THE NORTHWEST SEAPORT ALLIANCE
MEMORANDUM

MANAGING MEMBERS
ACTION ITEM

Item No. 5B
Date of Meeting April 3, 2018

DATE: March 21, 2018

TO: Managing Members, The Northwest Seaport Alliance

FROM: John Wolfe, Chief Executive Officer

Sponsor: Jason Jordan, Director, Environmental and Planning Services

Project Manager: Sara Cederberg, Environmental Senior Project Manager

SUBJECT: Briefing: 2016 Puget Sound Maritime Emission Inventory, 2016 NWSA Greenhouse Gas Inventory, and NWSA Greenhouse Gas Glidepath

1. SYNOPSIS

The Northwest Seaport Alliance (NWSA) has made significant efforts to quantify its impact on air quality in the region and broader climate by funding two important emissions inventories, both of which were completed in the first quarter of 2018. These emissions inventory projects allow the NWSA to track progress towards its Northwest Ports Clean Air Strategy (NWPCAS) emission targets, establish a baseline for the NWSA Greenhouse Gas (GHG) Resolution targets, plan and prioritize future emission reduction programs.

This briefing:

- Summarizes the NWSA-related results of both inventories,
- Assesses progress towards the NWSA's current NWPCAS emission targets,
- Presents the NWSA GHG Glidepath for achieving greenhouse gas emissions targets set forth in the NWSA Greenhouse Gas Resolution, and
- Presents proposals for upcoming air quality programs and initiatives.

1.1 Summary – Puget Sound Maritime Emissions Inventory

For a third time, the Puget Sound Maritime Air Forum (a committee of seven ports, six government agencies and three industrial partners), led by The Northwest Seaport Alliance (NWSA), conducted an update of the Puget Sound Maritime Air Emissions Inventory (PSEI) for calendar year 2016. Before the formation of NWSA, project leadership was assumed by Port of Seattle in 2005 and Port of Tacoma in 2011. The objective of the PSEI is to quantify air emissions in the Puget Sound Airshed from all maritime-related activities. Within the inventory, emissions were reported for each port as well as the entire airshed, allowing NWSA's progress towards emission goals to be assessed.

Results from the inventory revealed that the NWSA has made significant progress in reducing its air pollutant emissions. Specifically, the NWSA has surpassed 2020 Northwest Ports Clean Air

Strategy (NWPCAS) emission reduction targets. Emission reduction targets, quantified in emissions per ton of cargo relative to the 2005 baseline are:

- 80% of diesel particulate (DPM)
- 15% of greenhouse gases (GHG, reported as CO_2 equivalents, CO_2e)

Airshed scale emission reductions per ton of cargo relative to 2005 levels achieved the 2020 targets and were:

- **80% for DPM**
- **17% for greenhouse gasses**

These emission reductions were primarily a result of switching to lower sulfur fuels, upgrading to newer, cleaner equipment, and improving shipping efficiency.

1.2 Summary – NWSA Greenhouse Gas Inventory

To estimate the total GHG emissions associated with NWSA operations and guide future emission reduction strategies, NWSA conducted a GHG inventory for 2016. The primary purpose of the GHG inventory was to comprehensively evaluate GHG emissions from NWSA operations, filling in the information gaps in the PSEI, and establish a baseline. The information gaps specifically addressed by the GHG inventory were tenant and organizational stationary fuel combustion, electricity use, employee commuting, business travel, waste removal, wastewater treatment, and fugitive emissions from refrigeration and A/C units.

Results of the GHG inventory demonstrated that mobile sources, that is any air pollution emitted by vehicles, vessels, locomotives, and other engines and equipment that can be moved from one location to another, inventoried in the PSEI accounted for greater than 98% of NWSA's GHG emissions.

Total GHG emissions associated with NWSA operations have decreased by approximately 20% from 2005 to 2016. The largest reductions from stationary sources was in emissions associated with electricity purchased by tenants due to the reduction in carbon intensity of the local grid.

1.3 Summary – NWSA Greenhouse Gas Glidepath

The NWSA Greenhouse Gas Reduction Resolution sets ambitious targets for 2030 and 2050, which is based upon the global targets of the Paris Agreement. To evaluate strategies to meet those targets, the NWSA Greenhouse Gas Glidepath (Glidepath) uses assumptions about growth to project future emissions and recommends a set of strategies that will allow NWSA to meet the aggressive greenhouse gas emission targets.

Future emission projections were generated using the forecasted 2.2% compound annual growth rate of the container trade from the "2017 Marine Cargo Forecast and Rail Capacity Analysis" prepared for the Washington Public Ports Association and the Freight Mobility Strategic Investment Board. As discussed previously, emissions decreased about 20% from 2005 to 2016. From then on, emissions are projected to grow at a compound rate of 2.2%, exceeding 2005 levels in 2030 and reaching 153% of 2005 levels by 2050.

The Glidepath analyzes the emission reduction measures that are currently feasible, or are likely to be technically feasible by 2030 and 2050, prioritizes the strategies that are likely to be the most effective and cost efficient, and presents a plan for GHG reductions to meet the GHG Resolution Goals. A conservative cost estimate was preformed, based on the methodology used by the Ports of Los Angeles and Long Beach when estimating costs of implementing their Clean Air Action Plan. The estimated industry-wide cost for meeting the targets is over $4 billion.

1.4 Summary – Proposals for Upcoming Emission Reduction Programs

To begin progress towards attaining the aggressive 2030 NWSA GHG emission reduction targets and continue NWSA initiatives to improve air quality, staff are developing proposals for updated air quality programs that will make significant progress towards GHG Resolution and NWPCAS goals. Staff are focused on opportunities where the NWSA has the greatest degree of control and influence in the near term, and therefore have prioritized heavy-duty truck efficiency measures, cleaner cargo handling equipment, and shore power. NWSA control and influence is often limited and relies heavily on advocacy and partnership with customers, community and other agencies; early action on current and emerging GHG initiatives reflects NWSA commitment to reaching these aggressive goals. The updated programs will then become part of the updated Northwest Ports Clean Air Strategy and will be vetted through that process of stakeholder outreach and engagement.

1. Staff are pursuing expanded use of shore power at NWSA facilities based on earlier commission, now Managing Member, direction. Shore power (or cold ironing) eliminates direct at-berth emissions from auxiliary engines while a ship is plugged-in and eliminates indirect GHG emissions if the electricity comes from a renewable source. Currently, TOTE is the only NWSA container terminal that currently uses shore power and the Port of Seattle Cruise terminal at Pier 91 also allows two vessels to plug in simultaneously. The NWSA has included shore power in the Terminal 5 modernization project design and is scoping the installation of shore power at additional terminals. With these electrical capacity upgrades, additional emission benefits are also likely through installation of more reefer plugs, which reduce or eliminate the need for diesel generators to power refrigeration units during high volume periods, and support the ability to deploy electric cargo handling equipment.

2. Staff are expanding on previous efforts to accelerate cargo handling equipment (CHE) fleet turnover by developing a Clean Cargo Handling Equipment Program. The new CHE program will focus on incentivizing the turnover of both port-owned and tenants' CHE fleets. The program will include elements of tenant training and grant funding for converting equipment. NWSA will be hosting its first Environmental Defense Fund Climate Corps fellow in the summer of 2018 to help build the financial model for the program.

3. Heavy duty trucks are becoming an increasingly important sector to focus on emission reduction strategies. To move toward the goal of a zero-emission fleet, staff recommend first optimizing the efficiency of the current system and then beginning to phase in new, more expensive equipment, like electric trucks.

Reaching these ambitious goals will require close collaboration and partnership across many groups of stakeholders, both regionally and internationally. Funding these projects will require a diverse source of funds, from grants to private investment.

2. BACKGROUND

2.1 Description of Emissions Inventories

An emissions inventory is an accounting of all emissions from a defined set of sources, in a delineated geographic area over a specific time period. The purpose of an emissions inventory is to provide scientifically defensible estimates of the nature, location, and magnitude of air pollutant emissions to assess the air quality impacts of the inventoried sources on their surrounding areas and to inform air quality policy. The PSEI and NWSA Greenhouse Gas Inventory were activity based inventories that primarily leaned on guidance from the EPA for its methodologies. Specifically, the Motor Vehicle Emissions Simulator (MOVES) was used to develop emission estimates for on-road and non-road vehicles, equipment, and vessels. Additional guidance was taken from EPA documents on rail and ocean-going vessel emissions inventory development, as well as other supplementary sources of information.

2.2 Analytical Methods Used for the PSEI and GHG Inventory

Emissions inventories are typically described as "activity based", meaning that emissions are estimated based on documented "activity levels". Activity levels are the types of equipment/sources inventoried, the duration of their operations, and the intensity of their operations. For the PSEI and the NWSA Greenhouse Gas (GHG) Inventory, data summarizing maritime operations, equipment usage, and stationary electricity and fuel usage was collected from ports, individuals, agencies and companies that own, operate, maintain and/or charter vessels and equipment, or are stationary users of fuel and/or electricity. The data collected summarized the numbers of equipment operating, equipment ages and subtypes, the mode/method of operation, hours of operation, electricity usage, and/or fuel usage. Emissions were estimated from the activity levels by applying emission factors, which quantify the amount of emissions per unit of activity.

Activity based inventories are typically preferred due to their practicability over direct emission measurements because of the sheer volume of equipment and stationary sources included in most emissions inventories. For example, it would be nearly impossible to make direct measurements of emissions from every ship, truck, train, and piece of equipment operating as a part of the NWSA's operations. While the activity based approach for assessing emissions is efficient, it does introduce a significant level of uncertainty because emission factors used are typically laboratory derived "fleet average" values, that may not be perfectly representative of each individual vehicle, vessel, or piece of equipment. Furthermore, emissions inventories do not typically evaluate the impact or spatial distribution of emissions. Hence, the total amount of emissions per year is estimated by the emissions inventories, but there are no estimates of local pollutant concentrations associated with which these emissions would be correlated with the expected health effects, nor is there an analysis of where the emissions occur beyond the attribution to the specific source category (truck, train, vessel, etc.). Air quality monitoring studies are better equipped than emissions inventories to assess the local and regional impacts of emissions, as measurements are made directly in the affected communities. Statistical methods exist that allow scientists to assess the impact of individual sources on the ambient levels of air pollutants. However, it is more difficult to directly assess the emissions associated with individual pieces of equipment using the monitoring approach and often difficult to differentiate between similar sources. Therefore, a robust air quality program would make use of both emissions inventories and air quality monitoring to assess the sources of pollution and their impacts on the community.

