CLIMATE OPPORTUNITY: MORE JOBS; BETTER HEALTH; LIVEABLE CITIES

QUANTIFYING THE BENEFITS OF CLIMATE CHANGE MITIGATION MEASURES IN BUILDINGS, TRANSPORT AND ENERGY SUPPLY

SUMMARY VERSION

GLOBAL COVENANT of MAYORS for CLIMATE & ENERGY

NEW CLIMATE INSTITUTE

C40 CITIES

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NewClimate Institute

NewClimate Institute supports research and implementation of action against climate change around the globe. We generate and share knowledge on international climate negotiations, tracking climate action, climate and development, climate finance and carbon market mechanisms. We connect up-to-date research with the real world decision making processes, making it possible to increase ambition in acting against climate change and contribute to finding sustainable and equitable solutions. Our projects are internationally recognised and followed and put us at the forefront of the climate change forum, where we seek to achieve maximum impact for the international climate change mitigation effort.

C40 Cities Climate Leadership Group (C40)

C40 connects more than 95 of the world's greatest cities to deliver the urgent and essential climate action needed to secure a sustainable, prosperous and healthy future for urban citizens worldwide. Representing 700 million people and one quarter of the global economy, mayors in the C40 network are, and have to be, committed to delivering on the most ambitious goals of the Paris Agreement. The benefits of urgent climate action by cities is increasingly clear. Those cities which make the sustainability transition fastest will also be the healthiest, wealthiest, most liveable cities of the future.

Global Covenant of Mayors for Climate & Energy (GCoM)

The Global Covenant of Mayors for Climate and Energy is the largest global coalition of cities and local governments voluntarily committed to actively combatting climate change and transitioning to a low-carbon and climate resilient economy. Led by UN Secretary-General's Special Envoy for Climate Action, Michael R. Bloomberg, and European Commission Vice President, Maroš Šefčovič, in partnership with local, regional and global city networks, the Global Covenant has thousands of city signatories across 6 continents and more than 120 countries, representing over 700 million people or nearly 10% of the global population. By 2030, Global Covenant cities and local governments could collectively reduce 1.3 billion tons of CO_2 emissions per year from business-as-usual – equal to the emissions of 276 million cars taken off the road.

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This document is a summary version of the Climate Opportunity report. The following materials are also available to further explore the content:

Interactive online dashboard

The results from the Climate Opportunity Report are presented in an interactive dashboard where users can explore and compare the findings between regions and define a specific city to visualise indicative results at this level. The dashboard is available at www.globalcovenantofmayors.org/climateopportunity

Full report and technical methodology document

See the full report and methodological document for a more thorough overview of the results and their discussion. These documents also include a full list of references used in this research as well as details of the methodologies developed, and the assumptions contained.

EXECUTIVE SUMMARY

Key Messages

- Climate policies on building retrofits, bus networks and district energy and cooling can generate millions of jobs, save households billions of dollars, and prevent hundreds of thousands of deaths related to urban pollution all over the world.
- The report helps policymakers **establish the case for climate action** by providing evidence on how climate measures are interrelated with, and support, other urban policy goals.
- Climate Opportunity shows that mitigating climate change through ambitious policies can help cities achieve their broader social and economic agendas and deliver outcomes for health and prosperity.
- By using Climate Opportunity's methodology and tools, policymakers can investigate further linkages between ambitious climate measures and their social and economic priorities.

Introduction

Cities account for 73 % of global GHG emissions (IEA 2016); if nations should be able to deliver on their commitments under the Paris Climate Agreement, it is necessary to encourage and facilitate large-scale urban climate action. Achieving substantial reductions in energy-related emissions requires simultaneous climate action across sectors.

Detailed, practical, and scientifically robust information exists on what type of climate actions urban areas can and must take to reduce their emissions. The aim of the Climate Opportunity report is to help local and national policymakers to **establish the case for action** by providing evidence on how climate policies are interrelated with, and deliver outcomes for, health, wealth and other development agendas.

The Climate Opportunity report outlines the benefits for three highly effective climate actions and provides local and national policymakers with a guiding methodology for how cities and nations can evaluate these impacts and **develop their own robust cases for climate action policies**.

Approach and Results

The Climate Opportunity report looks at the wider impacts of climate change, up to 2030, by analysing how efforts to promote **energy efficiency retrofits in residential buildings, enhanced bus networks, and district-scale renewable energy** reduce emissions as well as affect health and prosperity in selected global regions. These measures, impacts and regions were selected based on insights from recent research that highlights the most relevant, high impact and achievable climate actions (ARUP & C40 Cities 2016; McKinsey & C40 2017). These actions are crucial to the delivery of the Paris Agreement. 2030 was identified as a reasonable timeframe for impacts to be captured, though immediate action from incumbent Mayors is still required in order to deliver the rate of necessary change to achieve these impacts in 2030.

The report's analysis focuses on two scenarios. First, **a reference scenario** that projects urban developments based on current trends and, second, **an enhanced action scenario** that assumes that each climate action is implemented at a level consistent with the requirements of the Paris Agreement.

The Climate Opportunity report has found positive impacts for various regions and countries in different stages of economic development. The report also shows that climate action can have proportionally greater benefits for lower income groups in the cities of developing countries, where populations often have the most to gain from the introduction of new technologies and practices.

Table 1 demonstrates the effects of taking urban climate action, in line with the enhanced action scenario. Climate action can be action for health and prosperity, with hundreds of thousands of prevented deaths, millions of jobs created, and billions generated in household savings.

Table 1: Overview of Climate Opportunity results.

MEASURE	REGIONS	CITY-LEVEL IMPACTS ASSESSED	IMPACTS IN 2030	EMISSIONS REDUCTIONS IN 2030
Energy efficiency retrofit of residential buildings	European Union; North America; China	**Job creation** **Household saving rates**	**Job creation –** EU (1 m); North America (1.5 m); China (1 m; Worldwide (5.4 m) **Household saving rates –** EU (+60 %); North America (+10 %); China (+2 %)	EU (124 $MtCO_2e$); North America (80 $MtCO_2e$); China (43 $MtCO_2e$)
Enhanced bus networks	North America; Latin America; South Asia	**Outdoor air pollution and health impacts** **Road traffic accident fatalities** **Reduced commuting time**	**Outdoor air pollution and health impacts (prevent deaths/year) –** North America (5,000); Latin America (22,500); South Asia (160,000); Worldwide (560,000) **Road traffic accident fatalities per year –** North America (4,000); Latin America (20,000); South Asia (110,000); Worldwide (415,000) **Reduced commuting time –** North America (1.1 bn hours); Latin America (6.9 bn); South Asia (7.6 bn); Worldwide (40 bn)	North America (120 $MtCO_2e$); Latin America (110 $MtCO_2e$); South Asia (85 $MtCO_2e$)
District heating and cooling	China; Africa, European Union	**Job creation** **Outdoor air pollution and health impacts** **Savings from reduced fuel imports**	**Job creation –** China (860,000); Africa (41,000-82,000); EU (2.8 m); Worldwide (8.3 m) **Outdoor air pollution and health impacts (prevent deaths/year) –** China (115,000); Africa (10,000-21,000); EU (29,000); Worldwide (300,000) **Fuel import savings –** China (marginal); Africa (marginal); EU (EUR 20 bn)	China (450 85 $MtCO_2e$); Africa (20-40 85 $MtCO_2e$); EU (200 85 $MtCO_2e$)

Conclusion

Climate Opportunity provides an evidence base that shows how acting to prevent climate change also helps cities to achieve multiple policy goals and deliver outcomes for health and prosperity.

- Investments in **residential energy efficiency retrofit** could result in the net creation of 5.4 million urban jobs, worldwide, and significant household savings – along with emission reductions.
- **Improved bus services and more extensive networks** could prevent the premature deaths of nearly 1 million people per year from air pollution and traffic fatalities worldwide, while saving 40 billion hours of commuters' time each year by 2030 – along with reducing emissions.
- **District-scale renewable energy for heating and cooling** in buildings could prevent a further 300,000 premature air pollution related deaths per year, by 2030, while also creating jobs for approximately 8.3 million people – and result in emission reductions.

Implications for Local Policymakers

Local governance is enabled and constrained by decisions, laws and institutions at a regional, national and international level of government (Broekhoff et al. 2018). Therefore, it is often necessary for city governments to coordinate a wide range of actors to fulfil their goals. National governments can, for example, control taxes, subsidies and regulatory frameworks that have a significant environmental impact or that, occasionally, hold back innovative policymaking at the urban level.

The Climate Opportunity report's impact assessment framework can help local policymakers, and other actors, to better understand the full socio-economic impact of taking ambitious climate action in line with the Paris Agreement. Thereby, the report's findings can aid urban areas in **making a robust case** for why climate action is about more than just climate and how the impacts of undertaking ambitious Paris Agreement-compliant measures will benefit many actors.

Implications for National Policymakers

Cities around the world are taking responsibility for their climate impact through ambitious action, as evidenced by the growing number of voluntary commitments cities are making through the Global Covenant of Mayors for Climate & Energy; along with the yearly progress that is being reported.

To enable local policymakers to take the climate action that is necessary for meeting national commitments under the Paris Agreement, national governments should formulate plans for how they can support their cities in adopting ambitious climate measures – while delivering on health and prosperity. There are many policies that can facilitate urban climate action in the form of regulations, fiscal measures, information-provision as well as governance reforms that strengthen the role of local decision-making (Broekhoff et al. 2018).

National policy can also have a key role in fostering coordination across sectors and levels of government. As the Climate Opportunity report shows, acting to prevent climate change is interrelated with, and delivers outcomes for, health, prosperity and wider development agendas. Helping a broad set of stakeholders see the benefits, as well as guide them on how to work together to realise positive impacts, should be both a local and a national priority.

01
STRATEGIC OBJECTIVES OF THE CLIMATE OPPORTUNITY PROJECT

The objectives of the 2015 Paris Agreement are to limit the global temperature increase to well below 2°C, pursue efforts towards 1.5°C, and to decarbonise the global economy in the second half of the century. Recent research has demonstrated that immediate action in cities is critical for achieving the goals of the Paris Agreement (ARUP & C40 Cities 2016; Stockholm Environment Institute 2018).

Despite this evidence and the urgency for action that it points to, cities may face significant barriers for **establishing and making a robust case** as well as ultimately taking climate action (C40 Cities, 2015; Compact of Mayors & C40 Cities 2016; Gouldson et al. 2015). This may be due to a lack of suitable knowledge, evidence and calculation tools to understand the wider benefits of climate action. With better tools, it will be easier for policymakers to estimate how climate policies can support other urban social and economic priorities, such as job creation and poverty alleviation. This report therefore seeks to change the way city stakeholders relate to climate action. It does this by providing concrete evidence on how climate action reduces emissions while also delivering positive outcomes for health and prosperity. In so doing, the report directly addresses key barriers that hamper the integration of impact and benefit analysis into sector-level planning in cities, by:

- demonstrating the scale of the benefits of taking climate action through the quantitative assessment of various measures in several regions;
- developing replicable methodologies for the evaluation of these impacts;
- making the results accessible to researchers, decisions makers and the general public
- identifying the links between the climate agenda and various development agendas;

This report presents analysis on the impacts of climate action up to 2030 through **energy efficiency retrofit in residential buildings, enhanced bus networks, and district-scale renewable energy** in major global regions, based on the development and utilisation of new impact assessment methodologies and tools. The 2030 timeframe was identified as a reasonable timeframe for impacts to be captured, though immediate action from incumbent Mayors is still required in order to deliver the rate of change necessary. The scenarios analysed in the research are derived from aggregated science-based targets to the extent possible, with these scenarios applied to all cities. It may be possible, or necessary, for some cities with higher capabilities to aim for action even further beyond these scenarios.

/ WITH BETTER TOOLS, IT WILL BE EASIER FOR POLICYMAKERS TO ESTIMATE HOW CLIMATE POLICIES CAN SUPPORT OTHER URBAN SOCIAL AND ECONOMIC PRIORITIES, SUCH AS JOB CREATION AND POVERTY ALLEVIATION. /

02
CLIMATE CHANGE ACTION IN CITIES AND THE ROLE OF IMPACT ANALYSIS FOR PLANNING

IMPORTANCE OF CITIES IN DELIVERING A CLIMATE SAFE FUTURE

To deliver the ambition of the Paris Agreement, urban areas will have to undertake significant, large-scale, climate action (ARUP & C40 Cities 2016; GCoM 2017; SEI 2015). Given that urban areas account for approximately 73% of global GHG emissions (IEA 2016a), scenarios for limiting global temperature rise to 2°C, such as the IEA's Energy Technology Perspectives (ETP), require a pivotal role for cities in reducing energy related emissions.

According to one analysis of the climate challenge facing cities, the Deadline 2020 report from ARUP and C40, the per-capita emissions in 84 C40 cities would have to drop from 5 tCO_2e per capita in 2015, to around 2.9 tCO_2e per capita by 2030, to have an opportunity to fulfil the objectives of the Paris Agreement (ARUP & C40 Cities 2016). The necessary emissions reduction is significant, but recent research outlines multiple pathways for urban areas to contribute to global climate change mitigation efforts (ARUP & C40 Cities 2016; SEI 2018).Fundamental, urgent, and large-scale shifts in worldwide, city-level energy use patterns across buildings, transport and industry will be required to address the climate challenge.

