Clean Energy Roadmap: WASHINGTON STATE

Cascade Power Group
10900 NE 8th Street, Suite 1000
Bellevue, WA 98004
www.cascadepowergroup.com

Prepared by:
Chuck Collins, Chief Executive Officer
Juliana Williams, Policy Analyst
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INTRODUCTION

By law, Washington State must reduce greenhouse gas emissions to 1990 levels by 2020; to 25 percent below 1990 levels by 2035; and to 50 percent below 1990 levels by 2050 (RCW 70.235.020). The 1990 Greenhouse Gas Emissions Inventory established the 1990 baseline at 88.4 million metric tons of carbon dioxide equivalent (MMTCE). Therefore, by 2035 emissions must be below 66.3 MMTCE. Because current greenhouse gas emissions are at 85.27, we need to reduce statewide emissions by 18.97 MMTCE by 2035 to reach these targets.[1]

In 2010, The Department of Commerce was directed by the legislature to identify priority areas for reducing greenhouse gas emissions while increasing competitiveness and keeping energy rates stable. The recommendations of the 2012 Washington State Energy Strategy (hereafter called the State Energy Strategy) focus on transportation electrification, energy efficiency in buildings, and distributed energy. The State Energy Strategy recommendations provide a cursory look at opportunities to reduce energy consumption and greenhouse gas emissions through waste heat recovery, electricity generation, and industrial operations.

This report outlines three scenarios that illustrate the impact of waste heat recovery, electricity generation and industrial policies on state energy load by 2035. These scenarios demonstrate ambitious but achievable pathways to meet our state's energy demands and emissions reduction goals while decreasing total energy consumption. This report is designed to complement the State Energy Strategy with specific thermal policy changes and illustrate the impact of these on Washington's energy future.

[1] 2012 Washington State Energy Strategy: http://www.commerce.wa.gov/DesktopModules/CTEDPublications/CTEDPublicationsView.aspx?tabID=0&ItemID=10206&MId=863&wversion=Staging

THE WASHINGTON STATE ENERGY SYSTEM (2009)

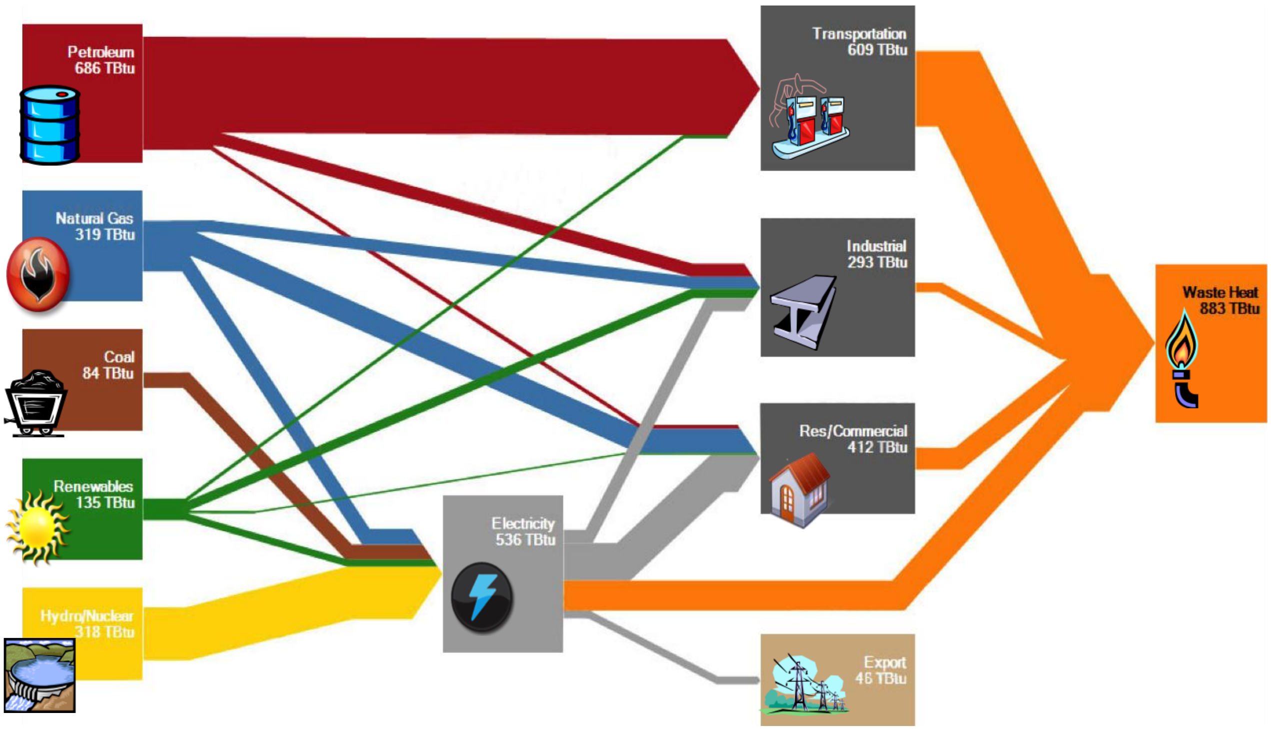

Figure 1. Energy Flows in Washington in 2009. *Note: The boxes on the left denote primary energy sources consumed, and the boxes on the right show energy demand from the sectors of our economy.*

The energy flows, or the supply and demand of energy sources, in Washington for 2009 are represented in Figure 1.[2] In 2009, Washington State consumed 1,543 trillion British thermal units (TBtu) of energy. Of that, 536 TBtu were used to generate electricity, while the remaining 1,007 TBtu were delivered directly to the transportation, industrial, commercial and residential sectors.

A total of 833 TBtu, or 54 percent, of the total energy consumed in 2009 was lost as waste heat. The majority of the waste heat came from the transportation sector, which wasted 457 TBtu. Of the remaining waste heat, 182 TBtu come from electricity generation, 59 TBtu from industry and 135 TBtu from the commercial and residential sectors. Most of the waste heat from electricity generation came from inefficiencies in fuel combustion, with a smaller amount lost through transmission and distribution lines. Waste heat from the industrial, commercial and residential sectors was lost through primary energy consumption or end-use of electricity. Waste heat results from inefficiencies in our energy system, but is also a free and largely untapped energy resource.

The 2012 State Energy Strategy focuses on transportation, building efficiency and distributed energy. However, this provides an incomplete roadmap for a comprehensive state energy policy. Electricity

[2] Ibid.

generation and industrial operations together account for nearly one third of the wasted energy in our state, yet receive very little attention in the State Energy Strategy. Waste heat recycling can meet growing energy demand and reduce the pressure on utilities to expand their generating capacity. Combined with the State Energy Strategy, the strategies presented here provide a more comprehensive approach for reducing energy consumption and greenhouse gas emissions.