2.3 PSEI and GHG Inventory Geographical Extents

The PSEI and GHG Inventory estimate emissions from maritime-related activities in tons per year within the U.S. portion of the Puget Sound/Georgia Basin International Airshed. The same airshed boundary was chosen for the GHG Inventory as the PSEI for consistency with previous work. This area spans from the U.S./Canadian border through the Strait of Juan de Fuca to just south of Olympia (~140 miles) north to south and from the Cascade Mountains to the Olympic Mountains and the mouth of the Strait of Juan de Fuca from east to west (~160 miles), as shown in Figure 1. This includes mobile source emissions off port terminals within the airshed boundary for relevant sources.

Figure 1. PSEI and GHG Inventory boundaries (Puget Sound Airshed). NWSA maritime-related activity that occurs in the US portion of the light green shaded area (below the dashed black US-Canada boundary line) is included in the NWSA's inventories.

Within the inventory, emissions were estimated on both the airshed scale and the port scale. The port scale includes only emissions that occur within port terminal boundaries, while airshed scale emissions include all emissions associated with port activity within the airshed. Notable emissions activity that are included in the airshed scale emission, but not in the port scale emissions are OGV transiting, trucks on-road driving, line-haul locomotive emissions and harbor vessel transiting.

3. 2016 PUGET SOUND MARITIME AIR EMISSIONS INVENTORY

The Puget Sound Maritime Air Emissions Inventory (PSEI) is an accounting of air emissions from maritime-related equipment operating in the greater Puget Sound region. The inventory was conducted voluntarily to provide a strong technical foundation for future environmental programs, initiatives and policy decisions. The baseline inventory was conducted in 2005 with updates performed every five years (2011 and 2016) to track emission reductions over time and ensure that emission estimates remain current.

3.1 Puget Sound Maritime Air Forum

The inventory was commissioned by the Puget Sound Maritime Air Forum, an association of private and public maritime organizations, ports, air agencies, environmental and public health advocacy groups and other parties with regulatory responsibilities associated with the maritime industry. The 2016 inventory update was funded by contributions from the Air Forum partner organizations, and Starcrest Consulting Group was competitively selected to develop the inventory.

Puget Sound Maritime Air Forum major partners:

- The Northwest Seaport Alliance
- Port of Anacortes
- Port of Everett
- Port of Olympia
- Port of Port Angeles
- Port of Tacoma
- Port of Seattle
- Northwest Clean Air Agency
- Puget Sound Clean Air Agency
- U.S. Environmental Protection Agency (EPA)
- Washington State Department of Ecology
- Washington State Department of Transportation
- Puget Sound Regional Council
- North West and Canada Cruise Association
- Pacific Merchant Shipping Association
- Western States Petroleum Association

3.2 Emission Source Categories

Data were gathered for six major maritime-related source categories:

- Ocean-going vessels (cargo, cruise, and tanker ships)
- Harbor vessels (tugs, ferries, and other government and commercial vessels)
- Recreational vessels, cargo-handling equipment (cranes, forklifts, straddle carriers, and yard tractors)
- On-road, heavy-duty vehicles (semi-trucks and buses)
- Terminal operator fleet vehicles (passenger cars and trucks)
- Rail operations

3.3 Pollutants Inventoried

The PSEI estimated emissions of relevant criteria pollutants and precursors as designated by the U.S. Environmental Protection Agency (carbon monoxide (CO), nitrogen oxides (NOx), sulfur dioxide (SO2), volatile organic compounds (VOCs) and particulate matter (PM), greenhouse gasses (carbon dioxide (CO2), methane (CH4) and nitrous oxide (N2O), reported as CO2 equivalents (CO2e)), diesel particulate matter (DPM) and black carbon (BC).

- Particulate matter (PM): Solid and liquid particles suspended in the atmosphere. The composition of particulate matter includes a wide variety of substances including unburned fuel components, soot, dust, pollen, sea salt, smoke, and many more. Particulate matter can be directly emitted (primary PM) or formed because of chemical transformation and/or condensation of certain gasses in the atmosphere that were previously emitted (secondary PM). PM is typically classified by size, specifically the particle diameter. Smaller particles are thought to be more dangerous than larger particles because the can travel deeper into the lungs, increasing the probability of toxic chemicals reaching the blood stream. Exposure to $PM_{2.5}$ is linked with respiratory disease, decreased lung function, asthma attacks, heart attacks, and premature death.
  - PM_1: Also known as ultrafine particulate matter, PM_1 refers to the fraction of PM that is 1 micrometer in diameter or less.
  - $PM_{2.5}$: Also known as fine particulate matter, $PM_{2.5}$ refers to the fraction of PM that is 2.5 micrometers in diameter or less.
  - PM_{10}: Also known as coarse particulate matter, PM_{10} refers to the fraction of PM that is 10 micrometers in diameter or less.
- Diesel Particulate Matter (DPM): DPM is the particulate component of diesel exhaust that is directly emitted from diesel engines. Diesel exhaust was classified as a carcinogen by the International Agency for Research on Cancer (IRAC) and was estimated to account for 70% of the total cancer risk from air pollution by the California Air Resources Board (CARB). Operators of diesel equipment and citizens who live in areas that are disproportionately impacted by diesel exhaust are thought to have an increased risk of cancer due to elevated exposure to DPM. In addition to being a known carcinogen, DPM poses similar acute health effects as $PM_{2.5}$.

- Carbon Monoxide (CO): Carbon is a product of incomplete combustion of fossil fuels and biomass. At high concentrations, CO is an asphyxiant, bonding to hemoglobin in the blood and preventing the distribution of oxygen to the body.
- Nitrogen Oxides ($NO_x = NO + NO_2$): Nitrogen oxides are formed during the combustion process either through oxidation of nitrogen in the fuel (fuel NO_x) or by breaking apart N_2 and O_2 molecules contained in ambient air due to the high temperatures of combustion. Therefore, high temperature combustion, such as diesel engines, is a large source of NO_x. NO_2 is a criteria pollutant as designated by the EPA and is associated with respiratory effects. NO_x is also a key component of the series of chemical reactions that forms ground level ozone (which is a criteria pollutant) and is there labeled as an ozone precursor.
- Volatile Organic Compounds (VOCs): VOCs are released in exhaust as unburned fuel components pass through the engine, or when fuel is partially combusted. VOCs are not criteria pollutants, but they are ozone precursors and many have been labeled as air toxics by the EPA, meaning that they are a cancer risk and are associated with other health effects.
- Sulphur Dioxide (SO_2): SO_2 is released as a result of the oxidation of Sulphur in the fuel, and is the main form in which fuel Sulphur is released. SO_2 is a criteria pollutant as designated by the EPA and is associated with respiratory discomfort and impairment.
- Greenhouse Gasses (reported as CO_2 equivalents, CO_2e): Greenhouse gasses are not associated with direct human health effects, but they affect the radiative balance of the earth by trapping solar radiation near the surface of the Earth, raising Earth's surface temperature. In other words, they contribute to climate change. Greenhouse gasses are reported in CO_2 equivalents by multiplying the emissions of each by their global warming potentials. The global warming potential accounts for how "strong" each GHG is and how long it lasts in the atmosphere. This product is then summed for all GHG.

  The three main greenhouse gasses inventoried were:

  - Carbon Dioxide (CO_2): When a carbon-based fuel (fossil fuels, biomass) is combusted for energy, the vast majority of the carbon in the fuel is released as CO_2. The global warming potential of CO_2 is 1-ton CO_2e per ton CO_2 emitted.
  - Nitrous Oxide (N_2O): Nitrous oxide is a byproduct of fuel combustion, and is typically emitted in much lower quantities than CO_2. The global warming potential of nitrous oxide is 298 tons CO_2e per ton N_2O emitted.
  - Methane (CH_4): Methane is a byproduct of combustion and can also be released as a result of fossil fuel supply chain leakages. The global warming potential of methane is 34 tons CO_2e per ton CH_4 emitted.

- Black Carbon: Black carbon, otherwise known as soot, is a particulate emission from the combustion of fossil fuels, specifically diesel engines. Black carbon has been linked to negative health effects including respiratory effects, cardiovascular disease, cancer and birth defects. Black carbon also accentuates climate change, by absorbing radiation while in the atmosphere, and accumulating on snow and ice, which decreases the amount of radiation reflected by Earth's surface.

3.4 NWSA Airshed Scale Emission Results

Emissions were quantified for each port within the Puget Sound Airshed, as well as the entire region. Results were also broken out for the NWSA. Between 2005 and 2016, emissions of all pollutants surveyed have decreased, demonstrating the effectiveness of port, local, regional, national and international emission reduction measures.

When compared with the NWPCAS goals, emission reductions have met the 2020 targets of 80% for DPM and 15% for greenhouse gases. Figure 2 shows the emission reductions for DPM and GHG per ton of cargo relative to the baseline year 2005. The figure also shows the cargo throughput in tons for reference. Emission reductions for NWSA were 80% and 17% per ton of cargo for DPM and GHG (CO2e) respectively.

Significant emission reductions were also observed for other pollutants, namely: 97% for SO2, 81% for PM10, 78% for PM2.5, 63% for black carbon, 44% for VOCs, 35% for CO and 33% for NOx. Table A1 (in Appendix A) summarizes the emissions associated with NWSA operations on the airshed scale for model years 2016, 2011, and baseline year 2005. The North American Emissions Control Area (ECA) played a substantial role in reducing DPM and SO_2 emissions.

Table A2 (in Appendix A) shows the absolute changes in emissions for 2016 and 2011 from the 2005 baseline, as well as emission changes relative to cargo throughput tonnage. Emission changes are normalized to throughput in order to minimize the effect of changing business on emission reduction progress. That is, to prevent the port from being penalized for bringing in more business, which is likely to increase emissions, but also not to get credit for losing business, which is likely to lower emissions.

Major reasons for emission reductions were:

- North American Emissions Control Area (ECA): Decreased fuel sulfur limit for ocean-going vessels from 3.5% to 0.1%, which drove large decreases of PM and SO_2 emissions. The ECA was implemented in 2015.
- Increased cargo transport efficiency for ocean-going vessels: Similar cargo tonnage moved by fewer vessels, drove emission reductions for all pollutants.
- Increased shore power usage influenced emission reductions for all pollutants.
- Switching on-road trucks, non-road equipment, locomotives, and harbor vessels to ultra-low sulfur diesel (ULSD), drove large reductions in SO_2 and PM emissions. The rule for on-road trucks was fully implemented in 2010, and the non-road rule was fully implemented in 2014. ULSD has a Sulphur content of 15 ppm, or 0.0015%. Before 2010, highway diesel fuel was 500 ppm Sulphur, or 0.05%. Non-road diesel was unregulated before 2007 and had a 500 ppm (0.05%) sulfur limit from 2007 to 2014.
- Stricter emission standards for on-road trucks, non-road equipment, locomotives and vessels along with fleet turnover, drove emission reductions for all pollutants.