AMBITIOUS CLIMATE ACTION CAN AID CITIES DEVELOPMENT AGENDAS

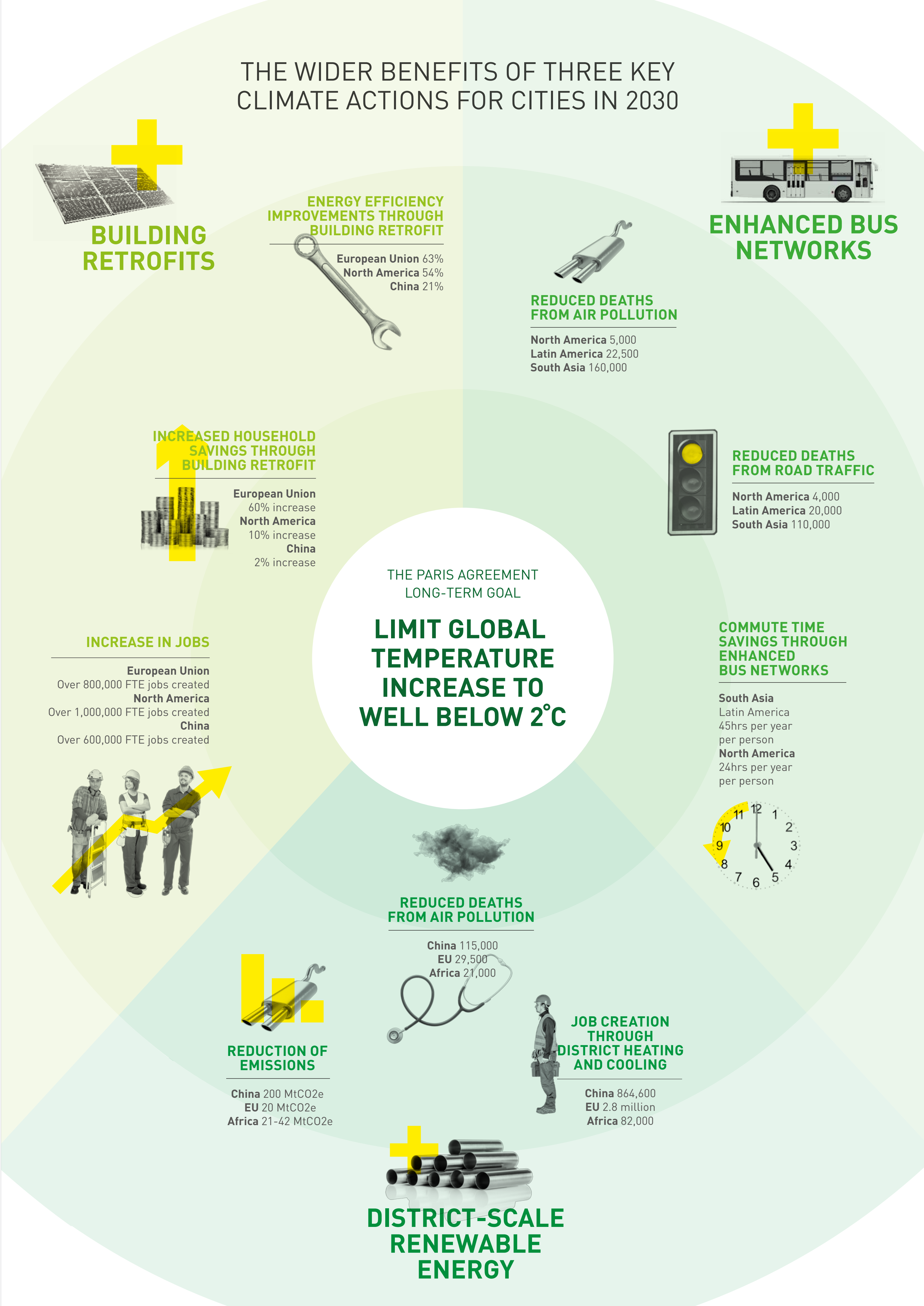
It is sometimes perceived that investments for the pursuance of climate change mitigation action represent a burden which may conflict with the development agenda.

However, there are many synergies between climate policies and the wider development agenda, as illustrated by Table 2, which shows the linkages between climate action the Sustainable Development Goals (SDGs). The climate change mitigation and adaptation agendas are increasingly being seen as opportunities for cities and national governments, as climate change action and sustainability can lead to greater outcomes for health and prosperity.

Table 2: Demonstration of some selected synergies between climate and development agendas[1].

SUSTAINABLE DEVELOPMENT GOALS (SDGs)	TYPICAL MEASURES FOR CLIMATE CHANGE ACTION AND LINKAGES TO SDGs		
	ENERGY SUPPLY (renewable and decentralised technologies)	ENERGY EFFICIENCY (e.g. in buildings and industry)	TRANSPORT (modal shift to public transport)
1. NO POVERTY	▲ Energy access boosts productivity and economic opportunities	▲ Reduce household energy bills	▲ Accessibility and mobility for poorer communities
3. GOOD HEALTH AND WELL-BEING	▲ Reduce air pollution and health risks	▲ Reduce indoor air pollution and sick building syndrome	▲ Reduce air pollution and health risks; potential physical activity benefits
4. QUALITY EDUCATION	▲ Enhance conditions for learning	▲ Enhance conditions for learning	▲ Enhance access to educational institutions
5. GENDER EQUALITY	▲ Successful introduction of programmes for reducing emissions depends on empowerment and participation of women in the household		
7. AFFORDABLE AND CLEAN ENERGY	▲▼ Energy security (affordability depends on policy options)	▲ Reduce energy consumption and bills	▲ Reduced total energy demand and use of fossil fuels
8. DECENT WORK AND ECONOMIC GROWTH	▲▼ Creation of decent jobs and new industries (Depends on policy options to avoid adverse outcomes of job losses in older industries)		
9. INDUSTRY, INNOVATION AND INFRASTRUCTURE	▲ Catalyse local enterprise and industries	▲ Improve efficiency and competitiveness of industry	▲ Develop long-term, sustainable infrastructure
10. REDUCED INEQUALITIES	▲ Decentralised energy can better address access for marginalised communities	▲ Energy expenditure burden is greater for lower income groups	▲▼ Lower income groups most disadvantaged for mobility (depends on policies to prevent gentrification)
11. SUSTAINABLE CITIES AND COMMUNITIES	▲ Technology suitable for long-term needs of cities and inhabitants	▲ Investments extend useable lifetime of built environment	▲ Infrastructure suitable for long-term needs of cities and inhabitants
13. CLIMATE ACTION	▲ Decarbonise cities; improve resilience to shocks related to natural hazards and weather extremes		

[1] For additional information on how climate actions are linked with the SDGs, please refer to the Urban Climate Action Impacts Framework (RAMBOLL & C40, 2018).



03
APPROACH OF THIS ANALYSIS

Table 3 provides an overview of the measures, impacts and regions included within this report.

Table 3: Overview of analysis scope.

MEASURE	CITY-LEVEL SPECIFIC IMPACTS ASSESSED	REGIONS
Energy efficiency retrofit of residential buildings (section 4)	**Job creation** (section 4.4.3). **Household cost savings and wealth** (section 4.4.4).	European Union; North America; China
Enhanced bus networks (section 5)	**Outdoor air pollution and health impacts** (section 5.4.2). **Road traffic accident fatalities** (section 5.5.2). **Available personal time** measured through **potential commuter time savings** (section 5.4.4).	North America; Latin America; South Asia
District heating and cooling (section 6)	**Job creation** (section 6.4.2). **Outdoor air pollution and health impacts** (section 6.4.3) **Enhanced energy security** (section 6.4.4).	China; Africa, European Union

These measures, impacts and regions were selected for analysis based upon insights from recent research (ARUP & C40 Cities 2016) on the most relevant, high impact, and achievable climate actions in the greatest number of cities, as well as feasibility of the quantitative analysis.

The analysis for the impacts of three measures was conducted through the development of new bottom-up quantitative calculation tools, built on the available literature[2].

The analysis focuses on two distinct scenarios for each measure for climate action:

- A **reference scenario** was constructed to project what may happen in cities in the case that current policies and trends persist.
- An **enhanced action scenario (EAS)** was constructed based on three types of actions implemented at levels that are assumed to be compatible with the fulfilment of the objectives of the Paris Agreement, to limit global temperature increase to well below 2°C, and informed by the science-based targets in the literature. Specific definitions of this scenario vary between the sectors analysed depending on the available information. In the case that studies or datasets identifying explicit 2°C and 1.5°C pathways were not available for some specific measures, scenarios were identified which were understood to represent generally high ambition and/or Paris Agreement compatibility, whilst also being realistic.

[2] Full details of the methodological approach are included in the separate technical methodological document.

04
ENERGY EFFICIENCY RETROFIT FOR RESIDENTIAL BUILDINGS

This chapter focuses on the analysis of accelerated residential energy efficiency retrofits, defined as the implementation of measures to improve the thermal energy performance of urban residential building structures, to reduce energy demand for spatial heating and cooling.

4.1/ IMPORTANCE OF RESIDENTIAL BUILDING RETROFIT IN CITIES

Energy consumption for spatial heating and cooling in urban residential buildings is projected to increase by approximately 50% by 2050 (IEA 2016b). This projected trend is in stark contrast to the increasing maturity of available technologies for the decarbonisation of the building sector, and the required progress in decarbonisation of the sector up to 2030 for a 2°C or 1.5°C compatible pathway. Rogelj et al. (2015) found that a 1.5oC target would require direct emissions in the building sector to be reduced by 70-90% between 2010 and 2050. Becqué et al. (2016) highlight that improving the energy efficiency of buildings, is one of the fastest and most cost-effective ways of reducing carbon emissions and improving local economic development, air quality, and public health.

Residential building retrofit is particularly relevant in countries that have already experienced high rates of urbanisation, population growth and economic development. In these countries, the majority of the future building stock has already been built, with emission pathways largely dependent on improvements to these structures. In contrast, for countries that are currently experiencing, or are projected to experience rapid urban expansion, existing buildings represent only a small portion of the future building stock and policies aimed at optimising new constructions may be even more relevant.

// FROM ROGERS PARK TO TRUMBULL PARK, BUILDINGS AROUND THE CITY ARE TAKING PART IN RETROFIT CHICAGO AND SHOWING THEY CAN WORK TOGETHER TO REDUCE EMISSIONS, SAVE MONEY AND PUT PEOPLE TO WORK. THE FINDINGS FROM THE NEWCLIMATE INSTITUTE AND C40 RESEARCH SUPPORT WHAT WE KNOW TO BE TRUE IN CHICAGO: THAT INNOVATIVE INITIATIVE LIKE RETROFITTING SAVE ENERGY, REDUCE COSTS AND IMPROVE BUILDING PERFORMANCE, ALL WHILE DRIVING CREATION OF CLEAN 21ST-CENTURY JOBS. //

MAYOR EMANUEL,
CITY OF CHICAGO

4.2/ POTENTIAL IMPACTS OF RESIDENTIAL BUILDING RETROFIT MEASURES

IImprovements in the urban environment can entail a broad range of benefits for urban populations who interact with the built environment on a continuous basis. Table 4 gives an overview of some of the key potential impacts from building retrofits, including considerations on equity, which is a central issue in the context of the Sustainable Development Goals.

Table 4: Overview of some potential direct and indirect impacts from residential building retrofit.

TYPE OF IMPACTS	EXAMPLES OF OUTCOMES AND SPECIFIC IMPACTS	EQUITY CONSIDERATIONS
Social impacts (Health and safety impacts)	+ Health benefits from better air quality from less fossil fuel burning and minimisation of the heat island effect + Reduction of health afflictions for building occupants caused by poor natural lighting, poor building ventilation and mould + Improved safety from new building technology with latest standards, minimising risk for accidents, fire or intrusion	Low income households often have a greater exposure to air pollution and extreme temperature events. Therefore, benefits will be more pronounced in these households.
Social impacts (Quality of life and urban liveability)	+ Increased ease of use and control of renovated buildings by users + Increased living comfort and well-being through ability to maintain comfortable temperatures + Direct assistance to low-income households in the case of EE programmes for social housing – Retrofit construction work can result in temporary discomfort for local residents	Lower-income groups have most to gain from improvements as they are generally the most likely to live in uncomfortable conditions, due to energy poverty. Enhanced building retrofit can play a role in the alleviation of not only energy poverty but also general economic poverty in lower-income households
Economic impacts (Individuals)	+ Reduced expenditure on fuel and electricity and reduced energy poverty + Reduced (financial) exposure to energy price fluctuations + Increased property values for buildings with high efficiency standards + Learning and productivity benefits through avoided "sick building syndrome" – Opportunity cost for use of personal income, associated with the household's initial investments	Cost savings from reduced energy consumption result in a proportionally greater increase in household savings for lower income households, depending on the financing model.
Economic impacts (wider economy)	+ Creation of unskilled, skilled and professional jobs + Cost savings and enhanced energy security through reduced dependence on fossil fuels + Increased economic activity through technical innovation for energy efficient solutions and new business opportunities + Reduced spending on energy in public buildings + Reduced national healthcare spend due to enhanced health and safety – Opportunity cost of large capital investments – Reducing energy consumption may result in job losses in the energy supply sector	The options for the implementation of measures for building retrofits should be carefully considered to avoid potential adverse outcomes for marginalised groups, such as job losses in specific industries, and to maximise the channelling of new employment opportunities to local and unskilled staff.
Environmental impacts	+ Improved air quality (indoor and outdoor) + Reduced noise pollution + Reduced greenhouse gas emissions + Micro-ecosystem services supported through better potential for urban vegetation on walls and roofs	Low income households are often the most adversely affected by indoor and outdoor air pollution, as well as by heat waves and cold spells, due to greater exposure. Therefore, benefits will be more pronounced in these households.

