

Sound Transit 2016 Sustainability Progress Report – Appendices

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Appendix A – 2016 Sustainability Inventory

This Appendix presents key data snapshots from Sound Transit's 2016 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 2016 as well as performance data trends over multiple years. Notably, the agency continued to increase its ridership more quickly than its use of natural resources, resulting in higher efficiency in nearly all resource categories compared to baseline years (2010 or 2011).¹

Sound Transit has made a number of valuable improvements to the quality and sustainability of its service over time. In 2016 Sound Transit made the largest expansion to its Link light rail system since the opening of the initial segment in 2009. Sound Transit added three stations—University of Washington, Capitol Hill, and Angle Lake—and 9.6 miles of track in total. As the population of the Central Puget Sound region increased, and service increased with new stations and additional trips, Sound Transit ridership has continued to grow.

As a result, boardings (unlinked passenger trips) increased by 7.8 million, or 22 percent, reaching nearly 43 million last year. Passenger miles traveled (PMT) across all modes increased by 14 percent. With the overall expanded service and ridership, along with increased staff at the agency, total resource use increased in some areas. However, normalized by ridership (PMT), resource use per passenger decreased from the previous year across nearly all areas of the agency's operations.

Some key findings in resource use and efficiency trends over the past six years include the following:

- Fleet energy use decreased by 24 percent per PMT since 2011.
- Water use decreased by 21 percent per PMT since 2010.
- Air pollution from Sound Transit operations decreased significantly since 2011 due to the improved emission control technologies of newer ST Express buses and upgrades to Sounder commuter rail engines. All criteria air pollutants have decreased, both in total and on a normalized basis, since 2011, including particulate matter (PM₁₀), volatile organic compounds (VOCs), nitrogen oxides (NO_x), carbon monoxide (CO), and sulfur dioxide (SO₂).

This document illustrates resource use trends over time from baseline years (2010 or 2011, depending on data) and the preceding inventory year, 2015. 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.

Ridership

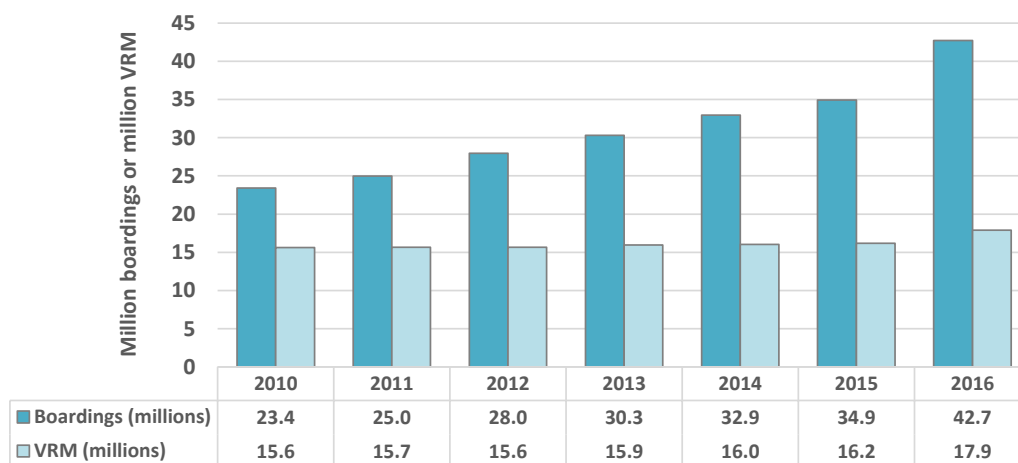
- Since 2010, ridership (measured in boardings) has grown by 83 percent.
- From 2015 to 2016, ridership grew by 22 percent.

Ridership has increased every year, growing by 83 percent since 2010 and reaching nearly 43 million boardings (unlinked passenger trips) in 2016. Meanwhile, the level of service, measured by vehicle revenue miles (VRM), has increased by 15 percent over the same period. This difference in growth in service and ridership demonstrates that

¹ Baseline year data vary for certain resource categories due to data constraints. Sounder data are available at the granularity needed to use the AFLEET emissions tool starting in 2011; therefore, the data categories that draw on Sounder data—criteria air pollutants, greenhouse gases, and energy use—show trends with a baseline year starting in 2011. Trends for all other data types have a baseline year of 2010.

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, 2010-2016



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.

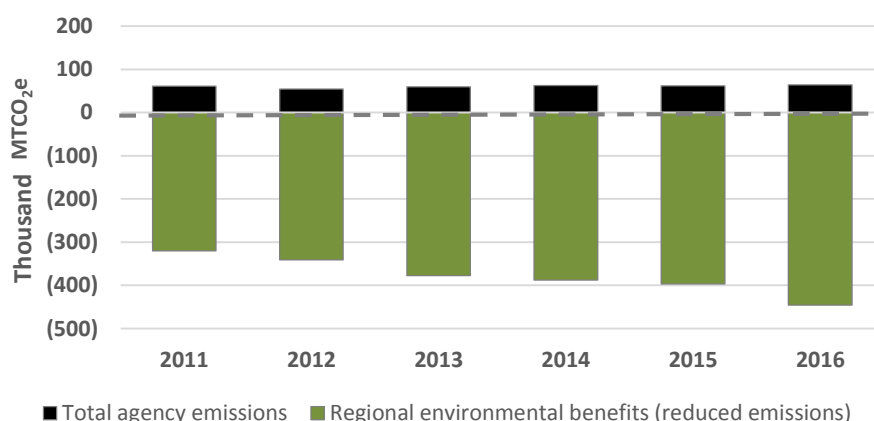
Using National Standards

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. Nonrevenue fleet; however, is normalized by employees as usage is tied more closely to staff levels than ridership.

