THE HEALTH BENEFITS OF CITIES

TAKING ACTION

ON CLIMATE CHANGE AND AIR QUALITY

APPENDICES

CONTENTS

C40 CITIES

Measuring the Benefits Of Climate Action: Air Quality And Health

A practical step-by-step guidance document to help cities collect data on air quality and calculate the health benefits of reduced air pollution due to an action.

C40 Cities have undertaken cutting-edge research to assess the (i) air quality, (ii) health and (iii) economic benefits of climate action- working with 30 cities to date.

The tool and methodology have been produced in collaboration with BuroHappold Engineering, London School of Hygiene and Tropical Medicine and Cambridge Environmental Research Consultants. It aims to quantify the benefits of improved air quality on mortality and morbidity, and the consequent economic value.

The tool is designed for policy makers from several sectors (transport, buildings, energy, environment or air quality), to inform stakeholders. Data inputs may need collaboration between departments to access relevant datasets.

See full report on the partnership and further resources on https://www.c40.org/benefits

1 | Plan the analysis

Planning the analysis in the specific context of your city: identify bold and ambitious actions that tackle the main sources of pollutants, pre-assess their impact and the population affected, determine the data available for the analysis and how the results may be used.

2 | Run the analysis

Collecting the (i) air quality, (ii) population & health and (iii) action related data, understanding the potential proxies to address data gaps.

3 | Communicate your results

Identifying the right message to bring to the appropriate stakeholders to effectively unlock action.

Annex: Data collection checklist and Glossary

1 | PLAN THE ANALYSIS

Before you start collecting and analysing data it is important to make sure the analysis is appropriate for the specific context of your city, and that it will deliver the results you need to drive more climate actions.

Identify the action: prioritisation of bold, ambitious and impactful actions

To ensure that your action is targeting your main sources of pollutants, look at local source apportionment studies.

- Does the action address one of the **main sources of GHG and air pollutants**?

Undertake a high-level analysis *(see example below)* to check the **potential level of impact**. In order to achieve maximum benefits, cities should look at **bold and ambitious scaled-up scenario as early as possible**, so that the end goal becomes an initial aim rather than a secondary thought.

- Does the action have a **local- or city-level** impact?
- Can the action be scale-up or accelerated?

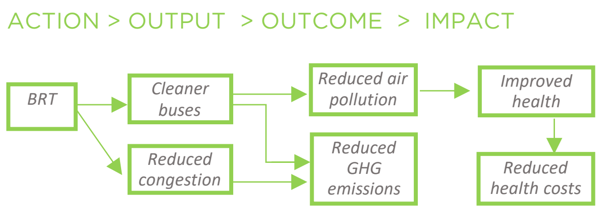
Example of a high-level sectoral analysis. Scaling-up could involve more upgraded buses and/or upgrading these buses to electric rather than just cleaner fossil-fuel standards.

Municipal bus-fleet fuel efficiency upgrade	Data	Source
Number of buses upgraded	*1,200*	
Total number of buses in use	*2,400*	
Transport emissions as a share of total city/region emissions	*70%*	
Road-based transport as a share of all transport emissions	*70%*	
Buses as a share of road-based transport	*10%*	*Add sources*
Proportion of bus fleet being targeted by specific action	*50%*	
Maximum possible reduction in emissions from upgrade	*50%*	
Maximum possible change in emissions from action = 0.7 x 0.7 x 0.1 x 0.5 x 0.5 = 0.01225	*1.23%*	

Understand the causal chain, from data inputs to health outcomes: inclusive climate action

The methodology is based on a **pathway logic** to map how a climate **action** translates into an **output** in the environmental conditions, which affects the air quality as an outcome, and finally have a social, economic or environmental **impact**. With CERC and LSHTM, C40 developed a methodology to understand how climate action translates into improvement in air quality and health. The different causal chains can be visualised here.

Example of a simplified causal chain for Bus Rapid Transit



Draw a causal chain to map out all the outputs and benefits that may result from your action.

- Does the analysis address **key city challenges** or deliver city objectives? Identify the priority benefits to measure.
- How might this compare to other urban actions? Where will those benefits happen?
- Who is affected? Does the policy affects vulnerable communities or groups of people?

Assess the data needed and available: boosting collaboration

Think about what data you will need, what data you have or are likely to be able to obtain and what data is not available from the **data checklist** (Annexes). **Assess if the analysis you want to undertake is likely to be feasible.**

- Where is the data available? **Discuss with your team, other departments and other partner private or academic organisations**.
- What proxy data may be needed?

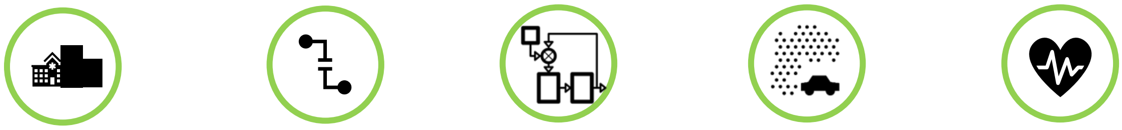
Plan the communication

Look **ahead to how you will present the findings, who to and why**. Start building your **communication plan** (see section 3).

- Who are the **key stakeholders** (internal and external)? What are their priorities?
- Are we measuring the benefits that people care most about?

2 | RUN THE ANALYSIS

Once you have understood the methodology process, you can start collecting the data and informing the tool. The analysis steps follow the analytical process and describe how the action translates into outputs, outcomes and impacts (the benefits).



CITY CONTEXT > ACTION > OUTPUT > OUTCOME > IMPACT

CITY CONTEXT	ACTION	OUTPUT	OUTCOME	IMPACT
Understanding the baseline	*Scoping the action*	*Defining the system change*	*From system change to air quality*	*From AQ to health and economic impact*

CITY CONTEXT | Understand the baseline

The city context concerns the current demographic, and air pollution data existing before the action. Pre-action data represents the **baseline scenario and provides a measure of $PM_{2.5}$ concentration before the action is implemented.**

Sheets: Input Population Health Data, Benefits Analysis PM2.5/NO2

ACTION to OUTPUT | Scope the action and defining the system change

The system change refers to a change in the main elements of the transport, building, energy or any system related to the action. You can use scenarios to determine the potential value of the action and scaling-up opportunities.

For example, introducing a 'low emission zone' may trigger changes in the city's travel system including: reductions of the number of cars on the road, changes to citizens' travel behaviour, increased alternative (public) transport, etc.

Sheets: SYSTEM CHANGE. Defining the system change will involve unique considerations for each city and each action. There are two examples given in the tool (for LEZ and bus electrification) in order to guide the user.

OUTCOME | From system change to air quality

This study concerns $PM_{2.5}$, and NO_2 primarily, as changes in these pollutants have demonstrated the most significant health impacts.

A fall in emissions from an urban system will normally lead to a fall in concentration levels but only as far as the background levels. The concentration of a given pollutant in the environment is a function of multiple factors including climatic conditions and all sources of emissions.

Sheets: Benefits Analysis PM2.5/NO2

IMPACT | From air quality to health impact

The link between the change in air quality and the health impact is represented by Concentration Response Functions (CRF). CRFs are established through epidemiological studies and define a predicted change in a health risk in response to a change in the concentration of a specific pollutant.

The CRFs used in this study link changes in concentrations of NO_2 and $PM_{2.5}$ with:

- **Premature deaths avoided** as a measure of mortality using the CRFs on life tables. Since everyone dies eventually, no lives are ever saved by reducing environmental exposures. Deaths are rather delayed, resulting in increased life expectancy.
- **Life expectancy from birth**: is calculated by comparing the current life expectancy based on mortality rates with the predicted life expectancy when mortality rates have changed with the reduction in air pollution.[1]
- **Life years gained:** we celebrate a year of life lived each time we celebrate a birthday. The concept can be extended to take account not only of survival, but of years lived in

[1] *These measures are averages or aggregates across the population; it is less well understood how the effects are distributed among individuals.*

good or poor health using concepts such as Quality Adjusted Life-Year (QALY).

- **Cardiovascular and Respiratory hospital admissions**, as measures of short-term morbidity risk change.[2]

Life-tables are used to calculate the changes in risk by sex and age group. Recognising these differences is crucial to understand how the AQ changes impact population demographics. *Sheets: Benefits Analysis PM2.5/NO2, Results PM2.5/ NO2*

IMPACT | From health impact to monetisation

To assess the value of premature deaths avoided, the impact from mortality can by multiplying the avoided Life Years Lost by the **Value of a Life Year** (VOLY).

The economic impact from morbidity can be monetised by multiplying the hospital admissions averted by the Value of a Statistical Hospital Admission (VHA), showing the **avoided costs of illn**ess.

There are other, more complex methods of linking health outcomes to monetised or economic outcomes. These are less universally accepted and will not be covered in this manual, but the tool allows to add extra calculation lines.

Sheets: Benefits Analysis PM2.5/NO2, Results PM2.5/ NO2

3 | COMMUNICATE YOUR RESULTS

Map your communication plan

It is important to understand that each group of audience (public, politicians or other departments) may have different sensitivities. Identifying the right message and vector for each group to share your findings will ensure more buy-in.

- **Audience**: who are the different audiences to be influenced?
- **Message** : what are the key messages to be delivered to each audience?
- **Data**: what data do you need to build these messages?
- **Obstacles**: what roadblock are you likely to encounter?
- **Mitigation**: What are the potential solutions to overcome them?

Several messages and vectors can be identified in your communication plans:

- Cross-departmental workshops
- Press release on the findings, advertisement supporting your project.