Source: Authors' elaboration based on Ferreira & Almeida (2015), Ürge-Vorsatz et al. (2009), IEA (2014), Copenhagen Economics (2012) and Heffner & Campbell (2011).

4.3/ SCOPE OF ANALYSIS AND SCENARIOS

The analysis of benefits and impacts for energy efficiency retrofit of existing residential buildings is presented in this report completed for cities within the **European Union, North America and China.**

The analysis for the potential of residential building retrofits is based on the following increases in the rates and depths of retrofitting activity[3]:

- **Renovation rate:** The proportion of the building stock which is retrofitted each year. This is set to remain at 1.4% in all regions under the reference scenario and to increase to 3% in the enhanced scenario, by 2020 in the EU and North America and by 2023 in China.
- **Retrofit depth:** The degree of energy efficiency improvement achieved through renovation. This is set to remain at 10% in all regions under the reference scenario and to increase to the level of new building standards under the enhanced scenario, by 2025 in the EU and North America and by 2028 in China.

This study focuses on the impacts of energy efficiency retrofit scenarios in the urban residential building sector for **net job creation** and **household savings and wealth.**

- **Job creation** is assessed with regards to the net employment impact including estimated creation and losses of jobs in various sectors.
- For **household wealth indicators,** the impacts of retrofit are assessed with regards to the impact on the household's final expenditure for spatial heating and cooling, and thus its effects on household asset accumulation and investment potential (annual savings rate). The annual savings rate represents the financial resources households have available each year for use towards increasing assets and making investments, after all expenditure from essential needs.

4.4/ QUANTIFIED IMPACTS OF RESIDENTIAL BUILDING RETROFIT

4.4.1 Greenhouse gas emission reductions

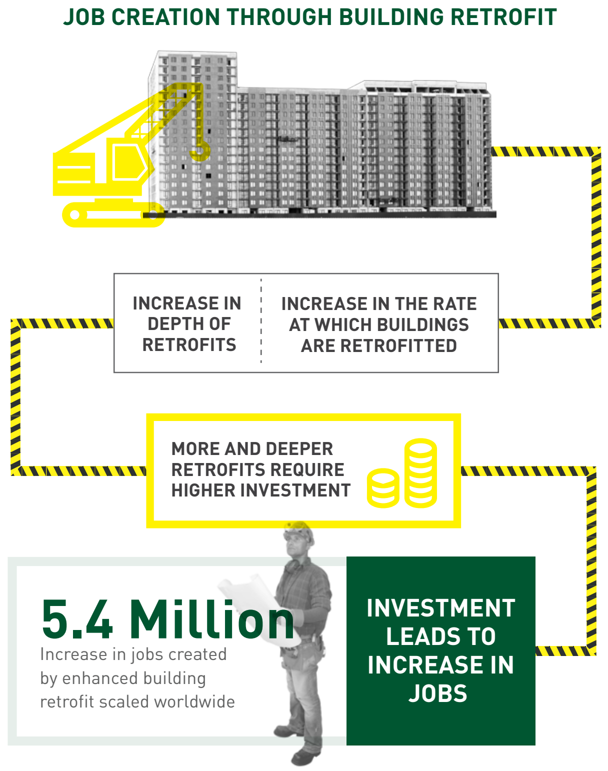
The enhanced retrofit scenario would result in the reduction of GHG emissions for spatial cooling and heating in the buildings sector by 124 $MtCO_2e$ in the European Union, 80 $MtCO_2e$ in North America, and 43 $MtCO_2$ in China, compared to the reference scenario. In China, the reduction in emissions of residential buildings per capita is significantly lower, partly because the emission intensity of the building sector in China is already considerably lower than the other two regions.

4.4.2 Retrofit activity and investments

The policy environment and economic circumstances of the European Union, North America, and China has led to the incentivisation of only minimal retrofit activity in all regions; the annual retrofit rate is approximately 1.4% of the building stock and the depths of retrofit are relatively minor. An estimated EUR 12 billion was invested in the retrofit of approximately 210 million m² of urban residential building floor space in 2014 in the EU. In North America and China, an estimated EUR 20 billion was invested in retrofitting around 310 million m² and 360 million m² of urban residential building floor space, respectively, with these rates of retrofit and investment set to continue under the reference scenario[4]. In contrast to the reference trajectory, the enhanced action scenario, which incorporates an increase in the rate and depth of retrofit, would increase the floor space retrofitted each year by 2025 to over 500 million m² in the European Union, over 800 million m² in North America and 1,100 million m² in China, with this rate of retrofit sustained towards 2030 and further into the future. Annual investment needs would increase in all regions to an average of approximately EUR 60 billion per year in the European Union and China and EUR 90 billion per year in North America, for the period between 2015 and 2030.

[3] Further details on the construction of the scenarios can be found in the Full Report.
[4] Details on the calculations for retrofit activity and investments can be found in the separate Technical Methodology document.

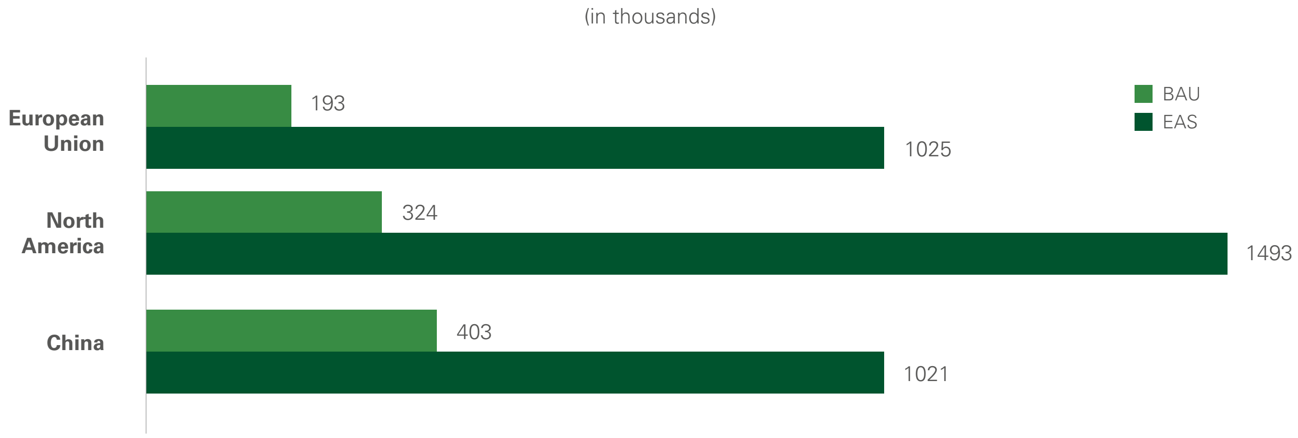
4.4.3 Job creation



Investments in building retrofit drives direct, indirect, and induced job creation in labour-intensive industries such as construction, engineering, maintenance, and contracting.

Figure 1 shows that a reference scenario pathway could be expected to lead to the creation of approximately 200,000 full-time equivalent (FTE) jobs sustained over the period 2015-2030 in urban areas of the European Union, approximately 320,000 in North America and approximately 400,000 in China. Jobs in the sector would increase almost five times under the enhanced action scenario (EAS), creating around 1 million FTE jobs in the European Union, 1.5 million in North America and 1 million FTE jobs in China. This difference in the net employment impact of the two scenarios is highly significant in the context of national unemployment rates: the gain is equivalent to approximately 4% of unemployed persons in the European Union, 12% in the United States and 6% in China in 2017 (18.5 million, 7.7 million, and 9.7 million people were unemployed in the European Union, North America and China, respectively, in 2017) (European Commission 2017; Trading Economics 2017). The 250% growth in jobs created under the enhanced scenario in China is highly significant but lower than for the other regions analysed. This is due to the country's lower marginal costs of renovation and the slower introduction of deeper retrofit action in the enhanced scenario, compared to in North America and the European Union[5].

Figure 1: Full-time equivalent jobs generated through retrofitting (2015-2030).



[5] The relatively slower introduction of deeper retrofit action in China is due to the scenario assumptions that the enacting of policies for building retrofit should be able to happen sooner in OECD countries. Details on these scenarios can be found in the separate Technical Note document.

At the global level, the enhanced building retrofit scenario is estimated to lead to the **creation of 5.4 million jobs worldwide in 2030,** compared to the reference scenario. Table 5 shows how the results can be scaled down to the city level[6].

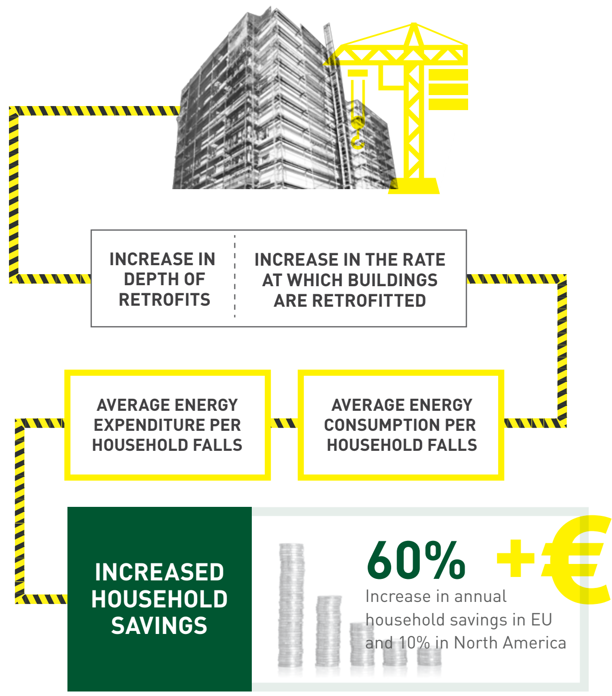
Table 5: Scaling up to the global level and down to cities and the C40 and GCoM networks.

SCALING UP THE RESULTS	The enhanced building retrofit scenario is estimated to lead to the **creation of 5.4 million jobs worldwide in 2030,** compared to the reference scenario.			
SCALING DOWN THE RESULTS				
Average annual job creation (2015-2030)	European Union	Average city	Reference	~ 250 jobs
			EAS	~ 1,300 jobs
		C40 network cities	Reference	~ 15,000 jobs
			EAS	~ 80,000 jobs
		GCoM network cities	Reference	~ 80,000 jobs
			EAS	~ 380,000 jobs
	North America	Average city	Reference	~ 500 jobs
			EAS	~ 2,200 jobs
		C40 network cities	Reference	~ 36,300 jobs
			EAS	~ 142,000 jobs
		GCoM network cities	Reference	~ 77,000 jobs
			EAS	~ 300,000 jobs
	China	Average city	Reference	~ 240 jobs
			EAS	~ 430 jobs
		C40 network cities	Reference	~ 17,200 jobs
			EAS	~ 30,500 jobs
		GCoM network cities	Reference	~ 4,300 jobs
			EAS	~ 7,600 jobs

Scaled down results are indicative approximations based on population, rather than a bottom up evaluation of specific cities. The "Average city" refers to the potential impact in the region for a city of 500,000 population. "C40 network cities" and "GCoM network cities" refer to the potential impact either across all of the C40 cities or Global covenant of Mayors cities in the region.

[6] Details on the calculations for the global and city-level scaling can be found in the separate *Technical Methodology* document.

4.4.4 Household cost savings and wealth



Energy bills play a significant role in households' regular expenditures in many countries. The burdens of energy related expenditure can be particularly relevant for lower-income households because a greater percentage of total available budget is dedicated to energy costs.