STATE ENERGY RESOURCES

The energy landscape in Washington combines a diverse mix of renewable resources with almost entirely imported fossil fuels. As the state transitions from fossil fuels toward renewable energy sources, it is important to recognize the capacity of these renewable resources to meet our energy needs.

HYDROPOWER

In 2009, large hydroelectric dams on Columbia River and its tributaries provided 46 percent of Washington's electricity. Although it is unlikely that any new large hydroelectric will be built, the "US Hydropower Resource Assessment for Washington" conducted by Idaho National Laboratories found that improving the efficiency of 11 existing hydroelectric dams could produce an additional 875 megawatts (MW), or 13TBtu, each year.[3] Adding electricity production to existing non-power dams could generate another 1777 MW, or 26.5 TBtu, each year.

WIND

Washington currently has an installed wind capacity of 2,358 MW[4], with an additional 649 MW under construction and 2,784 MW under development.[5] The total wind potential in the state is 18,479 MW,[6] or approximately 190 TBtu, each year. According to the National Renewable Energy Laboratory, Washington's wind resources could supply nearly two-thirds of our state's electricity demand.

SOLAR

The solar resources in Washington range from approximately 2.5-5.0 kWh/m^2 each day.[7] This is more than enough to meet all of our state's energy demand. However, there is currently only 8 MW of grid-connected solar capacity and another 75 MW of utility-scale under development.[8] This does not include distributed solar systems that provide power directly to consumers and are not connected to the grid.

BIOENERGY

The "Washington State Biomass Inventory" has found that there is a total biomass capacity to produce 2215 MW, or 53 TBtu, each year.[9] Currently, there are 437 MW of installed biomass capacity, ranking

[3] http://hydropower.inl.gov/resourceassessment/pdfs/states/wa.pdf
[4] http://www.nrel.gov/analysis/pdfs/51680.pdf
[5] http://www.rnp.org/project_map
[6] http://www.windpoweringamerica.gov/wind_resource_maps.asp?stateab=wa
[7] http://www.nrel.gov/gis/data_solar.html
[8] http://www.seia.org/galleries/pdf/Major percent20Solar percent20Projects.pdf
[9] http://www.pacificbiomass.org/WABiomassInventory.aspx

Washington as tenth in the country in biomass capacity.[10] Most of the biomass used to produce power in this state is wood waste, but other sources include animal, municipal and food waste.

GEOTHERMAL

Much of Eastern Washington has good low-temperature (less than 100˚C) geothermal resources, and there are more than 900 thermal wells in the Columbia River Basin. Currently, geothermal resources generate about 0.4 MW, or 0.011 TBtu, per year.[11] The U.S. Geological Society estimated in 2009 that in the next thirty years Washington would develop 7 to 47 MW of geothermal power.[12] The State's geothermal power policy expired in 2011.[13] In addition to electricity generation, geothermal energy can be used directly for ground source heating. There are over 7,800 MW of installed ground source heat pump units in the country, with an annual growth rate of about 15 percent each year.[14]

WAVE AND TIDAL

Although wave and tidal energy are not yet sending electricity to the grid, there are 135 MW of wave and tidal projects currently under development in Washington.[15] Collectively, Washington, Oregon and California have potential annual wave and tidal capacity of 167,428 MW, or 1501 TBtu.[16] Wave and tidal technologies are still in development and have not reached widespread commercial use.

INDUSTRIAL WASTE HEAT

Recycled waste heat from industrial operations and electricity generation has the potential to meet energy demands without needing to burn additional fossil fuels. The U.S Department of Energy's Northwest Clean Energy Application Center found that the technical potential for industrial (non-utility) combined heat and power (CHP) technology could generate 3,070 MW, or 73.4 TBtu each year.[17] Currently, there are 1,265 MW of installed CHP capacity at 34 industrial sites in Washington.[18] Recycling waste heat from power plants also has the capacity to generate a similar amount of energy.

THERMAL ENERGY TECHNOLOGIES

According to the U.S. Energy Information Administration (EIA), thermal energy consumption accounts for roughly one third of total U.S. energy demand.[19] Almost 80 percent of that thermal demand is used to provide heat below 150°C, which falls within the range of temperature produced by the following thermal technologies. By directly utilizing heat, thermal energy technologies lower the demand for primary fuel sources by recycling waste heat or displacing the need for electricity or fossil fuels to generate heat. Direct thermal use also lowers the grid demand for electricity to produce heat and

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[10] http://www.nrel.gov/analysis/pdfs/51680.pdf
[11] http://www.energy.wsu.edu/documents/geothermal.pdf
[12] http://www.energy.wsu.edu/Documents/WashingtonGeothermalEnergyStatusAndRoadmap.pdf
[13] http://apps.leg.wa.gov/RCW/default.aspx?cite=43.140&full=true
[14] http://geoheat.oit.edu/bulletin/bull28-2/art1.pdf
[15] http://www.rnp.org/project_map
[16] http://www.fas.org/sgp/crs/misc/R41954.pdf
[17] http://www.chpcenternw.org/NwChpDocs/WA percent20CHP percent20Technical percent20Potential percent2008 percent202010.pdf
[18] http://www.eea-inc.com/chpdata/States/WA.html
[19] http://pangea.stanford.edu/ERE/pdf/IGAstandard/SGW/2011/fox.pdf

therefore reduces losses along transmission lines. Thermal energy systems can operate independently from the grid, and are more resistant to extreme weather that can produce power outages.

Combined Heat and Power (CHP): A typical U.S. natural gas power plant is roughly 40 percent efficient, meaning that less than half of the fuel is fully utilized. The rest of the fuel generates wasted heat that is vented into the atmosphere. Combined heat and power (CHP) engines, also called cogeneration, generate electricity and usable heat from a single fuel source. The heat recycled by a CHP engine can be used for industrial purposes or to heat buildings in a surrounding area through a hydronic loop or a forced-air system. As a result, CHP systems are approximately 70-80 percent efficient in using fuel to produce electricity and usable heat. Micro CHP, or micro-cogeneration, units have an electrical output of less than 5kW and are used in single or multi-family homes and commercial buildings.[20] By 2007, installed CHP capacity in the US was 85,000 MW and CHP produced 9 percent of U.S. electric power.[21]