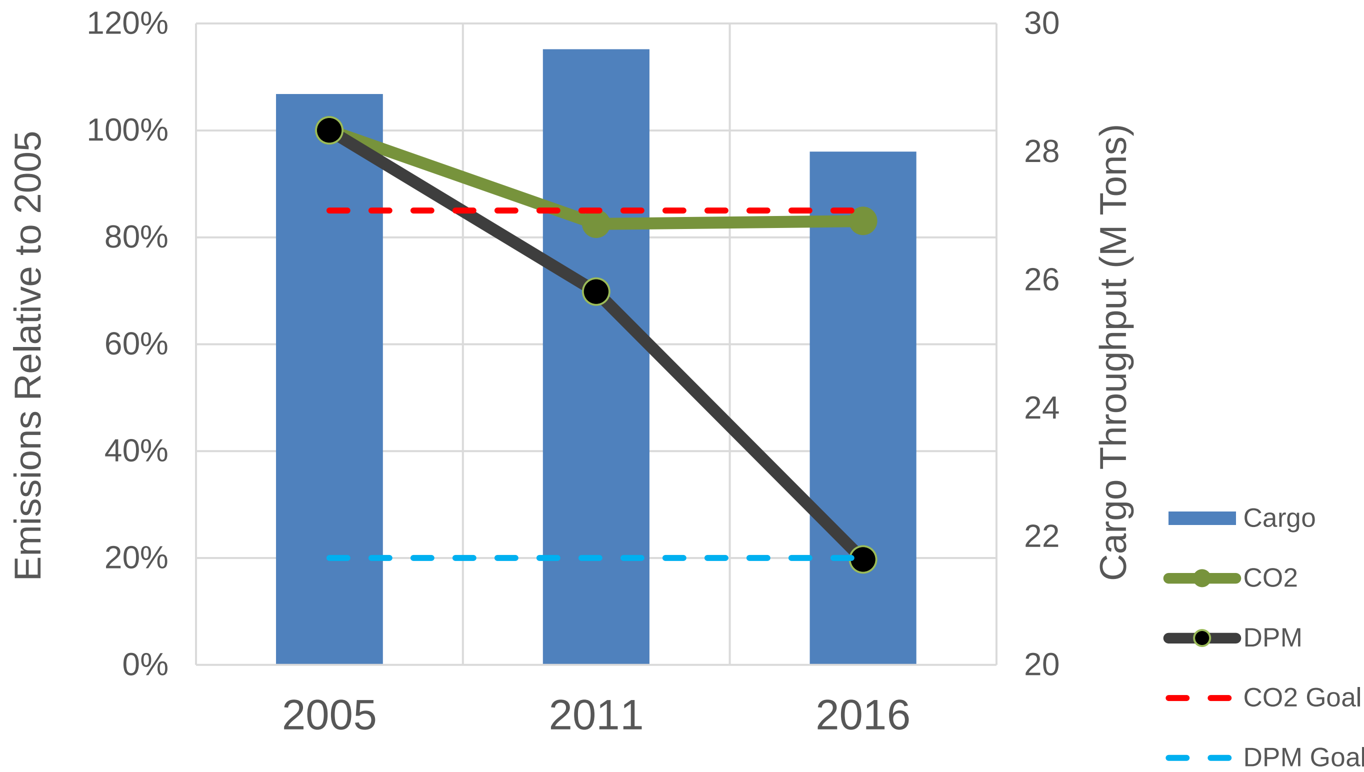


Figure 2. DPM and CO_2e emissions relative to 2005, demonstrating achievement of NWPCAS targets.

3.5 NWSA Emission Distribution Changes

As a result of the large emission reductions from ocean going vessels, the distribution of emissions from airshed scale NWSA operations changed substantially between 2005 and 2016. Figure 3 shows the emission distributions of DPM for model years 2005, 2011, and 2016. With the large decrease in OGV emissions between 2011 and 2016 associated with the ECA, OGV emissions become a smaller portion of the total emissions and other sectors become more important. For instance, trucks went from making up 9% of the total emissions in 2011 to 23% of the total emissions in 2016. Despite the percentage share of truck emission increasing, actual truck emissions still fell in total DPM tons per year, dropping from 89 tons in 2005, to 66 tons in 2011, to 47 tons in 2016.

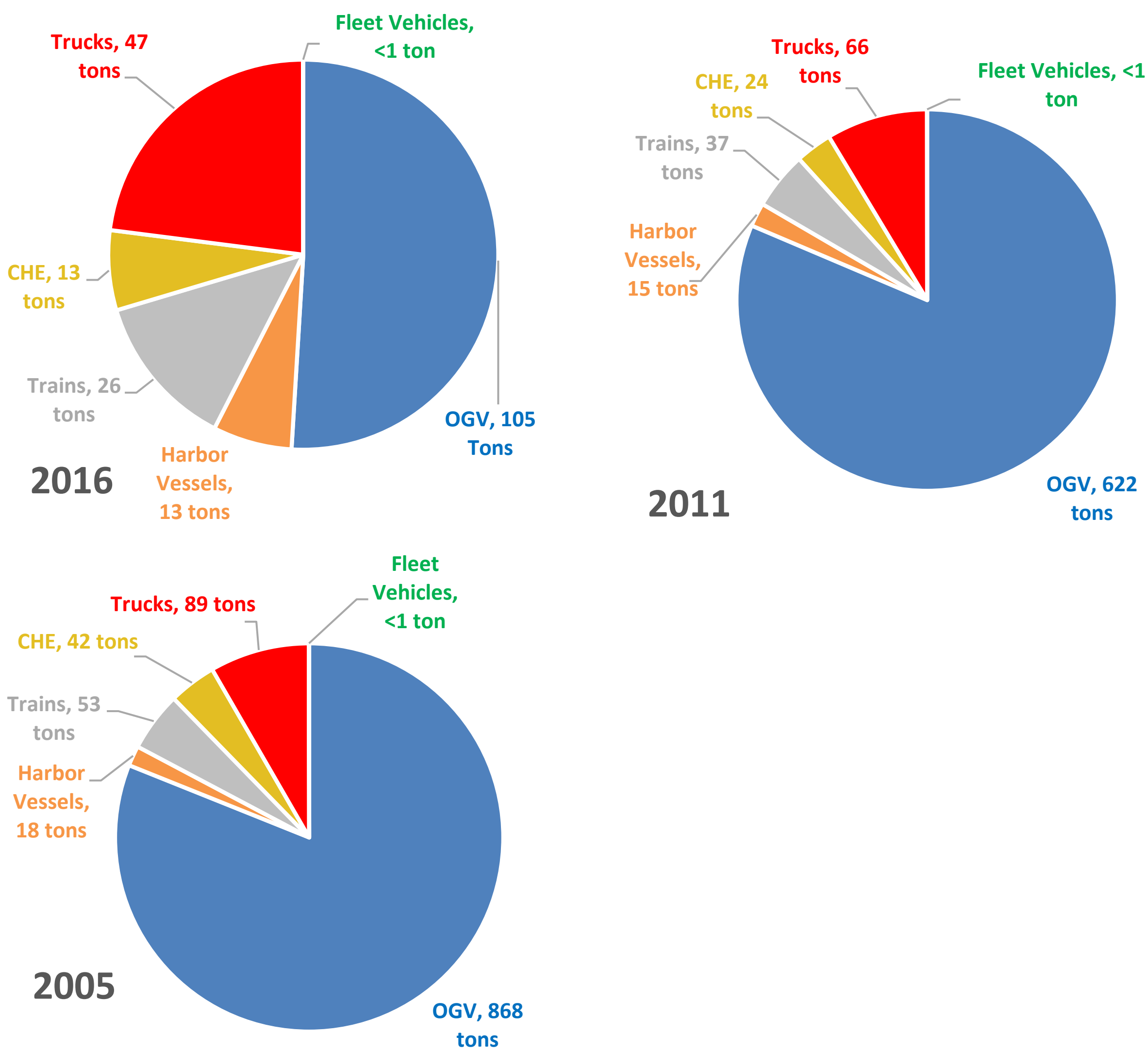
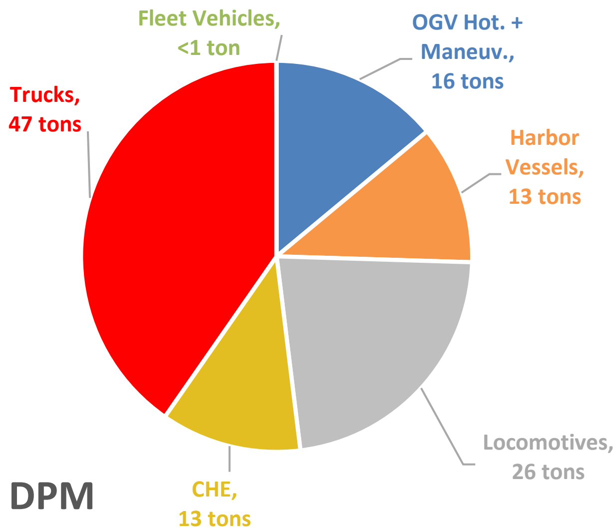


Figure 3. DPM emission Distributions for 2005, 2011, and 2016.

3.6 NWSA "Near Shore" Emission Distributions

Emissions distributions can be further dissected to "near shore" emissions, excluding the transiting component of OGV emissions. The reasoning behind examining emissions without OGV transiting is twofold. First, the Port has very little influence over the shipping lines' choices when it comes to propulsion fuel use other than the ECA regulations. Second, OGV transiting emissions are less likely to impact human health than the near shore emissions, since the transiting emissions occur mostly in open water away from major population centers. When near shore emissions are examined, trucks, OGV hoteling, locomotives, cargo handling equipment, and harbor craft are all substantial contributors to the NWSA's total emissions, stressing the importance of a comprehensive clean air strategy that addresses all sectors.

Of specific interest are the truck and cargo handling equipment since trucks make up the largest portion of near shore emissions, and the Alliance exerts more control over cargo handling equipment than the other sectors. DPM emissions were reduced by 68% from 2005 to 2016 as a result of fuel sulfur reductions and fleet turnover, but still remain a significant fraction (11%) of near shore DPM emissions. The Alliance should focus on finding ways to influence and incentivize fleet turnover through programs and lease agreements.



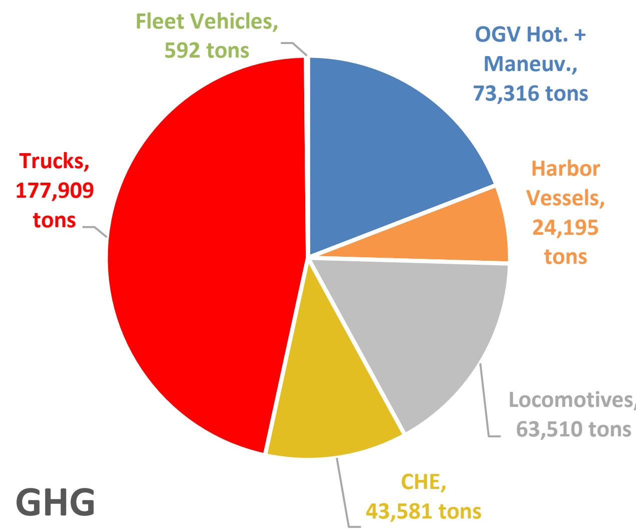


Figure 4. DPM and GHG "near shore" emissions distributions for year 2016.