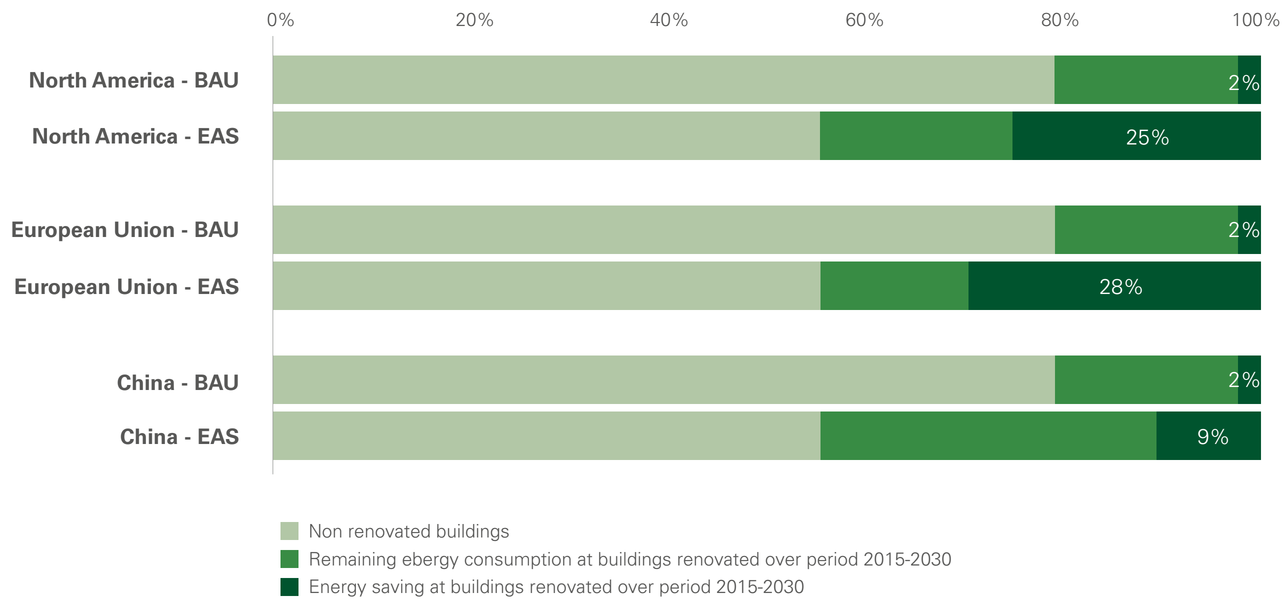
The impacts of retrofit measures[7] in the urban residential building sector are assessed in this section with regards to:

- the impact on the household's final expenditure on energy related to spatial heating and cooling; and
- the potential effects on annual household saving rates.

Reduction of household primary energy consumption

Figure 2 shows that the average energy demand for spatial heating and cooling of households in the three regions may be 9-28% lower in 2030, under the enhanced action scenario, compared to the current demand. The reduction under the reference scenario would be just 2%.

Figure 2: Reduction of energy demand for spatial heating and cooling in the urban residential building stock in 2030.



[7] Details on the calculations for the impacts can be found in the separate *Technical Methodology* document.

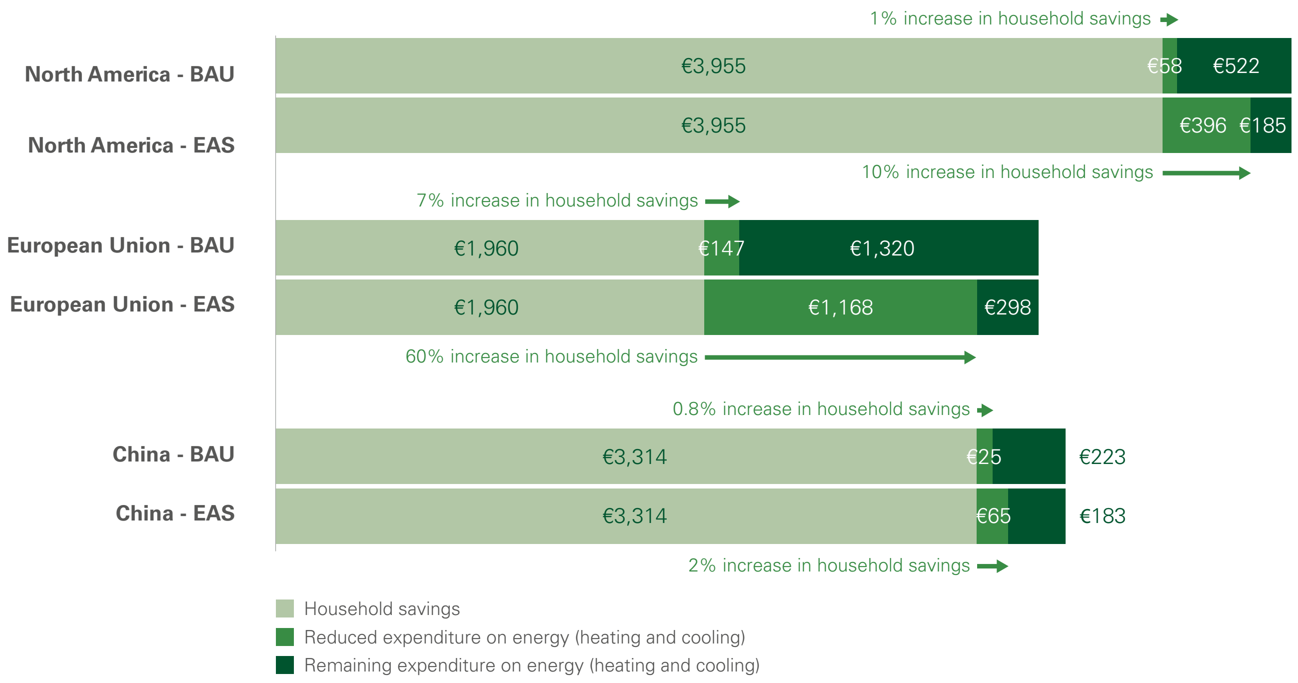
Household savings and wealth

Household savings and wealth are assessed based on the impacts of reduced household energy expenditure on annual household cash flows, disposable incomes and typical household annual saving rates[8].

Figure 3 shows the reduction in energy expenditure for each region, next to the annual household savings, showing the impact that this reduced expenditure could have on increasing household savings.

Through reduced expenditure for spatial heating and cooling in the enhanced action scenario, **households could effectively increase their annual household savings, after the payback period, by approximately 60% (or close to 1,170 EUR annually) in the European Union and 10% (or about 400 EUR annually) in North America.** The impact for household savings and wealth in China is rather low, approximately 2%, due to high existing level of household savings and relatively low energy expenditure.

Figure 3: Reduced expenditure on energy and potential impact on household annual savings compared to 2030 cashflows, after completion of project cost payback period.



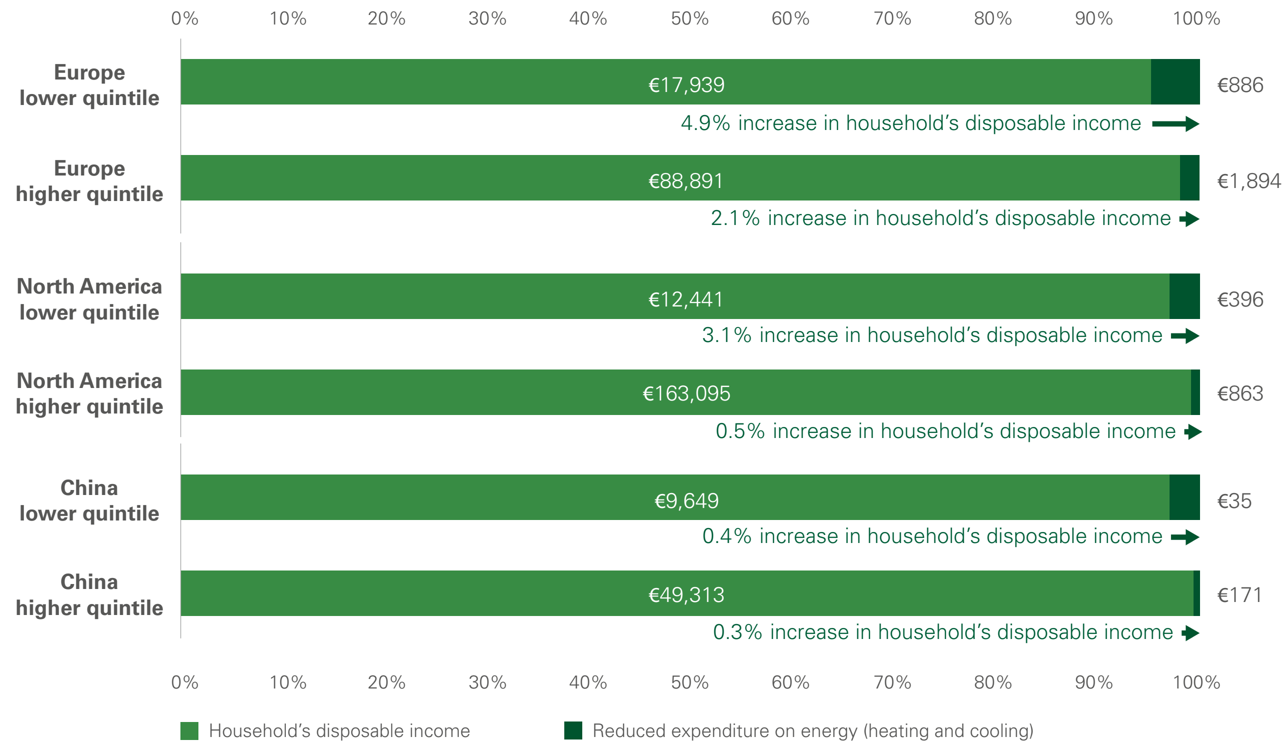
[8] For more details on the assumptions related to financing of the measures, please refer to the full report and the separate *Technical Methodology* document.

Implications for the lowest income quintile

Figure 4 shows that while a financial benefit of retrofit activities exists for households in the lowest and highest quintiles, the **relative benefit for lower income households is higher.** The disposable income of a European household in the lowest income quintile could be effectively increased by 4.9%, compared to a 2.1% increase for households in the highest quintile.

Similarly, for North America, a household in the lowest income quintile could effectively increase its disposable income by 3.2%, compared to a 0.5% increase for households in the highest income quintile. The increment in household disposable income in China is modest when compared to the other regions, staying at around 0.3-0.4% for both highest and lowest household quintiles.

Figure 4: Potential increase in disposable income for lower and higher income households, due to reduced energy expenditure under the enhanced action scenario.



4.5/ EXPERIENCES FROM LONDON, TORONTO AND KWADUKUZA AND STEVE TSHWETE MUNICIPALITIES

London

Emissions from buildings account for 77% of London's total emissions (BSI 2014). Retrofitting the built environment across the city is an essential strategy, given that at least 80% of London's existing buildings will still be standing by 2050 (Regeneris 2016), and considering that 11% of households in London, including those within the social sector, are deemed to be fuel poor (Mayor of London 2016). RE:NEW is a programme to help make London's homes more energy efficient, providing opportunities to help householders to reduce fuel bills, stimulate the local economy, and achieve wider priorities such as health-related outcomes. RE:NEW offers free technical support to landlords and mixed tenure schemes at every stage of the retrofit process, from initial strategy and reviewing the retrofit potential to funding and procurement support. Since 2009, RE:NEW has helped improve the energy efficiency of over 130,205 of London's homes, saving around 46,000 tCO_2 a year and approximately £8.85m in annual energy bill savings (Mayor of London 2018). Program data suggests that retrofitting homes has led to over 2,100 person-years of employment being supported.

// THE MAYOR IS COMMITTED TO MAKING LONDON A ZERO-CARBON CITY BY 2050 AND PROGRAMMES LIKE RE:NEW ARE KEY TO HELPING US MEET THIS AMBITION AND REDUCE FUEL POVERTY. OVER 130,000 LONDON HOMES HAVE BENEFITED FROM THE RE:NEW RETROFITTING PROGRAMME, SAVING £8.85M IN ANNUAL ENERGY BILLS AND LOWERING EMISSIONS. MOREOVER, EVIDENCE SUGGESTS THAT THE BENEFITS OF IMPROVING OUR HOMES GO BEYOND BILLS AND EMISSIONS, INCLUDING SUSTAINING JOBS IN THE RETROFIT SECTOR AND IMPROVING HEALTH OUTCOMES FOR RESIDENTS IN LONDON. //

SHIRLEY RODRIGUES,
DEPUTY MAYOR FOR
ENVIRONMENT AND ENERGY

Toronto

Buildings generate approximately half of the greenhouse gas emissions in Toronto, as reported to C40 in accordance with the Global Covenant of Mayors for Climate & Energy. As many of these residential dwellings were built prior to the advent of energy efficiency standards in the Ontario building code (1986), the City of Toronto recognised this as an opportunity to address climate change. The municipality identified energy efficiency retrofits of single family homes and multi-residential buildings as a strategic priority to reduce GHG emissions by 80% by 2050, as outlined in the programme *TransformTO* – the Climate Action Program for a Healthy, Equitable, and Prosperous Toronto (City of Toronto 2017b). The City has established a goal to retrofit all existing buildings by 2050 to the highest emission reduction technically feasible, achieving on average a 40% energy performance improvement over 2017 levels, while maintaining affordability for residents. Launched in 2014, the *Residential Energy Retrofit Pilot Program* operates as two streams – the *Home Energy Loan Program* (HELP) and the *High-rise Retrofit Improvement Support Program* (HI-RIS)(City of Toronto 2017a). Through a 'one-window' service delivery model, property owners gain access to financing, utility rebates and incentives and support services. Initial findings, from January 2014 to December 2017, demonstrate the wide benefits of the programme and encourage its continued development to address the full untapped potential of the sector: approximately 90 jobs were created by the projects taking place in these years.

