Reaching Seattle's Climate Goals in the Building Sector: Quantifying Targets and Tracking Progress

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ABSTRACT

Meeting the City of Seattle's goal to become carbon neutral by 2050 will require overall energy use in the building sector to drop from 48.8 (2008) to 23.3 trillion Btu and GHG Intensity from 28.7 to 10.6 tCO2e/GJ CO2e. These broad goals are a critical starting point, but less useful in understanding whether the sum of individual building performance aligns with the policy goal. An owner has no metric for how their building's performance relates to the overall goal, and policymakers don't know where to focus priorities.

To address this gap, the City is working with the research consultant Ecotope to conduct analysis that establishes granular energy use intensity and greenhouse gas emissions targets by building type (e.g., office, grocery, mid-rise multifamily), at 5–10 year intervals. The analysis is part of Seattle's ongoing work to implement its Climate Action Plan, and results will be used to communicate the need for policy interventions, to identify priority building types, and to track progress. Data from local utility conservation potential assessments, building stock assessments, population and employment forecasts, and the City's climate goals inform energy use intensity and GHG business-as-usual forecasts and target forecasts by building type, building end use, and fuel type. In addition, the resulting base year data and business-as-usual forecasts for Seattle create a powerful planning tool for evaluating the projected impact of potential municipal policy strategies. This paper covers the analysis methodology and results of the analysis, and discusses how the results can be used as a planning tool to inform policy decisions.

Introduction

The City of Seattle has the ambitious goal to be a carbon neutral city by 2050. Seattle's Climate Action Plan (CAP), adopted in 2013, identifies the projected emission reductions needed to get to carbon neutral (OSE 2013). With 33% of Seattle's core emissions from building energy, the carbon emissions from buildings will need to be reduced by 82% from a 2008 baseline. This will come from both reducing building energy use—a 45% reduction in the commercial buildings and a 63% reduction in the residential buildings—and by reducing the greenhouse gas (GHG) intensity of the fuels supplying these buildings by 63%. Overall building energy use (i.e., the total energy consumed in any given year, inclusive of all buildings existing in that year) will need to drop from 48.8 in 2008 to 23.3 trillion Btu in 2050 and GHG Intensity from 28.7 to 10.6

$tCO_2e/GJ\ CO_2e$.[1] All while Seattle continues to gain new people and new jobs; an additional 120,000 people and 115,000 jobs are projected by 2035 (DPD 2015, 13). The City's Climate Action Plan identifies projected energy and GHG reductions at two points in time, 2030[2] and 2050, with a greater proportion of the reductions projected in the 2030–2050 timeframe. However, for the purposes of tracking progress and developing policy, Seattle's Office of Sustainability & Environment (OSE) evaluates against simple average annual reductions for the full planning horizon 2008–2050 (i.e., 1.95% per year over 42 years to achieve a total 82% GHG emissions reduction).

Seattle currently has two primary means of tracking reductions in GHG emissions and energy use: 1) annual Building Energy Benchmarking data and 2) Community Greenhouse Gas Emissions Inventories. Each is valuable for its own purpose, but both have limitations for a comprehensive understanding of building energy and GHG emissions. Seattle has had mandatory Building Energy Benchmarking since 2010 for non-residential and multifamily buildings 20,000 square feet or larger. This program provides annual aggregate energy use for individual buildings, which the City uses to establish total energy use for these buildings and average energy use intensities (EUI) by building type. While benchmarked buildings comprise over 80% of the non-residential and multifamily square footage, buildings smaller than 20,000 square feet, including single-family homes, leave over 60% of the total building square footage untracked. Seattle Community GHG Emissions inventories are prepared every 2–3 years and utilize energy consumption data for Seattle City Light (electricity), Puget Sound Energy (natural gas), Enwave (steam), and the University of Washington (steam), as well as estimates for fuel oil. Consumption is based on customer accounts and is distinguished broadly as commercial or residential. Energy consumption in industrial buildings is accounted for separately as part of the emissions from industrial operations.

