CURB Tool

Climate Action for Urban Sustainability

Version 2.0 (Open Beta)
User Guide

June 2017

WORLD BANK GROUP | C40 CITIES | GLOBAL COVENANT of MAYORS for CLIMATE & ENERGY | AECOM

Contents

INTRODUCTION

Welcome to **CURB: Climate Action for Urban Sustainability**. This toolkit is designed to help guide cities through the process of planning and implementing a range of actions to reduce energy use, save money, and cut local greenhouse gas (GHG) emissions. The technology and policy actions covered by CURB can also help deliver important local quality of life benefits, including improved air quality, local economic development and job creation

CURB was developed through collaboration between the World Bank Group, C40 Cities Climate Leadership Group, Bloomberg Philanthropies, and AECOM Consulting. Each institution is actively engaged in supporting climate, energy, and sustainability planning efforts at the local scale in cities around the world. CURB is intended to allow planners to assess the implications of different policy and technology interventions.

CURB's flexible and modular design responds to local realities, recognizing that impacts germane to one city (e.g. energy or emission impacts, cost savings, etc.) may be valued differently by others. CURB therefore presents information in different ways so users can select the information most relevant to their work.

The calculations made by the CURB tool are based on modeling approaches or assumptions developed by world-class engineers, economists, and urban planners. The accuracy of the calculations is, however, linked to the quality of the data used in the tool, which is why CURB consistently asks the user to provide locally relevant information. Since data gaps are a common problem in cities, CURB does provide city, national or regional proxy data that the user can rely on if local information is unavailable or considered unreliable.

This *User Guide* explains the purpose and approach used in each of the six modules contained in the Toolkit. This *User Guide* also explains what types of information are required to run each module, and what type of output is generated to support local planning and decision-making.

If any section of this user guide is unclear, please offer suggestions on how it can be improved by contacting the development team via this feedback form or at curb@worldbank.org.

CURB contains a total of six modules:

- **Setup** is where the user can enter basic data about the overall situation in a city and sectoral profiles. This information is then used repeatedly throughout the Tool to help make different calculations.
- **Inventory** converts the information provided in the *Setup* module into estimates of which sectors create the greatest energy demand and GHG emissions and how the situation may change over time. It is in this module that the user also has the option to set future reduction performance targets against which progress can be measured.
- **Context** provides details regarding the sub-activities, end uses, and materials that currently generate the city's emissions. The module also allows users to compare their cities with other cities across a range of key performance indicators in each sector.
- **Actions** is the heart of the tool. This module allows the user to select which sectors she would like to focus on, and then to rate the city's authority to take action in each sector. This information is then quickly translated into a rapid assessment of the maximum impact potential and implementation feasibility of every action included in CURB. This module is intended to help users decide which actions are worthy of further exploration. Users then determine whether each action will be included or excluded in the overall plan. Detailed cost and impact assessments are

calculated based on information provided about the anticipated deployment level of each action. At any time, users may go back and change the options selected, either to drop or add actions or to change the anticipated deployment rate that will ultimately be achieved.

- **Results** shows the combined impact of selected actions on urban GHG emissions, local energy demand, and spending levels. This module also demonstrates how successful the particular scenario will be at delivering the city's emission or energy demand reduction targets.
- **Database** provide users with the proxy data that serves as inputs for the tool, as well as data sources.

In the **Introduction** sub-module tabs, users can understand the tool's purpose, learn about the CURB partners, and ensure that the tool is displayed in an optimal manner for their computer settings.

CURB is optimized for use on Microsoft Excel 2010 (32-bit version) for Windows. The development team has made extensive efforts to ensure cross compatibility with other versions of Excel (64-bit for Windows) and Excel for Mac Operating Systems. Since these are not the primary platforms, users should consider saving their file frequently to avoid loss of data. Additionally, please note that graphics may be modified on Mac computers.

1. SETUP

Setup is where the user can enter basic data about the city that will be used in other modules.

All user entry fields are highlighted in blue.

1.A) City Context

City Context first asks the user to provide basic information about the city's urban environment, including climate and population. It then allows the user to set baseline and target years for emissions.

1. Basic Data

A. City Characteristics

Data Item	Value	Units	Source
City Name	Oakland	N/A	
Country	United States of America	N/A	
Area of City (exclude water, natural, and agricultural areas)	126	Square kilometers	
City Annual Precipitation	Moderate (750-1000mm)	mm/year	
City Climate	Dry	N/A	

B. Planning Base Year and Target Years

Year	Value	Units	Source
Base Year	2013	N/A	
Target Year 1	2020	N/A	
Target Year 2	2035	N/A	
Target Year 3	2050	N/A	

C. City Population and Non-Resident Commuters

Data Item	Value	Units	Source
Population of Oakland in 2013	373,910	Number of people	Census 2005 ACS
Daily non-resident commuters in Oakland in 2013		Number of commuters	Currently not used

The next step is to enter a greenhouse gas emissions inventory if the city has one. A greenhouse gas emissions inventory shows how much emissions are produced within each sector, such as buildings, waste, and transportation among others. If the city has conducted an emissions inventory that was developed in accordance with the Global Protocol on Community Scale Greenhouse Gas Emission Inventories (GPC), and the city has reported this information using the official template developed by the C40 and World Resources Institute, then this information can be easily entered into CURB. When entering data manually, users should ensure that any information submitted as part of their GHG inventory is consistent with city data entered throughout the rest of City Context. Refer to section 1.E) Data Import of this user guide for additional details on automatically importing a GPC compliant inventory from the C40 City Network's City Inventory Reporting and Information System.

2. Community Greenhouse Gas Emissions Inventory Data

Select One:

- (•) Option 1: Enter the city's base year greenhouse gas emissions inventory (a GPC-compliant inventory is recommended)
- ( ) Option 2: Use a CURB-generated greenhouse gas emissions inventory

Enter Community Emissions Inventory Data

[Link to Inventory Input Page]

If the city does not have an inventory, CURB will automatically generate one based on the sectoral activity data provided. This sectoral data includes:

- Residential and commercial buildings
- Municipal buildings and public lighting
- Grid-supplied energy profile

- Solid waste generation levels, composition, and management practices
- Wastewater generation and management
- Water conveyance system design
- Transportation patterns

These data comprise the bulk of the data requirements for CURB. For a detailed view of the data required, please consult Annex 1: CURB Data Requirements or the CURB Data Template. For cities that have already completed a comprehensive energy study or GHG emissions inventory, many of the data points required for the sectoral activity data in this section will already have been collected. If the city has conducted an emissions inventory that was developed in accordance with the Global Protocol on Community Scale Greenhouse Gas Emission Inventories (GPC), and the city has reported this information using the official CIRIS tool developed by the C40, then this information can be easily uploaded into CURB.

Where available, the far right column marked "source" provides space to add any additional comments, such as noting if a particular data point is from a year other than the Baseline Year. In subsequent versions, CURB will adapt calculations accordingly. Some of the blue cells provide dropdown menus to select different options. Selecting the cell will display the dropdown arrow to choose from different options.

Enter City-Specific Waste Facility Condition Assumptions

Waste Facility Type	Condition	Units	Source
Open Dumps	Unmanaged (>5m deep)	NA	
Landfills	Managed - anaerobic	NA	
Incinerators	Batch-type Incineration (Fluidized Bed)	NA	

To the extent possible, the user should seek to enter locally specific data to improve the accuracy of the results. At the same time, CURB recognizes that data is not always readily available. The tool thus provides the option to select default values that draw on proxy data already built into CURB. These estimates are linked to data from a similar city, country or larger geographic region where the user is located.

The option to use proxy data will typically appear as Option 1 in the selection menu for each section. When the user clicks on Option 1, the proxy values that are assumed will appear. Ideally, the default option will only be used in cases where there is no or only partial city-specific data available.

A. Solid Waste Generation Data

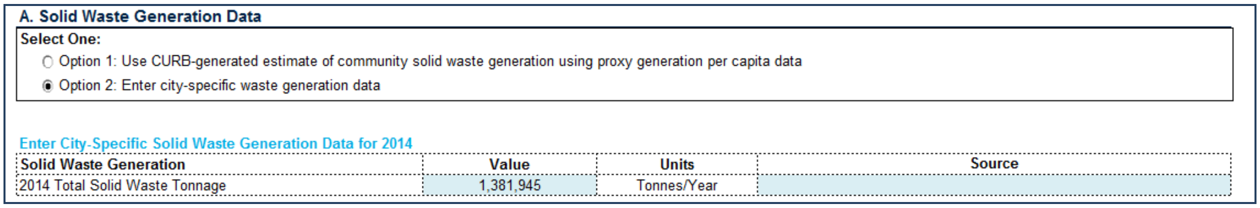
Select One:

- (●) Option 1: Use CURB-generated estimate of community solid waste generation using proxy generation per capita data
- ( ) Option 2: Enter city-specific waste generation data

Select Waste Generation Proxy Data

Data Item	Region/Country/City	Data Available?	Proxy Data Region/Country/City Selected	
Region	Sub-Saharan Africa	Yes	Sub-Saharan Africa	
Country	South Africa	Yes	South Africa	
Solid Waste Generation Data Proxy City	Johannesburg	No, select proxy city >	South Africa Average	

If the user opts to rely on certain proxy data, he can move onto the next question. If the user selects the option to provide local data, lines will appear for the user to provide city-specific information.



A. Solid Waste Generation Data

Select One:

○ Option 1: Use CURB-generated estimate of community solid waste generation using proxy generation per capita data

◉ Option 2: Enter city-specific waste generation data

Enter City-Specific Solid Waste Generation Data for 2014

Solid Waste Generation	Value	Units	Source
2014 Total Solid Waste Tonnage	1,381,945	Tonnes/Year	

If partial data is available, the user can enter the available data for certain sections and paste in proxy data for the remaining sections.

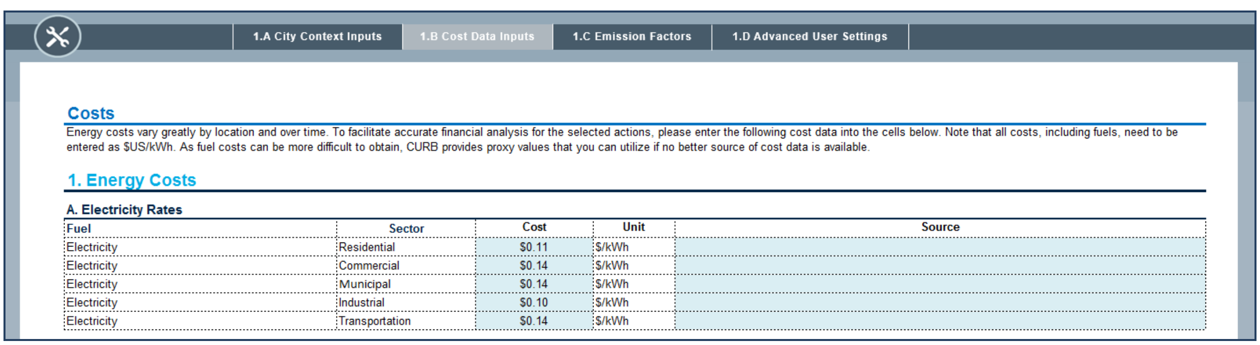
The underlying data assumptions can be changed in Advanced User (1.D) which are outlined in the Advanced User Options (1.D) section below.

Throughout the tool, users may see a gray button to set "Actions to Match Base Case". By clicking on this button, the action conditions in the Actions module (described later in this guide), will be set to reflect the baseline context. The default conditions are set to zero, that is, they reflect the absence of any city activities. If users should use this function after entering data in the Setup module, this will update action conditions to the baseline scenario, upon which the city's actions can be easily designed. Please note that any previously designed actions will be overridden.

1.B) Cost Data

This section asks the user to enter various inputs on the cost of energy in the target city and provides proxy data for each region if data is unavailable. To the extent that the user is able to provide locally-specific data, CURB will better model the costs and savings of various actions as they contribute to changes in energy use over time.

Each data point is sorted by sector (e.g. residential, commercial) and fuel type (e.g. electricity, natural gas). The user is also asked to enter a discount rate for financial analysis.



1.A City Context Inputs | 1.B Cost Data Inputs | 1.C Emission Factors | 1.D Advanced User Settings

Costs

Energy costs vary greatly by location and over time. To facilitate accurate financial analysis for the selected actions, please enter the following cost data into the cells below. Note that all costs, including fuels, need to be entered as $US/kWh. As fuel costs can be more difficult to obtain, CURB provides proxy values that you can utilize if no better source of cost data is available.

1. Energy Costs

A. Electricity Rates

Fuel	Sector	Cost	Unit	Source
Electricity	Residential	$0.11	$/kWh	
Electricity	Commercial	$0.14	$/kWh	
Electricity	Municipal	$0.14	$/kWh	
Electricity	Industrial	$0.10	$/kWh	
Electricity	Transportation	$0.14	$/kWh	

1.C) Emission Factors

The emissions page allows the user to specify different emission factors for their city. For grid energy emission factors, CURB allows the user to select from three options: select national emission factors that are obtained from the International Energy Agency (IEA) database; enter city specific emission factors to be applied to all sectors; or enter city and sector specific emission factors.

For fuel energy emission factors, users can use default emission factors or enter custom emission factors.

Selecting any these options will display a set of cells, similar to previous sections, which will allow the user to view or enter the information for the specified option. When entering custom emission factors, users should ensure emission factors are present for each greenhouse gas and that the units are accurate.

Emission Factors

Accurate emissions calculations depend on using appropriate emission factors. Emission factors for electricty and district energy (e.g., steam) can vary greatly between locations. Emission factors for other fuels are often less variable, but can change depending on their specific chemical composition. This page allows you to select default emission factors or enter custom factors for each fuel.

1. Grid Energy Emission Factors

A. Electricity Emission Factors

Select One:

- ○ Option 1: Use national electricity emission factor for South Africa (Source: IEA)
- ◉ Option 2: Enter one city-specific electricity emission factor and apply the same value to all sectors
- ○ Option 3: Enter city-specific electriciy emission factors to apply to each individual sector

Enter the City-Specific Emission Factor for 2014 or the Closest A

Fuel type or activity	Category	Sub-Sector	Reference	Type	GWP	Units	Convert to tonnes	CO_2	tCO2e	CH_4
Electricity	All	All	Electricity_All_Custom	GHG	5AR	kg / kWh	0.001	1.0700000	0.00107	

2. Fuel Energy Emission Factors

A. Fuel Emission Factors

Select One:

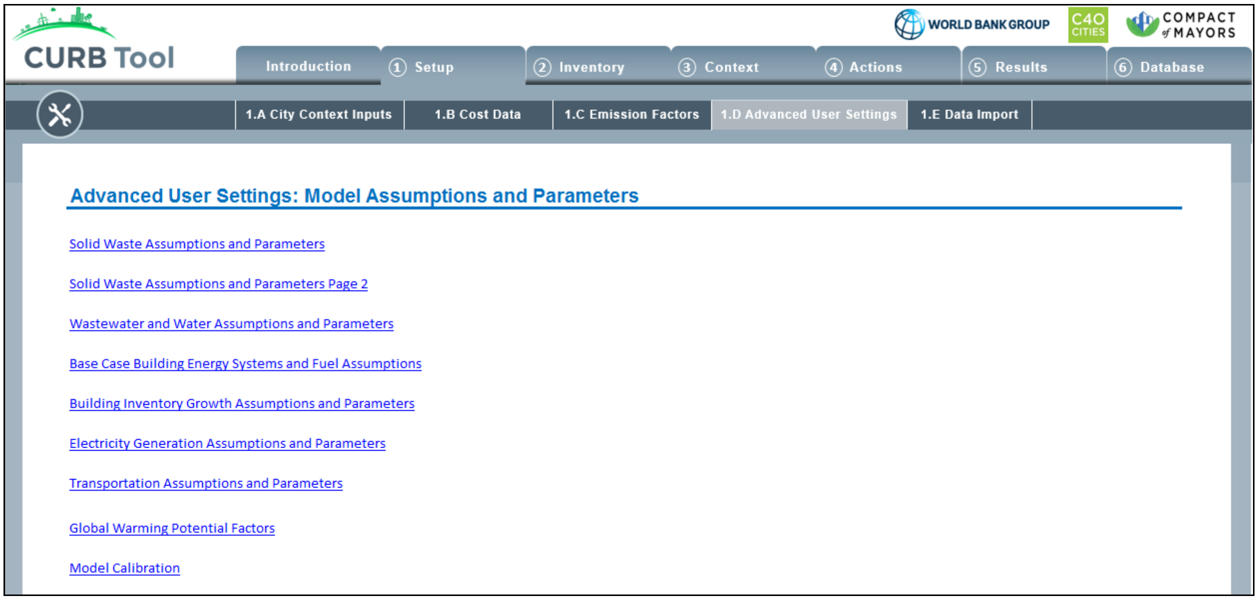
- ○ Option 1: Use default fuel emission factors
- ◉ Option 2: Enter custom fuel emission factors

Enter Custom Emission Factors

Fuel type or activity	Category	Sub-Sector	Reference	Type	GWP	Units	Convert to tonnes	CO_2	tCO2e	CH_4
Aviation gasoline	Stationary	All	Aviation gasoline_Stationary_Custom	CO2e	5AR	t / kWh	1			
Aviation gasoline	Mobile	All	Aviation gasoline_Mobile_Custom	GHG	5AR	t / kWh	1			
Biodiesels	Stationary	All	Biodiesels_Stationary_Custom	GHG	5AR	t / kWh	1			
Biodiesels	Mobile	All	Biodiesels_Mobile_Custom	CO2e	5AR	t / kWh	1			
Biogasoline	Stationary	All	Biogasoline_Stationary_Custom	GHG	5AR	t / kWh	1			
Biogasoline	Mobile	All	Biogasoline_Mobile_Custom	GHG	5AR	t / kWh	1			
Bitumen	Stationary	All	Bitumen_Stationary_Custom	GHG	5AR	t / kWh	1			

1.D) Advanced User Options

Advanced User Settings allow the user to change the technical assumptions underlying the Building Energy, Electricity Generation, Solid Waste, Wastewater, and Transport models. These include information such as estimates of how much energy is consumed by different energy technologies (in different contexts), emission "factors" used to convert energy data into GHG emissions, etc. Due to the advanced nature of this option, it is not recommended that users change these default estimates. If this action is desired, however, please contact the CURB team for information on how to access this data.



1.E) Data Import

Data Import allows the user to import Setup data entered in another version of CURB or inventory data from the GPC inventory from the C40 City Network's City Inventory Reporting and Information System.

The first option allows a user to upload a setup data from a previous version of CURB that they have populated with city-specific data. The upload function will import the setup data, the setup settings, and inventory data. At this time, the upload feature will not import the projections assumptions or the actions implementation assumptions.

The second upload option allows a user to import a GPC compliant inventory from the CIRIS Tool. CURB allows the user to select and upload the file and use it as the Inventory section of CURB.

Both functions, can take about 2-10 minutes to complete depending on the computer's specifications. The user, is given the opportunity to stop the upload at certain points. The data upload to that point will be preserved in the current version of CURB.

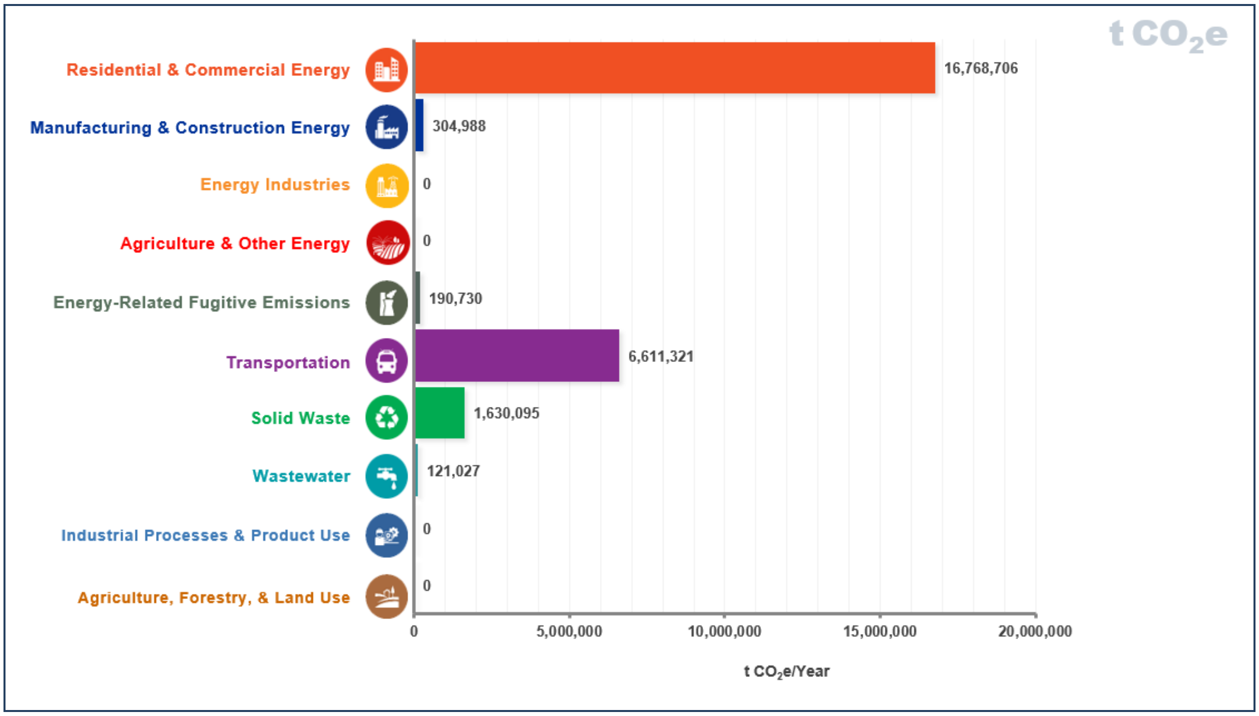
2. INVENTORY

Inventory takes the information provided by the user in the Setup module and visualizes emissions sources and how they will change over time. It is in this module that users have the option to set an emissions or energy use reduction target against which progress can be measured.

2.A Base Year Inventory

I. Base Year Charts

The Base Year Chart tab provides a graphical representation of emissions in each sector in the baseline year that was selected in City Context (1.A).

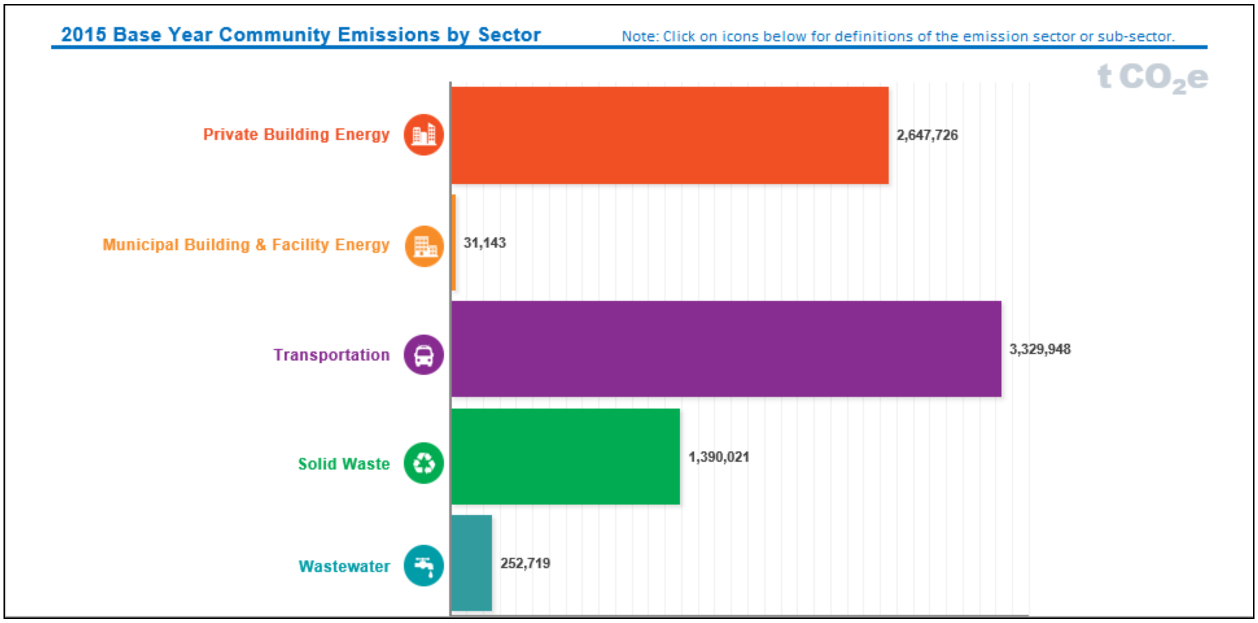


The toggle at the bottom right of the chart allows users to switch between viewing this information in terms of emissions (tonnes of carbon dioxide equivalent: tCO_2e) or energy (MWh).

Note that if a user chooses to view information by energy rather than emissions, the user will not be able to see as many sectors; results are confined to Building and Facility Energy, Manufacturing and Construction Energy, Energy Industries, Agriculture and Other Energy, and Transport. Other sectors like Solid Waste, Wastewater, Industrial Processes and Product Use, and Land, Forestry and Land Use are omitted here because they do not involve energy use. For instance, any energy use from solid waste trucks would be included in Transport, while energy use in industry would be covered under Manufacturing and Construction Energy.

Categorization of sectors in this section is consistent with GPC methodology. By clicking on the sector logo for each sector, the GPC reference number and a description of the sector will pop up. For more information, see [Global Protocol for Community-Scale Greenhouse Gas Emission Inventories].

If a CURB generated inventory as described in section 1.A. City Context is used, then the categories of sectors will be different from the GPC sectors. These sectors are as follows: Private Building Energy, Municipal Building and Facility Energy, Transportation, Solid Waste and Wastewater. This chart will be generated by CURB based on data provided by the user in the Setup module, rather than a user-provided GPC inventory. This option is best for cities that are collecting data from scratch and also allows cities to easily compare baseline emissions and energy usage against gains or reductions achieved through actions in CURB.



II. Base Year Tables

This tab shows the same information as in Base Year Charts, but in tabular format and with additional detail. It goes beyond aggregate emissions in each sector to give a detailed breakdown of energy use and emissions for each fuel type and end use. In other words, this tab provides a full emissions inventory.