Regional Environmental Benefit

Increased transit reduces regional environmental impacts. As more people choose transit over driving, they are reducing the use of 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, 2011-2016



As seen in Figure 2 above and Table 1 below, Sound Transit saves more GHG emissions than it produces. For every ton of GHG emissions Sound Transit produced in 2016, the region avoided 7.0 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 the related congestion relief; these benefits have consistently been at least five times the agency's emissions (in black) since 2011.

Table 1. Regional Greenhouse Gas Emissions (CO₂e) Savings from Sound Transit, 2016

Regional metric tons CO ₂ e Saved			
Mode Shift Benefits	Congestion Benefits	Land-Use Benefits	Total Benefits
111,790	39,178	294,760	445,729
Displacement ratios - CO ₂ e units saved in the region per unit of CO ₂ e from Sound Transit operations			
Mode Shift Benefits	Congestion Benefits	Land-Use Benefits	Total Benefits
1.7	0.6	4.6	7.0

Note: Totals do not sum due to rounding.

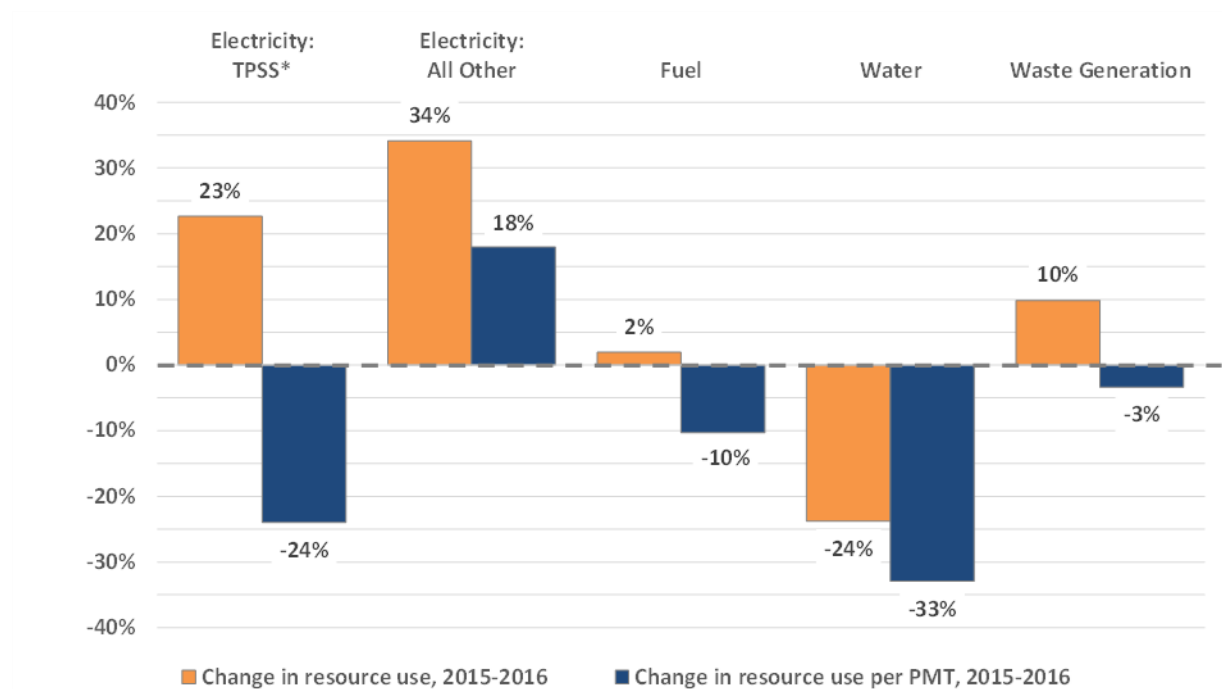
The definitions for each of the identified types of benefits are below:

- **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.
- **Congestion benefits** quantify the secondary effect of transit—opening roadway capacity, which may result in smoother traffic flow and fewer stops, starts and traffic jams. (Note: The number above was calculated using data from Texas Transportation Institute's 2012 Urban Mobility Report, the most recently published report.)
- **Land use change benefits** measure the reduced carbon outputs due to the denser land use patterns supported by transit systems.

Resource Use

Total 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 shows the change in total resource use from 2015 to 2016, as well as how efficient that resource use is (resource use normalized by PMT).

Figure 3. Change in Total Resource Use, 2015-2016; Change in Resource Use per PMT, 2015-2016²



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.

² "Electricity: All Other" includes electricity associated with administrative, customer and maintenance facilities. Within this category, 18 percentage points of the increase in electricity usage is from new or heavily renovated facilities, including three new Link light rail stations (Capitol Hill, University of Washington, Angle Lake), a renovated Sounder facility (Mukilteo station), and two new administrative facilities (Tacoma administrative building and 705 Union Station). Two of the new customer facilities also have associated TPSS electricity uses that were affected by increased service.

Fleet Energy Use

- Since 2011, total fleet energy use has grown by 10 percent but decreased 24 percent per PMT.
- From 2015 to 2016, fleet energy use grew by 3 percent but decreased 9 percent 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 39 percent since 2011, and increased by 23 percent from 2015 to 2016 due to increased vehicle mileage from additional service.
- Diesel fuel for Sounder commuter rail and ST Express buses increased by 12 percent and 7 percent since 2011, respectively; compressed natural gas (CNG) use in ST Express buses remained unchanged.
 - Sounder fuel use has historically varied with changes in weather, as Sounder trains idle when the outside temperature is below 40 degrees F.
 - In 2016 winter weather was colder than the previous year, but there was little change in overall diesel fuel usage, indicating increasing fuel efficiencies in Sounder commuter rail services.