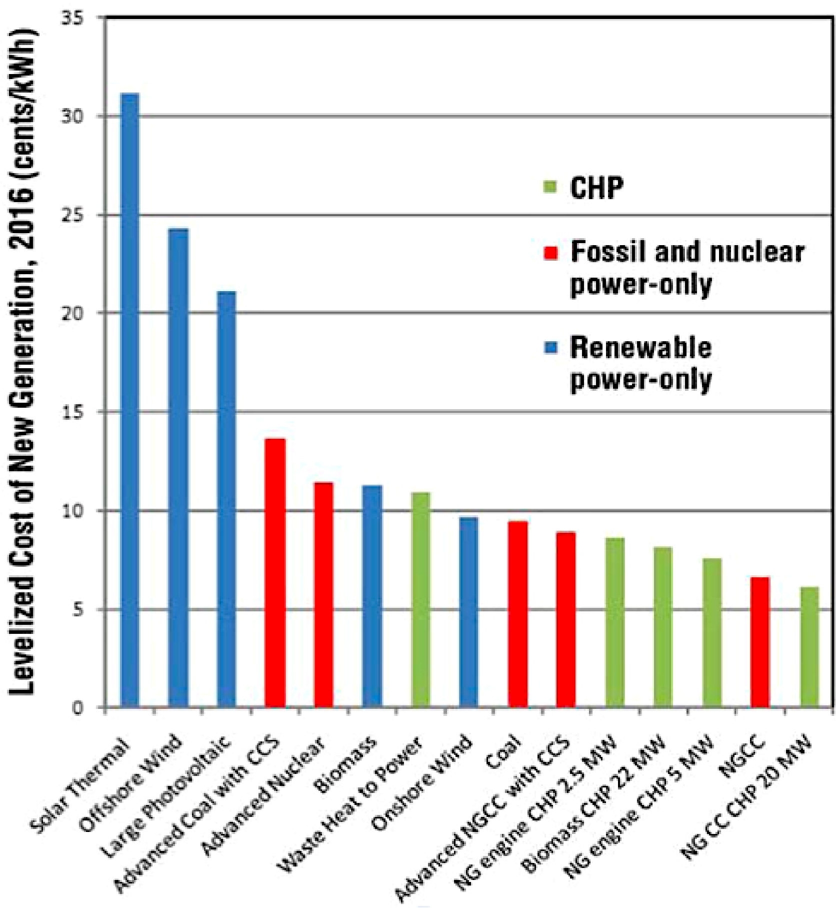

Figure 2. Levelized Cost of Greenhouse Gas Reduction for Generation Resources On Line in 2016[22]

As shown by Figure 2, CHP technologies can provide the cheapest greenhouse gas reductions. Likewise, the Oak Ridge National Laboratory has found that "CHP should be one of the first technologies deployed

[20] http://www.marketsandmarkets.com/Market-Reports/micro-chp-market-419.html
[21] http://www.iea.org/files/CHPbrochure09.pdf
[22] http://www.districtenergy.org/assets/pdfs/Webinars/Webinar-4-7-2011/Mark-Spurr-Why-CHP.pdf

for near-term carbon reductions. The cost-effectiveness and near-term viability of widespread CHP deployment place the technology at the forefront of practical alternative energy solutions."[23, 24]

Waste Heat Recovery (WHR): Waste heat recovery (WHR) recycles heat discharged as a byproduct of one process to provide thermal energy needed by a second process. WHR boilers use high-temperature excess heat to raise the temperature of fluid-filled tubes and produce a vapor, usually steam, which then powers a turbine to create electricity. The waste heat may come from industrial processes, wastewater treatment, livestock waste, fuel combustion and other sources. For the purposes of this report, WHR technologies that produce electricity are considered a type of CHP technology.

District Energy Systems: District energy systems produce steam, hot water or chilled water at a central plant, which is distributed through a network of underground hydronic pipes to multiple buildings in an area, campus or district. As a result, individual buildings connected to a district energy system do not need their own boilers, furnaces, chillers or air conditioners. This allows district energy to achieve greater economies of scale and employ more efficient technologies. District energy systems can be run using a variety of fuels and can provide greater reliability than electricity-based heating and cooling systems. Widespread deployment of CHP technologies depend on district energy systems to distributed recycled heat. As of 2009, Washington had 14 district energy systems with 538 MW capacity, or about 14.5 TBtu per year.[25] In the past few years, Washington produced surplus electricity when high river flows coincide with peak wind production. This has resulted in 'negative-pricing' situations, where Washington must pay other states to take our electricity. Because district energy systems are fuel flexible, they can absorb excess energy to produce heat and serve as energy storage. In Denmark, district heating plants are installing electric heating elements to produce hot water during off-peak hours or times of electricity surplus.[26] This reduces the need for fossil fuels to power district heating, further reducing emissions.

Solar thermal: Solar thermal systems use collectors to absorb the energy from the sun to produce heat, using either a fluid or the air to circulate the heat from outside the building to the inside. Solar thermal heat is generally used for heating water or for space heating. Passive solar buildings are designed to utilize the heat from the sun without mechanical or electronic devices. Key design features include window placement and type, insulation, thermal mass of building materials and shading.

Ground-source heating: Ground-source systems provide heating and/or cooling to buildings using the ambient temperature of the earth. In Washington the average ambient ground temperature is above 52˚ F.[27] Typically, a fluid circulates through a series of pipes and absorbs the heat from the earth in winter and carries it into the building. In the summer, the fluid carries heat from the air, which is absorbed by the earth to provide cooling. Ground-source heat pumps require electricity to circulate the fluid, which usually comes from the electric-grid or nearby gas-fired generators.

[23] http://info.ornl.gov/sites/publications/files/Pub13655.pdf
[24] For a description of various CHP technologies, see: http://info.ornl.gov/sites/publications/files/Pub13655.pdf
[25] http://districtenergy.org/operational-data-2009-summary
[26] http://www.cdea.ca/sites/cdea/files/news/attachments/CDEA%20Report%20Final%20%20Dec%2015%202010.pdf
[27] http://geoheat.oit.edu/pdf/tp32.pdf

APPROACH

The 2012 Washington State Energy Strategy includes both near-term and long-term policy recommendations. The long-term horizon is based on forecasts out to the year 2035, which is slightly less than 25 years from now. Twenty-five years is a standard long-term time frame for energy forecasting, used by both the Energy Information Administration (EIA) and the Northwest Power and Conservation Council. The year 2035 also coincides with the first benchmark for Washington's greenhouse gas emissions goals, which requires emissions to be 25 percent below 1990 levels by 2035. The State Energy Strategy forecasts are based on EIA forecasts, but incorporate the effect of the new federal corporate average fuel economy (CAFE) standards, which require a 5 percent annual increase in vehicle fuel efficiency from 2017 to 2025. In the reference case in the State Energy Strategy, primary energy consumption increases by about 0.8 percent each year, whereas the population is forecasted to grow by 1 percent each year.

To be consistent, the 2035 scenarios presented in this report are based on the reference case in the State Energy Strategy. However, the reference case was based on 2007 data, and so the values for energy demand in 2009 in the reference case were 9 percent below actual energy consumption. Therefore, the energy demand in the scenarios in this report was adjusted by 9 percent from the reference case to reflect current data.