Based on Seattle's most recent Community GHG Emission Inventory, from 2008–2012 total GHG emissions in the building sector have gone down 10%, or 2.5% per year (OSE and SEI 2014, 40). This meets the goal of a 1.95% per year average GHG reduction. However, reductions in building energy use are not on track, which is a key component of Seattle's approach. In residential buildings, total energy use has declined 1.25% per year (vs. a goal of approximately 1.5% per year) and only 0.25% per year in commercial buildings (vs. an approximate 1.1% per year goal). More recent energy use data for buildings benchmarked in both 2012 and 2013 (those 20,000 square feet and larger) indicates a 0.6% reduction. This reduction was driven by a decrease in electric consumption of 1.7%, but balanced somewhat by an increase in natural gas consumption of 2.8% (OSE and EMI 2015, 42). This illustrates the complexity of having both GHG emissions targets and energy reduction targets for the building sector. But having both targets is important because the building analysis and targets fit into a larger multi-sector effort to reduce GHG. Switching to a less carbon-intense energy source and

[1] Targets and projections are based on a proof of concept analysis conducted for OSE by the Stockholm Environment Institute (OSE and SEI 2011) and on additional analysis by OSE during the development of the Climate Action Plan.

[2] 2030 targets are tied to goals previously established by Seattle City Council in 2011: 10% commercial energy use reduction; 20% residential energy use reduction; and 25% GHG intensity reduction (City of Seattle, 2011)

using less energy overall provides an opportunity to use the low-intensity energy in other sectors, such as transportation. The purpose of this model is to enable the City to see and understand the relationships of GHG emissions and energy in the building sector at a more granular level than the Climate Action Plan.

Seattle's Climate Action Plan (CAP) outlines a range of near-term (by 2015) and long-term (by 2030) actions related to building energy to put the City on a path to meet its goals. With the majority of the 2015 actions in place or underway, OSE was tasked with developing a plan for the next generation of policy approaches. The broad energy and GHG reduction targets and tracking mechanisms mentioned above provide a critical starting point for assessing progress and identifying next steps, but they are less useful in understanding whether individual building performance aligns with citywide policy goals. No metric exists to help owners understand how their buildings' energy performance relates to the City's overall GHG emissions or energy use reduction goals, and policymakers don't know where to focus energy efforts to improve energy efficiency or promote less GHG intensive fuels. To address the need for greater specificity, the City has been conducting analysis to establish granular business-as-usual forecasts and target forecasts by building type. Initial baseline data were developed by The Cadmus Group as part of a larger Conservation Potential Assessment (CPA) conducted for Seattle City Light (SCL) (SCL 2015). This included base-year energy use and GHG emissions data for 2015, as well as business-as-usual (BAU) forecast for 2015–2035 for gas and electricity. Ecotope has refined the base-year data and BAU forecast and developed the specific targets. Performance goals identify the energy and GHG intensities by building type that would be needed for Seattle to achieve its climate goals. The gap between BAU projections and the 2050 performance goals highlights where, and to what degree, intervention will be needed. Results of the analysis will be used to track progress, to communicate additional policy intervention needs, and as a planning tool to evaluate the impact of specific approaches.

This paper presents the methodology for calculating EUI and GHG emissions for the base-year, BAU forecasts, and reduction targets by building type. The paper also presents preliminary results from the model and discusses opportunities and challenges associated with the data collection and assembly process.

Methodology Overview

The EUI and GHG emissions BAU forecast by building type is an aggregation of many data sources, including city, state, regional, and national data sets on population and energy consumption. These data sets provide the foundation for a generalized building end use (space conditioning, hot water, etc.) model by building type. Coupled with fuel use saturations, a forecast of total energy consumption and GHG emissions can be constructed. The BAU forecast assumes buildings achieve the goals of existing policies and utility energy efficiency incentives, such as appliance standards and recent code adoptions, but does not include future policy decisions. The energy and GHG reduction goals from the City's 2050 carbon neutral plan are then overlaid on the BAU model to find the difference between the BAU forecast and the City's goal. The difference is the basis for the reduction targets by building type. The model is a planning tool for analyzing individual policy ideas to determine their impact on energy and GHG reductions. Each added successful policy initiative brings the City closer to the 2050 CAP goal.