Figure 4 **Error! Reference source not found.** below shows the trend in fleet fuel use over time. Table 2 below shows the percent change in energy use from 2015 to 2016 per mode, as well as the percent change in efficiency (fuel use normalized by PMT for each mode).

Figure 4. Revenue Fleet Energy Use, 2011-2016

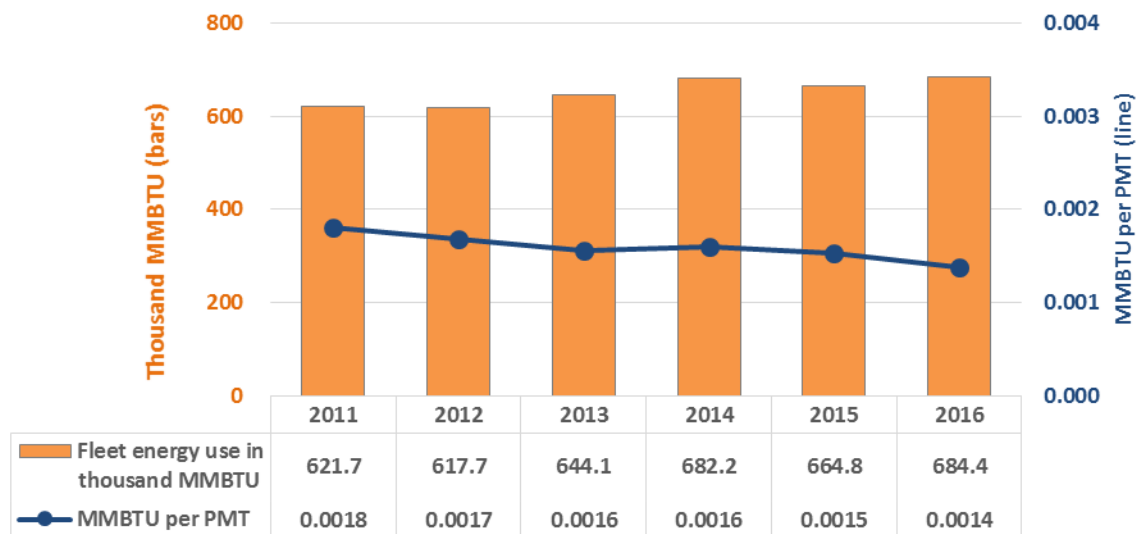


Table 2. Change in Energy Use by Mode, 2015-2016

Mode	% Change in Total Energy Use	% Change in Energy Use per PMT
Sounder commuter rail	2%	-13%
ST Express buses	1%	2%
Link light rail traction power (electricity)	23%	-24%

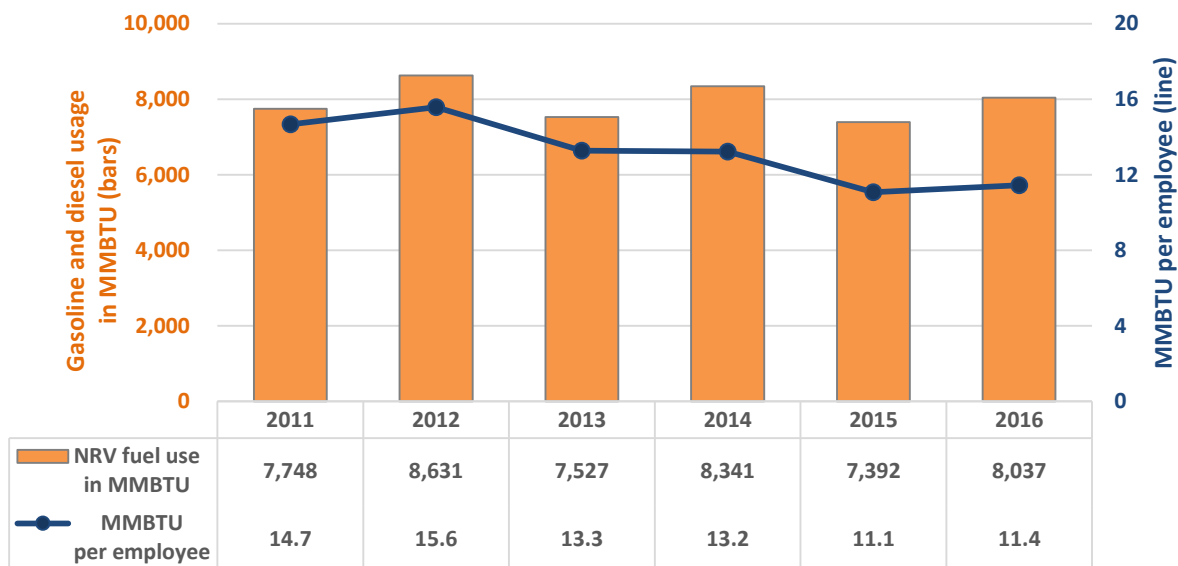
Note: Mode energy use is normalized by PMT for each mode.

Nonrevenue Fleet Energy Use

- Since 2011, nonrevenue fleet energy use has grown by 4 percent, but it decreased by 22 percent per employee.
- From 2015 to 2016, nonrevenue fleet energy use increased by 9 percent and increased by 3 percent per employee.