You can visualise some examples from case studies on https://www.c40.org/benefits

ACTION PLAN

AUDIENCE/S			Responsible	Deadline
MESSAGE				
DATA				
OBSTACLES				
MITIGATION				

[2] *Long term is uncertain, however there is a strong correlation between peaks in daily pollution and hospital admissions brought forward.*

Data collection checklist

Informing the sources

Perfect data does not exist and there will always be data gaps and limitations. Cities should use the best available data. Please note it is vital that you record your assumption regarding the data you are using when progressing with the analysis. This may include:

- **Source of the data**: reliability, rigour, date, Institution, authors etc.
- **Manipulation**: any manipulation you may carry out to get the data in the correct format, i.e. unit conversion, weighting, etc.
- **Transparency** is vital when using different data sets and from various sources, as it logs accountability

Addressing data gaps

There will always be data gaps and limitations, cities should undertake analysis with the data they have and sensible proxy data.

We encourage you to talk to your Health, Environment, Air Quality and appropriate department to get as much local data as possible and advice on proxies. Benefit

At the same time, we encourage cities to work in parallel to improve data collection and address key data gaps.

CITY CONTEXT | Understanding the baseline	
Physical boundaries	*Source within your city*
There are a number of ways to identify the intervention area depending on the actions, i.e. BRT corridors or LEZs area of jurisdiction. The intervention area can also be city-wide, or on the metropolitan area. ☐ **City area**, expressed in km^2	
☐ **Intervention area**, expressed in km^2	
☐ **Population in the city area**	
☐ **Population in the intervention area**	
Air Quality baseline	*Source within your city*
When selecting a data point for these pollutants it is important to understand how and where the data was collected as the sensors can be located in various parts of the city (i.e. roadside, parks/public spaces, residential areas, transport hubs). It is therefore vital when selecting average concentration and to take readings from the most representative sites in relation to the intended action. ☐ **Average $PM_{2.5}$ /NO_X/NO_2 [3] concentration** in the city, expressed in $\mu g/m^3$ ☐ **Average $PM_{2.5}$ /NO_X/NO_2 concentration** in the intervention area, expressed in $\mu g/m^3$ *Pollutant data may be available in different formats and units parts per billion (ppb), or measuring PM2.5 emissions in opacity. Be careful to translate them into Microgram per Cubic Meter ($\mu g/m^3$)*	

[3] The name NO_X is given to the mixture of two pollutants: NO and NO_2. The two pollutants are both emitted from combustion sources and are involved in chemical reactions after they are emitted. NO can be converted to NO2 and vice versa. Changes in concentration in NOx are used to estimate changes in concentration of NO2. In effect, we are assuming that the chemical behaviour is the same before and after the action and that the NOx:NO2 ratio remains constant.

If you don't know the PM2.5 average concentration, you can use the following link from the WHO database.	
Background concentrations come from sources outside the city: national or international pollution (eg. Industries located in the region), or natural sources (dust, sand, salt). Those concentrations will not be altered by any city action as these levels are imported. This value is particularly sensitive to inaccuracies as it strongly correlates with the change in health impact and ultimately economic benefits. ☐ **Background $PM_{2.5}$ /NO_X/NO_2 concentration** in the city, expressed in µg/m³ *Your environment department or national ministry, or Meteorological Agency may hold this data. You can also determine it by taking the concentration from a station in a rural area around the city (local winds and topography has to be considered).*	
ACTION to OUPUT | Scoping the action and defining the system change, from system change to air quality	
System baseline	*Source within your city*
☐ **Description of the current system** *Example list (non-exhaustive), please provide as many details as possible:* *- if it is a transport action: what are the current vehicle and time restrictions (LEZ), current state of the bus or vehicle fleet per type and standards, average distance per bus fleet…* *- if it is an industry or energy action: how many industries or infrastructure exist, what power is produced, what fuel are being burned, existing emission standards.* *- if it is a building action: how many buildings are concerned, what population lives in them, what fuels are currently used for heating/cooking/electricity.*	
☐ **Contribution to non-background concentration** of **$PM_{2.5}$ /NO_X/NO_2** from source group, expressed as percentage. *The source group could be roads, industry or, more generally, the representative sector from each action. The contribution can be determined from source apportionment studies.*	
Scoping the action	*Source within your city*
☐ **Description of the future system after the action** (non-exhaustive list, please provide as many details as possible): *- if it is a transport action:* *What are the vehicle and time restrictions (LEZ), how many buses or vehicle will be upgraded (bus electrification or upgrade), what is the length of the new transport system (BRT line)…* *- if it is an industry or energy action:* *What infrastructure are you planning to implement, what power will it produce, what fuel will be banned, what industries are concerned…* *- if it is a building action:* *How many building will be retrofitted, what kind of retrofit of system will be replaced…* ☐ **Reduction in $PM_{2.5}$ /NO_X/NO_2 emissions** from source group (roads, industry…) due to action, expressed in % or directly in change in pollutants concentration expressed in µg/m³ *In order to arrive at % reduction in $PM_{2.5}$ emissions from Source group due to action, you may need to carry out specific analysis regarding the impact of the action. There are two examples given in the tool (for LEZ and bus electrification) in order to guide the user with obtaining an indicative assumption for this value.* *For example, implementing a LEZ will lead to a reduction in higher polluting vehicles, this will lead to a reduction in emissions calculated as a proportion of total emissions from the transport source group.*	

IMPACT | From air quality to health impact	
Concentration Response Functions	*Source within your city*
The health impact of each pollutant – NO_2 and $PM_{2.5}$ – needs to be measured separately, as they have different effects. ☐ **Local Concentration response functions (CRF):** refer to a quantitative relationship between the change in concentration of a pollutant and the change in risk of an effect on health, based on effects estimates reported from epidemiological studies. *Figures derived from COMEAP and HRAPIE project which are UK Government / European Union validated methodologies for calculating AQ and Health.* **You are encouraged to use the multipliers from the tool, unless you have local data.** *Note: COMEAP's (the UK Government Committee on the Medical Effects of Air Pollutants) recommendation was that the NO2 coefficient should be reduced by up to 33% to take account of double-counting of effects associated with PM2.5.*	
Population Heath Data	*Source within your city*
☐ **Age and gender-specific population,** in expressed in count numbers. ***You can also enter national data****, provided it is scaled down appropriately. National UN database available here.*	
☐ **Age and gender-specific all-cause mortality** (deaths per year), expressed in count numbers. ***You can also enter national data****, provided it is scaled down appropriately. National UN database available here.*	
☐ **Respiratory and Cardiovascular Hospital admissions,** expressed in rate per 1,000 population, per age and gender. *If proxy data is used from a similar city, please ensure transparency and outline potential risks and uncertainties it may carry.* ***You can also enter national data.***	
IMPACT | From health impact to monetisation	
☐ **VOLY (Value of a Life Year),** the monetary value of a year of life lost, in local currency or dollars. *This is based on studies that assess the willingness to pay for reducing mortality risks associated with air pollution. if data exists, the city should use specific age-group data.* *If no data is available, the city should use proxy values from a similar city-context, and convert the value using a purchasing power parity method. Please note that VOLY totals should not be taken as direct cost savings, but rather economic gains to the economy via a sum of the total value of life years retained accrued to the improvements in health. A specific definition of VOLY can be found in the 'terminology' tab.*	
☐ **VHA (Value of a statistical Hospital Admission) for Cardiovascular or Respiratory diseases**, in local currency or dollars. *If no data is available, the city should use proxy values from a similar city-context, and convert the value using a purchasing power parity method.*	

APPENDIX B: Benefits of Air Quality Methodology

B.1 Introduction

B. 1.1. Why measuring the benefits of climate action?

In order to meet the dual challenges posed by global warming and air pollution, cities need to be bold and take action at a large scale. The benefits can be substantial: significant changes in air quality will bring about immense improvements in the health of citizens, as well as economic benefits.

C40 Cities have undertaken cutting-edge research to assess the (i) air quality, (ii) health and (iii) economic benefits of climate action- working with 30 cities to date. It aims to quantify the benefits of improved air quality on mortality and morbidity, and the consequent economic value.

The methodology and accompanying toolkit developed through this research will support cities to take bold measures by quantifying these benefits:

- **Increase policymakers' understanding of the links between climate, air quality, health and economics;**
- **Help policymakers in achieving existing targets, to better design projects and plans for scaling-up climate action; and**
- **Make the case for investments by demonstrating public health returns and engaging the public health sector in environmental policymaking and planning.**

B. 1.2. Who can use the tool?

The tool is designed for policy makers from several sectors (transport, buildings, energy, environment or air quality). Data inputs may need collaboration between departments to access relevant datasets.
The Annex A describes the several steps to run a health benefits analysis:

- **Planning the analysis** in the specific context of your city: identify bold and ambitious actions that tackle the main sources of pollutants, pre-assess their impact and the population affected, determine the data available for the analysis and how the results may be used.
- **Collecting data** on (i) air quality, (ii) population & health and (iii) action, understanding the potential proxies to address data gaps
- **Identifying the right message** to bring to the appropriate stakeholders to effectively unlock action.

B. 1.3. How was the tool developed?

The methodology was developed by C40 Cities in collaboration with BuroHappold Engineering, London School of Hygiene and Tropical Medicine and Cambridge Environmental Research Consultants. It is based on C40 Urban Climate Action Impact Framework to build the causal pathways between a climate action and its outputs, outcomes and impacts.

This methodology was tested by the 25 participating cities, to ensure the usability of the tool by all C40 cities, and the resulting tool and support materials are now available (on demand to hvandenbroek@c40.org) as a toolkit for any city to use to assess their climate action plans.

B.1.4. What are the limitations?