The following definitions are used in this paper and in the model:

- The **reference year** is 2008, which is the starting year for referencing the Climate Action Plan GHG emission reduction goal.
- The **base year** is 2015, which is the latest year for data availability.
- The **forecast years** are 2020, 2025, 2035, and 2050.
- The "**business-as-usual**" (BAU) forecast is the scenario where the conservation and fuel reduction potential in Conservation Potential Assessments (CPAs) are taken as the baseline conditions independent of any carbon reduction strategy; the BAU forecast includes utility programs, already-legislated codes and standards, and naturally occurring conservation (market transformation).
- The **goal forecast** is a linear application of the Climate Action Plan reduction target (e.g., 82% for GHG emissions in 2050) back to the reference year (0% in 2008).
- **Reduction targets** are then the difference between the BAU forecast and the goal forecast, representing the EUI and GHG reduction goals. Each year in the forecast will have energy and GHG reduction targets so actual reductions can be compared to the goal.

The model is a disaggregation of total energy consumption by building type into energy use by fuel type and building end use. GHG emissions are calculated from this fuel disaggregation. Each building type is split into existing (2015 and earlier) and new (post-2015), which helps in accounting for code implementations and retrofits. Fuel types are **Electricity**, **Natural Gas**, **Oil**, and two district **Steam** types, Natural Gas Steam and Biomass Steam.[3] District steam is separated from the general natural gas accounting because of the potential to convert to biomass on a large scale.[4] Building end uses are split into four major categories: **HVAC** (heating, ventilation, and air conditioning), **DHW** (domestic hot water), **Process Loads** (commercial cooking, laboratory equipment, etc.), and **Other** (lights, plug loads, etc.).[5] The intersection of building end uses and fuel uses can be seen in Table 1.

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[3] Electricity is provided by the municipal utility, Seattle City Light, gas by an investor owned utility, Puget Sound Energy, and steam by either Enwave (an investor owned steam utility in central Seattle) or by large campus systems.
[4] The term "fuels" in this paper is being used loosely since steam is not a fuel, but rather gets generated from natural gas and/or biomass. Natural gas steam and biomass steam will just be referred to as the steam fuel type and the model has an accounting for splitting natural gas steam and biomass steam.
[5] On-site renewables (e.g., solar PV) are treated as a change in the energy efficiency of the building and not as a separate "fuel" source.

Table 1. Building end uses and fuel types

Fuel Types	Building End Uses				Fuel Supplier
	HVAC	DHW	Process	Other	
Natural Gas	•	•	•	•	Puget Sound Energy (PSE)
Electricity	•	•	•	•	Seattle City Light (SCL)
Fuel Oil	•				(Various)
Steam	•	•			Enwave, Univ. of Wash., Seattle Center

There are sixteen building types in the model, which are shown in Table 2.

Table 2. Model Building Types

Commercial			Residential
Assembly	Office	Retail	Single Family
Grocery	Other	School (K-12)	Multifamily (1–3)
Hospital	Other Health	University	Multifamily (4–6)
Lodging	Restaurant	Warehouse	Multifamily (7+)

Establishing BAU Forecast

Development of the BAU forecast began with the initial base-year data developed as a supplement to the SCL CPA process, with the base-year data incorporating all fuel types (SCL is only electricity). This base-year data set provided 2015 estimates of EUI by fuel type for each of the building types, along with the associated GHG intensities and conversion rates. EUIs were reported as fuel consumption per square feet, per capita, per employee, and per housing unit. All of the fuels were then aggregated to provide total consumption (in kBtu). A list of data sources are provided below.

Data sources for this effort:

- City of Seattle Department of Planning and Development (DPD) population, household count, and employment estimates;
- SCL floor space estimates from nonresidential customer database;
- U.S. Census Bureau decennial census and American Community Survey;
- U.S. Green Building Council (USGBC) estimates of floor space per employee;
- SCL 2016 Conservation Potential Assessment;
- Puget Sound Energy (PSE) 2016 Conservation Potential Assessment;
- City of Seattle 2014 building benchmarking database;
- Northwest Energy Efficiency Alliance (NEEA) Residential Building Stock Assessment (RBSA) and Commercial Building Stock Assessment (CBSA) (including SCL oversample for each of these assessments); and
- 2012 Seattle Community Greenhouse Gas Emissions Inventory.

