

Appendix A – 2017 Sustainability Inventory

This Appendix presents key data snapshots from Sound Transit's 2017 Annual Sustainability Progress Report and identifies patterns of resource use compared to earlier years of performance. The report provides a snapshot of performance data in 2017 as well as performance data trends over the last five to seven years.

Sound Transit has made a number of valuable improvements to the quality and sustainability of its service over time.

- As the Central Puget Sound regional population and Sound Transit services increased, ridership continued to grow. Passenger miles traveled (PMT) across all modes increased by 5 percent in 2017.
- Total resource use at Sound Transit has generally increased, though there are some reductions in fleet fuel and electricity use when normalized by PMT. The increase is a result of overall expanded service and ridership, along with increased staff at the agency
- Greenhouse gas emissions per PMT have decreased slightly since 2016, though it is worth noting the increase in the carbon intensity of Sound Transit's electricity use. This increase is due in large part to more electricity usage at sites located in Puget Sound Energy's service territory, such as Angle Lake Station.
- Sound Transit has significantly decreased air pollution from Sound Transit operations, including a 17 percent reduction in volatile organic compounds (VOCs), a 17 percent reduction in carbon monoxide (CO), and 14 percent reduction in particulate matter (PM) since 2016. These reductions are primarily a result of ST Express service utilizing newer CNG buses.

Additional key findings in resource use and efficiency include the following:

- Fleet energy use decreased by 24 percent per PMT since 2011.
- Water use decreased by 4 percent per PMT since 2011.
- Waste diversion increased to 43 percent, up from 27 percent in 2010.

Understanding the data

This document illustrates resource use trends over time from baseline years (2010 or 2011, depending on data) and the preceding inventory year, 2016. In the following graphs, solid bars indicate total emissions, resource use, and resource costs. The trend lines show the resource use per passenger mile traveled over time.

Using National Standards

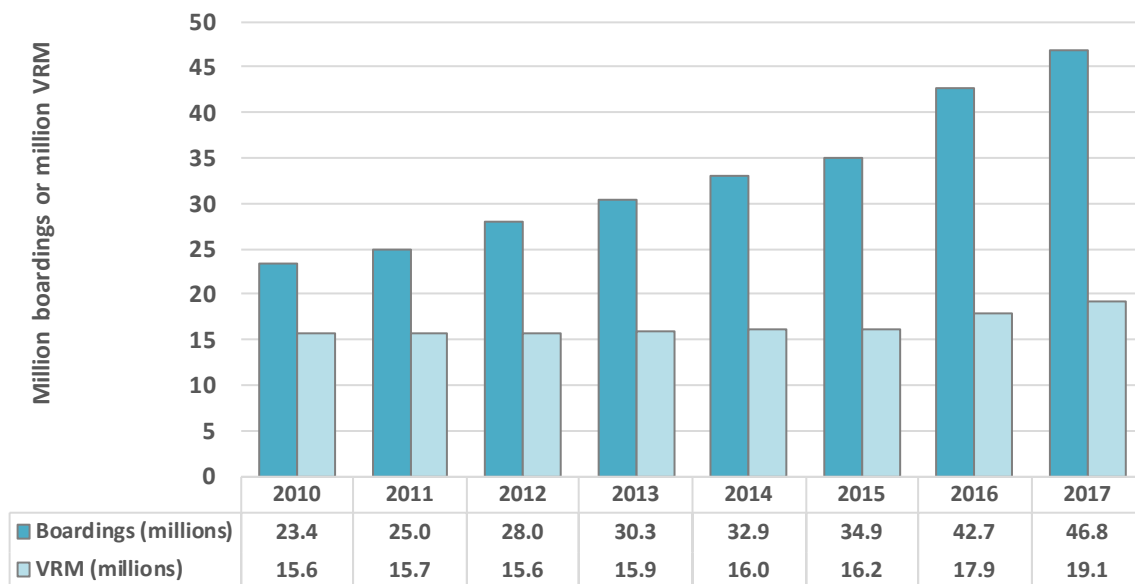
Sound Transit and the other signatories of the American Public Transportation Association (APTA) Sustainability Commitment use a standard set of metrics developed by APTA to measure annual progress. Passenger miles traveled represents both a measure of boardings and vehicle revenue miles, tracking both growth in service and increases in ridership. Using passenger miles traveled to normalize data allows Sound Transit to compare resource use over time using a single, consistent metric. Therefore, this report normalizes by PMT in nearly all cases. Non-revenue fleet. However, is normalized by employees as usage is tied more closely to staff levels than ridership.

Ridership

- Since 2010, ridership (measured in boardings) has grown by 100 percent.
- From 2016 to 2017, ridership grew by nearly 10 percent.

Ridership has increased every year, growing by 100 percent since 2010 and reaching nearly 47 million boardings (unlinked passenger trips) in 2017. Meanwhile, the level of service, measured by vehicle revenue miles (VRM), has increased by nearly 23 percent over the same period. This difference in growth in service and ridership demonstrates that more people are using Sound Transit service every year. Figure 1 below shows the increasing trend of boardings per mile of service.

Figure 1. Ridership, 2010-2017



Measuring Efficiency

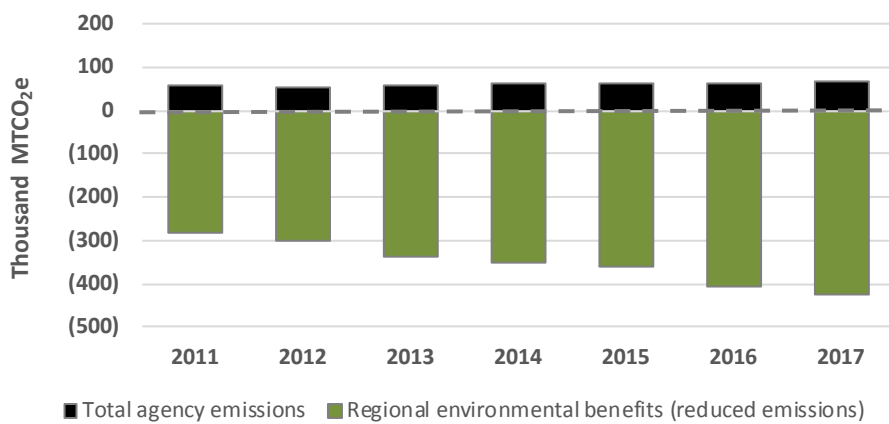
Ridership has important implications for resource use; as the agency grows and serves more passengers, total resource use is expected to increase. To understand the efficiency of its operations as the agency grows, Sound

Transit tracks resource use normalized by passenger boardings, vehicle revenue miles, and passenger miles traveled.

