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City Climate Finance Gap Fund

GAP FUND TECHNICAL NOTES

URBAN GREENHOUSE GAS MODELING TOOLS

JANUARY 2022

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Urban Greenhouse Gas Modeling Tools

Gap Fund Technical Note[1]

Introduction

Why are urban greenhouse gas emissions modeling tools useful?

Urban areas are responsible for over 70% of the world's carbon emissions.[2] Actions in cities could achieve up to 40% of the emissions reductions necessary to limit global warming to 1.5 degrees C, suggesting an important role for cities in climate change mitigation.[3]

In general, the greenhouse gas (GHG) emissions in cities come from vehicles, the use of energy for heating and cooling buildings, electric lighting for streets and buildings, industrial processes, waste management, and embodied carbon in urban infrastructure.[4,5] However, the relative proportion of emissions from these sources varies based on various characteristics. For example, a city's size, population density, land use patterns, income levels, and social and cultural factors determine the mode share of private, public, and nonmotorized transportation, which in turn impacts vehicular emissions per capita. Similarly, the sources of electrical energy and heat that a city uses, the age of its buildings, and prevalent energy efficiency standards determine the contribution of buildings to emissions. These factors also determine which actions are most likely to be effective in reducing emissions in a particular city.

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[1] Acknowledgements: This note was prepared by Chandan Deuskar, with input from David Ryan Mason, Augustin Maria, and the rest of the World Bank City Climate Finance Gap Fund team. The following provided information about the tools or their application (in alphabetical order, affiliated with World Bank unless otherwise specified): Rafeef Abdelrazek, Cesar Carreno (ICLEI), Hans Dreesen (Futureproofed), Tarek El Azzouzi (Futureproofed), Andrew Fang (USAID), Andrea Fernández (C40), Lisen Follin (ClimateView), Angie Fyfe (ICLEI), Ryan Green (C40), Ellen Hamilton, Klaus Heidinger (Siemens), Max Jamieson (C40), Prashant Kapoor (IFC), Silpa Kaza, Ricardo Ochoa (CAPSUS), Poonam Pillai, Antonio Arce Romero (Futureproofed), Gayatri Singh, Lorraine Sugar (IFC), Culley Thomas (C40), Fredrik Uddenfeldt (ClimateView), Guillermo Velasco (CAPSUS), Xueman Wang, Mårten Wilkens (ClimateView), Jiang Yang (China Sustainable Transportation Center), and Eli Yewdall (ICLEI). In addition, Sandrine Boukerche, Isabel Margarita D. Cantada, Daniel Hoornweg, Noriko Oe, Duru Oksuz, Alexandrina Platonova-Oquab, Apoorva Narayan Shenvi and a team at the Global Covenant of Mayors for Climate and Energy reviewed drafts and provided valuable feedback.

[2] https://www.c40.org/why_cities

[3] C40 and Arup (2016). *Deadline 2020. How cities will get the job done - An analysis of the contribution C40 cities can make to delivering the Paris Agreement objective of limiting global temperature rise to 1.5 degrees*

[4] Carter and Boukerche (2020). *Catalyzing Private Sector Investment in Climate Smart Cities* (English). Invest4Climate Knowledge Series Washington, D.C.: World Bank Group. http://documents.worldbank.org/curated/en/179101596519553908/Catalyzing-Private-Sector-Investment-in-Climate-Smart-Cities

[5] None of the tools discussed here quantifies embodied (Scope 3) emissions, although it may be possible to include these emissions in customized applications of the tools.

Urban emissions inventories are necessary for a city to understand their *current* sources of emissions in a comprehensive and comparable manner. A separate note discusses approaches to developing such inventories. Urban GHG emissions modeling tools, like the ones discussed in this note, can help estimate the *future* impacts of various actions on emissions in a particular city. By doing so, they can help planners and policymakers to identify and prioritize investments and policy interventions that are likely to have the greatest impact on mitigating emissions, and to estimate the contribution of these actions to national and international emissions reduction targets. In terms of a city's climate action "journey," as described by the Global Covenant of Mayors for Climate & Energy (GCoM), these tools are most applicable after a city has made mitigation commitments and set carbon targets, when it is ready to identify and develop mitigation actions.[6]

Aims of this knowledge note

Urban GHG modeling tools vary in their intended uses, user interfaces, inputs, outputs, costs, etc. This knowledge note is intended as a primer, to help cities and organizations working with cities understand and select from among the tools available, based on their needs.[7] It does not endorse any one tool over others.

The selection criteria for the tools included in this note are as follows. This note:

- only includes tools that are available for use in cities in low- and middle-income countries, and therefore excludes some of the more sophisticated urban modeling tools that are only available (or have only been used) in high-income countries;[8]
- only includes tools that can be used in any country, i.e. it excludes tools that are designed for use in specific countries;[9]
- includes tools that model future emissions scenarios, not those that only produce inventories of current emissions;[10]
- excludes tools that focus on just one sector or type of mitigation action;
- excludes tools that estimate potential GHG reductions for entities other than cities;[11]

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[6] https://www.globalcovenantofmayors.org/journey/#1594376564336-552a1d5f-aad4

[7] A publication by the World Bank's Global Platform for Sustainable Cities (GPSC)—*A Review of Integrated Urban Planning Tools for Greenhouse Gas Mitigation* (May 2020)—provides a technical comparison of the modeling behind some of the tools described below, among others. It is available here. This note does not aim to replicate or summarize the information provided in the GPSC paper, but instead to provide more basic, practical information not included in that publication, for those without much prior knowledge of these tools.

[8] These include Calthorpe Analytics' Urban Footprint, ICLEI's ClearPath USA, CommunityViz, Envision Tomorrow, I-PLACE3S, UPlan, MetroQuest, or others.

[9] These include AKSARA (Indonesia), BEST Cities and Urban-RAM (China).

[10] These include ICLEI's ClearPath Global and C40's CIRIS tool.

[11] E.g. LEAP

- focuses on tools relevant for climate mitigation, not adaptation or other co-benefits (lower infrastructure costs, less land consumption, etc.); and
- includes both free and paid tools.

The annex lists 59 tools identified in a survey of the urban GHG modeling tools landscape conducted by the Global Covenant of Mayors for Climate & Energy (GCoM), together with Bloomberg Associates and World Resources Institute. The annex also explains briefly why each tool was included or excluded from this note.[12]

The tools described in this note are:

I. APEX, developed by IFC, which evaluates various impacts of actions related to the built environment, transportation, solid waste, and water/ wastewater;

II. City Performance Tool (CyPT), developed by Siemens, which evaluates various impacts of actions related to buildings, transportation, and energy;

III. ClimateOS, developed by ClimateView, which evaluates the impacts on emissions and other outcomes of actions related to transportation, building energy, industry, energy, and waste;

IV. CURB, developed by the World Bank in partnership with AECOM Consulting, Bloomberg Philanthropies, Global Covenant of Mayors for Climate and Energy, and the C40 Cities Climate Leadership Group, which evaluates emissions and energy consumption impacts and financial costs of actions related to buildings, transportation, solid waste, water/wastewater, and electricity generation;

V. FutureproofedCities, developed by Futureproofed, which evaluates the emissions mitigation, risk adaptation, and financial impacts of actions related to buildings, transportation, waste, water, electricity generation, and other sectors;

VI. Pathways, developed by C40, which evaluates the emissions impacts of actions related to building energy, transportation, solid waste, and water/ wastewater;

VII. RapidFire, developed by Calthorpe Analytics, which evaluates various impacts of actions related to spatial planning and transportation; and

VIII. Urban Performance, developed by the World Bank and CAPSUS, which evaluates various impacts of related to spatial planning, transport, waste, and energy.

The next section describes these tools in detail. The table in the appendix compares key aspects of the tools.

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[12] GCoM, Bloomberg Associates, and WRI (2021). "Understanding data and tools to accelerate city climate action: A Decision-making and Tools Project White Paper." https://www.globalcovenantofmayors.org/press/understanding-data-and-tools-to-accelerate-city-climate-action/

Tools

APEX (Advanced Practices for Environmental Excellence in Cities)

APEX has been developed by the IFC (International Finance Corporation), part of the World Bank Group. Its focus is on estimating the impacts and costs of actions related to the built environment, transportation, solid waste, and water/ wastewater. The tool estimates the impacts of these actions in terms of GHG emissions, fossil fuel energy use, private fossil fuel vehicle travel, unmanaged/landfill waste, water consumption, and investment cost. The tool is still relatively new, but it has been applied in a few pilot cities, including Ekurhuleni (South Africa), Ahmedabad (India), Ho Chi Minh City (Viet Nam), and Almaty (Kazakhstan), to prioritize investments and policy measures in one or more of these sectors. Brief information on these cases is available on the APEX website's home page.

APEX builds on a previous World Bank tool known as CURB (see below). According to IFC, APEX has additional features for smart investment planning, including a list of the most effective green measures and capital costs that cover planning, policy and investment options. It also adds built-in calculations to give city-specific results for green measures and display of co-benefits in terms of cost savings, air quality improvements and job creation. While CURB can be downloaded and used offline in Excel, APEX has an online interface (which is modeled on that of EDGE, IFC's building energy efficiency tool).

How APEX works

The APEX tool is available here. APEX allows a user to choose a specific city from among 300+ cities around the world which come with pre-loaded baseline values based on available data. These cities include all cities in OECD countries with populations greater than 1 million and all cities in other countries with populations greater than 500,000. This allows basic users working on these cities to start using the tool without needing to have any input data of their own. Users also have the option to override the pre-loaded baseline values with their own data.

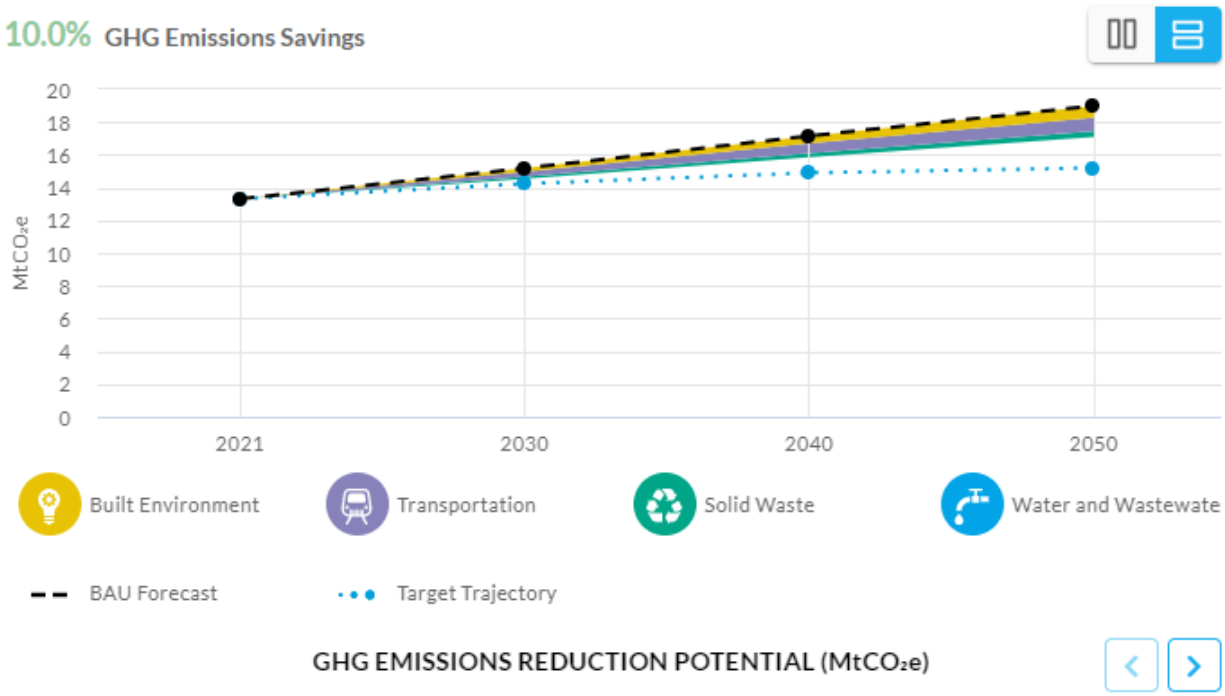
To create a scenario, the user starts by selecting a start year, final year, and emissions reduction target in percentage terms. The tool displays graphs showing the emissions in the selected city from the four sectors (built environment, transportation, solid waste, and water/ wastewater) in the start year, and compares its per capita emissions it to other cities. It tabulates city data along various metrics for the start year and projections for the final year assuming business as usual.