After developing the EUI estimates for the base-year, results were compared against local, regional, and national datasets as a reasonableness check. These include:

- Seattle Benchmarking
- Residential and Commercial Building Stock Assessments for SCL (RBSA/CBSA)
- Residential Energy Consumption Survey (RECS)
- Commercial Building Energy Consumption Survey (CBECS)
- California Energy Use Survey (CEUS)

The base-year data gives the 2015 estimate of EUI, GHG intensity, and population by building type and fuel type. From there, the EUIs were disaggregated into building end uses, and the model was forecasted out from 2015 to 2050 for EUIs and populations. The model also extends backwards to 2008 in order to compare values to the reference year.

Building End Use Disaggregation

The four main building end uses (HVAC, DHW, Process, and Other) were obtained for each building type by developing consumption ratios by fuel saturations by building type from the Seattle City Light (SCL) CPA and Puget Sound Energy (PSE) CPA. Once these estimates are totaled they are calibrated in the context of *total* consumption reported by these utilities for each building type. The PSE CPA covers a much larger area than just the City of Seattle, so the ratios are not always consistent with the building stock of the City. Adjustments for this inconsistency were developed using Seattle RBSA and CBSA data. Figure 1 shows the base-year breakdown by building end use for each building type.

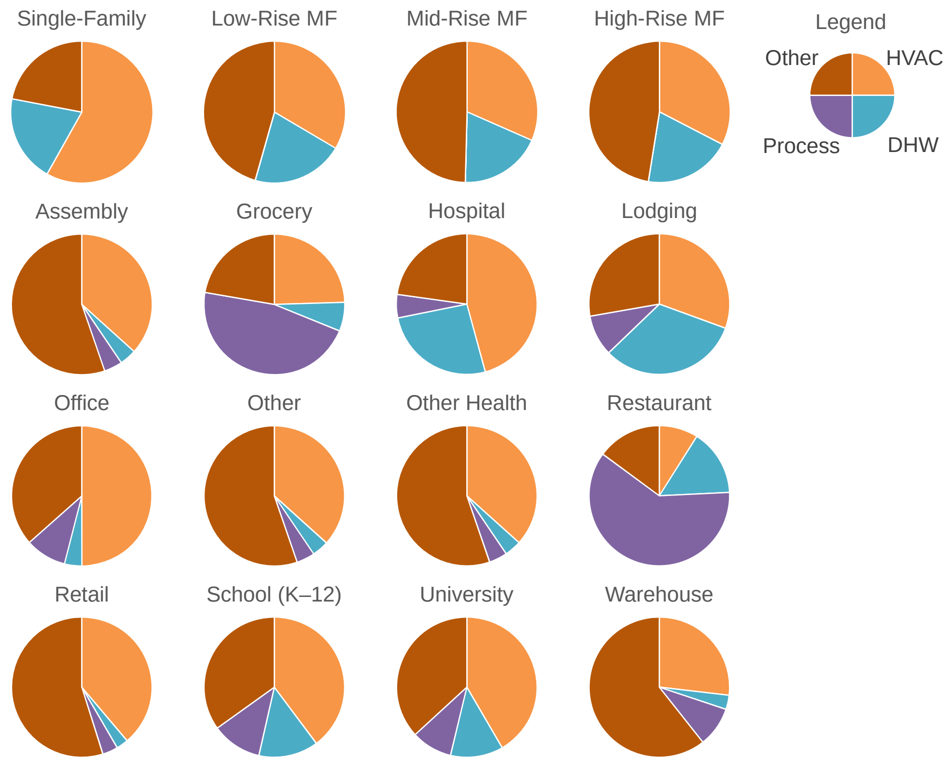

Figure 1. Building End Use Disaggregation by Building Type (Base Year 2015)

These building end uses are obtained from the adjusted CPA models by fuel type, and then aggregated across fuels to produce Figure 1, which shows the fraction of kBtu per square foot consumption by building type. End uses for steam and oil are assigned directly from CBSA data, RBSA data, and the Seattle GHG inventory data. When combined with the building type populations, forecasts can be used to derive the BAU demand for GHG emitting fuels in each building type.