If the user entered information from a community greenhouse gas in City Context (1.A), that information is seen here. If the user selected a CURB generated inventory, these values are modeled from the other inputs provided in the Setup module. If there are any values that seem inaccurate, users have the option to override them with their own data.

2014 Base Year Community Emissions

I. Stationary Energy

I.1 Residential Energy

GPC Ref No.	Scope	GHG Emissions Source	Activity Data		Converted Activity Data			Emission Factor		GHG Emissions
		Activity	Activity/Year	Unit	Factor	Activity/Year	Unit	Value	Unit	t CO_2e/Year
I.1.1	1									**47,544**
I.1.1	1	Kerosene	1,247,717	gal (US)	0.1424	177,716	GJ	0.0723390	tCO2e/GJ	12,856
I.1.1	1	Coal (Bituminous or Black coal)	4,703	tonne	29.0519	136,643	GJ	0.1033975	tCO2e/GJ	14,129
I.1.1	1	Natural gas	239,000	GJ	1.0000	239,000	GJ	0.0562665	tCO2e/GJ	13,448
I.1.1	1	Wood or wood waste	208,825,504	kWh	0.0036	751,772	GJ	0.0094600	tCO2e/GJ	7,112
I.1.1	1									
I.1.1	1									
I.1.2	2									**7,064,518**
I.1.2	2	Electricity	4,281,390,662	kWh	1.0000	4,281,390,662	kWh	0.0010700	tCO2e/kWh	4,581,088
I.1.2	2	Electricity	1,026,359,241	kWh	1.0000	1,026,359,241	kWh	0.0010700	tCO2e/kWh	1,098,204
I.1.2	2	Electricity	1,294,603,201	kWh	1.0000	1,294,603,201	kWh	0.0010700	tCO2e/kWh	1,385,225
I.1.3	3									**467,707**
I.1.3	3	Electricity	385,325,160	kWh	1.0000	385,325,160	kWh	0.0010700	tCO2e/kWh	412,298
I.1.3	3	Electricity	51,784,128	kWh	1.0000	51,784,128	kWh	0.0010700	tCO2e/kWh	55,409
I.1.3	3									
I.1	**Residential Building Energy Use**									**7,579,769**

The GPC inventory is broken down to three levels of detail:

- **Scope 1**: Direct emissions from sources within the defined boundary
- **Scope 2**: Energy-related indirect emissions from the use of grid-supplied electricity, heating, and/or cooling
- **Scope 3**: All other indirect emissions

More detailed information on scopes can be found in the GPC guidance.

2.B) Growth Factors

This section allows users to set growth factors for emissive activities in the target city. The information entered here will allow CURB to take the Baseline Inventory and project energy use and emissions until the final Target Year in the form of a "business as usual" scenario. The results of these projections are available in the next section, Projections (2.C).

There are a four types of growth factors that may be considered to represent activity growth:

- **Population growth** (projected or historic): This assumes that growth in energy use and emissions across all sectors will be proportionate to citywide or national population growth. Population data is drawn from the United Nations Department of Economic and Social Affairs Population Division and their report World Urbanization Prospects: The 2014 Revision.
- **GDP growth** (projected or historic): Using GDP growth as a proxy assumes that activity growth corresponds to economic growth.
- **Emissions growth** (historic only): Historic emissions growth is derived from EA's 'CO_2 Highlights 2015' study. While this report is linked to fossil fuels, selecting this growth factor will apply the emissions growth rates to all sectors.
- **Custom growth rate**: City-specific growth rates likely to provide the most accurate estimate of how energy use and emissions will change over time, yet it is also the most demanding for the user. The user is asked to enter growth factors for each fuel type by end use, across multiple time periods. In most cities this data will not be readily available.

The options presented allow users to select the type of growth factors to be applied independently or in combination.

Activity and Emission Growth Factors

Choose which method you would like to use to estimate the growth in emissions-generating activity over time.

Select One:

- (●) Option 1: Use population growth rate as a proxy for activity growth
- ( ) Option 2: Use population and GDP growth rates as proxy for activity growth
- ( ) Option 3: Use historic national population, GDP, or emissions growth rates as proxy for activity growth (using data from IEA/OECD, 2015)
- ( ) Option 4: Enter custom sub-sector-level growth factors

Once a growth factor type is selected, the user can view and adjust the growth factors and how they will apply to each sector or activity.

If Option 1 (population growth rate) is selected, users must choose whether to use a standard national rate, enter city specific population growth rates, or to specify individual rates for the resident population as well as the commuter population. The commuter growth rate assumes that commuters contribute to greenhouse gas emissions and energy consumption and will take this population into account in emissions calculations. If commuters are to be taken in to account, users should complete a table that estimates commuter activity as a proportion of resident activity (e.g., the average commuter is likely to consume zero residential building energy in the City, but will likely consume approximately 50% as much commercial building energy as a resident does). If commuters are not specified, only the resident population growth rate will be used to drive activity growth.

Option 1. Population Growth Rates

A. Define Population Growth Rates

Select One:

- ( ) Option 1: Use national population growth rate for urban areas of South Africa (Source: United Nations, DESA, 2014)
- ( ) Option 2: Enter city-specific population growth rates
- (●) Option 3: Enter city-specific population and commuter growth rates

Enter City-Specific Population Growth Rates

Growth Driver	2014 - 2020	2020 - 2030	2030 - 2040	Source
	Annual Average Growth Rates			
City Resident Population	2.0%	2.0%	2.0%	
City Commuter Population	1.3%	1.4%	1.2%	

Calculated Population and Commuters

Growth Driver	Base Year	2014 - 2020	2020 - 2030	2030 - 2040	Source
	Value				
City Resident Population	4,765,329	5,366,534	6,541,776	7,974,388	Calculated
City Commuter Population	4,000,000	4,322,317	4,967,023	5,596,305	Calculated

Enter Commuter Activity As Percent of Resident Activity

Sector/Sub-Sector	Value
I. Stationary Energy	
I.1 Residential Energy	0%
I.2 Commercial and Institutional Buildings and Facilities	50%
I.3 Manufacturing Industries and Construction	0%
I.4 Energy Industries	0%
I.5 Agriculture, Forestry, Fishing Activities	0%
I.6 Other Non-Specified Sources	0%
I.7 Fugitive Emissions from Mining, Processing, Storage and Transportation Of Coal	0%
I.8 Fugitive Emissions from Oil and Natural Gas Systems	0%

If a combination of growth factors is selected in the *Define Population Growth Rates* section, users have the option to apply only one of the selected growth factors to every sector, or, to apply custom growth rates to each sector using drop down menus.

B. Select How Growth Drivers Are Applied to Sectors

Select One:

- ○ Option 1: Apply same drivers to all sectors
- ◉ Option 2: Apply different drivers to different sectors/sub-sectors

C. Select Growth Drivers

Select a growth driver for each activity type sub-sector.

I. Stationary Energy

GPC No.	GPC Sector / Scope	Type	Growth Driver	Annual Average Growth Rates 2014 - 2020	2020 - 2030	2030 - 2040	Rationale
I.1	Residential Buildings						
I.1.1	Scope 1						
I.1.1	Scope 1	Kerosene	Population	1.5%	2.0%	1.5%	
I.1.1	Scope 1	Coal (Bituminous or Black coal)	GDP/capita	1.3%	1.4%	1.4%	
I.1.1	Scope 1	Natural gas	GDP/capita	1.3%	1.4%	1.4%	
I.1.1	Scope 1	Wood or wood waste	Population & GDP/capita	2.8%	3.4%	2.9%	

If a user would like to apply a historic growth rate, he or she must select the past time period for which the historic average should be taken.

A. Define Period of Analysis

Period	Year
Start Year	2005
End Year	2013

If Option 4 is selected, the user can apply custom growth factors to every item in each sector from the base year inventory. As expected, this provides the most accurate results for the city if local data is available, but is the most user demanding. If some data is available, then a combination of proxy growth rates and sector specific rates may be used.

Option 4. Custom Activity Growth Rates

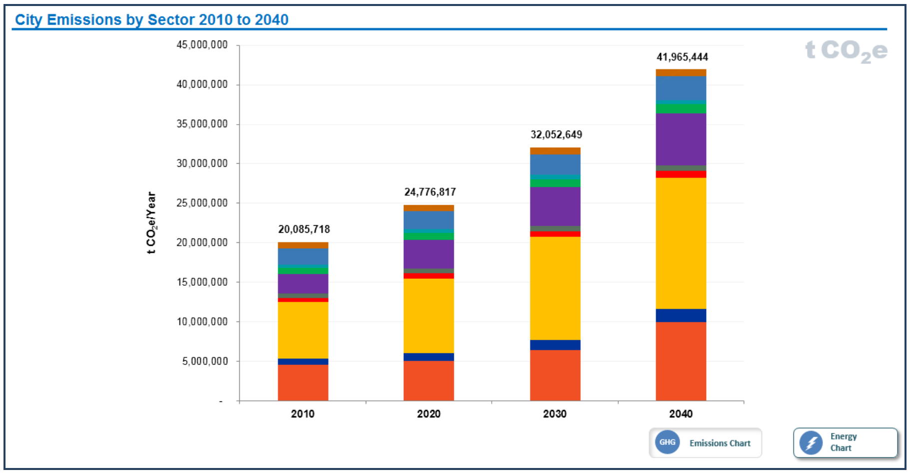
I. Stationary Energy

GPC No.	GPC Sector / Scope	Type	Annual Average Growth Rates 2015 - 2021	2021 - 2025	2025 - 2032	Source
I.1	Residential Buildings					
I.1.1	Scope 1					
I.1.1	Scope 1	Natural gas	0.7%	0.8%	0.9%	
I.1.1	Scope 1	Liquefied Petroleum Gas (LPG)	0.7%	0.8%	0.9%	
I.1.1	Scope 1					
I.1.1	Scope 1					
I.1.1	Scope 1					
I.1.1	Scope 1					
I.1.1	Scope 1					
I.1.1	Scope 1					
I.1.1	Scope 1					
I.1.1	Scope 1					
I.1.1	Scope 1					
I.1.1	Scope 1					
I.1.1	Scope 1					
I.1.1	Scope 1					
I.1.1	Scope 1	Biodiesels	0.0%	0.0%	0.0%	
I.1.2	Scope 2					
I.1.2	Scope 2	Electricity	0.0%	0.0%	0.0%	
I.1.2	Scope 2					

2.C) Projections

I. Sector Projections

The resultant emissions using the data from sections 2.A and 2.B are displayed in *2.C.I – Projection Charts*. On this screen the user can view aggregate emissions or energy use in each sector and how they are likely to change over time, based on the growth factors entered in 2.B. Like in section 2.A above, the user can toggle back and forth between viewing energy and emissions using the buttons at the bottom right of the graph. The sectors shown in the graph will correspond with those in the inventory. If a user entered inventory was selected in 1.A City Context, the sectors will be the 10 GPC sectors, and if a CURB generated inventory was selected, the sectors will be the 6 CURB sectors.



II. Inventory Projections

Here the user can see a more detailed version of forward projections in tabular format, with emissions and energy use broken down by fuel type and end use.

City Emissions in 2020

Building and Facility Energy (Private and Municipal)

GPC No.	GPC Sector / Scope	Type	Activity/Year	Unit	Activity/Year (converted to kWh/year)	Unit	Emission Factor	Unit	Emissions (t CO_2e/Year)
I.1	**Residential Buildings**				**7,814,163,722**	**kWh/year**			**4,785,055**
I.1.1	**Scope 1**				**2,796,221,340**	**kWh/year**			**507,367**
I.1.1	Scope 1	Natural gas	2,764,356,289	kWh/year	2,764,356,289	kWh/year	0.000181	t CO2e /kWh	500,586
I.1.1	Scope 1	Liquefied Petroleum Gas (LPG)	110,462	GJ/year	30,683,948	kWh/year	0.000211	t CO2e /kWh	6,482
I.1.1	Scope 1	Distillate fuel oil No 2	110,462	Liter (l)/year	1,181,103	kWh/year	0.000253	t CO2e /kWh	299
I.1.2	**Scope 2**				**5,017,390,071**	**kWh/year**			**4,277,384**
I.1.2	Scope 2	Electricity	4,986,706,123	kWh/year	4,986,706,123	kWh/year	0.000550	t CO2e/kWh	2,743,187
I.1.2	Scope 2	District Energy	110,462	GJ/year	30,683,948	kWh/year	0.050000	t CO2e/kWh	1,534,197
I.1.3	**Scope 3**				**552,311**	**kWh/year**			**304**
I.1.3	Scope 3	Electricity (T&D Losses)	552,311	kWh/year	552,311	kWh/year	0.000550	t CO2e/kWh	304
I.2	**Commercial/Institutional Facilities**				**796,713,377**	**kWh/year**			**247,655**
I.2.1	**Scope 1**				**518,085,250**	**kWh/year**			**93,832**
I.2.1	Scope 1	Natural gas	517,828,043	kWh/year	517,828,043	kWh/year	0.000181	t CO2e /kWh	93,771
I.2.1	Scope 1	Liquefied Petroleum Gas (LPG)	116,169	kWh/year	116,169	kWh/year	0.000211	t CO2e /kWh	25
I.2.1	Scope 1	Distillate fuel oil No 2	141,039	kWh/year	141,039	kWh/year	0.000253	t CO2e /kWh	36
I.2.2	**Scope 2**				**277,967,977**	**kWh/year**			**153,460**
I.2.2	Scope 2	Electricity	277,956,860	kWh/year	277,956,860	kWh/year	0.000550	t CO2e/kWh	152,904

2.D) Targets

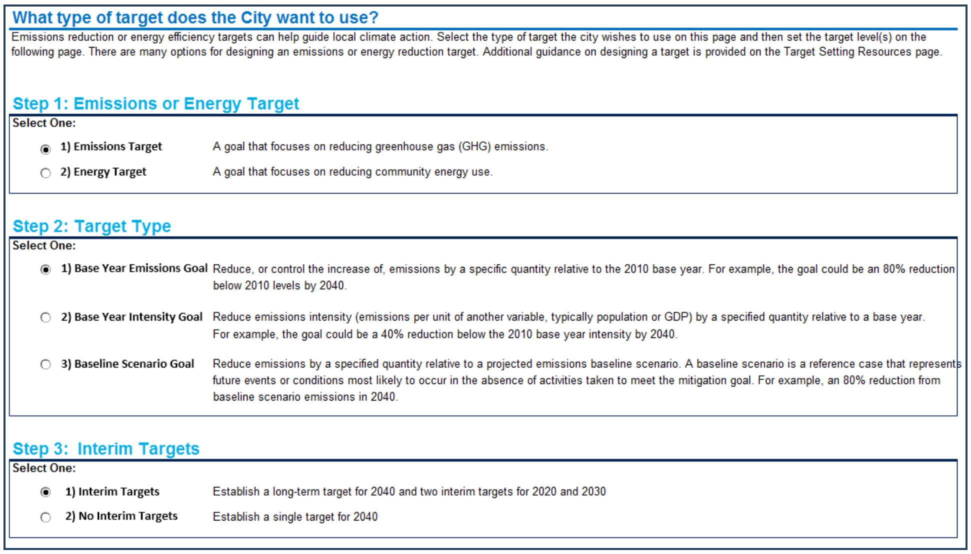
This section helps the user to set a citywide target to reduce either greenhouse gas (GHG) emissions or energy use.

Once the target is set, subsequent modules will guide the user through the process of selecting and customizing different actions to reduce energy use and emissions in the target city.

In the Results module (5), users can see how far chosen actions take their city towards achieving the city's target. Note that it is possible to make changes to the target at any point in the tool.

I. Target Type Selection

There are three main steps in this section, with further guidance on each provided in Target Setting Resources (III).



What type of target does the City want to use?

Emissions reduction or energy efficiency targets can help guide local climate action. Select the type of target the city wishes to use on this page and then set the target level(s) on the following page. There are many options for designing an emissions or energy reduction target. Additional guidance on designing a target is provided on the Target Setting Resources page.

Step 1: Emissions or Energy Target

Select One:

- (●) **1) Emissions Target** — A goal that focuses on reducing greenhouse gas (GHG) emissions.
- ( ) **2) Energy Target** — A goal that focuses on reducing community energy use.

Step 2: Target Type

Select One:

- (●) **1) Base Year Emissions Goal** — Reduce, or control the increase of, emissions by a specific quantity relative to the 2010 base year. For example, the goal could be an 80% reduction below 2010 levels by 2040.
- ( ) **2) Base Year Intensity Goal** — Reduce emissions intensity (emissions per unit of another variable, typically population or GDP) by a specified quantity relative to a base year. For example, the goal could be a 40% reduction below the 2010 base year intensity by 2040.
- ( ) **3) Baseline Scenario Goal** — Reduce emissions by a specified quantity relative to a projected emissions baseline scenario. A baseline scenario is a reference case that represents future events or conditions most likely to occur in the absence of activities taken to meet the mitigation goal. For example, an 80% reduction from baseline scenario emissions in 2040.

Step 3: Interim Targets

Select One:

- (●) **1) Interim Targets** — Establish a long-term target for 2040 and two interim targets for 2020 and 2030
- ( ) **2) No Interim Targets** — Establish a single target for 2040

The first step asks the user to select whether to set the target in terms of emissions or energy reductions. The relative merits of each are described in more detail in Target Setting Resources (III). It should be noted that when setting an emissions reduction target, the user will still be able to see the impact of various actions in terms of energy use—and vice versa.

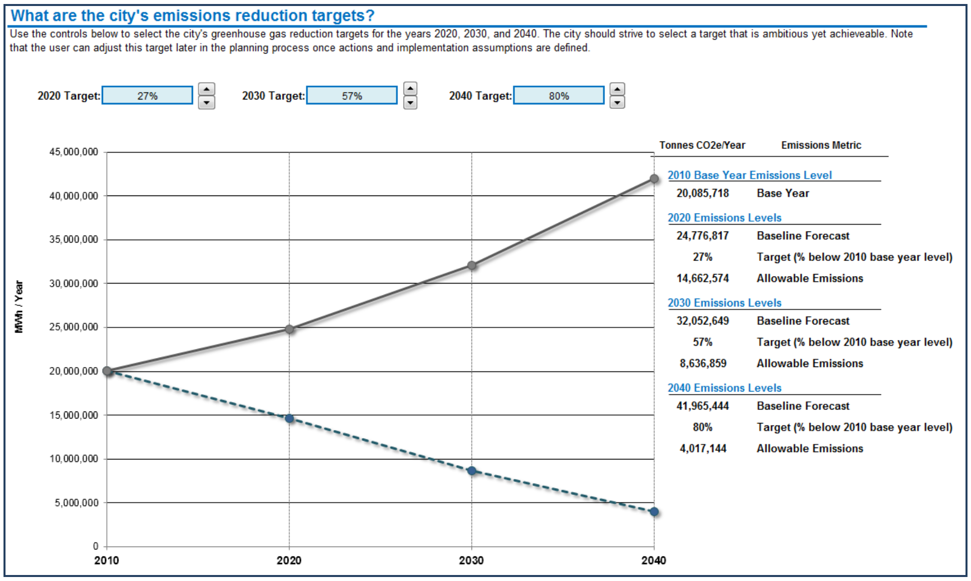
The second step asks the user to select what specific type of energy or emissions target he would like to select. There are three main options in CURB: base year goal, base year intensity goal, and baseline scenario goal. Some types of targets may be more appropriate than others for the target city. More information is provided on each in Target Setting Resources (III).

The final step asks whether the user would like to set interim targets in addition to longer-term energy or emissions reduction goal. More information is available in Target Setting Resources (III).

II. Target Level

Once the type of target to set has been selected, the next page allows the user to choose how much to reduce energy use and emissions and by when.

Research by C40 Cities and Arup has identified 228 cities across the world that have set emissions reduction targets, most of which are set for 2020 or 2050. These targets vary in the level of ambition from less than 20% all the way to 100% reductions in GHG emissions.



III. Target Setting Resources

This section provides the user with detailed information and guidance on how to approach selecting the target type (Section I) and target level (Section II). A brief overview is provided below; please refer to the CURB Excel tool for more detail.

To set targets, the user must choose between options in 3 areas:

1. **Emissions vs. energy target:** The user may choose to set their targets in terms of emissions or energy use.
    a. Emissions is a commonly used benchmark, and more than 200 cities around the world have set greenhouse gas reduction targets to help guide local climate action. Further, an emissions target covers actions in all sectors.
    b. Energy reduction may be appropriate for cities focused primarily on energy reduction goals. However, not all actions may lead to energy reduction, such as those in Solid Waste and Water and Wastewater.

2. **Target type**: This step determines the reference point upon which targets are calibrated.
    a. A base year goal calculates each final and interim target as a relative quantity to the base year. Because base year information is known, this target type grants a degree of certainty and few additional data requirements.
    b. A base year intensity goal refers to targets relative to a ratio in the base year, such as emissions per person or per unit of GDP. This method may be advantageous for cities experiencing large economic or population growth, but provides less certainty due to the introduction of an additional projected variable.
    c. A baseline scenario goal sets targets relative to projected emissions in a "business as usual" scenario. This target type is suitable for cities in which emissions are expected to increase significantly over time if no actions are taken.

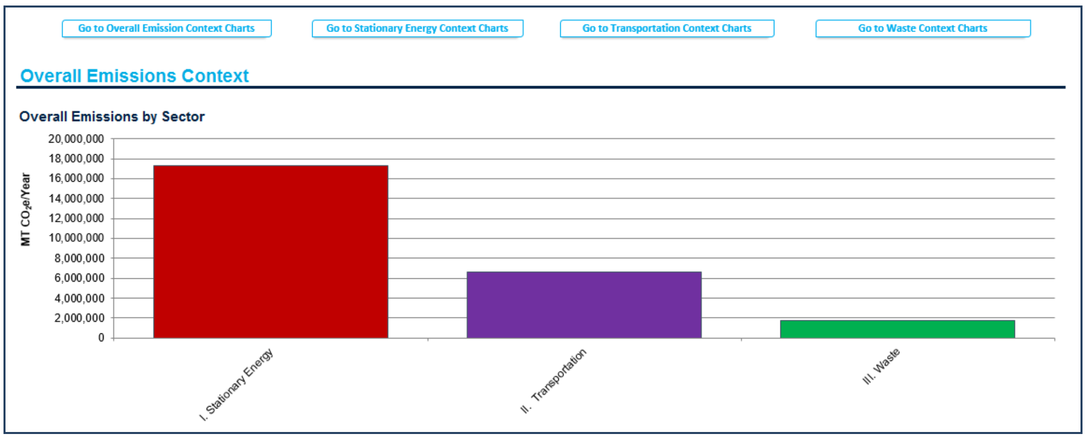
3. **Interim targets**: Users may choose to set interim targets for the intervening years between the base year and the long term target. Interim targets help to track progress over time, but requires user inputs for those intervening years.

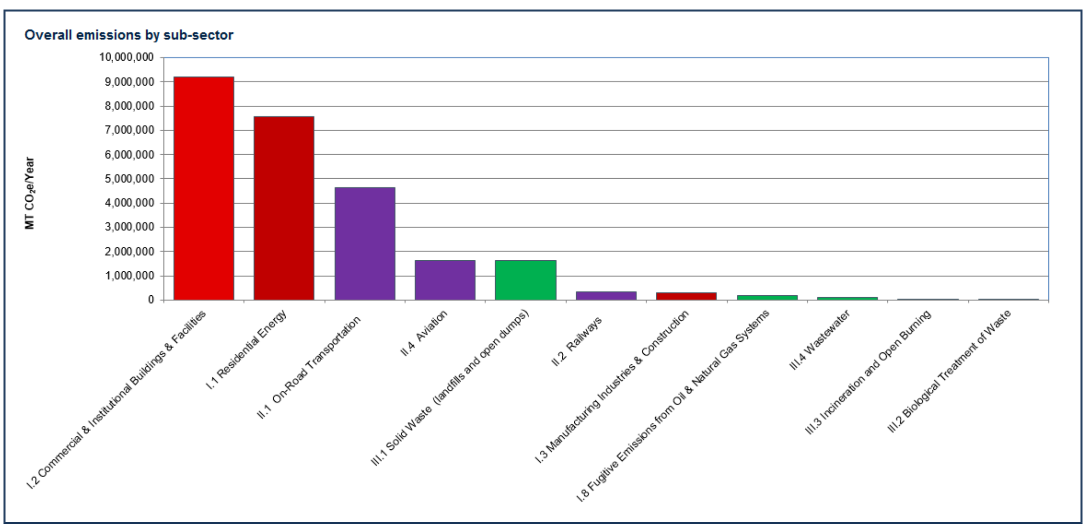
3. CONTEXT

Context provides details regarding the sub-activities, end uses, and materials that currently generate the city's emissions. The module also allows users to compare their cities with other cities across a range of key performance indicators in each sector.

3.A) Emissions Context

The *Emissions Context* section provides context into the drivers of emissions and energy use for the city's sectors. This is achieved through detailed breakdowns of emissions and energy use sources. Charts can provide high-level views of emissions components or sector-specific views. By understanding the key drivers within each sector, the user can begin identifying action areas to focus on.