// IMPROVING THE ENERGY PERFORMANCE OF RESIDENTIAL BUILDINGS, THROUGH PROGRAMS SUCH AS *HELP* AND *HI-RIS*, ALSO IMPROVES HOUSING AFFORDABILITY AND CREATES JOBS. OUR EFFORTS TO RETROFIT BUILDINGS NEED TO BE DRAMATICALLY ACCELERATED TO ACHIEVE TORONTO'S LOW-CARBON GOALS AS ENVISIONED BY *TRANSFORMTO*. //

MIKE LAYTON,
TORONTO CITY COUNCILLOR

KwaDukuza and Steve Tshwete Municipalities, South Africa

The municipalities of KwaDukuza and Steve Tshwete have been designated as model intermediary cities by ICLEI's Urban-LEDS project, which gathers a group of local governments and communities that are at the forefront of feasible, sustainable, and impactful climate action. In 2015, after years of consultation and development, the two South African municipalities published green building guidelines designed to encourage building retrofits and provide recommendations, tools, and best practice references for local designers, developers and building operators (KwaDukuza Local Municipality 2015; Steve Tshwete Local Municipality 2015).

Building retrofits can reduce operation costs, improve structural integrity, and foster safer built environments across the two municipalities' existing housing stock. Retrofitting is therefore encouraged as a pathway to both mitigate building-related GHG emissions and optimize a wider set of socioeconomic benefits. Local officials, in conjunction with implementation partners ICLEI and UN-HABITAT, highlight that both aesthetic changes and building system upgrades can increase local employment opportunities (KwaDukuza Local Municipality, 2015; Steve Tshwete Local Municipality, 2015). These employment opportunities may generate the development of skills and knowledge across the local labor market, specifically on building construction, retrofits, operations and maintenance, bringing safer and better homes, as well as potential jobs, to the local economy.

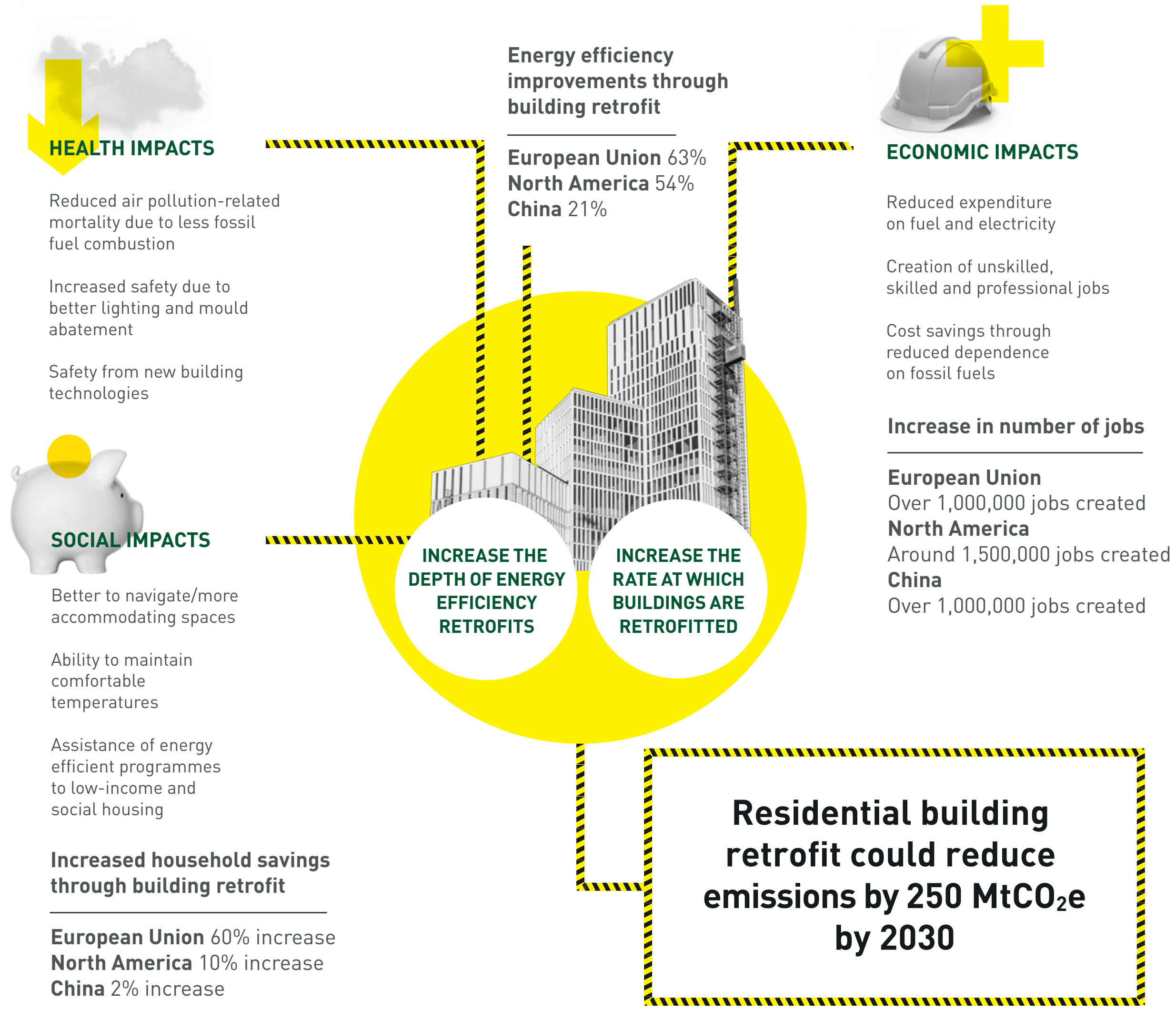
Sources

ICLEI - Local Governments for Sustainability. (2015, November 23). Green Building resources released for use by municipalities and developers. Retrieved August 28, 2018, from http://africa.iclei.org/fr/news-events/news-details/article/green-building-resources-released-for-use-by-municipalities-and-developers.html

KwaDukuza Municipality. (2015). *Green Building Guidelines of KwaDukuza Municipality*. KwaDukuza, South Africa. Retrieved from http://africa.iclei.org/fileadmin/user_upload/Africa/Energy/Green_Building_Guidelines/KDM_Green_Building_Guidelines.pdf

Steve Tshwete Local Municipality. (2015). *Green Building Guidelines of Steve Tshwete Municipality*. Steve Tshwete, South Africa. Retrieved from http://africa.iclei.org/fileadmin/user_upload/Africa/Energy/Green_Building_Guidelines/STLM_Green_Building_Guidelines.pdf

BUILDING RETROFIT



05
ENHANCED BUS NETWORKS AND BUS SERVICES

This chapter looks at some of the impacts of specific measures for improvement of bus networks and incentivising the use of public transport, including enhancements to the density of the bus network, the frequency of bus services, the usage of dedicated segregated bus lanes or fully-fledged bus rapid transit (BRT), and the uptake of zero carbon technologies in the vehicle stock.

// AN ADVANCED CITY IS NOT ONE WHERE EVEN THE POOR USE CARS, BUT RATHER ONE WHERE EVEN THE RICH USE PUBLIC TRANSPORT. //

ENRIQUE PEÑALOSA, MAYOR OF BOGOTÁ, COLOMBIA (2013)

5.1/ IMPORTANCE OF ENHANCED BUS NETWORKS AND BUS SERVICES IN CITIES

Continuing rapid growth in previous decades, emissions from the transport sector look to continue to grow at a considerable rate, in particular due to anticipated growth of transport activity in developing countries. Under current policy projections, global transport sector emissions, excluding shipping and aviation, are projected to increase from 7.6 $GtCO_2e$ in 2014 to approximately 10-11 $GtCO_2e$ in 2050. Compatibility of the sector with the goals of the Paris Agreement would require transport emissions to significantly reduce to 2-3 $GtCO_2e$ by 2050 (IEA 2017a). The urban action scenario of ARUP & C40 Cities (2016) indicates a mitigation potential by 2050 of approximately 300 $MtCO_2e$/a from enhanced bus services and bus rapid transit in cities of the C40 network worldwide. This is identified as the most important measure for reducing emissions in urban transport in these cities.

The objective of enhanced bus networks, to shift private vehicle users to public transport networks, is a key priority for many cities. Problems associated with excessive volumes of private vehicles manifest themselves as everyday issues for productivity and quality of life for most city dwellers: time lost to rush-hour congestion, accessibility disadvantages and health-endangering local air pollution are examples of issues that many city dwellers experience on a daily basis.

5.2/ POTENTIAL IMPACTS OF ENHANCED BUS NETWORKS AND BUS SERVICES

Transport systems are so deeply integrated in urban planning and urban lifestyles that the impacts of enhanced bus networks are felt beyond the users of the networks, also extending to businesses, city dwellers and the wider economy. Table 6 gives an overview of some of the key potential positive and negative impacts from the improvement of bus networks, including considerations on equity.

Table 6: Overview of some potential direct and indirect outcomes and impacts from improvement of bus networks.

TYPE OF IMPACTS	EXAMPLES OF OUTCOMES AND SPECIFIC IMPACTS	EQUITY CONSIDERATIONS
Social impacts (Health and safety impacts)	+ Health benefits from improved air quality due to reduced traffic (reduced emissions of local air pollutants from vehicles) + Reduced fatal and non-fatal injuries (due to reduced congestion and improved transport safety) + Stress reduction due to enhanced quality of environment + Health impact from increased exercise in between public transport journeys	Lower-income communities are often located in areas with greater exposure to pollution and risk of road fatalities. Therefore, benefits will be more pronounced in these communities.
Social impacts (Quality of life and urban liveability)	+ Reduced community fragmentation caused by wide, high-speed roads used by private vehicles + Increased available personal time (reduced travel time due to reduced congestion	Such community fragmentation normally occurs in lower-income communities.

TYPE OF IMPACTS	EXAMPLES OF OUTCOMES AND SPECIFIC IMPACTS	EQUITY CONSIDERATIONS
Economic impacts (Individuals)	+ Higher disposable income for households (cost savings from reduced of car ownership and maintenance) + Improved employment opportunities due to improved mobility: better access to jobs and services due to reduced congestion, reduced journey times, and enhanced public transport links + Potential reduced price of public transport for users due to reduced marginal cost of service from the increase in ridership – Alternatively, price of public transport could increase to users if expensive investments are to be recouped, depending on the implementation model	Lower income groups are often the most marginalised and the most restricted in terms of mobility and accessibility to jobs and urban services. These groups have the most to gain from enhancements.
Economic impacts (Wider economy)	+ Cost savings and enhanced energy security through reduced dependence on fossil fuels + Increased productivity through reduced travel time + Energy conservation for use in other economic activities + Technology spill-overs and enhanced development of markets for advanced technologies – Potential loss of jobs in car manufacturing industries – Opportunity costs of investments in expensive public infrastructure, unless private finance is leveraged	
Environmental impacts	+ Improved air quality + Noise reduction + Reduced greenhouse gas emissions + Improved water quality from reduced polluting emissions and fluid leaks + Reduced habitat fragmentation when linked with strategic land-use planning objectives	

Source: Authors' elaboration based on VTPI (VTPI 2015), Broaddus et. al. (Broaddus et al. 2009), Sims et. al. (Sims et al. 2014).

5.3/ SCOPE OF ANALYSIS AND SCENARIOS

The analysis of benefits and impacts for enhanced bus networks is presented in this report for cities within **North America, Latin America and South Asia.**

The analysis for the potential of enhanced bus networks considers the impacts of the following measures[9]:

- **Increasing network coverage length of bus system and increased frequency of bus service:** In the enhanced bus networks scenario, major network improvements are implemented by 2030 to increase the bus network coverage and service frequency as far as required in order to increase passenger numbers in line with the Robust Governance scenario of ITF 2017 (OECD 2017). This means approximately doubling the network coverage and service frequency in Latin America and South Asia, and increasing both by a factor of 2.5 in North America, up to 2030. For comparison, these parameters increase by 6-25% under a reference scenario.
- **Usage of dedicated bus lanes / bus rapid transit:** In the enhanced action scenario 22-24% of the bus network will have dedicated lanes by 2030, compared to 1-4% in the reference scenario.
- **Penetration of low carbon buses in the vehicle stock:** Under the enhanced action scenario, electric buses are set to account for the entirety of the bus stock in 2030, compared to less than 1% in the reference scenario.

This study focuses on the outcomes and impacts of enhanced bus networks in cities for **premature mortality from outdoor air pollution, reduced road fatalities** and **potential commuter time savings.**

5.4/ QUANTIFIED IMPACTS OF ENHANCED BUS NETWORKS[10]

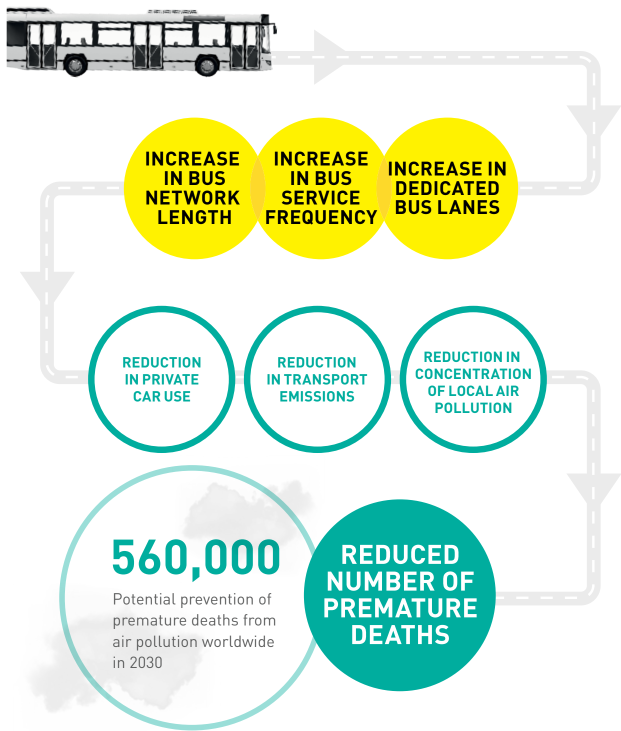
5.4.1 Transportation activity and greenhouse gas emissions

The implementation of measures to enhance bus networks can have a significant impact on reducing private vehicle activity by 2030. Measures could achieve a 21% reduction in light duty vehicle (LDV) activity in North American cities by 2030, and as much as a 35% reduction in South Asia and Latin America, compared to the reference scenario. In North America, the enhanced bus network scenario would see LDV activity fall to around 10% below its 2015 level, with total vehicle-kilometres travelled and road congestion also falling. These shifts would be initiated by rapid increases in the volume of bus riders under the enhanced bus networks scenario, with bus passenger activity increasing nearly three-fold in Latin American and South Asian cities and increasing by a factor of five in North America between 2015 and 2030.