3.7 Maritime Industry-Wide Emissions in the Puget Sound Airshed

Throughout the Puget Sound Airshed, industry-wide maritime emissions have decreased for all pollutants and in most sectors since 2005. Table A3 (in Appendix A) shows the emissions for all maritime-related emissions in the airshed for 2016, 2011, and 2005. Table A4 shows the emission changes for 2016, 2011, and 2005.

Major reasons for emission changes were:

- The North American Emissions Control Area (ECA) decreased the fuel sulfur limit for ocean-going vessels from 3.5% to 0.1%, which drove large decreases of PM and SO_2 emissions. The ECA was implemented in 2015.
- Switching on-road trucks, non-road equipment, locomotives, and harbor vessels to ultra-low sulfur diesel (ULSD) drove large reductions in SO_2 and PM emissions. The rule for on-road trucks was fully implemented in 2010, and the non-road rule was fully implemented in 2014. ULSD has a Sulphur content of 15 ppm, or 0.0015%. Before 2010, highway diesel fuel was 500 ppm Sulphur, or 0.05%. Non-road diesel was unregulated before 2007 and had a 500 ppm (0.05%) sulfur limit from 2007 to 2014.
- Stricter emission standards for on-road trucks, non-road equipment, locomotives and vessels, along with fleet turnover drove emission reductions in all sectors.

- Emission increases in NO_x, VOCs, CO, and CO_2e occurred for harbor craft due to increases in vessel activity (more vessels operating for more hours) and a more relaxed CO emission standard for newer vessels. A large component of harbor craft emissions in the maritime industry-wide inventory was the Washington State Ferries. These increases were compensated by reductions in other sectors.
- Increases in recreational vessel CO_2e and NO_x emissions were attributable to increased activity, partially due to including more private marinas in 2016 than in 2005. Ports do not have any significant influence over the emissions from recreational vessels.
- Stricter emission standards for on-road trucks, non-road equipment, locomotives and vessels along with fleet turnover, drove emission reductions for all pollutants.

3.8 Future Applications of the PSEI Data

Staff plan to use the PSEI data to demonstrate achievement of the 2020 NWPCAS targets, inform the NWPCAS 2018 strategy update, and to provide technical justification for emission reduction projects and allow staff to choose the most effective and cost-efficient emission reduction strategies.

As part of the emissions inventory project, Starcrest is developing an Emissions Scenario Evaluation Tool, which will estimate the effect of speculative changes in operating or equipment parameters on the 2016 inventory results. The tool will provide technical justification for emission reduction projects, both internally and when applying for outside funding. Emission projections from the tool will empower staff to help set air quality goals that are both aggressive and realistically attainable.

4. 2016 NWSA GHG INVENTORY

To fully assess its' GHG footprint, the NWSA completed a GHG inventory for model year 2016 and baseline year 2005 in addition to participating in the PSEI. While the PSEI does include GHG emissions as part of its scope, the PSEI only accounts for emissions from equipment and transportation and does not include all sources of emissions, namely stationary sources such as marine terminal operator purchased electricity, tenant stationary fuel use, and employee commuting, among others. Accounting for all GHG emissions is essential for setting the baseline for NWSA GHG Resolution (2017-02) targets, updating the NWPCAS, and creating a glidepath for achieving GHG Resolution emission reduction targets.

4.1 NWSA Greenhouse Gas Resolution

In keeping with the Paris Agreement, NWSA has renewed its commitment to GHG emission reductions through the adoption of its Greenhouse Gas Policy Resolution (2017-02). The airshed scale GHG emission reduction targets are as follows:

By 2030:

- 50% below 2005 levels (Scope 1,2, and 3 emissions)

By 2050:

- Carbon neutral (Scope 1 and 2)
- 80% below 2005 levels (Scope 3 emissions)

To accomplish these goals, NWSA will work with the homeports to advance emission reduction initiatives and work to influence other stakeholders whose emissions fall beyond the NWSA's authority.

4.2 Greenhouse Gas Inventory Description of Scope

The GHG Inventory covers all sources of GHG associated with NWSA operations. This includes mobile sources associated with cargo movement inventoried by the PSEI in addition to port and tenant staff commuting, port staff business travel, tenant electricity usage, tenant natural gas usage, solid waste and wastewater treatment, and fugitive emissions from A/C and refrigeration units. The geographical extents of the GHG inventory were the same as the PSEI airshed scale as described in section 2.3. The pollutants inventoried were the same as the GHG inventoried in the PSEI as described in section 3.3 in addition to commercial and industrial refrigerants. These compounds are used in A/C and refrigeration units in vehicles, buildings, and refrigerated containers and are released as the systems that contain them slowly leak. There are many compounds that fit this classification, but a common example is hydrofluorocarbon (HFC)-134a. While leakage rates are typically very low, refrigerants are typically potent GHGs. For example, HFC-134a has a global warming potential of 1550 tons CO2e per ton HFC-134a emitted.

Greenhouse gas emissions are classified in three different categories, or "scopes", depending on how much control an organization has on the emissions. These scopes are defined as:

- Scope 1 emissions refer to direct emissions from buildings or equipment owned by the Port. Examples of scope 1 emissions would be natural gas burned in office buildings and fuel burned in company owned vehicles.
- Scope 2 emissions refer to purchased electricity for use in buildings and equipment owned by the port.
- Scope 3 emissions refer to indirect emissions associated with employee business travel and commuting, tenant electricity use, tenant fuel use, and other outsourced activities. Mobile source emissions are considered on the airshed scale, to incorporate as much of the GHG impacts as was feasible and to maintain consistency with the PSEI.

Because the NWSA did not own any property or equipment in 2016, all NWSA emissions were, by definition, scope 3. Stationary fuel combustion and electricity use at leased property that housed NWSA cargo handling operations were included in the inventory as scope 3 tenant stationary sources. Mobile source emissions associated with NWSA cargo transport and handling from the PSEI were incorporated into the inventory as well. Fugitive refrigerant emissions were calculated for expected leakages from vehicle A/C systems as well as refrigerated containers. Finally, NWSA staff's business travel, commuting, solid waste, and liquid waste were included.

All properties owned by the home ports (Port of Tacoma and Port of Seattle) that were not involved in NWSA operations were assumed to be the responsibility of the home ports. Additionally, cargo handling and cruise operations that were not included in the formation of NWSA were assumed to be the responsibilities of the home ports. As NWSA purchases equipment and property, NWSA will take responsibility for its scope 1 and 2 emissions and adjust the GHG inventory and emission reduction strategies accordingly. A GHG inventory was conducted in parallel with this study for Port of Tacoma, while Port of Seattle is conducting its own inventory independent of this study.

4.3 Greenhouse Gas Inventory Results

Results of the NWSA GHG Inventory demonstrated that mobile sources made up greater than 98% of the total GHG emissions, demonstrating that reducing emissions from mobile sources is the most important component of meeting the GHG Resolution targets. GHG emission estimates are shown in Table 1. Emissions decreased by 20% from baseline year 2005 to 2016, reflecting improvements in supply chain efficiency as discussed in the PSEI. GHG emissions from tenant electricity use decreased substantially from 2005 to 2016, reflecting decreases in energy grid carbon intensity. Emission charges were impossible to assess for many sectors, as data was not available for model year 2005 and in many cases 2005 activity was assumed to be the same as 2016.

Table 1. NWSA GHG Emissions

GHG Emissions (Tons CO_2e)				
Emissions Scope	**Source**	**Description**	**2005**	**2016**
Scope 1	None		NA	NA
Scope 2	None		NA	NA
Scope 3	Cargo Transportation: • OGV • harbor vessels • locomotives • CHE • trucks • fleet vehicles	Mobile Sources (PSEI)	800,140	640,556
	Employee Commuting	Port	164	186
		Tenants	4,143	4,305

	Ports' Staff Business Travel [a]	Air	129[b]	129
		Automobile	45[b]	45
	Solid Waste and Wastewater Disposal and Treatment	Solid Waste	682	446
		Wastewater	198	189
	Port Tenant Stationary Sources	Natural Gas Combustion	28[b]	28
		Purchased Electricity	5,102	1,838
	Fugitive Emissions – Refrigerants [c]	Stationary Sources	3,679	3,679
		Mobile Sources	3,062	2,966
		Refrigerated Containers	130	151
Total Scope 3			**817,502**	**654,518**

[a] Includes both NWSA and Port of Tacoma Staff

[b] 2005 data not available. 2016 data used to gap fill for 2005

[c] Refrigerant leakages estimated based on building sizes, equipment counts, and reefer counts

4.4 Emission Projections

Future emission projections were generated using the forecasted 2.2% compound annual growth rate of the container trade from the “2017 Marine Cargo Forecast and Rail Capacity Analysis” prepared for the Washington Public Ports Association and the Freight Mobility Strategic Investment Board. A business as usual scenario was presented, where emission rates were assumed to grow at the same rate as cargo throughput, which does not account for future efficiency improvements. Future efficiency improvements are not accounted for in projections because they are extremely difficult to predict and highly dependent on technology that does not yet exist.

The NWSA emission projections are displayed in Figure 5. As discussed previously, emissions decreased about 20% from 2005 to 2016. From then on, emissions grow at a compound rate of 2.2%, exceeding 2005 levels in 2030 and reaching 153% of 2005 levels by 2050. To reach 50% of 2005 levels by 2030, 461,826 tons of business as usual emissions need to be mitigated. To reach an 80% reduction from 2005 emission levels in year 2050, 1,093,277 tons of business as usual emissions would need to be mitigated. Of course, supply chain efficiency improvements are expected in future years, meaning that the entirety of these emission reductions may not fall on port initiatives. However, significant operational changes will be needed if the NWSA is to meet the GHG Resolution targets as discussed below in the NWSA GHG Glidepath.