Regional Environmental Benefit

Increased transit reduces regional environmental impacts. As more people choose transit over driving, fuel and greenhouse gas (GHG) emissions are saved throughout the region. Greenhouse gas emissions savings are a measure of the regional environmental benefit produced by transit. Sound Transit follows a methodology developed by APTA and The Climate Registry to account for savings from transit ridership, measured in carbon dioxide equivalents (CO₂e), as shown in Figure 2 and Table 1. Greenhouse gas emissions can also serve as a proxy for fuel use savings.

Figure 2. Regional Greenhouse Gas Emissions (CO₂e) Savings from Sound Transit, 2011-2017



As seen in Figure 2 above and Table 1 below, Sound Transit saves more GHG emissions than it emits. For every ton of GHG emissions Sound Transit emitted in 2017, the region avoided 6.4 tons of emissions through the benefits of transit. The regional environmental benefits shown in Figure 2 (in green) include the benefits from people taking transit instead of driving (mode shift) and reduced emissions associated from denser land use patterns supported by transit; these benefits have consistently been between four and seven times the agency's emissions (in black) since 2011.

The definitions for each of the identified types of benefits are:

- **Mode shift benefits** measure the reduced greenhouse gas emissions (amount displaced) resulting from shifting from one mode of transportation (e.g., single occupancy vehicle) to another (e.g., transit), measured on a per-passenger-mile (PMT) basis.
- **Land use change benefits** measure the reduced carbon outputs due to the denser land use patterns supported by transit systems.

Table 1. Regional Greenhouse Gas Emissions (CO₂e) Savings from Sound Transit, 2017

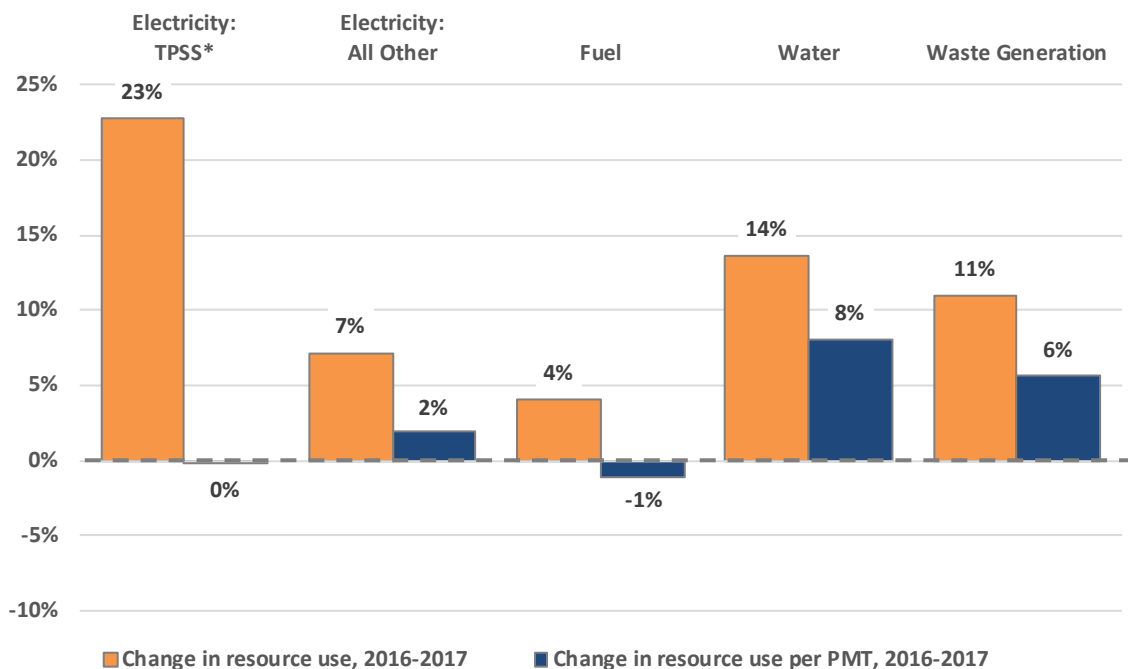
Regional metric tons CO ₂ e Saved		
Mode Shift Benefits	Land-Use Benefits	Total Benefits
116,998	308,492	425,490
Displacement ratios - CO ₂ e units saved in the region per unit of CO ₂ e from Sound Transit operations		
Mode Shift Benefits	Land-Use Benefits	Total Benefits
1.8	4.7	6.4

Note: Totals do not sum due to rounding. Due to revised APTA GHG methodology guidelines – congestion relief is no longer included in displacement calculations.

Resource Use

Overall resource use has been increasing over time, reflecting Sound Transit's expanded system and services. Most increases in resource use have been in line with service changes and ridership increases as well as operational equipment changes, as described further in the sections below. Figure 3 below shows the change in total resource use from 2016 to 2017, as well as resource use normalized by PMT. Remaining figures show trends in specific resource categories over time.

Figure 3. Change in Resource Use, 2016-2017



Note: Electricity: TPSS is normalized by Link PMT, as TPSS is exclusively associated with the Link line of business. All other resource categories are normalized by total agency PMT, as they span multiple lines of business.

Fleet Energy Use

- Since 2011, total fleet energy use has grown by 16 percent but decreased 24 percent per PMT.
- From 2016 to 2017, fleet energy use grew by 5 percent but has been stable (less than 1 percent increase) per PMT.

Fleet energy use across Sound Transit's three modes—ST Express bus, Sounder commuter rail, and Link light rail—has been increasing slowly over time as more service has been provided. However, service has become more efficient per passenger and PMT, as the system ridership has grown significantly faster than level of service (VRM).

- Traction power electricity use for Link light rail grew by 70 percent since 2011, and increased by 23 percent from 2016 to 2017 due to increased vehicle mileage from additional service;
 - Link light rail energy use is greatly impacted by cooling degree days. 2017 was 17% colder than 2016.
- Diesel fuel for Sounder commuter rail and ST Express buses increased by 21 percent and 6 percent since 2011, respectively; and compressed natural gas (CNG) use in ST Express buses has increased by 68 percent over the same timeframe.
 - Sounder fuel use has historically varied with changes in weather, as Sounder trains idle when the outside temperature is below 40 degrees F.
 - In 2017, winter weather was colder than the previous year.
 - While CNG has increased significantly since 2011, CNG is a less common fuel source compared to diesel; in 2017 CNG was 9 percent of ST Express energy use (in MMBTU).

Figure 4 below shows the trend in fleet fuel use over time. Table 2 below shows the percent change in energy use from 2016 to 2017 per mode, as well as the percent change in efficiency (fuel use normalized by PMT for each mode).