Users can then select from over 100 potential actions related to the four sectors. They can also manually enter an implementation level for most (e.g. number of stations or kilometers for a transportation measure, share of buildings for a built environment measure), or use default values. Graphs show the combined emissions impact of these measures and compare the trajectory under the user-defined scenario with a business-as-usual trajectory and with user-defined reduction targets. There is no explicit spatial component in APEX, although among the actions for which users can estimate the transportation-related emissions impacts is the densification of city areas.

The APEX models use elasticities based on international case studies, from diverse income groups and city types, where possible.

Figure 1: Screenshots from the transportation module of APEX

Figure 2: Screenshot from APEX, showing the extent to which user-selected actions in four sectors help achieve target emissions reductions by a user-defined year



Working with APEX

An example city is publicly accessible without a user account for demonstration purposes, though scenarios cannot be saved or shared. In order to access the database of 300+ cities, a user must request a free account by filling a form, and when the account is approved, the user can access the complete city database and can save and share scenarios. Basic users can adjust input data and implementation level for actions. Advanced user access is required for customizing underlying assumptions and implementation timelines. (Note that as of early 2022, APEX is still under development and account registrations are being activated for only a few users. After the official public launch of the tool, tentatively planned for November 2022, the APEX team will open up registrations to the general public, and the basic version of the tool will be free for all users to use on their own.)

The IFC APEX team offers two main types of direct collaboration with client cities, both of which build on the insights and outputs of the APEX software: Climate Action Plan (CAP) & Climate Investment Opportunities Diagnostics (CIO).

- The Climate Action Plan costs between USD 50,000[13]-85,000 per city and takes about 4-6 months, depending on the local situation. The IFC APEX team provides hand-holding project coordination assistance, supports data collection, and carries out meetings and workshops

[13] IFC is currently developing a scalable and more affordable approach for developing CAPs and CIOs via a third-party support process to enable decentralization and upscaling of APEX deployments to more cities.

with the help of local consultants. The APEX team produces draft and final Climate Action Plan reports with a 'roadmap for ambition, acceleration, and delivery.'

- Climate Investment Opportunities Diagnostics (CIO) cost between USD 30,000-50,000 per city and take at least 3 months. Based on insights from the APEX software and existing climate action scoping (action plans, carbon inventories), the team undertakes an opportunity prioritization based on costs, payback, GHG emissions, and feasibility. The APEX team produces a draft climate investment plan covering analysis and prioritization of potential investments across different urban sectors.

Alternatively, the APEX team has a specific offering for projects supported by the Gap Fund and/or led by other World Bank teams. The World Bank team takes responsibility for data collection, client engagement, and action selection, while the APEX team provides technical assistance and analytical support for using the APEX software. The cost is approximately USD 40,000 based on a 4-month delivery timeline. The output is a Skeletal Action Plan, a basic factual report including the APEX results and essential information on each selected measure. The World Bank team then adds further city context and implementation strategies to complete the Climate Action Plan (CAP) or Climate Investment Opportunities Diagnostic (CIO) report.

For more information about APEX, contact Prashant Kapoor (pkapoor1@ifc.org) or Lorraine Sugar (lsugar@ifc.org) at IFC.

Summary

- APEX focuses on the emissions impacts of actions in the built environment, transportation, solid waste, and water/ wastewater.
- Options for using APEX vary. Users may work with IFC or other World Bank Group teams to lead local data collection and the production of a full, customized analytical report. Following the public launch of the tool, users will also have the option of using a free online tool based on pre-loaded city data to quickly estimate the emissions impacts of various scenarios.

City Performance Tool (CyPT)

CyPT, developed by Siemens, estimates the impacts of 70 different actions related to buildings, transport, and energy on a range of urban outcomes, including GHG emissions, air pollution, jobs, and capital and operating expenses related to the actions. CyPT has been used in 40 cities in Europe, Asia, and the Americas. An example of a city in a middle-income country that Siemens has conducted a CyPT analysis for is Mexico City.

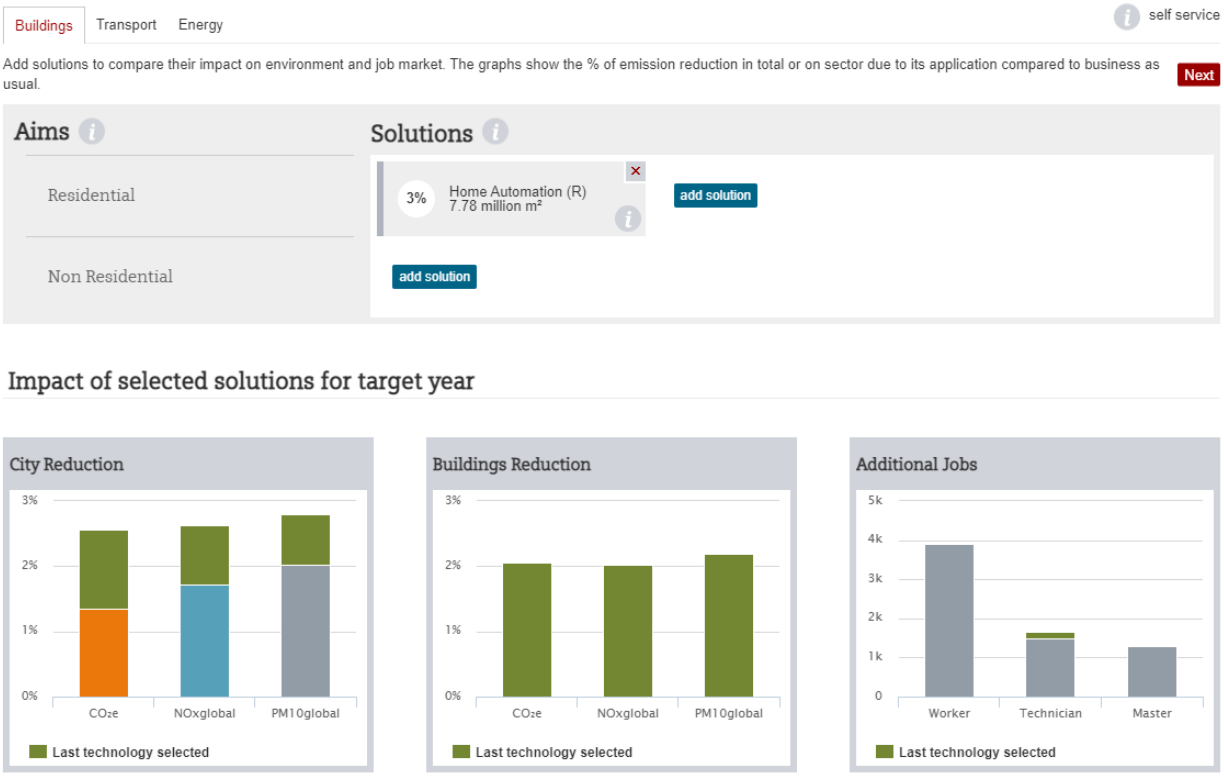
How CyPT works

CyPT has a freely accessible online version, available here, in addition to a paid version customized by Siemens for a specific city (see next section). The free version allows the user to choose a city type by selecting among the options provided for region, energy mix, transport modal split, and building pattern, and entering a city population. The user then selects which actions to adopt and chooses from among three implementation levels for each action. The tool produces graphs

showing the estimated impact of these actions on GHG emissions, air quality, and jobs (see Figure 3). They also compare the emissions and air quality impacts to a business-as-usual scenario and to city targets entered by the user. The user can export the results as a report in PDF format. Unlike Urban Footprint and RapidFire, there is no explicit spatial component in CyPT, which means that no maps or other spatial data on urban form are generated.

The model uses elasticities based on international standards, regional studies, and Siemens' own technology implementation projects.

Figure 3: Screenshots from CyPT



Create PDF Next

Projected Environmental Results	Today	2020	2025	2050
Greenhouse Gas Emissions [Mt CO_2e per year]				
City Target	3.13	3.19	3.28	3.69
with applied technologies	3.13	2.82	2.66	1.57
	3.13	3.16	3.19	3.44
Air Quality [kt NOx per year]				
City Target	0.45	0.45	0.46	0.5
with applied technologies	0.45	0.4	0.38	0.22
	0.45	0.45	0.44	0.47
Air Quality [kt PM10 per year]				
City Target	6.09	5.86	5.75	6.3
with applied technologies	6.09	5.48	5.18	3.05
	6.09	5.81	5.6	5.93
Additional Jobs [FTE accumulated]		1,100	7,000	51,500

Year

2050

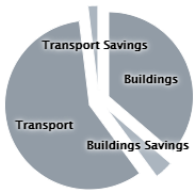
Greenhouse Gas Emissions [Mt CO_2e per year]

Buildings		2.17
	Savings:	0.20
Transport		1.27
	Savings:	0.04
Energy		
	Savings:	0.00

Air Quality [kt NOxglobal per year]

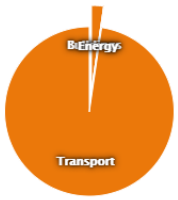
Buildings		2.95
	Savings:	0.27
Transport		2.98
	Savings:	0.10
Energy		
	Savings:	0.00

Air Quality [kt PM10global per year]



Buildings		0.18
	Savings:	0.02
Transport		0.29
	Savings:	0.01
Energy		
	Savings:	0.00

Additional Jobs [FTE accumulated]



Buildings	1,200 Jobs
Transport	50,500 Jobs
Energy	0 Jobs

Working with CyPT

The basic online tool can be used for free in a web browser without the need to create a user account. For a fee, Siemens can customize the analysis to use city-specific data, provide a wider set of actions, modify the assumptions and level of implementation as needed, and perform the analysis on behalf of the city. The cost depends on the scope of the analysis, the actions selected, and the number of scenarios being analyzed, but can range from approximately USD 50,000 to USD 150,000. Cities usually require 3-6 months to gather data, with building data being the most time-consuming.

For more information about CyPT, contact Klaus Heidinger (klaus.heidinger@siemens.com) at Siemens Advanta.

Summary

- CyPT's focus is on building, transport, and energy technologies rather than urban spatial form.
- CyPT's free online tool allows a user to perform rapid, basic analysis and produce rough numerical estimates and graphic outputs quickly and at no cost, although it is advisable to check whether the underlying assumptions in the model apply to the city in question. Alternately, cities can hire Siemens to produce customized analysis using a much more comprehensive version of CyPT.

Climate Action for Urban Sustainability (CURB)

CURB was developed by the World Bank in partnership with AECOM Consulting, Bloomberg Philanthropies, Global Covenant of Mayors for Climate and Energy, and the C40 Cities Climate Leadership Group in 2016. It has been used in cities around the world, including Buenos Aires (Argentina), Quito (Ecuador), multiple cities in India, Johannesburg (South Africa), Bangkok (Thailand), and Oakland (USA).