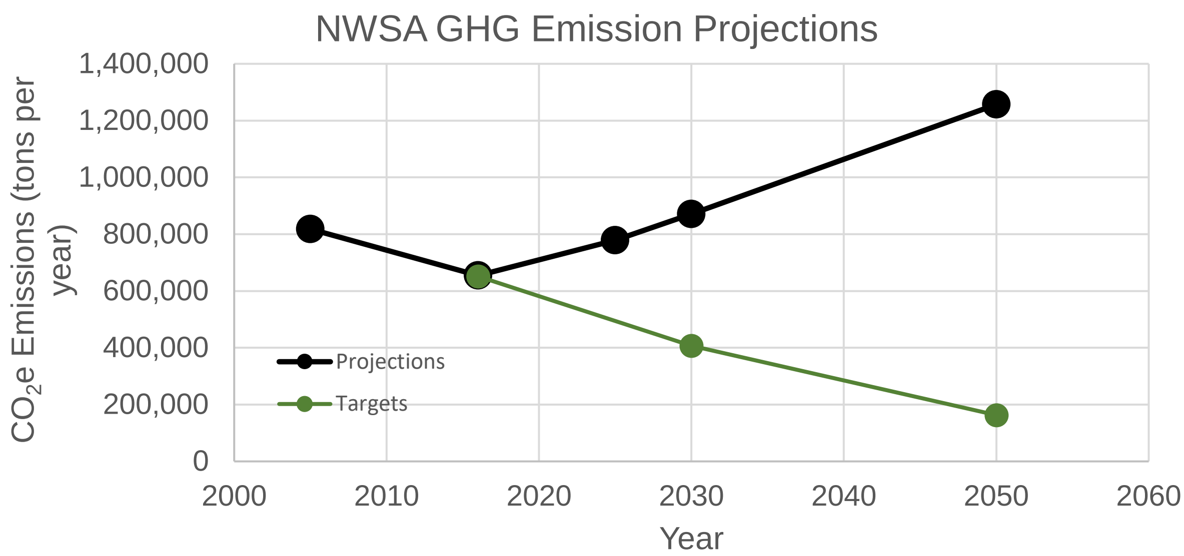


Figure 5. NWSA GHG "business as usual" emission projections and glidepath for achieving GHG Resolution Targets. The green dots at year 2030 and 2050 indicate the emission reduction targets. The dots at years 2005 and 2016 indicate emission estimates from the GHG Inventory.

4.5 <u>GHG Inventory Lessons Learned</u>

Gathering complete activity data is the most important aspect of conducting a GHG Inventory. Gap filling procedures are robust and provide adequate estimates of GHG emissions, but add significant levels of uncertainty to the results. Approximately 50% of tenants completed the request for data. In future studies, staff will provide additional time for tenants to respond to requests for data and work to increase automation of certain data through better utility metering and record-keeping. Additionally, requests for data will be sent out to terminal operators in advance, so that they can log the data throughout the year, rather than trying to find the information after the fact. Many of the Port's utility services are used by multiple locations and entities, making it difficult to differentiate responsibility. Staff will recommend specific opportunities for submetering for future inventories.

Many of the records needed for the inventory were incomplete, particularly for backcasting the 2005 baseline inventory. This was partially due to inadequate record keeping. Many terminal operators that did respond did not have data from as far back as 2005. In addition, the Port did not have employee commuting or business travel records from 2005. Business travel records from NWSA's travel agent were not kept at a fine level of detail and did not separate Port of Tacoma and NWSA. Procedures should be put in to place to more rigorously log this information.

Staff recommends GHG inventories be performed annually to keep pace with a dynamic market, ensure that the latest information is captured and to continue to refine data collection and record keeping procedures.

5. NWSA GREENHOUSE GAS GLIDEPATH

The NWSA GHG Glidepath is an emission reduction strategy aimed at achieving the emissions reduction targets set forth by the NWSA GHG Resolution. The glidepath estimates the amount of emission reductions required in each sector as well the technological feasibility of possible emission reduction strategies to identify the best methods of reaching the targets in the Resolution.

5.1 Glidepath Methodology

Development of the glidepath was largely a technology review, where emission reduction measures were assessed in each source category for technological feasibility and emission reduction potential. The goal of the study was to understand to what extent operation changes would be necessary to achieve the GHG targets. The glidepath is split in two phases, the 2030 targets and the 2050 targets. Each includes the measures that are expected to be technologically feasible in their respective timeframes. Mobile sources are by far the largest sources of emissions and are the focus of the glidepath. The emission reduction results of the various measures are summed to demonstrate their cumulative effect and their efficacy at meeting the GHG Resolution targets. Where shortfalls exist, renewable fuels should be considered as a means to achieve the targets and GHG offsets may be considered where renewable fuels are not available.

The glidepath is focused on emission reduction potential. Other commercial and social factors have not yet been included in this assessment. The costs stated are initial costs for equipment and infrastructure and do not take into account maintenance, replacement, or fuel costs. The glidepath also does not take into account future policy decisions that might impact fuel costs (e.g. a Carbon Tax or Low Carbon Fuel Standard).

5.2 Glidepath Emission Reduction Strategies and Efficacy

The GHG emission reduction glidepath focuses primarily on zero emission technology where possible as well as efficiency improvements. Due to the prevalence of hydropower in the Pacific Northwest, NWSA has a unique opportunity to take advantage of inexpensive clean electricity that both reduces operational costs and emissions. Switching from internal combustion engines to electric engines reduces maintenance costs and reduces fuel costs. The proposed emission reduction measures are tabulated below.

Costs are provided for the 2030 and 2050 goals. These costs represent the additional, incremental costs of implementing the proposed technology relative to purchasing new diesel equipment and include both the equipment and electrical infrastructure upgrades where applicable. Incremental equipment and infrastructure costs were taken from existing resources from the Ports of Los Angeles and Long Beach[1], California Air Resources Board (CARB), and Campbell Foss. These are high level cost estimates that are likely conservative and carry significant contingencies based on the unpredictability of future shipping line operations, terminal operations, technological progress, and other factors. For example, the estimates for infrastructure costs included in the Port of LA and Long Beach were developed with a 100% contingency and assumed no operational efficiencies that could lower costs. The conservative nature of these estimates means that this is likely a worst-case estimation. Additionally, many of

[1] *Preliminary Cost Estimates for Select 2017 Clean Air Action Plan Strategies*

the technologies surveyed are in the infant stages of adoption, or still in prototype phase, suggesting that the price and incremental costs of equipment will likely decrease as they become widely adopted.

The total estimated cost to achieve the NWSA 2050 targets (including 2030 costs) is **$4.0 billion**. By comparison, the estimate for the Ports of LA and Long Beach combined Clean Air Action Plan is $7.05 billion to $13.6 billion and does not include shore power infrastructure since it has already been constructed in California.

To reach 50% of 2005 levels by 2030, 461,826 tons of business as usual emissions need to be mitigated. To reach an 80% reduction from 2005 emission levels in year 2050, 1,093,277 tons of business as usual emissions would need to be mitigated.

2030 Emission Reduction Measures (In order of emission reduction potential)
Costs included are for the entire time frame, while GHG emission reductions are calculated annually.

1. Shore Power ($601,500,000; 83,208 tons CO_2e per year)

- All vessel visits
  - Shipside infrastructure: $511,500,000,
    - $1.5 million per ship retrofit cost (436 different vessels in 2016, 95 shore power equipped, 341 require retrofit)
    - Assumed that all ships servicing the gateway that currently are not equipped with shore power infrastructure would be retrofitted before 2030 and this would be done strategically to avoid retrofitting a vessel that would soon be taken out of service or rerouted.
    - Assumed that cargo throughput would grow through increasing ship size rather than number of vessels.
    - Costs could be higher if shipping strings change frequently requiring more retrofits.
    - Costs could be lower if global policy requires shore power and ships are built shore power capable. No requirement exists that new ships be built with shore power equipment.
  - Terminal Infrastructure: $90,000,000.
    - $5 million per berth (assumed 2 berths per terminal and 9 NWSA needing shore power infrastructure).
    - Used estimates of cost for shipside and landside infrastructure from CARB's "Technical Support Document on Regulations to Reduce Emissions from Diesel Auxiliary Engines from Ocean Going Vessels while at Berth at a California Port" to determine cost

Labor costs are not included as there are too many variables to calculate. Costs could range from $1.0 million to $8.3 million annually assuming a low bound of 6 man hours per call and high bound of 48 man hours per call at $100 per hour.

2. Electric Trucks ($197,505,000; 74,395 tons CO_2e per year)

- 33% of fleet
  - Cost calculated using the number of unique trucks that called the NWSA in 2016 (4500) and projecting future numbers using 2.2% compound annual growth rate
  - Incremental cost of electric truck vs. diesel truck used was $100,000, taken from Ports of LA and Long Beach's "Preliminary Cost Estimates for Select 2017 Clean Air Action Plan Strategies"

3. Cargo Handling Equipment ($423,388,284, 17,967 tons CO_2e per year)

- 33% electric
  - Equipment: $165,868,725
    - Assumed incremental costs for each piece of equipment (electric vs. diesel) from Ports of LA and Long Beach's "Preliminary Cost Estimates for Select 2017 Clean Air Action Plan Strategies"

      Used CHE fleet from 2016 PSEI and projected equipment numbers forward using 2.2% compound growth rate.
  - Infrastructure: $257,519,559
    - Assumed infrastructure costs from Ports of LA and Long Beach's "Preliminary Cost Estimates for Select 2017 Clean Air Action Plan Strategies". It should be noted that the infrastructure costs were not discounted for duplicate pieces of equipment at the same terminal that could share much of the same infrastructure. Therefore, infrastructure costs are very conservatively high.

4. Truck Fuel Efficiency Improvements (11,093 tons CO_2e per year)

- Projected fleet fuel efficiency improvements driven by national new vehicle standards.
  - Emission reductions were assessed using the EPA Motor Vehicle Emissions Simulator (MOVES) model output to project emission rates from the 2030 vehicle fleet.

4. Hybrid Tug Assist Vessels ($20,000,000; 4,827tons CO_2e per year)

- 50% of fleet
  - Incremental cost of hybrid tug is $2,000,000 from "Hybrid Retrofit Report" from Campbell Foss.
  - 15 Assist tugs in 2016, assumed 20 in 2030, and 29 in 2050.

The total estimated cost of all 2030 measures is $1,242,393,284.

2050 Emission Reduction Measures (In order of emission reduction potential)
Costs included are for the entire time frame, while GHG emission reductions are calculated annually

1. Electric Trucks ($580,095,000; 305,163 tons CO2e per year)
    - 90% of fleet
    - Assumes $100,000 incremental cost per truck

2. IMO Efficiency Improvements (150,090 tons CO2e per year)
    - Energy Efficiency Design Index (EEDI) stipulates 30% efficiency improvement by 2050

3. Shore power ($549,360,000; 120,120 tons CO_2e per year)

➢ All vessel visits
    - Ship side infrastructure: $549,360,000
    - Shore side infrastructure: built in 2030 measures
    - Assumed that the current fleet would be changed out strategically between the present and 2030 as summarized above.
    - Assumed that after 2030, ships would be replaced and require retrofits on a 25-year time horizon, or that 1/25th of the fleet would be replaced and require shore power infrastructure each year. This cost could be much lower if new ships are built with shore power capabilities and could be higher if the useful life is less than 25 years, or if shipping strings change frequently.