Energy use for the agency's nonrevenue fleet has remained relatively stable over time, though it has fluctuated from year to year, as shown in Figure 5. Nonrevenue fleet energy use was 4 percent higher in 2016 than in the 2011 baseline year. **Error! Reference source not found.** 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. Nonrevenue Fleet Energy Use, 2011-2016



Facility Energy Use

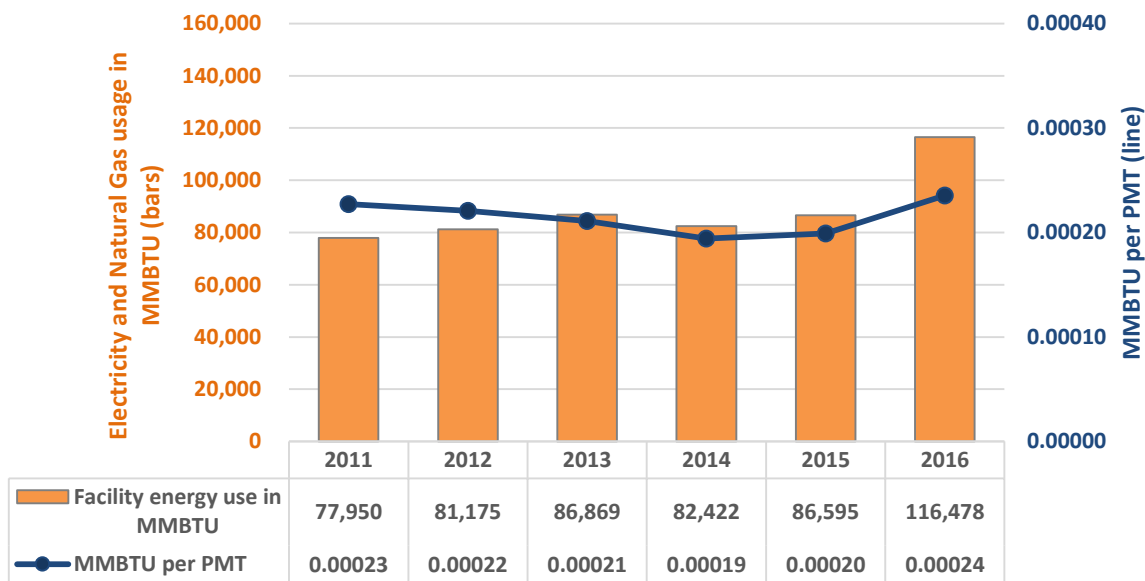
- Since 2011, total facility energy use has grown by 49 percent and 4 percent per PMT.
- From 2015 to 2016, facility energy use increased by 35 percent and 18 percent per PMT.

Facility energy use has increased 49 percent since 2011 as the agency added staff and 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

Error! Reference source not found., is also dependent on weather. Colder winter weather during 2016, coupled with malfunctioning lighting systems at two facilities, further contributed to increased facility energy use. For example, a drop in 2014 was due to reduced heating needs during winter, as well as efficiency upgrades and improved operational practices.

From 2015 to 2016, facility electricity use—the main driver of energy use—varied by line of business. Sounder commuter rail and ST Express bus facilities decreased usage by 2 percent and 6 percent, respectively. Link light rail facility electricity increased by 63 percent due to new stations coming online in 2016. Specifically, new Link stations at Angle Lake, University of Washington, and Capitol Hill resulted in increased facility energy use; the latter two stations have electricity meters that are combined with traction power. The facilities are also tunnel stations with high electricity needs associated with lighting, ventilation and monthly testing of emergency systems. Angle Lake Station also includes a large, multi-story parking garage. These new stations accounted for 44 percent of all customer facility electricity usage in 2016.³

Figure 6. Facility Energy Use, 2011-2016



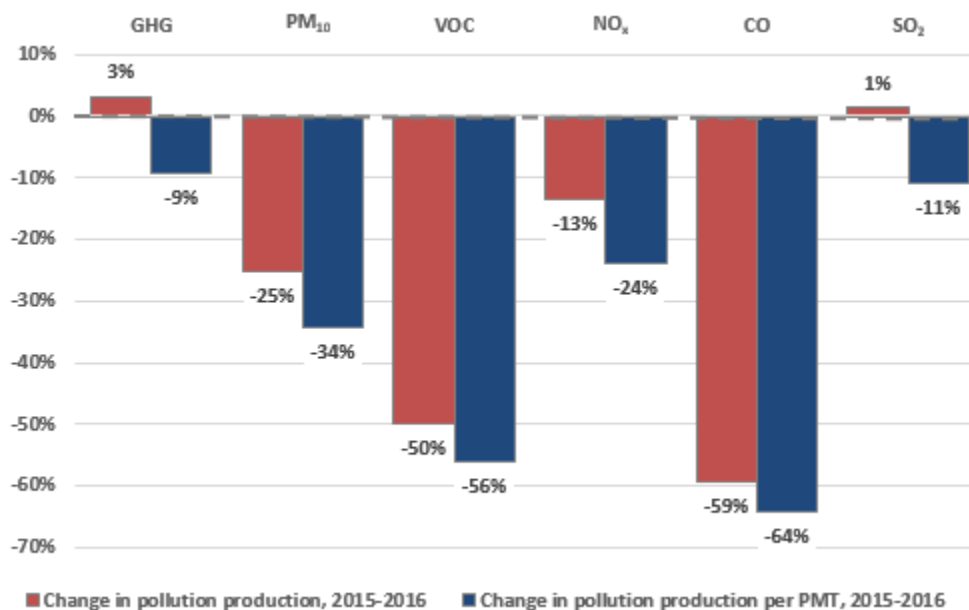
³ Note that two of the new stations include traction power which means that part of this additional facility energy use is due to increased Link light rail service.

Air Pollutant Emissions

Air pollution from Sound Transit operations decreased significantly since 2011 due to the improved emission control technologies of newer ST Express buses and upgrades to Sounder commuter rail engines. Greenhouse gas emissions have decreased on a normalized basis, and all criteria air pollutants have decreased—both in total and on a normalized basis—since 2011, including particulate matter (PM₁₀), volatile organic compounds (VOCs), nitrogen oxides (NO_x), carbon monoxide (CO), and sulfur dioxide (SO₂).