Data gaps and uncertainties are part of any modeling process due to the simplifications listed below. It is important to characterise the 'unknown', in order to be aware of the level of precision of the analysis.

- **Data availability:** Cities should undertake analysis with the data available and sensible proxy data. Collaboration with the Health, Environment, Air Quality and appropriate departments will help to get as much local data as possible and advice on proxies. At the same time, we encourage cities to work in parallel to improve data collection and address key data gaps.
- **Concentration-response function:** CRF come from an extensive literature review to ensure the robustness of the multipliers. However, most of epidemiological studies available are from Northern America and Europe, and the range of exposures studied does not necessarily represent what is observed around the world. If cities have local robust studies, they are encouraged using them.
- **Effects of pollutants as a mixture:** It's still unclear to what extent the health effects are due to the individual pollutants rather than the general mix of air pollution. Measures to avoid double counting are described below (section B.3.1).
- **Disbenefits:** It should be reminded that the tool aims at unlocking actions and policies that tackle both air pollution and climate change. When defining the action, it is necessary to have a look at both to avoid malinvestments (eg. Investing in electric infrastructure when the energy grid relies on fossil fuel), and missed opportunities to maximise the impact.

B.2 Methodological approach

B2.2 Using the pathways as a global approach: action, output, outcome, impact

The C40 Benefits program proceeded under a 'pathway logic' developed in alignment with the C40 Urban Climate Action Impacts Framework, which maps how a climate action or policy can be translated into a change related to society, the economy, or the environment. Benefits can be mapped into pathways which link four stages of an intervention: actions, outputs, outcomes, and impacts. Pathways facilitate a comprehensive mapping of how one action translates into multiple impacts, but also how multiple actions across different sectors may contribute to the same impact (C40 Cities and Ramboll, 2018). For the purposes of the Benefits program specifically, the step-by-step benefits pathway, articulated as Action–Output–Outcome–Impact, was translated into:

Table 1. Step by step pathway

Action	A range of climate actions cities could undertake that tackle both urban air quality and GHG emissions simultaneously. Here, these were high-impact actions on road transport, buildings, and industrial activity.	*Example: Introduction of a vehicles low-emission zone.*
Output	A variety of material changes within the given system – i.e. 'system change' – brought about by the action. System change refers to a change in the main elements of the system or systems related to the action being evaluated.	*Example: introducing a low-emission zone triggers changes in the city's travel system including: reductions of the number of cars on the road, changes to citizens' travel behaviour, initiatives to encourage alternative (public) transport modes, etc.*
Outcome	The change in conditions as a result of the shift in system output. This includes both behaviour and non-behaviour outcomes. In this program, outcome is understood as the resultant reduction in air pollution from the system change. Annual average $PM_{2.5}$ and NO_2 concentrations are here used as the key indicators of air quality in cities.	*Example: Increased public transport use by urban population (behavioural outcome); reduction in concentration of $PM_{2.5}$ and NO_2 (non-behavioural outcome).*
Impact	The medium- or long-term effects of the outcomes. In the Benefits of Urban Climate Action methodology, the direct impacts were understood as public health benefits brought by the improvements in air quality, as well as the monetisation of these health gains. Further impacts were also illustrated within the program, with wider benefits including improvements in safety, productivity, congestion, etc.	*Health impacts were expressed in terms of both impacts on morbidity (cardiovascular- and respiratory-related hospital admissions) and mortality (premature deaths averted). The monetisation of these two metrics was then able to provide a cost-benefit basis for discussion, as averted hospital admissions provided direct indication of healthcare cost savings, whereas a valuation of the 'life years gained' by the population provided a more overarching metric for economic gains.*

B.3 Literature review

C40 and BuroHappold, in collaboration with Cambridge Environmental Research Consultants (CERC) and London School of Hygiene and Tropical Medicine (LSHTM), conducted an extensive literature review to identify the key evidence on the causal links between urban climate action and the related outputs, outcomes and impacts. This helped build a more complete picture of the potential Benefits of urban climate action, how these are connected to each other and, where possible, how they can be quantified. Contact C40 research team for a full list of literature.

B.3.1 Concentration-Response Functions

In particular, the link between air quality and health was investigated in detail and studies were analysed to find relevant multipliers, or concentration-response functions (CRFs). These refer to a quantitative relationship between the change in concentration of a pollutant and the change in risk of an effect on health, based on effects estimates reported from epidemiological studies. For the purposes of this study, a number of reliable, globally used and recognised CRFs have been selected and validated by leading experts in the field. The CRFs selected are primarily linked to two key pollutants: $PM_{2.5}$ and NO_2. The reason for this is that epidemiological evidence from cohort studies (based on long-term exposure) is largely based on $PM_{2.5}$ and, to a lesser extent, NO_2.

It's still unclear to what extent the health effects are due to the individual pollutants rather than the general mix of air pollution. As such, making health impact estimates using multiple pollutants risks double counting. In 2015, COMEAP (the UK Government Committee on the Medical Effects of Air Pollutants) recommended that when the coefficient for concentrations of NO_2 and mortality is combined with an assessment of health impacts on the basis of $PM_{2.5}$, a percentage reduction needs to be applied to the NO_2 coefficient to avoid double-counting. COMEAP's recommendation was that the NO_2 coefficient should be reduced by up to 33% to take account of double-counting of effects associated with $PM_{2.5}$.

Through the identified CRFs, changes in concentration of $PM_{2.5}$ and NO_2 are associated to changes in death rates (mortality) and disease rates (morbidity), expressed in terms of hospital admissions. It should be noted that since everyone dies eventually, no lives are ever saved by reducing environmental exposures. Deaths are instead delayed, resulting in increased life expectancy.

These CRFs are captured in the table below and the relevant source highlighted.

Table 2. Air quality-Health CRFs

Impact Pathway	Pollutant	CRF (% Change in Risk Rate per 10 **Q**g/m^3 change in Pollutant Concentration)	Source
Death rates (Mortality)	NO_2	5.5%	(WHO, 2013)
Respiratory hospital admission (Morbidity)	NO_2	1.8%	(WHO, 2013)
Death rate (Mortality)	$PM_{2.5}$	6.0%	(COMEAP, 2010)
Respiratory hospital admission (Morbidity)	$PM_{2.5}$	1.9%	(WHO, 2013)
Cardiovascular disease hospital admission (Morbidity)	$PM_{2.5}$	0.9%	(WHO, 2013)

B.3.2. Causal Pathway Map

Climate action in cities has a range of wider benefits beyond air quality and health. Although not quantified as part of this analysis, these were studied in the literature review. The causal chain relationships that link urban climate action to the key benefits are outlined in the pathway maps. Figure 1.2 to Figure 1.7 show these for a range of high-impact actions.

Please note it is important to understand which benefits that are priorities for the city before starting the analysis. This keeps data collection and analysis targeted on the benefits that are likely to be most valuable or persuasive for city stakeholders.