Labor costs are not included as there are too many variables to calculate. Costs could range from $1.0 million to $8.3 million annually assuming a low bound of 6 man hours per call and high bound of 48 man hours per call at $100 per hour.

4. Cargo Handling Equipment ($1,557,324,116; 77,811 tons CO_2e per year)
    - 100% electric
    - Equipment: $610,033,775
    - Infrastructure: $947,290,341
    - Cost assumptions the same as 2030 analysis

5. Electric Switching Locomotives ($60,000,000; 39,021 tons CO_2e per year)
    - 100% by 2050
    - Incremental cost of a switching locomotive is estimated at $1,000,000 from CARB’s Freight Locomotive Technical Assessment

6. Hybrid tug assist vessels ($38,000,000; 13,936 tons CO_2e per year)
    - 100% of fleet
    - Incremental cost of hybrid tug is $2,000,000 from "Hybrid Retrofit Report" from Campbell Foss
    - 15 Assist tugs in 2016, 29 in 2050
7. Truck Fuel Efficiency Improvements (2,390 tons CO_2e per year)
    - Projected fleet fuel efficiency improvements driven by national new vehicle standards

The total estimated cost of all 2050 measures is $2,784,779,116.
The total cost for both phases is $4,072,172,400.

Additional Emission Reduction Measures:

- Employee commuting trip reduction
- Maintenance program to replace building and container based air conditioning and refrigeration units new low global warming potential units
- Replace all building natural gas usage with renewable electricity
- Require tenants to purchase electricity from 100% renewable sources

Figure 6 displays the emission reductions associated with each strategy along with the total emission reductions. Even with the aggressive plan laid out above, the emission reductions associated with the proposed strategies do not provide sufficient emission reductions to meet the targets. It is evident from Figure 6 that the emission reductions do not reduce the projected emission levels to the targets, missing the target by 270,339 tons in 2030, and 384,746 tons in 2050. By fully electrifying the truck and CHE fleets by 2030, an additional 186,977 tons CO2e could be mitigated, leaving a 83,362 ton shortfall.

Transiting emissions from ocean going vessels are projected to be 346,562 tons in 2030 and 500,301 tons in 2050 and are very difficult to reduce. There are no technological changes imminent that are likely to drastically change OGV fueling patterns or efficiency. The EEDI efficiency targets call for a 30% improvement in efficiency by 2050, which only reduces the transiting emissions to 350,210 tons, much higher than the 163,539 ton target for all emissions in year 2050. Given the lack of organizational control over OGV transiting emissions and the fact that they exceed the targets on their own, renewable fuels should be targeted where possible and offsets may be necessary for NWSA to meet its emission targets. It should also be noted that if additional efficiency measures unaccounted for by this analysis are instituted by the shipping lines, or if growth does not meet the 2.2% compound rate used in the emission projections, fewer offsets may be necessary to meet the targets. Carbon offsets currently cost approximately $11 per metric ton of CO_2e.

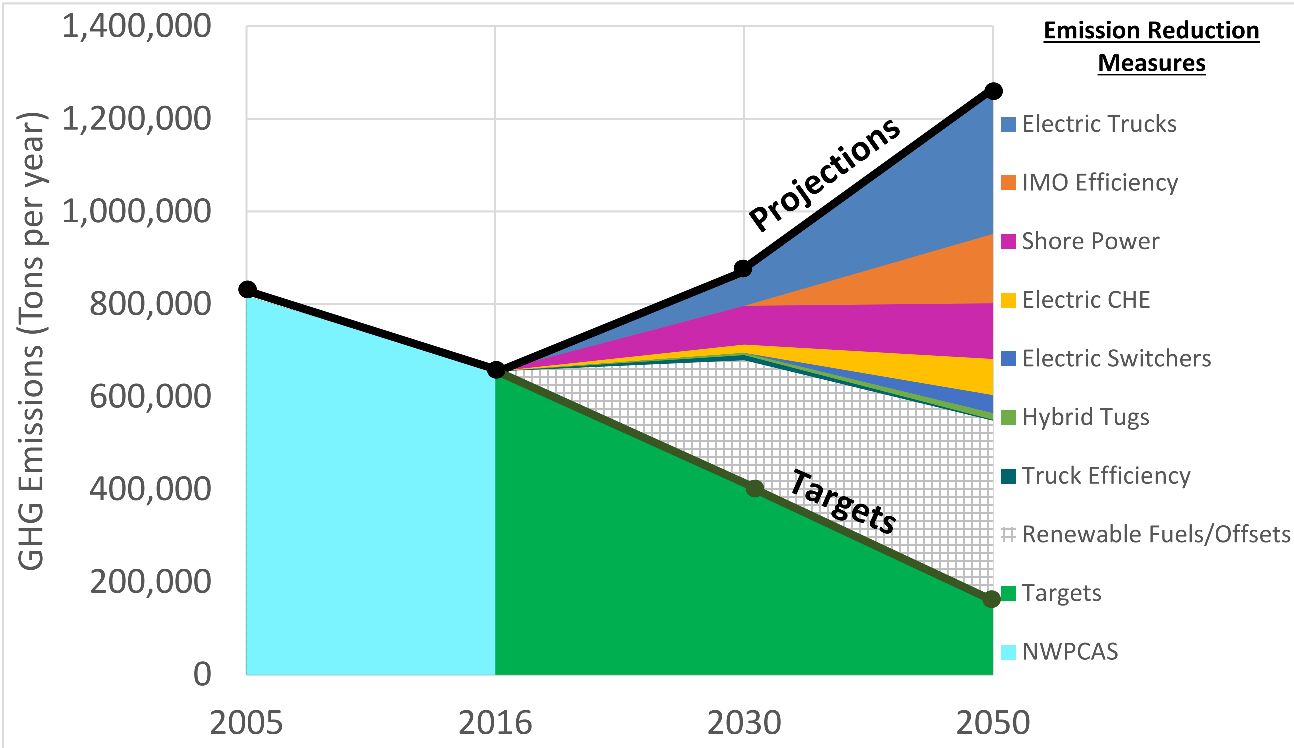


Figure 6. Cumulative effect of glidepath emission reduction measures as summarized above, illustrating the emission reduction measures necessary to get from the projections (black line) to the targets (green line). The light blue shaded area indicates the emission levels associated with the emissions estimates for 2005 and 2016. The decrease reflects progress made by the NWPCAS. The green shaded area and dark green line indicate the GHG Resolution targets in 2030 and 2050. The hatched area is the difference between proposed emission reduction measures and the targets, indicating the extent to which renewable fuels and GHG offsets must be considered. The other shaded areas represent the emission reductions associated with each individual reduction measure, where the black line on top indicates estimated and projected emissions.

6. UPCOMING EMISSION REDUCTION PROGRAMS

Using the data from the inventories, staff have prioritized programs and projects that have high emission reduction potential and are within the control of the NWSA. One of the guiding principle of the Northwest Ports Clean Air Strategy is to implement programs comprehensively across the gateway, striving to make significant investments in both the North and South Harbors. Listed below are proposals for three programs to begin to implement over the next few years, 1) a shore power program to reduce emissions from hoteling vessels, 2) a clean cargo handling equipment program to accelerate fleet turnover, and 3) a revised Clean Truck Program with a focus on improved data collection and drayage efficiency to reduce emissions from heavy duty trucks.

6.1 Clean Vessel Shore Power Program

At berth emissions make up a substantial fraction of NWSA's GHG emissions (66,358 tons in 2016, or 10% of the total emissions) and unlike many of the other emission sectors, there is a technologically feasible means to reduce emissions substantially in a cost-effective manner. Shore power (or cold ironing) eliminates direct at-berth emissions from auxiliary engines by plugging ships in to the electrical grid to satisfy energy requirements, allowing engines to be shut off. Indirect emissions can be eliminated if energy is obtained from a renewable source.

Currently, TOTE is the only NWSA container terminal with shore power infrastructure. Port of Seattle also has shore power capability at Pier 91, allowing two cruise vessels to plug in simultaneously. Additionally, many NWSA terminals have been outfitted with conduit for shore power wiring during modernization projects, allowing full shore power infrastructure to be installed later at significantly less cost. Shore power has been implemented at many other cruise and container terminals on the west coast as a means to improve air quality and decrease GHG emissions including the Port of LA, Port of Long Beach, and Port of Oakland. Port of Vancouver B.C. is currently in the process of implementing their container vessel shore power program. According to a study performed by Starcrest consulting group in 2015, 33% of ships calling the gateway are shore power capable.

Staff plans to systematically evaluate the installation of shore power at all NWSA terminals and will prioritize its efforts based on available funding, infrastructure installation costs, operational costs, expected use, and community impacts. In this way, staff will prioritize projects that realize the largest emissions benefit for the lowest cost while also making an effort to distribute investments throughput the gateway.

By turning off a ship's auxiliary engines and powering a ship with shore based electricity while at berth, up to 100% of the auxiliary engine air pollutant and GHG emissions can be mitigated. Indirect GHG emissions can still be substantial if the electricity is supplied from a fossil fuel source, but the Pacific Northwest energy grid receives a substantial fraction from GHG-free hydropower. For example, 84% of the energy distributed by Tacoma Power in 2016 was from hydropower. Additionally, the port purchases renewable energy credits to ensure that 100% of its energy comes from renewable sources. This avenue could be pursued with terminal operators to maximize the GHG emission savings associated with shore power usage.

There are alternative technologies under development that can or will achieve similar air pollutant emission reductions while at berth, but do not provide the same GHG emission reductions. Some examples of these technologies are:

- Barge based "hood" systems that connect to a ship's exhaust stack and remove emissions from effluent air. An example of this would be the Advanced Maritime Emission Control System (AMECS) by Advanced Technology Inc.
- Barge based generators, either powered by diesel and fitted with exhaust treatment systems, or powered by alternative fuels such as liquefied natural gas (LNG).
- Container based LNG generators that can be lifted on to the deck of the ship and provide power while at berth.

While these alternative technologies can provide substantial air quality benefits over running a ship's auxiliary engines, they provide modest to no GHG emission reductions. According to the California Air Resources Board (CARB) Low Carbon Fuel Standards (LCFS), fossil fuel LNG ranges in supply chain carbon intensity from about the same as diesel to 30% lower, depending on the efficiency of the upstream supply chain and of liquefication. This means that modest, but not large GHG emission reductions could be achieved by powering ships with fossil fuel LNG. Exhaust treatment systems do nothing to reduce GHG emissions, as CO2 is not easily trapped and treated.