ASSUMPTIONS

In developing the policy scenarios for 2035, the following assumptions were made:[28]

- Coal is phased out of Washington electricity production by 2025, in accordance with the closure of the TransAlta plant in Centralia. (RCW 80.80.04)
- All new electric generating resources, including those under long term contract, meet a greenhouse gas emission performance standard equal to the industry average for natural gas combined cycle facilities. (RCW 80.80.040)
- The State Energy Codes adopted from 2013 through 2031 incrementally moves toward achieving seventy percent reduction in annual net energy consumption for new residential and commercial buildings by 2031. (RCW 19.27A.160)
- By 2035, the Energy Independence Act of 2006 requires 15 percent of electricity to come from renewable sources. Current law requires 15 percent renewables by 2020, so maintaining the same level by 2035 does not require policy change. (RCW 19.285)
- No changes in federal energy policy are made.

The scenarios in this report do not include any additional transportation efficiency improvements or building efficiency improvements, because the State Energy Strategy discusses these issues in detail. Although advances in energy production technologies are likely to occur between now and 2035, the scope of these improvements are difficult to forecast, and are therefore not considered in this report.

[28] For a more complete list of existing policies related to climate change and energy, see: http://www.ecy.wa.gov/climatechange/laws.htm

In addition to these specific policy assumptions, the capacity factors in Table 1 were used to calculate the total amount of energy produced in a year (MWh or TBtu). Capacity factors represent the proportion of time that a facility is operating at full nameplate capacity (MW).

Table 1. Capacity factors for Renewable Energy Sources

Energy Technology	Assumed Capacity Factor
Wind Turbines (80 meter hub height)[29]	30%
Solar Photovoltaics[30]	20%
Biomass Boilers[31]	80%
Natural Gas power plants[32]	80%
Hydroelectric dams[33]	50%
Wave and Tidal power[34]	30%
Ground Source Heat Pumps[35]	20%
Micro CHP	12-30%
District Energy Systems	90%

[29] http://www.windpoweringamerica.gov/wind_resource_maps.asp?stateab=wa
[30] http://www1.eere.energy.gov/maps_data/pdfs/eere_databook.pdf
[31] Ibid.
[32] http://www.nrel.gov/docs/fy00osti/27715.pdf
[33] Bowers, Rich. February 27th, 2012. Hydropower Reform Coalition. Personal Communication
[34] http://www.fas.org/sgp/crs/misc/R41954.pdf
[35] http://geoheat.oit.edu/pdf/tp32.pdf

2035 SCENARIOS

The following three scenarios reflect changes to our state's energy system accomplished through specific policy changes. Each policy scenario is based on the 2035 reference case, and incorporates the changes of the previous one, demonstrating the cumulative impact of the proposed policies.

SCENARIO 1

Under Scenario 1, all waste heat from natural gas combustion is utilized through CHP engines or district energy systems. Three-quarters of the recycled heat from electricity production is used by industry, though the remainder is used for residential and commercial district heating. All natural gas consumed by the residential and commercial sectors uses micro-cogeneration or district energy systems. Additionally, petroleum consumed by the industrial sector decreases due to the relative high price of oil compared to natural gas.

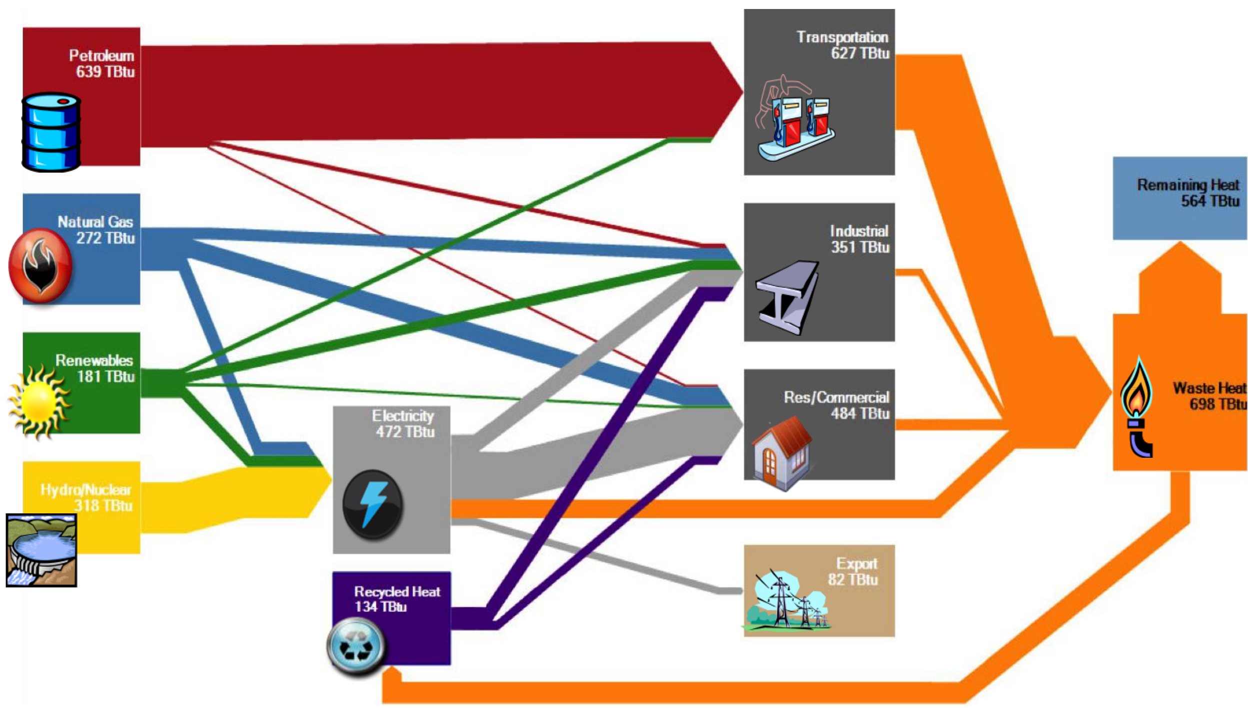

Figure 2. Energy flows in Washington in 2035 if all natural gas combustion employs CHP and/or district energy.

Scenario 1 demonstrates that by improving the efficiency of natural gas combustion we can meet our state's growing energy demands while lowering our total primary energy consumption. Combined with existing policy measures, this focused change can achieve 72 percent of the required greenhouse gas emissions reductions by 2035 (Table 2).