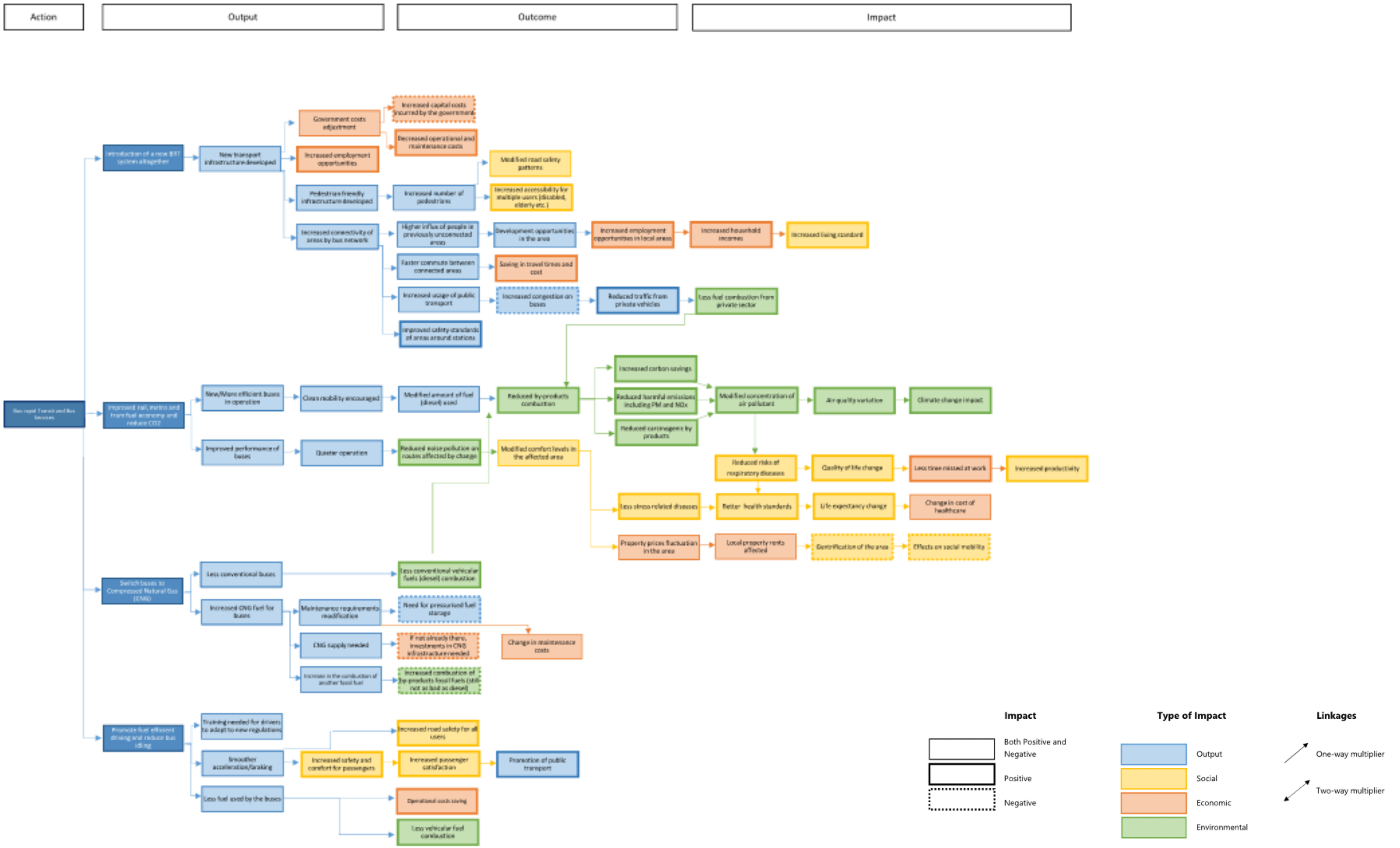
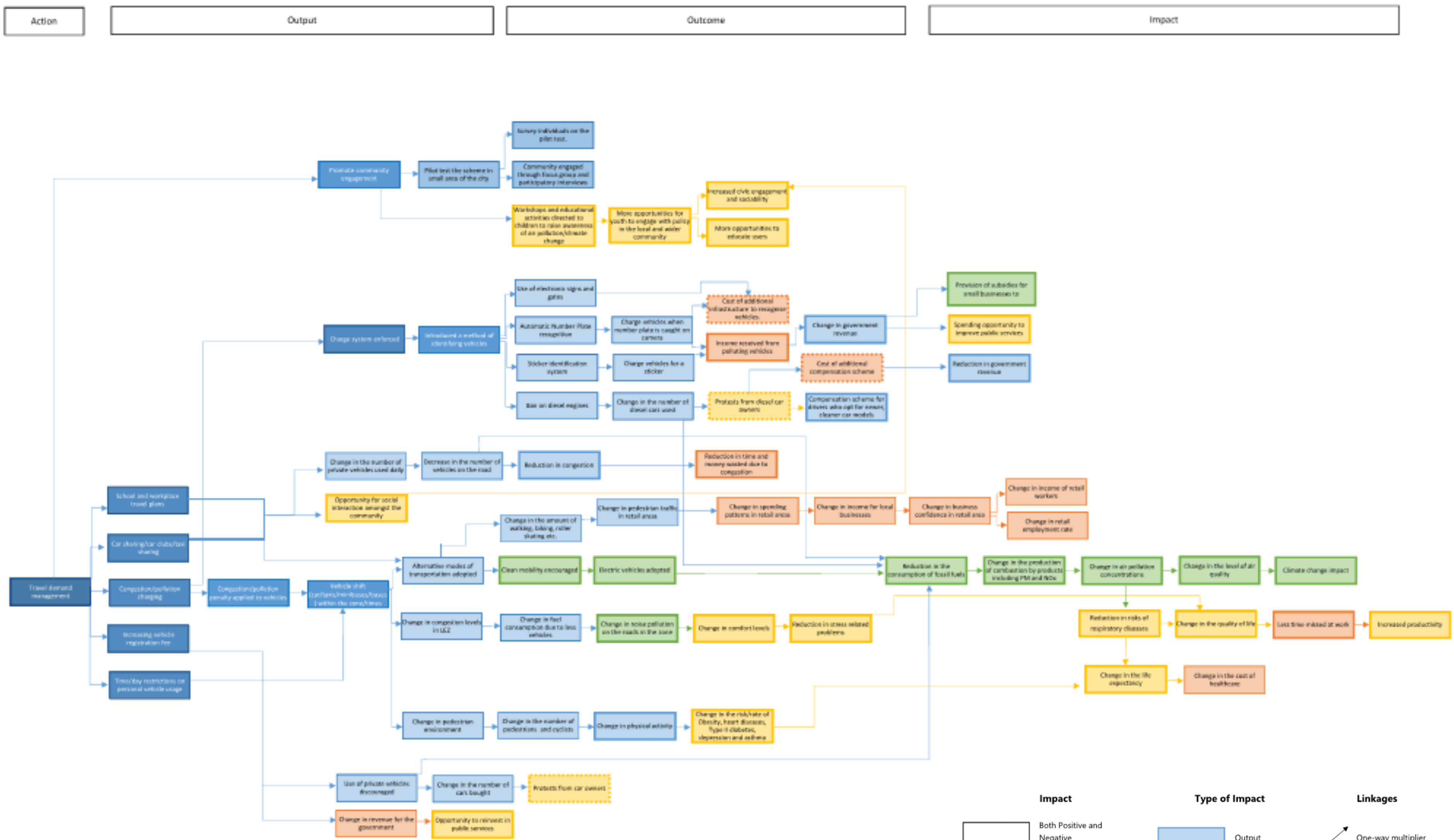