The utilities are a critical partner in developing shore power proposals. In 2017, Tacoma Public Utilities (TPU) approached NWSA staff with interest to collaborate on the installation of shore power at South Harbor container terminals. TPU has volunteered their own staff time to scope infrastructure proposals as well as to develop an electricity rate structure. Absent of a policy mechanism that requires shore power use, successful implementation of a shore power program requires that a there be a financial incentive for the shipping lines to plug in. Staff are currently working collaboratively with Tacoma Public Utilities to create an electricity rate structure that will provide cost savings when ships plug in.

Staff is also working with Seattle City Light on updating a 2004 Port of Seattle planning study for shore power use at Terminals 18 and 46 as well as performing a similar study for Terminal 30.

In the North Harbor, shore power infrastructure is included in the Terminal 5 modernization project, as well as electrical system upgrades to expand reefer capacity and accommodate electric cargo handling equipment in the future. Shore power use at Terminal 5 is a condition of the City of Seattle Substantial Shoreline Development Permit, with expected shore power utilization increasing from 30% in the first 10 years of operation, to 50% in years 10 – 20, to 70% thereafter.

In the South Harbor, staff is scoping the installation of shore power infrastructure and expanded reefer capacity at Pacific Container Terminal (PCT), Husky Terminal, and Washington United Terminal (WUT).

The Volkswagen Mitigation Fund presents a unique opportunity for grant funding for electrical infrastructure. In early 2016, NWSA and Port of Seattle created a list of potential projects and prioritized that list based on cost effectiveness and ability to implement. Shore power was and continues to be a key initiative for VW funding. The revised planning study for the T-18, T-30, and T-46 will allow evaluation of associated costs in the North Harbor. Terminal 5 development could be eligible for funding, provided benefits in addition to those included in the permit can be demonstrated, e.g. achieving higher utilization rates, faster.

In collaboration with Tacoma Public Utilities (TPU), staff have begun to scope a South Harbor scenario. The proposal uses largely existing infrastructure to install shore power capabilities at Pacific Container Terminal (PCT) and adds an electrical substation to the General Central Peninsula (GCP) to provide shore power capabilities to Husky and Washington United (WUT) Terminals. Additional reefer capacity is also a component. TPU estimates the cost to be $7 million for the off-terminal infrastructure costs required for each, though this is a preliminary, high level estimate, subject to change and does not include on terminal costs such as wiring through existing conduit, reefer plugs, and shore side plugs and cables.

PCT

- Install shore power infrastructure for two berths
- Increase reefer capacity by 400 plugs to bring total to 1000

GCP

- Add electrical substation to increase grid capacity
- Add CHE charging infrastructure at POT maintenance

PCT

- Install shore power infrastructure for two berths
- Increase reefer capacity by 400 plugs to bring total to 1000

Husky

- Install shore power infrastructure for two berths
- Increase reefer capacity by 400 plugs to bring total to 1000

WUT

- Install shore power infrastructure for two berths
- Increase reefer capacity by 200 plugs to bring total to 1000

TOTE

Increase reefer capacity by 100 plugs

6.1.1 <u>Cost Effectiveness for Shipping Lines</u>

An important component of shore power implementation is ensuring that plugging-in to shore power provides a financial incentive for the shipping lines. A cost analysis of a typical vessel visit was performed to assess financial impact to the shipping lines of utilizing shore power as opposed to burning fuel to satisfy at berth auxiliary power demands.

The results of this cost analysis demonstrated that operating on shore power while at berth is competitive with burning fuel for auxiliary power demands. The hoteling cost burning fuel was $16,483 per visit, while the hoteling cost using shore power was $15,119 per visit (~8% reduction in cost). This is promising because conservative assumptions were made for added labor costs and the electricity cost.

Additional labor requirements are highly uncertain. Based on contact with other ports, labor costs can be negligible, but are variable and specific to individual agreements between labor and the terminal operator. The hoteling cost on shore power without additional labor was $13,344 (~19% cost reduction).

This analysis revealed the economics of shore power visits are highly sensitive to the price of fuel, the electricity rate structure, and the number of shore power calls per month at the terminal. Beyond the direct effects of electricity and fuel, the number of vessel calls per month is important because it determines how many ways the electricity demand charge can be divided. Electricity is typically billed as a combination of a cost per usage (dollars per kilowatt-hour), and a demand charge (dollars per kilowatt), which is assessed based on the maximum power draw of the electrical service during the month. This demand charge would be distributed among the vessels calling each month and therefore, the more vessels that call, the lower the cost. Staff is currently working with TPU to develop a rate structure that would provide significant cost savings through plugging in while at berth.

6.1.2 Emission Benefits from Increasing Reefer Capacity

Due to the seasonal nature of the perishable cargo export business, emission savings achieved by installing additional plugs for refrigerated containers (reefers) is highly uncertain, dependent on the length of time terminals exceed their plug capacity, requiring the use of generators. The peak export season for apples and cherries (Washington's major export crops) fall from approximately July to September (3 months long). Terminal operators plan to stagger their reefer exports to maximize plug utilization and to avoid the expense of running generators. Therefore, generators are only used when plug capacity is exceeded. Yearly emission savings from each reefer plug that replaces generator power for 2 months are tabulated below. It should be noted that these emission savings may be unrealistically high if generators would not be necessary for a full two months per year. Emission reduction estimates will be refined as more information becomes available on the frequency of generator use for reefer power.

Emission savings per reefer plug per year:

- DPM: 0.0024 tons
- CO_2: 7.8 tons
- NO_x: 0.037 tons

Emission savings per year for all 1100 reefer plugs proposed in the scenario:

- DPM: 2.64 tons
- CO2: 8580 tons
- NOx: 40.7 tons

6.2 Clean Cargo Handling Equipment Program

Reducing emissions from cargo-handling equipment is a key initiative for the NWSA to meet the targets of the GHG Resolution and the targets of the Northwest Ports Clean Air Strategy. The NWSA and its customers are making steady progress, but still have room for improvement. The NWSA proposes establishing a Clean CHE Program to accelerate the turnover of CHE to newer, cleaner, and more efficient pieces of equipment, to help meet our goals. Beginning June 1, 2018 Chapter 194-29 of the Washington Administrative Code requires all local governments, to the extent practicable, to satisfy one hundred percent of their fuel usage for operating publicly owned vehicles, vessels and construction equipment from electricity or biofuel.

For the first time, the NWSA will be hosting an Environmental Defense Fund (EDF) ClimateCorps Fellow in summer 2018 to examine ways the NWSA can incentivize tenants to accelerate CHE turnover. Cargo-handling equipment can be expensive and have long operational life spans. The EDF Fellow will work alongside staff to identify ways to accelerate fleet turnover to reduce emissions, without compromising performance. The goal is to design a financially sustainable program. The Fellow will evaluate a range of ways to accelerate fleet turnover, such as grants, discounted rates, scrappage schemes, awards, and tenant education. A final program recommendation will be made in the Fall of 2018. Staff propose pursuing DERA grants and VW funding to seed the program.

The NWSA engaged ClimateSmart, alongside Seattle-Tacoma International Airport (SeaTac), to build internal capacity on GHG management. An internal pilot training workshop was conducted with Port of Seattle Environmental and Port of Tacoma Maintenance staff in November 2017. As part of a wider Clean CHE Program, staff are proposing ClimateSmart training and certification by tenants be a prerequisite for any incentives the NWSA would potentially offer for scrapping and replacing old equipment. ClimateSmart gives tenants the expertise to conduct their own GHG inventories and identify GHG reduction strategies that are uniquely tailored to their own operations and includes a focus on calculating life cycle costs and return on investment.

6.3 <u>Clean Truck Program</u>

The long-term objective of the Clean Truck Program is to transition heavy duty vehicles from internal combustion engines to cleaner equipment, such as electric or hydrogen fuel cell trucks. Those technologies are just becoming available and may not be financially viable for drayage for a few more years. In the interim, three key lessons learned while implementing the current Clean Truck Program are 1) it is difficult to convert the entire fleet at one time, 2) there is little data on the trucks serving the gateway and 3), there is opportunity to improve the efficiency of the drayage system to reduce unnecessary idling while also increasing the number of trips per day for short haul drivers. Before recommending a change to truck technology, staff recommends first better measuring the current fleet and increasing efficiency.

Staff are developing a truck study to evaluate the number of trucks needed to move cargo efficiently and anticipate future needs for growth. A smaller fleet has the potential to increase the number of turns for drivers and make converting trucks to cleaner technology a more manageable task. Better data to track and report on the number of dual-transactions and truck wait time will enable staff to prioritize operational programs like appointment systems or extended gates.

The focus of the current Clean Truck Program is to reduce emissions of diesel particulate matter. Fuel efficiency standards did not come into effect until 2014 for heavy duty trucks. The GHG emission standard for trucks is phased in over time; Phase 2 of the standard has incremental steps in 2018, 2021, 2024, and 2027. The Phase 2 standard will cut GHG emissions from trucks up to 25% by 2027. By comparison, electric heavy-duty trucks are scheduled to become available in 2020 and would reduce emissions by nearly 100%, depending on the source of the electricity. As noted in the 2030 targets in Section 5, to meet the targets of the GHG Reduction Resolution, staff is proposing converting at least 1/3 of the fleet to electric trucks by 2030. Cost, availability, battery life and charging time are the major limiting factors. New electric trucks are estimated to cost 50% more than a new diesel truck, but have lower fuel costs and minimal required maintenance required.

In order to meet the 2030 targets and address concerns from truck drivers about high ongoing costs, staff are evaluating prioritizing electric trucks for Clean Truck Fund eligibility.

6.4 Funding

The NWSA cannot fund all of the investments needed to convert the equipment used at the Port. To reach the amounts needed to convert equipment, the NWSA will rely on a combination of private and public funds including grant dollars, pooling resources with other ports and supporting creative funding solutions like the Clean Truck Fund.

The 2018-2023 CIP budget includes $1.5 million per year in funding for air quality projects. This includes staff time, consultant services and funding toward future incentive programs.

Upcoming grant opportunities include:

- Volkswagen Mitigation Fund

  In early 2016, NWSA and Port of Seattle created a list of potential projects and then prioritized the top opportunities for VW funding. For the NWSA, those include shore power infrastructure, heavy duty trucks and cargo handling equipment.

  - Total fund for Washington State: $112.7 million
  - Applications in late 2018
  - Port-related funding available:
    - Up to $50.7 million for maritime projects (e.g. shore power)
    - Up to $50.7 million for heavy duty vehicles
    - Up to $5.6 million for cargo-handling equipment
    - 50% DERA grant match
- 2018 DERA Grants
  - Total fund for the U.S. is expected to be at least $20 million
  - Maximum project award for Region 10 TBD; Maximum award in 2017 was $800,00
  - Application criteria expected in Spring 2018
  - Recommend applying for Clean CHE Program

7. CONCLUSIONS/NEXT STEPS

Results of the 2016 PSEI and NWSA 2016 GHG Inventory validate the effectiveness of port, local, regional, national, and international emission reduction programs and demonstrate the NWSA's commitment to environmental stewardship and sustainability. Results of the PSEI have been shared with the media and staff is currently conducting outreach to communicate the results with the local communities.