Table 2. Scenario 1 Energy System Changes from 2009 to 2035		
	Change in Energy Consumption (TBtu)	Change in CO2 (MMTCE)
Petroleum	-47	-3,347,059
Natural Gas	-47	-2,492,305
Coal	-84	-7,810,863
Renewables	+46	0
Hydropower/Nuclear	0	0
Recycled Heat	+134	0
Total	**-50**	**-13,652,227**

To gain a more detailed picture of the energy resources that would be need to be developed for Scenario 1, projections for renewable and recycled heat development are shown in Table 3. Based on the total renewable potential discussed earlier and projected growth rates, 50 percent of the increase in renewable energy is met by wind, 35 percent by bioenergy, 5 percent from solar, 5 percent from ground-source heating and 5 percent from tidal projects. The amount of recycled heat generated is proportional to the amount of natural gas consumed by each sector, with the assumption that 75 percent of the recycled heat from utility operations is used by the industrial sector. The remaining 25 percent is used by the residential and commercial sectors through district energy systems.

Table 3. Scenario 1 Increases in Energy Resources		
	Generation (TBtu)	Capacity (MW)*
Wind	23	2,565
Bioenergy	16.1	673
Solar	2.3	382
Ground-source	2.3	382
Tidal	2.3	257
Total Renewables	**46**	
Utility CHP	33	1,380
Industrial CHP	55	2,300
District Energy	46	1,710
Total Reused Heat	**134**	

*Calculated using the Capacity Factors listed in Table 1.

The increase in energy produced with CHP would increase to about 7 percent, still lower than the national average of 9 percent. The scenario also shows a threefold increase in district energy capacity from 2009 to 2035. For comparison, Denmark transformed from being 98 percent dependent on imported fuel to providing heating for over 60 percent of all buildings in Denmark through district heating by 2007.[36] Similarly, district heating in Finland accounts for almost 50 percent of the total heating market. The examples from Denmark and Finland demonstrate that even greater expansion of district energy is possible, given commitment to a consistent policy framework.

SCENARIO 2

In Scenario 2, all natural gas combustion achieves the efficiency of a natural gas combined cycle turbine with a CHP engine, as in Scenario 1. Further, all fuel oil petroleum is eliminated from heating and industrial operations.

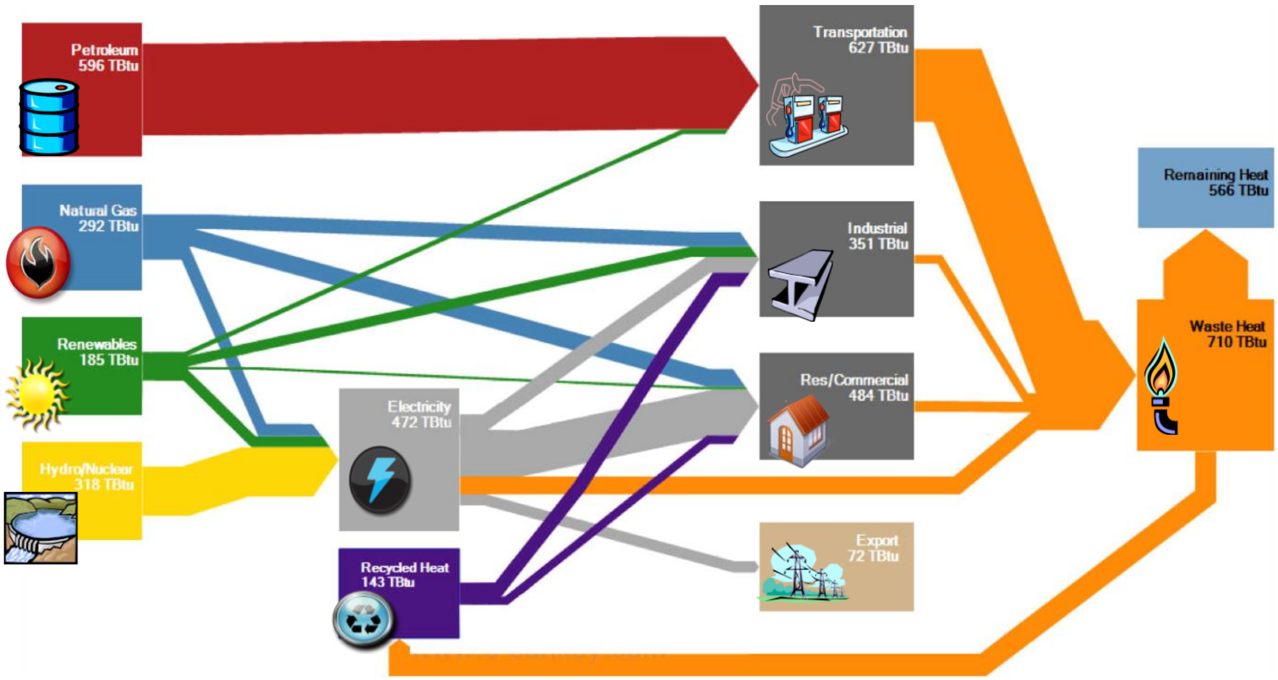

Figure 3. Energy flows in Washington in 2035 if all natural gas combustion employs CHP and/or district energy, and fuel oil heating is eliminated.

Scenario 2 is very similar to Scenario 1, except that petroleum use is eliminated from the industrial, residential and commercial sectors. Natural gas and district heating increase in order to meet the same energy demands. Residential and commercial backup generators could still operate on diesel, but are an insignificant percentage of Washington's energy consumption that they do not show up on these energy flow diagrams. With the further reduction in petroleum, Scenario 2 can achieve over 82 percent of the required greenhouse gas emissions reductions by 2035 (Table 4).

[36] http://www.cdea.ca/sites/cdea/files/news/attachments/CDEA percent20Report percent20Final percent20 percent20Dec percent2015 percent202010.pdf

Table 4. Scenario #2 Energy System Changes from 2009 to 2035		
	Change in Energy Consumption (TBtu)	Change in CO2 (MMTCE)
Petroleum	-90	-6,409,262
Natural Gas	-27	-1,432,899
Coal	-84	-7,810,863
Renewables	+50	0
Hydropower/Nuclear	0	0
Recycled Heat	+143	0
Total	**-79**	**-15,653,023**

Because the total amount of electricity generated between Scenario 1 and Scenario 2 is very similar, the proportion of renewable sources is the same: 50 percent of the increase in renewable energy is met by wind, 35 percent by bioenergy, 5 percent from solar, 5 percent from ground-source heating and 5 percent from tidal projects. Likewise, the proportion of recycled heat consumption remains the same from Scenario 1 to Scenario 2.

Table 5. Scenario 2 Increases in Renewable Energy		
	Generation (TBtu)	Capacity (MW)*
Wind	25	2,788
Bioenergy	17.5	732
Solar	2.5	418
Ground-source	2.5	418
Tidal	2.5	279
Total Renewables	**50**	
Utility CHP	33	1,380
Industrial CHP	64	2,676
District Energy	46	1,710
Total Recycled Heat	**143**	

*Calculated using the Capacity Factors listed in Table 1.