Figure 3 Pathway map – Bus Rapid Transport



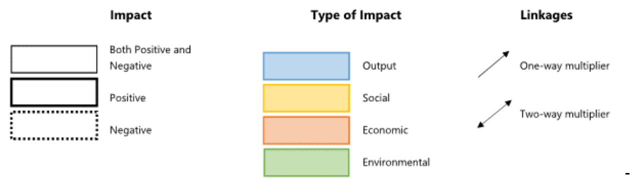


Figure 4 Pathway map – Travel demand management

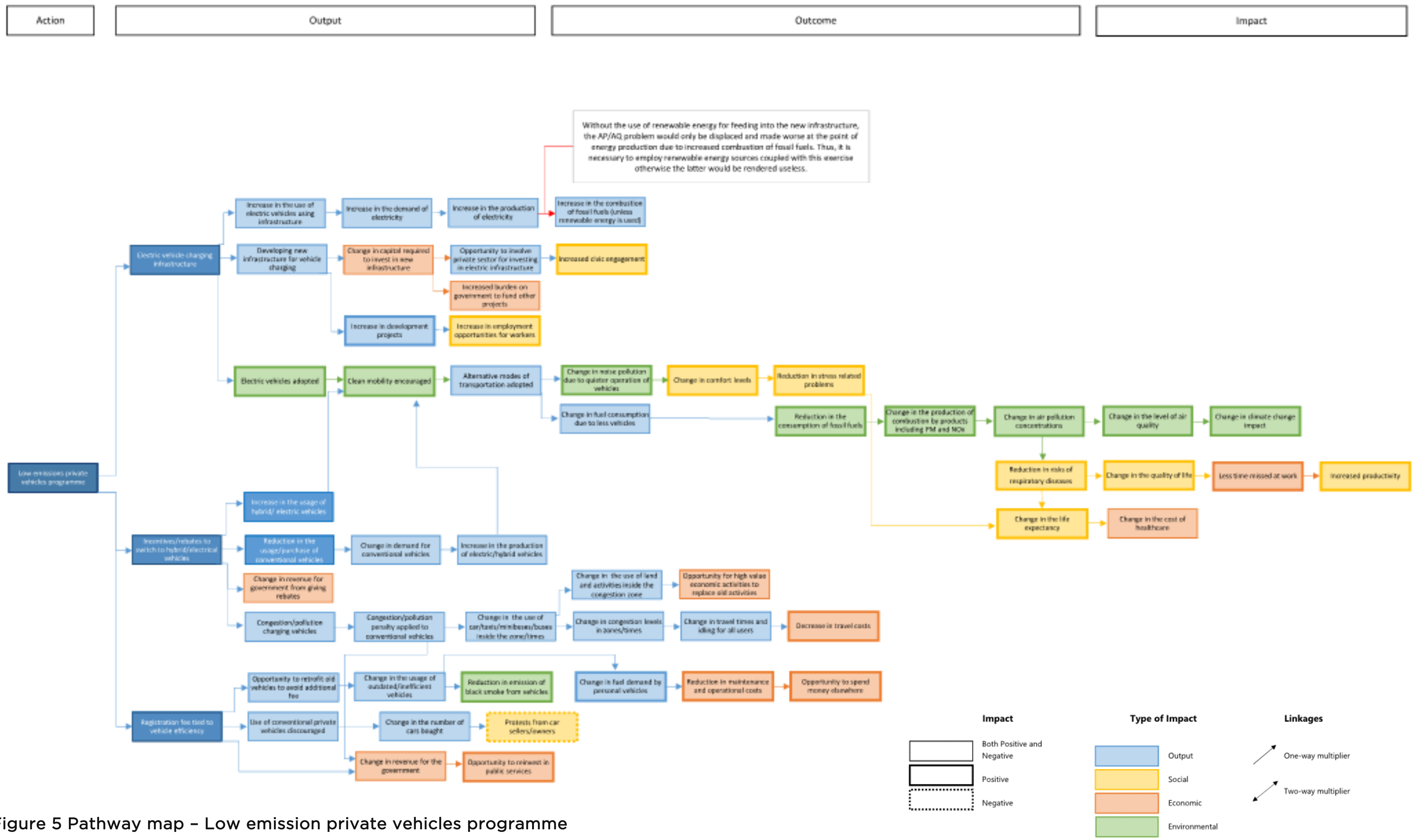


Figure 5 Pathway map – Low emission private vehicles programme

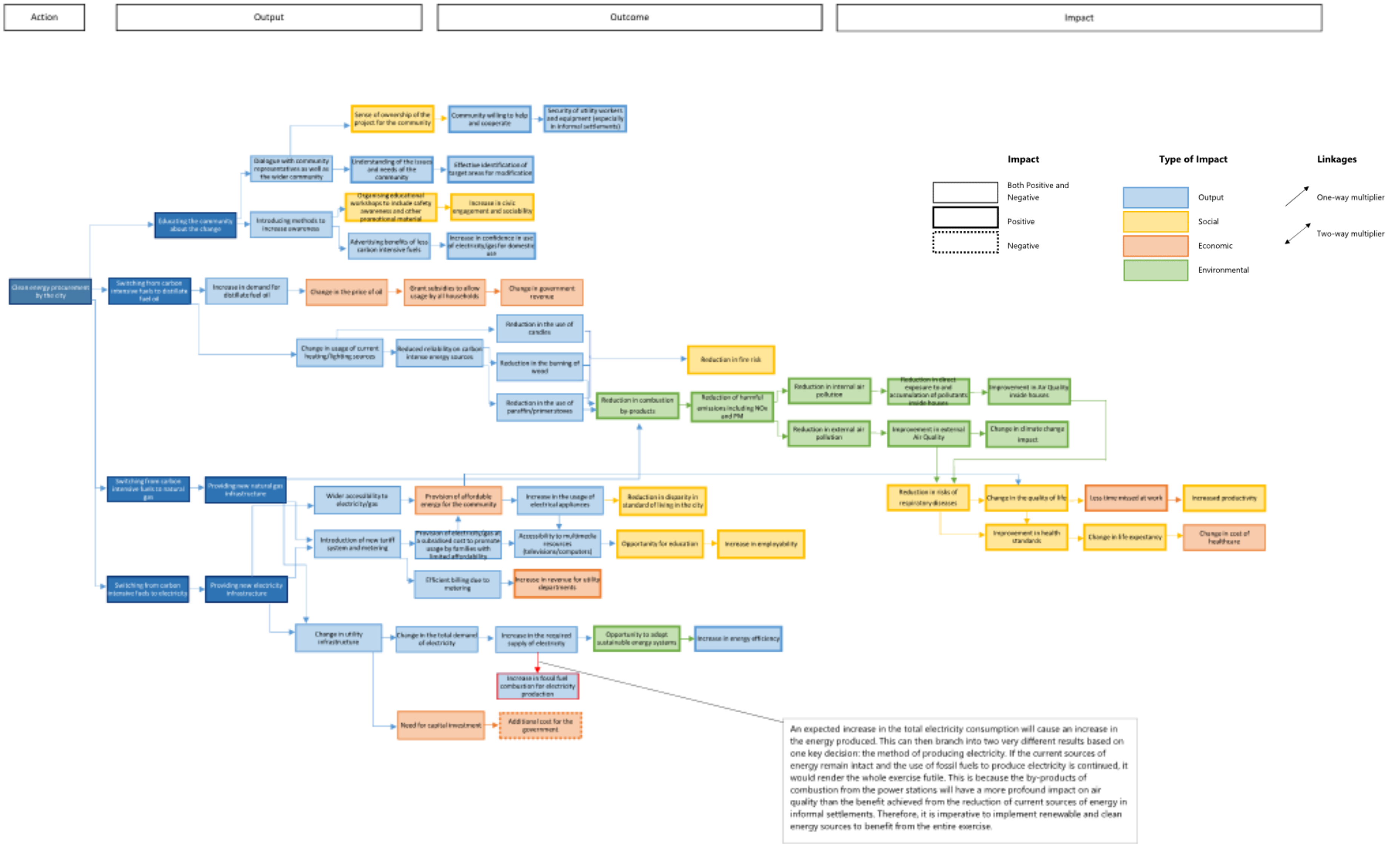


Figure 6 Pathway map – Clean energy procurement

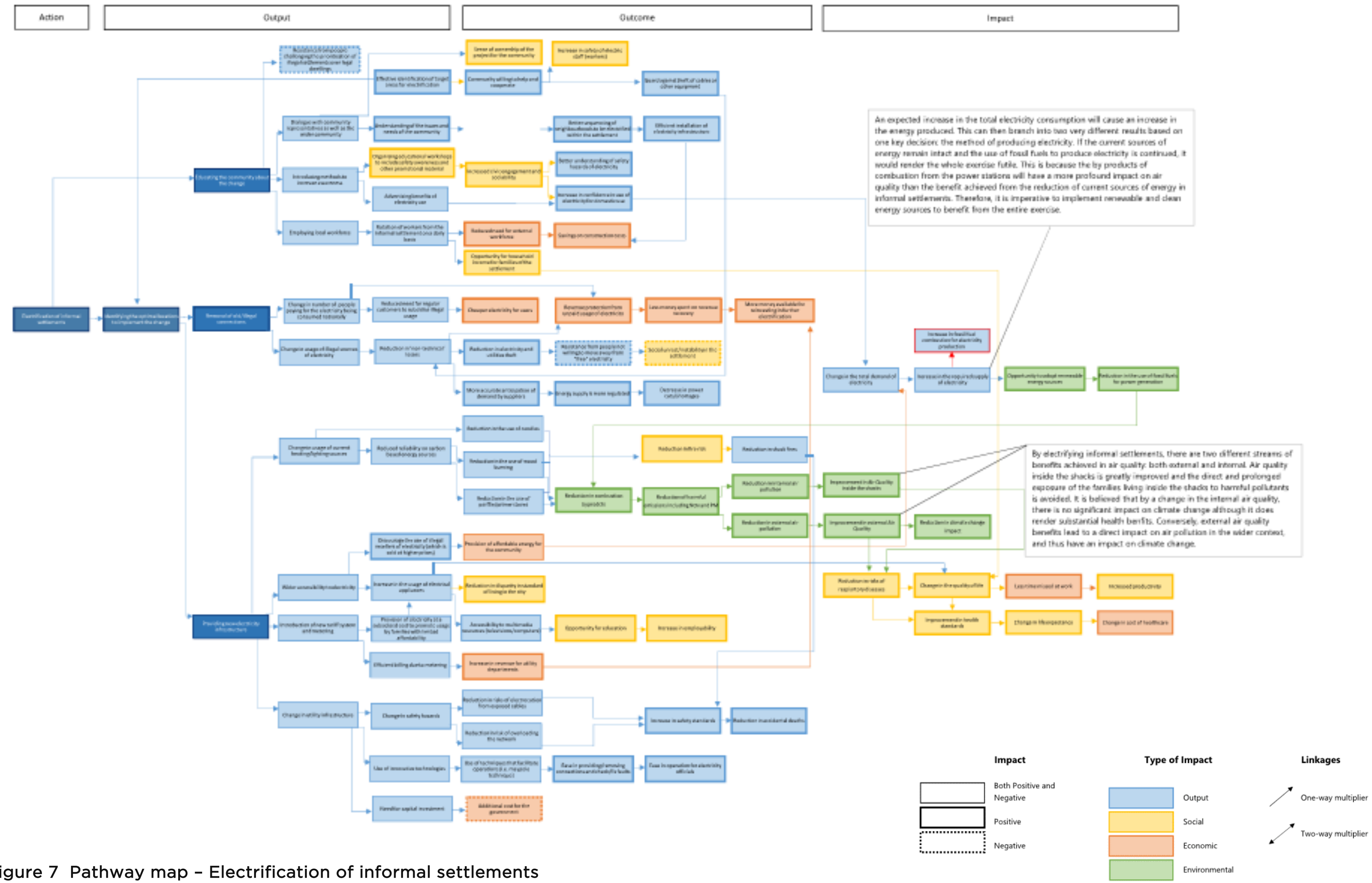
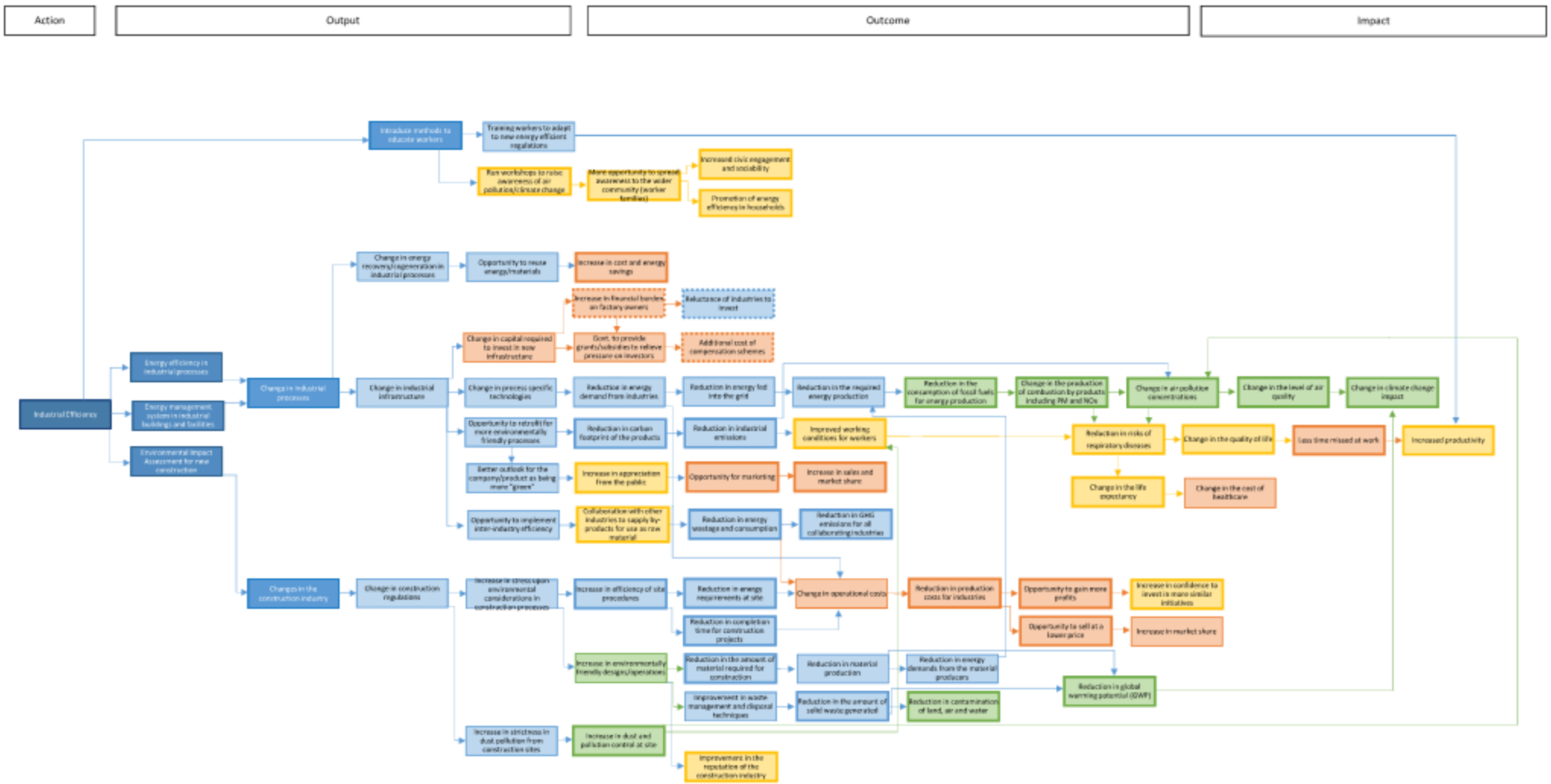


