Item No. 7c_attach
Meeting Date: February 28, 2017

Developing the Port of Seattle's Energy Portfolio

Final Recommendations

October 21, 2016

Port of Seattle®

Table of Contents

Energy Committee Members

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Project Approach

Objective: Identify opportunities to achieve the Port of Seattle's Century Agenda energy load growth and GHG reduction goals.

Task 1: Summarize Port-Wide Energy Use and GHG Projections

1. Sum Port-operated energy sources & uses
2. Estimate 20-year load growth and emission projections

Task 2: Strategy Identification and Exploration

1. Review energy strategies from peer organizations and private sector
2. Brainstorm with Port staff for additional opportunities
3. Screen list of opportunities

Task 3: Develop Energy Portfolio Recommendations

1. Estimate relative costs and impacts
2. Prioritize by Level of Confidence
3. Estimate impacts on Century Agenda goals
4. Develop final recommendations

Developing Port-Wide Energy Use and GHG Projections

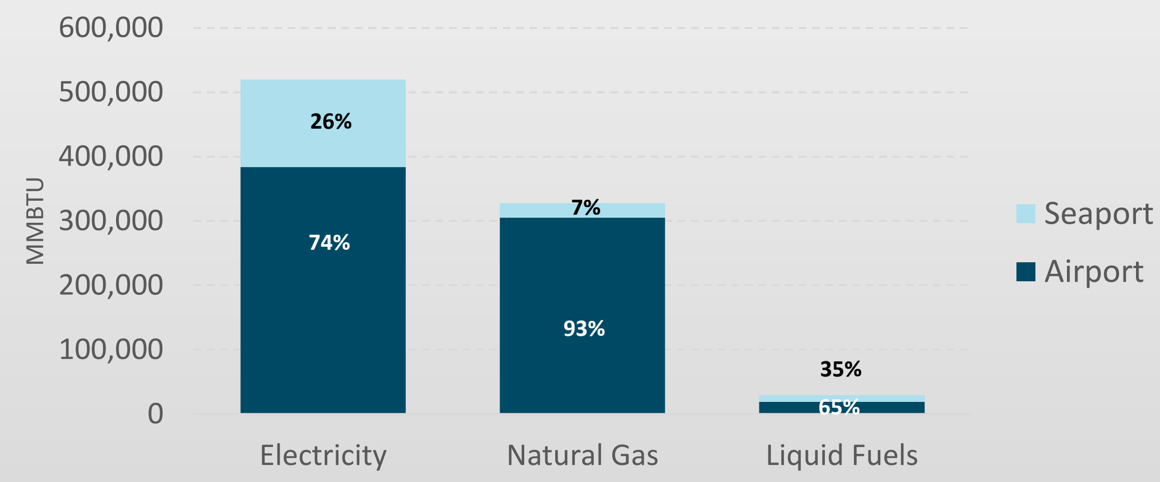
- All electricity, natural gas, and liquid fuel bills paid by Port of Seattle were evaluated,
- All energy converted to MMBTU,
- Energy sub-metered and billed to tenants was not included in this evaluation,
- In many Port facilities, energy costs are recovered via flat fees, with no visibility into actual energy use,
- Future load growth was based on building model estimates completed for the Sustainable Airport Master Plan (SAMP).

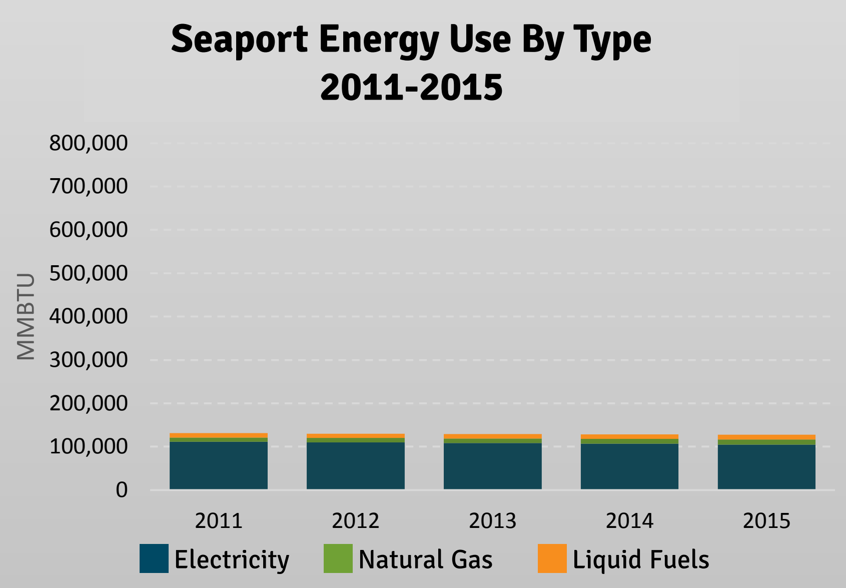
Utility Bill Availability (does not include sub-metering)

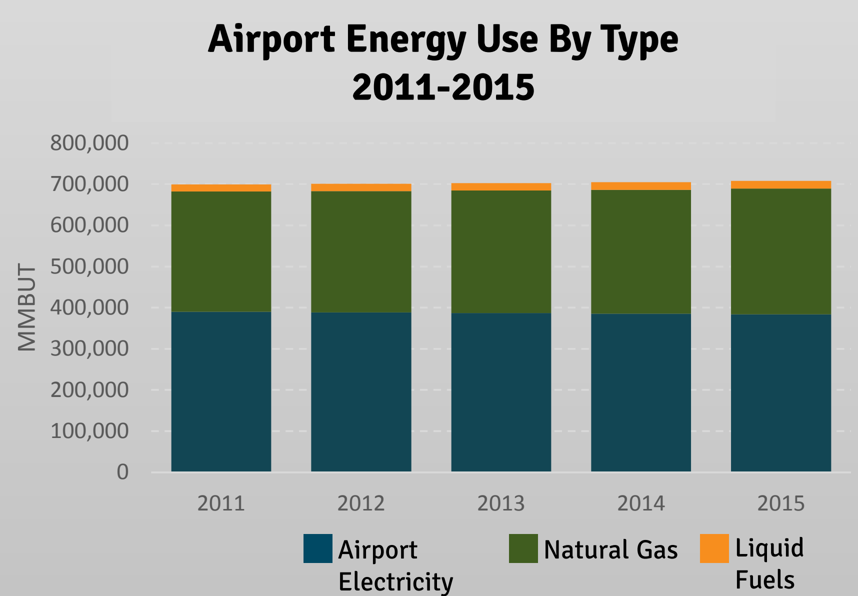
	Included	
Airport	Electricity	Natural Gas
Terminals/Cargo	✓	✓
Bus Maintenance Facility	✓	✓
Fire Station	✓	✓
Pumphouse	✓	✓
Distribution Center	✓	✓
Airfield & Perimeter Lighting	✓	N/A
Tenant Facilities (other than dining & retail)	✓	N/A
Generators (Liquid Fuels)	✓	
Fleet Vehicles (Liquid Fuels)	✓	