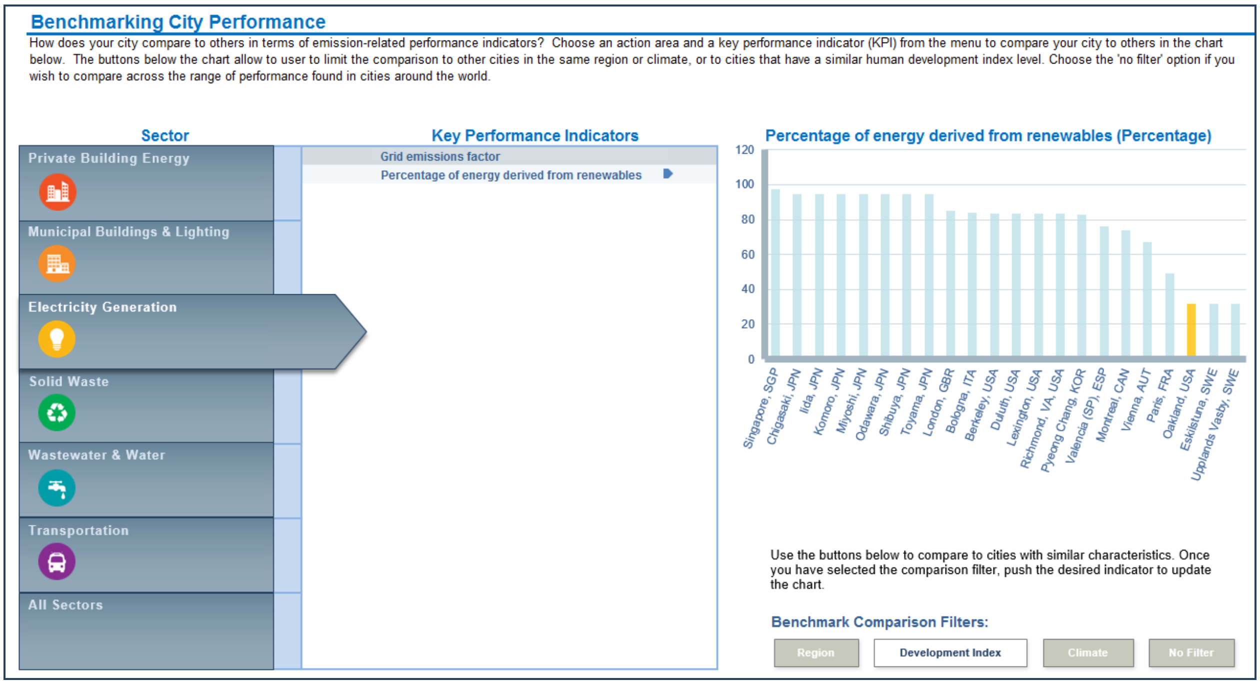




3.B) Benchmarking

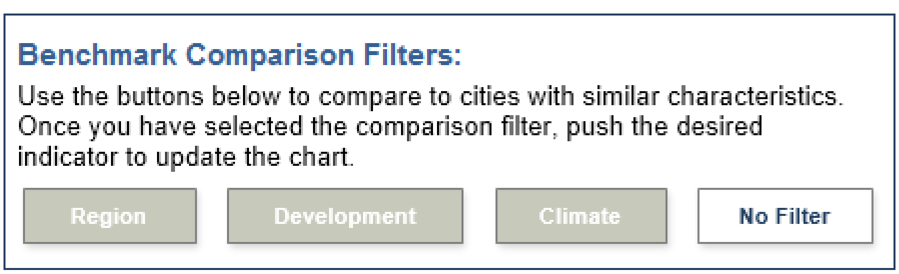
I. City Comparison

CURB allows the user to compare the target city's performance to other cities around the world in the Benchmarking module. CURB currently includes 23 different Key Performance Indicators (KPIs) across six sectors. Data from other cities was obtained from a variety of datasets. To the maximum extent possible, the CURB team has relied on data sets that are updated on a regular basis to ensure CURB stays as current as possible.



To assess the target city's performance, select a Sector by clicking the logo on the left. The Key Performance Indicators available for that sector will then appear in the middle of the screen. Select one of these KPI's and the bar chart on the right will change, displaying a city-by-city comparison of the selected KPI. In the bar chart, the target city will be highlighted in yellow, with other cities represented in light blue. In general, the best-performing cities are those closer to the right side of each graph.

By default, the target city is compared to all other cities for which data was available. To narrow the list of cities to which the target city is compared, select one of the "Benchmark Comparison Filters", which include:



- "Region" -- this filter compares the target city with others in the same geographic region.

- “Development” -- this filter compares the target city with others at a similar level of socio-economic development, as measured by the Human Development Index (HDI) rating.
- “Climate” – this filter compares the target city with others in a similar climatic zone.

While the Region and Development filters may be of general interest to the target city, the Climate filter is designed primarily for use in two specific KPIs: “Building GHG emissions per capita” in Private Building Energy and “Public building energy consumption” in Municipal Building Energy. This is because climate type is a strong driver of energy demand and associated emissions in buildings, since heating and cooling loads vary widely across regions with different climates. For instance, all other things being equal, a city with hot summers and cold winters is likely to have much higher energy use in its buildings sector than a city with a more temperate climate.

When selecting a filter, click on the filter and then re-click on the KPI of interest to update the chart.

At the bottom of the screen, the user can see the information from the bar graph in tabular format, with precise values, the year the data is from, and the source of the data.

II. Indicator Summary

The 23 KPIs referenced within CURB are listed below. Please refer to the CURB Excel tool for more information on each of the KPIs, including definitions of each and data sources.

Sector	KPI
Private Building Energy	Building GHG emissions per capita
	% population with electrical service
Municipal Building Energy and Public Lighting	Public building energy consumption
	Average streetlight energy use
Electricity Generation	Grid emissions factor
	% of energy derived from renewables
Solid Waste	Solid waste GHG emissions per capita
	Solid waste generated per capita
	% of population with solid waste collection
	% of solid waste recycled
	% of solid waste biologically treated
Water and Wastewater	Wastewater GHG emissions per capita
	Water GHG emissions per capita
	% of city’s wastewater that is untreated
	% of population with wastewater collection
	% of population with access to improved water
Transportation	Transport GHG emissions per capita
	Private automobiles per capita
	% trips in personal automobiles
	% trips via public transit
	% trips via non-motorized modes
Overall	Total GHG emissions per capita
	Electricity use per capita

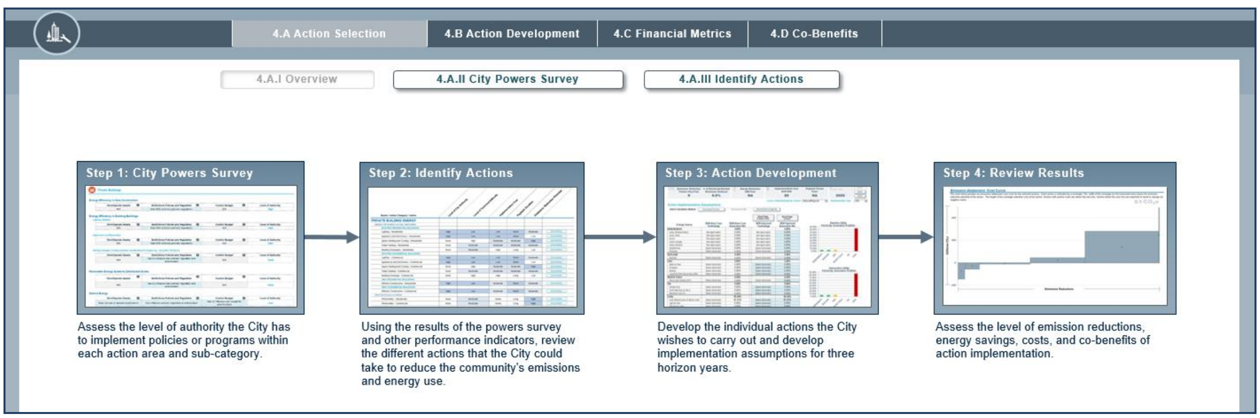
4. ACTIONS

Actions is the heart of the CURB tool. This module allows users to select which sectors they would like to focus on and rate the target city's authority to take action in each sector. Estimates of feasibility, cost, and emissions reduction potential allow users to quickly compare potential actions and make a preliminary selection of actions that seem most suitable for the city. Users then have the chance to customize each of the chosen actions and see how each contributes to the overall emissions reduction target. After customizing actions, users will be able to view more detailed information on costs and co-benefits. At any time, the user may go back and change the options selected, either to drop or add more as desired.

4.A) Action Selection

I. Overview

Action Selection (4.A) provides a brief overview of the different steps involved. First, users are asked to rate the target city's level of authority to take action in each sector City Powers Survey (4.A.II). Second, users are asked to select which actions they would like to develop further in the next section, based on more detailed data about feasibility and potential impact in Identify Actions (4.A.III).



II. City Powers Survey

This section asks the user to assess what authority the local government has to take action in each sector and sub-sector. This is important because the degree of authority a city has in a particular area will necessarily reflect the feasibility of any given action. Users are only asked to evaluate city authority for those sectors selected in the previous section.

Electricity Generation

Utility Electricity Generation

Own/Operate Assets	Set/Enforce Policies and Regulation	Control Budget	Level of Authority:
Manages procurement of operator	Sets policies/ regulations, but does not enforce	Has influence over budget for asset/function	*Moderate*

Solid Waste

Solid Waste Collection and Management

Own/Operate Assets	Set/Enforce Policies and Regulation	Control Budget	Level of Authority:
Manages procurement of operator	Sets policies/ regulations, but does not enforce	Has influence over budget for asset/function	*Moderate*

Waste-to-Energy

Own/Operate Assets	Set/Enforce Policies and Regulation	Control Budget	Level of Authority:
Manages procurement of operator	Sets policies/ regulations, but does not enforce	Has influence over budget for asset/function	*Moderate*

Authority is measured across three different parameters:

(i) **Own/Operate**: the degree of ownership the city exercises over the particular asset/function/service in question. For instance, a city which owns/operates the local public transport system is likely to have a stronger ability to take action in that area than a city that has limited or no influence over operations.

(ii) **Set/Enforce Policies and Regulations**: the degree to which a city is able to set and enforce policy in each sector. For instance, a local government that is able to set and enforce policy over private buildings will have a greater capacity to act than one which lacks the authority to set policy in that sector, or which can set policy but has limited power in terms of enforcement.

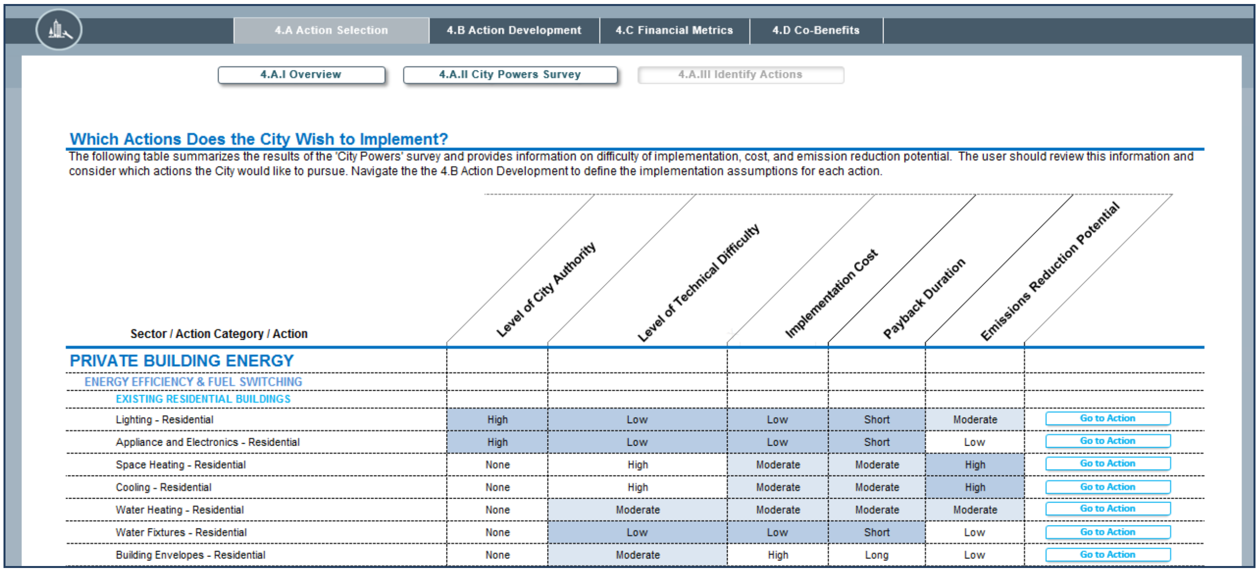
(iii) **Control Budget**: the degree to which the city controls the budget for the asset/function/service in question. For instance, a local government that controls the budget for public street lighting is likely in a better position to take action in that sector than one in which the local government has no budgetary control.

It is important that the user select the appropriate degree of authority the target city has over each sector, since this will help determine the feasibility of each action as displayed in Identify Actions (4.A.III)

Note that in the case of private buildings, it is only possible to determine the city's authority in terms of policies, regulations and enforcement, since it is assumed the city authority does not by definition own or control the budget of private assets, except for district energy.

III. Identify Actions

This section summarizes the inputs from this module in a single table, which allows comparison of different actions in order to decide which actions the user would like to develop further in Action Development (4.B). The last column on the right allows users to jump to the design page for each action. Note that the user can return to this summary page at any point during the action design process.



Sector / Action Category / Action	Level of City Authority	Level of Technical Difficulty	Implementation Cost	Payback Duration	Emissions Reduction Potential	
PRIVATE BUILDING ENERGY						
ENERGY EFFICIENCY & FUEL SWITCHING						
EXISTING RESIDENTIAL BUILDINGS						
Lighting - Residential	High	Low	Low	Short	Moderate	Go to Action
Appliance and Electronics - Residential	High	Low	Low	Short	Low	Go to Action
Space Heating - Residential	None	High	Moderate	Moderate	High	Go to Action
Cooling - Residential	None	High	Moderate	Moderate	High	Go to Action
Water Heating - Residential	None	Moderate	Moderate	Moderate	Moderate	Go to Action
Water Fixtures - Residential	None	Low	Low	Short	Low	Go to Action
Building Envelopes - Residential	None	Moderate	High	Long	Low	Go to Action

In this module, each column uses the terms "high", "medium", and "low" to assess each action across a few dimensions.

Level of City Authority summarizes the results of the City Powers Survey (4.A.II).

Level of Technical Difficulty gives an overall sense of how difficult each action is from a technical perspective, unrelated to the target city's capacity.

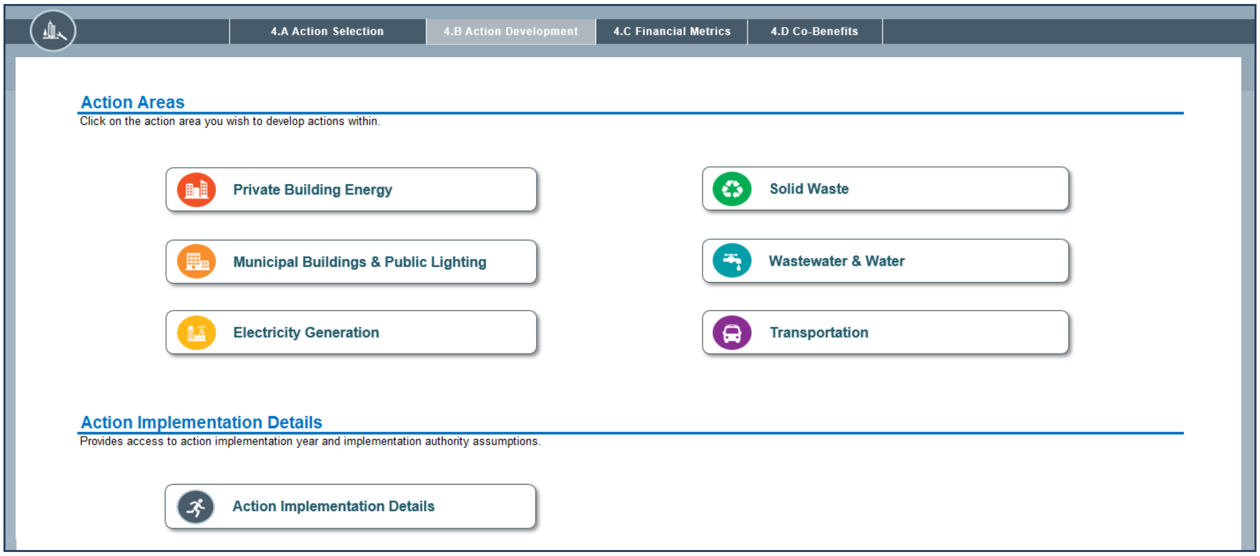
The following two columns, *Implementation Cost* and *Payback Duration* provide information on expected implementation cost and the payback duration, or the amount of time it takes to recoup costs.

The final column, *Emissions Reduction Potential*, is related to the emissions abatement potential.

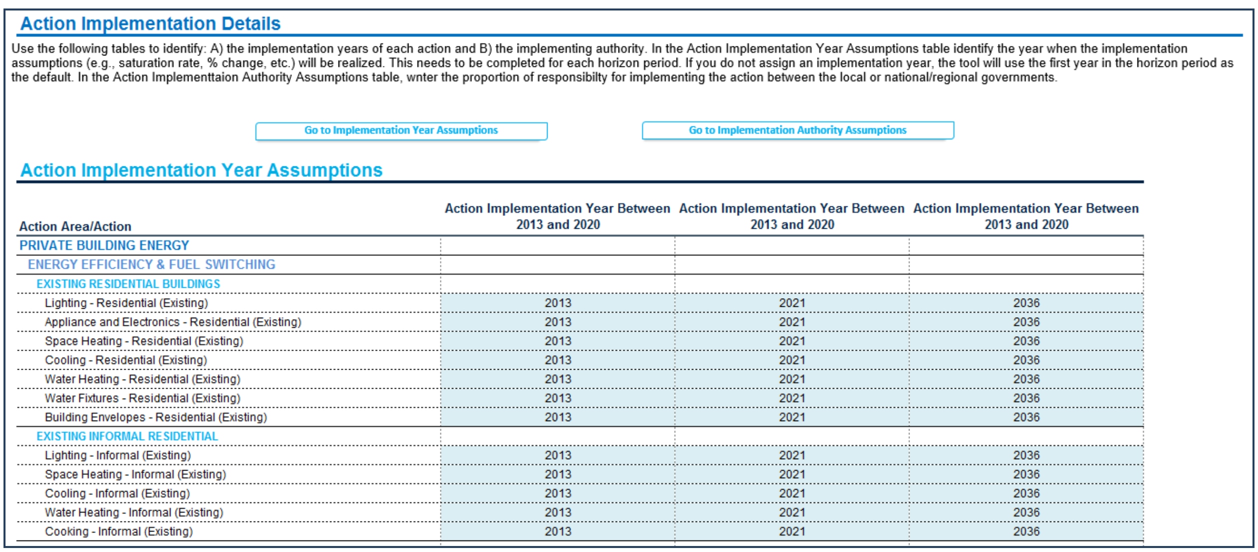
The user should review the provided information and select actions that the city wishes to pursue.

4.B) Action Development

The *Action Development* sub-module allows the user to customize each individual action for the city. It is the largest sub-module and will likely be where the user will spend the most amount of time. The user begins by clicking on a sector to start with, as shown on the screen below. At any time, the user can return to this screen (by clicking Action (4.B) at the top of the page) or switch to a different action area without losing any progress made in developing different actions.



At the bottom of this screen, there is a page called *Action Implementation Details*. In this section, users can view a summary table of all the implementation years they have chosen for each action. Implementation year can be set for each action taken by typing in the blue boxes. This information is used in various calculations, including emissions impact and cost projections. This information helps the user make a more realistic plan for the city by staggering actions as appropriate for local circumstances. Additionally, this information provides insights into cash flows for each action.



Action Implementation Details

Use the following tables to identify: A) the implementation years of each action and B) the implementing authority. In the Action Implementation Year Assumptions table identify the year when the implementation assumptions (e.g., saturation rate, % change, etc.) will be realized. This needs to be completed for each horizon period. If you do not assign an implementation year, the tool will use the first year in the horizon period as the default. In the Action Implementtaion Authority Assumptions table, wnter the proportion of responsibilty for implementing the action between the local or national/regional governments.

Go to Implementation Year Assumptions

Go to Implementation Authority Assumptions

Action Implementation Year Assumptions

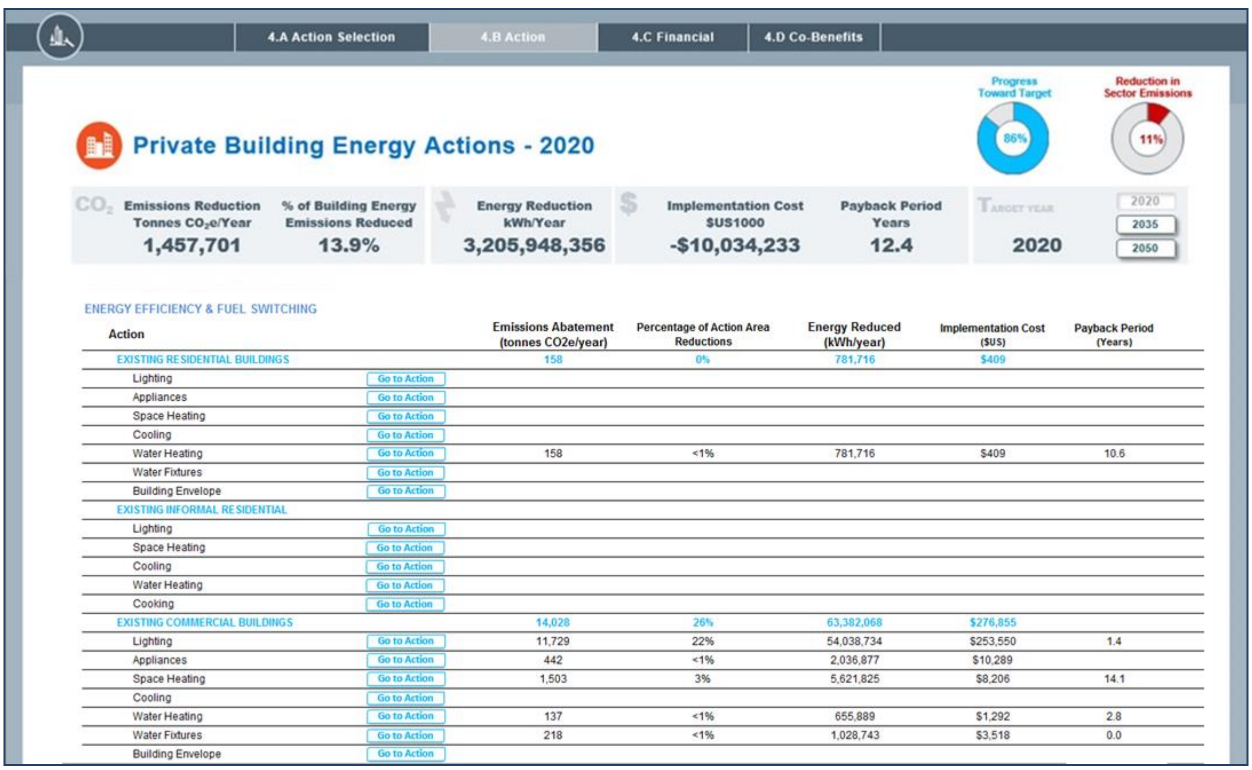
Action Area/Action	Action Implementation Year Between 2013 and 2020	Action Implementation Year Between 2013 and 2020	Action Implementation Year Between 2013 and 2020
PRIVATE BUILDING ENERGY			
ENERGY EFFICIENCY & FUEL SWITCHING			
EXISTING RESIDENTIAL BUILDINGS			
Lighting - Residential (Existing)	2013	2021	2036
Appliance and Electronics - Residential (Existing)	2013	2021	2036
Space Heating - Residential (Existing)	2013	2021	2036
Cooling - Residential (Existing)	2013	2021	2036
Water Heating - Residential (Existing)	2013	2021	2036
Water Fixtures - Residential (Existing)	2013	2021	2036
Building Envelopes - Residential (Existing)	2013	2021	2036
EXISTING INFORMAL RESIDENTIAL			
Lighting - Informal (Existing)	2013	2021	2036
Space Heating - Informal (Existing)	2013	2021	2036
Cooling - Informal (Existing)	2013	2021	2036
Water Heating - Informal (Existing)	2013	2021	2036
Cooking - Informal (Existing)	2013	2021	2036

Users can also see a summary of whether each action is under the control of the local government or the national government. Users can indicate the percentage of each action that is implemented by the city or the national or regional authority. This information will be used to visualize the impact from local versus national/regional actions in *Results*.

Action Implementation Authority Assumptions

Action Area/Action	% of Action Implemented by City	% of Action Implemented by National or Regional Authority
PRIVATE BUILDING ENERGY		
ENERGY EFFICIENCY & FUEL SWITCHING		
EXISTING RESIDENTIAL BUILDINGS		
Lighting - Residential (Existing)	100%	0%
Appliance and Electronics - Residential (Existing)	100%	0%
Space Heating - Residential (Existing)	100%	0%
Cooling - Residential (Existing)	100%	0%
Water Heating - Residential (Existing)	100%	0%
Water Fixtures - Residential (Existing)	100%	0%
Building Envelopes - Residential (Existing)	100%	0%
EXISTING INFORMAL RESIDENTIAL		
Lighting - Informal (Existing)	100%	0%
Space Heating - Informal (Existing)	100%	0%
Cooling - Informal (Existing)	100%	0%
Water Heating - Informal (Existing)	100%	0%
Cooking - Informal (Existing)	100%	0%

Each action area is described in more detail later on in this user-guide, but there are some common features to each that are worth pointing out upfront. Once the user clicks on an action area, for instance private buildings, he will be taken to a home screen for that sector. On this home screen there are several important pieces of information, as shown on the screen below.



On the left is a list of different actions, grouped by category. In the example above, actions related to lighting, appliances and so on are all grouped within the *Existing Residential Buildings* category.

Each action has a button to the right hand side called “Go to Action” which the user can click on to begin customizing that individual action.

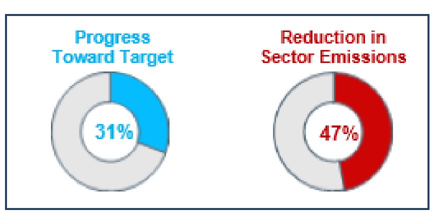
Once the user begins customizing actions, the impact of that action will appear in the columns on the right hand side. Impact is expressed in terms of emissions abatement (tonnes CO_2/year), energy reduced (kWh/year), implementation cost ($US) and annual savings ($US/year). Users can also see what percentage of total emissions abatement in that particular action area any given action contributes. For instance, in the screen above, 22% of the total emissions reductions from private buildings are coming from lighting upgrades in existing residential buildings.

The bar at the top of the screen summarizes the combined impact of actions in that action area. In the example above for instance, the combined impact of all actions related to private buildings have resulted in carbon abatement of 1,457,701 tonnes $CO_{2/}$e each year (13.9% of total emissions reduced through all actions developed in the tool), with energy savings of 3,205,948,356 kWh/year.