Figure 4. Revenue Fleet Energy Use, 2011-2017

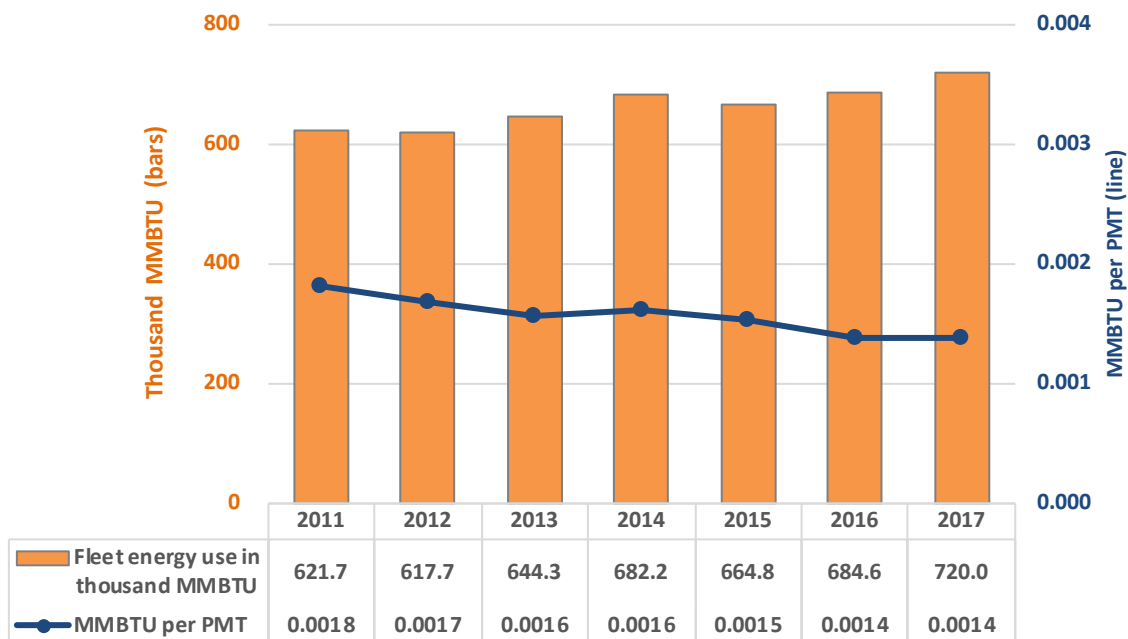


Table 2. Change in Energy Use by Mode, 2016-2017

Mode	% Change in Total Energy Use	% Change in Energy Use per PMT
Sounder commuter rail	8%	4%
ST Express buses	2%	5%
Link light rail traction power (electricity)	23%	0%

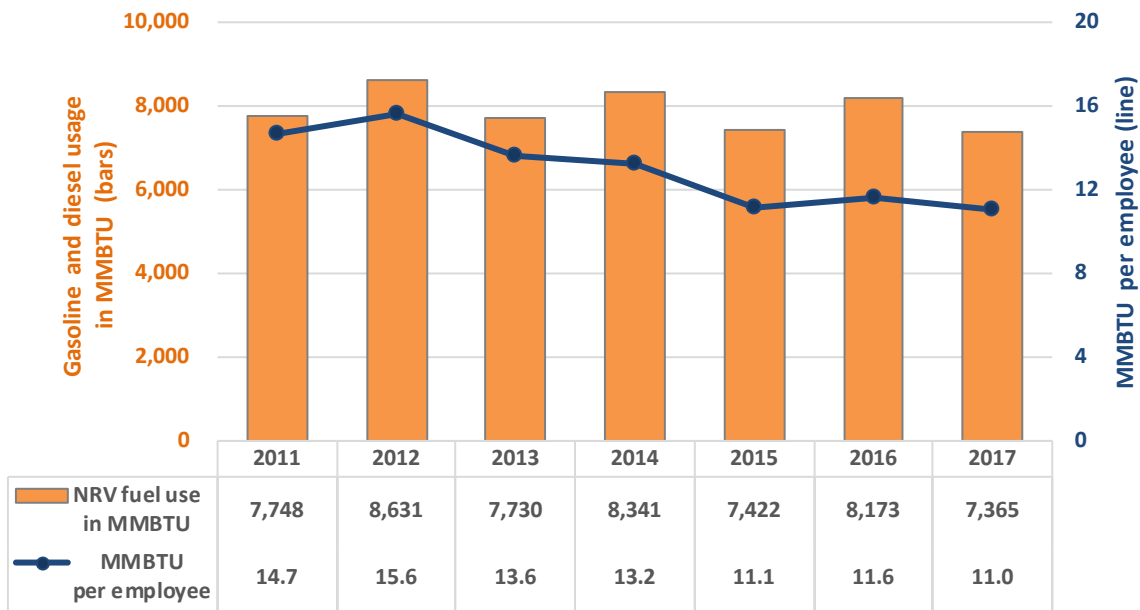
Note: Mode energy use is normalized by PMT for each mode.

Non-Revenue Fleet Energy Use

- Since 2011, non-revenue fleet energy use has decreased by 5 percent overall and by 25 percent per employee.
- From 2016 to 2017, non-revenue fleet energy use decreased by 10 percent overall and by 5 percent per employee.

Energy use for the agency's non-revenue fleet has remained relatively stable over time, though it has fluctuated from year to year, as shown in Figure 5. Non-revenue fleet energy use was 5 percent lower in 2017 than in the 2011 baseline year. While the agency's headcount has increased every year, contributing to more driving, Sound Transit has also purchased more hybrid vehicles, helping to reduce per-mile and per-employee energy use and air pollutant emissions. The agency also encourages carpools and use of transit options whenever feasible.

Figure 5. Non-Revenue Fleet Energy Use, 2011-2017



Facility Energy Use

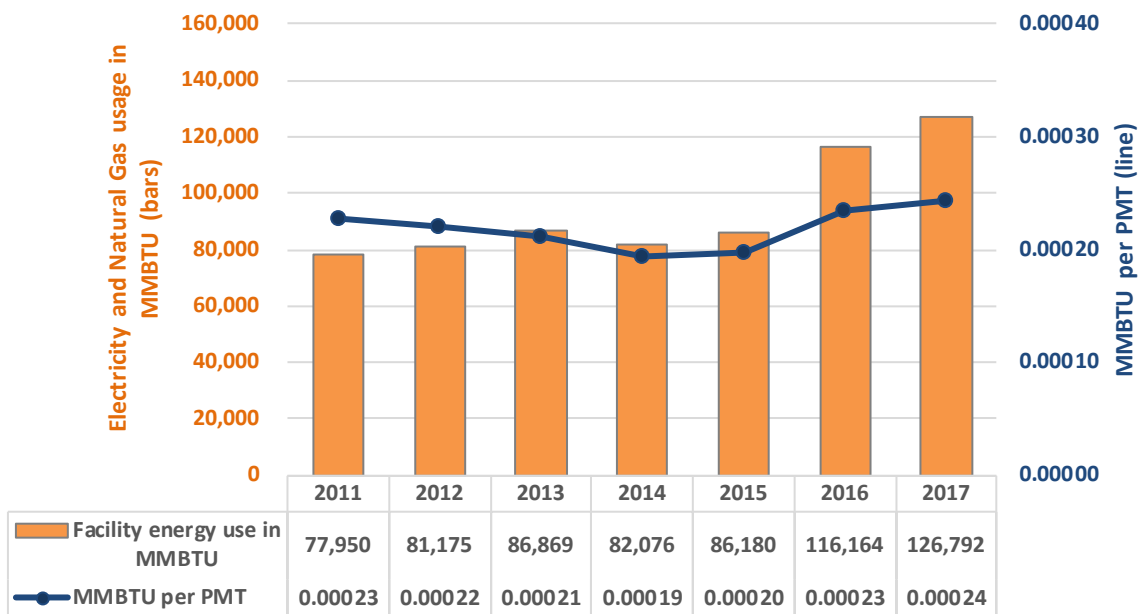
- Since 2011, total facility energy use has grown by 63 percent and 7 percent per PMT.
- From 2016 to 2017, facility energy use increased by 9 percent and 4 percent per PMT.