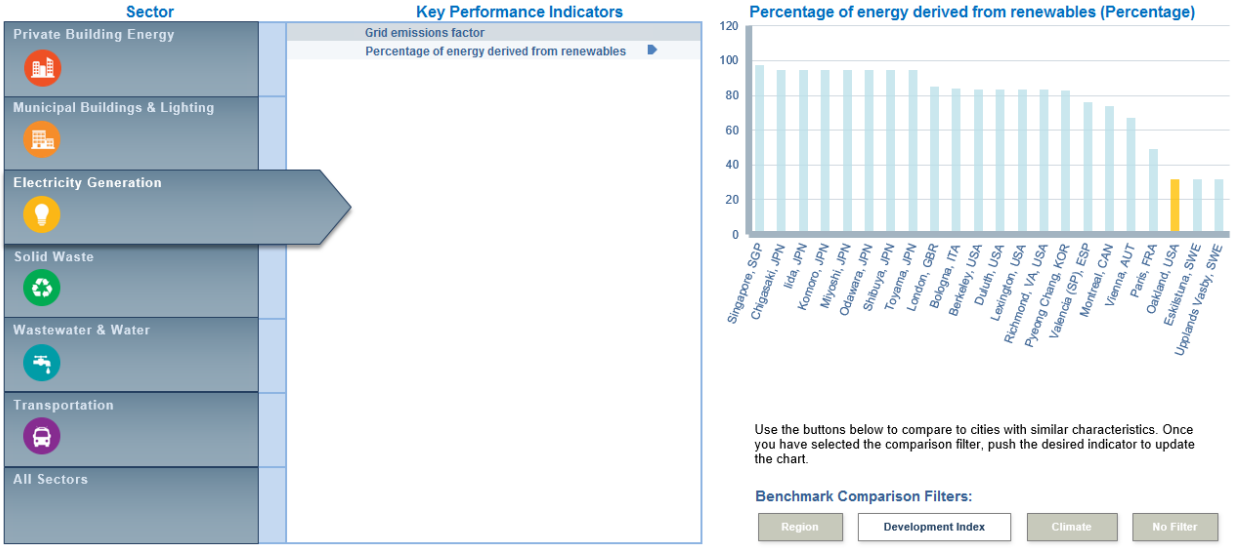
CURB is not currently being updated or actively maintained, but continues to be available for free download online, along with documentation and video guides. IFC's APEX and C40's Pathways tools build on CURB and can be considered the "next generation" of the tool. However, this note includes CURB because, in certain circumstances, cities may still find CURB to be the best option, e.g. if it is not feasible for a city to work with IFC to use APEX or with C40 to use Pathways, or if baseline data for the city in question is already pre-loaded in CURB and not in APEX.

How CURB works

The CURB tool, in the form of an Excel file, as well as training documents and videos on the use of the tool are available here. Users begin by entering data about the city into the tool. A city may upload an existing emissions inventory, if available. If not, the tool includes pre-loaded baseline data for 200-300 cities for some data points (last updated in 2016). It also includes national or regional proxies for other data points or for cities not included in the database. Based on these data, the tool generates an inventory and produces a range of charts comparing the sources of emissions and

energy use by sector and comparing these to other cities (Figure 4). The methods used in CURB comply with GPC/IPCC methodologies.

Figure 4: Benchmarking city performance in CURB



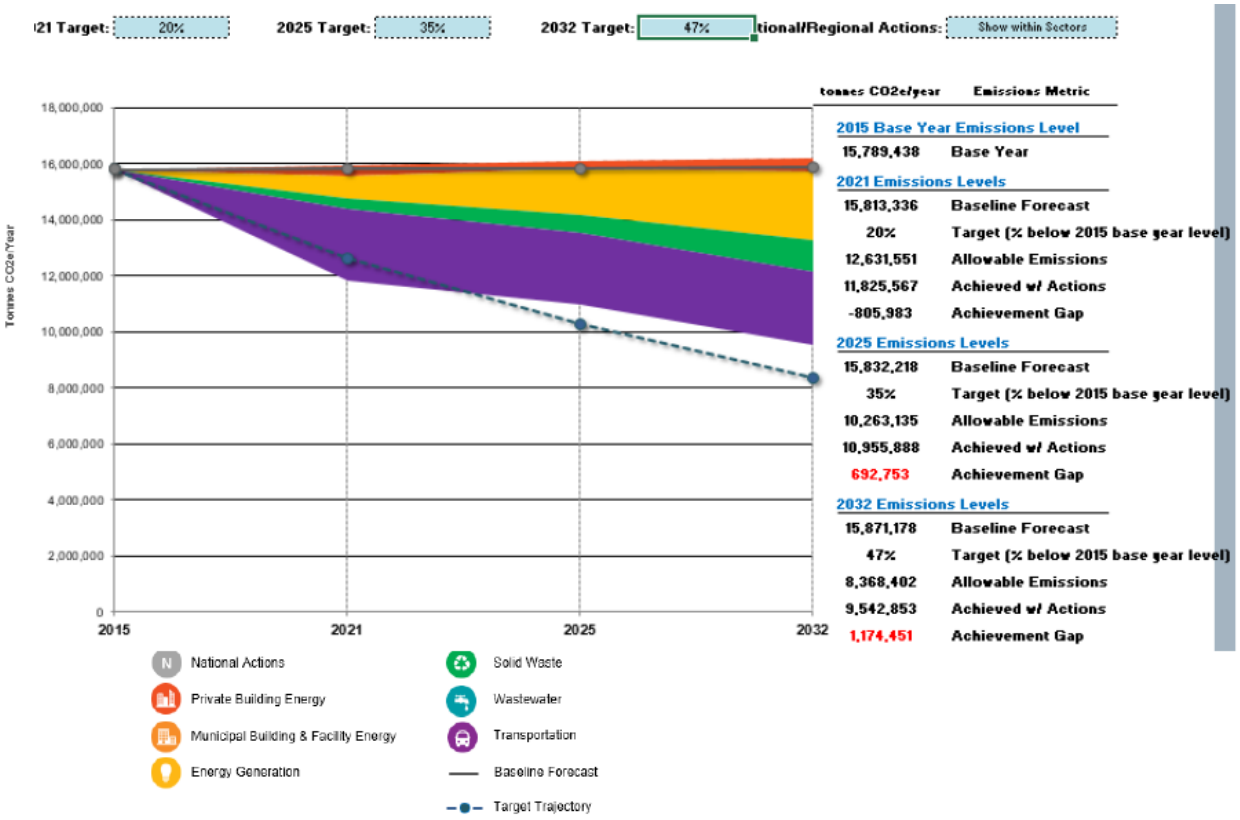
Source: CURB 2.0 User Guide

Users set goals for emissions or energy use in their city for a target year of their choice. They then create scenarios by selecting actions from a pre-defined list of 68 common actions. These actions are oriented towards a range of cities and income levels, including actions relevant to low-income cities, e.g., slum upgrading, moving from open burning of waste to improved management. For each action, users also specify how much authority the city has over the implementing the action. They can also customize the action, e.g., by specifying the area over which the action will be implemented, or public adoption rates of actions. The actions are categorized into private building energy (36 actions), municipal building and public lighting (11 actions), electricity generation (one action, i.e., grid decarbonization), solid waste management (7 actions), water and wastewater (10 actions), and transportation (3 actions). The tool also lists the co-benefits associated with each action. The tool helps users select actions by characterizing the level of city authority (based on user input), technical difficulty, implementation cost, payback cost, and emissions reduction potential, each as low, medium, or high.

The tool then displays the cost and impact on emissions and energy use for each action as well as for all the actions selected in the scenario combined. It does so both numerically and graphically, including in the form of an emissions abatement cost curve and a "waterfall" chart. Users can save and compare the results of different scenarios.

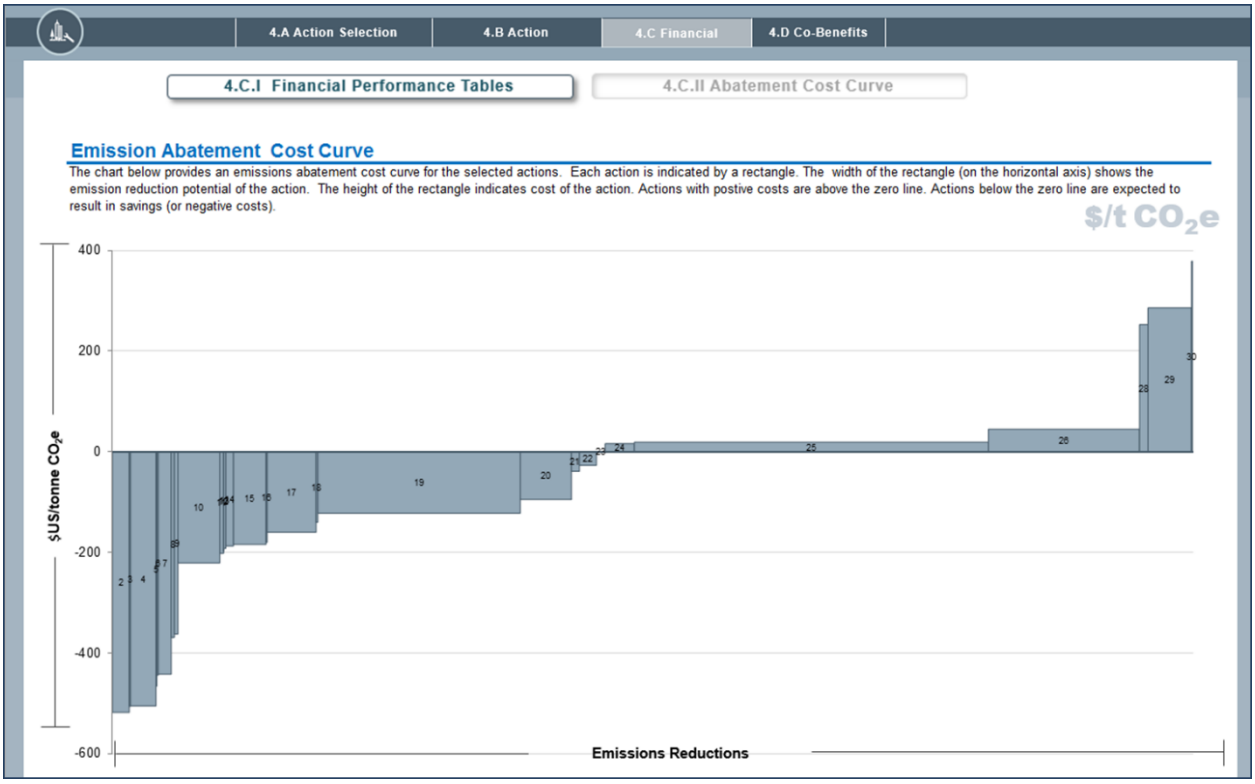
Users can view and modify the assumptions used in the modeling of emissions and energy use (but not costs).