SCENARIO 3

Where Scenarios 1 and 2 reflected a few targeted key policy changes, Scenario 3 illustrates a more comprehensive approach to reduce greenhouse gas emissions. In Scenario 3, all natural gas combustion employs CHP or district energy, and fuel oil heating is eliminated, as in Scenario 2. Additionally, renewable sources produce 20 percent of electricity by 2035, an increase from the 15 percent by 2020 currently required by law. Further, the state achieves full vehicle electrification, eliminating petroleum consumption from all uses except heavy transport. Finally, efficiency improvements are made to hydroelectric dams, increasing their electricity output.

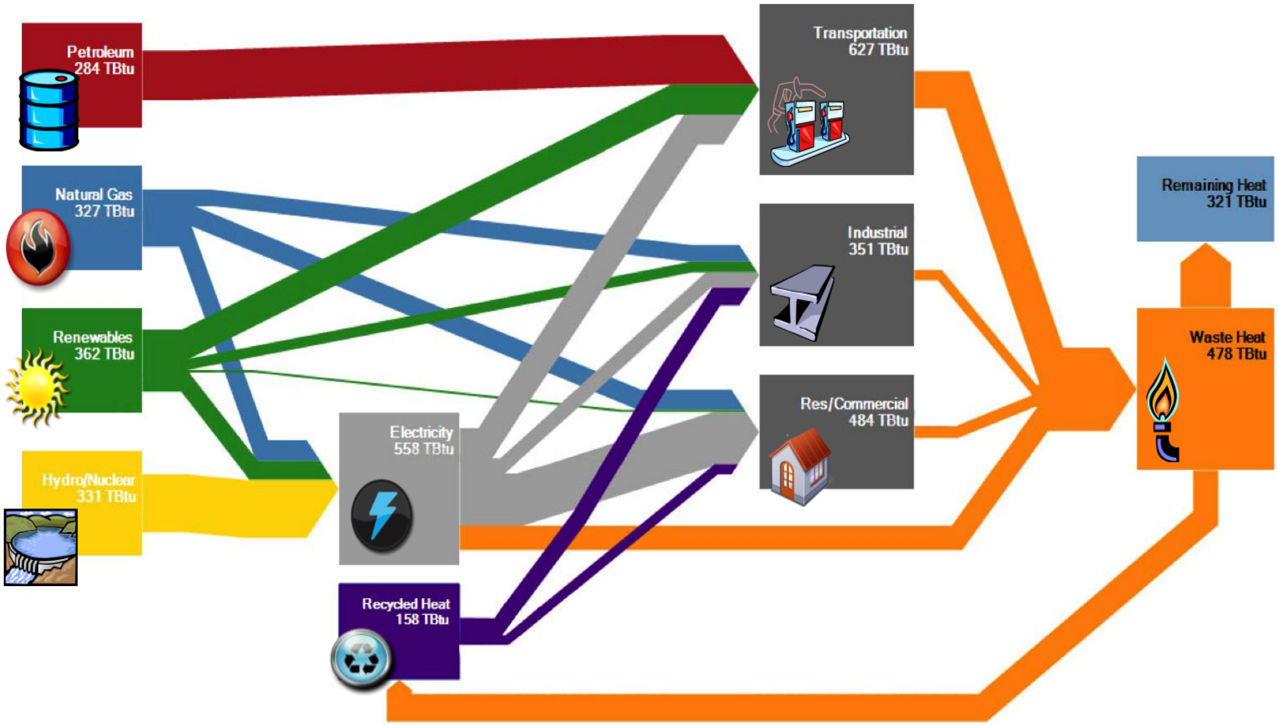

Figure 4. Energy flows in Washington in 2035 if all natural gas combustion employs CHP and/or district energy, fuel oil heating is eliminated, renewable sources produce 20 percent of electricity by 2035, full vehicle electrification and efficiency improvements to hydroelectric dams.

Scenario 3 requires quadrupling the amount of energy produced by renewable sources, as a direct result of full vehicle electrification. In this scenario, approximately half of the energy demand for electric vehicles comes from off-grid renewable charging stations, while the other half comes from grid-connected electric charging stations. The increase in electricity demand from the transportation sector of 172 TBtu is largely offset by efficiencies achieved through CHP and district energy systems. As a result total electricity demand only increases by 22 TBtu, or about 4 percent, from 2009. Scenario 3 demonstrates that vehicle electrification does not required substantial expansion to the grid, if it is pursued in concert with recycled heat utilization.

It is important to note that transportation energy demand will likely decline with passenger vehicle electrification because electric vehicles achieve far greater efficiencies than internal combustion vehicles. Electric vehicle technology is expected to improve significantly by 2035, but is difficult to forecast. Therefore transportation demand was held at the same level as Scenarios 1 and 2. Many of the recommendations in the State Energy Strategy address transportation behavior through mass transit investment and pricing mechanisms. Vehicle electrification was chosen for this report because it holds the greatest potential for emissions reductions.[37] The increased efficiency of Washington's hydroelectric dams was not included in Scenarios 1 or 2 because it requires federal investment.

Taken as a whole, Scenario 3 reduces greenhouse gas emissions by over 40 percent by 2035, shattering the state goal of 20 percent by 2035 (Table 6). Total primary energy demand is 238 TBtu lower in Scenario 3 compared to 2009, due to the increased generation and transportation efficiencies.

Table 6. Scenario 3 Energy System Changes from 2009 to 2035

	Change in Energy Consumption (TBtu)	Change in CO2 (MMTCE)
Petroleum	-402	-28,628,036
Natural Gas	+8	+424,563
Coal	-84	-7,810,863
Renewables	+227	0
Hydropower/Nuclear	+13	0
Recycled Heat	+158	0
Total	**-238**	**-36,014,336**

Although the outcomes described in this scenario are ambitious they are also achievable through aggressive and comprehensive renewable energy development (Table 7). Due to the natural limit in biomass resources, bioenergy accounts for 20 percent of the increase in renewable energy, compared to 35 percent in the other scenarios. Solar makes up a larger proportion of renewable development, due to the distributed generation demands for vehicle electrification. Wind produces 45 percent of the increased generation, tidal produces 7 percent, and ground-source heating produces 3 percent.

[37] The remaining petroleum in Scenario 3 is consumed by aviation, rail, shipping and other heavy transportation.

Table 7. Scenario 3 Increases in Energy Production		
	Generation (TBtu)	**Capacity (MW)***
Wind	102	11,375
Bioenergy	45	1,882
Solar	57	9,535
Tidal	16	1,784
Ground-source	8	1,171
Hydropower	13	875
Total	**227**	
Utility CHP	46	1,924
Industrial CHP	66	2,760
District Energy	46	1,710
Total Reused Heat	**158**	

*Calculated using the Capacity Factors listed in Table 1.