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 shows the overall percent change and the change normalized per passenger mile traveled (PMT) for pollution sources from 2015 to 2016. As previously noted, PMT increased by 14 percent from 2015 to 2016.

Figure 7. Changes in Pollution Production, 2015-2016; Change in Pollution Production per PMT, 2015-2016

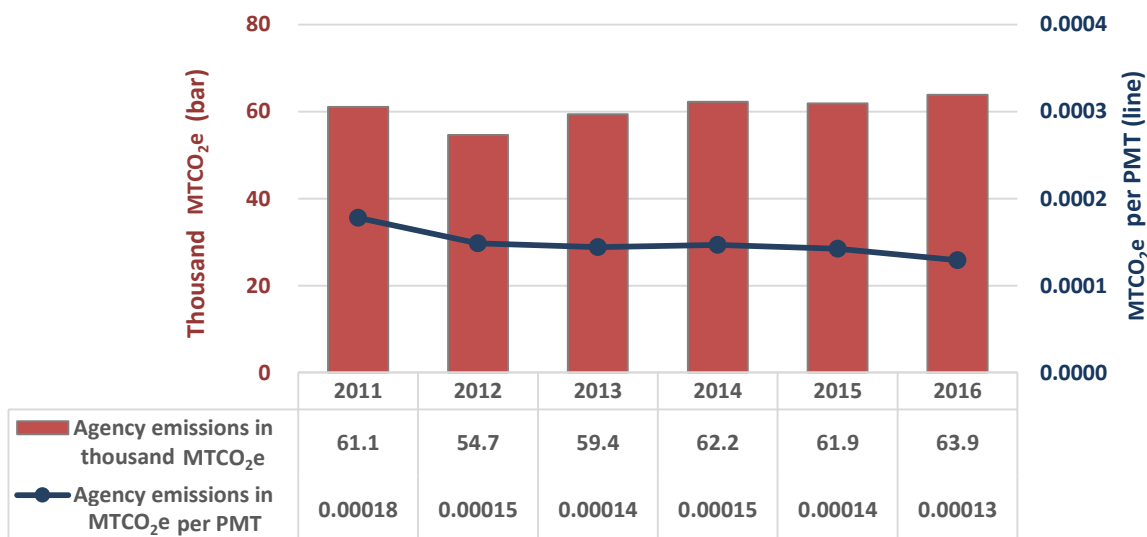


Greenhouse Gas Emissions

- Since 2011, total GHG emissions have grown by 5 percent but decreased by 27 percent per PMT.
- From 2015 to 2016, total GHG emissions grew by 3 percent but decreased by 9 percent 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, a small portion of Sound Transit's overall footprint, increased by 40 percent. This increase is largely due to greater heating needs during the colder winter as well as new Maintenance of Way facilities, a new Tacoma administrative building, and increased square footage at Auburn Warehouse.

Figure 8. Agency GHG Emissions, 2011-2016 (thousand metric tons of carbon dioxide equivalents, MTCO₂e)



Criteria Air Pollutants

Sound Transit's criteria air pollutants (CAPs) have declined over the past several years, in many cases significantly. Criteria air pollutants—including particulate matter (PM₁₀), volatile organic compounds (VOCs), nitrogen oxides (NO_x), carbon monoxide (CO), and sulfur dioxide (SO₂)—contribute to smog and health issues such as asthma and heart attacks. This decrease is primarily driven by fleet turnover as older, less efficient vehicles are used less and 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.

- Since 2011, CAP emissions have decreased by the following amounts:
 - PM₁₀ has decreased by 55 percent in total and 69 percent per PMT.
 - VOCs have decreased by 65 percent in total and 76 percent per PMT.
 - NO_x has decreased by 38 percent in total and 57 percent per PMT.
 - CO has decreased by 64 percent in total and 75 percent per PMT.
 - SO₂ has decreased by 7 percent in total and 36 percent per PMT.
- From 2015 to 2016, CAP emissions changed by the following amounts:
 - PM₁₀ decreased by 25 percent in total and 34 percent per PMT.
 - VOCs decreased by 50 percent in total and 56 percent per PMT.
 - NO_x decreased by 13 percent in total and 24 percent per PMT.
 - CO decreased by 59 percent in total and 64 percent per PMT.
 - SO₂ increased by 1 percent in total and decreased by 11 percent per PMT.

Figure 9 and Figure 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 55 percent and 64 percent overall since 2011, respectively. These reductions are even more dramatic per PMT.