Figure 5: Emissions reductions over time by sector, an output in CURB



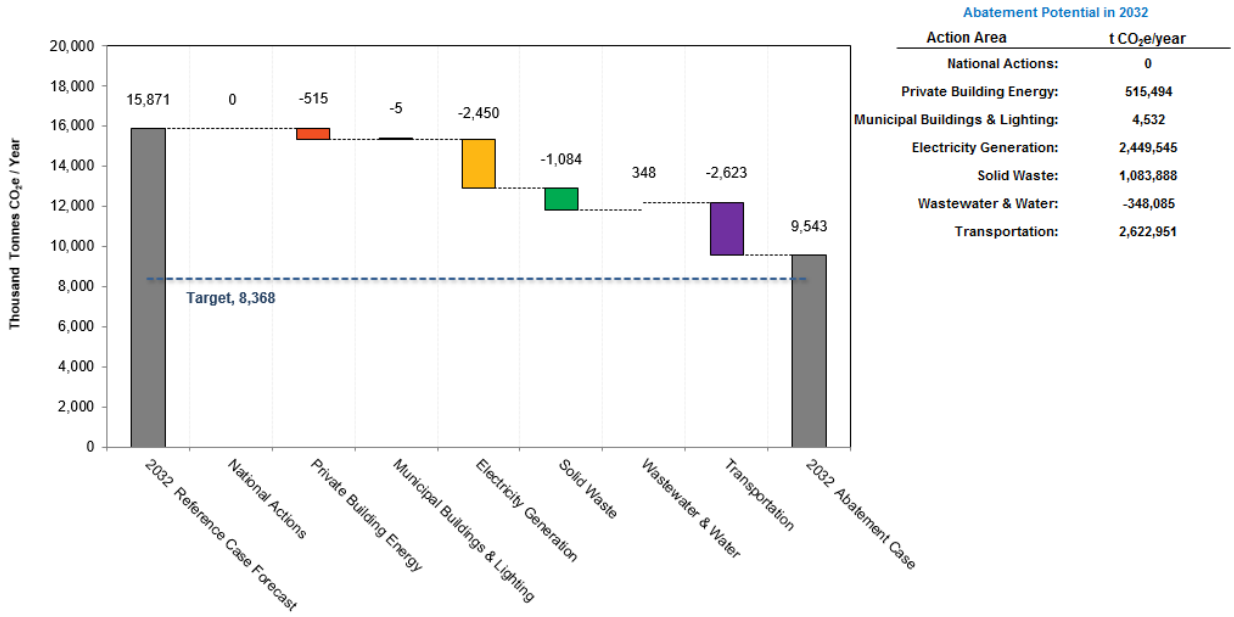
Source: CURB 2.0 User Guide

Figure 6: The emissions abatement cost curve in CURB



Source: CURB 2.0 User Guide

Figure 7: The "waterfall" chart in CURB



Source: CURB 2.0 User Guide

Working with CURB

The CURB tool is available for free download, and was designed to be simple enough to require little or no external consulting costs. However, cities may choose to hire experts depending on local data and resource availability within individual cities. The time required to run CURB depends on the extent of analysis required and may range from a few hours to a week, excluding internal coordination and data collection. Once analyses are complete, cities may use CURB on an ongoing basis for progress monitoring and other communications-related activities.

For more information about CURB, email curb@worldbank.org.

Summary

- CURB is a free tool, designed to be used by local governments with limited support from external consultants.
- CURB includes pre-loaded baseline data for hundreds of cities and proxy data for others.
- CURB is no longer being maintained, but is still available for use and in certain circumstances may be the best tool for a city's needs.

ClimateOS

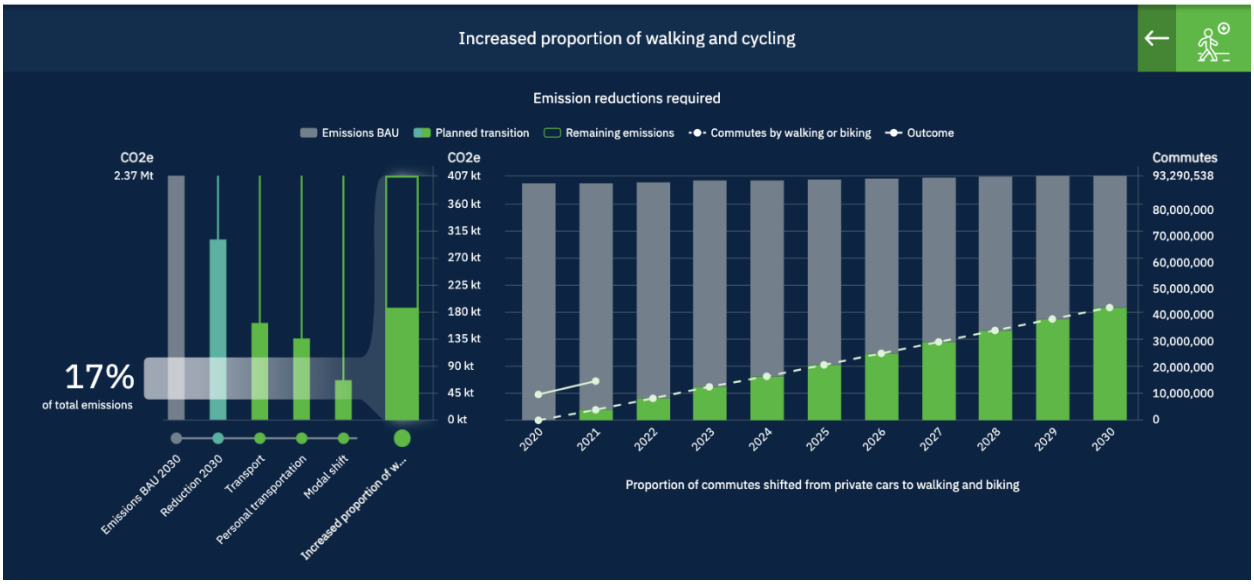
ClimateOS is an online platform developed by ClimateView, a firm headquartered in Stockholm, Sweden, with staff in five other countries. It is currently working with around 70 cities in Western Europe and North America, but it aims to expand to other regions, including low- and middle-income contexts.

How ClimateOS works

ClimateOS allows a city to develop or modify a climate action plan, monitor progress, and make the plan available to the public through an interactive website to facilitate stakeholder engagement. The platform's main output is a climate action plan presented in a dynamic dashboard that can also be made public (Figure 8). The dashboard displays the city's emissions for the target year based on a business-as-usual trajectory, the city's target emissions for that year, and the emissions reductions resulting from the actions selected so far. Users can click on a sector to look at subsectors, "shifts", and actions. For example, the transportation sector includes personal mobility and freight transport subsectors. Personal mobility includes "modal shift" among its shifts, which in turn includes three actions. There are over 100 of these actions ("Transition Elements") in the platform. A forthcoming version of the platform will allow users to create customized actions. ClimateOS does not focus on spatial planning, although its actions include changes to residential density.

Figure 8: ClimateOS plan visualization

Figure 9: ClimateOS dashboard – example of an emissions trajectory associated with a specific action (increased proportion of walking and bicycling)



The platform further helps cities to build this plan by setting targets, simulating cross-sectoral emissions reduction trajectories ("pathways"), designing action programs and visualizing relationships. Users can evaluate different scenarios by interacting directly with graphs by clicking and dragging sliders, which dynamically shows the effect on emissions (Figure 10). This models the interconnected impacts of decisions using an agent-based model. For example, if the user increases the transition from driving to walking, the remaining potential emissions reduction from a transition from driving to public transport shrinks accordingly. If certain actions are associated

with new emissions, e.g., the emissions from grid energy associated with an increase of electric vehicle use, these are indicated in the graph as well.

Figure 10: Editing emissions trajectories in ClimateOS

The platform also calculates the costs and other resource requirements associated with the selected actions. For example, the platform can calculate the total need for a given resource, such as biofuel or electricity, arising from the actions selected in the plan. It can also calculate co-benefit impacts, such as reduced air pollution.

The model uses data entered in the inventory section, which is GPC/IPCC compatible (a forthcoming version will include more protocols). This inventory can be for Scope 1, 2, or 3 emissions. It can be exported in a format that allows the city to comply with emissions reporting and disclosure requirements, for example disclosing to the Carbon Disclosure Project. The modeling in the tool is based on data entered into this inventory. (The next section discusses data collection.)

The elasticities and assumptions ("carbon causal chains") used in the model are visible to the user, along with references for sources. The user can also edit these assumptions. Edits are logged, and users can leave comments for other users, to aid collaboration.

The tool also includes functions which allow users to monitor progress through targets and indicators, including a "transition score."

Working with ClimateOS

A free version of ClimateOS can be used by up to two users per city. The free version includes all the data management, reporting, scenario building and action creation tools needed to understand how the city can meet its Paris Agreement obligations. Several features are not available in the free

version, including the ability to add additional users, publish the plan visualization externally, cost and co-benefit calculations, and access to workshops and live chat support from the ClimateView team beyond email support. The first "Collaboration" upgrade requires an annual subscription fee of between USD 15,000 and 150,000. The exact fee depends on a city's requirements in terms of user numbers and support.

Currently, pre-populated data inventories are only available in certain wealthy countries (Sweden, Germany, the United Kingdom, and soon also Spain and the United States). For cities in other markets with a paid subscription, ClimateView provides dedicated support to locate the best-available public data resources for the city in question. However, as ClimateView is a technology company rather than a consulting firm, it is not involved in on-the-ground data collection.

Depending on local capacity and preparedness, cities require a minimum of 6 weeks to produce an initial plan and can then work in the platform on an ongoing basis to finetune, co-create, and update scenarios, as well as track progress.

For more information about the ClimateOS platform, contact Lisen Follin at ClimateView (lisen@climateview.global).

Summary

- ClimateOS is designed for city-wide climate planning and decision-making with modeling and planning of mitigation of actions and associated costs, as well as for monitoring, collaboration, and public engagement.
- The tool has only been used in Europe and North America so far, but ClimateView aims to work with cities in all regions.
- It has an interactive graphic interface designed for non-specialist users.
- It is available as a free version or through an annual subscription.

FutureproofedCities

FutureproofedCities (FPC) is an online tool developed by Futureproofed, a firm based in Leuven, Belgium. Futureproofed launched the tool in 2017 and since then has worked with over 140 municipalities in Europe. As of September 2021, it was beginning a collaboration with WWF (World Wide Fund for Nature, also known as World Wildlife Fund) on their One Planet City Challenge. Cities selected to participate in this program, which are expected to include dozens of cities around the world including in Latin America, East Asia, and elsewhere, will get free access to the FPC tool.

How FutureproofedCities works

FPC has four main pillars: climate action plan development, monitoring and tracking of progress, peer-to-peer collaboration, and citizen participation. As this note focuses on modeling of climate impacts, it will focus on FPC's climate action planning pillar. When a city signs up for FPC, the

Futureproofed team works with the city to train users. This has been done in person for European cities, but will be conducted remotely for global cities.

At a minimum, the tool requires data on local energy consumption per sector and fuel type. Additional local data, such as emission factors and energy efficiency figures of climate measures, are helpful if available. If not, national or regional proxies can be used instead. While the FutureproofedCities team does not directly collect data on behalf of cities, it supports the cities in identifying publicly available proxies. Futureproofed offers free access to emission data for 95,000 areas within the European Union via the open-source platform Launchpad, but the Futureproofed data infrastructure can also support data for countries outside Europe.

Users can create a climate action plan by choosing from among 100+ pre-defined actions ("measures" in the tool's terminology). Futureproofed evaluates and updates the list of pre-defined actions on an annual basis, and users can also create their own. Each measure can be linked to steps ("actions" in the tool's terminology) for the purpose of monitoring progress. Users can divide the plan into districts or other sub-plans ("structures" and "clusters" in the tool's terminology), each with different sets of measures selected. The tool estimates the impact of these actions on CO2 emissions, as well as their financial costs and returns (Figure 11). It displays these estimates in the form of an abatement curve (Figure 12) and other charts. It also identifies the co-benefits of measures, categorized according to the Sustainable Development Goals, and evaluates their impact qualitatively as low, medium, or high. Users can create reports in the tool and export them as PDFs.