The enhanced action scenarios would reduce GHG emissions by approximately 120 $MtCO_2e$ in North America, 110 $MtCO_2e$ in Latin America and 85 $MtCO_2e$ in South Asia in 2030, compared to the reference scenario.

[9] Further details on the construction of the scenarios can be found in the Full Report.
[10] Details on the calculations for the impacts can be found in the separate *Technical Methodology* document.

5.4.2 Premature deaths from outdoor air pollution



One in eight of total global deaths in 2012 - around 7 million people – was related to excessive exposure to air pollution (WHO, 2014).

Of the three focus regions, Figure 5 shows that South Asia has the greatest potential to benefit from alleviated air pollution resulting from enhanced bus networks. With average $PM_{2.5}$ concentration exposures in the region of 77 ug/m³ in 2015, South Asian cities are some of the world's most polluted urban areas.

Levels of emissions and air pollutant concentrations look set to rapidly increase in the next decade due to an increase in travel demand, alongside growth in other heavily polluting sectors. Our methodology estimates that approximately 700,000 premature deaths are caused by ambient air pollution in South Asia each year; this burden will continue to increase, without significant policy interventions, to over 1.6 million premature deaths each year by 2030. Against this reference, the enhanced bus networks scenario could prevent approximately 160,000 premature deaths in South Asia each year by 2030.

Whilst not at the same scale, the impacts of the enhanced bus networks scenario for air pollution are also compelling for Latin America and North America. In Latin American cities, the enhanced bus networks scenario could lead to more than a 20% reduction in the emission of air pollutants from urban passenger transport, compared to the reference scenario, resulting in the prevention of approximately 22,500 premature deaths per year. This scenario would also entail an absolute reduction in the emissions from the sector between 2015 and 2030. In North America, Figure 5 shows that enhanced bus networks could lead to the prevention of approximately 5,000 premature deaths each year from air pollution related disease.

At the global level, the enhanced bus network scenario is estimated to lead to the potential **prevention of approximately 560,000 premature deaths from ambient air pollution worldwide in 2030,** compared to the reference scenario.

Figure 5: GHG emissions from urban passenger transport, average $PM_{2.5}$ exposure and annual premature deaths from air pollution in cities of North America, Latin America and South Asia.

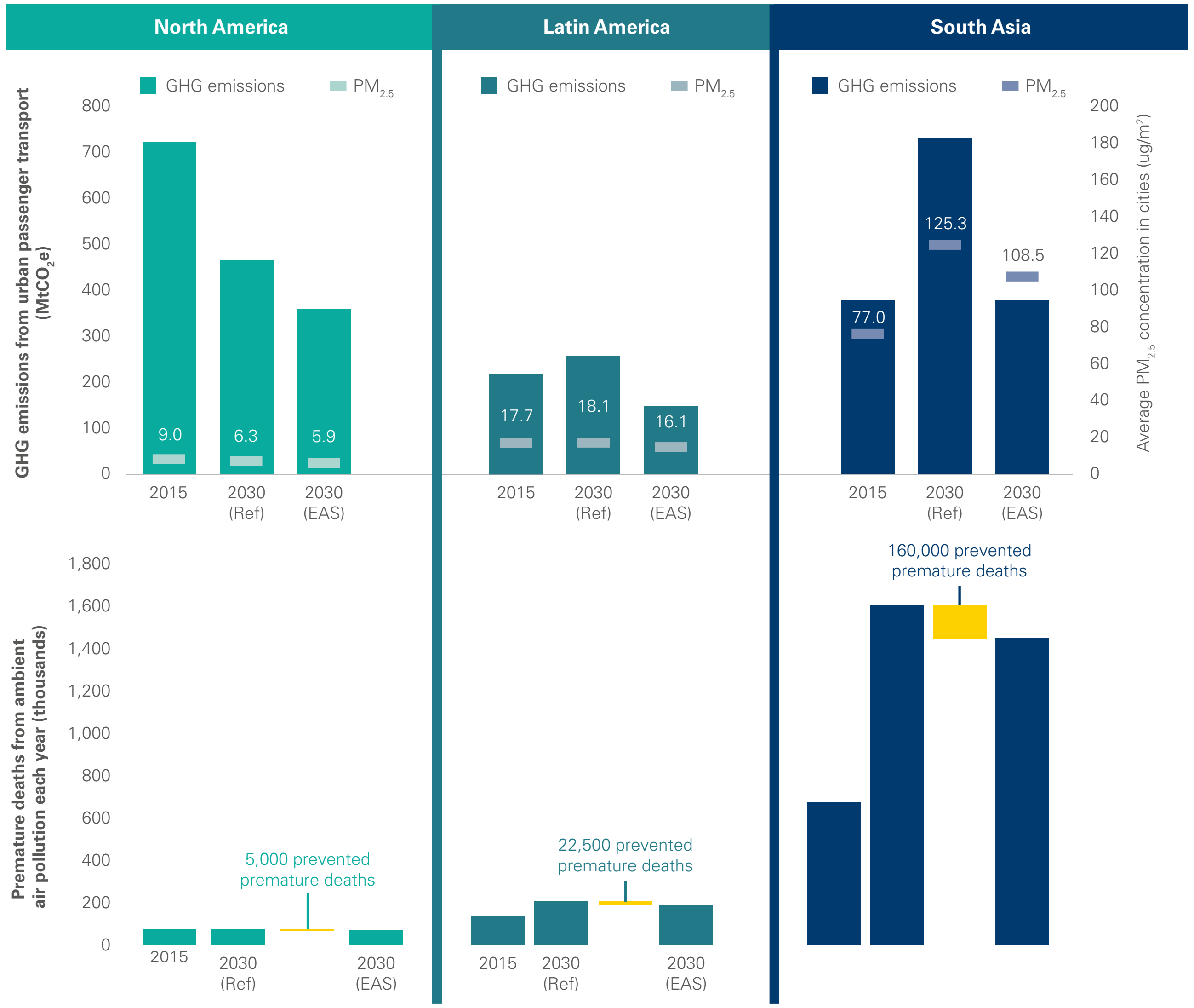
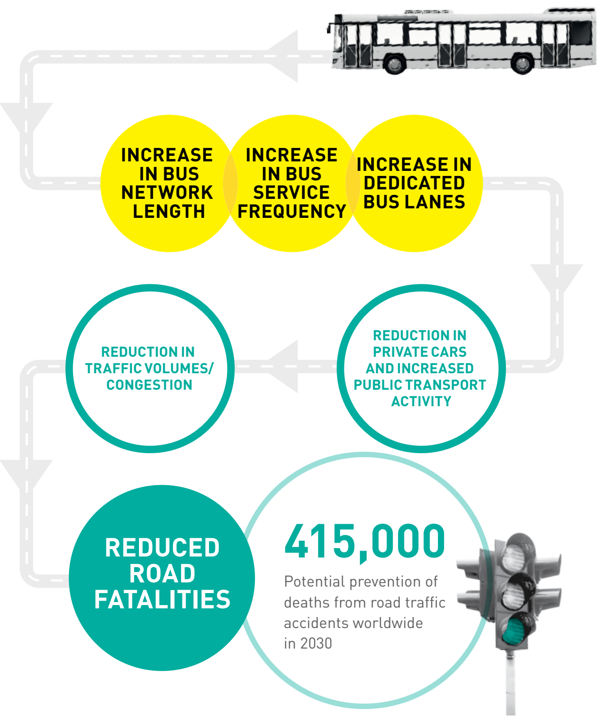


Table 7: Scaling up to the global level and scaling down to cities and the C40 and GCoM city networks.

SCALING UP THE RESULTS	The enhanced bus network scenario is estimated to lead to the **prevention of 560,000 premature deaths from ambient air pollution worldwide in 2030,** compared to the reference scenario.		
SCALING DOWN THE RESULTS			
Prevented premature deaths in 2030 (compared to reference scenario)	North America	Average city	7 prevented premature deaths
		C40 network cities	560 prevented premature deaths
		GCoM network cities	1,000 prevented premature deaths
	Latin America	Average city	19 prevented premature deaths
		C40 network cities	2,700 prevented premature deaths
		GCoM network cities	5,000 prevented premature deaths
	South Asia	Average city	90 prevented premature deaths
		C40 network cities	26,000 prevented premature deaths
		GCoM network cities	7,400 prevented premature deaths

Global-level results are indicative approximations based on a methodology to scale up the regional results to the global level (see methodological document chapter 7 for further details). Scaled down results are indicative approximations based on population, rather than a bottom up evaluation of specific cities. The "Average city" refers to the potential impact in the region for a city of 500,000 population. "C40 network cities" and "GCoM network cities" refer to the potential impact either across all of the C40 cities or Global covenant of Mayors cities in the region.

5.4.3 Road traffic accident fatalities



Motor vehicle accidents are the leading cause of death amongst 15-29 year olds globally, and within the top-10 causes of death for all other segments of the global population (World Bank 2014).

In contrast to the goal of SDG 6.3 to reduce global road fatalities by half by 2020, Figure 6 shows that fatalities are projected to increase under a reference scenario in all three analysed regions up to 2030, due to further projected increases in urban transport activity and congestion, taking annual fatalities in the three regions combined to approximately 400,000 per year.

The enhanced bus networks scenario could lead to a reduction of more than 130,000 road traffic fatalities per year in the three regions combined, compared to the reference scenario. The vast majority of this reduction is from South Asia, where approximately 110,000 deaths could be prevented, while 20,000 deaths are estimated to be avoided in Latin America and 4,000 in North America.

At the global level, the enhanced bus networks scenario is estimated to lead to the **prevention of approximately 415,000 deaths from road traffic accidents worldwide** in 2030, compared to the reference scenario.

Figure 6: Road traffic accident fatalities in urban areas of North America, Latin America and South Asia.

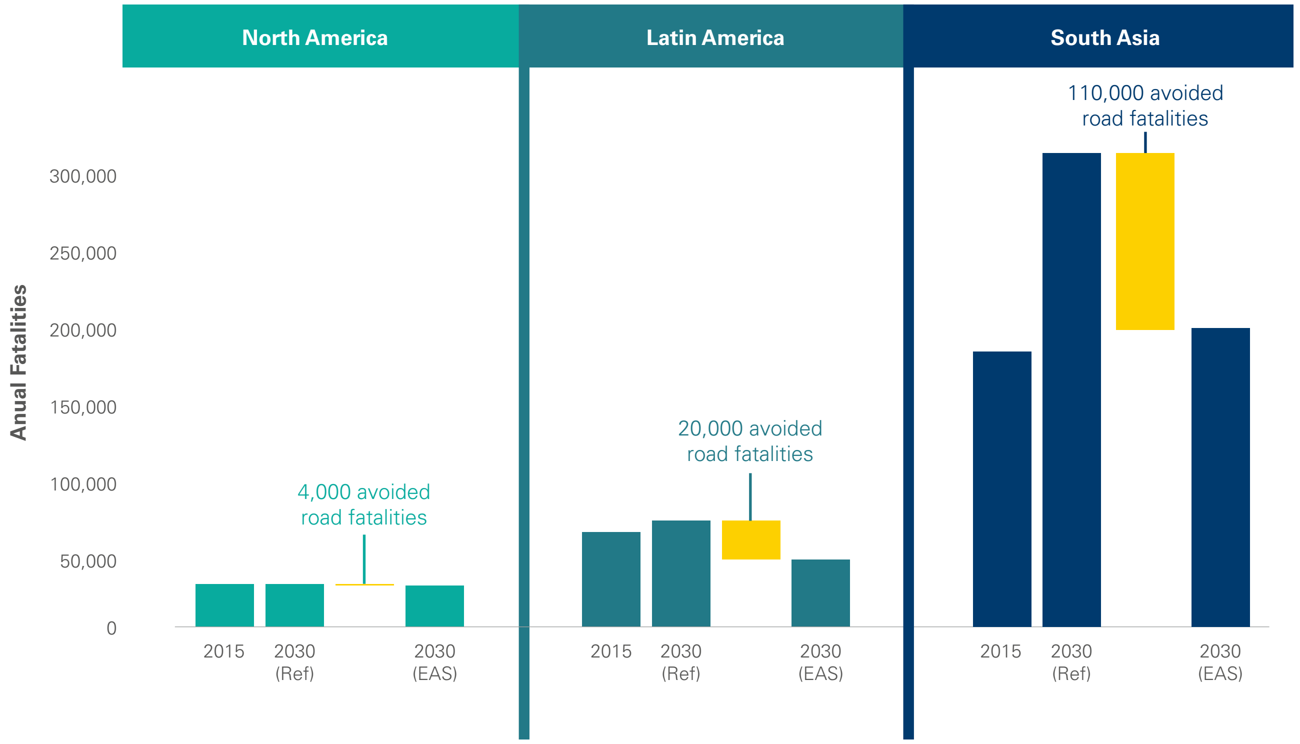
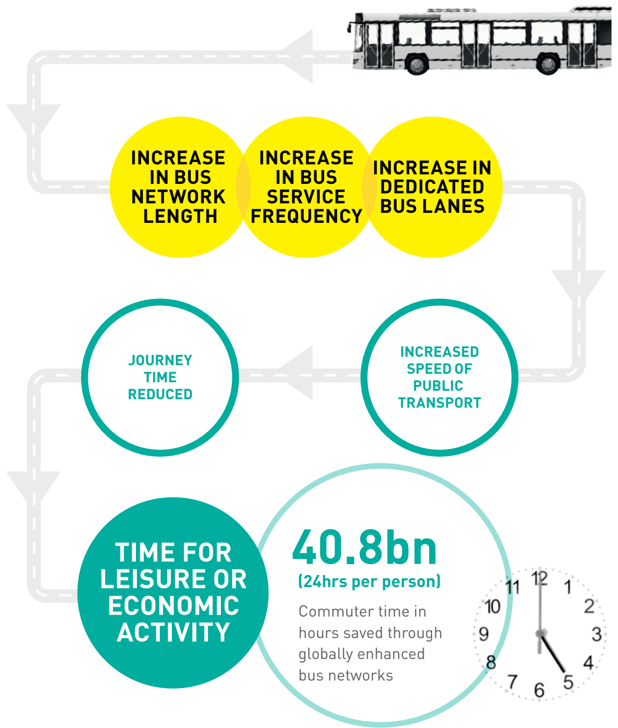