BAU Energy Use Intensity and Greenhouse Gas Emissions Forecast

The energy use intensity (EUI) of buildings will change over time, through both intentional and unintentional conservation efforts, as well as new building stock being added to the total building stock or replacing old building stock. New buildings, particularly in the State of Washington and City of Seattle, are subject to a more stringent energy code compared to the existing building stock in Seattle, so the model splits out the existing population (2015 and earlier) from the new population (post-2015) to allow for different policy treatment of the two groups.

The BAU EUI forecast begins with the SCL and PSE CPA forecasts. Adjustments are made in the CPA models to account for Seattle-specific building stock characteristics, but the overall time trends in the existing conservation efforts built into the CPA are retained. The conservation time trends include utility programs, already-legislated codes and standards, and market transformation. The Seattle-adjusted CPA models provide the building end use EUI forecasts for gas and electricity.

Steam and oil are much smaller components of the model when compared with gas and electricity, but do provide opportunity for GHG intensity reductions. Data for these fuels are more limited, but the models also are not as complex since these fuels are mostly used for heating with some domestic hot water use as well. In general, these fuels are held constant over the time horizon, except where data are available from Enwave or University of Washington Steam. The ratio of natural gas steam to biomass steam, however, does change over time based on the forecasts from Enwave and their agreement with the City to increase biomass generation.

The total EUI is the sum of all the fuel EUIs. Figure 2 shows the BAU forecasted Seattle EUI trends through 2050, by building type, using the Seattle-adjusted CPA values and steam and oil data.

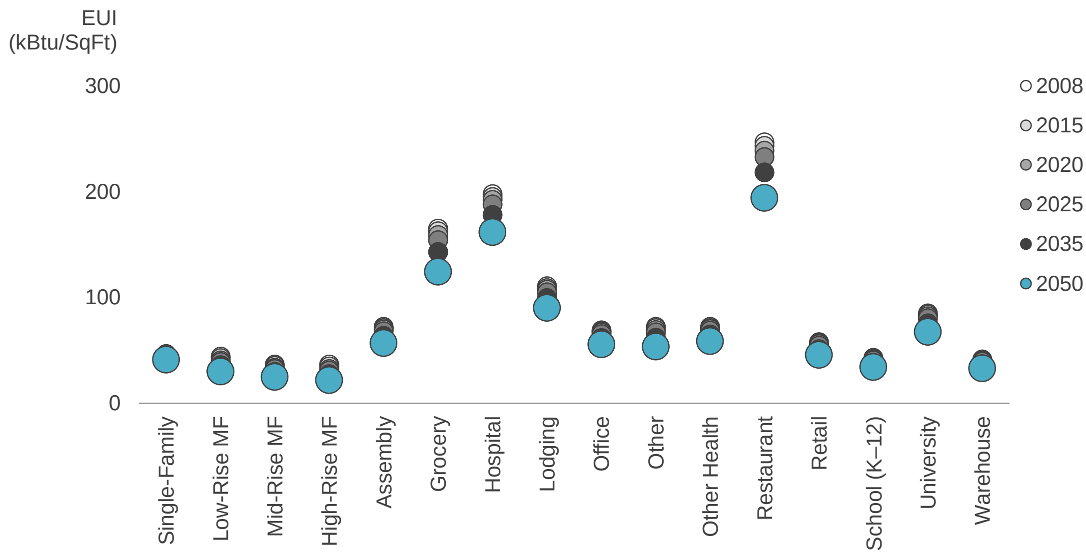

Figure 2. Total EUI Change over Time by Building Type

Population Forecast

The methodology for generating building square feet and unit forecasts varies by building type. For residential building types, the model relies on the residential population (number of people) and people per unit forecast from the City through 2040 and extends that general trend through 2050. This gives the overall population and number of housing units. The model then segments the units into single-family, low-rise, mid-rise, and high-rise multifamily, and into existing units and new units for each of those building types.