Figure 11: A feature in the FutureproofedCities tool showing selected measures, their financial and CO_2 savings, and progress towards their implementation

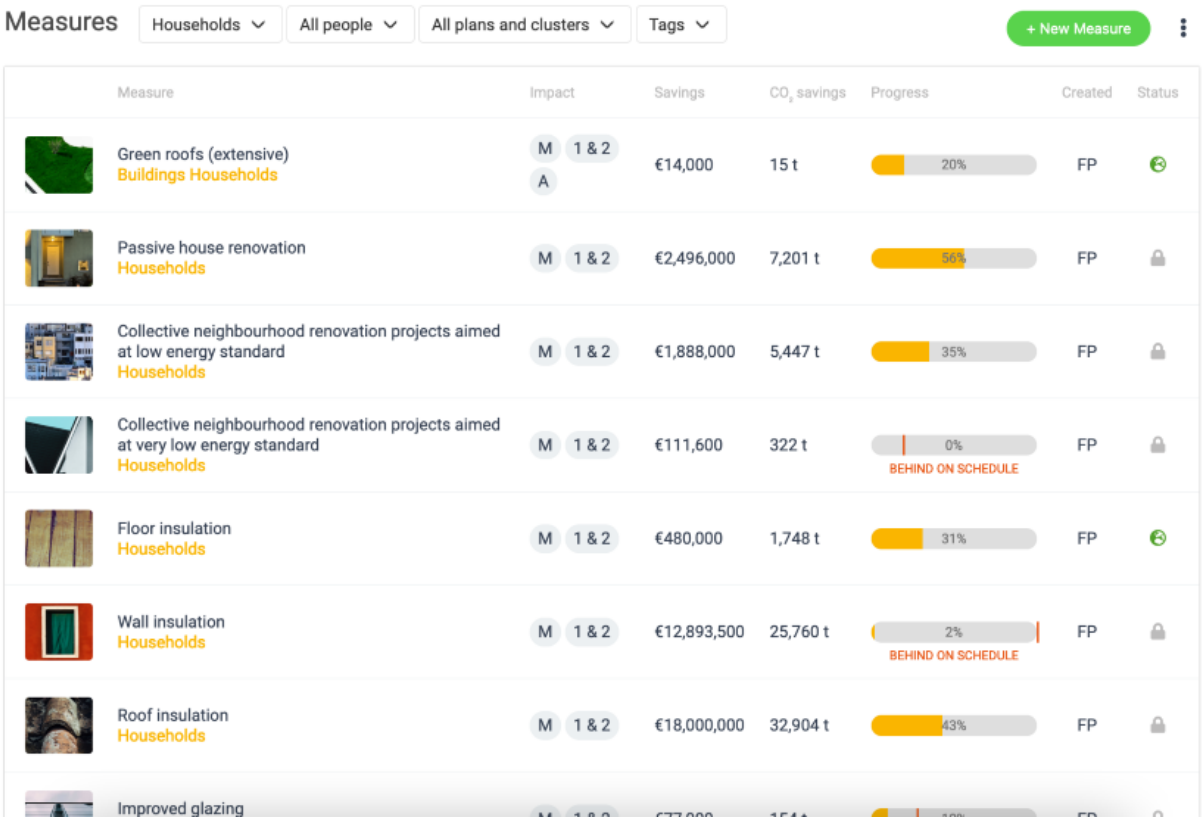
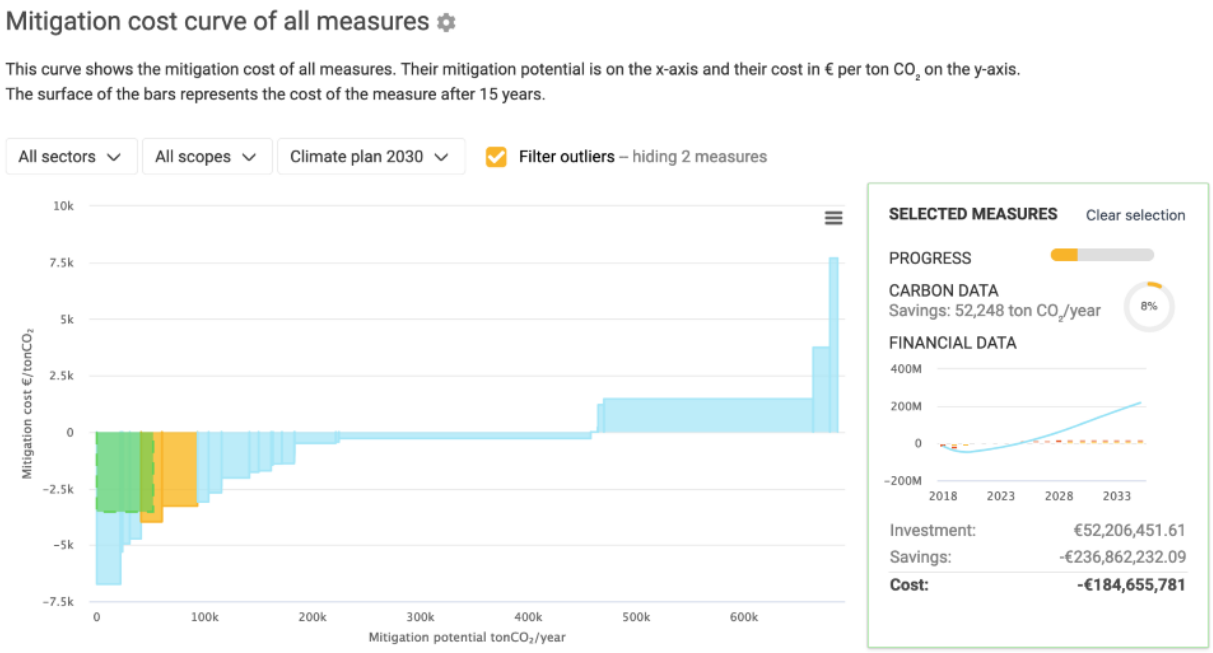


Figure 12: Abatement cost curve generated in the FutureproofedCities tool



Working with FutureproofedCities

FPC is available by subscription. Cities can choose one of three plans, which are described in Table 1. In US dollars, the annual plan costs are approximately USD 5,900 (Essential), USD 11,000 (Standard), and USD 16,200 (Expert). Following the launch session, municipal staff usually require one or two months to become familiar with the tool. Cities are likely to require 1-2 months to create a first draft plan, and another 2-3 months to fine-tune and finalize it with inputs from various departments. Once the plan is finalized, Futureproofed recommends that city staff spend between two hours and one day per week working with the tool to keep it updated for monitoring and collaboration purposes.

Table 1: FutureproofedCities subscription plans

	Get your plan started **Essential** 5.000 € / year	Move your plan forward **Standard** 9.400 € / year Most Popular	Further advance your plan **Expert** 13.800 € / year
Plan Overview	•	•	•
Catalogue of measures and actions	•	•	•
Dedicated launch session	1 session	1 session	2 sessions
Export detailed reports	•	•	•
Access to the global user community	•	•	•
Simultaneous Users	Up to 7 internal users	Unlimited internal users	Unlimited users (int. + ext.)
Analytical Features	Basic	Advanced (Financial, etc.)	Advanced (Financial, etc.)
Internal structures	Up to 2 Plans	Unlimited number of plans	Unlimited number of plans
Benchmark with other cities	-	•	•
Public Page	-	•	•
Impact in co-benefits	-	•	•
Pre-filled with your climate plan	+900 €	+900 €	•
Extra day of coaching	+900 € / day	+900 € / day	2 days
Customisable public pages	-	-	•
API to connect with other tools	-	-	•

Source: Futureproofed

For more information about FutureproofedCities, email Tarek El Azzouzi, Head of International Development, at tarek@futureproofed.com.

Summary

- FPC is designed for modeling and planning of mitigation of actions and associated costs, as well as for monitoring, collaboration, and public engagement.
- The tool has only been used in Europe so far, but it will soon be applied to cities in other regions.
- It is available through an annual subscription.

Pathways

Pathways is a scenario modeling tool developed by C40 as part of a set of tools aimed at helping cities prepare Climate Action Plans. The other tools are (1) CIRIS, used to develop GHG inventories which can be used as an input into Pathways; (2) ASAP (Action Selection and Prioritization), which supports decision-makers by scoring actions based climate mitigation, climate adaptation, climate co-benefits, and feasibility, using outputs from Pathways as inputs; and (3) the Integrated Impact Assessment Tool, which quantifies project-level emissions.

As of April 2021, Pathways had been used in 36 cities, mostly as part of the C40 Climate Action Plan (CAP) process. These include 12 Sub-Saharan African cities, 10 Latin American cities, 5 cities in the East Asia & Pacific region, and 3 cities in South Asia. The tool is intended not only for technical analysis but also for engagement with stakeholders through bottom-up data collection and workshops.

How Pathways works

Like APEX, Pathways is also a spreadsheet tool based on CURB. However, unlike APEX, it is an offline tool. The tool uses data from the city's emissions inventory, compiled using C40's CIRIS tool, and the Pathways data collection sheet. The fact that Pathways is a bottom-up modelling tool based on the city's own GHG inventory differentiates it from other city-level modelling tools which start with top-down assumptions. The data collection sheet requires data on the city's size, population growth, income growth, and detailed technical data on building energy, electricity, solid waste, water, and transport. There are pre-loaded estimates for some but not all these inputs.

Users may select up to three horizon years, e.g. 2030, 2050, 2060. Users can model up to 6 different bottom-up GHG scenarios in Pathways. C40 recommend three scenarios: (1) a business-as-usual scenario, (2) one that takes into account existing and planned measures, and (3) the most ambitious feasible scenario. Users may also choose to evaluate an optional fourth scenario, which calculates emission reductions in a future with none of the barriers the city faces in reality. Some cities have used scenarios to demonstrate the impact of a specific action, e.g. mini-grids for informal housing or national action on grid decarbonization.

Users define these scenarios by choosing up to 36 pre-defined actions related to electricity generation, building energy, industrial energy, transportation, urban planning (transit-oriented development), and waste (see Table 2). Each action can be set at preset 'current trend', 'moderate', or 'maximum' levels, but the actions are also highly customizable, with each action being linked to a detailed customization page. If potential emissions reductions are known that will result from other actions that are not included in the list, users may enter these reductions directly.

Table 2: Actions available in C40 Pathways tool

Electricity Generation	**Building Energy**	**Industrial and Other Stationary Energy**	**Transportation**
• Distributed renewables • Grid decarbonization	• New construction - efficiency • Building envelope - retrofits • Space cooling - efficiency	• Industrial - fuel switch • Industrial - efficiency • Water delivery/treatment - efficiency	• Mode shift - walk/bike • Mode shift - transit • Passenger vehicle - fuel switch/efficiency • Transit vehicle - fuel switch/efficiency

	• Space heating - efficiency/fuel switch • Water heating - efficiency/fuel switch • Cooking - fuel switch • Lighting - efficiency • Equipment - efficiency • Informal settlement energy • Other building energy reductions		

Urban Planning	**Waste**	**Residual Emissions**
• Transit oriented development	• Recycling • Composting • Anaerobic digestion • Landfill gas capture • Wastewater treatment • Other waste reductions	• Offsets • "Wait and see"

The tool produces several graphs and tables that show the emissions reductions that would result from these choices, including the overview graph shown in Figure 13. It also includes a 'remaining emissions' graph (Figure 14) and table, which helps to identify priority areas for reaching carbon neutrality, broken down by fuel and source. C40 also has a template that specifies how the graphs and tables produced in the tool can be used in a report.

Figure 13: Example of graph showing the emission reduction potential of selected actions from the C40 Pathways tool.