Facility energy use has increased 63 percent since 2011, as the agency has increased its staff as well as brought many new stations and facilities online, including the Capitol Hill, University of Washington, and Angle Lake Link light rail stations in 2016. Further development of the Mukilteo station in 2016, with a second platform, additional elevators, and a new pedestrian bridge, added to energy loads. Energy use at Sound Transit facilities, shown in Figure 6, is also dependent on weather. The drop in 2014 was due to reduced heating needs during winter, as well as efficiency upgrades and improved operational practices. Colder winter weather during 2017, contributed to increased facility energy use – 2017 showed 17% more cooling degree days than 2016.

From 2016 to 2017, facility electricity use – a large driver of energy use – varied by line of business. Sounder and ST Express facilities decreased usage by 1 percent and 9 percent, respectively. Link light rail facility electricity increased by 6 percent due to a full year of service at Angle Lake Station, which includes a large, multi-story parking garage.

Additionally in 2017, solar panels at Angle Lake Station generated 74,320 kWh of electricity.

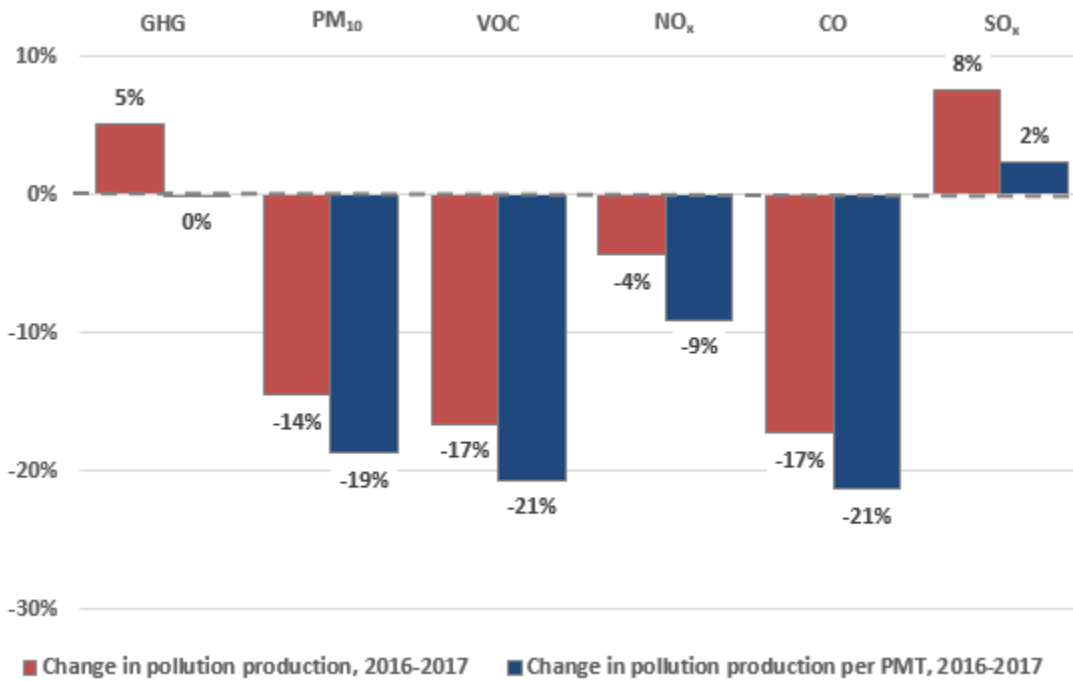
Figure 6. Facility Energy Use, 2011-2017



Air Pollutant Emissions

Sound Transit's air pollutant emissions result from its fuel and electricity consumption. The sections below show the trends in GHG emissions and criteria air pollutant production. Figure 7 below shows the overall percent change and the change normalized per passenger mile traveled (PMT) for pollution sources from 2016 to 2017. As noted above, PMT increased by 5 percent from 2016 to 2017.

Figure 7. Changes in Pollution Production, 2016-2017

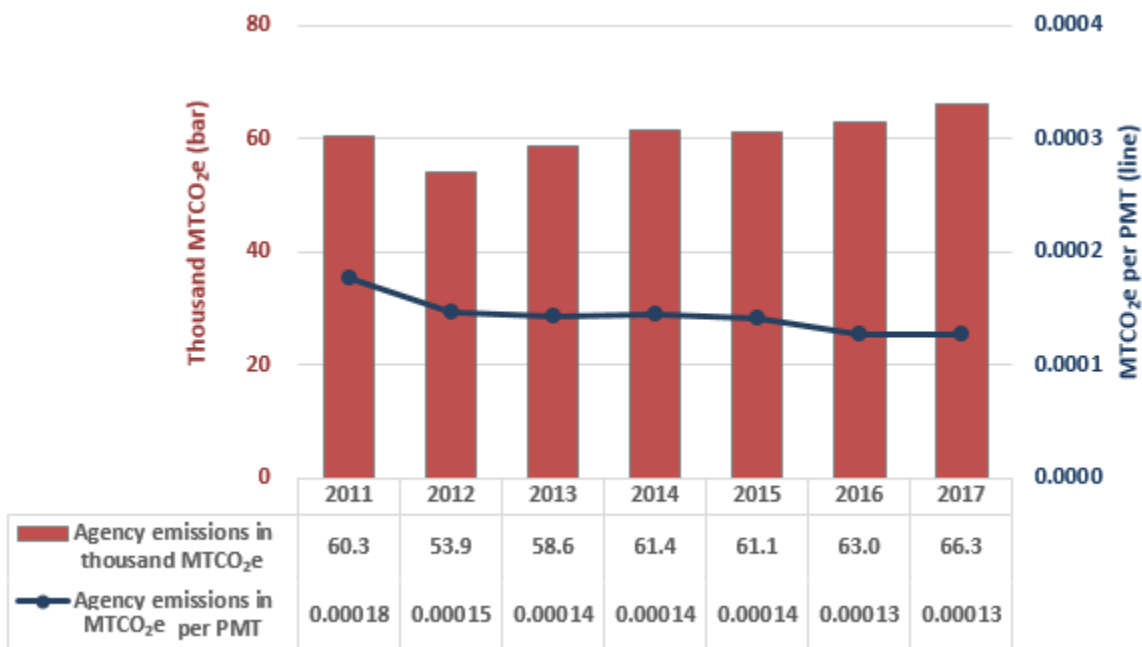


Greenhouse Gas Emissions

- Since 2011, total GHG emissions have grown by 10 percent but decreased by 27 percent per PMT.
- From 2016 to 2017, total GHG emissions grew by 5 percent but were stable (less and 1 percent decrease) per PMT.