The tabs on the right hand side of the summary bar refer to the target year and interim targets set in *2.D Targets*—in this case 2020, 2035 and 2050. These are important as they control the timing of different actions. Clicking 2020 sets the timeframe for any action customized between the baseline year and 2020. Clicking 2035 sets the timeframe for any action customized between 2020 and 2035. Clicking 2050 sets the timeframe for any action customized between 2035 and 2050. This allows staggering of different actions across time. For instance, the user may wish to pursue energy efficiency upgrades in existing buildings between now and 2020, while focusing on new buildings post 2020. Users may wish to pursue some actions in all years until the target; others may be shorter term and begin or end in one of the interim targets.

Please note that the emissions impact of any action selected in on time frame (e.g. 2020) are only accounted for within that time period; to realize benefits across multiple time frames, the action should be selected for each interim target year. For convenience, many actions in later target years provide a "Set Page to Prior Year" button. This enables users to quickly design actions from where they left off in earlier target years.

The dials in the upper right corner show progress towards the emissions reduction target set earlier in the tool (if one was set). The dial on the left shows overall progress towards the target through all actions in all sectors that have been customized so far. The dial on the right shows the emissions reductions achieved for a given action area—in this case private buildings.



PRIVATE BUILDING ENERGY

Actions related to private buildings can be split broadly into demand side and supply side actions. Demand side actions involve energy efficiency (plus some fuel switching), while supply side actions include distributed renewables and district energy.

All actions can be applied to residential buildings, commercial buildings, or informal buildings. Residential buildings are divided into low, low-middle, high-middle, and high-income buildings. Commercial buildings are divided into retail, office, hospital and hotel spaces. Informal buildings are not divided into sub-categories.

For energy efficiency and fuel switching measures, the user can choose to apply actions to both existing buildings (i.e. retrofit) and new buildings (i.e. new construction).

As with other sectors, the user can specify a time period in which the action is to be implemented by using the buttons in the top right hand corner. Users should ensure action design is provided for all target years.

The following is a brief summary list of the actions in the private buildings sector:

Energy Efficiency in Existing Residential, Commercial, and Informal Buildings

Includes separate actions for lighting, appliances & electronics, space heating and cooling, water heating and fixtures, and building envelope. Cooking is assessed for informal buildings. Actions involving heating allow for fuel switching in addition to efficiency upgrades.

Energy Efficiency in New Residential, Commercial, and Informal Buildings

Similar to existing buildings, actions for new buildings assess actions for lighting, appliances & electronics, space heating and cooling, water heating and fixtures, and building envelope. Cooking is also assessed for informal buildings.

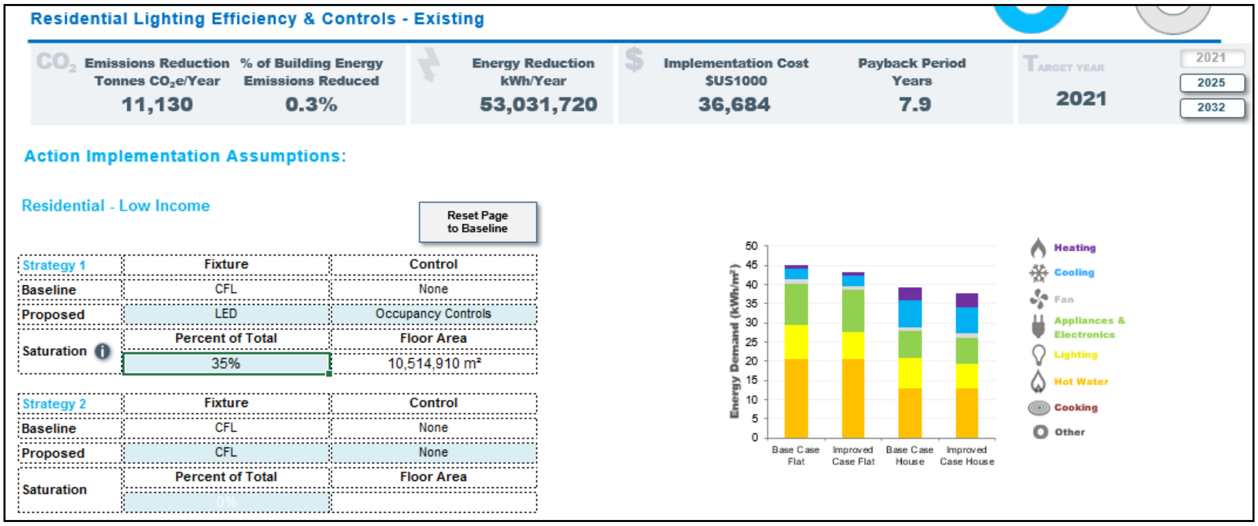
Distributed Photovoltaic Systems in Existing Buildings

These actions allow the user to select the average system size (kWh/m^2) and the percentage of buildings the action will target, with separate inputs for different income cohorts or building types.

District Energy in Existing Buildings

The *District Energy* action allows the user to determine the efficiency of the boilers, whether cogeneration is to be used, and the fuel. For district cooling, the user can select the chiller efficiency. The user can then decide what percentage of different types of buildings to which heating and/or cooling systems should be applied.

In each case, clicking on the “Go to Action” button will take the user to a design page:



The page above shows the lighting efficiency action for residential buildings. Within the action, users can specify how lighting fixtures and controls will change for their city. Fixtures refers to the type of light bulb that is used (e.g., Incandescent, Fluorescent, CFL). Controls refers to how the lighting will be turned on or off (e.g., Occupancy Controls, Daylighting, or a combination). Using drop down menus, users can alter the baseline situation, which should already reflect the inputs in the Setup module. Then, users can design the proposed situation.

Below the selections of fixtures and controls, users can specify the "saturation" level of each separate design item, i.e. what percentage of the building stock will the actions target?

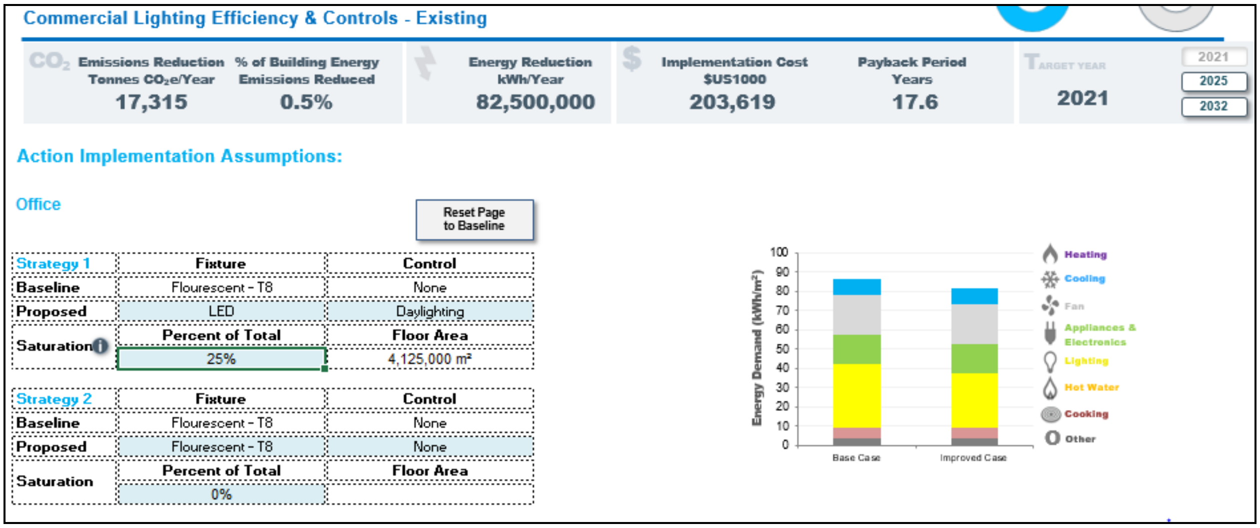
Users can design two strategies for four income groups: low income residential housing, low-middle income, high-middle income and high income residential housing. This allows for flexibility in customizing actions. For instance, a user may wish to pursue upgrades to CFL lightbulbs that target only low income households (e.g. 80% of low income households, determined by the saturation level) rather than all income groups, or vice versa.

Upon changing the saturation level, users can immediately see changes reflected in the summary bar at the top. This shows emissions reductions, energy reductions, costs and savings for *this specific action* (i.e. residential lighting efficiency for existing buildings, in this case).

The bar charts on the right hand side show the impact of each different action on energy demand. There is a separate chart for each income group. The vertical axis shows energy demand in kWh per square meter. The horizontal axis has two different bars showing energy demand before/after action has been taken. The base case bars represent energy demand for that building type and income group (in this case low income residential housing) before any actions were taken. The improved case bars show decreased energy demand accounting for all actions taken (including those designed in other page views). The charts are dynamic, such that they immediately reflect changes in energy use resulting from entering the saturation level of technology. Each color represents a different source of energy use: purple for heating, blue for cooling, light grey for fan energy, green for appliances and electronics, yellow for lighting, orange for hot water, red for cooking and dark grey for other.

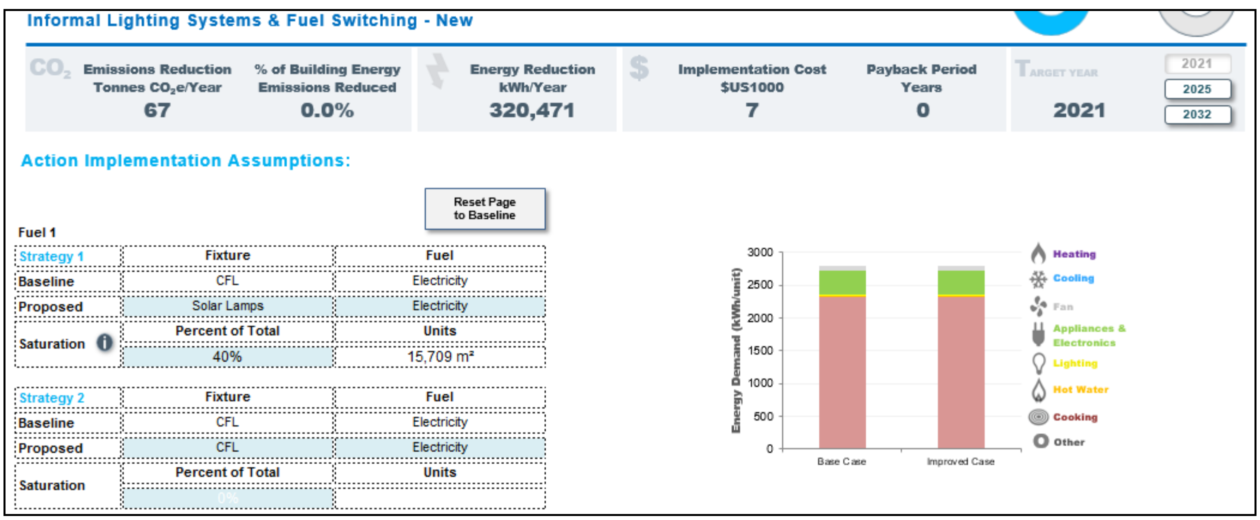
Once the user has finished entering the proposed strategy for this action, the user can return to the private buildings summary screen by clicking "Private Building Energy" in the top left corner. All the data is automatically saved and the user can return to the action page to edit selections at any point.

For *Commercial Lighting Efficiency* in existing buildings, the action page looks very similar:



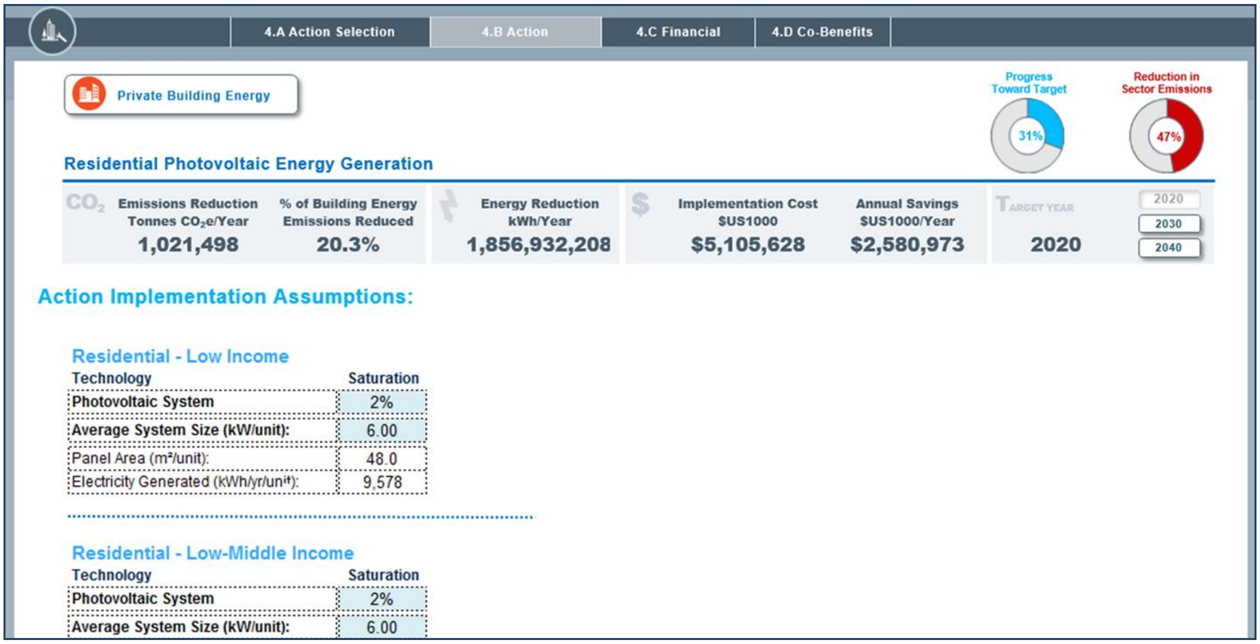
Instead of different income groups, the actions can be customized for different commercial building types: retail, office, hospital and hotel. Similar to residential buildings, users can specify what percentage of buildings are impacted by each action. The bar charts on the right show a base case and improved case for each building type.

For *Informal Lighting Efficiency* in existing buildings, the action page is slightly different:



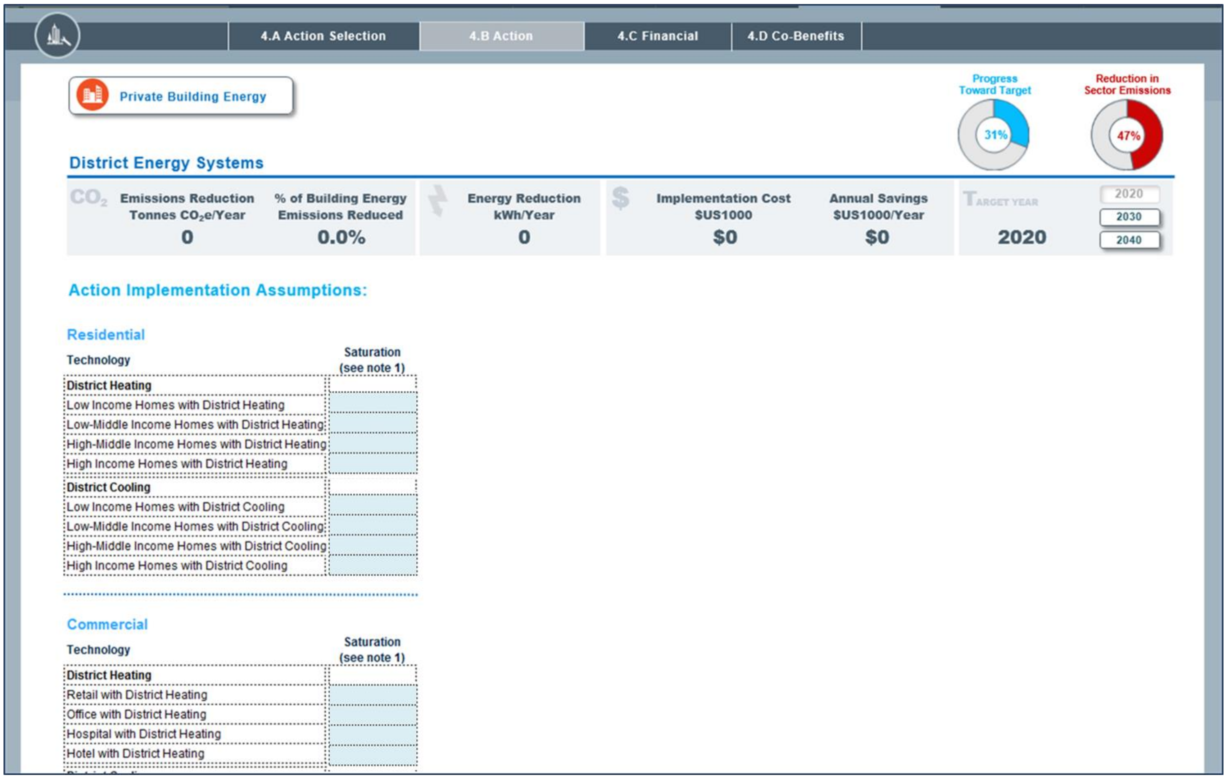
Efficiency adjustments are made by fuel type (Kerosene, Propane, Charcoal) as detailed in the Setup module. For example, Kerosene-based fuel lamps can be switched to solar lamps or CFL bulbs. Users can select the existing fixture type using drop down menus, as well as the proposed fixture type and fuel source.

In the next category of actions related to buildings, Distributed Renewables, the action design pages look slightly different:



In addition to selecting a saturation level that determines what percentage of each building type the action will target, the user can also choose the size of the average solar system in kW/unit. Here, "unit" refers to an individual building. Users can change the total panel area installed and the amount of electricity generated per unit. The action page for commercial buildings is very similar.

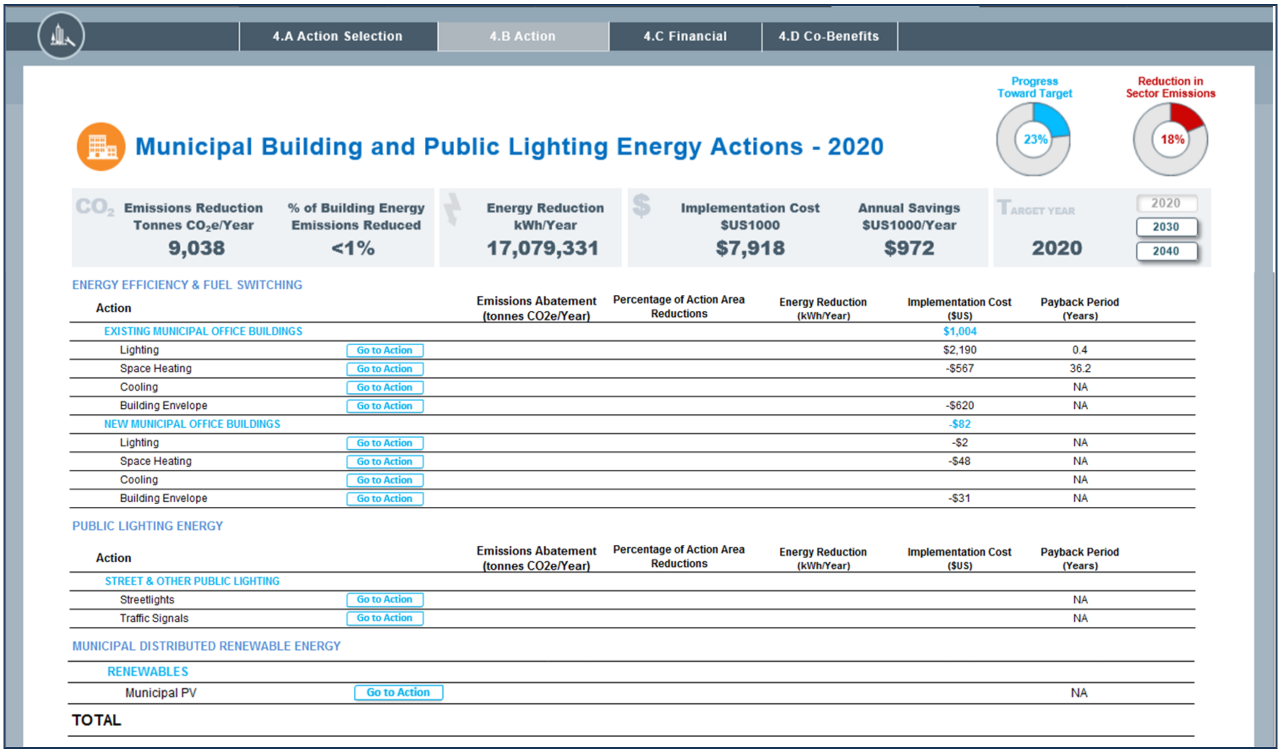
The final action page in the private buildings sector is for *District Energy*:



Here, users can select the percentage of buildings covered by district heating and cooling. This can be done for each building type. Users can also specify details regarding the district heating system, such as boiler type and heating fuel.

MUNICIPAL BUILDINGS AND PUBLIC LIGHTING

There are three types of actions in *Municipal Buildings and Public Lighting*: 1) Energy Efficiency and Fuel Switching, 2) Public Lighting Energy, and 3) Municipal Distributed Renewable Energy.



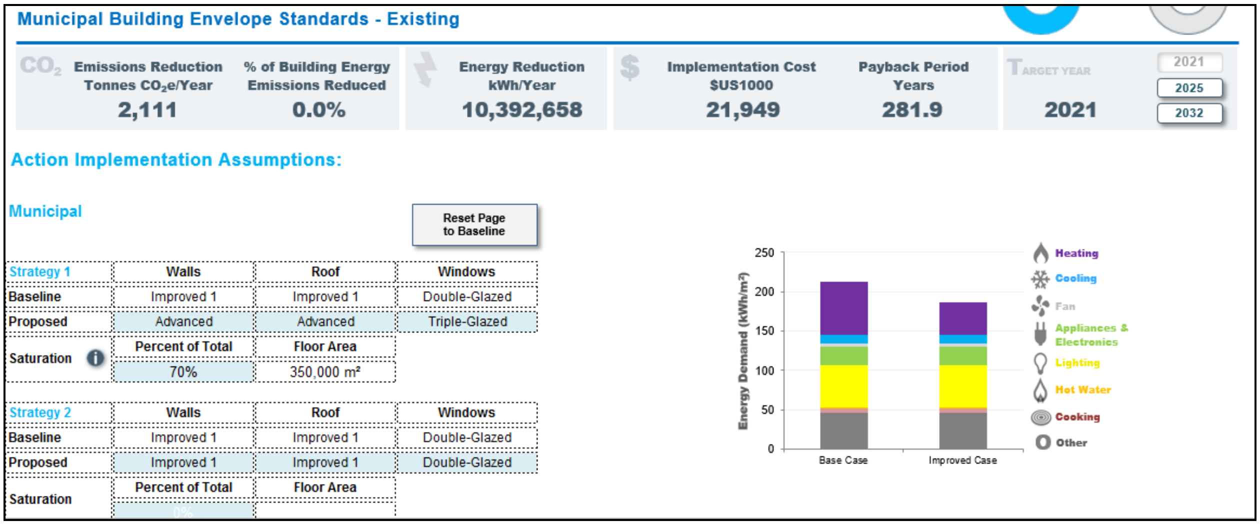
<u>Energy Efficiency and Fuel Switching</u>
Municipal Building actions related to energy efficiency and fuel switching are very similar to the Private Building Energy actions. They are essentially a subset of *Private Building Energy* actions. For example, for *Municipal Office Building Envelope* standards, the user can propose multiple strategies for how the future state will differ from the baseline.

There are multiple strategies that the city can pursue, represented by distinct sections. Using drop down menus, users can first alter the baseline situation in the first row, which should already reflect the inputs in the Setup module. Then, users can design the future state scenario using the dropdown menus. The options presented specify different wall, roof, and window insulation types.

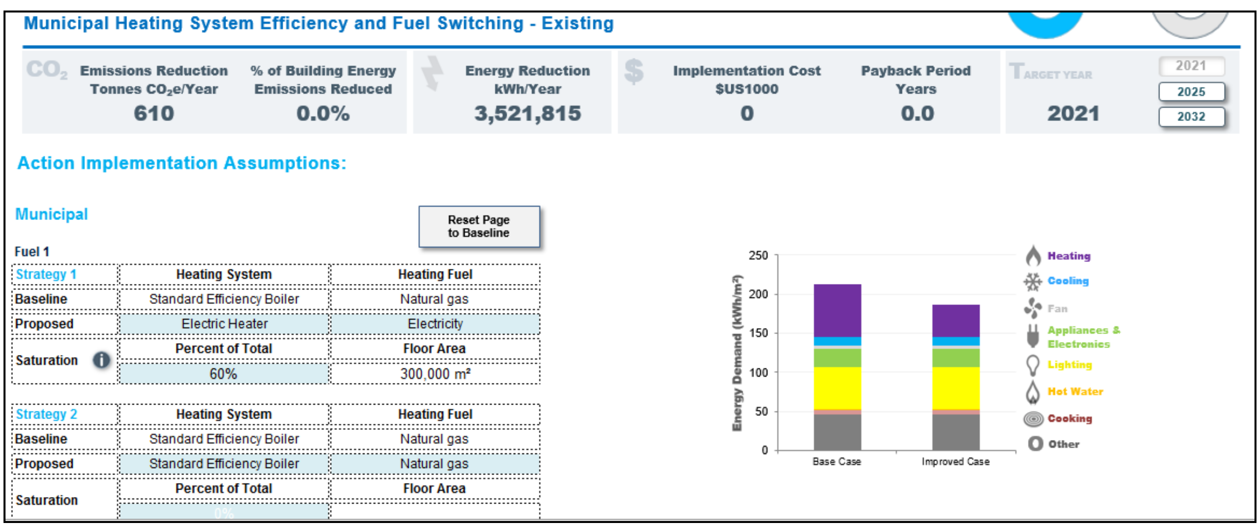
For each strategy, users can specify the floor area to which these actions should be applied. When the saturation level is changed, users can immediately see changes reflected in the summary bar at the top. This shows emissions reductions, energy reductions, costs and savings for this specific action (i.e. municipal building envelope standards for existing buildings, in this case).