POLICY OPTIONS

The three scenarios described above describe a vision of Washington's energy future for the year 2035 that utilizes waste heat and reduces primary energy demand. A few key changes to our energy landscape can make significant headway in reducing greenhouse gas emissions while improving the efficiency of our energy consumption. The report now turns to the various policy pathways that enable this vision to take place. The following policy recommendations are complimentary to those in the State Energy Strategy and are intended to provide a menu of options that will help achieve the three scenarios.

Combined Heat and Power (CHP)

The most critical outcome of the three scenarios is ensuring that all natural gas combustion employs CHP systems to utilize recycled heat. CHP technology is mature and widely deployed in other parts of the country, but policy is needed in Washington to overcome barriers such as cheap electricity rates and interconnection costs.

1. Expand the output-based emissions performance standard

Washington currently has an output-based emissions standard (RCW 80.80.040), where all new electric generating resources, including those under long term contract, are required to meet a greenhouse gas emission performance standard equal to the industry average for natural gas combined cycle facilities. Expanding the output-based emissions standard beyond base-load generating facilities to include all grid-connected, non-emergency generating facilities would greatly accelerate the deployment of CHP technology. Broadening the use of output-based emissions standard for non-utility generating facilities would result in CHP deployment in the industrial sector as well.

2. Create Energy Conservation Credits

Under the Energy Independence Act, regulated utilities are required to "pursue all available conservation that is cost-effective, reliable and feasible." The utilities must develop aggressive conservation goals and targets, and are allowed to count high-efficiency cogeneration (CHP) for a retail customer toward those targets. The creation of Energy Conservation Credits would expand the pool of conservation resources by allowing more customers to contribute to conservation targets. Similar to Renewable Energy Credits (RECs), which can be produced and sold by utility and non-utility energy generators alike, Energy Conservation Credits would create additional market value for certified energy conservation projects.

Because Energy Conservation Credits broaden the pool of available conservation resources, the Energy Independence Act should be modified to include conservation targets.

3. Require utilities to consider CHP and District Energy in Integrated Resource Plans (IRPs)

Under RCW 19.280.030, utilities are required to complete Integrated Resource Plans that "explain the mix of generation and demand-side resources they plan to use to meet their customers' electricity needs in both the short term and the long term." These plans may include high efficiency cogeneration (CHP), but do not require inclusion of CHP and district energy potential. Requiring utilities to consider CHP and district energy resources in the planning process would help shift the focus from building new generating capacity to using energy more efficiently.

4. Adjust process for setting standby rates for CHP systems

Utility customers with onsite generation typically require electricity from the grid, sometimes at variable levels. As a result, utility companies must have additional capacity to meet the maximum demand from these customers and are charged as a 'standby-rate'. Utilities typically charge standby rates to cover the cost of maintaining additional resources. The U.S. Environmental Protection Agency (EPA) has found that most states, including Washington, do not have standby rate structures that value the costs and benefits of CHP systems.[38, 39] The American Coalition for an Energy Efficient Economy (ACEEE) has found that best practices for standby rates include: rates weighted toward energy charges rather than demand charges; demand charges based on the probability of an emergency outage at a CHP facility coinciding with a period of peak grid demand; and elimination or limitation of demand ratchets.[40]

5. Require waste heat utilization at industrial facilities

One of the policy drivers in Denmark that led to widespread industrial deployment of CHP and district energy technology was a requirement that all industrial facilities utilize waste heat. Adopting a similar requirement in Washington could include recycling waste heat from industrial operations, using district energy to provide heating and/or cooling to industrial buildings, and installing CHP engines on generation equipment. While this is a more direct mechanism for recycling waste heat than many of the other policy options mentioned in this report, it proved highly effective in not only reducing industrial waste heat, but also shifting the organizational values of industrial companies in Denmark toward sustainability and waste management.

6. Convene a CHP working group

As CHP technology is further deployed in Washington State, new barriers and obstacles may emerge. The Department of Commerce should convene a CHP working group to identify barriers to deployment, share best practices and develop further recommendations for state action to support CHP deployment in target markets.

District Energy

Due to cheap electricity, electric resistance heating has become the standard for new building construction, despite the fact that district energy can provide building owners and tenants with more reliable and lower cost heating. Policy support is needed to support investment in district energy systems in favor of the current industry standard of electric heating. Local governments have a major role in supporting district energy and the International District Energy Association (IDEA) and National Trust for

[38] http://www.epa.gov/chp/documents/standby_rates.pdf
[39] http://www.epa.gov/chp/state-policy/utility.html
[40] http://aceee.org/sector/state-policy/toolkit/chp/standby-rates

Historic Preservation have excellent resources for local policy-makers.[41] There are several key state actions that will encourage greater investment in district energy systems.

7. Allow utilities to rate-base investments in district energy

District energy systems provide customers with lower energy rates over time, but most of the costs are in the initial construction. Therefore, authorizing the Utilities and Transportation Commission to allow utilities to recover the cost of district energy construction will help spread out the cost over time and reduce the financial risk to utilities.

8. Include district energy consideration in the Evergreen Sustainable Development Standard

The Evergreen Sustainable Development Standard (ESDS) is a building performance standard required of all affordable housing projects or programs that receive capital funds from the Housing Trust Fund. Projects receiving ESDS funds are required to meet energy efficiency and heating and cooling standards. The ESDS should require evaluation of district energy compatibility for the housing projects supported the Housing Trust Fund. Some sites will be compatible with district energy, whereas others will not be. Regardless, requiring an assessment of district energy compatibility will help familiarize project developers with district energy systems.

9. Provide guidance for county and local government to develop Heat Zones for planning

The State can assist local governments in planning for district energy systems through support and guidance on creating Heat Zones for local development. Heat Zones can be used to site industrial and commercial facilities with high thermal loads near facilities that generate useful thermal energy. This facilitates the development of district energy systems by locating thermal sources near thermal consumers. Additionally, it provides incentive for facilities with high thermal needs to locate in a particular city. The Department of Commerce should develop model guidelines from local governments to create Heat Zones and help simply permitting requirements.

10. Update State Energy Code to support district energy

The Washington State Residential and Non-Residential Energy Codes will incrementally require efficiency improvements in new buildings and building modification. Although district energy systems are more energy efficient that electric baseboard heating and individual furnaces, the efficiency standards in the State Energy Codes only set efficiency standards for heating technologies. The standards should be updated to increase the efficiency required of electric resistance heating compared to hydronic (district energy) systems.