As service and ridership have increased, total agency GHG emissions have remained relatively stable since 2011 and have been declining on a normalized basis, as shown in Figure 8. GHG emissions associated with facility natural gas usage, while a small portion of Sound Transit's overall footprint, increased by 34 percent. This increase is largely due to greater heating needs during the colder winter as well as increased usage at Maintenance of Way facilities. GHG emissions associated with Link Light Rail have increased 86 percent since 2011 but decreased by 23 percent per PMT.

Figure 8. Agency GHG Emissions, 2011-2017 (thousand metric tons of carbon dioxide equivalents, MTCO₂e)



Criteria Air Pollutants

- Since 2011, criteria air pollutant (CAP) emissions have decreased by the following amounts:
 - PM₁₀ decreased by 53 percent in total and 69 percent per PMT.
 - VOCs decreased by 64 percent in total and 76 percent per PMT.
 - NO_x decreased by 41 percent in total and 61 percent per PMT.
 - CO decreased by 79 percent in total and 86 percent per PMT.
 - SO_x increased by 19 percent in total and decreased 21 percent per PMT.
- From 2016 to 2017, CAP emissions changed by the following amounts:
 - PM₁₀ decreased by 14 percent in total and 19 percent per PMT.
 - VOCs decreased by 17 percent in total and 21 percent per PMT.
 - NO_x decreased by 4 percent in total and 9 percent per PMT.
 - CO decreased by 17 percent in total and 21 percent per PMT.
 - SO_x increased by 8 percent in total and 2 percent per PMT.

Criteria air pollutants—including particulate matter (PM₁₀), volatile organic compounds (VOCs), nitrogen oxides (NO_x), carbon monoxide (CO), and sulfur oxides (SO_x)—contribute to smog and health issues such as asthma and heart attacks. Sound Transit’s CAPs have declined over the past several years, in many cases significantly. This decrease is primarily driven by a shift from diesel to CNG in the bus fleet and fleet turnover. Over time, older, less efficient vehicles are used less, newer vehicles with better emissions control technologies make up a larger percentage of the agency’s fleet and vehicle miles. The agency has also worked to overhaul Sounder commuter rail engines to reduce air pollution.

Figures 9 and 10 below show the decrease in total PM₁₀ and CO production over time as well as the decrease per PMT since 2011. These criteria air pollutants were down 64 percent and 79 percent overall since 2011, respectively. These reductions are even more dramatic per PMT. The noticeable drop in CO emissions between 2015-2016 and then 2016-2017 is primarily due to phasing out model year 2001 CNG buses. As technology has improved, the CO emissions per mile for CNG buses has dropped dramatically. From 2012-2015 the 2001 CNG buses contributed about 80 percent of total inventory CO emissions. The mileage usage of the 2001 CNG buses stepped down in 2016, and was then eliminated in 2017. This accounts for the large drop in CO emissions in those years.

Figure 9. Particulate Matter (PM₁₀), 2011-2017

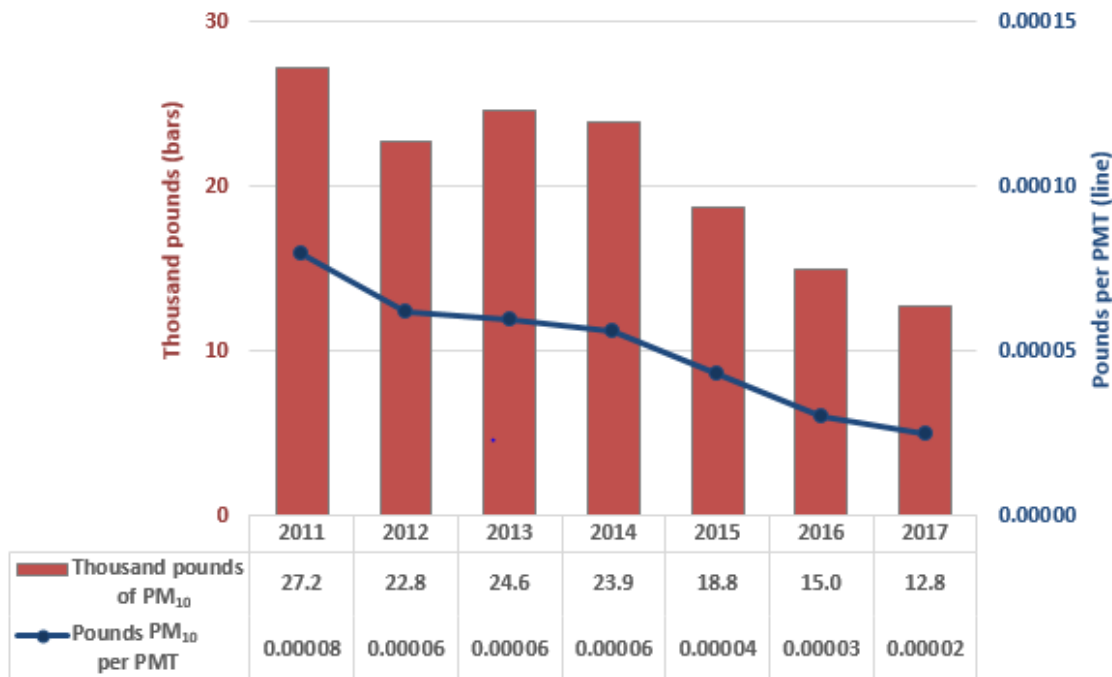
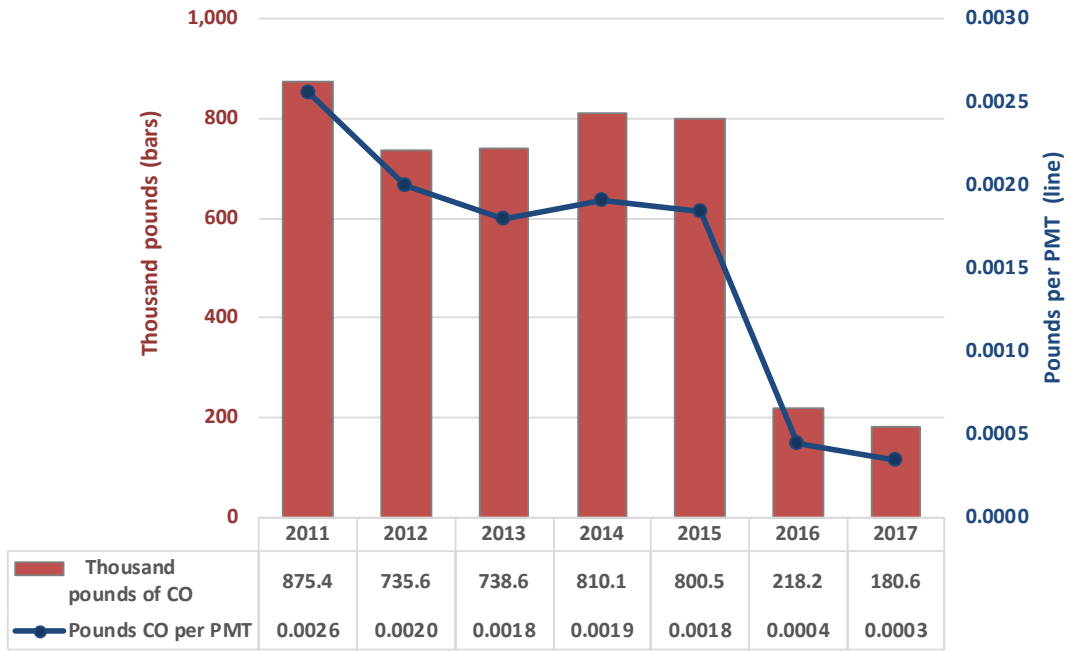