Over the past ten years, Seattle has experienced stagnation in the new single-family housing stock and a large surge in the multifamily housing stock. This is due to geographical limitations where new single-family construction is increasingly limited to only infill replacement. In addition, many neighborhoods zoned for multifamily but constructed with single-family units are seeing more and more multifamily units being built where single-family units used to stand.

To account for these trends in residential buildings, an optimization model was built using current estimates of the total unit forecast and the current distribution of the four building types (single-family and three multifamily building types) in the existing residential building stock. Estimates are made of the rate of single-family growth (or decline) over time. These estimates are based on analysis of census and American Community Survey (ACS) data, King County Assessor data, and Seattle Department of Planning & Development (DPD) land use data and forecasts. The total multifamily units is then the difference between the total residential units and the single-family units. The number of units for each multifamily category is developed using the trends observed in multifamily construction in the city.

The split between new and existing units for each of the residential types is based on setting a demolition rate from analyzing ACS data and DPD data, and filling in the remaining population with new construction. The final model of all eight residential building segments[6] over time is then checked for reasonableness, and engineering estimates are adjusted if necessary.

Unlike residential buildings, an overall square foot and building type forecast estimate was not available for commercial buildings. Consequently, the commercial energy use and GHG model was built from the ground-up rather than top-down. For each commercial building type, general construction and demolition rates from the Northwest Power and Conservation Council (NPCC) are used as a starting point. But these rates are for the entire state and not for Seattle, so they were reviewed against DPD data and engineering judgment about local industry trends. The current population of building square footage was estimated by the utility CPA analyses. This was done using EUIs derived from local surveys (including the CBSA and the Seattle Benchmarking database). The energy use by major commercial building types was developed for the CPA and the square footage was merely the result of a division between the EUI data and the total energy use by building type. While this method is approximate, it does take into account the known distribution of energy and buildings in the city.

Developing EUI & GHG Reduction Targets

The EUI and GHG intensity reduction targets are the difference between the BAU forecast and the Seattle CAP reduction goals by 2050. In subsequent phases of this project, the City will use this difference to assess additional policies to target deeper reductions in energy use and carbon-based fuel use—an example of such a policy analysis is given later in this paper. Targets are also generated for a few intermediate points (2020, 2025, 2035) using a linear interpolation from 2008 to 2050. These intermediate points give the City a checkpoint for assessing progress towards the GHG reduction goal. They also inform future program and regulatory actions to achieve the 2050 target. Reduction targets are generated by building type, so building owners can also assess how they are doing in relation to the city-wide goal.

[6] New and existing for single family and low-rise, mid-rise and high rise multifamily buildings

Reduction targets account for the savings necessary by building type in the context of detailed population changes and natural efficiency improvements.

The detailed targets are currently under development. EUI and GHG reduction targets will use a top-down approach for each building type. This will be done by reconciling the BAU forecast with the EUI and GHG intensities reductions necessary to meet the targets. The target setting included the following steps:

- **Establish 2050 Building Type Targets**. Use the original Seattle CAP 2050 targets and apply to building types developed for this plan.
- **Establish 2020, 2025, 2035, 2050 Building Level EUI and Emission Targets**. Set the EUI and emission levels of fossil-fuel energy use across the building types included in the detailed BAU forecasts. These levels imply that non-carbon emitting substitutes such as efficient electric systems and biomass or waste-heat based district heating sources will be ramped up in each forecast period. The rate of this ramp is, in effect, set by the carbon reduction goal and by the total energy use and fuel use derived from the forecast population by 2050 in each building type.
- **Establish 2020, 2025, 2035, 2050 Electric Building Level EUI Targets**. Assuming continued carbon neutrality of SCL electricity through 2050, the main driver for setting electric EUI targets is to account for the increase in electricity required to offset the reduction in fossil-fuel energy use discussed in the previous bullet. The current scope does not include a calculation for offsets to electrify large parts of the transportation sector; however, the methodology would be similar.