	Included	
Seaport	Electricity	Natural Gas
Terminal 91	✓	✓
Fisherman's	✓	✓
Shilshole Bay	✓	✓
Pier 66	✓	✓
Pier 69	✓	N/A
Marine Maintenance	✓	✓
MIC	✓	✓
Terminal 102	✓	✓
Terminals 5	✓	✓
Terminals 18, 102, & Parks	✓	✓
Fleet Vehicles (Liquid Fuels)	✓	

Port-Wide Annual Energy Usage

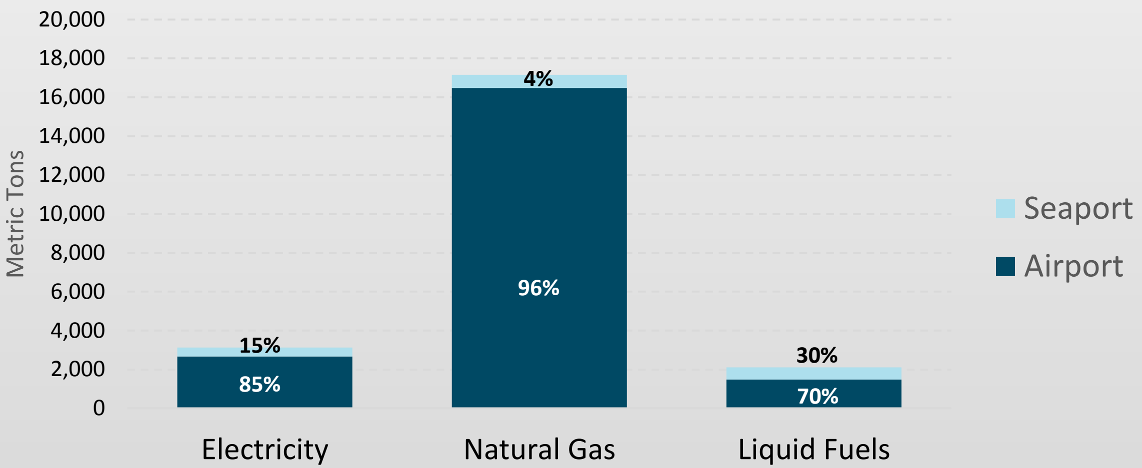


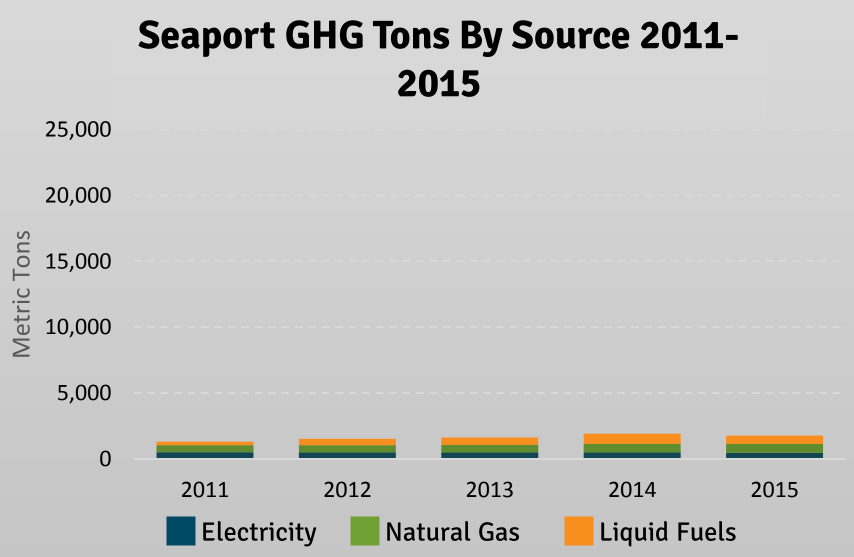


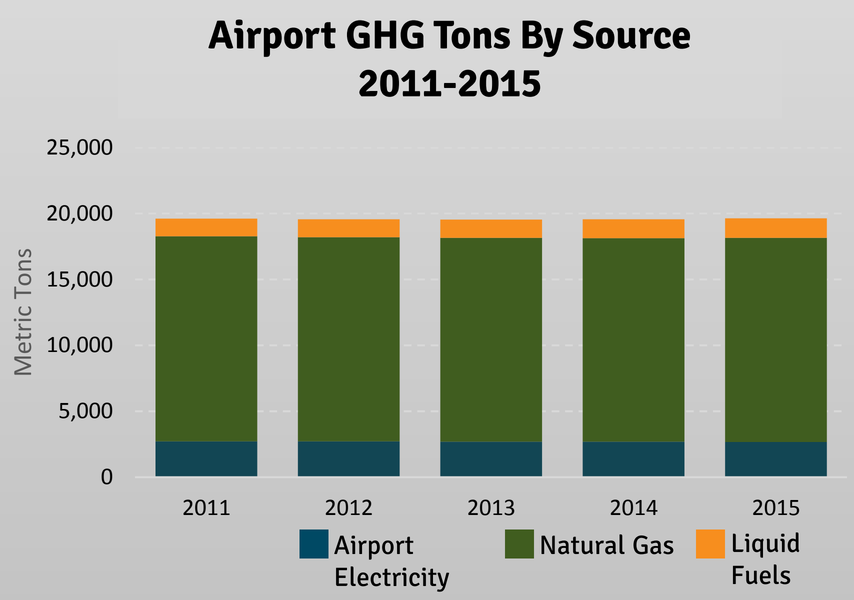


Source: Port of Seattle MMBTU Analysis

Port-Wide Annual Greenhouse Gas Emissions

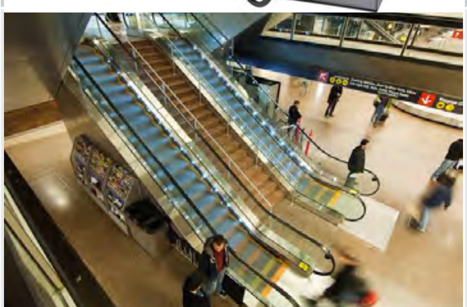




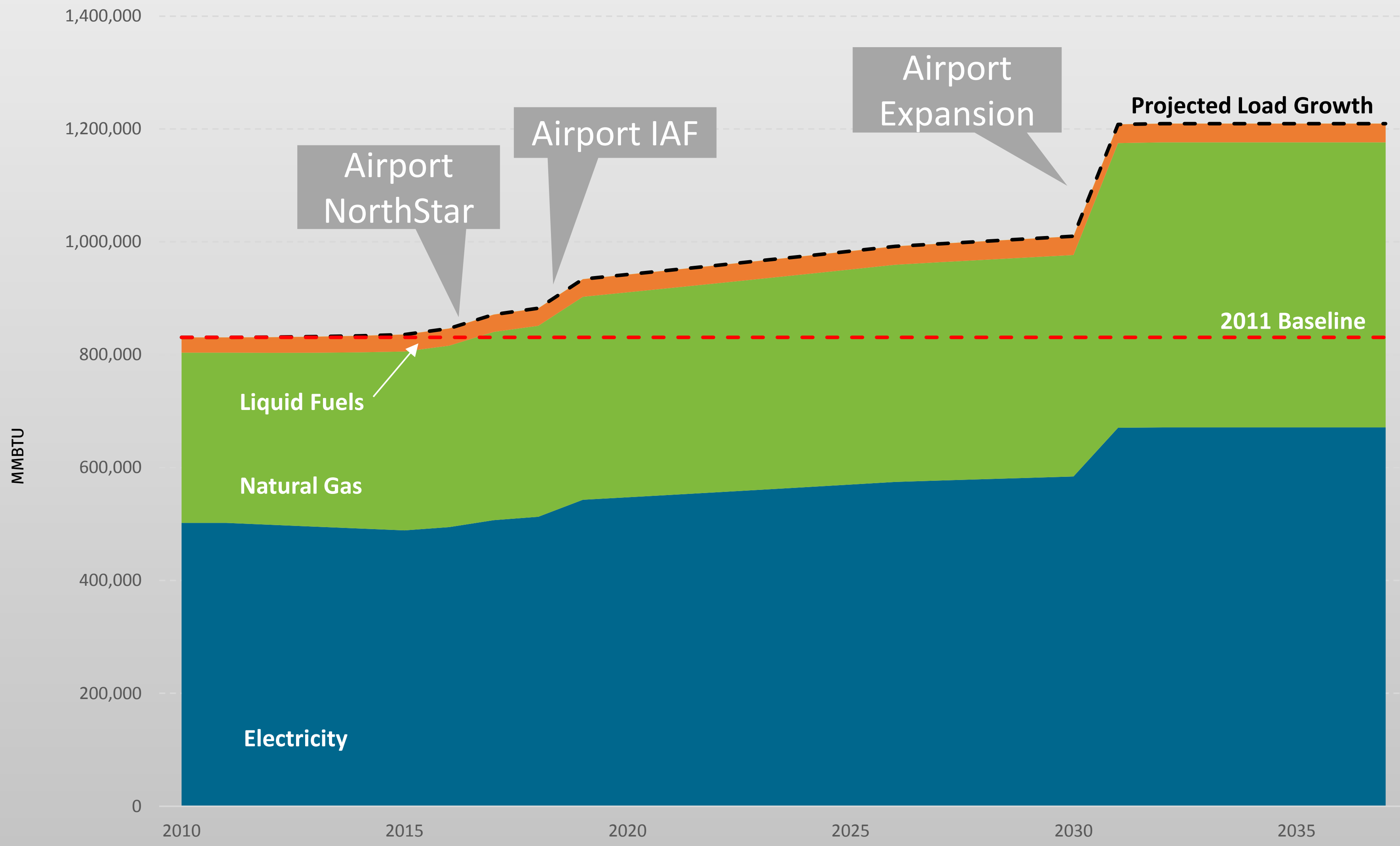