Figure 10. Carbon Monoxide (CO), 2011-2017



Water Use

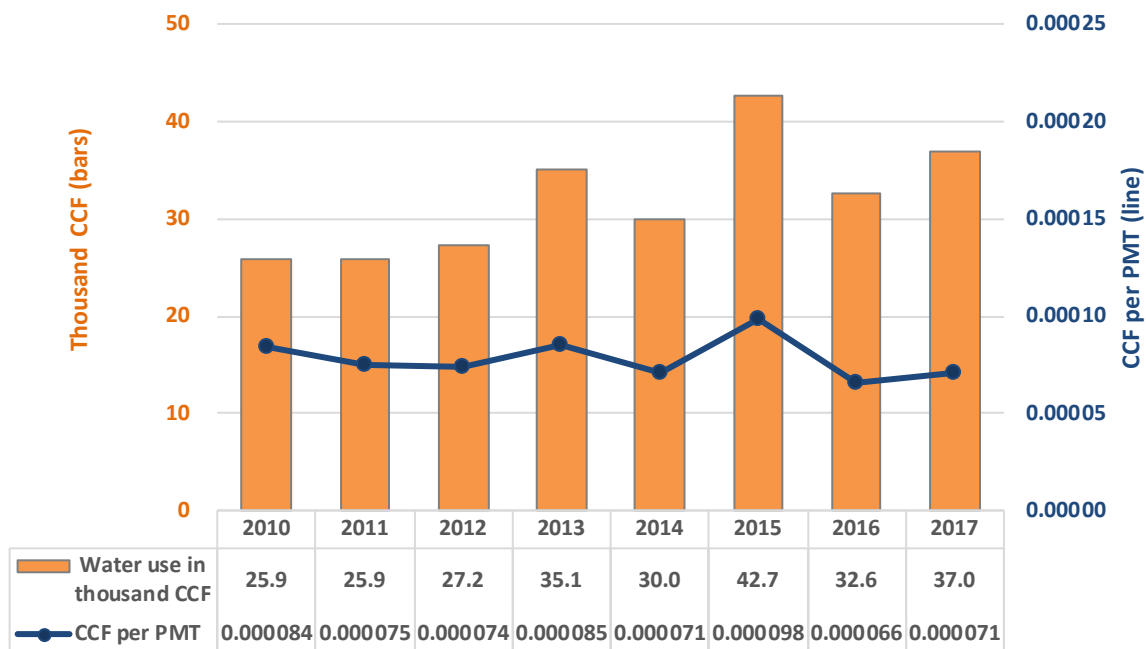
- Since 2010, water use has grown by 43 percent in total but decreased by 15 percent per PMT.
- From 2016 to 2017, water use increased by 14 percent in total and 8 percent per PMT.

Water use overall has increased 43 percent since 2010 with increased agency headcount and expanded service, although water use for various functions has fluctuated considerably. This is an area that the agency will continue to monitor closely to better manage water resources and understand the fluctuating trends.

- Water use at customer facilities has generally grown over time, and the increases in 2013 and 2015 were substantial. Customer facility water use is largely driven by landscape irrigation, and the drought conditions of summer 2015 and a drier summer in 2013 led to much higher water use.
- Water use also varies depending on the maturity of landscaping vegetation, with new plants requiring more water. In 2014, water use decreased as several large leaks were repaired, landscaping plants at several facilities reached maturity, and a rain sensor was installed at Union Station. Usage increased again in 2015, however, due to drought, a leak at SODO station, and the addition of new facilities with young landscaping.
- Water use, not counting property management, increased by 14 percent between 2016 and 2017, driven by increases in use at administrative and maintenance facilities.
 - Water use at maintenance facilities continued to increase in 2017 as the fleet of revenue and non-revenue vehicles has grown, resulting in additional vehicle washings.
 - Administrative water use increased dramatically, 264 percent between 2016 and 2017. This may be due in part to a water line break at Freighthouse Square that remained unfixed from September until December. This may also be due to an increase in heating degree days, meaning a warmer summer. The summer of 2017 experienced 55 straight days without rain.
- Water use at customer facilities decreased by 14 percent.

Figure 11 below shows the change in water use over time in total and per PMT.

Figure 11. Water Use, 2010-2017 (thousand CCF; 1 CCF equals 100 cubic feet, or 748 gallons)



Note: Stormwater and sewer costs are not included because costs were not in the inventory prior to 2013.