Figure 9. Particulate Matter (PM₁₀), 2011-2016

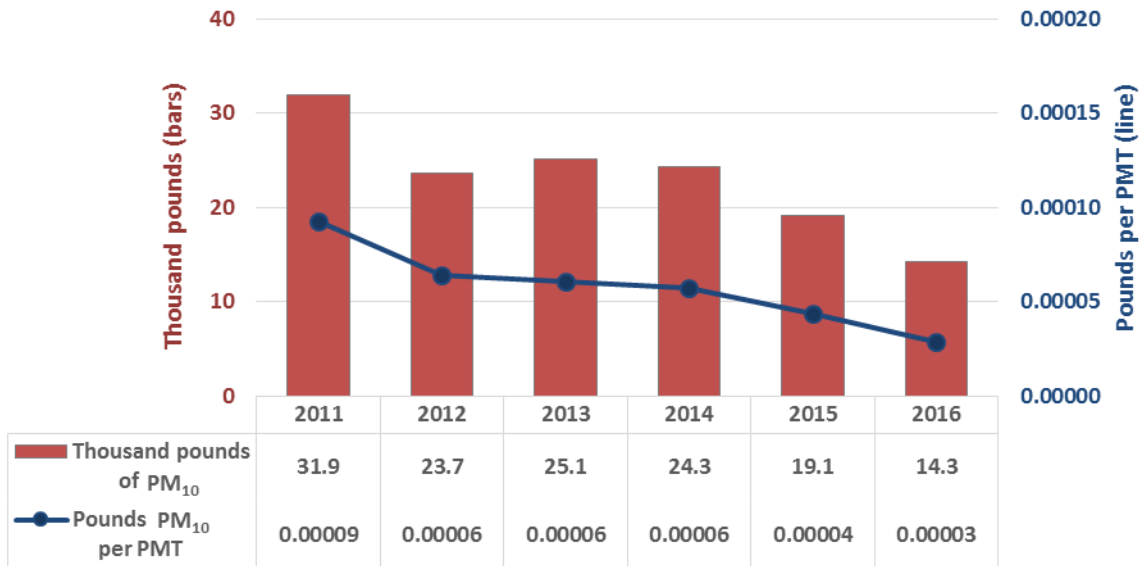
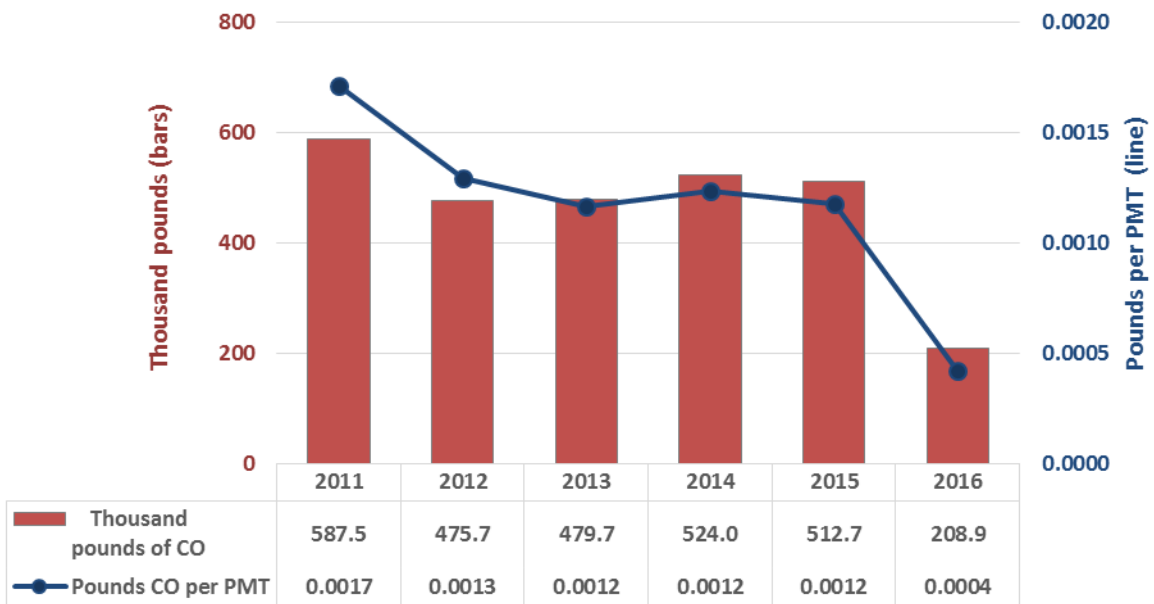


Figure 10. Carbon Monoxide (CO), 2011-2016



Water Use

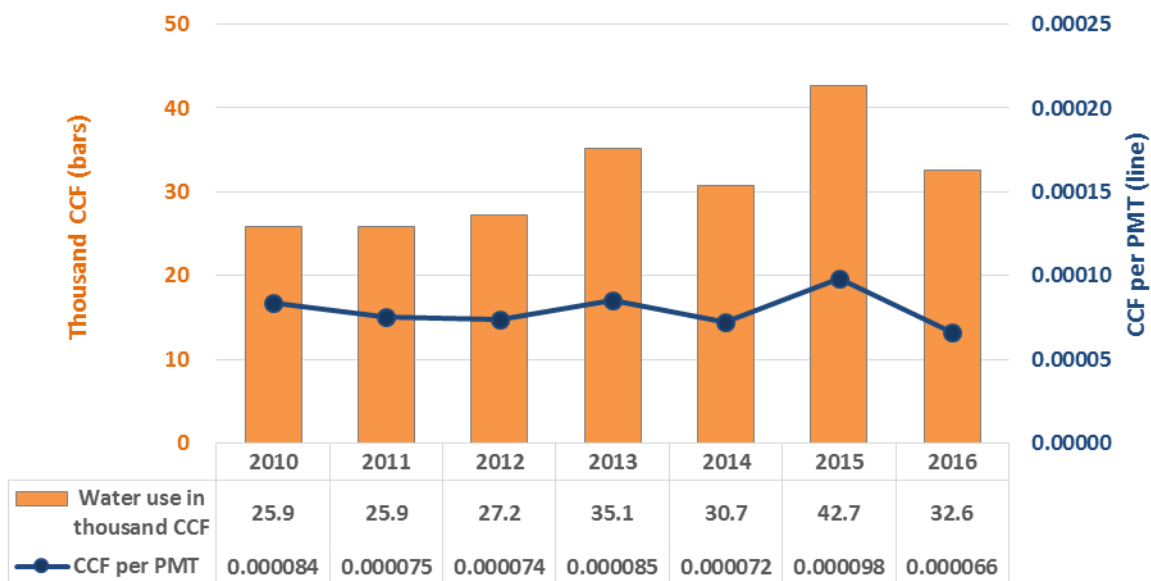
- Since 2010, water use has grown by 26 percent in total but decreased by 21 percent per PMT.
- From 2015 to 2016, water use decreased by 24 percent in total and 33 percent per PMT.