Source: Port of Seattle MMBTU Analysis

Port has a Strong Legacy of Energy Conservation

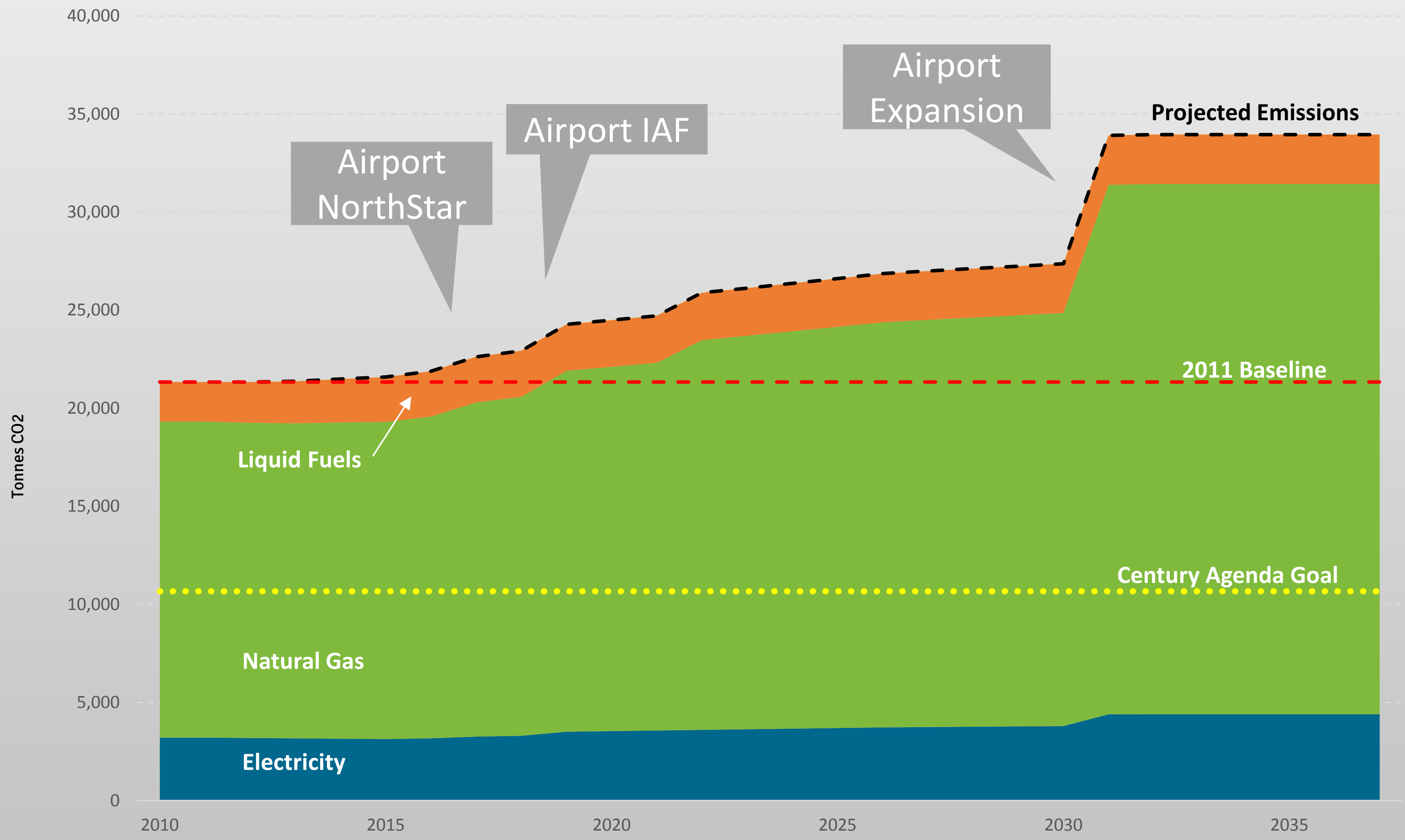
A Few Examples from Just the Last Three Years	
	**Stage 2 Mechanical (2012-2014)** Energy Savings Estimate: 12,296 MMBTU/year
	**Escalator Upgrades and Replacement (2013)** Energy Savings Estimate: 1,568 MMBTU/year Scope of work was 44 Escalators across the entire airport
	**Parking Garage LED & Emergency Lighting (2013 & 2015)** Energy Savings Estimate Emerg Lighting: 5,361 MMBTU/year Energy Savings Estimate LED Lighting: 6,096 MMBTU/year