Figure 7 Pathway map – Electrification of informal settlements



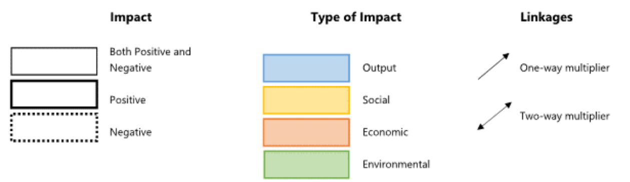


Figure 8 Pathway map – Industrial efficiency

B.4. Data collection

In order to evaluate the air quality, health and economic benefits of climate action, cities had to collect a range of data, showing the characteristics of the city and the air quality for pre- and post-action scenarios. Collecting pre- and post-intervention data is essential for understanding the change over time, and any available time-series data can be particularly useful.

The key data requested include:

Action data	• Extent of intervention area (i.e. a specific area of the city where the action will be implemented) Other inputs may be dependent on the specific action. In the example of a bus upgrade programme, required data includes: • Fleet breakdown by fuel type • Exhaust and non-exhaust emission factors for buses, broken down by fuel type • Proportion of bus fleet allocated for upgrade • Bus system relevant to the upgrade – including specific bus routes/city coverage
Pollutant data	• $PM_{2.5}$ ($\mu g/m^3$): annual average background and urban concentration (in the city and in the intervention area) • NO_2 ($\mu g/m^3$): annual average background and urban concentration (in the city and in the intervention area) • NO_X ($\mu g/m^3$): annual average background and urban concentration (in the city and in the intervention area) • Source apportionment of NO_2 and $PM_{2.5}$ concentration for the specific sector considered, in the example of the bus upgrade programme, this is the percentage contribution to non-background concentration coming from buses
Population and health data	• Annual deaths by age and gender • Population by age and gender • Respiratory-related hospital admissions by age and gender • Cardiovascular-related hospital admissions by age and gender
Economic data	• Value of a respiratory-related hospital admission • Value of a cardiovascular disease-related hospital admission • Value of a Life Year

To have full guidance on the data collection, you can refer to the data collection checklist (Annex A.4)

The tool has been tested by 30 cities to date to ensure its usability worldwide. Data provided by the city team was reviewed and gaps in the data were identified against the essential data required to measure the benefits for this study. Gaps were discussed with the city to understand what further local information might be available to fill any of these gaps, and which gaps should be addressed through a literature review (e.g. using proxy data and benchmarks). Proxy data was often used from cities either from a similar country or region, in order to replicate as similar climatic conditions as possible.

B.5 Data analysis

City data is combined with multipliers and proxy data from wider research - where city data is not available - to estimate the benefits of the action. Three types of measurement are used to estimate the benefits:

- **Quantification** –the change in air pollution, in terms of reduction in $PM_{2.5}$ and NO_2 concentration, as a result of the action was calculated; and Life tables were used to estimate the associated health benefits of the action from reduced air pollution. Results are reported in terms of number of attributable deaths avoided, life-year gained, life expectancy increase and change in the number of hospital admissions. It is important to note that those metrics are applied to populations and cannot be used to individuals
    - The reduction in the **number of deaths** that are caused by a risk factor (such as air pollution), across the whole population in any one particular year, at current levels of pollution.
    - **Life expectancy increase** is the average number of years that a new-born could expect to live if he or she were to pass through life subject to the age-specific mortality rates of a given period.
    - **Years of life gained** are a measure of the years of life gained as a result of premature death averted. In simplified terms, the calculated number of deaths attributable to changes in exposure to air pollution is multiplied by the standard life expectancy at the age at which death occurs.
    - **Hospital admissions** illustrate the change in the number of cardiovascular and respiratory diseases.

- **Monetisation** – economic multipliers were used to convert health benefits, into a monetary value. The **Value of Life Years** (VOLY) is used to quantify the economic burden of death. It is based on studies that assess the willingness to pay for reducing mortality risks associated with air pollution. The avoided **healthcare costs** show the impact of reduced hospital admissions.

- **Illustration** – based on research, examples of interventions in other cities can be used to provide an indication of what the benefits might be. Illustration is particularly useful in cases where local city data is not available, but an indication of potential benefits is still needed.

APPENDIX C: Programme and summary of actions

Partner engagement

The project was instigated around preliminary partner engagement, wherein the strategic partners (BuroHappold) and technical partners (CERC and LSHTM) came together around the formation of the benefit calculation methodology. To provide substance for this discussion, the literature review was conducted, providing empirics regarding the illustrative, qualitative, and quantitative relationship between urban climate actions and air quality, health and economic impacts.

2017 Technical Assistance

Technical assistance was provided to five cities, listed below, which used the methodology to quantify the impact of proposed climate and air quality actions. The C40 project team provided technical assistance, involving extensive engagement with the cities through remote communication. The initial support involved a series of calls with the cities to understand and shape the chosen action of the city. The cities were further supported throughout the data collection and the step-by-step analysis, with experts available to respond to any clarifications needs on the methodology.

Cities: Paris, Salvador, Santiago de Chile, Barcelona, Johannesburg

2017 Masterclass

The learnings from Wave 1 Technical Assistance were used to roll out the methodology to a larger group of cities. A Masterclass was then organised in November 2017 in London. Prior to the masterclass, attending cities were engaged through calls and regional webinars to discuss choosing appropriate actions to bring forward with support on data collection. The masterclass itself consisted of 9 attending cities, listed below, that undertook a three-day process of familiarising themselves with the methodology and the relation between city actions, air quality and health. The cities participated in activities aimed at understanding their actions, the data required, the system change, the intervention area, and ultimately the action plan that would set a roadmap for driving further action. Experts also presented during the masterclass on the wider benefits of urban climate action and showed previous examples of successful implementation strategies.

Workshop attendees: Mexico City, Quito, Istanbul, Athens, Hanoi, Karachi, Medellin, Buenos Aires, Quezon City

2018 Masterclass

A masterclass, similar to the one carried out in 2017, was held in June 2018. The purpose of this was to get more cities involved, by explaining to them the methodology and supporting them in making the case for climate action. 11 cities, listed below, attended the masterclass.

Workshop attendees: Rome, Durban, Dubai, Amman, Venice, Chennai, Chengdu. Ho Chi Minh City, Jakarta, Auckland, Dar es Salaam

2018 Scaling-Up Technical Assistance

Technical assistance was offered to 7 cities that had participated in either of the two masterclasses. The assistance was focussed on building on what cities had learned within their respective masterclasses and driving scaled-up action scenarios. Cities were encouraged to think big and propose and evaluate enhancements to their initial actions. The cities were chosen based upon the potential scale of impact, as well as existing financial and political buy-in surrounding the future up-scaling.

The seven cities involved in the scaling-up: Quito, Ho Chi Minh City, Durban, Mexico City, Venice, Chennai, Quezon

2019 Technical Assistance

A new series of technical assistance was offered to 4 additional cities. As previous technical assistance, the support involved a series of calls with the cities to understand the chosen action, help on data collection and the step-by-step analysis, with experts available to respond to any clarifications needs on the methodology.

The team also conducted post-support webinars, calls and mails in order to both assist with any queries relating to the methodology upon cities returning home, as well as more generally tracking the progress of cities in implementing the action plan devised during the workshop. This largely entailed updates on how and where the results had been communicated within their respective administrations, and importantly these discussions were held in group seminars in order to facilitate as much peer-to-peer learning as possible where cities could learn from the experience and success of others.