The bar charts on the right hand side show the impact of each different action on energy demand. There is a separate chart for each income group. The vertical axis shows energy demand in kWh per square meter. The horizontal axis has two different bars showing energy demand before/after action has been taken. The base case bars represent energy demand before any actions were taken. The improved case bars show decreased energy demand accounting for all actions taken (including those designed in other page views). The charts are dynamic, such that they immediately reflect changes in energy use resulting from changing the saturation level. Each color represents a different source of energy use: purple for heating, blue for cooling, light grey for fan energy, green for appliances and electronics, yellow for lighting, orange for hot water, red for cooking and dark grey for other.

Once the user has finished entering the saturation level for each technology, the user can return to the municipal buildings summary screen by clicking “Municipal Building and Public Lighting” in the top left corner. All the data is automatically saved and the user can return to the action page to edit selections at any point.



For *Municipal Heating System Efficiency and Fuel Switching*, actions are grouped by fuel type. For each fuel type, users can record two strategies for switching to more efficient fuels or improved heating systems. As with other actions, users can select a new heating system and choose to change the fuel associated with the system through the dropdown menus.



Municipal Cooling System Efficiency and *Municipal Lighting Efficiency and Controls* are designed in similar ways. Using dropdown menus, users can specify the infrastructure differences between the baseline and the proposed scenarios and then enter the saturation rate of the proposed strategy.

Public Lighting Energy

The *Public Lighting Energy* action allows the user to change what percentage of streetlights and traffic lights are using various lighting technologies. Users can specify the number and percentage of baseline lamps that should be upgraded to an improved technology.

Public Streetlight LED Retrofit

CO_2 Emissions Reduction Tonnes CO_2e/Year	% of Building Energy Emissions Reduced	Energy Reduction kWh/Year	Implementation Cost $US1000	Payback Period Years	Target Year
11,758	<1%	56,021,469	-$9,653	16.2	2021

2021 | 2025 | 2032

Action Implementation Assumptions:

Reset Page to Zero

Technology	Rated Power per Lamp (Wattage)	No. of Lamps of Baseline Technology	Baseline % Share	No. of Lamps Improved to LED	LED %
High Pressure Sodium		**348,000**	**87%**	**174,000**	**50%**
High Pressure Sodium	70				0%
High Pressure Sodium	150	348,000	87%	174,000	50%
High Pressure Sodium	250				0%
High Pressure Sodium	350				0%
High Pressure Sodium	400				0%
Metal Halide		40,000	**10%**	**40,000**	**100%**
Metal Halide	70	40,000	10%	40,000	100%
Metal Halide	150				0%
Metal Halide	250				0%

LED Traffic Signals

CO_2 Emissions Reduction Tonnes CO_2e/Year	% of Building Energy Emissions Reduced	Energy Reduction kWh/Year	Implementation Cost $US1000	Payback Period Years	Target Year
168	<0.1%	801,651	$2,251	5.4	2021

2021 | 2025 | 2032

Action Implementation Assumptions:

Reset Page to Zero

Technology	Baseline Lamp Wattage	No. of Lamps of Baseline Technology	No. of Lamps Improved to LED	LED %
Traffic Lights	150	1,300	390	30%
Directional Arrow Lights	150	500	250	50%
Pedestrian Signal Lights	75	500	400	80%

<u>Municipal Distributed Renewable Energy</u>

In *Municipal Distributed Renewable Energy,* the user can determine how much power the city would want to generate through photovoltaic systems. Since the city might choose to put photovoltaic systems in places other than rooftops of buildings such as open land or parking lots, this action is extremely flexible to accommodate what the city chooses. The user will enter the anticipated photovoltaic system size into the blue cell.

Municipal Photovoltaic Systems

CO_2 Emissions Reduction Tonnes CO_2e/Year	% of Building Energy Emissions Reduced	Energy Reduction kWh/Year	Implementation Cost $US1000	Annual Savings $US1000/Year	Target Year
3,711	0.1%	6,745,899	$17,500	$11,502	2020

2020 | 2030 | 2040

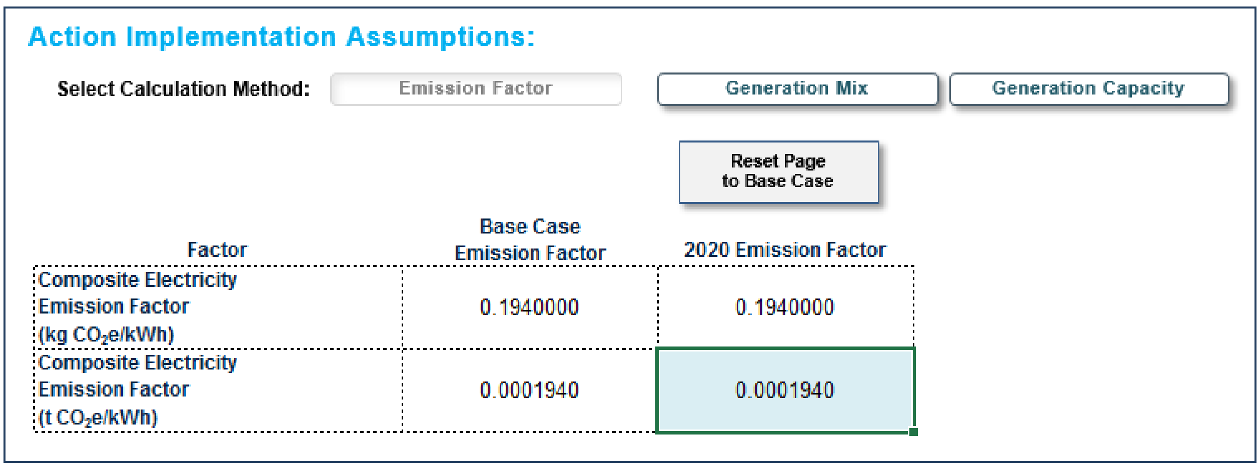
Action Implementation Assumptions:

Technology	Saturation
Photovoltaic System Size (MW)	5.0
Panel Area (m^2):	33,333

ELECTRICITY GENERATION

There is only one action that the user can take in *Electricity Generation* and that is *Grid Decarbonization*. The user can change the carbon intensity of grid-supplied electricity by altering how much electricity is generated from each energy source. To do so, the user must design three different components: the electricity grid emission factors, the mix of electricity generation energy sources, and the amount of electricity generated from each source. Clicking on each of these options at the top bar will generate a new input form below.

When *Emission Factor* is selected, the user has the option to customize the grid emission factor used, or simply use the “base case” emission factor.



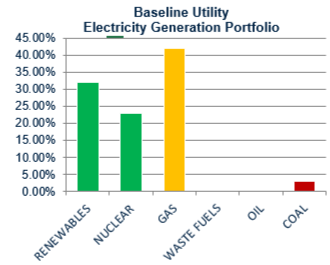
When *Generation Mix* is selected, the user is shown a portfolio of energy sources. The proposed energy mix can then be changed by adjusting the dropdown menus for “2020 Improved Technology” and adjusting the percentages associated with each energy source. The total electricity being generated should be equal to 100% of the energy being generated in the baseline case. If this is the case, there will be a green checkmark and 100% written at the bottom of the table. If not, there will be a number in red to indicate that the user is lacking or in excess of the generation of electricity. The base case and adjusted emission factors are displayed below the energy source table. There are graphs to the right of the action to visually depict the changes being made.

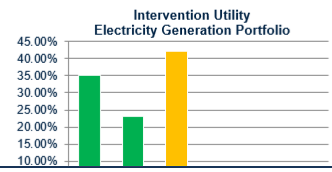
Action Implementation Assumptions:

Select Calculation Method: Emission Factor | Generation Mix | Generation Capacity

Reset Page to Base Case | Reset Page to Zero

Energy Source	2020 Base Case Technology	2020 Base Case Generation Mix	2020 Improved Technology	2020 Improved Generation Mix
RENEWABLES		**32.00%**		**35.00%**
Solar (Photovoltaic)	Not Applicable	0.00%	Not Applicable	0.00%
Solar (CSP)	Not Applicable	0.00%	Not Applicable	0.00%
Wind	Not Applicable	2.00%	Not Applicable	5.00%
Hydro (Large)	Not Applicable	19.00%	Not Applicable	19.00%
Hydro (Small)	Not Applicable	4.00%	Not Applicable	4.00%
Geothermal	Steam Generator	2.00%	Steam Generator	2.00%
Biomass	Steam Generator	5.00%	Steam Generator	5.00%
NUCLEAR		**23.00%**		**23.00%**
Nuclear	Steam Generator	23.00%	Steam Generator	23.00%
GAS		**42.00%**		**42.00%**
Natural Gas	Combined Cycle	42.00%	Combined Cycle	42.00%
Propane	Steam Generator	0.00%	Steam Generator	0.00%
Butane	Steam Generator	0.00%	Steam Generator	0.00%
Liquefied Petroleum Gas (LPG)	Steam Generator	0.00%	Steam Generator	0.00%
WASTE FUELS		**0.00%**		**0.00%**
Municipal wastes (all)	Steam Generator	0.00%	Steam Generator	0.00%
OIL		**0.00%**		**0.00%**
Waste Oils	Steam Generator	0.00%	Steam Generator	0.00%
Distillate fuel oil No 2	Steam Generator	0.00%	Steam Generator	0.00%





Finally, when *Generation Capacity* is selected, the user will see a similar page. Here, the user should indicate the generation capacity (in mega-Watts, MW) of each energy source.

Action Implementation Assumptions:

Select Calculation Method: Emission Factor | Generation Mix | Generation Capacity

Reset Page to Base Case | Reset Page to Zero

Energy Source	2020 Base Case Technology	2020 Base Case Generation (MW)	2020 Improved Technology	2020 Improved Generation (MW)
RENEWABLES		**104.00**		**213.51**
Solar (Photovoltaic)	Not Applicable	0.00	Not Applicable	0.00
Solar (CSP)	Not Applicable	0.00	Not Applicable	0.00
Wind	Not Applicable	9.11	Not Applicable	30,000.00
Hydro (Large)	Not Applicable	78.38	Not Applicable	160.91
Hydro (Small)	Not Applicable	12.38	Not Applicable	25.41
Geothermal	Steam Generator	4.13	Steam Generator	8.48
Biomass	Steam Generator	0.00	Steam Generator	0.00
NUCLEAR		**36.94**		**75.84**
Nuclear	Steam Generator	36.94	Steam Generator	75.84

The carbon intensity of grid-supplied electricity is an important driver of urban emissions. However, cities across the world may have varying degrees of control over the electricity generation mix, ranging from little to no control to high levels of control. Regardless of the level of control that the city has, including this sector allows cities the flexibility to understand how changes in the local/regional/national electricity mix might influence their emissions over time—especially in cases where these changes are likely to be significant. Those cities which with less influence over this sector could begin to consider what additional actions beyond their scope of control might be needed to reach their target, i.e. it is possible that some cities will find it very difficult to reach their emissions target without changes in grid supplied electricity, which may help them to better articulate what changes are needed on the part of other stakeholders if local sustainability efforts are to be successful.

It should be noted that calculating or modelling a specific emission factor without sufficient facility level operations data is challenging. Therefore, the emission factor calculated from the Improved Generation mix is an approximation. When using this action, the results are more accurate when major changes are made to the generation mix, as opposed to marginal or small changes.

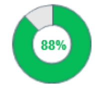
SOLID WASTE

The Solid Waste Action page has four main categories of actions: 1) Waste Management, 2) Waste-to-Energy, 3) Fugitive Emissions Capture, and 4) Waste Collection and Transfer as seen below.

Solid Waste Actions - 2020

Progress Toward Target

Reduction in Sector Emissions



CO_2 Emissions Reduction Tonnes CO_2e/Year	% of Solid Waste Emissions Reduced	Energy Generated[1] kWh/Year	Implementation Cost $US1000	Payback Period Years	Target Year
1,958,681	89%	458,716,593	$3,151,482	46.3	2020

2020 | 2035 | 2050

Action		Emissions Abatement (Tonnes CO_2e/Year)	% of Action Area Reductions	Energy Reduction (kWh/Year)	Implementation Cost ($US)	Payback Period (Years)
WASTE MANAGEMENT						
PAPER WASTE MANAGEMENT	Go To Action	292,180	15%	0	$97,548	56.2
Paper Waste Management		292,180	15%	NA	$97,548	56.2
FOOD AND YARD WASTE MANAGEMENT	Go To Action	1,006,220	51%	0	$4,542,889	73.5
Food Scrap and Yard Waste Management		1,006,220	51%	NA	$4,542,889	73.5
OTHER ORGANIC WASTE MANAGEMENT	Go To Action					
Other Organic Waste Management						
PLASTIC WASTE MANAGEMENT	Go To Action	0	0%	0	0	NA
Plastic Waste Management						
WASTE-TO-ENERGY						
Action		Emissions Abatement[2] (Tonnes CO_2e/Year)	% of Action Area Reductions	Energy Generated (kWh/Year)	Implementation Cost ($US)	Payback Period (Years)
WASTE-TO-ENERGY	Go To Action	214,419	11%	428,474,103	-$1,290,596	3.4
Anaerobic Digestion Optimization		214,419	11%	428,474,103	-$1,290,596	3.4
Waste Incineration-to-Energy Optimization						
FUGITIVE EMISSIONS CAPTURE						
Action		Emissions Abatement[3] (Tonnes CO_2e/Year)	% of Action Area Reductions	Energy Generated (kWh/Year)	Implementation Cost ($US)	Payback Period (Years)
LANDFILL FUGITIVE EMISSION CAPTURE	Go To Action	431,437	22%	0	$0	NA
Enhanced Landfill Methane Recovery - Future Waste		431,437	22%	NA	$0	NA
WASTE COLLECTION AND TRANSFER ENERGY						
Action		Emissions Abatement[2] (Tonnes CO_2e/Year)	% of Action Area Reductions	Energy Generated (kWh/Year)	Implementation Cost ($US)	Payback Period (Years)
WASTE COLLECTION AND TRANSFER	Go To Action	14,426	<1%	30,242,490	-$198,359	1.0
Waste Collection and Transportation Energy		14,409	<1%	30,208,333	-$198,174	1.0
Waste Transfer Station Energy		17	<1%	34,157	-$185	0.0
TOTAL		**1,958,681**		**458,716,593**	**$3,151,482**	

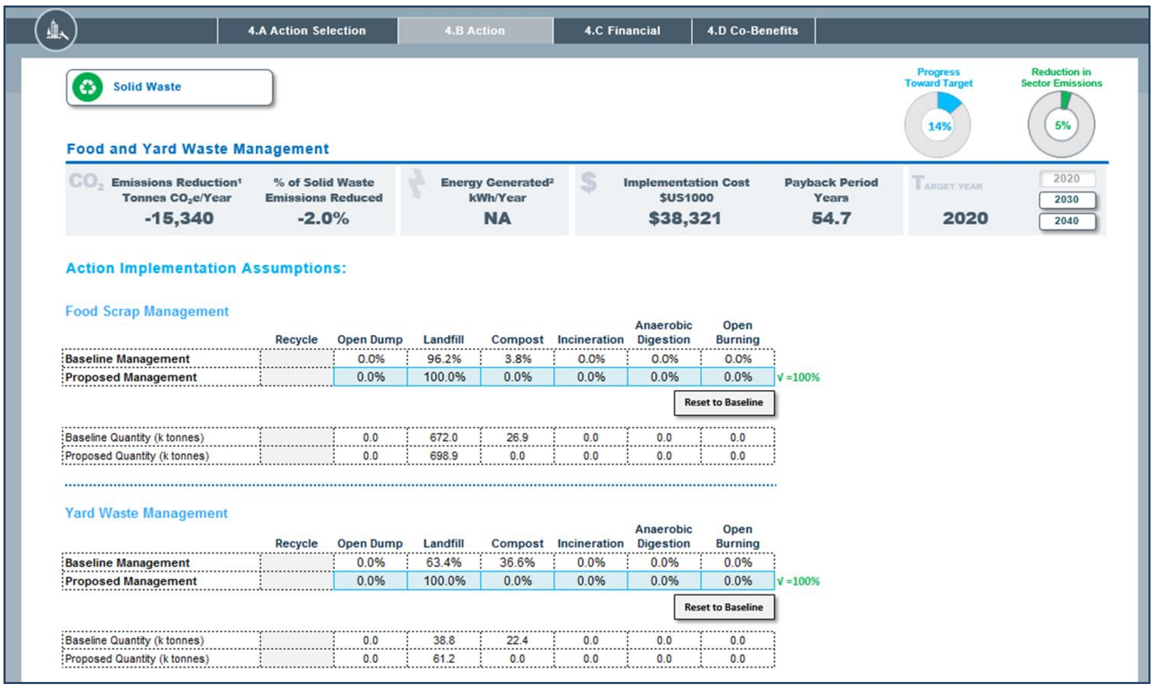
The user must **first make decisions about how to manage different types of waste** in the actions listed under *Waste Management*. Each type of waste has several options for how it can be managed. For example, plastic waste would not be composted or put into an anaerobic digester, but rather managed via a landfill, recycling, or incinerator. The tool is designed to allow the user to select how to manage each type of waste that has climate implications. Please note that after completing the waste management actions, it is possible that the actions in *Waste-to-Energy* and *Fugitive Emissions Capture* might not be relevant for the user. These actions are only appropriate for specific waste management methods: anaerobic digestion, incineration and landfilling. More information follows.

Once the user has chosen how to manage each type of waste, **if there is waste being treated via an anaerobic digester or incinerator**, then the user should select the action under *Waste-to-Energy*. This action will allow the user to determine how to use the biogas from the anaerobic digester and the heat energy from the incinerator. How the user chooses to treat the end product will determine the climate, energy and cost implications of each technology.

If any waste in the city is being disposed of in a landfill, then the user could select the action under *Fugitive Emissions Capture*. This will enable the user to decide whether and how much methane generated in the landfill will be captured.

Lastly, the user can decide how to collect and what kind of facility would be used to transfer waste prior to treating or disposing of it.

<u>Waste Management</u>
Within each *Waste Management* action, the user will see their baseline and proposed waste management situation in two ways: 1) the percent of the waste type (i.e. paper, organic, plastic) going to each management method, and 2) the total quantity of the waste type going to each management method. The user can take action by changing the percent of the waste type going to each management method in the blue boxes. The user can reset the proposed management actions to the baseline at any point by clicking on the *Reset to Baseline* button. Below the *Reset to Baseline* button, the user will see their baseline and proposed waste management situation in terms of quantity of waste (thousands of tonnes). These quantities will automatically adjust as the user changes the percent of waste being moved.



Once the user has gone through all of the waste types that the city would like to improve management of, he should click on the *Solid Waste* button at the top left corner of the screen to return to the main Solid Waste Action page. At this time, if the user has chosen to manage some waste with either anaerobic digestion or incineration, he should select the *Waste-to-Energy* action. If not, and the user has chosen to manage some waste via a landfill, then he should select the *Enhanced Landfill Methane Recovery* action. If the user has not chosen any of these methods to manage the city's waste then he can proceed to another sector.

<u>Waste to Energy</u>
The *Waste-to-Energy* actions allow the user to determine how the end product (i.e. biogas, heat energy) of the waste-to-energy technology will be utilized. If the city already has an anaerobic digester and incinerator, the user can enter what the city currently does with the biogas and/or heat energy in the left column of the blue cells under *Baseline Split*. For example, if the city currently manages some waste via anaerobic digestion, the user can enter how much of the anaerobic digester biogas is flared, used to generate electricity, used for thermal energy and/or used for co-generation (both thermal and electricity).

Otherwise, the user can directly enter in the proposed split of how the biogas and/or heat energy will be used in the right column of the blue cells. How the biogas and/or heat energy is used will determine the emissions impact of the anaerobic digester and/or incinerator.

Fugitive Emissions Capture

If the city manages some waste at a landfill, the user should select the *Enhanced Landfill Methane Recovery* action. In this action, the user can decide how much of the methane generated in the landfill the city will be able to capture. The user will input the anticipated recovery into the blue cell and immediately see the emissions abatement that will result by each waste type.

Waste Collection and Transfer Energy

In *Waste Collection and Transfer* the user can enter information changes to the vehicle fleet that collects waste as well as to the energy currently consumed at any transfer stations. Changes to waste transportation emissions occur through fuel switching to cleaner or more efficient fuels. Changes to transfer station energy consumption can occur to fuel switching to cleaner fuels, changes in fuel usage, and changes in electricity usage. Then the user can determine emissions, energy and financial implications of anticipated changes in fuel and quantity consumed for both the vehicle fleet and transfer station.

Waste Collection and Transportation Vehicle Conversion

	Baseline
Baseline Fuel	Motor gasoline (petrol)
Number of Diesel Trucks	10.0
Motor gasoline (petrol) WasteTruck Travel (km/year)	50,000.0
Motor gasoline (petrol) Truck Fuel Efficiency (liter/km)	0.8
Motor gasoline (petrol) Consumed (liter equivalent/year)	40,000

	Proposed
Proposed Alternative Fuel	Compressed Natural Gas (CNG)
Number of Trucks Converted to Compressed Natural Gas (CNG)	5
Compressed Natural Gas (CNG) Waste Truck Travel (km/year)	25,000
Compressed Natural Gas (CNG) Truck Fuel Efficiency (liter equivalent / km)	0.8
Compressed Natural Gas (CNG) Consumed (liter equivalent/year)	20,000
Proposed Number of Municipal Fuel Stations	2

Use Calculated Data

Enter Manual Data

Transfer Station Energy Consumption

	Baseline
Type of Fossil Fuel Used at Transfer Stations	Motor gasoline (petrol)
Motor gasoline (petrol) Consumed (liter equivalents/month)	1,000.0
Amount of Electricity Used (kWh/month)	25,000.0

	Proposed
Proposed Alternative Fuel	Compressed Natural Gas (CNG)
Compressed Natural Gas (CNG) Consumed (liter equivalents/month)	0
Amount of Electricity Used (kWh/month)	0

Return to the main *Solid Waste Actions* page to see the summary of emissions, energy, and financial implications of the solid waste actions.

WATER AND WASTEWATER

The Wastewater and Water Action page has three main categories of actions: 1) Wastewater Treatment Switching and Optimization, 2) Wastewater Biogas-to-Energy, and 3) Water Conveyance Energy Improvements as seen below.

Wastewater and Water Actions - 2020

CO_2 Emissions Reduction Tonnes CO_2e/Year	% of Wastewater Emissions Reduced	Energy Reduction[1] kWh/Year	Implementation Cost $US1000	Payback Period Years	Target Year
84,243	30%	214,900,757	-$10,768	No Payback	2020

2020 | 2035 | 2050

WASTEWATER TREATMENT SWITCHING AND OPTIMIZATION

Action		Emissions Abatement (Tonnes CO_2e/Year)	% of Action Area Reductions	Energy Reduced (kWh/Year)	Implementation Cost ($US1000)	Payback Period (Years)
WASTEWATER TREATMENT TYPE SWITCHING		-438	-1%	-3,145,574	$18,554	
Wastewater Treatment Type Switching	Go To Action	-438	-1%	-3,145,574	18,554	No Payback
LATRINE IMPROVEMENTS						
Sediment Removal and Treatment	Go To Action					NA
ANAEROBIC TREATMENT LAGOON IMPROVEMENTS						
Surface Aerators	Go To Action					NA
FACULTATIVE TREATMENT LAGOON IMPROVEMENTS						
Surface Aerators	Go To Action					NA
ACTIVATED SLUDGE TREATMENT PLANT IMPROVEMENTS		1,997	2%	-596,889	$8,563	
Improved Nitrification/Denitrification	Go To Action	1,997	2%	-596,889	8,563	No Payback
DIRECT DISCHARGE IMPROVEMENTS		31,062	37%	0		
Preliminary and Primary Treatment	Go To Action	31,062	37%	0		

WASTEWATER BIOGAS-TO-ENERGY

Action		Emissions Abatement (Tonnes CO_2e/Year)	% of Action Area Reductions	Energy Generated (kWh/Year)	Implementation Cost ($US1000)	Payback Period (Years)
WASTEWATER BIOGAS-TO-ENERGY OPTIMIZATION		29,384	35%	53,415,406	-$37,885	
Biogas Use and Management - Energy	Go To Action	29,384	35%	53,415,406	-37,885	2.4

WATER CONVEYANCE ENERGY IMPPROVEMENTS

Action		Emissions Abatement (Tonnes CO_2e/Year)	% of Action Area Reductions	Energy Reduced (kWh/Year)	Implementation Cost ($US1000)	Payback Period (Years)
WATER CONVEYANCE EFFICIENCY IMPROVEMENTS		82,684	98%	165,227,814		
Water Conveyance Pump Efficiency	Go To Action	82,684	98%	165,227,814		NA
WATER DELIVERY LOSS REDUCTION						
Water Delivery Loss Reduction	Go To Action					NA
TOTAL		**84,243**		**214,900,757**	**-$10,768**	

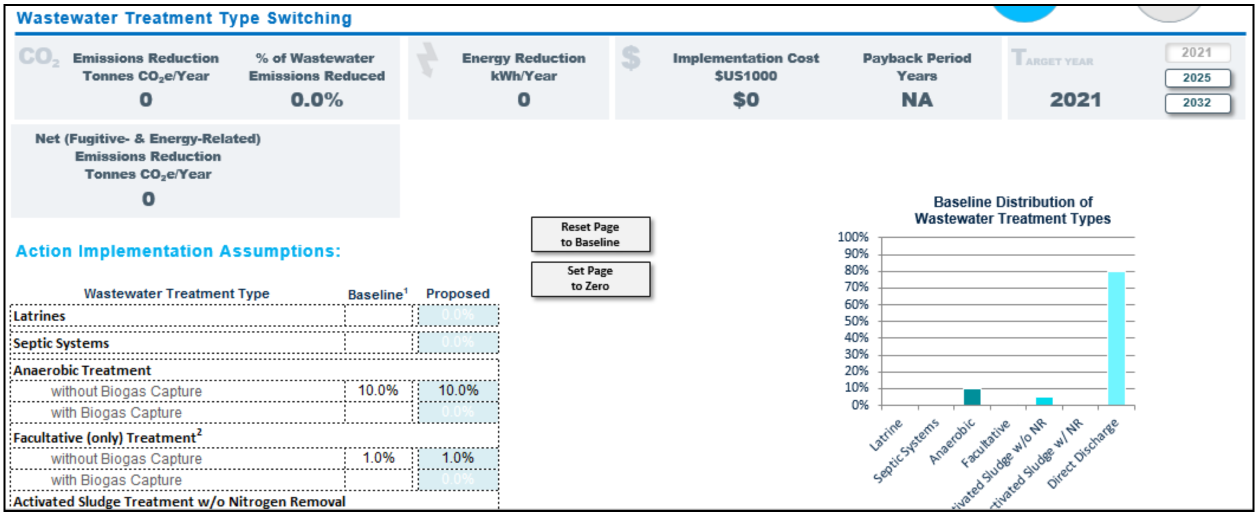
In *Wastewater Treatment Switching and Optimization*, the user can change their current wastewater treatment methods and/or improve their current treatment methods. In *Wastewater Biogas-to-Energy*, the user can determine how to use any biogas being generated through anaerobic digestion. How the user chooses to treat the end product will determine the climate, energy and cost implications of each technology.