Water use overall has increased 26 percent since 2010 with increased agency headcount and expanded service, although water use for various functions has fluctuated considerably. This is an area 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; the drought conditions of summer 2015, as well as 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. Due to drought, a leak at SODO station, and the addition of new facilities with young landscaping, usage increased again in 2015.

Water use decreased by 24 percent in 2016. Water use at customer facilities decreased by 35 percent, driven by lower irrigation needs due to weather conditions, repairs to a water line and irrigation systems, and water conservation projects. Water use at maintenance facilities; however, continued to increase in 2016 as the fleet of revenue and nonrevenue vehicles has grown, resulting in additional vehicle washings. Active construction projects at the Sounder Lakewood Operations and Maintenance Facility also contributed to higher water usage. Figure 11 below shows the change in water use over time in total and per PMT.

Figure 11. Water Use, 2010-2016 (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

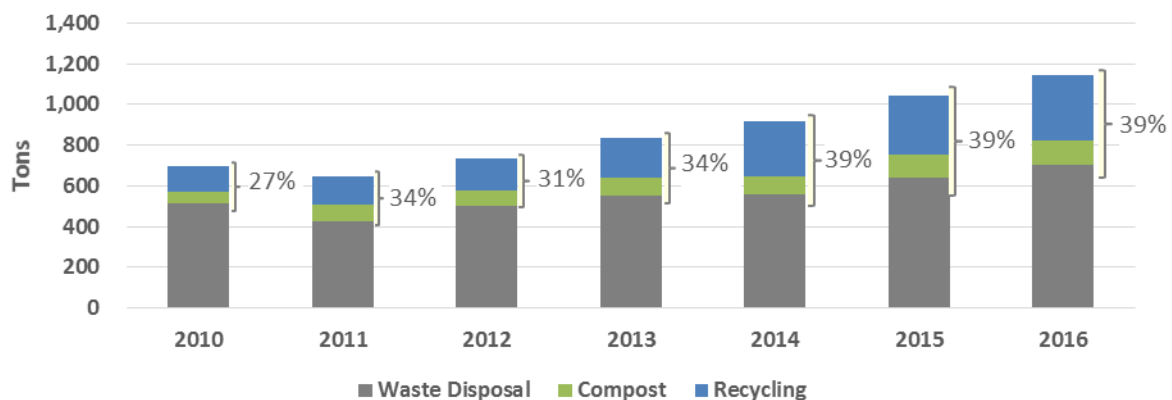
- Since 2010, waste generation has grown by 64 percent.
- From 2015 to 2016, waste generation increased by 10 percent

Waste generation at Sound Transit facilities has increased 64 percent since 2010 as service (vehicle revenue miles) and agency staff have increased by 15 percent and 43 percent, respectively. The total amount of garbage has increased by 37 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 has increased from 27 percent in 2010 to 39 percent in 2014-2016 due to improved recycling education and implementation of paper towel composting in the restrooms at Union Station. In 2016, the disposal bins at the Central Link Operations and Maintenance 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 2015 to 2016 waste generation increased by 102 tons, or 10 percent, while agency staff increased by 5 percent in that time frame. While recycling and composting quantities were up by 11 percent and 6 percent, respectively, the overall diversion rate during that period remained stable at 39 percent, as shown in Figure 12 below.

Figure 12. Waste Generation and Diversion, 2010-2016



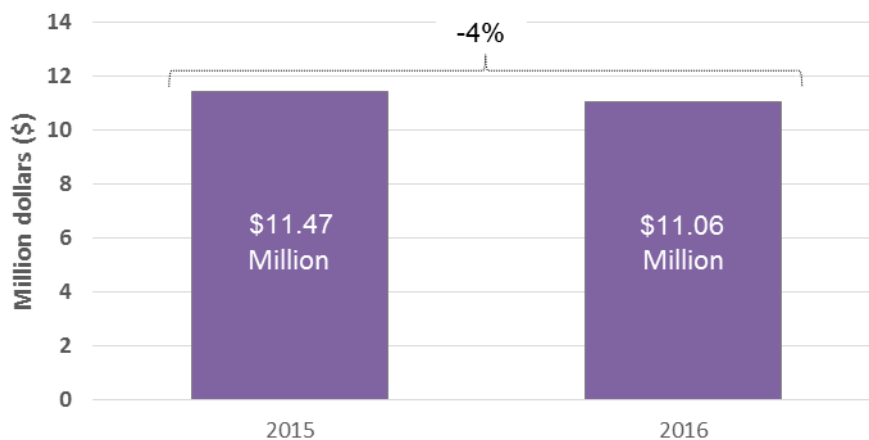
Fuel and Utility Expenses

- Since 2010, diesel fuel costs for ST Express buses and Sounder commuter rail have decreased by 31 percent in total and 53 percent per PMT.
- Since 2010, utility costs have changed by the following amounts:
 - Traction power electricity costs for Link light rail have increased by 45 percent in total but decreased by 34 percent per Link PMT.
 - Facility electricity costs have increased 127 percent in total and 42 percent per PMT.
 - Facility natural gas costs have increased 19 percent in total but decreased by 26 percent per PMT.
 - Water costs have increased 18 percent but decreased by 26 percent per PMT.

- Waste, recycling, and compost costs have increased by 211 percent in total and 94 percent per PMT.
- From 2015 to 2016, diesel fuel costs decreased by 16 percent in total and 19 percent per PMT.
- From 2015 to 2016, utility costs changed by the following amounts:
 - Traction power electricity costs for Link light rail increased by 30 percent in total but decreased by 19 percent per Link PMT.
 - Facility electricity costs increased 40 percent in total and 23 percent per PMT.
 - Facility natural gas costs increased 28 percent in total and 12 percent per PMT.
 - Water costs decreased by 17 percent in total and 27 percent per PMT.
 - Waste, recycling and compost costs increased by 14 percent in total and 1 percent per PMT.