Results from First Application of Model for Policy Analysis

One of the key goals of this effort was to provide the City with a tool for assessing the impact of various policies designed to reduce GHG emissions. In March 2016, Seattle passed legislation requiring periodic tune-ups for non-commercial buildings 50,000 square feet or larger (OSE 2016). The ordinance requires a periodic (every 5 years) tune-up to optimize energy and water performance and encourage active management in Seattle's commercial buildings. Tune-ups would identify and correct no- or low-cost changes to building operations, measures that would pay back in 2-3 years. Exemptions would take into account buildings that already conduct tune-ups or demonstrate high performance. The tune-up ordinance was one of the first City policies analyzed using the model.

In order to assess the citywide impact of the tune-up ordinance, Ecotope implemented a multistep process to determine applicability, energy use impacts, and ultimately GHG impacts. The City estimates a 10% to 15% average per building energy savings, based on a current tune-up study (Katipamula 2015), measures identified by PSE in their commercial building recommissioning program (PSE 2014), and recurring measures Ecotope developed in Seattle municipal buildings from building characteristics audits for the Seattle’s City-owned buildings. However, understanding how the energy savings are distributed across building types, and the actual GHG implications of the savings, requires granular data such as total square feet, building end use ratios, and fuel use EUIs for each building type. The model provided this fundamental data for the analysis in a readily accessible format. Ecotope assembled the total square feet and EUIs by building type and then determined the proportion of each building type's total square footage eligible for the ordinance. Eligibility was determined by a combination of applicability and exemption criteria established by the City Council. The distribution of tune-up savings for eligible buildings by building end use was then determined. This process separated the total energy use and energy savings from the fuel use and fuel saving. It is necessary to calculate the energy savings by building end use in order to properly apply fuel types and thereby identify GHG impacts. The energy savings by building end use were then applied to the base-year building end use EUIs in the model. Ecotope then used the model fuel saturations by building end use and building type to determine the GHG reduction impact of these savings. Table 3 below presents a summary of the projected GHG reductions for the tune-up ordinance by building type.

Table 3. GHG Reductions Summary for Tune-Up Ordinance

Building Type	GHG Pre for All Buildings (MgCO2e)	Buildings Affected by Ordinance			Savings for All Buildings (%)
		GHG Pre (MgCO2e)	GHG Post (MgCO2e)	GHG Savings (%)	
Assembly	22,218	13,276	10,449	21.3%	12.7%
Grocery	14,571	4,318	3,531	18.2%	5.4%
Hospital	43,465	38,924	32,444	16.6%	14.9%
Hotel Motel	36,292	27,702	23,346	15.7%	12.0%
Office	79,524	38,937	31,663	18.7%	9.1%
Other	5,630	3,230	2,543	21.3%	12.2%
Other Health	10,969	7,212	5,677	21.3%	14.0%
Restaurant	78,262	7,469	6,321	15.4%	1.5%
Retail	15,919	6,379	5,022	21.3%	8.5%
School	12,501	8,667	7,132	17.7%	12.3%
University	13,037	9,741	7,955	18.3%	13.7%
Warehouse	9,834	4,268	3,138	26.5%	11.5%
Total	987,879	170,123	139,220	18.2%	9.0%

The totals in Table 3 assume a 15% energy use savings, per the studies mentioned above. The first column in the table shows the GHG emission totals for the entire population of each building type. The next two columns show the pre and post tune-up GHG emissions for only eligible buildings (non-exempt). The last two columns show the percent GHG reduction from the tune-up for just the eligible buildings (18.2%) and the overall commercial buildings (9%). Adding in residential buildings (at 0% savings) yields 3.1% overall savings across all residential and commercial buildings in Seattle.

Conclusions

The model provides a valuable tool for predicting the energy use and GHG emissions reductions of potential City policies. Results can be used to assess a range of options and prioritize those expected to yield the greatest impact, as well as to communicate the need for particular strategies. Results of the tune-up analysis were used by City staff to help communicate the value of the policy to elected officials and to the community.