Water Conveyance Energy Improvements allows the user to change the pump efficiency for water conveyance, increase the number of improved water conveyance pumps in the city and improve distribution water loss.

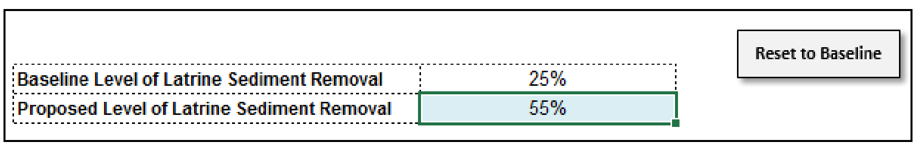
<u>Wastewater Treatment Switching and Optimization</u>

In the first action, *Wastewater Treatment Type Switching*, the user will see their baseline and proposed wastewater treatment types. The user can take action by changing the percent of wastewater being treated by each treatment type. The two graphs on the right side of the screen show how the proposed distribution of wastewater treatment types compares to the baseline in a visual format.

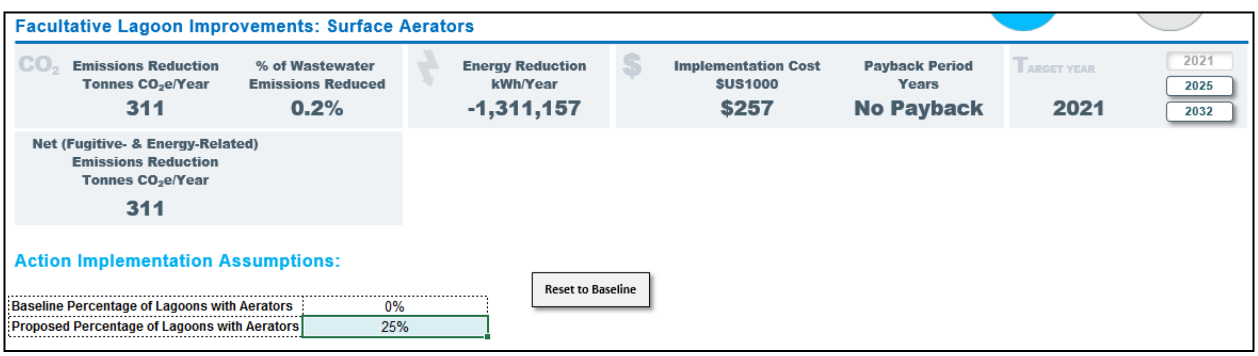
The user should ensure that the total amount of wastewater that is being managed does not exceed 100% of the original wastewater quantity. To do so, the user can see below the table if there is a green checkmark with a corresponding text of 100% indicating that all of the wastewater is being managed or if there is a red number that is less than or greater than 100. The user can reset the proposed management actions to the baseline at any point by clicking on the *Reset to Baseline* button.



The user can also choose to improve the treatment technologies beyond the baseline through the rest of the actions in *Wastewater Treatment Switching and Optimization*. In *Latrine Improvements*, the user can change the level of sediment being removed from latrines by entering the proposed level in the given cell.



For *Anaerobic Treatment Lagoon Improvements* and *Facultative Treatment Lagoon Improvements,* the user can change the percentage of lagoons with surface aerators specifying it in the cell provided. Note that aerators are only applied to lagoons without biogas capture systems.



For *Activated Sludge Treatment Plant Improvements*, the user can specify the maintenance level of activated sludge plants with or without nitrogen removal. Activated sludge plants can be 1) Poorly Managed or Overloaded or 2) Well Managed.

Activated Sludge Treatment Plant Improvements

CO_2 Emissions Reduction Tonnes CO_2e/Year	% of Wastewater Emissions Reduced	Energy Reduction kWh/Year	Implementation Cost $US1000	Payback Period Years	Target Year
5,524	2.8%	0	$0	NA	2021

2021 / 2025 / 2032

Net (Fugitive- & Energy-Related) Emissions Reduction Tonnes CO_2e/Year: **5,524**

Operational Maintenance and Energy Management Improvements:

Activated Sludge Plant without Nitrogen Removal

Baseline Maintenance Level for Non-Nit/Denit Systems:	poorly managed or overloaded
Proposed Level of Maintenance:	well managed
% of Plants with Proposed Maintenance Level:	20%

Reset Page to Baseline

There are three options for nitrogen removal levels at activated sludge plants: 1) Basic (50% removal), 2) Advanced (80% removal), or 3) Limit of Technology (3 mg/L).

Effluent Nitrogen Removal Enhancements:

Activated Sludge Plant with Nitrogen Removal

Baseline Level of Nitrogen Removal:	Basic
Proposed Level of Nitrogen Removal:	Advanced
% of Plants with Denitrification Technology:	25%

For *Direct Discharge Improvements*, the user can select a new pre-treatment technology to increase BOD removal efficiency and that what portion of flow the new technology should apply to. The options for pre-treatment technology are 1) coarse screens or 0% removal, 2) fine screens or 5% removal, or 3) primary settling or 30% removal.

Direct Discharge Improvements: Preliminary and Primary Treatment

CO_2 Emissions Reduction Tonnes CO_2e/Year	% of Wastewater Emissions Reduced	Energy Reduction kWh/Year	Implementation Cost $US1000	Payback Period Years	Target Year
0	0.0%	0	$1,217,886	No Payback	2021

2021 / 2025 / 2032

Net (Fugitive- & Energy-Related) Emissions Reduction Tonnes CO_2e/Year: **0**

Action Implementation Assumptions:

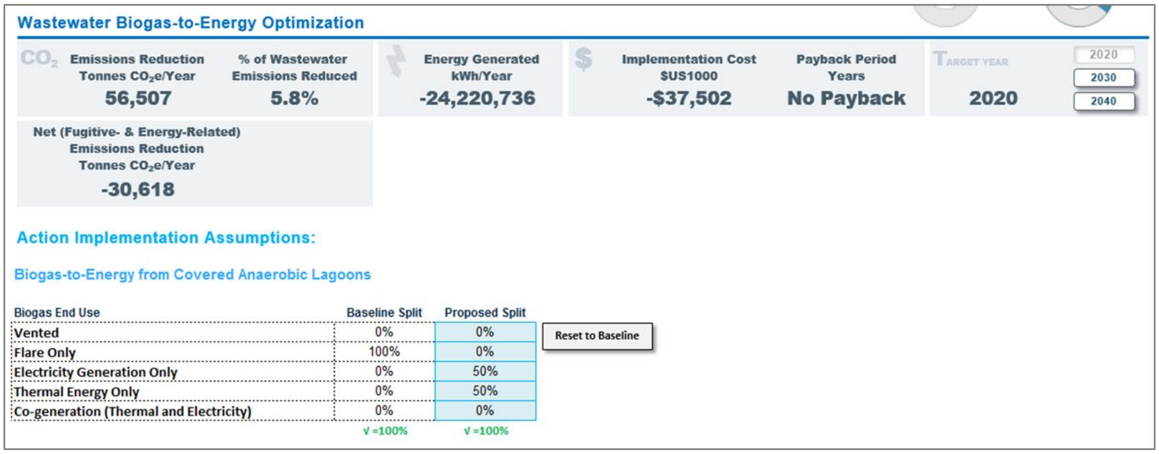
Baseline Pre-Treatment Technology	Fine screens
Baseline Pre-Treatment BOD Removal Efficiency	5%
Baseline Portion of Flow with Pretreatment	100%

Proposed Pre-Treatment Technology	Primary settling
Proposed Treatment BOD Removal Efficiency	30%
Proposed Portion of Flow with Pretreatment	100%

Reset to Baseline

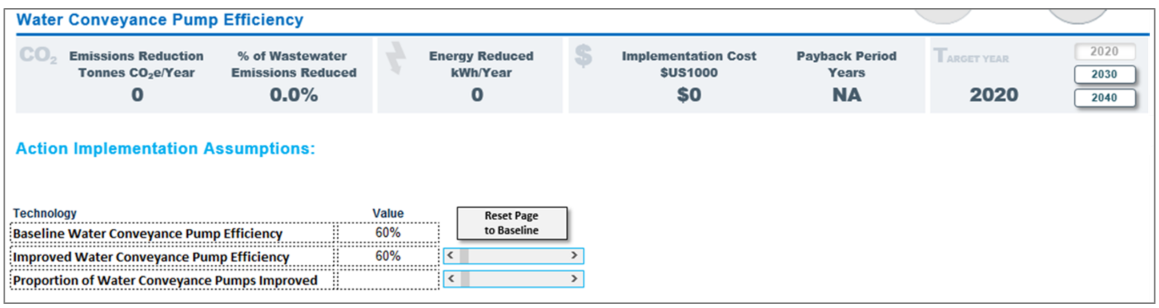
Wastewater Biogas-to-Energy

The *Wastewater Biogas-to-Energy Optimization* action allows the user to determine how generated biogas will be utilized. The user should only select this action if biogas is being generated through an anaerobic lagoon or anaerobic digester. The user can view the baseline assumptions in the "Baseline Split" column for each action. Then, the user can decide how to use the biogas from each treatment type by entering in the proposed split of end uses (vented, flare only, electricity generation, thermal energy, and/or co-generation) in the right blue column. How the biogas is used will determine the emissions impact of a lagoon or anaerobic digester.

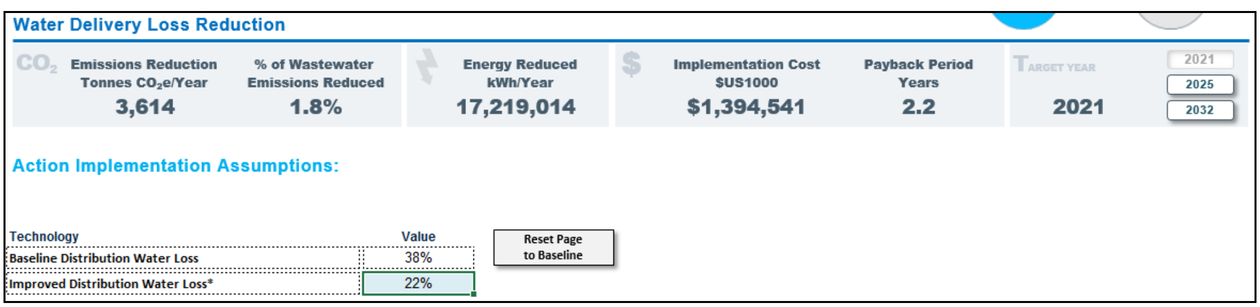


Water Conveyance Energy Improvements

There are two water conveyance actions, one to improve pump efficiency and the other to reduce losses during water distribution. For *Water Conveyance Pump Efficiency*, the user is able to improve the efficiency of water conveyance and increase the proportion of improved water conveyance pumps.



In *Water Delivery Loss Reduction*, if the user anticipates any improvements in water distribution losses then the new rate can be specified.



Return to the main *Wastewater and Water* main action page to see the summary of emissions, energy, and financial implications of the solid waste actions.

Transportation

The transportation scenario planning builds upon the Avoid-Shift-Improve[1] strategy framework that is commonly used in cities to calculate the emission and energy effects of different types of transportation actions. This framework categorizes actions as one of the following:

- Avoid/Reduce: addresses the need to improve the transportation system by a reduction in length of trips or number of daily trips
- Shift/Maintain: aims to improve efficiency by promoting modal shift from high energy consuming modes (i.e. Auto) to public transportation or non-motorized options.
- Improve: focuses on vehicle fuel efficiency, low carbon fuels and energy carriers

The following is a brief summary list of the actions in the transport sector:

Low Carbon Urban Design
This module allows the user to specify the reduction in future total trips or trip distance that come as a product of efficient and compact urban design, and transit oriented development.

Passenger Mode Shift
CURB allows the user to specify the modal shift expectations for the future of the following modes: private automobiles, motorcycle, taxis, moto-taxis, micro/minibus, standard bus and BRT, subway, light rail, commuter rail and ferryboats

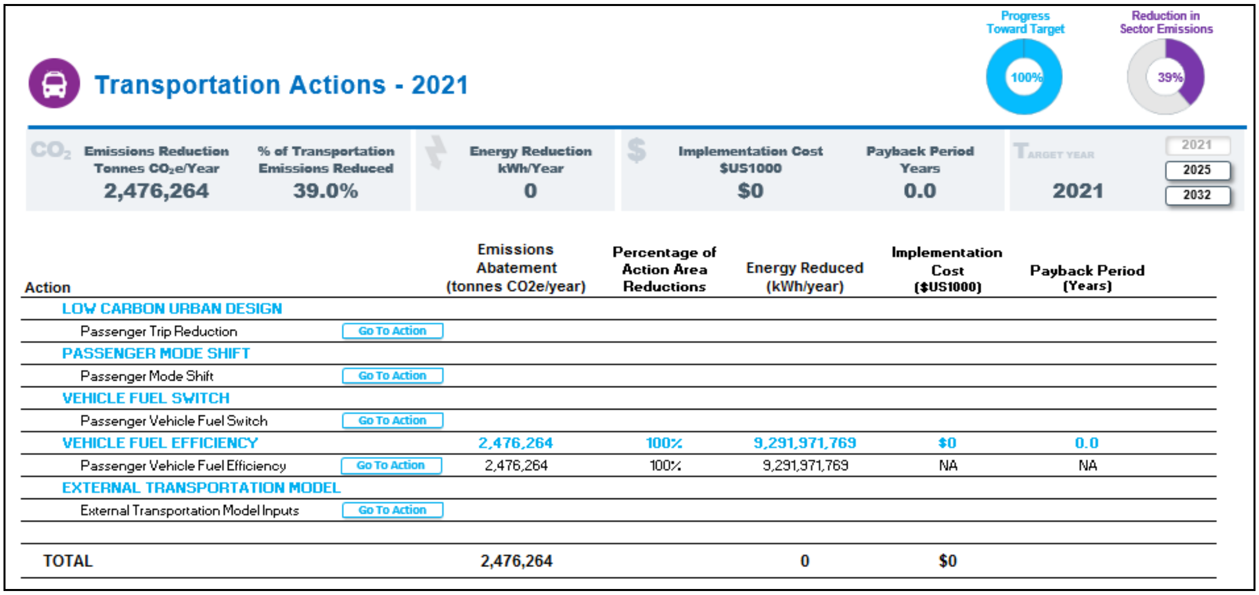
Vehicle Fuel Switch
This action allows the user to change the fuel usage (motor gasoline, diesel/gas oil, biodiesel, biogasoline, ethanol, compressed natural gas, liquefied petroleum gas, hydrogen and electricity) of different vehicle types (passenger automobiles, light and medium-duty trucks, motorcycle, taxis, moto-taxis, micro/minibus, standard bus and BRT, subway, light rail, commuter rail and ferryboats).

Vehicle Fuel Efficiency
This action allows the user to change the fuel efficiency of remaining internal combustion powered vehicles. The user can select to enter the efficiency improvements as a percent improvement or as specific fuel efficiency in units of km/liter or km/liter equivalent.

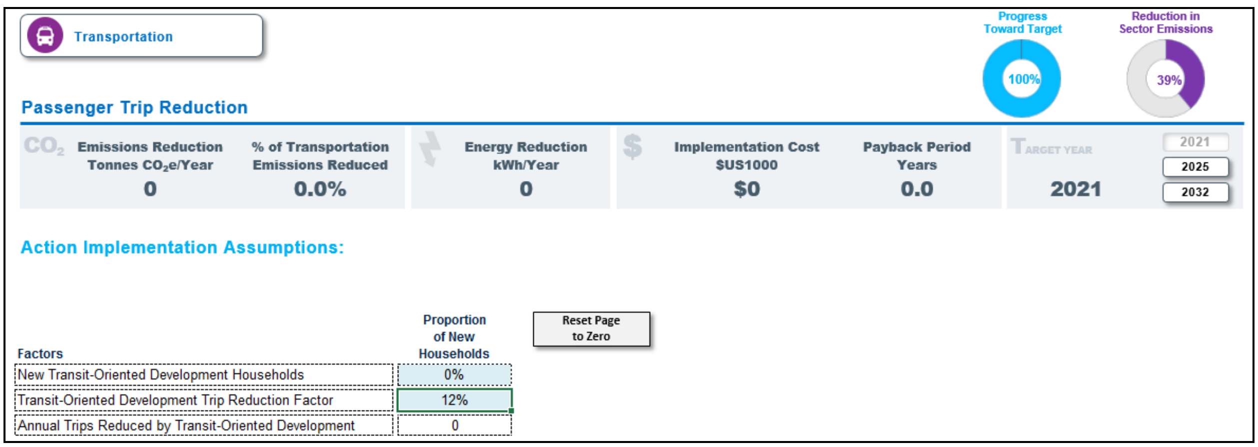
External Transportation Model
This action will allow the user to input from other scenario planning or transportation planning models.

Once entering the transportation sector, the user will find a summary of all sector actions:

[1] Dalkman, H. Branningan, C. Leferve, B. and Enriquez, A. *Urban Transport and Climate Change.* Deutsche Gesellschaft für Internationale GIZ

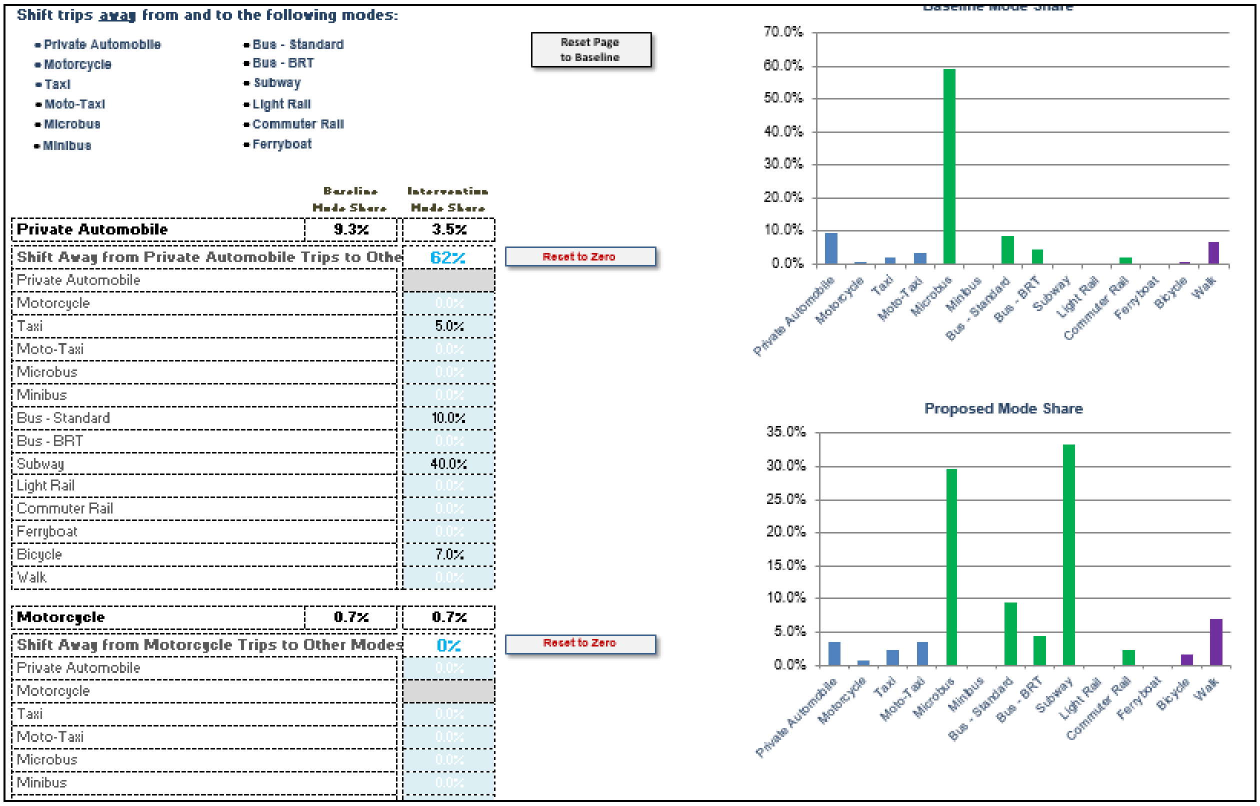


In selecting the *Passenger Trip Reduction* action, the user will be presented with the following page:



In this action, the user can change the percentage of households that will be in transit oriented development areas in the selected horizon year. The user can then select the percentage of trips that will decrease in these households as a result of transit-oriented development. This cell is locked to a maximum value of 25%, as this has been the maximum level of decrease that has been observed in new transit development projects.

In selecting the *Passenger Mode Shift* action, the user will be presented with the following page:



The passenger mode shift action allows the user to specify the modal shift for the future. The Action Implementation Assumptions section allows the user to view the modes that passengers may shift away from. A set of cells below each mode type allow the user to specify the new distribution of total trips by mode.

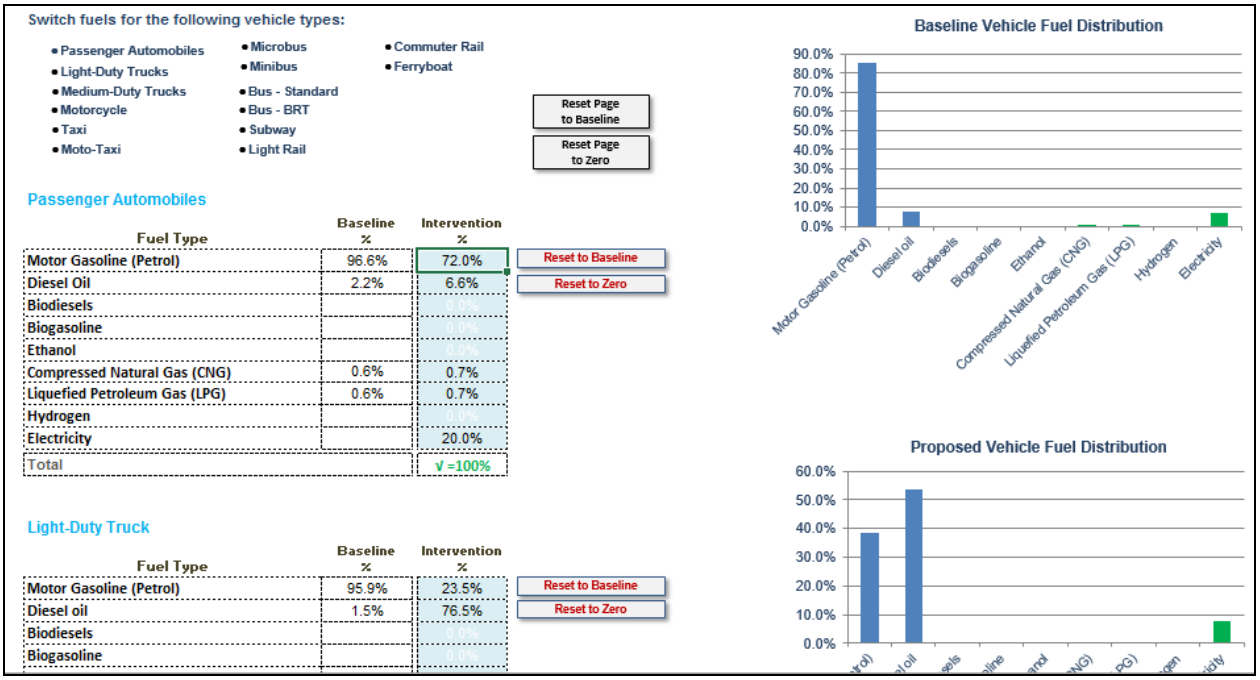
By entering percentages in these cells, the user can redistribute the trips from the selected mode to a new mode. For example, the image above shows that the user has chosen to move trips away from private automobiles. The sliders allow the user to redistribute trips, in this case, 40% of those trips will now be taken by subway, 10% by bus, 7% by bicycle and 5% by taxi. The tool displays the current and new percentage of trips that will be taken in each mode.

The top graph on the right displays the current modal distribution of trips, while the one in the bottom shows the proposed future mode share.

The user can immediately see any changes made in the cells reflected in the summary bar at the top. This shows emissions reductions and energy reductions for *this specific action* (i.e. passenger mode shift, in this case).

The user can return to the transportation sector summary page by clicking on the Transportation button in the top left corner.

From there the user can select the *Vehicle Fuel Switch* action, which will lead to the following page:



Similar to the previous action, the *Passenger Vehicle Fuel Switch* action allows the user to change the fuel used by vehicles and follows the same logic. The top left section allows the user to view the vehicles types for which the future fuel use can change. Below, a set of cells is provided for each vehicle type. The user may propose a new fuel for each specific vehicle type by specifying the percentage in the cells.

By entering the percentage in the cells, the user will be able to redistribute the fuel usage from the selected vehicle type to a new usage mix. For example, the image above shows that the user has chosen to change the fuel usage of private automobiles and light-duty trucks. The total mix of fuels must equal 100%; the total sum at the bottom of the page will highlight green when it is correct.

The top graph on the right displays the current vehicle fuel distribution, while the one in the bottom shows the proposed fuel distribution.

The user can return to the transportation sector summary page by clicking on the Transportation button in the top left corner. From here the user can go the *Vehicle Fuel Efficiency* action. Which will lead to the following page.