Port-wide Energy Forecast



Source: Sustainable Airport Master Plan, Sustainable Airport Mater Plan Calculator

Port-wide GHG Emissions Forecast



Source: Sustainable Airport Master Plan, Sustainable Airport Mater Plan Calculator

Task 2: Strategy Identification and Screening

Step 1:

Identify Potential Strategies

Step 2:

Screen By Impact & Feasibility

Step 3:

Estimate Energy Reduction and Generation Potential

Step 1: Identify Potential Strategies

We identified a range of conservation and renewable strategies currently undertaken by:

Port of Seattle

Peer Port Organizations

- Port of Amsterdam / Schiphol International Airport
- Port of Long Beach
- Port of Portland
- Port of Rotterdam
- Port of San Francisco / San Francisco International Airport
- Port of San Diego

Private Sector Entities

- Amazon
- Boeing
- Ikea
- GE
- Google
- Lockheed Martin
- Microsoft

Step 2: Screen By Impact & Feasibility

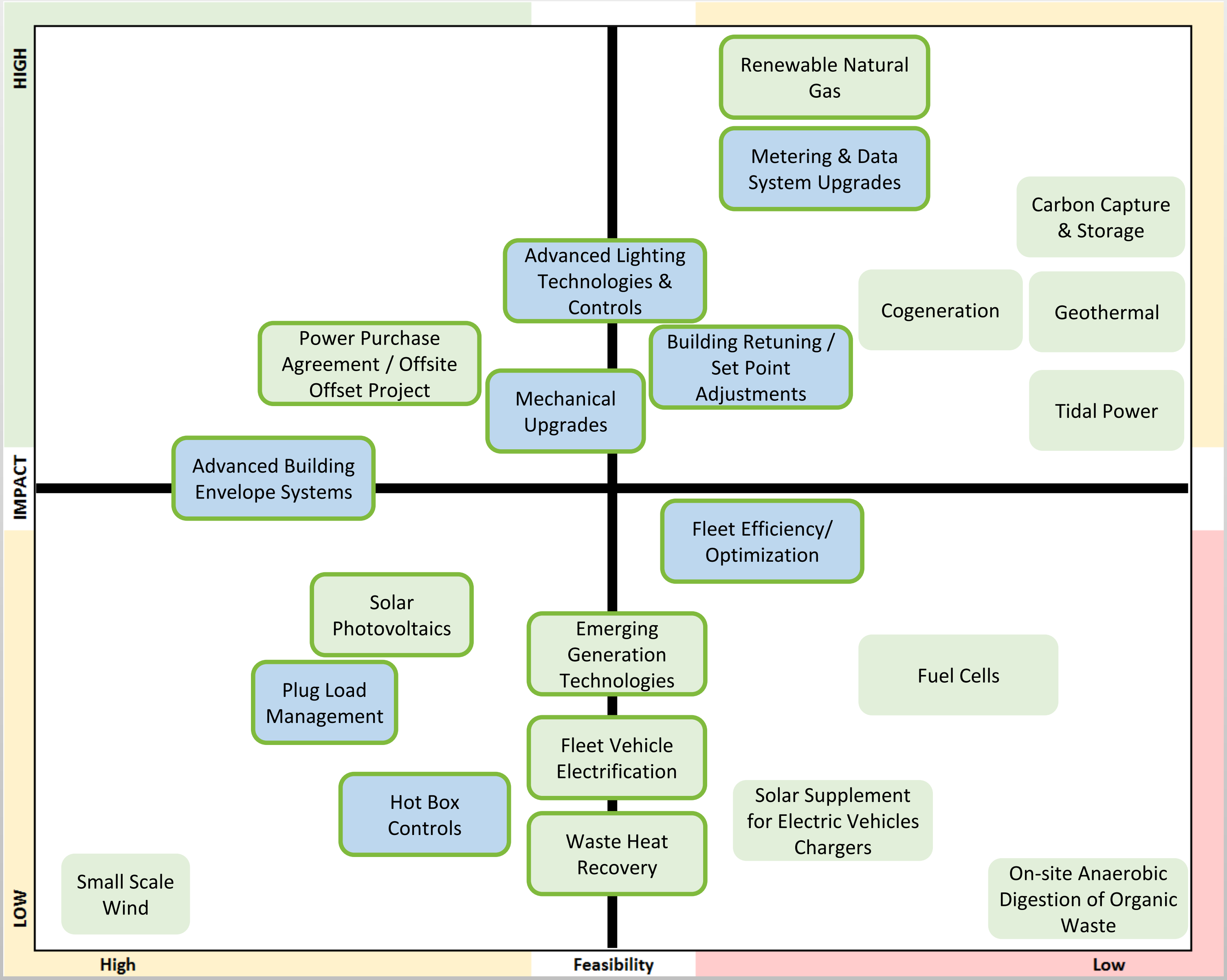
IMPACT

- Contribution toward load growth & GHG reduction goals
- Energy use reduction potential
- Renewable energy generation potential

FEASIBILITY

- Anticipated payback period
- Technical, physical, commercial availability
- Human factors & implementation difficulty

Step 2: Impact-Feasibility Results



High Impact:

- Achieves/helps with load growth goal
- Significant energy use reduction
- Significant renewable energy generation potentials

High Feasibility:

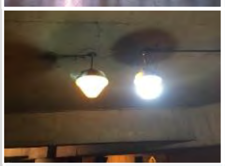
- Financial: >5 year payback
- Technical, physical, commercial availability
- Political: tenant reactions and human factors

Conservation

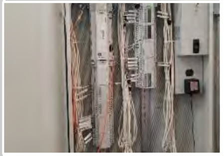
Renewables

Selected Strategy

Energy Conservation Strategies: Initial Screening

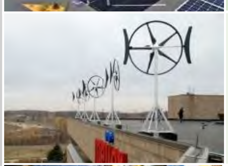
Strategy		Impact?	Feasible?
	Advanced Building Envelope Systems	High	High
	Advanced Lighting Technologies & Controls	High	High
	Fleet Optimization	Low	High
	Hot Box Controls	Low	High
	Idle Reduction Programs	Low	High

Energy Conservation Strategies: Initial Screening

Strategy	Impact?	Feasible?
 Mechanical System Upgrades	High	High
 Metering & Data Acquisition System Upgrades	High*	High
 Plug Load Management	Low	High
 Building Retuning / Temperature Set Point Adjustments	Low	High

*Metering does not reduce energy use but is a critical component of energy management that can directly lead to energy savings and aids in renewable energy deployment.