Waste Generation and Diversion

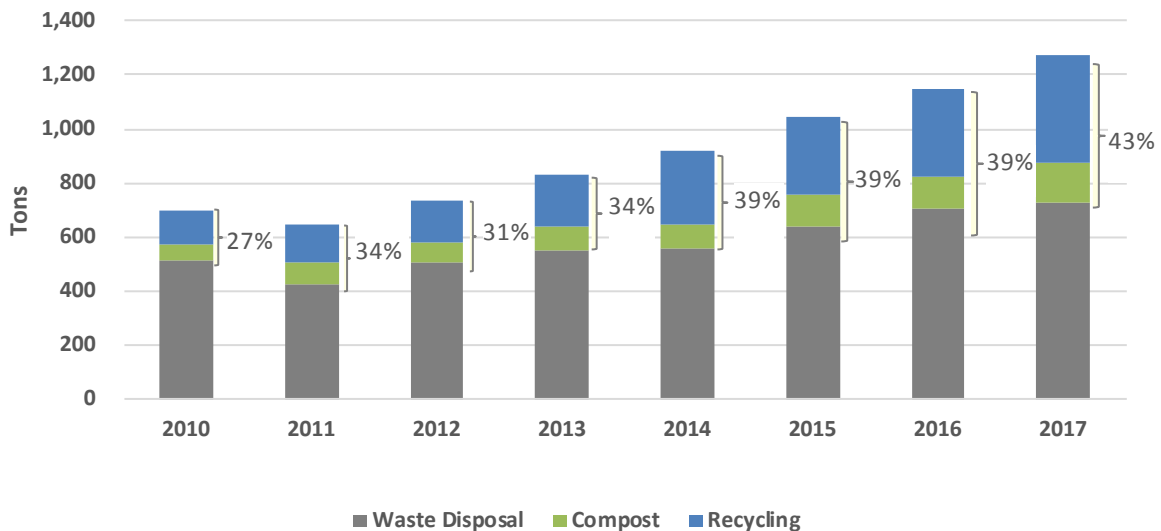
- Since 2010, waste generation has grown by 82 percent.
- From 2016 to 2017, waste generation increased by 11 percent

Waste generation at Sound Transit facilities has increased 82 percent since 2010 as service (vehicle revenue miles) and agency staff have increased. The total amount of garbage sent to landfill has increased by 42 percent over the same timeframe, as the rate at which recyclables and compost have been diverted from the landfill (diversion) has also trended upward.

Diversion from the waste stream to recycling and composting has increased from 27 percent in 2010 to 39 percent in 2014-2016 and then to 43 percent in 2017. This increase was due to improved recycling education and implementation of paper towel composting in the restrooms at Union Station. In 2016, the disposal bins at the CLOMF facility were too small for the volume of garbage, leading to commingling of solid waste and recyclables until bins were upgraded. This problem underscores the importance of ongoing assessment and education, as well as appropriate infrastructure, to support recycling and composting efforts.

From 2016 to 2017, waste generation increased by 126 tons, or 11 percent, while agency staff increased by 14 percent in that timeframe. Recycling and composting quantities were up by 24 percent and 17 percent, respectively, and the overall diversion rate during that period increased to 43 percent, as shown in Figure 12 below.

Figure 12. Waste Generation and Diversion, 2010-2017

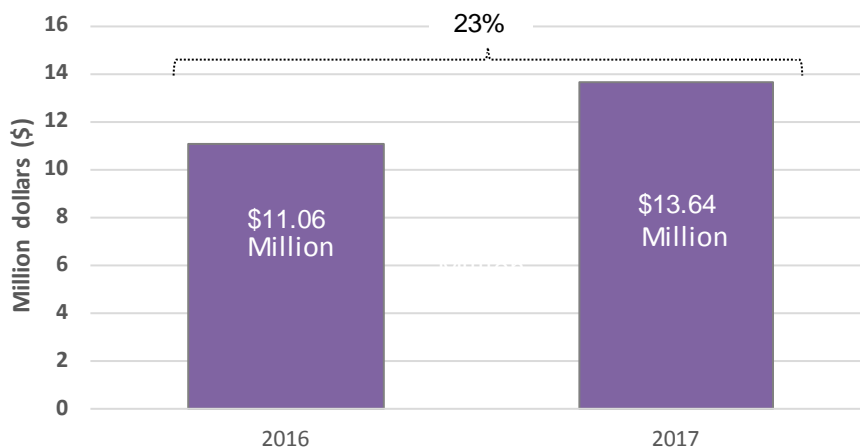


Fuel and Utility Expenses

- Since 2010, fuel costs for ST Express buses and Sounder commuter rail have decreased by 12 percent in total and 40 percent per PMT.
- From 2016 to 2017, fuel costs increased by 28 percent in total and 29 percent per PMT.
- Since 2010, utility costs have changed by the following amounts:
 - Traction power electricity costs for Link light rail have increased by 85 percent in total but decreased by 32 percent per Link PMT.
 - Facility electricity costs have increased 146 percent in total and 46 percent per PMT.
 - Facility natural gas costs have increased 58 percent in total but decreased by 6 percent per PMT.
 - Water costs have increased 51 percent but decreased by 10 percent per PMT.
 - Waste, recycling, and compost costs have increased by 214 percent in total and 87 percent per PMT.
 - Since 2010, utilities rates have increased 15 percent regionally, while at Sound Transit utility rates have increased 27 percent..
- From 2016 to 2017, utility costs changed by the following amounts:
 - Traction power electricity costs for Link light rail increased by 27 percent in total and 4 percent per Link PMT.
 - Facility electricity costs increased 8 percent in total and 3 percent per PMT.
 - Facility natural gas costs increased 33 percent in total and 26 percent per PMT.
 - Water costs increased by 28 percent in total and 22 percent per PMT.
 - Waste, recycling, and compost costs increased by 1 percent in total and decreased by 4 percent per PMT.

Costs for nearly every resource category have trended upward since 2010, except for fuel. Figure 13 below shows the change in agency operating costs from 2016 to 2017. Passenger miles traveled increased by 5 percent from 2016 to 2017.