Change fuel efficienceis for the following vehicle types:

- Passenger Automobiles
- Light-Duty Trucks
- Medium-Duty Trucks
- Motorcycle
- Taxi
- Moto-Taxi
- Microbus
- Minibus
- Bus - Standard
- Bus - BRT
- Subway
- Light Rail
- Commuter Rail
- Ferryboat

Reset Page to Baseline

Passenger Automobiles

Fuel Type	Baseline km/liter	Improvement %	Intervention km/liter
Motor Gasoline (Petrol)	9.19	10%	10.11
Diesel Oil	12.68	5%	13.31
Biodiesels	12.20	0%	12.20
Biogasoline	9.39	0%	9.39
Ethanol	6.18	0%	6.18
Compressed Natural Gas (CNG)	9.19	0%	9.19
Liquefied Petroleum Gas (LPG)	6.70	0%	6.70
Hydrogen	25.29	0%	25.29
Electricity	46.10	0%	46.10

Reset to Zero

This action allows users to change the fuel efficiency of the different vehicle types as well as fuel types for each by specifying the percentage improvement. It follows a logic similar to the previous actions. The top left section allows the user to view the vehicles types for which the fuel efficiency can change. Below, a set of cells is provided for each vehicle type by fuel type. The user may propose new fuel efficiencies for each specific vehicle type by specifying the percentage in the cells.

The final transportation action, *External Transportation Model Inputs*, enables users to utilize the outcomes of more complex behavioral models within CURB. **Inputs within this action replace any other actions within the Transportation module.**

External Transportation Model Inputs

Emissions Reduction Tonnes CO_2e/Year	% of Transportation Emissions Reduced	Energy Reduction kWh/Year	Implementation Cost $US1000	Payback Period Years	Target Year
40,000	1.0%	50,000	NA	NA	2021

2021 | 2025 | 2032

Action Assumptions:

User enters results from an external transportation model in cells below:

Factor	tonnes CO2e/year
Emissions Reduction in 2021	40,000

Factor	kWh/year
Energy Reduction in 2021	50,000

Factor	Trips/year
Trip Reduction in 2021	2,346,437

Factor	VKT/year
Reduction in Vehicle Kilometers Traveled in 2021	0

Factor	VKT/year
NPV of Implementation Cost 2015 to 2021	NA

* If not available put NA

Factor	VKT/year
NPV of Cost Savings 2015 to 2021	NA

* If not available put NA

The action allows the user to input the following:

- Emissions Reduction in 2020 (CO2/Year)
- Energy Reduction in 2020 (kWh/Year)
- Trip Reduction in 2020 (Trips/Year)
- Reduction in Vehicle Kilometers Traveled in 2020 (VKT/Year)
- Net Present Value (NPV) of Implementation Cost 2010 to 2020 ($US1000)
- NPV of Cost Savings 2010 to 2020 ($US1000/Year)

These results will then be used to compare the sector outcomes with the other sectors' emission reductions, energy impact and costs.

4.C) Financial Metrics

I. Financial Performance Table

This sub-module provides the cumulative financial implications for every single action that was chosen. The information includes net present value of cost of capital, net present value of gain from investment, net present value of implementation, annual savings (or revenues), and payback period.

4.A Action Selection | 4.B Action Development | 4.C Financial Metrics | 4.D Co-Benefits

4.C.I Financial Performance Tables | 4.C.II Abatement Cost Curve

Financial Performance Tables

The following page shows the financial performance of the City's emission reduction actions as developed in Section 4.B.

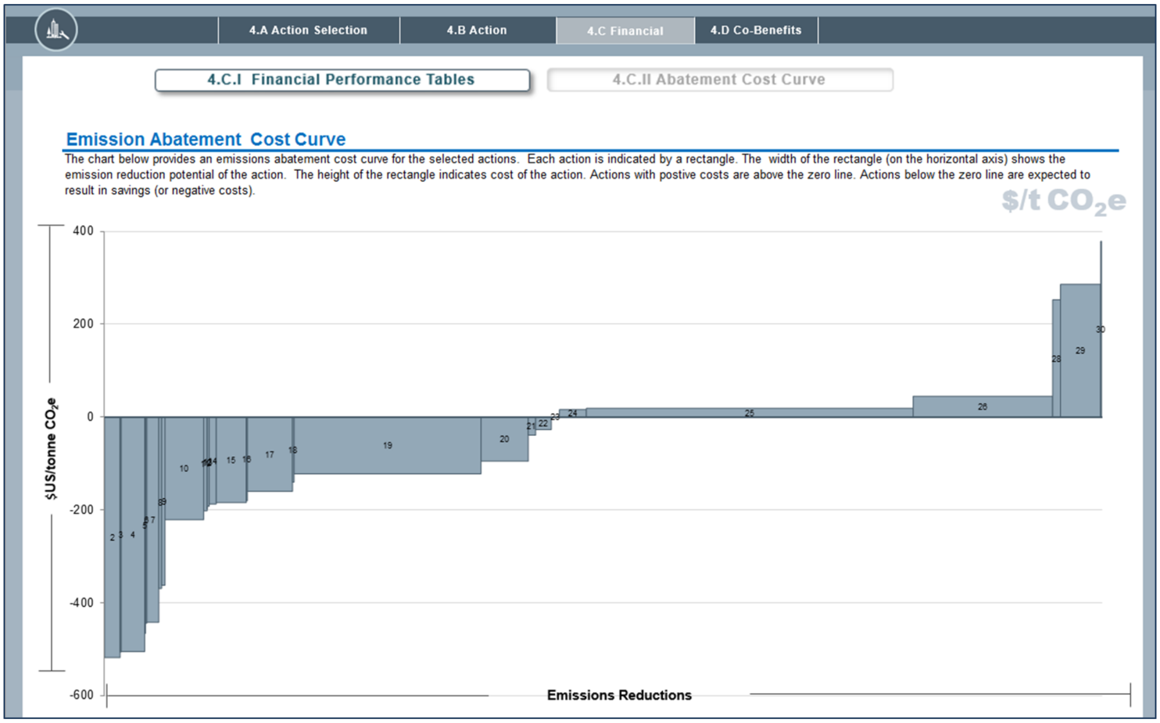
Sector / Action Category / Action	NPV of Capital Costs (cumulative $)	NPV of Gain From Investment (cumulative $)	NPV of Implementation (cumulative $)	Annual Savings or Revenues ($/year)	Payback Period (Years)
PRIVATE BUILDING ENERGY	$22,906,295,644	$24,960,445,620	$2,054,149,975	$995,214,927	17.2
ENERGY EFFICIENCY & FUEL SWITCHING	$15,023,339,676	$17,065,866,845	$2,042,527,169	$564,866,205	17.7
EXISTING RESIDENTIAL BUILDINGS	$12,315,686,163	$15,100,623,410	$2,784,937,247	$495,676,753	15.6
Lighting - Residential	$508,930,016	$2,868,656,691	$2,359,726,675	$84,709,793	3.2
Appliance and Electronics - Residential	$120,195,122	$393,583,562	$273,388,440	$9,324,993	6.1
Space Heating and Cooling - Residential	$6,972,684,475	$3,295,560,596	-$3,677,123,879	$94,640,769	44.5
Water Heating - Residential	$2,508,072,211	$2,926,409,756	$418,337,545	$85,838,165	13.9
Building Envelopes - Residential	$2,205,804,339	$5,616,412,805	$3,410,608,466	$221,163,032	9.1
EXISTING COMMERCIAL BUILDINGS	$567,768,921	$550,052,790	-$17,716,131	$18,404,729	20.2
Lighting - Commercial	$18,959,121	$164,666,373	$145,707,252	$4,976,468	1.3
Appliances and Electronics - Commercial	$21,532,051	$4,050,000	-$17,482,051	$108,000	121.9
Space Heating and Cooling - Commercial	$420,950,715	$242,095,707	-$178,855,007	$7,863,112	32.4
Water Heating - Commercial	$1,288,228	$6,231,356	$4,943,128	$265,479	3.4
Building Envelope - Commercial	$105,038,806	$133,009,354	$27,970,548	$5,191,671	18.3
NEW RESIDENTIAL BUILDINGS	$2,076,831,760	$1,375,680,845	-$701,150,914	$49,304,100	37.3
Efficient Construction - Residential	$2,076,831,760	$1,375,680,845	-$701,150,914	$49,304,100	37.3
NEW COMMERCIAL BUILDINGS	$63,052,832	$39,509,799	-$23,543,032	$1,480,624	23.5
Efficient Construction - Commercial	$63,052,832	$39,509,799	-$23,543,032	$1,480,624	23.5

II. Abatement Cost Curve

This section provides a chart of the emission abatement cost curve for each of the selected actions. Each action is indicated by a rectangle:

- The **width** of the rectangle (on the horizontal axis) shows the reduction potential of the action
- The **height** of the rectangle indicates the cost of the action
- Actions with positive costs are **above** the zero line
- Actions **below** the zero line are expected to result in savings (or negative costs)

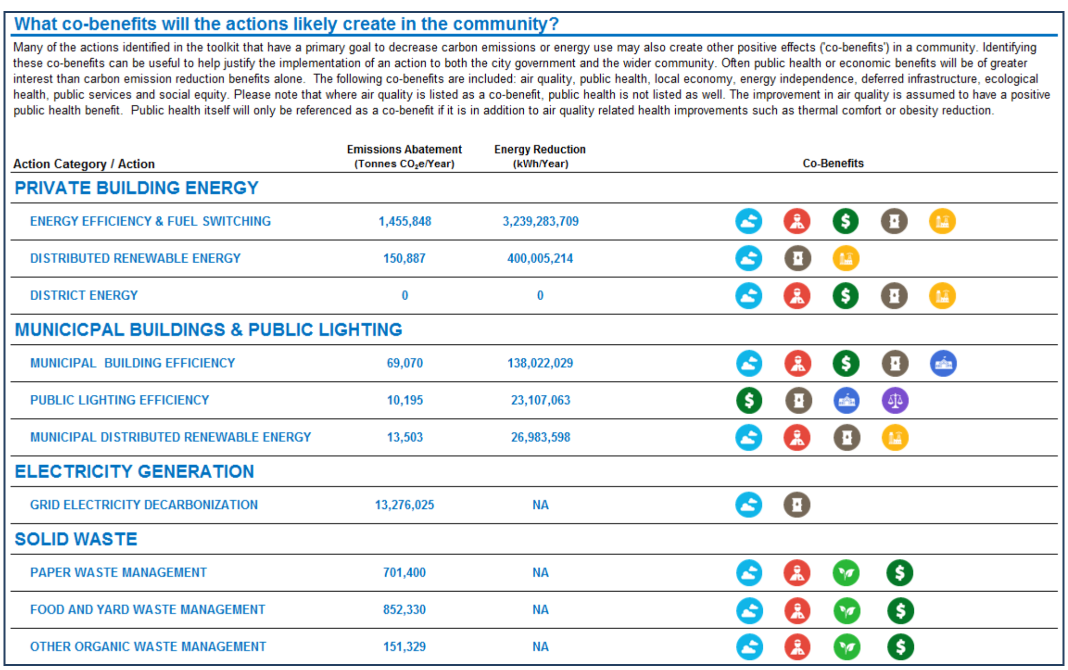
The legend below the cost curve allows the user to select and deselect the actions included in the abatement curve and provides detailed information. It should be noted that the abatement cost curve only displays the actions which have emission reductions and a financial cost or savings.



4.D) Co-benefits

I. Co-benefits Matrix

The co-benefits matrix displays the final selection of actions, the emissions abatement (tonnes CO_2/year) and energy reduction (kWh/year) for each action, and the co-benefits associated with each action. The co-benefits are currently shown qualitatively with the intention of having quantitative co-benefit information in subsequent versions.



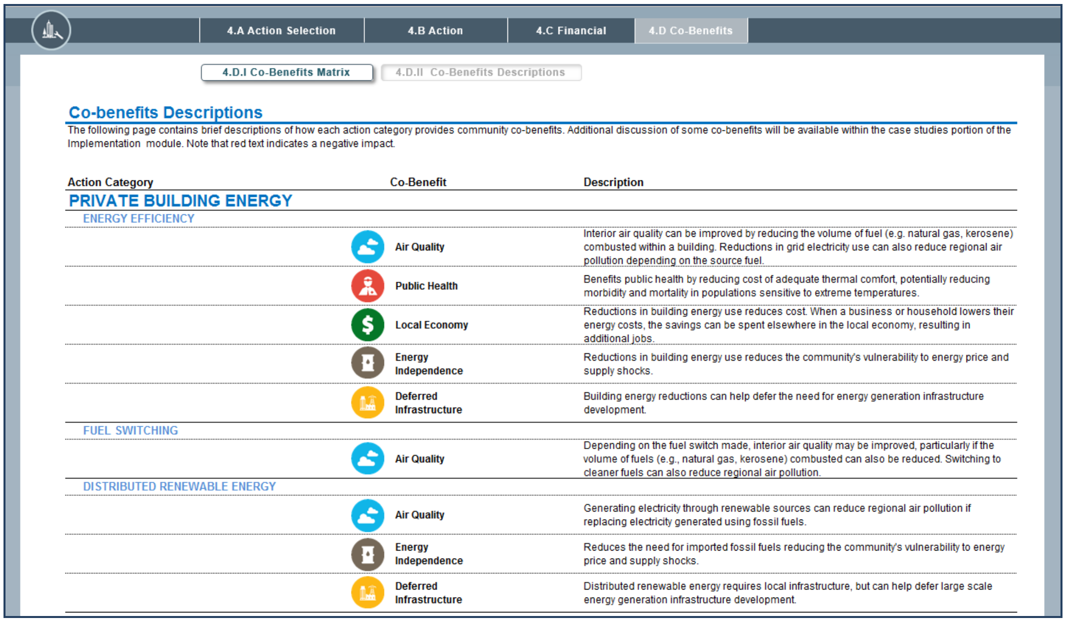
What co-benefits will the actions likely create in the community?

Many of the actions identified in the toolkit that have a primary goal to decrease carbon emissions or energy use may also create other positive effects ('co-benefits') in a community. Identifying these co-benefits can be useful to help justify the implementation of an action to both the city government and the wider community. Often public health or economic benefits will be of greater interest than carbon emission reduction benefits alone. The following co-benefits are included: air quality, public health, local economy, energy independence, deferred infrastructure, ecological health, public services and social equity. Please note that where air quality is listed as a co-benefit, public health is not listed as well. The improvement in air quality is assumed to have a positive public health benefit. Public health itself will only be referenced as a co-benefit if it is in addition to air quality related health improvements such as thermal comfort or obesity reduction.

Action Category / Action	Emissions Abatement (Tonnes CO_2e/Year)	Energy Reduction (kWh/Year)	Co-Benefits
PRIVATE BUILDING ENERGY			
ENERGY EFFICIENCY & FUEL SWITCHING	1,455,848	3,239,283,709	
DISTRIBUTED RENEWABLE ENERGY	150,887	400,005,214	
DISTRICT ENERGY	0	0	
MUNICICPAL BUILDINGS & PUBLIC LIGHTING			
MUNICIPAL BUILDING EFFICIENCY	69,070	138,022,029	
PUBLIC LIGHTING EFFICIENCY	10,195	23,107,063	
MUNICIPAL DISTRIBUTED RENEWABLE ENERGY	13,503	26,983,598	
ELECTRICITY GENERATION			
GRID ELECTRICITY DECARBONIZATION	13,276,025	NA	
SOLID WASTE			
PAPER WASTE MANAGEMENT	701,400	NA	
FOOD AND YARD WASTE MANAGEMENT	852,330	NA	
OTHER ORGANIC WASTE MANAGEMENT	151,329	NA	

II. Co-benefits Description

The co-benefits associated with each action selected are listed with information on why each co-benefit exists. This can be used as supplementary materials to support the selected actions. CURB provides information on co-benefits related to air quality, public health, ecological health, deferred infrastructure, local economy, energy independence, public services and social equity.



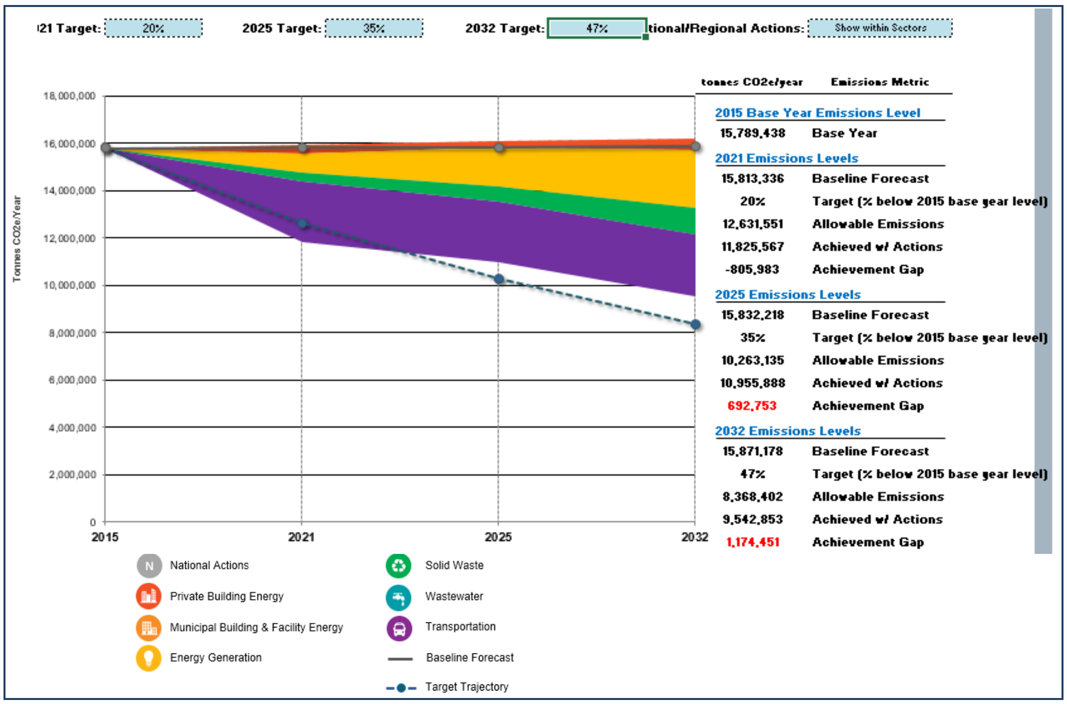
5. RESULTS

Results demonstrates the combined and individual impact of chosen actions on urban emissions, energy and costs. Here the user can see how actions add up to reach the city's emissions target, understand the financial implications, and view the emissions and energy impacts. If desired, the user can go back to adjust or select additional actions.

5.A) Aggregate Results

I. Emissions Performance

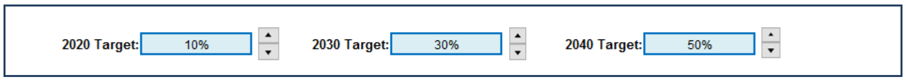
This section demonstrates results in terms of GHG emissions. In the graph, the dark line represents the Reference Case Forecast, which is a "business as usual" scenario of how emissions are likely to change over time in the absence of action to reduce emissions. The Reference Case Scenario is based on the growth factors entered in Section 2.B.



The dashed blue line represents the emissions target set in Section 2.D. The colored wedges represent emissions reductions from the Reference Case Scenario based on the different actions selected and developed in Section 4.B, which each color representing a different sector**. In the example shown in the graphic, a portion of the wedges is above the baseline forecast line. This is because certain actions have caused an increase in emissions.** For example, certain wastewater treatment actions cause an increase in emissions although they have other benefits like those related to public health and ecological health.

The graph helps demonstrate whether the actions developed have helped to meet emissions reduction targets, showing also the relative contributions of actions in each sector. If current actions do not meet the target, there are at least two options for further action.

First, the user may wish to adjust the ambition of the target, either by changing the level of the target or the target type. To change the level of the target, the user can simply use the arrow keys at the top of the graph. To change the type of target, the user can use the buttons at the top right of the page to choose a different or more or less ambitious goal (for instance, a baseline scenario target instead of a base year target).

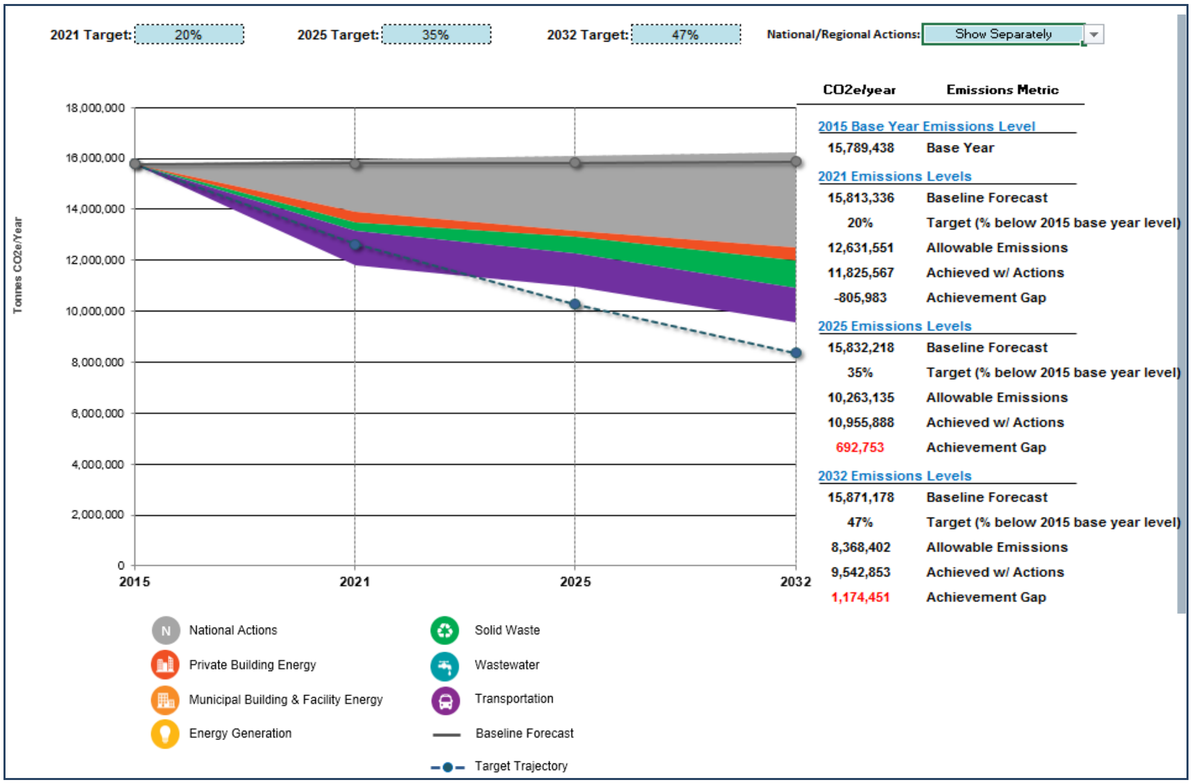


The second option is to return to the Action module and select more or different actions, or else increase the ambition of actions already selected, for instance by increasing the penetration rate. Note that it is generally better to pick actions that are achievable if target and results are to be realistic.

The table on the right gives a more detailed breakdown of the information displayed in the graph. For each target year, the user can see emissions quantities for the Reference Case, the target set, the reductions achieved with actions, and any potential gap between the target and delivered reductions.

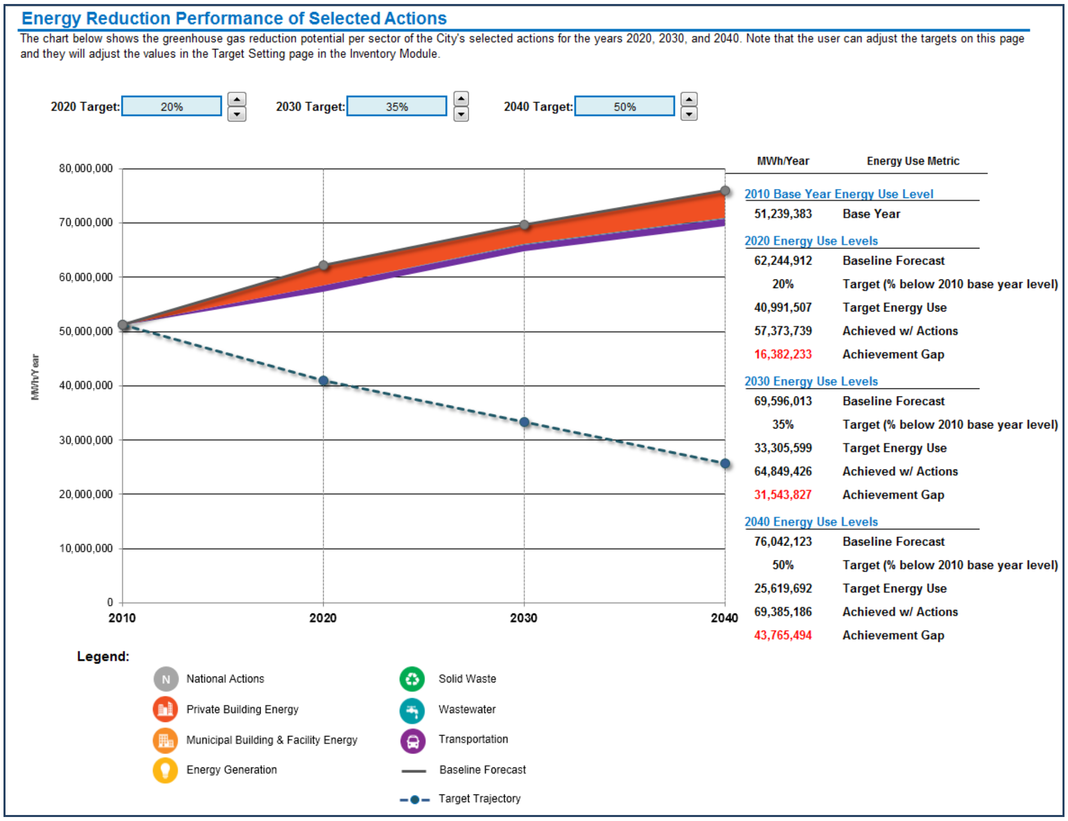
CO2e/year	Emissions Metric
2015 Base Year Emissions Level	
15,789,438	Base Year
2021 Emissions Levels	
15,813,336	Baseline Forecast
20%	Target (% below 2015 base year level)
12,631,551	Allowable Emissions
11,825,567	Achieved w/ Actions
-805,983	Achievement Gap
2025 Emissions Levels	
15,832,218	Baseline Forecast
35%	Target (% below 2015 base year level)
10,263,135	Allowable Emissions
10,955,888	Achieved w/ Actions
692,753	Achievement Gap
2032 Emissions Levels	
15,871,178	Baseline Forecast
47%	Target (% below 2015 base year level)
8,368,402	Allowable Emissions
9,542,853	Achieved w/ Actions
1,174,451	Achievement Gap

Users also have the option to view reductions from actions that will fall under the authority of national and regional governments separately, by clicking on the dropdown menu to the right of the target entry cells, and selecting the option “*Show Separately”*. The reductions from national and regional actions will be be shown in grey.