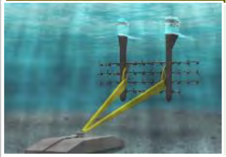
Renewable Energy Strategies: Initial Screening

Strategy		Impact?	Feasible?
	Emerging Generation Technologies	Unknown	Unknown
	Solar Photovoltaics	Low	High
	Solar Supplement for Electric Vehicle Chargers	Low	Low
	Small Scale Wind	Low	High
	Vehicle Electrification	Low	High

Renewable Energy Strategies: Initial Screening

Strategy		Impact?	Feasible?
	Renewable Natural Gas	High	High
	Power Purchase Agreement or Offsite Offset Project	High	High
	Waste Heat Recovery	Low	Med

Energy Strategies
Removed from Further Consideration

Strategy		Impact?	Feasible?
	On-site Anaerobic Digestion of Organic Waste	Low	Low
	Fuel Cells	Low	Low
	Carbon Capture & Storage	High	Low
	Cogeneration	High	Low
	Geothermal	High	Low
	Tidal Power	High	Low

Prioritizing Energy Strategies by Level of Confidence

High

- Technical analysis complete
- Understand energy reduction potential
- Understand return on investment

Med

- Industry best practice
- Proven technology
- Understand potential benefits and costs at high level
- Further exploration warranted

Low

- Emerging technology
- Shows promise for potential application in Port context
- Many unknowns
- Further exploration warranted

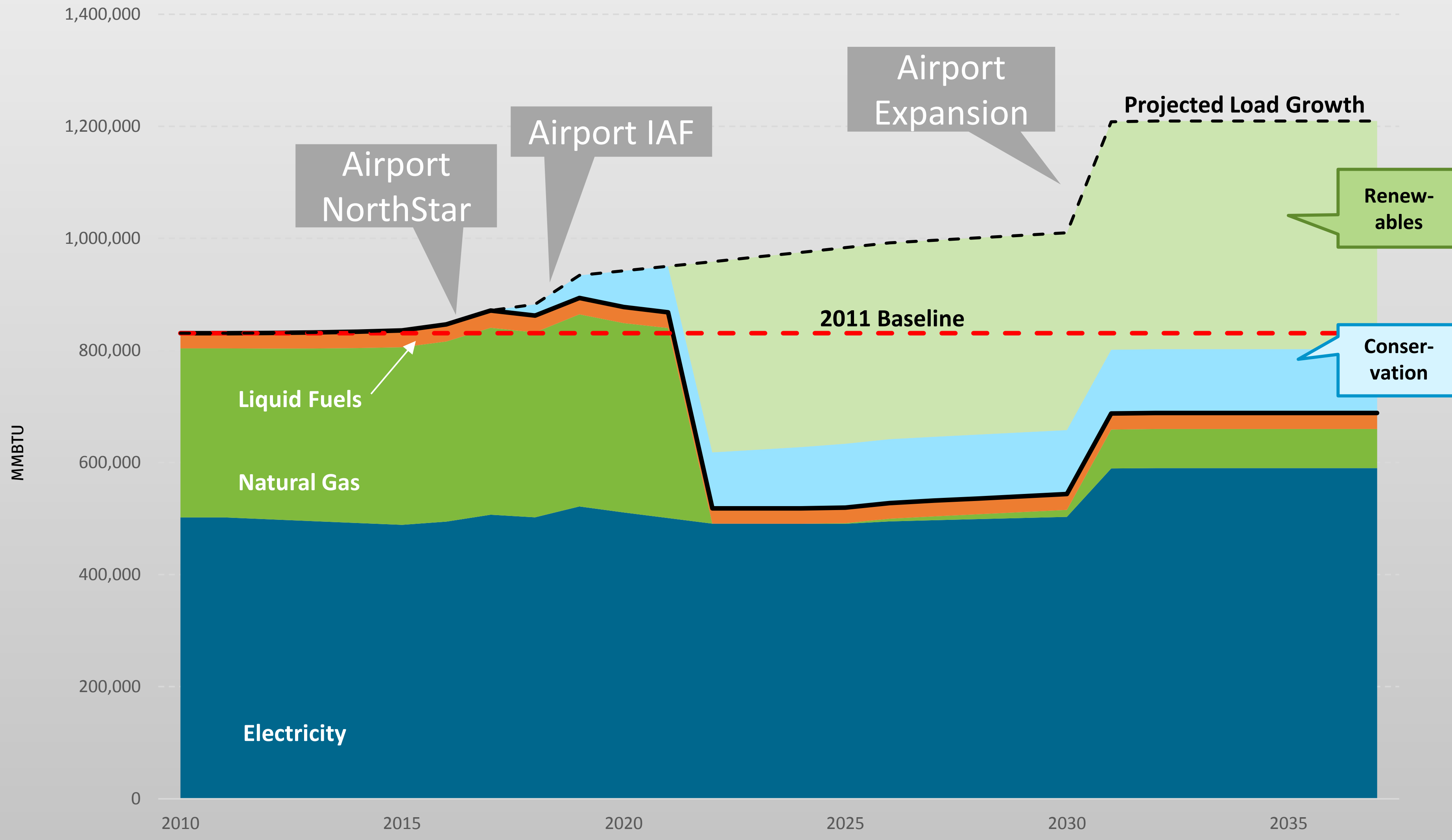
Task 3: Recommended Energy Conservation Strategies

Confidence	Conservation Measure	Key Components	Energy Use Reduction Potential (% Port Use)	Relative Cost per MMBTU Reduction	Relative Cost per CO2 Reduction
High	**Metering & Data System Upgrades**	• Comprehensive metering and submetering of Port facilities • Upgrades to SCADA (data acquisition) system	Enabling strategy	N/A	N/A
High	**Mechanical Upgrades**	• Includes metering, chiller sequencing, building envelope, pump optimization, data center & other upgrades	2%	Med	Med
Med	**Advanced Lighting Technologies & Controls**	• Emerging lighting technologies such as plasma lighting • Lighting controls (automation) & policy measures	5%	Low	Med
Med	**Plug Load Management**	• Schedule-based timing controls to automate power supply to plug-load equipment such as electronics	1%	Low	Med
Med	**Building Retuning**	• Temperature setpoint adjustments & policy • Diagnosis and correction of building systems operations & controls	2%	Low	Low
Med	**Fleet Optimization**	• Replacement of diesel and gasoline powered vehicles with electric equivalents	1%	TBD	TBD
Low	**Advanced Building Envelope Systems**	• Daylighting • Adaptive envelope systems such as "electrochromic" (self-tinting) glass	3%	Med	Med