Table 8: Scaling up to the global level and scaling down to cities and the C40 and GCoM city networks.

SCALING UP THE RESULTS TO THE GLOBAL LEVEL	The enhanced bus network scenario is estimated to lead to the **prevention of 415,000 premature deaths from road traffic accidents worldwide in 2030,** compared to the reference scenario.		
SCALING DOWN THE RESULTS			
Annual traffic accident fatalities in urban areas (2030)	North America	Average city	6 prevented deaths
		C40 network cities	450 prevented deaths
		GCoM network cities	820 prevented deaths
	Latin America	Average city	17 prevented deaths
		C40 network cities	2,400 prevented deaths
		GCoM network cities	4,400 prevented deaths
	South Asia	Average city	60 prevented deaths
		C40 network cities	17,000 prevented deaths
		GCoM network cities	5,000 prevented deaths

Scaled down results are indicative approximations based on population, rather than a bottom up evaluation of specific cities. The "Average city" refers to the potential impact in the region for a city of 500,000 population. "C40 network cities" and "GCoM network cities" refer to the potential impact either across all of the C40 Cities or Global covenant of Mayors cities in the region.

5.4.4 Potential commuter time savings



Traffic congestion is a significant burden for commuters in all regions of the world. In 2015, the commuter in the average city lost around 40 hours per year due to congestion during their commutes (INRIX 2017).

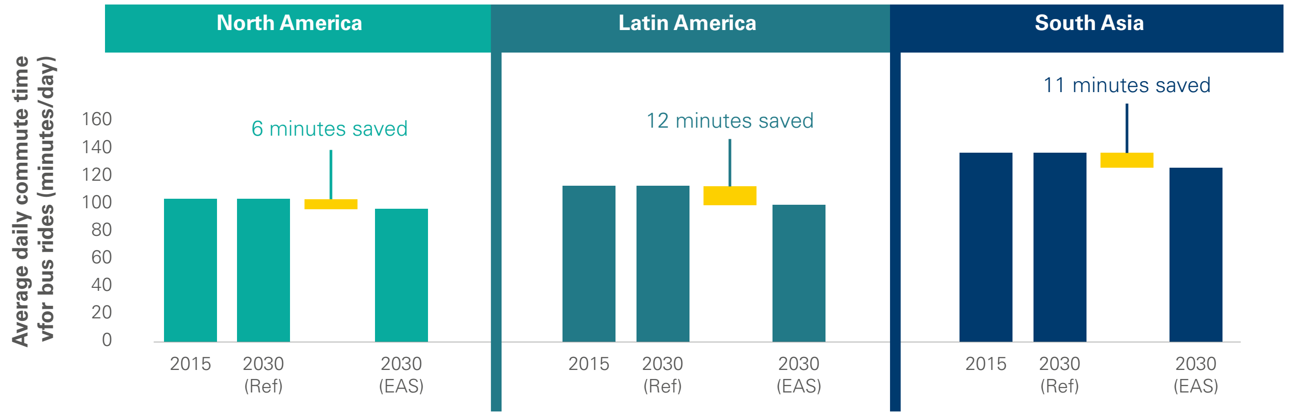
Congestion is the major cause of excessive commute times, exacerbated by deficiencies in public transport infrastructure in many cities. The segregation of buses from public roadways to dedicated lanes can considerably reduce travel time for commuters using public transport.

Average commute times in North America, Latin America and South Asia in 2015, including two daily journeys, were around 95 minutes, 110 minutes and 140 minutes, respectively. Figure 7 shows that commuting times up to 2030 under the reference scenario will likely remain relatively constant, whilst the segregation of bus lanes under the enhanced bus networks could lead to time savings of approximately 6-11% in the three regions, or 6-12 minutes per day[11]. For the average commuter with a 48-week working year, this potential time savings adds up to a significant 24 hours per year in North America or approximately 45 hours per year in South Asia and Latin America, equivalent to more than a week's full-time work. This translates into a total of 1.1 billion hours, 6.9 billion hours and 7.6 billion hours saved across public transport commuters in North America, Latin America and South Asia, respectively. For the economy as a whole, this time is comparable to that spent by over 580,000 full time equivalent workers in North America, 3.6 million full time equivalent workers in Latin America and 4 million full time equivalent workers in South Asia. The economic value of this time could be worth approximately EUR 16 billion in North America, EUR 20 billion in Latin America and EUR 8 billion in South Asia by 2030.

At the global level, it is estimated that **the enhanced bus networks scenario could save bus commuters a total of 40 billion hours per year, equivalent to around 20 million additional full-time workers,** based on a time saving of 10 minutes per day for approximately 1 billion daily bus commuters worldwide. **The economic value of this time saving would be approximately EUR 115 billion.**

[11] The calculated impact is a potential time saving, but multiple feedback loops could lead to this time saving not being realised or being used for other economic purposes. See the full report and methodological document for further information.

Figure 7: Potential commuter time savings from enhanced bus networks in North America, Latin America and South Asia.



	NORTH AMERICA	LATIN AMERICA	SOUTH ASIA
Commuters using bus networks in 2030 (ES)	46,626,944	147,784,768	170,480,914
Impact for average commuter using bus networks under enhanced scenario			
Commute time saved	6%	11%	8%
Minutes per day saved	6	12	11
Hours per year saved	24	47	45
Combined impact across population under enhanced scenario			
Million hours commuting time saved per year	1,120	6,950	7,600
Equivalent additional full-time workers*	585,000	3,620,000	3,950,000
Estimated annual economic value**	ca. EUR 16 bn	ca. EUR 20	ca. EUR 8
Combined impact for average 1-million city under enhanced scenario			
Million hours commuting time saved per year	1.7	2.8	4.3
Equivalent additional full-time workers*	880	3030	2200
Estimated annual economic value**	ca. EUR 25 m	ca. EUR 33 m	ca. EUR 5 m
Combined impact for C40 Cities network under enhanced scenario			
Million hours commuting time saved per year	126	840	1,220
Equivalent additional full-time workers*	66,000	438,000	634,000
Estimated annual economic value**	ca. EUR 1.9 bn	ca. EUR 2.4 bn	ca. EUR 1.3 bn
Combined impact for GCoM Cities network under enhanced scenario			
Million hours commute time saved per year	231	1540	350
Equivalent additional full-time workers*	120,500	799,400	182,307
Estimated annual economic value**	ca EUR 3.4 bn	ca EUR 4.4 bn	ca EUR 0.4 bn
Scaling up to the global level			
Million hours commuting time saved per year		40,800	
Equivalent additional full-time workers*		21,250,000	
Estimated annual economic value**		ca. EUR 115 bn	

Source: Results from author developed quantitative analysis models. * The number of equivalent full-time workers is included as a demonstrative reference point. It may not be that the impact on the economy is equivalent to this additional workforce, since potential time savings will not only be used for productive purposes.

5.5/ EXPERIENCES FROM SEATTLE, RIO DE JANEIRO AND PITTSBURGH, PA

Seattle

Road transportation is the largest source of air pollution in the city and represents two thirds of Seattle's GHG emissions. Seattle has been developing a wide transportation program, largely focused on smart growth policies combined with the enhancement of bus and light rail networks, to help achieve the goal of carbon neutrality by 2050. The RapiRide System, a bus service with dedicated corridors, will be expanded from 3 lines to an integrated bus network with 10 lines. The city also committed to transition to Fossil-Fuel-Free Streets by only procuring zero-emission buses from 2025 (C40 Cities 2015). Recent commuter trip data show nearly half of commuters rely on public transit and that the programme has led to an overall decrease of 4,500 drive-alone commuters, alongside the creation of 60,000 jobs. The expansion of the RapidRide System is expected to speed up travel time during the busiest commute hours by around 10-15% and improve the punctuality of services as well.

// AS ONE OF THE FASTEST GROWING CITIES IN THE U.S., SEATTLE IS A LEADER NATIONWIDE IN CUTTING OUR EMISSIONS AND BUILDING A CLIMATE FRIENDLY CITY. CITIES DON'T HAVE THE LUXURY OF CLIMATE DENIAL AND CANNOT WAIT FOR FEDERAL LEADERS TO EMBRACE SCIENCE. THE EFFECT OF INACTION IS ALREADY AT OUR DOORSTEP. OUR BOLD AND TRANSFORMATIVE INVESTMENTS IN OUR GREEN ECONOMY, RESILIENT INFRASTRUCTURE AND TRANSPORTATION PROVIDE A STRONG FOUNDATION ON WHICH TO BUILD THE NEXT GENERATION OF CLIMATE ACTIONS. //

MAYOR DURKAN,
CITY OF SEATTLE

Rio de Janeiro

Between 2009 and 2017, in order to mitigate and reverse the increasing trend of greenhouse gas emissions and to reduce traffic congestion, the city increased its high-capacity public transport systems, through the implementation of 120 km of Bus Rapid Transit (BRT). The share of trips made by high-capacity transport has increased from 18% to 63%. The TransOeste corridor, the first BRT corridor implemented, has reduced the average inner-city trip by 55%, from 1 hour and 40 minutes to around 45 minutes, directly benefiting 185,000 passengers which are being transported per day. The BRT is expected to save an estimated 107 ktCO_2 per year over a 20-year period, thanks to fuel-efficient buses, optimised bus routes and the attraction of new users to the public transport system (C40 Cities 2016; ITDP 2014). With the implementation of the system, a 20% reduction in traffic fatalities has also been observed[12]. The decarbonisation of the bus fleet has the potential to further enhance the quality of air, reducing by more than 50% the exposure of fine particulate matter ($PM_{2.5}$) and the effects on premature mortality (ISSRC 2013).

// INVESTMENTS IN THE CAPACITY OF PUBLIC TRANSPORTATION IN RIO DE JANEIRO NOT ONLY LED TO A REDUCTION OF GREENHOUSE GAS EMISSIONS AND TRAFFIC RELATED PROBLEMS, BUT ALSO CONTRIBUTE TO THE REDUCTION OF INEQUALITY BETWEEN CITIZENS, SINCE IT OFFERS MORE TRANSPORT OPTIONS TO LOW-INCOME AND VULNERABLE USER GROUPS, WHILE BUILDING A MORE LIVEABLE AND SUSTAINABLE CITY. //

MAYOR CRIVELLA,
CITY OF RIO DE JANEIRO

[12] Source: Assessment of the Secretary of Transportation of the City of Rio.

Pittsburgh, PA, United States of America

In the process of transitioning to an energy-efficient public transport system, the American city of Pittsburgh is revitalizing a former industrial low-income district. With dedicated corridors and signal prioritization for an initial fleet of 25 electric buses, the Downtown-Uptown-Oakland-East End Bus Rapid Transit (BRT) project is set to reduce GHG emissions and improve local air quality when it enters into service in late 2021 (ICLEI 2018; Port Authority 2018).