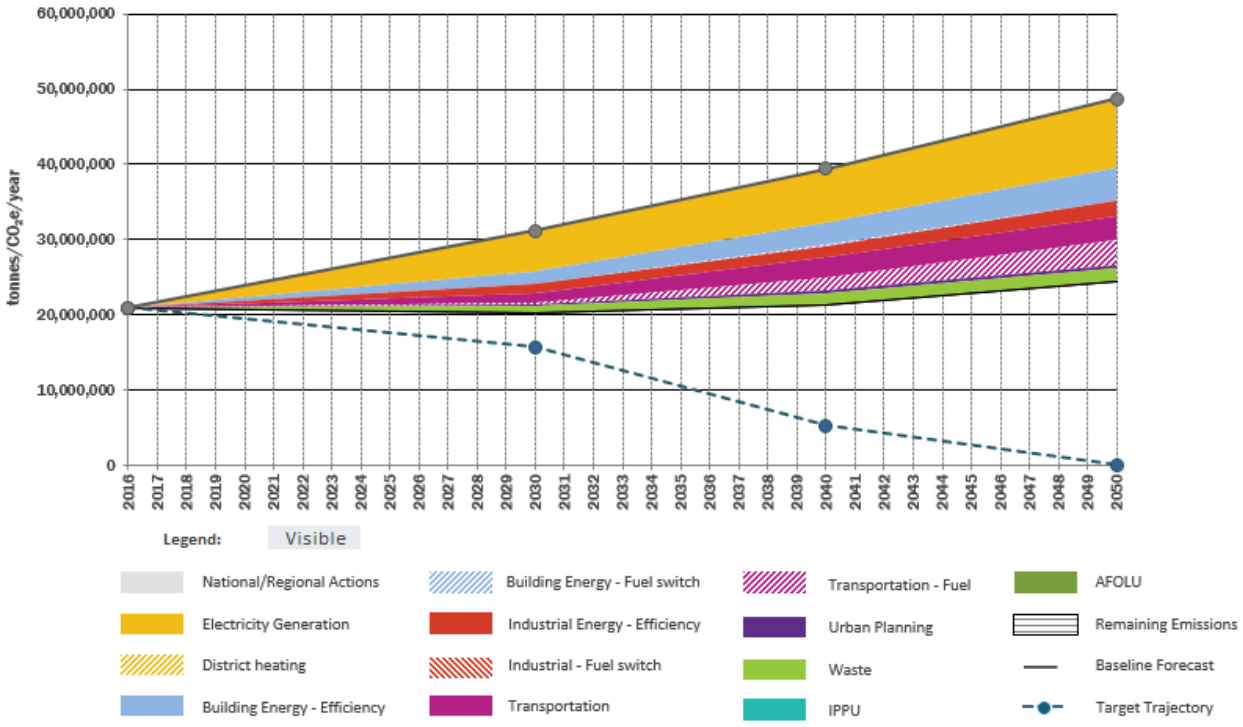
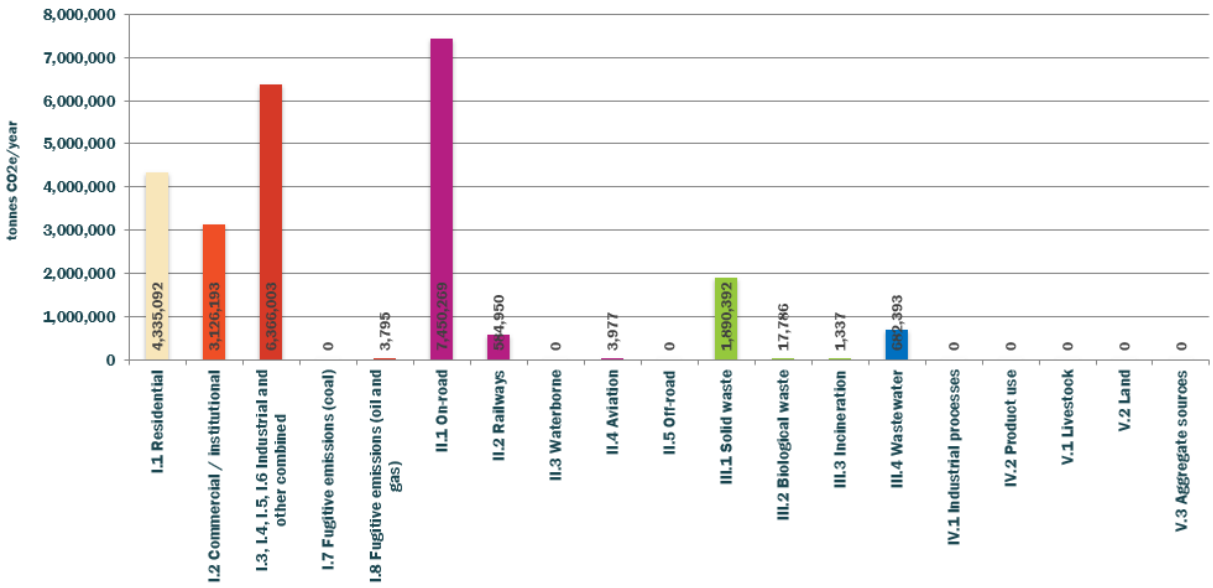


Figure 14: Example of graph showing a city's remaining emissions after the implementation of actions selected in the C40 Pathways tool.



Working with Pathways

So far, Pathways has mainly been used as part of the CAP process. While Pathways is not currently available publicly, C40 intends to make it available on request for potential use beyond C40's CAP process. For now, the use of Pathways depends on technical support from C40 to ensure correct setup and calibration. Cities also need to hire local or international consultants to collect and input data. Consultants require some familiarity with Nationally Determined Contributions and emissions targets. During the CAP process, consultants are usually hired to handle the data collection for both the emissions inventory using CIRIS and the scenario modeling using Pathways. C40 staff are responsible for loading the data into the tool, conducting workshops, validating assumptions, and providing other technical support.

The time taken to run the tool varies based on data availability. With fully available data, the analysis can be completed in two weeks. However, the entire process of data collection and stakeholder consultation through 2-3 workshops may take between two months and a year, depending on the depth of stakeholder engagement across city agencies.

For more information about Pathways, contact C40's CAP tools team at toolshelp@C40.org.

Summary

- Pathways is designed to be used as part of the C40 Climate Action Plan process, with technical support from C40.
- It has been used by cities in all world regions and across country income groups.
- Unlike other tools that calculate emissions outcomes among several other outcomes, Pathways focuses primarily on emissions.
- The fact that Pathways is a bottom-up modelling tool based on the city's own GHG inventory differentiates it from other city-level modelling tools which start with top-down assumptions.

RapidFire

RapidFire is a tool developed and implemented by Calthorpe Analytics, a firm led by Peter Calthorpe, a highly influential advocate for compact urban growth and transit-oriented development (TOD) since the 1980s. Its focus is on the various impacts of urban form, including GHG emissions. RapidFire is a simplified, spreadsheet-based version of 'Urban Footprint', a web-based mapping and scenario planning tool developed for the US context which relies on a detailed property map that usually does not exist in developing country contexts. RapidFire has been applied in Chongqing (China) and two cities in Viet Nam as part of a World Bank activity, as well as in Mexico City.

How RapidFire works

Like Urban Performance, RapidFire uses local data to develop scenarios. The building blocks of a scenario in RapidFire are 'Place Types,' which are associated with different densities, features of the built environment like street grids and building heights, job proximities, transportation

accessibility, and income levels. These Place Types for each city are based on variations of locally existing places. Different combinations of Place Types constitute the different scenarios. For example, for Chongqing, Calthorpe Analytics developed 36 Place Types, using a schema illustrated in Figure 15. For each of the 12 Place Types in the third row, there were commercial, medium-density residential, and high-density residential land use versions, making 36 in total.

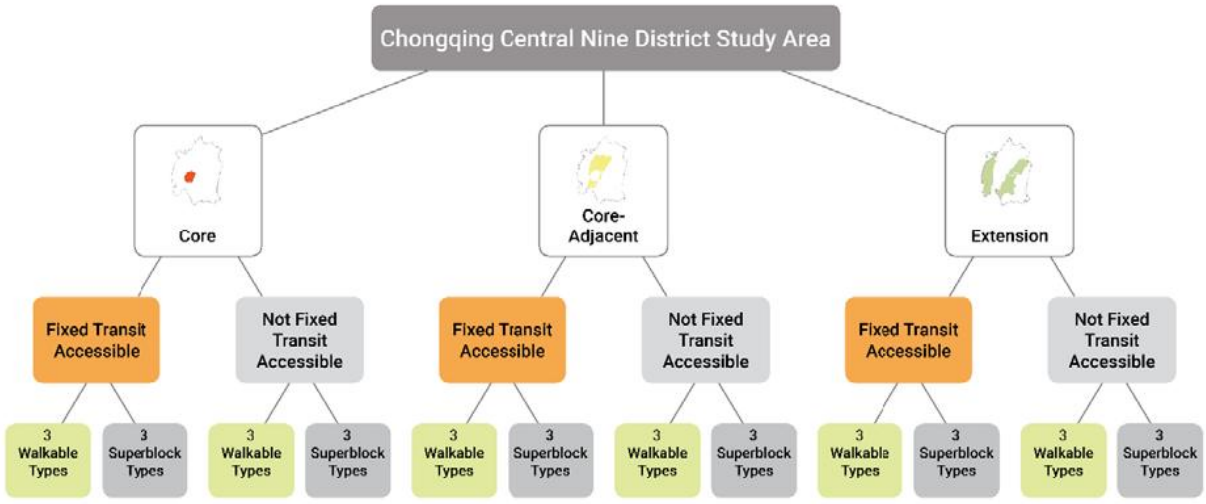


Figure 15: Schema of Place Types developed for use in RapidFire for Chongqing, China

Source: Calthorpe Analytics/ World Bank

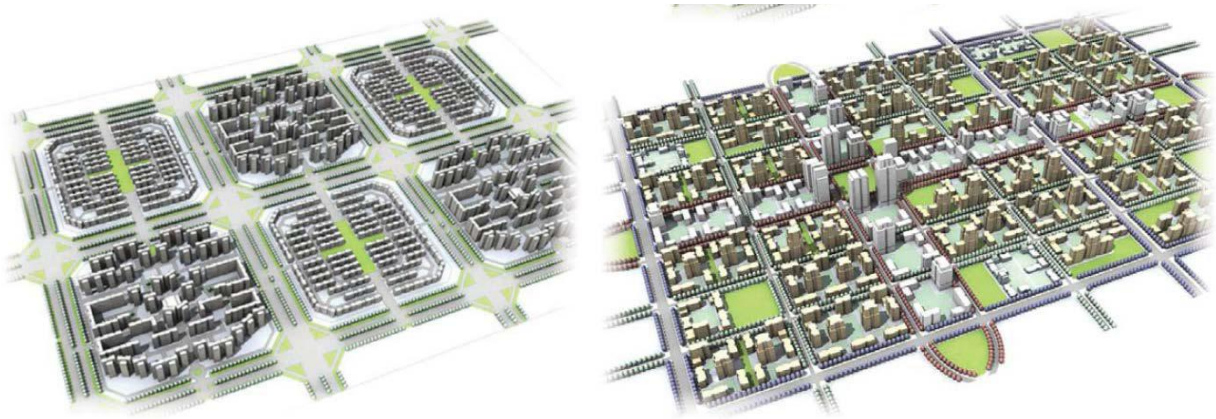


Figure 16: Illustrations of superblocks (left) and walkable urban form (right), drawn at the same scale, used in in RapidFire for Chongqing, China

Source: Calthorpe Analytics/ World Bank

RapidFire uses data on population, housing, jobs, transit, and land use as inputs to estimate the proportion of population and jobs in walkable or TOD areas, the jobs-to-population ratio in different

areas, land consumption, transportation mode share, vehicle kilometers traveled, GHG emissions, energy use, water use, household transport and energy costs, and infrastructure costs under various scenarios. The elasticities used in the RapidFire model are locally derived. Rather than producing maps projecting the urban footprint in each scenario, the tool estimates the amount and type of development in broad zones (e.g. core, core-adjacent, and extension) under the different scenarios.

Working with RapidFire

Using RapidFire involves hiring a firm, Calthorpe Analytics, which leads the data collection process and runs the RapidFire tool. The process can be time consuming, especially in places with poor data availability and municipal staff who are not familiar with the methodology. In the case of Chongqing, the process took around 1.5 years, despite the city having worked with Calthorpe Analytics previously. Costs vary on a case by case basis.

Further information about the scenario analysis of Chongqing, including the methodology and results, is available in this technical paper and this report. For more information, contact Erika Lew (erika@urbanfootprint.com) at Calthorpe Analytics. For a user perspective, contact Xueman Wang or Poonam Pillai at the World Bank.

Summary

- RapidFire focuses on the benefits of compact, transit-oriented, walkable urban growth.
- It benefits from the credibility of a leading global expert in the field.
- As a US-based firm led by a prominent global expert, Calthorpe Analytics can be relatively expensive.