11. Convene a District Energy working group

As cities around the state explore and invest in district energy, there is a distinct need for coordination and sharing best practices. This type of communication should not be limited to cities in close proximity

[41] http://districtenergy.org/assets/pdfs/White-Papers/CommEnergyPlanningDevelopandDelivery2.pdf and http://www.preservationnation.org/issues/sustainability/green-lab/additional-resources/District-Energy-Long-Paper.pdf

to each other. The Department of Commerce should convene a district energy working group that involves city planners, private developers and utilities to identify barriers to deployment, share best practices and develop further recommendations for state action to support district energy development.

Fuel Oil

The key difference between scenarios 1 and 2 is that fuel oil heating is eliminated from the industrial, residential and commercial sectors. Although the relative high cost of oil compared to natural gas, electricity and district heating will likely reduce new installations that use fuel oil, phasing out existing petroleum-based heating systems will require policy action.

12. Establish output-based performance standards for industrial facilities

As discussed above, broadening the use of output-based emissions standard for non-utility generating facilities would result in CHP deployment and the reduction of petroleum fuels for industrial processes. Like the existing standard for base-load generation facilities, an industrial standard could be phased in to apply to new construction and to major equipment modifications. As facilities replace or upgrade equipment, petroleum fuels would be gradually eliminated from the industrial sector.

13. Update State Energy Codes to phase out fuel oil heating for new buildings

The Washington State Residential and Non-Residential Energy Codes will incrementally require efficiency improvements in new buildings and building modification. Natural gas furnaces, electric resistance heating and district heating are all more efficient and produce lower emissions than fuel-oil heaters. The State Energy Codes should phase out all fuel oil heating, because efficiency improvements to fuel oil heaters will not be sufficiently cost-effective to reduce greenhouse gas emissions and other pollutants.

14. Require retrofits when buildings change owners

While updates to the State Energy Code would take effect when there are major equipment modifications, another option to reduce fuel oil heating is through requiring equipment upgrades when buildings undergo a change in ownership. The cost of upgrading the heating system can be integrated into the selling price of the building, reflecting the increased value from more efficient and less polluting heating.

15. Require disclosure of building energy consumption, cost and fuel mix

The City of Seattle passed an ordinance requiring all buildings of a certain size to benchmark and report their energy performance. This information will allow for comparison between similar buildings and can inform decision-makers regarding purchasing, leasing or financing the buildings. A similar requirement should be adopted statewide to ensure that the energy performance, including the fuel mix, of our state's largest buildings is public knowledge.

Distributed and Renewable Energy

Some policy vehicles to help achieve the 2035 scenarios are not technology-specific and apply to distributed energy as a whole. Although existing policies require 15 percent of electricity to come from renewable sources by 2020, the increase in electricity demand due to transportation electrification will require additional policy support to deploy the needed scale of renewable technologies.

16. Revise distributed generation interconnection rules

The Utilities and Transportation Commission (UTC) sets interconnection requirements for generating facilities with a nameplate generating capacity of less than 300kW and for generating facilities greater than 300kW and less than 20MW (WAC 480-108), however, the existing categories are insufficient to fully promote the development of distributed energy systems, including combined heat and power. The UTC should adopt a three-tiered approach that addresses systems with nameplate generating capacity less than 25kW, greater than 25kW but less than 2MW, and greater than 2MW. Net metering policies should be consistent with these tiers, to simplify the approval process. Additionally UTC should convene a stakeholder group to identify priorities for updating the interconnection rules, address new technologies and develop recommendations for the interconnection rule.

17. Include thermal energy in state financial incentives

Many financial incentives for distributed energy exist, but most of them focus on electricity generation or specific technologies.[42] Incentives could include tax credits, exemptions or reductions; guaranteed or low-interest loans; grants or direct subsidies; and research, development and demonstration funding.

18. Establish a Transmission and Distribution Avoidance Credit

Line losses along high-voltage transmission lines are a real source of wasted energy. A 2010 Carnegie Mellon Study found that 1MW of distributed generation can displace 1.2 to 2.25 MW of grid-connected generation, depending on siting.[43] As utilities seek to meet their conservation goals, they should be given credit for reducing transmission losses. This could take the form of a multiplier for distributed generation that is applied toward conservation goals.

19. Require BPA to give priority to district energy systems to absorb surplus electricity before exporting it

In recent years, negative pricing situations have resulted in lost revenue and inefficient management of renewable energy resources. District energy systems are fuel flexible and can provide thermal energy storage during times of surplus electricity production. The Bonneville Power Administration is responsible for managing the Northwest transmission system and has the authority to shut down certain generating

[42] See page 138 of the State Energy Strategy for an overview of distributed energy incentives. For a more detailed description of the incentives see: http://dor.wa.gov/content/findtaxesandrates/taxincentives/incentiveprograms.aspx#Energy

[43] Nazari, M.H. October 2010 "Enhancing Efficiency and Robustness of Modern Distribution Systems" Carnegie Mellon Departments of Engineering & Public Policy and Electrical & Computer Engineering.

facilities or export excess electricity. Federal action would be necessary to require BPA to offer surplus electricity to in-state district energy systems before exporting electricity to other states. This change would take advantage of intermittent renewable energy resources that are currently being wasted.

Transportation

Reducing waste heat, and therefore lowering primary energy consumption and greenhouse gas emissions, from the transportation sector is one of the most effective ways to improve the performance of Washington's energy system. Scenario 3 illustrates the emissions reduction potential of full electrification of motor vehicles, which will require strong commitment from state policymakers. Because the electric vehicle market is emerging, many of the policies described in the State Energy Strategy will assist electric vehicle deployment in the short-term, including: investing in electric vehicle charging stations; streamlining permitting for charging stations; and financial incentives for electric vehicle purchases and private charging station investment. Further studies into system reliability and infrastructure changes are needed to determine long-term policy recommendations.

CONCLUSION

In order to meet the greenhouse gas emissions reductions as required by law (RCW 70.235.020), Washington policymakers need to consider the full range of clean energy resources. The State Energy Strategy provides a solid foundation of policy actions related to transportation, building efficiency and distributed energy. The cumulative impact of those policies is uncertain. Instead of building a strategy based on policies to see how far they get us, the State should begin with a vision of its energy future and identify the necessary policies and projects to reach that vision.

This report outlines three visions for Washington's energy system in 2035 based on utilizing wasted thermal energy, heat. The simplest of those visions achieves 72 percent of the emissions reductions needed by 2035, simply by capturing and recycling the waste heat from natural gas combustion. The most ambitious vision achieves 189 percent of the 2035 emissions reduction goal, comprehensively transforming the state energy system and our air emissions profile.

Committing to using clean energy technologies will not only reduce our impact on the climate, but diversify our energy supply, keep energy spending in the state economy, spur job creation, and create a world-class business environment. That future is achievable, but it requires state action and leadership to make it a reality.