Toward a Healthier World

In reaction to the success of the main Benefits programme, Johnson & Johnson and C40 Cities sought to deliver a thought leadership report with the purpose of communicating to the wider audience the benefits of combined climate and air quality action in cities. The report, titled 'Toward a Healthier World' and released in December 2018, provides a call for action for cities to address climate change now, simultaneously harnessing the related air quality and health benefits. The report was articulated around four main areas:

- Encouraging cities to start from the problem by looking to address their key sources of GHG and air pollutants
- Presenting on the top actions to achieve cleaner transport, buildings and industry sectors
- Showing the potential climate, air quality, health and economic benefits if all C40 Cities (96 cities, as of 2018) delivered clean road-transport, buildings, and industry
- Sharing key learnings from the the Benefits programme

The priority actions outlined in the 'Toward a Healthier World' report are defined both as all-city actions and as city-specific actions (based on cities' income and density levels). The actions are based on the McKinsey 'Focused Acceleration' report which defines priority actions to tackle climate change by city typology. The main difference is that the "Toward a Healthier World" reports focuses on actions that tackle both air quality and climate change, while the McKinsey report dealt with GHG emissions reductions only. Specifically, actions such as zero emission area and reducing congestion, clean heating and cooling networks, and retrofits of informal settlements have been added. In addition to the McKinsey report, priority actions for the industry sector have been derived from the Breathelife campaign, complemented with learnings from the Benefits research with C40 Cities. The identified priority actions are shown in Figure 3.1.

The report also showed that if all the C40 cities (96 cities, as of 2018) committed to clean transport, buildings and industry (underpinned by a zero carbon grid), they would achieve substantial climate, air quality, health and economic benefits: 87% drop in GHG emissions, average 49% drop in PM2.5 levels and 223,000 premature deaths averted every year – corresponding to up to $583bn value.

Please refer to 'Toward a Healthier World' report (C40 Cities and BuroHappold, 2018a) and to the relative methodology report (C40 Cities and BuroHappold, 2018b) for further details.

APPENDIX D : Additional annexes

D.1 GHG Calculations – Methodology Summary

GHG calculations were led by C40 Modelling team, based on the system change calculated for the air quality analysis, cities inputs and where necessary proxy data. Proxy data was sourced from international datasets (COPERT CO2 emissions factors per vehicle type and ICCT Global Transportation Roadmap, 2012), national datasets and/or similar city or action contexts. For all actions a snapshot scenario was used comparing a pre-action baseline with a post-action scenario. For the post-action scenario this was based on city data, modelling, expert judgment, proxy data from similar scenarios and/or a range of scenarios depending on availability.

Table 9 summarizes the data inputs needed per type of action, and any assumptions made.

Sector	Action	City example	Data used
Clean transport	BRT	Dar es Salaam has launched a programme to implement BRT corridors across the city.	▪ Number of buses per category and fuel type ▪ Distance travelled per day (km) (City data or proxies) ▪ Engine type emission factors (gCO2/km) (COPERT 5) ▪ To calculate the baseline: GHG source apportionment of buses, or transport mode share (%), mode shift (%) and emission factors linked to each transport mode (gCO2/km)
	Bus electrification	Salvador is looking to replace the full STCO fleet (2,348) upgrade to fully electric vehicles.	▪ Number of buses per category and fuel type ▪ Distance travelled per day (km) ▪ Electric buses energy efficiency (kWh/km) (ICCT, 2012) ▪ Engine type emission factors (gCO2/km) (COPERT 5)
	Private vehicles electrification	Ho Chi Minh City is testing a pilot project to promote the use of electric motorbikes. The city looked at upgrading 10% of the fleet to electric.	▪ Number of vehicles per category and fuel type ▪ Distance travelled per day (km) ▪ Vehicles energy efficiency (kWh/km) (ICCT, 2012) ▪ Engine type emission factors (gCO2/km) (COPERT 5) ▪ Fuel emission factors (IPCCC, 2006) ▪ City grid electricity emission (kgCO2e/kWh) (IGES, 2019)
	Low-emission zone	Venice plans to ban the circulation of Euro 0 motorcycles, Euro 0-1 petrol cars, Euro 0-4 diesel car and Euro 0-3 diesel LDV vehicles during the winter season, from Monday to Friday between 08.30 and 18.30 in the urban agglomeration.	▪ Current and future number of vehicles per category and fuel type (city data or assumptions) ▪ Distance travelled per day (km) ▪ Engine type emission factors (gCO2/km) (COPERT 5) ▪ Second option is to assume that all GHG emissions are null in Zero Emission Zones and use the current GHG emissions inventory to compare scenarios. Limitation: we assume traffic is NOT re-routing elsewhere.
	Congestion charge	Auckland investigated the benefits of implementing congestion pricing in the city.	The methodology would be similar to LEZ. For the report, calculations from the city transport modelling team have been directly used.
	Vehicle testing	Jakarta is working to implement mandatory emission testing for private vehicles.	Because opacity is measuring particulate matter emissions, the programme would have a big impact on black carbon emissions. Black carbon is a potent climate pollutant (~3,000 times as much warming as an equivalent amount of CO2 over a 20-year period) and can account for a significant fraction (~75%) of PM emissions from diesel vehicles that are not equipped with filters. The programme would have a positive impact on climate, but this has not been quantified in this report.

Clean buildings	Indoor air quality	Santiago proposed to replace wood-burning cook stoves with more efficient, cleaner cook stoves.	▪ Percentage of homes per fuel type (city specific sources) ▪ Energy use per household per fuel type (GJ/house/year) (city specific sources) ▪ CO2 equivalent emission factor per fuel type (tonnes CO2e/GJ) (IPCCC 2006) ▪ Fuel heating values (MJ/kg) (Engineering ToolBox, 2003) ▪ City grid electricity emission factors (national or CDM project emissions factors) (kgCO2e/kWh)
Clean industry	Industrial efficiency	Mexico City currently has a voluntary industrial efficiency programme to monitor and reduce industrial emissions, which they want to expand city-wide.	For the report, calculations from the city modelling team have been directly used.
Decarbonising the grid	Renewables	Istanbul is planning to install floating solar PV panels on the city's water reservoirs, reducing GHG and pollutants emissions deriving from electricity generation.	▪ National grid electricity emission factors (IEA, 2015) (kgCO2e/kWh) ▪ Energy generation from the solar installation – calculated with PVGIS ▪ Assumption that renewable energy is considered as null carbon emissions

References and proxy data sources:

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D.2. Analysis of City of Los Angeles Emission Reduction Initiatives

The South Coast Air Quality Management District (SCAQMD) conducted a rough estimate of the health and associated monetized benefits resulting from the City of Los Angeles's emission reduction targets. The socioeconomic report for the 2016 Air Quality Management Plan (AQMP) estimated the benefits of ozone attainment in terms of health outcomes and monetized health benefits associated with reduced mortality and morbidity.

LA used the air quality and health outcomes resulting from the emission reductions in the ozone attainment demonstration for the year 2023 presented in the 2016 AQMP. The city assumed a linear relationship between emission reductions and benefits to estimate the air quality and health benefits of several emission reduction initiatives proposed for the City of LA. This linear assumption provides a rough approximation for such analysis since the effects of complex chemistry, precursor pollutant interactions, and finer- scale geographical effects are not taken into full account. A more rigorous analysis would require an analogous approach to what it was used for the 2016 AQMP, where comprehensive emissions and photochemical air quality models with high resolution were employed to analyze air quality improvements of spatially-resolved emissions, and comprehensive socioeconomic models were used to calculate health outcomes and monetized health benefits. This linear approximation assumes that ozone and PM2.5 formation, and health effects are linear, which could be a reasonable assumption for small emission changes. However, the error and uncertainty of linear extrapolation increases with the increasing changes in emissions. Results in this analysis should be considered as a "preliminary analysis" with a full understanding of its limitations.

Table 1 presents the extrapolated health outcomes and monetized health benefits of a series of emission reduction initiatives for the City of Los Angeles. A description of the methodology to calculate those values follows.

Table 1. Reduced mortality and morbidity, and monetized public health benefits estimation resulting from LA City's emission reduction initiatives, using outcome reduction factors calculated with attainment demonstration for 2023

		Overall Health Outcomes Avoided			Monetized Health Benefits ($ millions)			
Scenarios		Pre-Mature Deaths	Hospital Admissions - Respiratory	Hospital Admissions - Cardiovascular	Pre-Mature Deaths	Hospital Admissions - Respiratory	Hospital Admissions - Cardiovascular	Total
25% ZEV	Light Duty	94	24	16	$901.21	$0.32	$0.60	$902.13
	Buses and MD	60	13	10	$581.98	$0.17	$0.39	$582.54
	HHDT	71	16	12	$686.97	$0.20	$0.46	$687.63
	All vehicles	245	58	42	$2,369.51	$0.75	$1.59	$2,371.85
80% ZEV	Light Duty	300	76	51	$2,883.87	$1.01	$1.93	$2,886.81
	Buses and MD	191	43	33	$1,862.33	$0.55	$1.25	$1,864.13
	HHDT	226	51	39	$2,198.29	$0.65	$1.47	$2,200.42
	All vehicles	783	185	135	$7,582.44	$2.40	$5.08	$7,589.93

100% ZEV	Light Duty	375	95	64	$3,604.84	$1.26	$2.42	$3,608.52
	Buses and MD	239	54	41	$2,327.91	$0.68	$1.56	$2,330.16
	HHDT	282	63	49	$2,747.87	$0.81	$1.84	$2,750.52
	All vehicles	978	231	169	$9,478.05	$3.00	$6.35	$9,487.41
Industrial Emissions	Reduction 38%	224	49	39	$2,184.59	$0.62	$1.46	$2,186.67
	Reduction 82%	484	106	84	$4,714.11	$1.34	$3.16	$4,718.61
100% Net Zero Carbon Buildings		190	41	33	$1,851.39	$0.52	$1.24	$1,853.15