To expand on the work of the PSEI, Starcrest is developing an Emission Scenario Evaluation Tool that will estimate the effect of speculative changes in operating or equipment parameters on the 2016 inventory results. Examples of equipment and operational changes that could be assessed by the tool are vehicle and equipment turnover, idle reduction initiatives, shore power usage, and fuel switching. This tool will allow staff to evaluate the effectiveness of emission reduction measures and allow staff to target emission reduction measures that provide substantial benefits and are cost effective. The tool will also empower staff to set air quality goals that are both aggressive and realistically attainable.

On the west coast, there are significant ongoing voluntary and regulatory efforts to reduce the impacts of ports on air quality and climate. Specifically, the state of California requires all vessels (with some exceptions) to use shore power or equivalent technology to reduce at berth emissions. Ports throughout California have made substantial capital investments in shore power infrastructure to meet this requirement. This may have significant impacts for implementing a shore power program in Washington, as vessels that also call in California must be shore power capable. Additionally, as a Part of the San Pedro Bay Clean Air Action Plan, the Ports of Long Beach and Los Angeles are making large investments in the development and piloting of low emissions harbor craft, and zero emissions terminal equipment and trucks. Port of Rotterdam opened an automated terminal in 2015, greatly increasing efficiency.

These commitments to technological advancement and investments in green technologies by other ports will accelerate the availability of low and zero emission technologies for implementation by NWSA. Through collaboration and participation in these efforts, NWSA can do its part to ensure that the technology exists to meet clean air and GHG targets, as well as making significant emission reductions.

In the coming months, staff will be participating in an update of the NWPCAS, setting emission reduction targets for the next 5 years and beyond. Particular focus will be placed on community engagement to ensure that emission reduction targets and strategies can be constructed in a way that is both feasible and that creates the most significant community benefit possible. Additionally, staff plan to work with industry partners and other ports to target specific measures that optimally leverage current technology and support and accelerate technological advancement in the areas of efficiency and emission reductions.

APPENDIX A – TABLES

Table A1. NWSA airshed scale emissions (tons per year).

	NO_x	VOC	CO	SO_2	PM_{10}	$PM_{2.5}$	DPM	BC	CO_2e
2016 emissions (tons per year)									
Ocean-going vessels	7,354	209	603	212	111	104	105	6	333,889
Harbor craft	407	13	67	0	13	12	13	9	24,195
Locomotives	893	52	169	1	26	24	26	19	63,510
Cargo-handling equipment	274	25	135	0	14	13	13	10	28,902
Heavy-duty vehicles	972	51	244	2	47	43	47	14	177,909
Fleet vehicles	2	0	8	0	0	0	0	0	592
Total	**9,858**	**348**	**1,221**	**213**	**210**	**196**	**204**	**59**	**625,386**
2011 emissions (tons per year)									
Ocean-going vessels	8,107	238	605	5,630	659	529	622	16	362,594
Harbor craft	385	13	59	0	15	14	15	11	23,102
Locomotives	1,046	66	165	8	37	34	37	26	62,139
Cargo-handling equipment	401	26	196	0	24	23	24	18	52,989
Heavy-duty vehicles	1,490	98	406	1	66	60	66	44	172,982
Fleet vehicles	5	1	23	0	0	0	0	0	2,178
Total	**11,434**	**442**	**1,455**	**5,640**	**801**	**661**	**764**	**114**	**675,984**
2005 emissions (tons per year)									
Ocean-going vessels	10,237	353	783	7,188	918	736	868	22	458,066
Harbor craft	413	13	54	43	18	17	18	13	23,356
Locomotives	1,928	97	241	153	53	49	53	38	82,659
Cargo-handling equipment	685	56	306	43	43	41	42	32	70,617
Heavy-duty vehicles	2,007	116	514	12	89	82	89	60	162,720
Fleet vehicles	10	2	30	0	0	0	0	0	2,723
Total	**15,281**	**638**	**1,928**	**7,440**	**1,121**	**924**	**1,070**	**164**	**800,140**

Table A2. NWSA airshed scale absolute emissions changes and changes normalized to cargo throughput tonnage.

	NO_x	VOC	CO	SO_2	PM_{10}	$PM_{2.5}$	DPM	BC	CO_2e
2005 - 2016 Change									
Ocean-going vessels	-28%	-41%	-23%	-97%	-88%	-86%	-88%	-72%	-27%
Harbor craft	-1%	-1%	24%	-99%	-26%	-26%	-26%	-26%	4%
Locomotives	-54%	-47%	-30%	-100%	-51%	-50%	-51%	-50%	-23%
Cargo-handling equipment	-60%	-56%	-56%	-99%	-68%	-68%	-68%	-69%	-38%
Heavy-duty vehicles	-52%	-56%	-53%	-88%	-47%	-47%	-47%	-76%	9%
Fleet vehicles	-84%	-82%	-75%	-94%	-88%	-88%	-91%	-90%	-78%
Total	**-35%**	**-45%**	**-36%**	**-97%**	**-81%**	**-79%**	**-81%**	**-64%**	**-20%**
2011 - 2016 Change									
Ocean-going vessels	-9%	-12%	0%	-96%	-83%	-80%	-83%	-61%	-8%
Harbor craft	6%	-2%	14%	5%	-13%	-13%	-13%	-13%	5%
Locomotives	-15%	-22%	2%	-93%	-30%	-29%	-30%	-29%	2%
Cargo-handling equipment	-32%	-6%	-31%	-43%	-43%	-43%	-43%	-44%	-18%
Heavy-duty vehicles	-35%	-48%	-40%	2%	-29%	-29%	-29%	-67%	3%
Fleet vehicles	-67%	-69%	-68%	-72%	-69%	-69%	-71%	-70%	-73%
Total	**-13%**	**-21%**	**-16%**	**-96%**	**-74%**	**-70%**	**-73%**	**-49%**	**-5%**
Total Emission Changes Normalized to Cargo Throughput Tonnage									
2005 - 2016	**-33%**	**-43%**	**-34%**	**-97%**	**-81%**	**-78%**	**-80%**	**-63%**	**-17%**
2011 - 2016	**-8%**	**-16%**	**-11%**	**-96%**	**-72%**	**-68%**	**-72%**	**-46%**	**1%**

Table A3. Puget Sound Airshed maritime industry-wide emissions (tons per year)

	NO_x	VOCs	CO	SO_2	PM_{10}	$PM_{2.5}$	DPM	BC	CO_2e
2016 (Emissions in tons per year)									
Ocean-going vessels	11,516	346	964	374	192	181	178	11	587,994
Harbor vessels	6,590	478	2,332	4	235	216	230	163	443,948
Recreational vessels	989	1,774	12,416	2	38	35	5	10	139,381
Locomotives	1,099	63	206	1	32	29	32	23	77,366
Cargo-handling equipment	332	32	182	<1	17	17	17	12	49,838
Heavy-duty vehicles	1,297	66	320	2	61	57	61	19	238,805
Fleet vehicles	3	1	12	<1	<1	<1	<1	<1	1,037
Total	**21,824**	**2,760**	**16,432**	**384**	**575**	**535**	**524**	**238**	**1,538,368**
2011 (Emissions in tons per year)									
Ocean-going vessels	13.284	400	999	10,880	1,202	962	1,076	29	669,104
Harbor vessels	6,270	438	1,417	4	278	255	274	194	392,613
Recreational vessels	810	1,909	11,654	2	39	37	5	9	106,523
Locomotives	1,293	83	205	11	46	42	46	33	77,187
Cargo-handling equipment	456	32	251	1	29	28	29	21	57.961
Heavy-duty vehicles	1,919	125	523	2	85	78	85	56	223,681
Fleet vehicles	8	2	38	<1	<1	<1	<1	<1	3,204
Total	**24,040**	**2,988**	**15,086**	**10,899**	**1,679**	**1,403**	**1,515**	**342**	**1,560,273**
2005 (Emissions in tons per year)									
Ocean-going vessels	15,836	542	1,202	12,789	1,514	12,12	1,336	36	827,705
Harbor vessels	6,122	380	1,144	405	277	255	274	194	368,087
Recreational vessels	734	2,590	15,966	23	55	51	6	11	113,354
Locomotives	2,460	123	308	193	67	61	67	47	106,058
Cargo-handling equipment	763	96	1,477	47	49	48	49	36	77,769
Heavy-duty vehicles	2,516	143	646	16	112	103	112	76	206,028
Fleet vehicles	13	3	42	<1	<1	<1	<1	<1	3,474
Total	**28,445**	**3,877**	**20,786**	**13,473**	**2,073**	**1,730**	**1,843**	**401**	**1,702,475**

Table A4. Puget Sound Airshed maritime industry-wide emission changes

	NO_x	VOCs	CO	SO_2	PM_{10}	$PM_{2.5}$	DPM	BC	CO_2e
Percentage Change 2005 - 2016									
Ocean-going vessels	-27%	-36%	-20%	-97%	-87%	-85%	-87%	-69%	-29%
Harbor vessels	8%	26%	104%	-99%	-15%	-15%	-16%	-16%	21%
Recreational vessels	35%	-32%	-22%	-91%	-31%	-31%	-17%	-9%	23%
Locomotives	-55%	-49%	-33%	-99%	-52%	-52%	-52%	-51%	-27%
Cargo-handling equipment	-56%	-67%	-88%	-100%	-65%	-65%	-65%	-67%	-36%
Heavy-duty vehicles	-48%	-54%	-50%	-88%	-46%	-45%	-46%	-75%	16%
Fleet vehicles	-77%	-67%	-71%	-91%	-84%	-85%	-89%	-88%	-70%
Total	**-23%**	**-29%**	**-21%**	**-97%**	**-72%**	**-69%**	**-72%**	**-41%**	**-10%**
Percentage Change 2011 - 2016									
Ocean-going vessels	-13%	-14%	-3%	-97%	-84%	-81%	-83%	-63%	-16%
Harbor vessels	5%	9%	64%	15%	-15%	-15%	-16%	-16%	13%
Recreational vessels	22%	-7%	7%	34%	-5%	-5%	11%	10%	31%
Locomotives	-15%	-22%	0%	-93%	-31%	-30%	-31%	-30%	0%
Cargo-handling equipment	-27%	-2%	-27%	-40%	-40%	-40%	-40%	-41%	-14%
Heavy-duty vehicles	-32%	-47%	-39%	6%	-28%	-27%	-28%	-67%	7%
Fleet vehicles	-66%	-71%	-68%	-68%	-69%	-69%	-71%	-70%	-68%
Total	-9%	-8%	9%	-96%	-66%	-62%	-65%	-30%	-1%