Costs for nearly every resource category have trended upward since 2010, except for water and diesel fuel. Figure 13 below shows the change in agency operating costs from 2015 to 2016. As noted above, passenger miles traveled increased by 14 percent from 2015 to 2016.

Figure 13. Fuel and Utility Expenses



Fuel Costs

- Oil and gas prices nationally have fallen dramatically since 2014. Diesel fuel prices dropped nearly 20 percent from 2015 to 2016 (from \$1.77 to \$1.48 per gallon, the lowest average price in the past six years).
- Transit vehicle fuel makes up the bulk of Sound Transit's fuel and utility expenses; from 2010 to 2016, transit vehicle fuel accounted for 79 percent of Sound Transit's total operating costs on average.
- Although fuel use remained relatively constant in 2016, the lower price of diesel drove transit vehicle fuel costs down 16 percent, accounting for 63 percent of the agency's total fuel and utility expenses in 2016. The cost of fuel from Sounder and ST Express are shown in Figure 14.

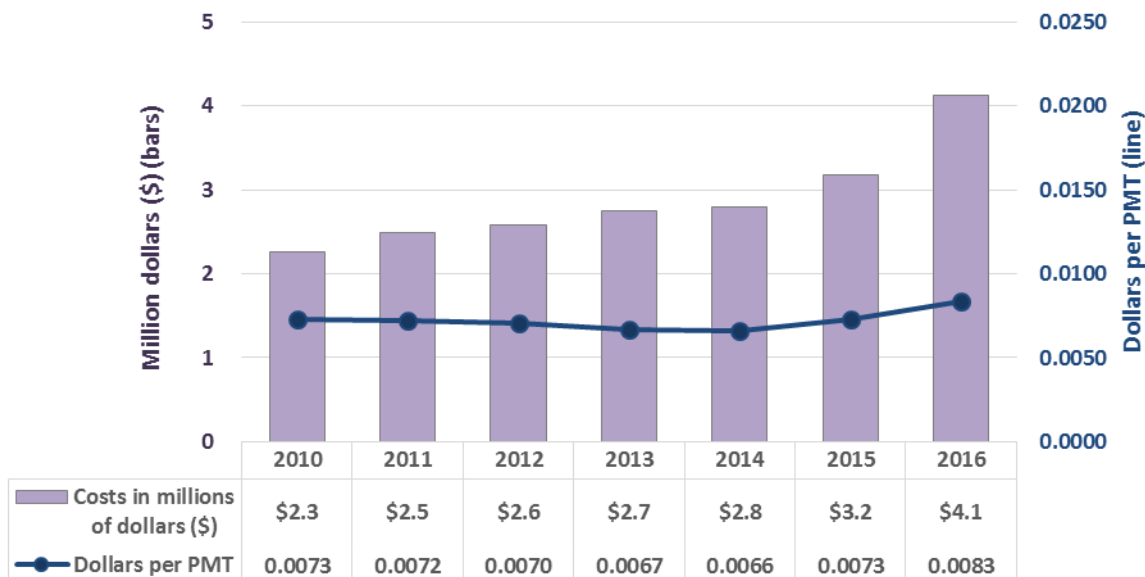
Figure 14. Sounder and ST Express Diesel Fuel Costs, 2010-2016



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 121 percent, water costs by 18 percent, and waste costs by 211 percent from 2010 to 2016. 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), 2010-2016



Appendix B – 2016 Sustainability Costs and Savings

Table 3 and Table 4 show 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.

Table 3. Costs and Savings from Annual Sustainability Targets—Projects Already Paid Back

PROJECT	YEAR	CAPITAL COSTS	2016 SAVINGS	SAVINGS TO DATE	PAY-BACK YEAR	DESCRIPTION
CAPITAL INVESTMENT PAID BACK						
ST Express mid-day bus storage	2008	\$0	\$76,600	\$1,790,280	2008	This program allows Pierce County buses to stay in Seattle until the afternoon commute to avoid driving back and forth empty, saving over 76,000 gallons of fuel in 2016.
Sounder Automatic Engine Start-Stop System	2009	\$230,596	\$65,345	\$533,657	2013	This equipment shuts down Sounder 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	\$43,282	133,695	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.
Sounder Lakewood-Seattle wayside power	2010 2013	\$490,000	\$80,583	\$616,498	2015	Electric wayside power units were installed in Tacoma in 2010 and then moved to Lakewood in 2013, where more units were added.

Table 4. Costs and Savings from Annual Sustainability Targets—Projects Paid Back in 5-7 Years

PROJECT	YEAR	CAPITAL COSTS	2016 SAVINGS	SAVINGS TO DATE	PAY-BACK YEAR	DESCRIPTION
CAPITAL INVESTMENT PAID BACK IN FIVE TO SEVEN YEARS						
Sounder Everett-Seattle wayside power	2011	\$315,000	\$14,061	\$195,620	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	\$32,277	\$116,404	2019	Four transit facilities were retrofit for energy efficiency upgrades. Lighting upgrades were made at Federal Way Transit Center and Kent and Auburn Sounder commuter rail stations. Union Station had upgrades made to its heating, ventilation and air conditioning system and controls. The 2016 Savings and Savings-to- Date columns in this chart only reflects electricity savings. However, the payback period estimate reflects grants and utility rebates.
Kent Station and Garage lighting upgrades	2013	\$111,995	\$7,586	\$32,008	2019	
Auburn Station	2013	\$219,503	\$8,853	\$41,804	2019	