Urban Performance

Urban Performance assesses a city's performance by evaluating growth scenarios that include public policies, investment projects, and land regulations. It was developed at World Bank's City Planning Labs and is maintained by CAPSUS, UPTech and a community of developers.[14] Urban Performance is open source and its source code can be found here. The tool is partly based on the analytics performed by CAPSUS in Jordan (for the World Bank), Mexico, Cote d'Ivoire, and elsewhere.

[14] The tools were developed as part of the "Urban Planning Tools as Agents of Change: Collaborative Spatial Data for Sustainable Urban Development in Indonesia" activity, which was submitted in response to the 2018 call for proposals by the World Bank's Development Economics Data Group (DECDG) and the Global Partnership for Sustainable Development Data (GPSDD). It was supported by the World Bank's Trust Fund for Statistical Capacity Building III (TFSCB) with financing from the United Kingdom's Foreign, Commonwealth & Development Office, the Department of Foreign Affairs and Trade of Ireland, and the Governments of Canada and Korea. The Government of Indonesia collaborated in the development of these tools. Local governments in Indonesia collaborated by sharing test data. An earlier proof of concept for the tools received financial support from the Swiss State Secretariat for Economic Affairs (SECO) through the Indonesia Sustainable Urbanization Multi-donor Trust Fund (IDSUN MDTF).

The current version of the tool has been applied in several Indonesian cities. For example, Denpasar used the Urban Performance tool to assess the economic and environmental outcomes of developing "eco-villages." This assessment helped officials to compare the impact of an environmentally favorable development versus a business-as-usual scenario. The tool was also used to evaluate the impacts of various versions of Bus Rapid Transit (BRT) in Bandung, Indonesia. The scenarios evaluated were regular bus transit (the base scenario), BRT with vehicles running on diesel, BRT using electric vehicles (E-BRT) and E-BRT with a cleaner electricity mix. The results of the scenario modeling are presented in Figure 17.

Figure 17: Urban Performance results for bus rapid transit in Bandung, Indonesia

	BASE	Diesel BRT	E-BRT	E-BRT + Clean Mix
Vehicle kilometers travelled [Million km/day]	48.88	46.09	46.09	46.09
Energy [TWh/day]	4.85	4.67	3.16	3.16
GHG emissions [GgCO2eq/day]	1.23	1.19	1.24	0.91

Source: World Bank City Planning Land and CAPSUS[15]

How Urban Performance works

Urban Performance evaluates outcomes from scenarios along various metrics. The scenarios evaluated in the tool can be based on comprehensive spatial plans or individual actions, e.g. a new BRT system, the provision of new public space, or others. Depending on the scenario evaluated, the outputs may include GHG emissions, population density, land consumption, vehicle kilometers traveled, energy use, and proximity to public transport, schools, healthcare facilities, and public space.

To access Urban Performance, users must log in to Geoportal. Users upload spatial data layers to be used in the analysis, which can be viewed and customized in the tool's GIS interface (see screenshots), as well as numerical assumptions, e.g. regarding emission factors and infrastructure costs. Users then create scenarios and select which indicators they wish to calculate. Depending on

[15] "Urban Planning Tools as Agents of Change: Collaborative Spatial Data for Sustainable Urban Development in Indonesia.
December 16, 2020.
http://pubdocs.worldbank.org/en/895401614014851662/WB-Indonesia-urban-planning-final-report-v3.pdf

the indicators selected, Urban Performance will require specific layers and assumptions to be entered as inputs. The tool then generates exportable tables and graphs allowing users to compare indicators for the different scenarios.

Urban Performance can connect to other platforms that run on various systems (WFS/ WMS, PostgreSQL, R, Python, or CKAN) which means that if a city has its own data portal, Urban Performance can pull data layers directly from them without having to download, convert, and reupload files.

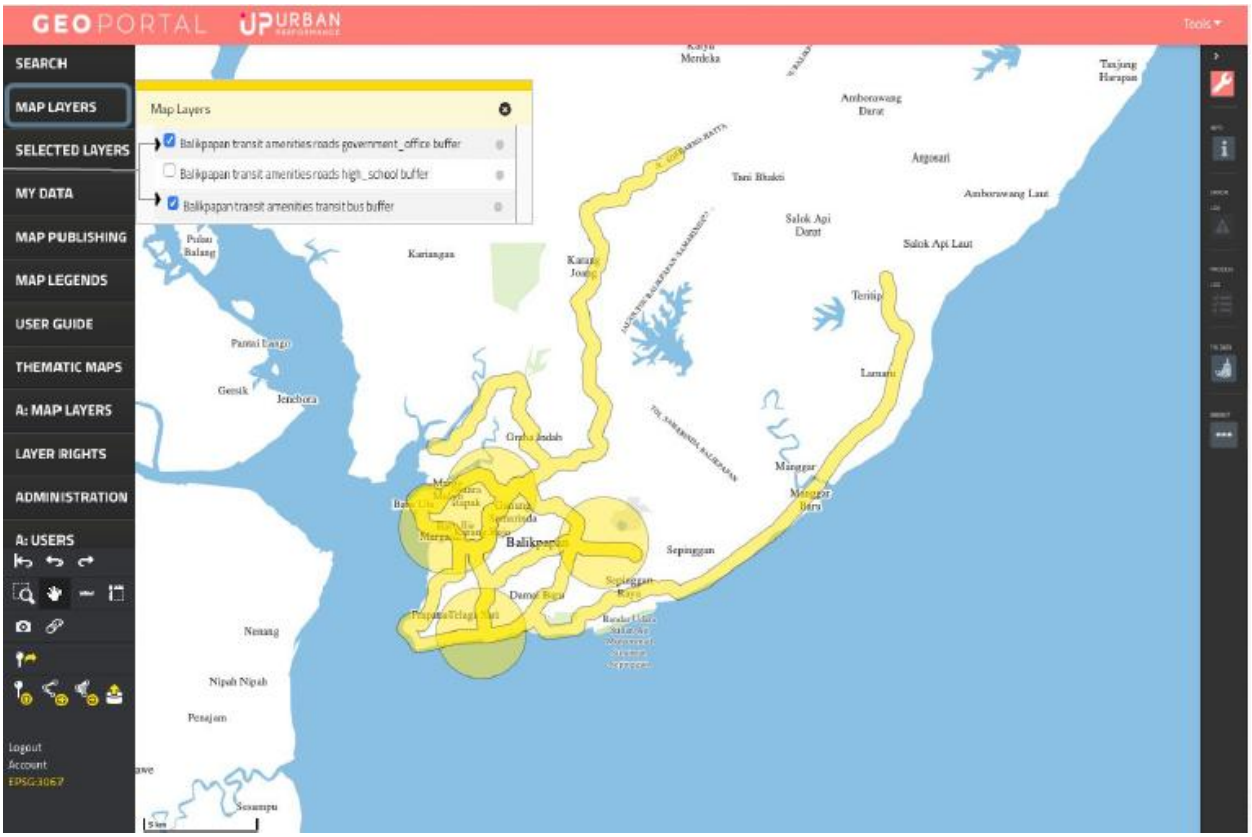
Another tool named Urban Hotspots was developed alongside Urban Performance. It is a web application that identifies optimal locations for a specific activity within a city and displays heat maps of access to urban services and infrastructure. It can be used to develop the scenarios evaluated in Urban Performance.

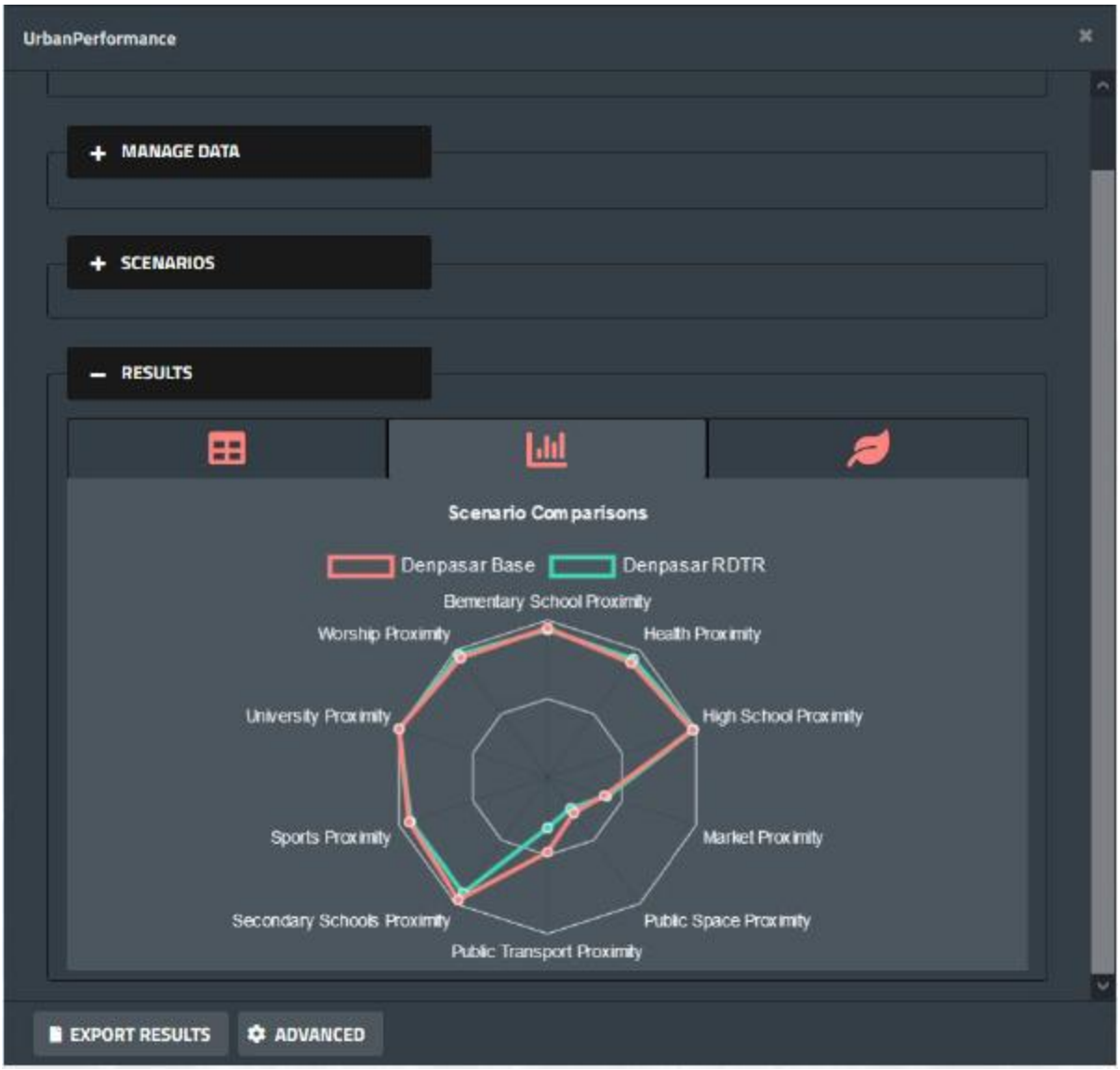
Working with Urban Performance

The tool is designed to allow city officials to use it with limited input from consultants. In recent uses of the tool, consultants from CAPSUS spent less than two hours training local government staff to use the tool, and only 10% of the work was done by the consultants. A detailed user manual is available here.

For further information about Urban Performance, contact Gayatri Singh at the World Bank (gsingh9@worldbank.org).

Figure 18: Sample screenshots from Urban Performance





Source: World Bank City Planning Labs and CAPSUS[16]

[16] Urban Performance User Manual.
https://pubdocs.worldbank.org/en/517251612401192506/Final-User-Manual-Urban-Performance.pdf

Summary

- Urban Performance has been developed and tested for use in a lower-middle income country context.
- Users define their own assumptions, scenarios, and indicators.
- It is intended for use by local governments with limited input from consultants.