Task 3: Recommended Renewable Energy Strategies

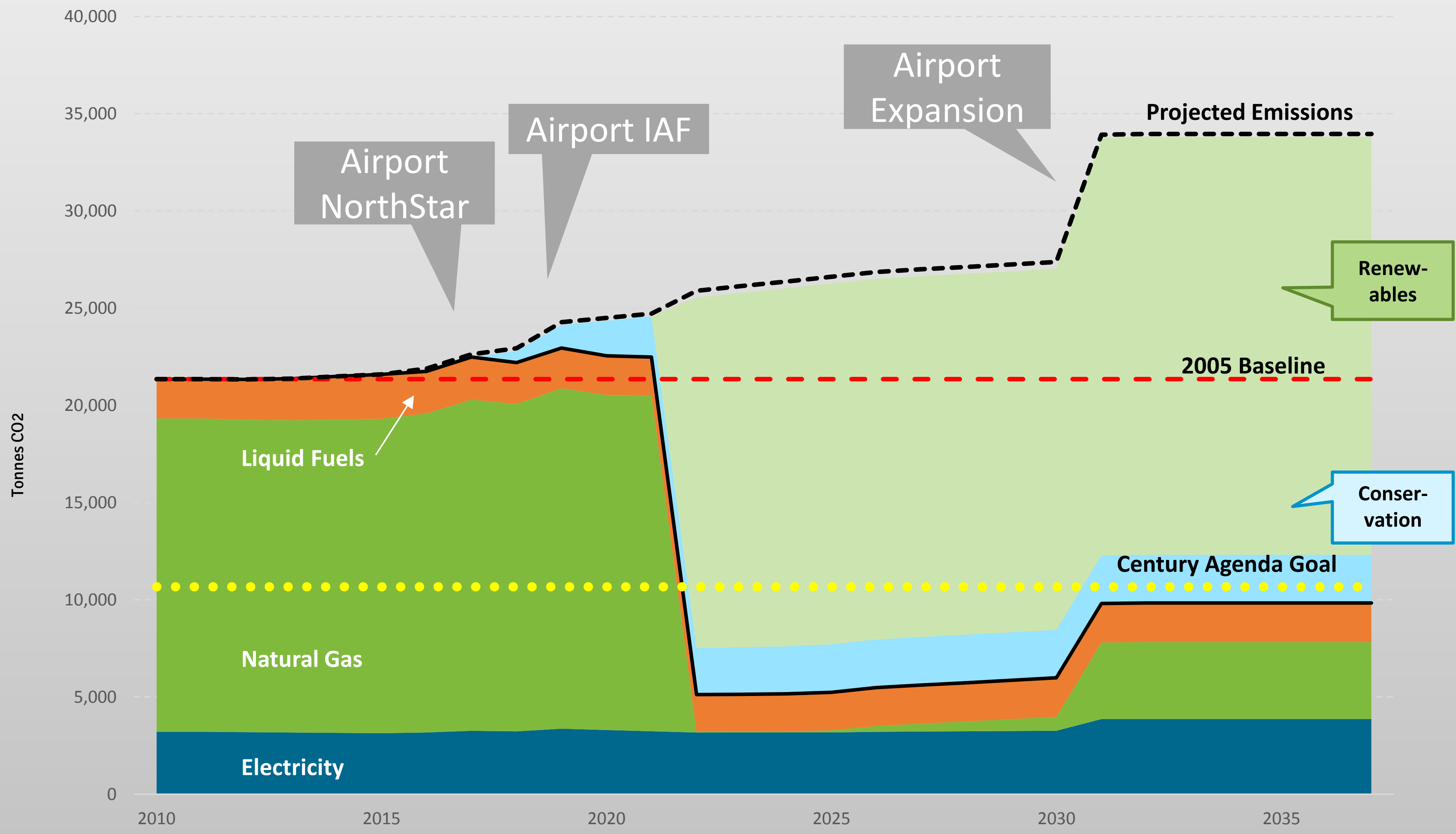
Confidence	Renewable Energy Measure	Description	Energy Generation Potential (% Port Use)	Relative Cost per MMBTU Reduction	Relative Cost per CO2 Reduction
High	**Renewable Natural Gas (RNG)**	• Source RNG from landfills, wastewater treatment, or agricultural sources	35%	Med	Med
	Solar Photovoltaics	• Install solar panels on existing terminal, garage, and cargo areas, and future expansion facilities	1%	Med	High
Med	**Power Purchase Agreement or Offsite Offset Project**	• Purchase wind or solar energy directly from third-party owned and operated renewable energy generation facility, on or off Port property	TBD	Med	Med
Low	**Emerging Generation Technologies**	• Microhydroelectric generators that power from harvested rainwater flows • Kinetic tiles that generate power from vibrations such as foot and vehicle traffic	TBD	TBD	TBD

Task 3: Impact of Strategies on Century Agenda Goal for Energy



Source: Sustainable Airport Master Plan, Sustainable Airport Mater Plan Calculator

Task 3: Impact of Energy Strategies on Century Agenda Goal for GHG Emissions



Key Findings

The Port's energy demand and GHG emissions have remained constant over the past 5 years. However, our forecast show **if we do nothing, our energy will increase by 46% and GHGs by 59%,** respectively, over the next 25 years due to airport expansion.

The Committee finds that the **Port will be able to meet the Century Agenda energy and GHG goals through a combination of efficiency and renewable fuel strategies, even in light of the projected growth in demand**.

According to our analysis, energy conservation strategies can meet about **25% of the projected increase** in energy demand.

The remaining **75% of our increased energy demand** must be met with renewable fuels.

Renewable Natural Gas is an essential component to our strategy, both in terms of energy load growth and GHG reductions, but is a high-risk strategy.

Solar offers limited reductions to both energy and GHG projections, but may have other sustainability benefits.

Key Findings Cont'd

Much of existing metering infrastructure is outdated and inconsistent.

Low-cost conservation opportunities remain, but cannot achieve our goals alone.

Payback thresholds for higher cost energy conservation investments are not aligned with long term goals.

Our energy demand forecasts assume future facilities are built to highest green standards, including going beyond current energy efficiency standards.

The Committee opted not to include Port electricity used for electric GSE and PC air, because increased load growth is minimal when compared to resulting GHG reductions (see following slide).

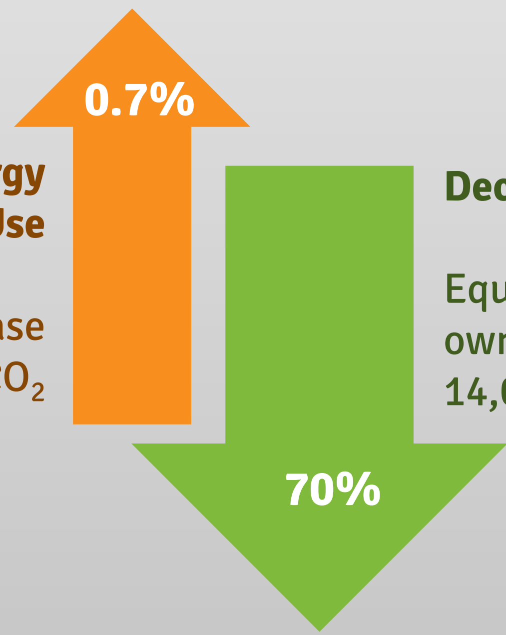
Tenant energy use is significant, but metering infrastructure is inconsistent and in some cases entirely lacking.