II. Energy Performance

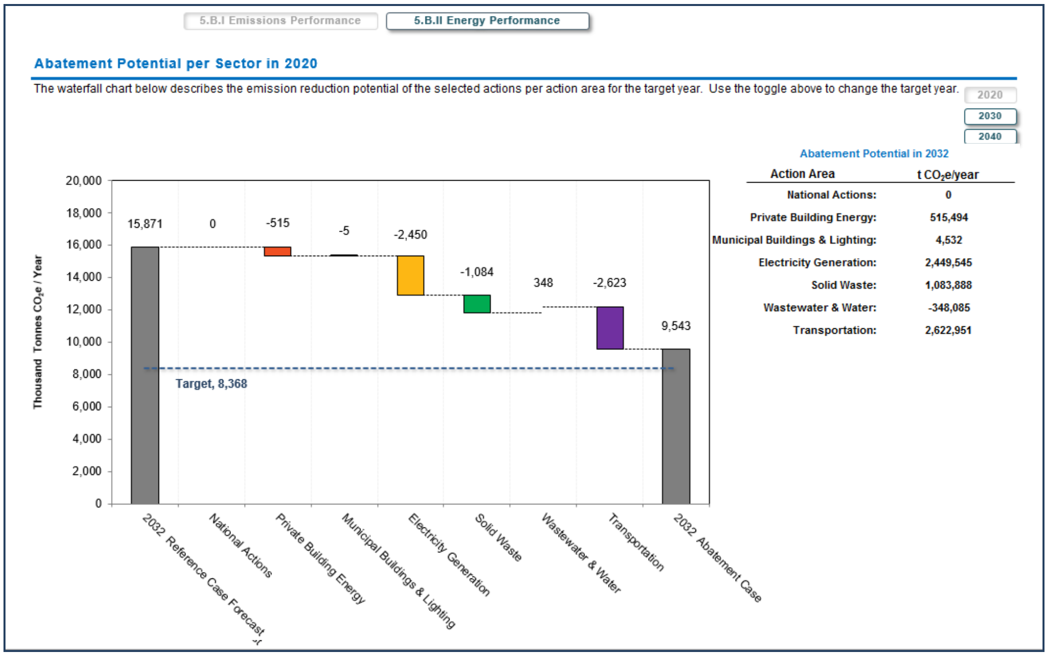
To understand results in terms of energy usage, select the Energy Performance (5.A.II) button at the top right of the page. This view of the chart demonstrates results in terms of energy performance. Information is presented in the same format as Emissions Performance (5.A.I) above, only with progress shown towards the energy reduction goal rather than emissions goal.



5.B) Sector Results

I. Emissions Performance

The graph in this section shows the same results as in 5.A.I, but with more emphasis on the relative contributions of each sector to emissions reductions, including those attributed to national actions. This graph is shown as a waterfall so that users can quickly see which sectors are contributing the most to emissions reduction.



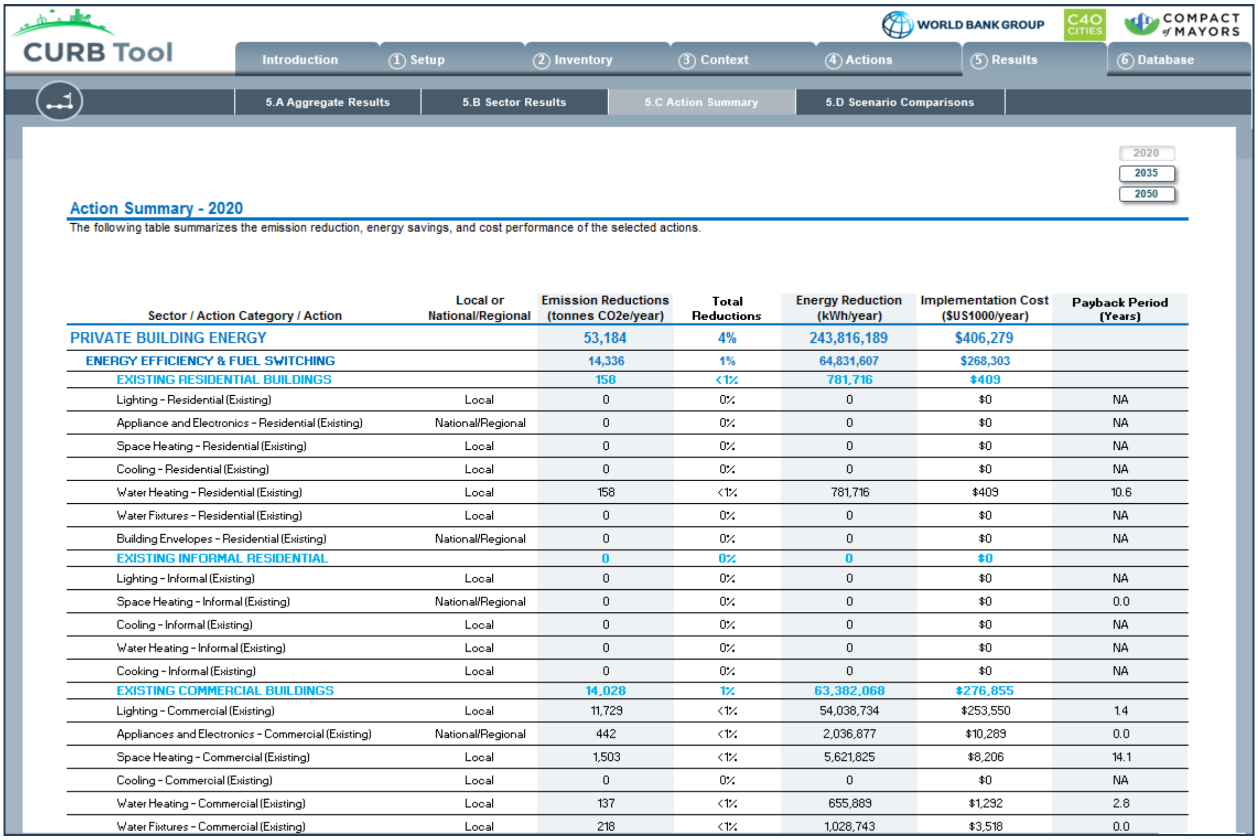
The user can select using a dropdown menu whether to view the waterfall graph in terms of sectors (as seen in the screenshot above) or in terms of national actions versus local actions by sector. The latter chart enables the city to quickly understand what sectors they have more control over and what they can contribute to emissions and energy use reduction.

II. Energy Performance

This section demonstrates results in terms of energy performance. Information is presented in the same format as Emissions Performance (5.B.I) above, only with progress shown towards energy reduction rather than emissions goal.

5.C) Action Summary

The table in this sub-modules shows the emissions reduced/year, % of total emissions reduction, energy reduced/year, implementation cost, and annual savings for every action in order to compare the results side-by-side rather than view these results individually or sectorally in the Action module. Users can return to the sub-module 4.B. Action at any time to alter actions.



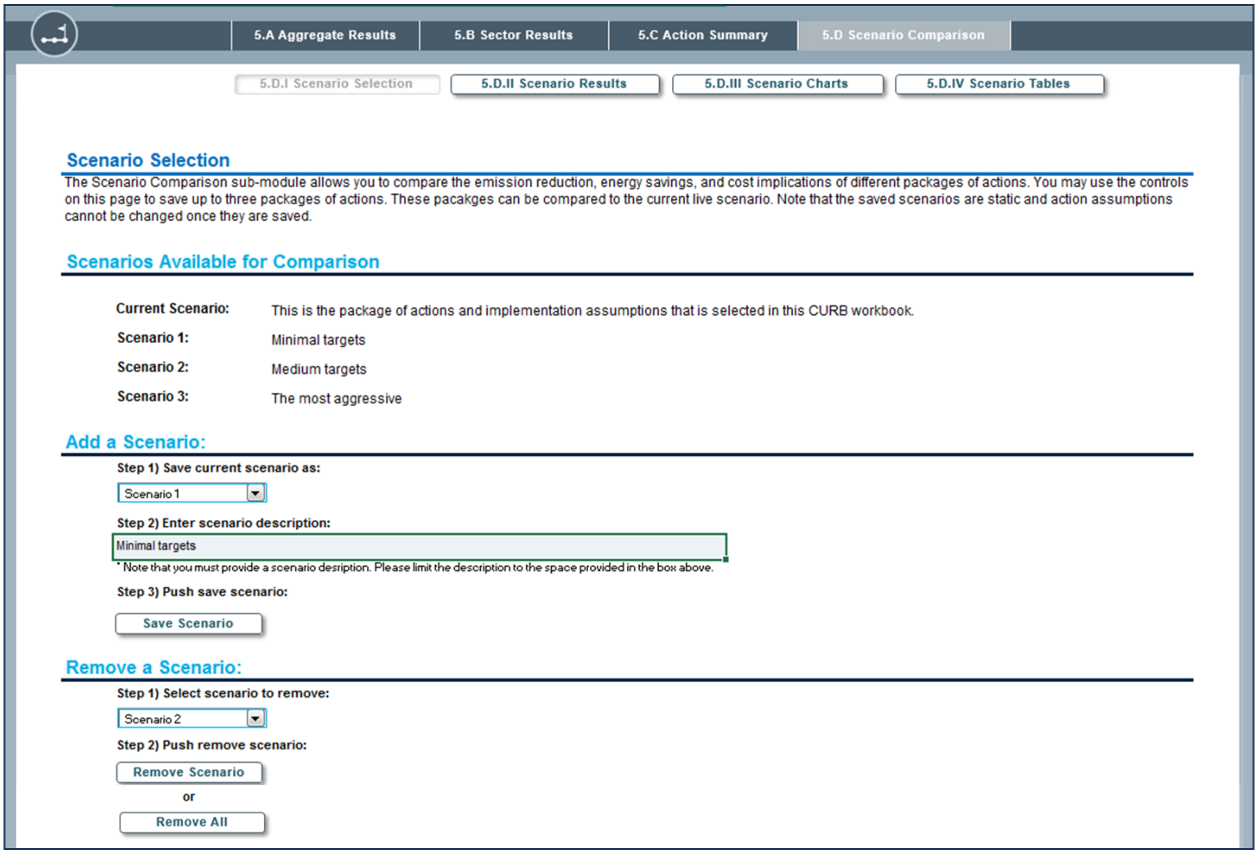
Sector / Action Category / Action	Local or National/Regional	Emission Reductions (tonnes CO2e/year)	Total Reductions	Energy Reduction (kWh/year)	Implementation Cost ($US1000/year)	Payback Period (Years)
PRIVATE BUILDING ENERGY		53,184	4%	243,816,189	$406,279	
ENERGY EFFICIENCY & FUEL SWITCHING		14,336	1%	64,831,607	$268,303	
EXISTING RESIDENTIAL BUILDINGS		158	<1%	781,716	$409	
Lighting - Residential (Existing)	Local	0	0%	0	$0	NA
Appliance and Electronics - Residential (Existing)	National/Regional	0	0%	0	$0	NA
Space Heating - Residential (Existing)	Local	0	0%	0	$0	NA
Cooling - Residential (Existing)	Local	0	0%	0	$0	NA
Water Heating - Residential (Existing)	Local	158	<1%	781,716	$409	10.6
Water Fixtures - Residential (Existing)	Local	0	0%	0	$0	NA
Building Envelopes - Residential (Existing)	National/Regional	0	0%	0	$0	NA
EXISTING INFORMAL RESIDENTIAL		0	0%	0	$0	
Lighting - Informal (Existing)	Local	0	0%	0	$0	NA
Space Heating - Informal (Existing)	National/Regional	0	0%	0	$0	0.0
Cooling - Informal (Existing)	Local	0	0%	0	$0	NA
Water Heating - Informal (Existing)	Local	0	0%	0	$0	NA
Cooking - Informal (Existing)	Local	0	0%	0	$0	NA
EXISTING COMMERCIAL BUILDINGS		14,028	1%	63,382,068	$276,855	
Lighting - Commercial (Existing)	Local	11,729	<1%	54,038,734	$253,550	1.4
Appliances and Electronics - Commercial (Existing)	National/Regional	442	<1%	2,036,877	$10,289	0.0
Space Heating - Commercial (Existing)	Local	1,503	<1%	5,621,825	$8,206	14.1
Cooling - Commercial (Existing)	Local	0	0%	0	$0	NA
Water Heating - Commercial (Existing)	Local	137	<1%	655,889	$1,292	2.8
Water Fixtures - Commercial (Existing)	Local	218	<1%	1,028,743	$3,518	0.0

5.D) Scenario Comparison

In the Scenario Comparison sub-module, users can save up to three scenarios, which are a comprehensive suite of actions, and then see how they compare when deciding the city's final set of actions. The sub-module provides information on how the scenarios compare to their targets, how they compare to each other by sectoral and overall emissions, and how they compare in terms of emissions, energy and costs. The scenarios that are saved are static and cannot be changed. The current scenario can always be adjusted based on lessons learned from previous scenarios.

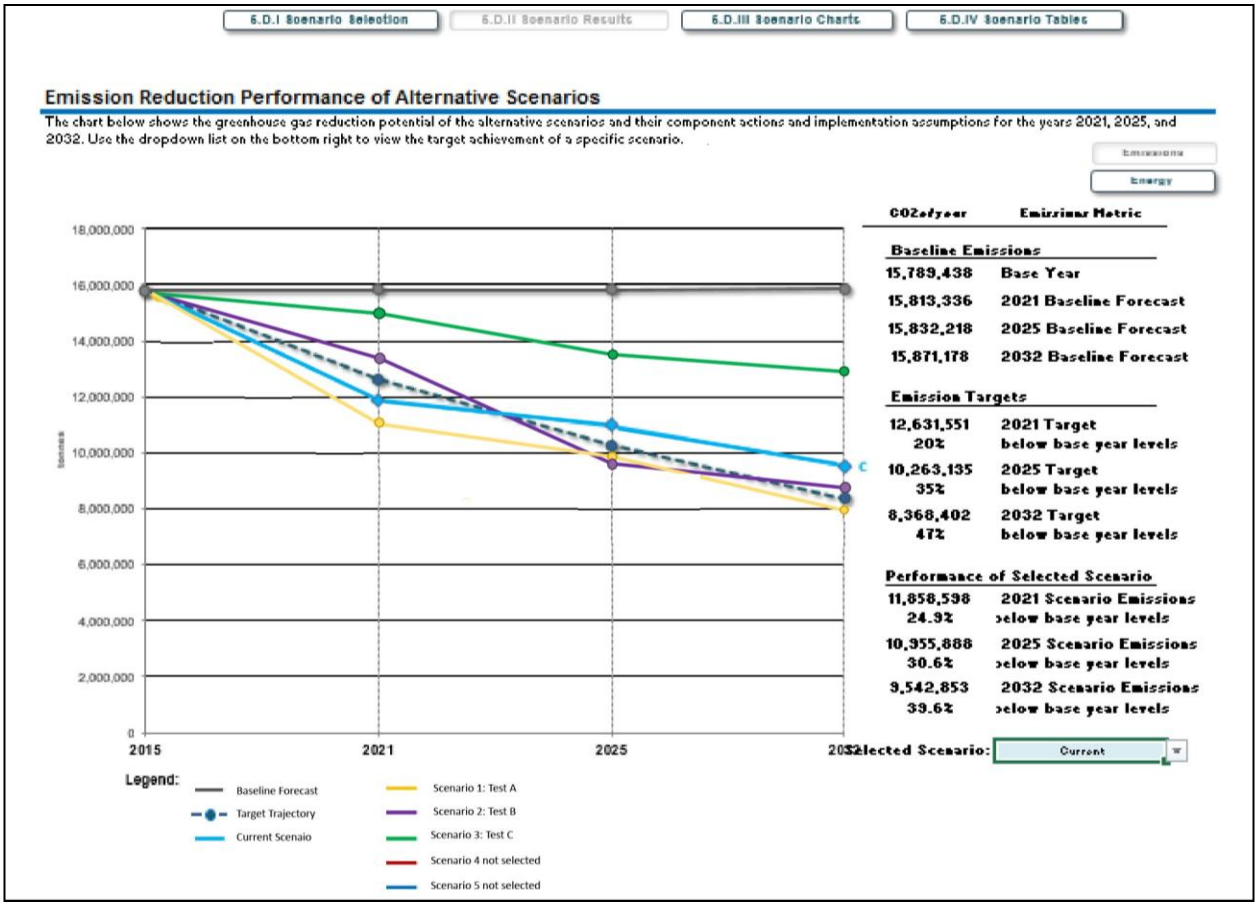
I. Scenario Selection

This action allows the user to name and save the current scenario in order to go back and build a new scenario. In *Add a Scenario*, users can select whether they wish to save the current scenario as Scenario 1, 2 or 3, name the scenario, and save it. As scenarios are developed, if the user wishes to remove any previous scenario and add the newly developed one, the user can scroll below to Remove a Scenario and select the scenario to be removed before pushing the associated button. The user can also choose to remove all scenarios.



II. Scenario Results

In the graph, users can see the emissions trajectory for all 3 saved scenarios, the current scenario and the baseline projections. Users can compare these results to any of the targets set by selecting the scenario with the desired targets. Users can select the scenario in a dropdown to the bottom-right of the chart.



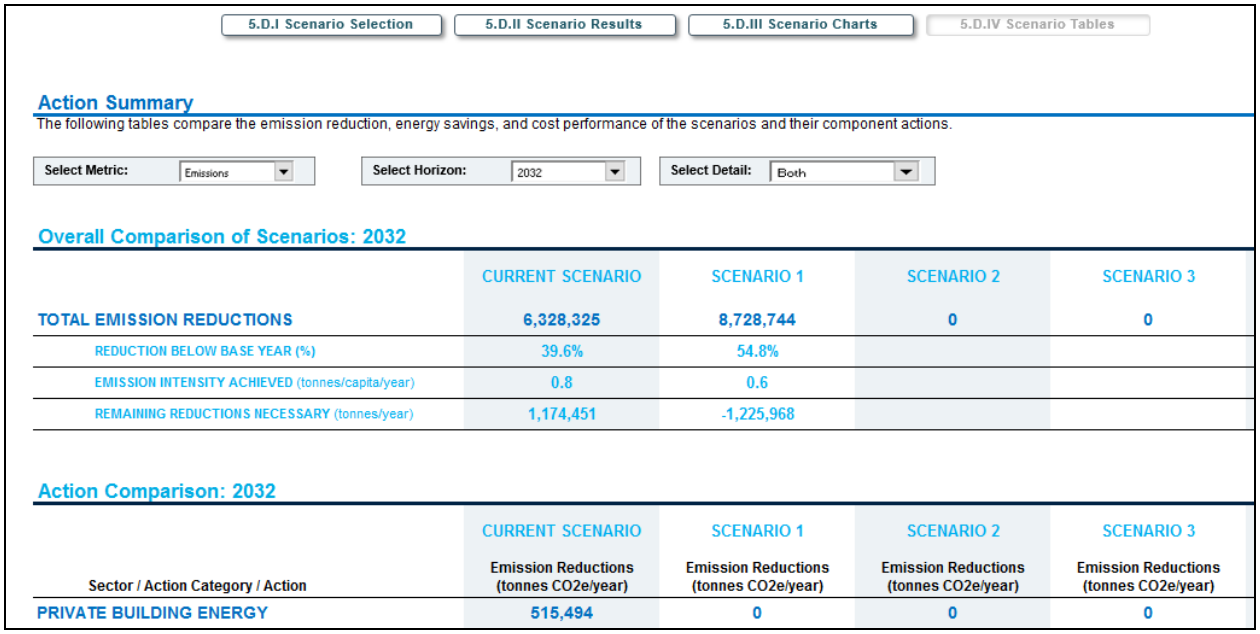
The table on the right side of the chart provides information for the selected scenario related to baseline emissions or energy, targets and performance of the selected scenario compared to the targets.

III. Scenario Charts

Users can select which metrics to compare for a given horizon year across the scenarios, whether they want to compare by sector or overall, and whether the impact of local and national should be separately viewed. Users can compare across emissions reduction, energy savings, and cost performance of the scenarios.

IV. Scenario Tables

This table provides the same information as in the Scenario Charts and more detailed information. It allows users to compare between all scenarios and actions taken. The user can select the metric (emissions reduction, energy savings, or cost performance), horizon year, and the level of detail desired. At any point, a user can revisit the current scenario to make adjustments as needed based on the comparisons.



5.D.I Scenario Selection | 5.D.II Scenario Results | 5.D.III Scenario Charts | 5.D.IV Scenario Tables

Action Summary

The following tables compare the emission reduction, energy savings, and cost performance of the scenarios and their component actions.

Select Metric: Emissions | Select Horizon: 2032 | Select Detail: Both

Overall Comparison of Scenarios: 2032

	CURRENT SCENARIO	SCENARIO 1	SCENARIO 2	SCENARIO 3
TOTAL EMISSION REDUCTIONS	6,328,325	8,728,744	0	0
REDUCTION BELOW BASE YEAR (%)	39.6%	54.8%		
EMISSION INTENSITY ACHIEVED (tonnes/capita/year)	0.8	0.6		
REMAINING REDUCTIONS NECESSARY (tonnes/year)	1,174,451	-1,225,968		

Action Comparison: 2032

Sector / Action Category / Action	CURRENT SCENARIO Emission Reductions (tonnes CO2e/year)	SCENARIO 1 Emission Reductions (tonnes CO2e/year)	SCENARIO 2 Emission Reductions (tonnes CO2e/year)	SCENARIO 3 Emission Reductions (tonnes CO2e/year)
PRIVATE BUILDING ENERGY	515,494	0	0	0

6. DATABASE

Module 6, *Database*, provides users with the proxy data that is used within CURB. In the first module, Setup, users had the choice to provide specific data for their city or to use CURB's proxy data. Here, users can view datasets for each sector. To do so, click on a specific dataset and a spreadsheet will appear. Users can return to the main page by clicking on the *Back to Database Main Page* button.

Annex 1: CURB Data Requirements

Overview

The following provides a high-level view of the key data requirements needed to use CURB, broken down by sector. In general, the more city-specific data you provide, the more accurate the results of the modelling exercise will be, although proxy data is available if needed.

For a full view of data requirements, please review the CURB Data Template or the full CURB Tool.

Basic City Data

To use CURB, you will first provide basic background data about your city's climate type, population, and employment. This section also asks you to pick a baseline year against which CURB will help you to compare energy use/emissions in the target year(s).

- City Name and Country
- City Area, Annual Precipitation, and Climate Type
- Population and Number of Commuters
- Choice of Baseline Year, 2 Interim Years, and Final Target Year
- Projected Growth Rates for: Population, Commuters, and GDP

Private Sector Building

This section asks for information on the quantity and types of buildings in the residential and commercial sectors.

- Total Number of Residential Units
- Percentage of Units per Income Cohort (High, Upper-Middle, Lower-Middle, Low, and Informal)
- Housing Type for each Income Cohort (Houses or Apartments)
- Area of Commercial Buildings (Retail, Office, Hospital, Educational, Hotel, and Warehouse)
- Percentage of Residents with Electricity Service

Municipal Buildings and Public Lighting Data

This section asks for information on energy consumption by municipal buildings, streetlights, traffic lights and other types of public lighting.

- Total Office Floor Area
- Amount of each Energy Type Consumed by Municipal Buildings (Electricity, Natural Gas, etc.)

- Streetlight Electricity Consumption, Hours of Operation per Day for Lighting, and Number of Each Type of Lamp (High Pressure Sodium, Metal Halide, etc.)
- Traffic Light Electricity Consumption and Number of Each Type of Lamp

Grid-Supplied Electricity

This section asks for information on grid-supplied energy that is consumed in your city. If this data is not available, the tool will use national-level proxy data.

- Electricity Generation Mix for Grid-Supplied Power (Percentage Solar, Wind, Hydroelectric, Geothermal, Biomass, Natural Gas, Propane, etc.)
- Emission Factors for Electricity and Fuel Energy (by Fuel Type)

Solid Waste Generation and Management Data

This section asks for information on the solid waste generation and management in your city.

- Total Annual Solid Waste Tonnage
- Solid Waste Composition by Type (Paper, Plastic, Wood, etc.)
- Proportion of Organic Waste from Food or Yard waste
- Percentage of Residential or Commercial Waste
- Waste Management Method by Waste Type (Recycling, Open Dump, Landfill, etc.)
- Landfill Methane Capture Rate
- Waste Facility Type (Type of Landfill, Open Dump, and Incinerator)
- Anaerobic Digester Biogas and Heat Energy End Use
- Solid Waste Collection and Transportation (Number of Trucks, Distance Traveled, and Fuel Consumption)
- Transfer Station Energy Consumption
- Percentage of Residents with Waste Collection Services

Wastewater Generation and Management & Water Conveyance Energy Data

This section asks for information on the amount of wastewater generated in your city and how it is managed, as well as how much energy is used to convey water.

- Wastewater Management Type (Percent Decentralized, Centralized, No Treatment)
- Percentage of Residents with Wastewater Collection Service
- Total Annual Water Consumed

- Water Loss Factor (Percentage of Supply)
- Fuel Types and Amounts Used
- Percentage of Residents with Access to Improved Water

Transportation Data

This section asks for information on how much energy is consumed by private vehicle transportation.

- Annual Passenger Trips per Capita
- Percentage Passenger vs. Freight Transportation
- Total Annual Vehicle Kilometers Travelled (VKT)
- Passenger Mode Share (Percentage Automobile, Motorcycle, Taxi, Moto-Taxi, etc.)

Energy and Other Costs

This section asks for information on energy costs to facilitate accurate financial analysis. As fuel costs can be more difficult to obtain, CURB provides proxy values that you can utilize if no better source of cost data is available

- Electricity Rates (For Residential, Commercial, Municipal, Industrial, and Transportation)
- Fuel Prices by Type (Natural Gas, Propane, Motor Oil, Kerosene, etc.)
- Average Wholesale Cost of Water
- Discount Rate