2	55.5	**1991**
1992	9.77	14.33	5.25	2.15	3.95	6.31	5.87	3.17	68.5	59.2	39.9	44.7	**1992**
1993	9.53	14.89	5.49	2.23	3.75	6.36	6.02	3.31	69.6	60.4	42.9	52.0	**1993**
1994	9.13	16.05	5.35	2.15	4.18	6.73	6.21	3.78	73.9	63.6	38.3	63.8	**1994**
1995	9.11	16.05	5.17	2.15	4.16	6.59	6.18	3.92	74.9	63.7	34.9	58.1	**1995**
1996	9.73	16.10	5.04	2.03	3.92	6.56	6.16	3.79	70.9	60.3	33.5	61.9	**1996**
1997	9.66	15.29	5.17	1.86	3.73	6.34	6.01	3.50	68.9	57.8	38.5	72.4	**1997**
1998	8.30	15.11	4.75	1.96	3.13	6.37	5.89	3.57	70.7	57.5	31.9	41.3	**1998**
1999	8.94	15.16	4.98	2.11	3.06	6.37	5.87	3.64	69.7	58.0	33.5	32.7	**1999**
2000	11.92	15.56	6.64	2.50	3.07	6.27	5.73	4.03	83.9	70.5	47.0	62.2	**2000**
2001	11.52	18.72	9.16	3.32	2.89	6.80	6.38	5.68	112.9	99.5	57.9	88.6	**2001**
2002	10.74	20.31	8.61	3.30	2.98	7.40	7.02	5.74	106.5	94.1	54.9	38.8	**2002**
2003	12.10	19.85	8.26	3.08	2.82	7.27	6.99	5.49	94.7	82.9	67.9	36.7	**2003**
2004	14.37	19.14	9.89	3.64	3.02	7.15	6.93	4.81	108.2	102.7	85.5	50.7	**2004**
2005	16.72	18.76	11.51	3.74	3.60	7.11	6.88	4.64	124.6	110.1	108.4	70.6	**2005**
2006	19.58	19.06	12.10	3.38	3.91	7.20	7.00	4.68	136.8	122.6	101.0	59.7	**2006**
2007	20.75	19.24	12.13	3.65	3.97	7.46	6.73	4.69	138.9	124.0	98.1	61.7	**2007**
2008	25.80	19.43	11.58	4.27	4.90	7.60	6.83	4.56	127.8	112.4	103.2	83.8	**2008**
2009	18.62	19.41	12.41	4.15	4.81	7.67	6.97	4.40	135.4	119.0	113.4	51.4	**2009**
2010	21.73	19.39	10.36	3.78	5.60	7.94	7.28	4.02	117.1	100.4	89.6	53.0	**2010**
2011	26.76	19.37	10.24	4.06	5.98	8.01	7.25	3.96	115.7	97.9	89.0	53.4	**2011**
2012	26.53	19.47	9.49	3.87	5.58	8.10	7.30	3.92	109.6	90.7	81.0	41.3	**2012**
2013	25.52	19.58	9.02	4.15	5.70	8.13	7.28	3.96	103.0	83.3	75.7	42.1	**2013**
2014	25.00	19.36	8.45	4.46	5.59	7.97	7.33	3.98	93.3	79.6	75.3	45.3	**2014**
2015	16.19	19.86	8.90	3.55	5.45	8.27	7.47	3.96	100.9	83.6	76.5	31.6	**2015**
2016	13.91	20.39	7.69	3.04	5.07	8.52	7.57	3.98	89.8	70.7	62.2	30.6	**2016**

[a] 1 therm = 100,000 Btu