Case In Point: Airport Gate Electrification

- Every gate at the Airport is equipped with remote ground power connections and pre-conditioned air supplied from a central plant
- Aircraft parked at gates use power and conditioned air provided by the Airport instead of their Auxiliary Power Units, which run on jet-fuel
- While Port-owned emissions increase slightly, the resulting overall emission reductions are significant

Increased Port Energy Use

0.7% GHG increase
324 tonnes CO_2



Decreased Tenant Jet Fuel Use

Equivalent of 70% decrease in Port-owned GHG emissions
14,000 tonnes CO_2

Final Recommendations

- Pursue RNG opportunities as a critical element of our energy and GHG strategy, with second phase to coincide with Airport expansion
- Align payback thresholds for energy investments (both O&M and capital) with the planning horizons for the Century Agenda and Airport Master Plan, and ensure life cycle costs and nonfinancial benefits are considered
- Ensure future facilities are built to highest green standard; building to a lower standard will increase our load growth
- Continued focus on conservation, such as through the Stage 3 Mechanical Conservation Project, will reduce our reliance on hydroelectricity and will free up clean energy capacity for other uses
- Enhanced metering will assist in prioritization of energy conservation opportunities for both Port and tenants
- Establish a strategy for emerging technologies to better evaluate viability for Port adoption

Appendix: Background Data for Energy Strategies

Conservation Measure	Metering & Data Acquisition System Upgrades
Key Components	• Comprehensive metering and submetering of Port facilities to enable measurement & verification of energy conservation strategies • Upgrades to SCADA (data acquisition) system
Energy Use Reduction Potential (MMBTU and % of total Port Energy Use)	• Does not lead to direct energy savings, but is necessary to enable participation in a wide range of industry best practices such as load curtailment, demand response, and measurement and verification of conservation programs. • Will assist in prioritization of energy conservation opportunities for both Port and tenants.
Port-Specific Supporting Analysis	• Current state and needs relative to metering and submetering are documented in the Sustainable Airport Master Plan (Section 6.12), the Cardno Report (Section 5), and Phase 3 University Mechanical Energy Conservation presentation. • Each of these documents presents recommendations for enhanced metering and submetering.
Feasibility Constraints	• Scale of implementation required to achieve desired technical consistency may be prohibitive
Recommendations	• Enhanced metering capabilities will allow the Port to recover its fair share for utility costs incurred by tenants, which are currently underrepresented through existing metering infrastructure. • This opportunity cost should be factored in payback analysis for this measure. • Explore partnership opportunities with BPA and SCL to support advanced metering technologies

Appendix: Background Data for Energy Strategies

Conservation Measure	Mechanical Upgrades
Key Components	• Includes metering, chiller sequencing, building envelope upgrades, pump optimization, data center & other upgrades
Energy Use Reduction Potential (MMBTU and % of total Port Energy Use)	• 20,449 MMBTU reduction in Port energy use • 2% reduction in Port energy use
Energy Use Reduction Potential - Assumptions	• Internal Airport reports indicate electricity can be reduced by 2,017 MMBTU and natural gas can be reduced by 18,432 MMBTU
Cost Information	• $4.95M (see Option 2 of Stage 3 Mechanical Energy Conservation Presentation) • $242 / MMBTU, $4,994 / metric ton of CO_2 • Port is eligible for rebates and incentives by BPA and SCL to offset cost of lighting upgrades and other energy efficiency projects
Port-Specific Supporting Analysis	• Mechanical Energy Conservation Stage 1-3 Reports
Feasibility Constraints	• Simple payback terms do not appear to be competitive on basis of energy efficiency alone, but some mechanical equipment past useful life
Recommendations	• Pursue Stage 3 Mechanical Energy Conservation project • Continue to identify equipment replacement opportunities

Appendix: Background Data for Energy Strategies

Conservation Measure	Advanced Lighting Technologies & Controls
Key Components	• Emerging lighting technologies such as plasma lighting • Lighting controls (automation) & policy measures
Energy Use Reduction Potential (MMBTU and % of total Port Energy Use)	• 45,368 MMBTU reduction in Port energy use • 4% reduction in Port energy use
Energy Use Reduction Potential - Assumptions	• Facilities team estimates this initiative can reduce the lighting load by 20% at the Airport and 10% at the Seaport • Lighting load was assumed to be 50% of total 2014 electricity
Cost Information	• Port is eligible for rebates and incentives by BPA and SCL to offset cost of lighting upgrades and other energy efficiency projects
Case Study Examples & Best Practice Data	• Berkeley National Lab Meta-Analysis of Energy Savings From Lighting Controls in Commercial Buildings • California Energy Commission, Achieving Energy Efficient Lighting in California, 2015
Feasibility Constraints	• Technologies continue to evolve • Many of Port's operations are 24/7, and many spaces are tenant controlled or directly impact tenants
Recommendations	• Institute lighting controls and policy measures in administrative areas • Explore opportunities for lighting controls in public spaces during off-peak periods • Identify funding to continue LED retrofits and lighting control projects • Continue to track developments in emerging technologies such as plasma lighting

Appendix: Background Data for Energy Strategies

Conservation Measure	Plug Load Management
Key Components	• Schedule-based timing controls to automate power supply to plug-load equipment such as electronics
Energy Use Reduction Potential (MMBTU and % of total Port Energy Use)	• 1,762 MMBTU reduction in Port energy use • 1% reduction in Port energy use
Energy Use Reduction Potential - Assumptions	• Facilities team estimates this initiative can reduce the plug load by 5% at the Airport • The plug load was assumed to be 8% of total electricity
Cost Information	• Most plug load strategies are no or low cost
Case Study Examples & Best Practice Data	• GSA Public Building Service: Plug Load Control • National Renewable Energy Laboratory: Assessing and Reducing Plug and Process Loads in Office Buildings • New Buildings Institute: Plug Load Best Practices Guide
Feasibility Constraints	• Many of Port’s operations are 24/7, and many spaces are tenant controlled or directly impact tenants • Growth planned to provide increased access to electronics charging for Airport passengers
Recommendations	• Institute plug management program in administrative areas • Explore opportunities for plug load management in public spaces during off-peak periods