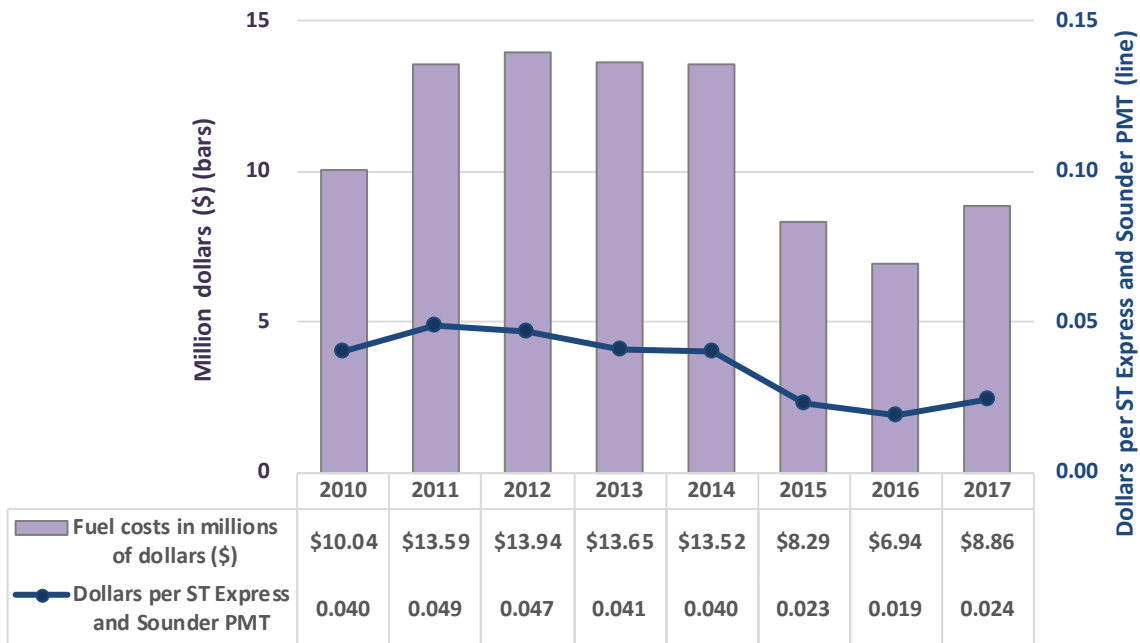
Figure 13. Fuel and Utility Expenses



Fuel Costs

- Oil and gas prices nationally have fallen dramatically since 2014, though prices increased between 2016 to 2017 (from \$1.48 to \$1.81 per gallon).
- Transit vehicle fuel makes up the bulk of Sound Transit's fuel and utility expenses; from 2010 to 2017, transit vehicle fuel accounted for 81 percent of Sound Transit's total operating costs on average.
- Fuel use accounted for 65 percent of the agency's total fuel and utility expenses in 2017. The cost of fuel from Sounder and ST Express are shown in Figure 14.

Figure 14. Sounder and ST Express Fuel Costs, 2010-2017

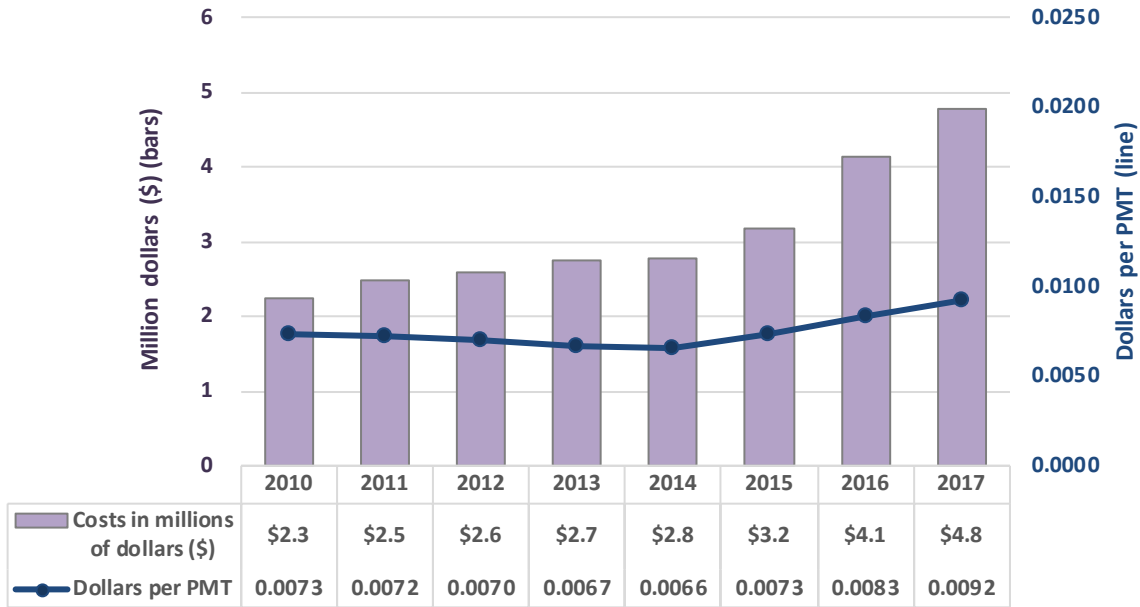


Other Utility Expenses

Other utility expenses for electricity, water, and waste have increased over time in line with usage trends. Figure 15 below shows the change in resource costs since 2010.

- Total facility electricity costs have increased by 146 percent, water costs by 51 percent, and waste costs by 214 percent from 2010 to 2017. However, as diesel and natural gas prices have been more volatile, the agency's diesel and gas expenses have fluctuated more than the other resource categories.

Figure 15. Utility Costs (excluding transit vehicle fuel), 2010-2017



Appendix B – 2017 Sustainability costs and savings

This table shows some of the major costs and savings from annual sustainability targets. Some significant program costs and savings are captured here. However, sustainability is integrated into many projects in ways that make it difficult to represent direct costs and benefits in these terms.

PROJECT	YEAR	CAPITAL COSTS	2017 SAVINGS	SAVINGS TO DATE	PAY-BACK YEAR	DESCRIPTION
CAPITAL INVESTMENT PAID BACK						
ST Express mid-day bus storage	2008	\$0	\$62,813	\$1,843,714	2008	This program allows Pierce County buses to stay in Seattle until the afternoon commute to avoid driving back and forth empty – saving over 52,000 gallons of fuel in 2017.
Souder Automatic Engine Start-Stop System	2009	\$230,596	\$112,170	\$645,828	2013	This equipment shuts down Souder commuter rail engines when not in use, reduces engine idling time by about 34 percent and significantly reduces air pollution.
Central Link OMF sewer deduct meter	2012	\$2,600	\$45,619	\$179,276	2012	This Central Link light rail Operations and Maintenance Facility meter reduces water costs by accounting for irrigation water that does not enter the wastewater stream.
Souder Lakewood–Seattle wayside power	2010 2013	\$490,000	\$97,918	\$714,416	2015	Electric wayside power units were installed in Tacoma in 2010 and then moved to Lakewood in 2013, where more units were added.

PROJECT	YEAR	CAPITAL COSTS	2017 SAVINGS	SAVINGS TO DATE	PAY-BACK YEAR	DESCRIPTION
CAPITAL INVESTMENT PAID BACK IN 5-7 YEARS						
Sounder Everett-Seattle wayside power	2011	\$315,000	\$17,270	\$212,890	2018	Electric wayside power units are used instead of the commuter rail locomotives' diesel engines to heat and power coach cars during layover, reducing diesel use and air pollutants.
Federal Way Transit Center lighting upgrades	2013	\$603,000	\$36,931	\$153,335	2019	Three transit facilities were retrofitted for energy efficiency upgrades. Lighting upgrades were made at Federal Way Transit Center and Kent and Auburn Sounder commuter rail stations. The 2017 Savings and Savings to Date columns in this chart reflect only electricity savings. However, the payback period estimate reflects grants and utility rebates
Kent Station lighting upgrades	2013	\$111,995	\$16,075	\$48,083	2019	
Auburn Station	2013	\$219,503	\$8,237	\$50,042	2019	