Summary

- *Spatial vs. non-spatial tools:* Users who are interested in the impacts of urban spatial form can use Urban Performance or RapidFire. Users interested in estimating the impacts of non-spatial actions may choose Urban Performance, CyPT, ClimateOS, CURB, APEX, Pathways, or FutureproofedCities.
- *Accessing the tools and required expertise:* Using RapidFire and FutureproofedCities requires hiring the firms that devised them (Calthorpe Associates and Futureproofed), while using Pathways requires partnering with C40. The remaining tools are free (CURB) or have free versions (APEX, CyPT, ClimateOS). APEX and CyPT also allow users to hire specialized experts, at IFC and Siemens respectively, to customize the inputs into the tools. Urban Performance and Pathways also require support from consultants. CURB is designed to be used with limited support from consultants, but some may be required. For these three tools, cities do not have to hire specific consultants (although having helped develop Urban Performance, the firm CAPSUS has experience in using the tool and training others to use it.) ClimateView and Futureproofed provide support on the use of their tools and some support in collecting data from publicly available sources, but are not involved in on-the-ground data collection or decision-making. The exact role of potential consultants in terms of data collection and decision-making support may vary based on the availability of data and in-house expertise in city agencies.
- *Pre-loaded input data:* Urban Performance and RapidFire do not have pre-loaded city data and require customized local data collection. FutureproofedCities has emissions pre-loaded data for the EU. It requires local data collection for the rest of the world but can use national or regional proxy data in the absence of local data. ClimateOS has pre-loaded data for cities in a growing list of countries. APEX and CURB come with pre-loaded baseline data for a large number of cities. CyPT's free version only allows the user to select from among certain default categories to approximate the city being analyzed. APEX, CURB, and CyPT allow baseline data to be customized as part of their paid versions.
- *Identifying potential actions:* APEX, CyPT, ClimateOS, CURB, Pathways, and FutureproofedCities have an in-built list of potential climate mitigation actions that they evaluate, which can be customized to various degrees, while RapidFire and Urban Performance require users to identify and define their own actions.

Table 3: Comparison of tools

Name of tool	***APEX***	***CyPT***	***ClimateOS***	***CURB***	***FutureproofedCities***	***Pathways***	***RapidFire***	***Urban Performance***
Primary focus	Modeling the impacts of non-spatial actions (100+ actions related to the built environment, transportation, solid waste, and water/ wastewater) (For the Climate Action Plan (CAP): development of a comprehensive roadmap that outlines the specific activities that the city will undertake to reduce GHG emissions, including investments, policies, and planning measures.)	Modeling the impacts of non-spatial actions (70 technologies related to buildings, transport and energy).	Modeling the impacts of non-spatial actions (100+ actions related to transportation, building energy, industry, energy, and waste).	Modeling the impacts of non-spatial actions (68 actions related to buildings, transport, energy, water, and waste).	Modeling the impacts of non-spatial actions (100+ different measures related to buildings, transportation, waste, water, electricity generation and other sectors).	Modeling the impacts of non-spatial actions (36 actions related to buildings, transport, energy, and waste.)	Modeling the impacts of spatial actions	Modeling the impacts of spatial and non-spatial actions
Developed by	IFC	Siemens	ClimateView	World Bank, AECOM, Bloomberg Philanthropies, C40	Futureproofed	C40 (as part of a larger Climate Action Plan toolkit)	Calthorpe Analytics	World Bank City Planning Labs, with CAPSUS
Places used/ in use	Ahmedabad (India), Ho Chi Minh City (Viet Nam), Almaty (Kazakhstan), Ekurhuleni (South Africa)	22 cities in Europe, Asia, and the Americas	~70 cities in Europe and North America	Several cities, including in Africa, Asia, Latin America, and North America.	140+ cities in Europe, others beyond Europe coming soon.	C40 cities in several regions	Chongqing (China)	Indonesia, Mongolia
Data inputs	Has pre-loaded baseline data for 300+ cities, which can be customized	Has default baseline values based on region, city size, transportation mix, and housing size (3-4 options each), or can work with Siemens to customize the baseline for a city.	Beyond Europe and North America, ClimateView helps cities with paid subscriptions identify the best publicly available data.	Has pre-loaded baseline data for 200-300 cities for several data points, and national/ regional proxy data for others.	Requires energy consumption per sector and fuel type. Other data can be estimated from national or regional proxies.	Detailed data on buildings, waste, water, electricity, and transport (includes some pre-loaded data).	Population, housing, jobs, transit, and land use	Spatial data layers and numerical assumptions (exact inputs depend on output indicators selected)
Output metrics	Climate Action Plan (CAP): roadmap for ambition, acceleration, and delivery. Climate Investment Opportunities Diagnostic (CIO): analysis of GHG emissions impacts of	GHG emissions, air quality, capital and operating expenses, jobs created	GHG emissions, resource use, abatement potentials, co-benefits	GHG emissions, energy use, costs, co-benefits.	GHG emissions, financial costs and returns of measures, co-benefits.	GHG emissions (and air quality in a separate module)	Proportion of pop. and jobs in walkable/ TOD areas; jobs to population ratio; land consumption; transportation mode share; VKT; GHG emissions; energy use; HH transport	GHG emissions, energy use, vehicle km traveled, proximity to amenities, and others.

Name of tool	*APEX*	*CyPT*	*ClimateOS*	*CURB*	*FutureproofedCities*	*Pathways*	*RapidFire*	*Urban Performance*
	existing projects/plans and additional opportunities. Skeletal Action Plan: basic factual report including the APEX results and essential information on each selected measure.						and energy costs; infrastructure costs	
Elasticities/ assumptions	Based on international case studies (from diverse income groups and city types, where possible)	Based on International standards, regional studies, and Siemens technology implementation projects	Based on the Global Protocol for Community-Scale Greenhouse Gas Emission Inventories (GPC) with the ability to customize.	Based on Global Protocol for Community-Scale Greenhouse Gas Emission Inventories (GPC) which mainly includes IPCC methodologies	Based on European standards but can be customized	Based on local emissions factors	Locally derived	User-defined
How WB teams/ cities can access tool	Free web-based tool.	Free web-based tool. Can hire Siemens to do customized version for that city.	Free version/ annual subscription	Free download of Excel tool	Annual subscription to service	Contact C40	Hire Calthorpe and work with them to develop scenarios using their spreadsheet-based tool.	Free web-based tool.
Associated costs	Basic version will be free (from late 2022 onwards). CAP: USD 50,000-85,000; CIO: 30,000-50,000; Skeletal Action Plan: USD 40,000.	Basic version is free; can hire Siemens to customize for city. The cost depends on the scope of the analysis, the actions selected, and the number of scenarios being analyzed, but can range from approximately USD 50,000 to 150,000.	Up to two users per city can use the basic tool for free. For more users and advanced features, cities must pay for an annual subscription, which ranges from USD 15,000 to 150,000, depending on the city's requirements of user numbers and support.	Free, but may require support from consultants.	Annual subscription of USD 5,900 (Essential plan), USD 11,000 (Standard plan), and USD 16,200 (Expert plan) giving access to the tool and services.	The tool is free but requires consultants to facilitate extensive data collection and stakeholder engagement process.	Fees of consulting firm (Calthorpe)	Fees of consultants to support data collection and assist in the scenario analysis process.
Time	CAP: 4-6 months; CIO: Minimum 3 months; Skeletal Action Plan: 4 months.	Cities usually require 3-6 months to gather data.	Cities require a minimum of 6 weeks to produce an initial plan, and can then work on an ongoing basis in the platform to refine or update scenarios, as well as track progress.	Excluding data collection, the analysis in the tool can take between a few hours and one week.	Excluding data collection, cities are likely to take 1-2 months to prepare a first draft plan and another 2-3 months to finalize it.	Can take between 2 weeks and a year, depending on data availability.	Can take 1-2 years	Depends on the analysis being undertaken and the availability of data

Annex

Table 4: Inventory of 59 urban climate analytics tools identified by GCoM, Bloomberg Associates, and WRI [17] and reason for exclusion from this note

Tool name	Reason for exclusion
A Community-Level GHG Inventory for Local Government Units in the Philippines	Country-specific
Action Selection and Prioritisation Tool (ASAP)	Does not model future emissions
Adaptation and Mitigation Integration Assessment Tool (AMIA)	Does not model future emissions
AKSARA	Country-specific
Anaerobic Digester Project Screening Tool (AD-PST)	Does not model future emissions
Avoided Emissions and Generation Tool (AVERT)	Country-specific
Benchmarking and Energy Saving Tool for Low Carbon Cities (BEST Cities)	Country-specific
Biogas Wastewater Assessment Technology Tool (BioWATT)	Sector-specific
City Building Energy Saver (CityBES)	Sector-specific
City Inventory Reporting and Information System (CIRIS)	Does not model future emissions
City Performance Tool (CyPT)	(Included)
CityLED Tool	Sector-specific
Clean Energy Emission Reduction Tool (CLEER)	Sector-specific
ClearPath	Does not model future emissions (Global version)
Climate Action for Urban Sustainability (CURB)	(Included)
Climate Policy Database	Does not model future emissions
ClimateOS (ClimateView)	(Included)
Co-Benefits Calculator for Transport	Sector-specific
Co-Benefits Risk Assessment Screening and Mapping Tool (COBRA)	Does not model future emissions
Data Portal for Cities	Does not model future emissions
Eco and Low-carbon Indicator Tool for Evaluating Cities (ELITE Cities)	Country-specific
Emission Quantification Tool for Estimation of GHGs/SLCPs from Solid Waste Sector (EQT)	Sector-specific
Energy Performance and Carbon Emissions Assessment and Monitoring (ECAM)	Sector-specific
Environmental Benefits Mapping and Analysis Program, Community Edition (BenMAP-CE)	Does not model future emissions

[17] GCoM, Bloomberg Associates, and WRI (2021). "Understanding data and tools to accelerate city climate action: A Decision-making and Tools Project White Paper." https://www.globalcovenantofmayors.org/press/understanding-data-and-tools-to-accelerate-city-climate-action/

Environmental Insights Explorer (EIE)	Does not model future emissions
Futureproofed	(Included)
GHG Contribution Analysis Tool	Country-specific
Global Solar Atlas	Does not model future emissions
Global Wind Atlas	Does not model future emissions
Harmonized Emissions Analysis Tool (HEAT+)	Inactive
Impact analysis: air quality benefits	Sector-specific
Impact analysis: congestion pricing	Sector-specific
Impact analysis: cool roofs initiatives	Sector-specific
Impact analysis: deep building retrofits for cold climates	Sector-specific
Impact analysis: improved waste collection and segregation	Sector-specific
Impact analysis: walking and cycling	Sector-specific
Job and Economic Development Impact Model (JEDI): International	Does not model future emissions
Klimaschutz-Planer	Country-specific
Landfill Gas Project Screening Tool	Sector-specific
Local Clean Energy Self-Scoring Tool	Sector-specific
Local Energy Efficiency Policy Calculator (LEEP-C) 2.0	Country-specific
Local Greenhouse Gas Inventory Tool	Country-specific
Long-Range Energy Alternatives Planning System (LEAP)	Not city-level
Marginal Abatement Cost Tool (MACTool)	Inactive
Motor Vehicle Emissions Simulator (MOVES)	Sector-specific
OrganEcs	Sector-specific
Partners for Climate Protection (PCP) Milestone Tool	Country-specific
Renewable Energy and Energy Efficiency Technology Screen (RETScreen)	Sector-specific
SCATTER	Country-specific
Scenario 360	Not focused on GHG emissions; used only in high-income contexts
SIGN-SMART	Country-specific
Snapshot	Country-specific
Solid Waste Emissions Estimation Tool 3.0 (SWEET)	Sector-specific
System Advisor Model (SAM)	Sector-specific
Tool for Rapid Assessment of City Energy 2.0 (TRACE)	Sector-specific
Uber Movement	Does not model future emissions
Urban Form Rapid Assessment Model (Urban-RAM)	Country-specific
Vertically Integrated Action Tool (VIA)	Does not model future emissions
Waste Reduction Model (WARM)	Sector-specific