Appendix: Background Data for Energy Strategies

Conservation Measure	Building Retuning
Key Components	• Temperature setpoint adjustments & policy • Diagnosis and correction of operational problems with building systems and their controls
Energy Use Reduction Potential (MMBTU and % of total Port Energy Use)	• 18,901 MMBTU reduction in Port energy use • 2% reduction in Port energy use
Energy Use Reduction Potential - Assumptions	• Facilities team estimates this initiative can reduce electrical HVAC use by 5%, and natural gas HVAC use by 15% • HVAC load is assumed to be 21% of total electricity and 23% of total natural gas
Cost Information	• Airport has budgeted $100,000 per year for this type of work which equates to: • $5 / MMBTU, $136 / metric ton of CO_2 • Some building retuning measures may be eligible for rebates and incentives from BPA and SCL
Case Study Examples & Best Practice Data	• US Department of Energy: Energy Savings Modeling of Standard Commercial Building Retuning Measures: Large Office Buildings
Feasibility Constraints	• Policy measure is needed in order to ensure sustainability/acceptance of temperature setpoint changes
Recommendations	• Pursue temperature setpoint adjustments as soon as practicable • Continue pursuit of retro-commissioning measures

Appendix: Background Data for Energy Strategies

Conservation Measure	Fleet Optimization & Electrification
Key Components	• Replacement of diesel and gasoline powered vehicles with electric equivalents
Energy Use Reduction Potential (MMBTU and % of total Port Energy Use)	• 4,735 MMBTU Potential Reduction • 1% of total Port Energy Use
Energy Use Reduction Potential - Assumptions	• Discussions have indicated that a 15% reduction in MMBTU use from diesel and gasoline powered vehicles is possible with fuel efficiency and additional electric vehicles
Cost Information	• TBD
Case Study Examples & Best Practice Data	
Feasibility Constraints	• Operational considerations of specific vehicle types may be a concern for some staff
Recommendations	• Continue to pursue fleet optimization activities Port-wide

Appendix: Background Data for Energy Strategies

Conservation Measure	Advanced Building Envelope Systems	
Key Components	• Daylighting • Adaptive envelope systems such as “electrochromic” (self-tinting) glass	
Energy Use Reduction Potential (MMBTU and % of total Port Energy Use)	• 27,521 MMBTU reduction in Port energy use	• 2% reduction in Port energy use
Energy Use Reduction Potential - Assumptions	• Facilities team estimates this initiative can reduce total electric load by 5%	
Cost Information		
Case Study Examples & Best Practice Data		
Feasibility Constraints	• Glint and glare considerations may be important for particular solar glass technolgies	
Recommendations	• As new facilities come online, evaluate potential for incorporation of electrochromic glass and other advanced envelope technologies • Ensure energy payback evaluations are taken into account	

Appendix: Background Data for Energy Strategies

Renewable Measure	Renewable Natural Gas (RNG)
Key Components	• Source RNG from landfills, wastewater treatment, or agricultural sources
Energy Generation Potential (MMBTU and % of total Port Energy Use)	• 350,000 MMBTU Potential Reduction • 30% of total Port Energy Use
Energy Use Reduction Potential - Assumptions	• Based on most recent discussions, local biogas production facility indicates they can steadily supply 350,000 MMBTU of renewable natural gas to the Airport
Port-Specific Supporting Analysis	• Airport has conducted multiple in-house explorations of RNG deals • 2 landfill operators have provided potential costs
Cost Data	• $7.50-$14/MMBTU • $100-$200/tonne CO2
Feasibility Constraints	• Pipeline and infrastructure costs are potentially prohibitive
Recommendations	• Pursue RNG opportunities as a critical element of our energy & GHG strategy, with second phase to coincide with Airport expansion

Appendix: Background Data for Energy Strategies

Renewable Measure	Solar Photovoltaics
Key Components	• Install solar panels on existing terminal, garage, and cargo areas, and future expansion facilities, either through power purchase agreement or Port-owned project
Energy Generation Potential (MMBTU and % of total Port Energy Use)	• 1,922 MMBTU Potential Reduction • 1% of total Port Energy Use
Energy Use Reduction Potential - Assumptions	• Solar PV panels at the Airport's T2 expansion and at the Seaport are assumed to generate 1,917 MMBTU and 5 MMBTU respectively
Cost Data	• $1,000 / MMBTU, $144,000 / tonne CO_2
Port-Specific Supporting Analysis	• SAMP Task 6.12 includes an evaluation of the solar generation potential using a RETScreen V4 simulation for existing and proposed expansion roof areas. The simulation used modern PV panels in Seattle, based on the optimal installation angle. The analysis assumes a roof available area of 65% for terminals and 90% available for the garage (assuming solar canopies).
Case Study Examples, Best Practice Data, and Other Resources	• Airport Cooperative Research Program (ACRP) Report 108: Guidebook for Energy Facilities Compatibility with Airports and Airspace • Port of San Francisco, Unified Port of San Diego, San Diego International Airport, Port of Amsterdam, Schiphol International Airport
Feasibility Constraints	• The amount of power generated by installing PV on both existing and future facilities would only power a fraction of the Port's electrical requirements • See FAA Technical Guidance for Evaluating Selected Solar Technologies on Airports
Recommendations	• Pursue smaller-scale PV installations on existing and new facilities as opportunities emerge

Appendix: Background Data for Energy Strategies

Renewable Measure	Power Purchase Agreement or Offsite Offset Project
Key Components	• Purchase wind or solar energy directly from third-party owned and operated renewable energy generation facility, on or off Port property
Energy Generation Potential (MMBTU and % of total Port Energy Use)	• Scalable as needed
Energy Use Reduction Potential - Assumptions	• Assumes Eastern Washington site
Cost Data	• \$144,000 / metric ton of CO_2 • \$45M wind farm = 1,248 tonnes CO_2
Port-Specific Supporting Analysis	• Airport has conducted in-house evaluation of offset projects
Case Study Examples, Best Practice Data, and Other Resources	• Google's Green PPAs • Multiple airport projects, including Denver International Airport, Indianapolis International Airport, Port of Portland
Feasibility Constraints	• Consider reviewing revenue diversion issues
Recommendations	• RECs can easily offset any shortfalls in goal achievement

Appendix: Background Data for Energy Strategies

Renewable Measure	Onsite Micro-Hydroelectric Power
Key Components	• Emerging technology that produces power from harvested rainwater flows • Potential for smaller scale, passenger-facing, public-private demonstration program
Energy Generation Potential (MMBTU and % of total Port Energy Use)	• TBD
Energy Use Reduction Potential - Assumptions	• TBD
Port-Specific Supporting Analysis	• N/A
Case Study Examples, Best Practice Data, and Other Resources	• N/A
Feasibility Constraints	• TBD
Recommendations	• Continue to track development of this technology for potential application

Appendix: Background Data for Energy Strategies

Renewable Measure	Kinetic Generators
Key Components	• Emerging technology that produces power from vibrations such as foot and vehicle traffic • Potential for smaller scale, passenger-facing, public-private demonstration program
Energy Generation Potential (MMBTU and % of total Port Energy Use)	• TBD
Energy Use Reduction Potential - Assumptions	• TBD
Port-Specific Supporting Analysis	• N/A
Case Study Examples, Best Practice Data, and Other Resources	• N/A
Feasibility Constraints	• TBD
Recommendations	• Continue to track development of this technology for potential application