In addition to the predictive uses for the model, the results establishing the forecast goals and reduction targets, as well as the existing base-year conditions, will support the City's efforts to implement its Climate Action Plan in a number of ways:

- Base-year results are being used to identify which building types have the biggest opportunity for emission reductions, and where to focus policy development. For instance, single-family buildings are often not considered a priority, as the return per building is small. However, the model has revealed that due to high saturations of gas space and water heating, single-family buildings are responsible for more than half of Seattle's GHG emissions from all residential and commercial buildings combined. Therefore, any policy strategy to achieve a carbon-neutral City will need to address these homes.
- The forecast goals and reduction targets by building type provide metrics that are relevant for individual building owners and provides a means to understand how their building's performance (both EUI and GHG) compares to the City's goals.
- The EUI and GHG reduction targets, at 5–10 year intervals through to 2050, also provide a key tracking tool for the City. Performance by building type, from annual building energy benchmarking data and from building stock assessments, can be compared against the targets to assess whether reductions are on track. In addition, future point-in-time comprehensive energy use and GHG emissions inventories, especially as new data become available, can be compared to the targets and used to re-calibrate the model.
- Lastly, projected energy and GHG savings for policies that are implemented (e.g., mandatory tune-ups) could be evaluated against measured results to further refine our predictive assumptions and recalibrate the modeled impact.

The model developed for the City of Seattle utilizes almost two decades of baseline studies that characterized the City's building stock. As a result, data about EUIs and fuel saturations could be used in this model with confidence that these represented the actual City of Seattle building stock. It is our belief that other cities could use this approach, but in most cases a set of estimates would be required that would bridge the gap between the anecdotal building type and energy end use distributions maintained by utilities or the Chambers of Commerce and the details needed to generate a model similar to that created for Seattle. Understanding the details of a particular city require experience in that locality.

Generalized models that could be applied across jurisdictions could be valuable, but only after a credible estimate of the building floor areas, number of residential units, building types, and building end uses in each locale can be made. Benchmarking can be an important part of that process and provide building and energy use information for a subset of a jurisdiction's building stock, but the baseline distribution of all of the buildings and building end uses is also important and would need to be developed.

References

City of Seattle. 2011. *Resolution 31312: A RESOLUTION adopting new climate protection and adaptation goals for Seattle and outlining the process for updating the Seattle Climate Action Plan to provide a roadmap for achieving those goals*.

DPD (Seattle Department of Planning and Development). 2015. *A Comprehensive Plan for Managing Growth 2015-2035: Draft*. www.seattle.gov/dpd/cs/groups/pan/@pan/documents/web_informational/p2294968.pdf

Katipamula, S. 2015. "Improving Commercial Building Operations thru Building Re-tuning: Meta-Analysis." PNNL-SA-11068.

OSE (Seattle Office of Sustainability & Environment). 2013. *Seattle Climate Action Plan*. www.seattle.gov/Documents/Departments/OSE/2013_CAP_20130612.pdf

OSE. 2016. *Next Generation Energy Efficiency Policy*. www.seattle.gov/environment/buildings-and-energy/energy-policy.

OSE and EMI Consulting. 2015. *Seattle Building Energy Benchmarking Analysis Report 2013 Data*. www.seattle.gov/Documents/Departments/OSE/EBR-2013-report.pdf

OSE and SEI (Stockholm Environmental Institute). 2011. *Getting to Zero: A Pathway to a Carbon Neutral Seattle*. www.seattle.gov/Documents/Departments/OSE/CN_Seattle_Report_May_2011.pdf

OSE and SEI. 2014. *2012 Seattle Community Greenhouse Gas Emissions Inventory*. www.seattle.gov/Documents/Departments/OSE/2012%20GHG%20inventory%20report_final.pdf

PSE (Puget Sound Energy). Comprehensive Building Tune-up (CBTU) Program Guide. 10/10/2014.

SCL (Seattle City Light). 2015. *Conservation Potential Assessment*. www.seattle.gov/light/conserve/cv5_pub.htm