Methods

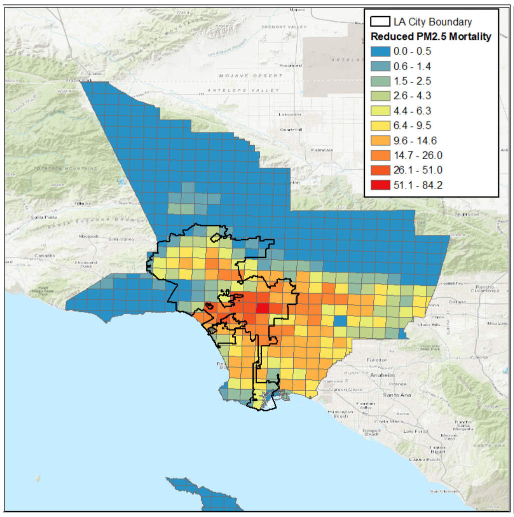
SCAQMD conducted an extensive analysis of the health benefits resulting from the ozone attainment demonstration for 2023 in the 2016 AQMP. The socioeconomic report estimated the benefits of ozone attainment in terms of health outcomes and costs savings associated with reduced mortality and morbidity. Monetized health benefits presented in the 2016 AQMP socioeconomic report were aggregated at a county level. Mortality was available at a 4 km by 4 km grid level. To estimate the LA city specific health benefits from the county level data, the grid-level mortality data was integrated within the rough LA city boundaries and compared with the county level value. The mortality ratio of the city to the county was used to scale all other health benefit outcomes to estimate LA city specific outcomes. For ozone, the reduced mortality in LA City is 52% of the overall reduced mortality in LA County, whereas PM2.5-related reduced mortality in LA City is 60% of the overall reduced mortality in LA County. The results for both LA county and the City of LA are shown in Table 2.

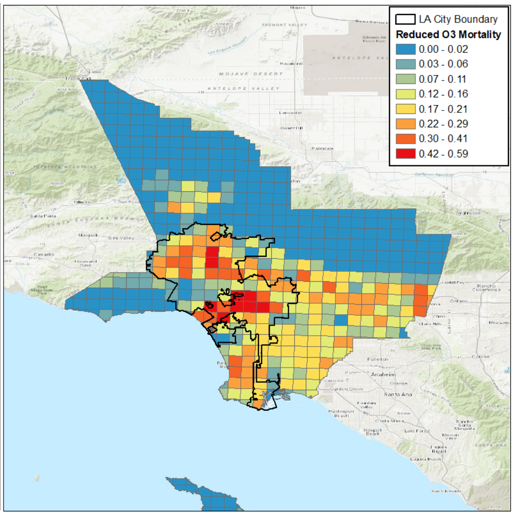
Table 2: Summary of emissions, pollutant concentrations, and health outcomes and benefits resulting from the ozone attainment demonstration in the 2016 AQMP for the year 2023

	LA County	LA City
Emission Reductions in LA County (tons/day)		
VOC	36.4	-**
NOx	72.3	-**
PM2.5	0.1	-**
Concentration Reductions		
Maximum Change in Daily 8 hour Maximum Ozone (ppb)	6.3	5.0
Average Change in Daily 8 hour Maximum Ozone (ppb)	3.8	2.9
Maximum Change in Daily PM2.5 (ug/m3)	1.6	1.6
Average Change in Daily PM2.5 (ug/m3)	0.5	0.8
Reduction in PM2.5-related Health Outcomes		
Mortality	985	591
Hospital Admissions, Respiratory*	194	116
Hospital Admissions, Cardiovascular*	172	103
Monetized PM2.5-related Health Benefits ($ millions)		
Mortality	$ 9,685.14	$ 5,825.16
Hospital Admissions, Respiratory	$ 3.21	$ 1.86
Hospital Admissions, Cardiovascular	$ 6.49	$ 3.91
Reduction in Ozone-related Health Outcomes		
Mortality	18	9
Hospital Admissions, Respiratory*	51	27
Ozone-related Monetized Health Benefits ($ millions)		
Mortality	$ 1.85	$ 0.96
Hospital Admissions, Respiratory	$ 0.86	$ 0.45
Total Monetized Health Benefits ($ millions)	$ 9,694.85	$ 5,816.69

* Health outcomes and cost benefits at the city level are prorated from the county values: Ozone-related reduced mortality in LA City is 52% of the overall reduced mortality in LA County, PM2.5-related reduced mortality in LA City is 60% of the overall reduced mortality in LA County

** Emission Reductions in the City of LA not shown because the analysis is conducted at county level





Reduced mortality related to PM2.5 reductions

Reduced mortality related to Ozone

Figure 1. Reduced mortality resulting from PM2.5 (left) and ozone (right) resulting from the ozone attainment demonstration. Reduced mortality for the City of LA is a fraction of the total mortality reduction in the County of LA.

Results from Table 2 were then used to calculate the improvement of ozone and PM2.5 concentrations and their health benefits per ton of precursor emissions reduced, shown in Table 3. Ozone precursor emissions are calculated as the sum of NOx and VOC emissions. PM2.5 precursor emissions are calculated as the sum of directly emitted PM2.5 and 0.2 times of NOx emissions (this assumes a NOx/PM2.5 emission formation ratio of 0.2, which was calculated for Central LA, Carreras-Sospedra et al., 2017). These factors are then applied to LA City's emission reduction targets to estimate the potential pollutant concentrations, reduced health impacts and avoided costs.

Table 3. Outcome reduction factors per ton of precursor emission* reductions in LA County projected for the ozone attainment demonstration for 2023.

	2016 AQMP 2023 Attainment
Concentration Reductions in LA City	
Maximum Change in Average Daily 8h Maximum Ozone (ppb/ton reduced)	0.05
Average Change in Average Daily 8h Maximum Ozone (ppb/ton reduced)	0.03
Maximum Change in Average Daily PM2.5 (ug/m3/ton reduced)	0.11
Average Change in Average Daily PM2.5 (ug/m3/ton reduced)	0.06
Ozone-related Health Outcomes	
Mortality (avoided deaths/ton reduced)	0.17
Hospital Admissions, Respiratory (avoided hospital admissions/ton reduced)	0.47
Ozone-related Monetized Health Benefits ($ millions/ton reduced)	
Mortality	0.02
Hospital Admissions, Respiratory	0.01
PM2.5-related Health Outcomes	
Mortality (avoided deaths/ton reduced)	67.47
Hospital Admissions, Respiratory (avoided hospital admissions/ton reduced)	13.26
Hospital Admissions, Cardiovascular (avoided hospital admissions/ton reduced)	11.81

PM2.5-related Monetized Health Benefits ($ millions/ton reduced)	
Mortality	663.33
Hospital Admissions, Respiratory	0.16
Hospital Admissions, Cardiovascular	0.44

* Ozone precursor emissions are calculated as NOx+VOC. PM2.5 precursor emissions are calculated as PM2.5 + 0.2*NOx

A number of emission reduction strategies considered in the City of LA are evaluated using the above outcome reduction factors. The emission reductions associated with the LA City's initiatives are presented in Table 4. They are LA county total annual average emissions for year 2017 from the 2016 AQMP. This approach does not include emission reductions expected from existing or future rules and regulations and natural fleet turnover.

Table 4. 2017 Baseline Annual Average Emissions for the County of Los Angeles

	VOC	NOx	PM2.5
Light Duty	52.37	42.08	4.73
Light Heavy Duty Trucks	2.84	9.2	0.22
Medium Heavy Duty Trucks	1.02	13.12	0.54
Heavy Duty Trucks	1.05	33.41	0.39
Buses	1.06	13.62	0.45
On-Road Total	58.34	111.43	6.33
Industrial Emissions			
Fuel Combustion*	5.09	9.85	3.2
Petroleum Production and Marketing	15.6	0.26	1.52
Industrial Processes	6.93	0.05	3.68
RECLAIM**		19.88	
Total Industrial Emissions	27.62	30.04	8.4
Building Related Emissions***	3.44	13.65	1.91

* excluding service, commercial, food and agriculture sectors

** Prorated allocation based on 2012 facility locations and emissions

*** from service, commercial and residential fuel combustion, excluding wood burning

Emission reductions from various scenarios and resulting reductions in daily maximum 8-hour ozone average and daily PM2.5 concentrations are presented in Table 5. Resulting health outcomes and monetized health benefits are summarized in Table 1 above.

Table 5. Emission reductions and air quality impacts of LA City initiatives, using outcome reduction factors calculated with attainment demonstration for 2023

		Emission Reductions (tpd)			Concentrations	
Scenarios		**VOC**	**NOx**	**PM2.5***	**Daily 8h Max Ozone (ppb)**	**Daily PM2.5 Mean (ug/m3)**
Light Duty	25% ZEV	13.1	10.5	0.2	1.09	0.24
	80% ZEV	41.9	33.7	0.5	3.48	0.78
	100% ZEV	52.4	42.1	0.6	4.35	0.98
Buses and MD	25% ZEV	0.5	6.7	0.1	0.33	0.16
	80% ZEV	1.6	21.4	0.4	1.06	0.51
	100% ZEV	2.1	26.7	0.5	1.33	0.63
HHDT	25% ZEV	0.3	8.4	0.1	0.40	0.19
	80% ZEV	0.8	26.7	0.2	1.27	0.60
	100% ZEV	1.1	33.4	0.2	1.59	0.75
All Vehicles	25% ZEV	14.6	27.9	0.4	1.96	0.64
	80% ZEV	46.7	89.1	1.2	6.26	2.06
	100% ZEV	58.4	111.4	1.5	7.82	2.57
Industrial Emissions	Reduction 38%	10.5	11.4	3.2	1.01	0.59
	Reduction 82%	22.6	24.6	6.9	2.18	1.28
100% Net Zero Carbon Buildings		3.4	13.7	1.9	0.79	0.50

* Emission reductions