The enhanced bus fleet will eschew the potent compounds emitted by Pittsburgh's current stock of diesel-powered buses anddeliver cleaner air along with the resulting health benefits. Built at an estimated US$ 195-million, the BRT system will also connect the residential community of Uptown with the Central Business District, facilitating neighborhood growth and linking residents to job centers, educational opportunities, and other sociocultural activities across the city (ICLEI, 2018; Port Authority, 2018). The Port Authority also intends to upgrade bicycle parking facilities adjacent to BRT stations, which would further affect the city's modal split and deliver benefits in the form of increased physical exercise, decreased congestion, and cleaner air.

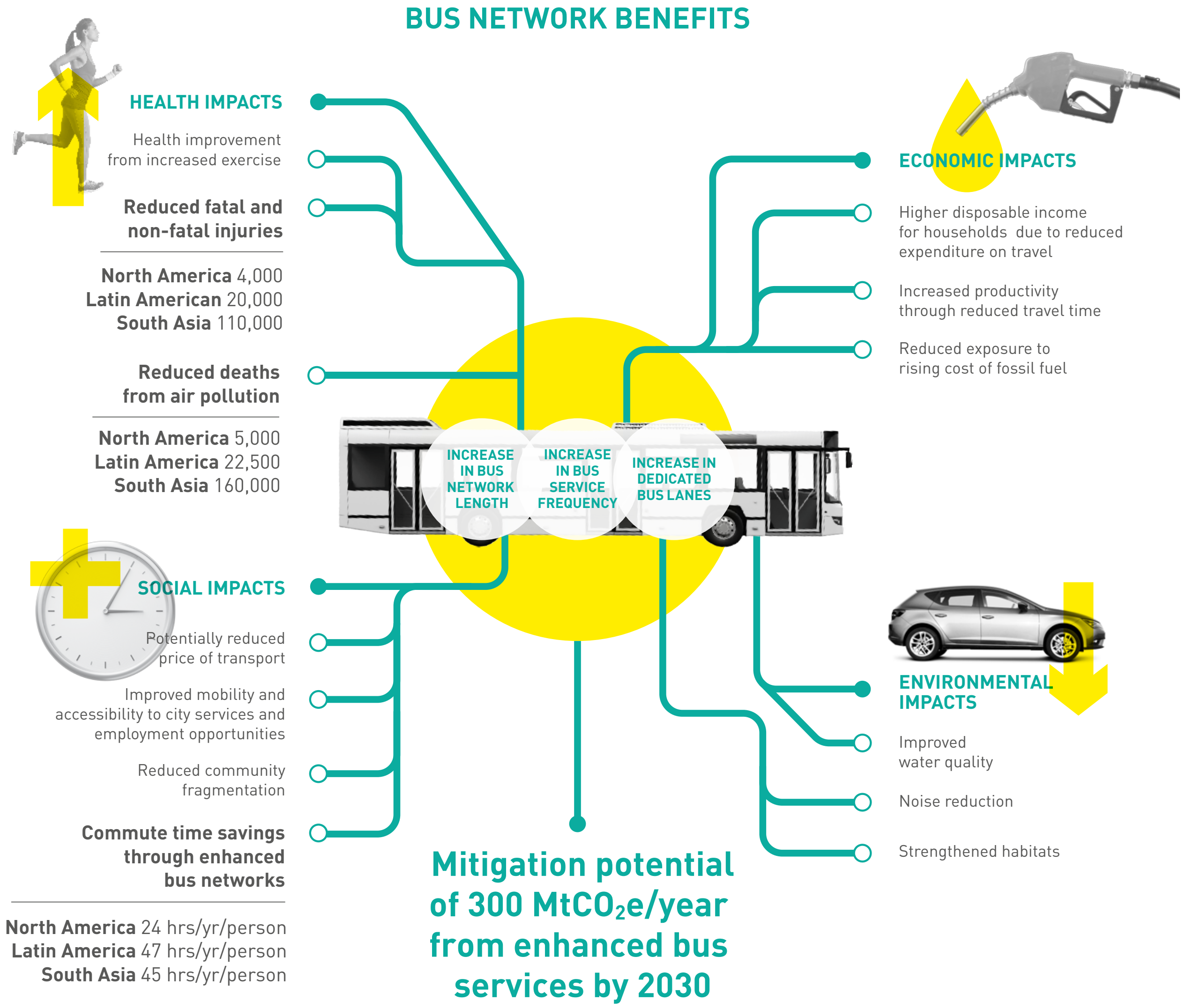
Improved transport linkages cultivate economic growth and bring about tangible benefits for Pittsburgh. It is an effort that can generate a 'snowball effect' through which individuals, businesses, and local government improve their quality of life over time. The potential value of Pittsburgh's BRT project is therefore expected to increase as the connections across the city amplify and multiply.

Rendering of Forbes Avenue at Miltenberger Street with Bus Rapid Transit. Source: Port Authority of Allegheny County

Sources

ICLEI - Local Governments for Sustainability. (2018). *Urban Transitions Alliance: Urban Transition Insights from Industrial Cities* (Urban Transitions Alliance). Bonn, Germany: ICLEI - Local Governments for Sustainability. Retrieved from https://worldcongress2018.iclei.org/wp-content/uploads/Transition-briefing-sheet_web.compressed.pdf

Port Authority of Allegheny County. (2018, May). Bus Rapid Transit. Retrieved August 28, 2018, from https://www.portauthority.org/paac/CompanyInfoProjects/brt.aspx



06
DISTRICT-SCALE RENEWABLE ENERGY

This chapter assesses some of the impacts of increased uptake of district renewable energy systems for spatial heating and cooling in cities. This includes the replacement of building-scale heating systems, electric heating and appliance-scale air conditioning units, with district heating and cooling systems, powered by renewable energies, industrial waste heat and combined heat and power (CHP).

6.1/ IMPORTANCE OF DISTRICT SCALE RENEWABLE ENERGY IN CITIES

The effort to reduce global GHG emissions implies a radical transformation of energy systems and patterns of energy consumption in end-use sectors. The promotion of energy-efficient and affordable district energy systems, making maximum use of available industrial waste heat and renewable energy technologies for heating and cooling in buildings, represents one of the most efficient ways to reduce emissions and primary energy demand in the building sector. Depending on specific local conditions, city decision makers may often have more control over potential measures for district energy, compared to other energy supply sectors, since the supply infrastructure is more likely to be built within city boundaries. It was estimated that the deployment of district scale clean energy could achieve emissions reductions of 0.7 $GtCO_2e$/a by 2050 (ARUP & C40 Cities 2016).

6.2/ POTENTIAL IMPACTS OF DISTRICT ENERGY SYSTEMS

Table 9 shows that the switch to district energy systems in the urban environment can entail a broad range of outcomes and impacts for equity considerations.

Table 9: Overview of some potential direct and indirect impacts from district energy systems in cities.

TYPE OF IMPACTS	EXAMPLES OF OUTCOMES AND SPECIFIC IMPACTS	EQUITY CONSIDERATIONS
Social impacts (Health and safety impacts)	+ Health benefits from improved air quality due to reduced indoor and outdoor emissions of local air pollutants + Health benefits from greater use of affordable heating and/or cooling (lower incidence of 'sick-building' syndrome')	Low income households usually have the greatest vulnerability to air pollution and sick-building syndrome. Therefore, the benefits will be more pronounced in these households.
Social impacts (Quality of life and urban liveability)	+ Better household access to heating and cooling – Construction work to install district energy systems can result in temporary discomfort for residents	Improved equity in reliable and affordable heating and cooling in urban areas (especially for low-income households)
Economic impacts (Individuals)	+ Reduced exposure of households to energy price fluctuation + Lower expenditure for heating and cooling and decreased risk to face fuel poverty for low-income households + Increase in property value for buildings connected to modern district energy systems + Insulation from energy price spikes and greater long-term certainty on heating and cooling bills	Reduced energy consumption results in a proportionally greater increase in household purchasing power for lower income households Lower-income households are the least resilient to energy price spikes which can have a significant impact on energy poverty and associated burdens.

TYPE OF IMPACTS	EXAMPLES OF OUTCOMES AND SPECIFIC IMPACTS	EQUITY CONSIDERATIONS
Economic impacts (Wider economy)	+ Job creation through installation, operation and maintenance of district energy systems and increased reliance on local energy sources for district scale renewable energy + Increase in local prosperity from greater use of local resources, reduced fossil fuel imports, and a more-efficient primary energy consumption + Potential source for additional local government revenue if district energy systems are publicly owned + Reduction in public health spending due to improvements in air quality + Technology spill-overs and enhanced development of markets for advanced technologies + Reduced fuel import dependency and cost savings + More-reliable energy source that can provide power and heat/cooling at times of disruption (e.g. extreme weather) and overall increase in network stability – Opportunity costs of investments in expensive public infrastructure, unless private finance is leveraged – Potential loss of jobs in sectors related to sales, installation and maintenance of conventional energy systems, as well as fossil fuel production (might be compensated by job growth in district energy system sector) – Increased risk of unused or insufficient infrastructure, if demand for district energy does not develop as expected	District heating systems can result in the creation of many jobs for local workers, but can also lead to the loss of jobs for local and unskilled staff in conventional energy industries. Measures to implement district energy should be implemented with sufficient considerations to maximise opportunities for local and unskilled staff and avoid adverse outcomes. Additional resources available for local governments and public health can result in additional pro-poor investments.
Environmental impacts	+ Improved indoor and outdoor air quality + Reduced GHG emissions and ozone depleting substances + Reduced consumption of water resources in urban areas with district cooling systems compared to conventional cooling systems + Improved water quality from reduced polluting emissions + Reduction of heat-island effects in urban areas	Water availability and quality is usually a more critical issue for lower-income areas, where infrastructure and supply are more frequently disrupted.

Source: Authors' elaboration based on IEA (2009), UNDP (UNEP 2015) and IRENA (IRENA 2017)

6.3/ SCOPE OF ANALYSIS

The analysis of benefits and impacts for district scale renewable energy is presented in this report for cities within **China, the European Union and Africa.**

The analysis for the potential of district-scale renewable energy systems considers the impacts of measures for enhanced scenarios for district heating and cooling separately[13].

Measures in the enhanced district heating scenario:

- Use of district scale systems for building heating: the proportion of the buildings heated by district scale systems increase from 78% to 85% in China, and from 9% to 30% in the European Union by 2030.
- Use of recovered industrial waste heat: the proportion of district scale energy generated by industrial waste heat increases from a negligible amount to 11% in China and 22% in the European Union.
- Use of renewable energy generation technologies for district scale heating: the proportion of district scale energy generated by renewable energy technologies increases from a negligible amount to 22% in China, and from 49% to 59% in the European Union by 2030.

Africa is not included in the heating analysis since aggregated heat demand across the region is not high or consistent enough to justify the installation of district heating systems.

Measures for district scale systems for building cooling:

- The scenarios consider the proportion of the urban area's cooling demand that is supplied by energy from district systems, which is set to expand from a negligible amount to 42% in China, 19% in the European Union, and 25-50% in Africa. District cooling is assumed to be supplied by a combination of renewable energy generation technologies and trigeneration from thermal plants, where the potential is available.

This study focuses on the impacts of district scale renewable energy systems in cities for **premature mortality from outdoor air pollution, reduced fossil fuel imports and job creation.**

6.4/ QUANTIFIED IMPACTS OF DISTRICT SCALE RENEWABLE ENERGY

6.4.1 Energy demand and greenhouse gas emissions

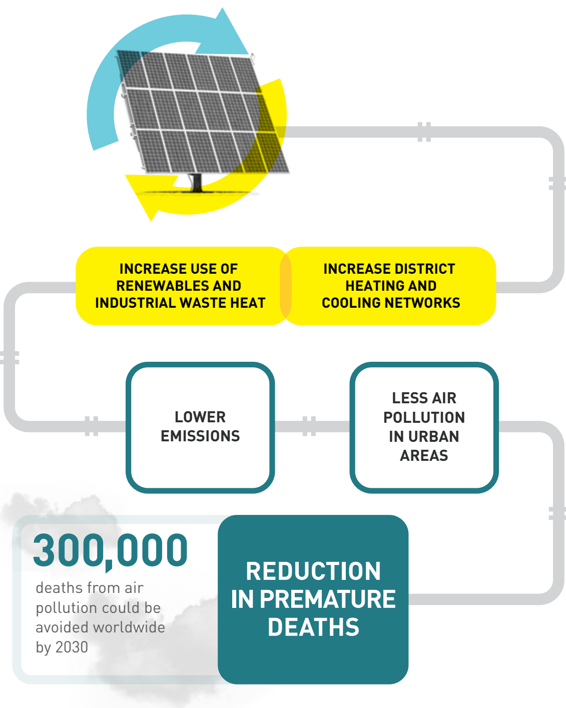
The enhanced district heating scenario results in an emission reduction of approximately 450 $MtCO_2e$ in China, compared to the reference scenario, and 200 $MtCO_2$ in the European Union, in 2030. This is due to a reduction in coal-fuelled electricity demand due to district heat, replacement of household coal stoves (amongst others) with district heat, and through more efficient use of existing coal plants for CHP.

[13] Further details of the scenarios can be found in the full report and the methodological document.

Further reduction in coal demand, through the replacement of coal-fired electric appliances for cooling with district cooling, under the enhanced district heating and cooling scenario, would further reduce emissions in 2030 by approximately 200 $MtCO_2e$ in China and 20 $MtCO_2$ in the European Union.

The district cooling scenarios for Africa would result in emission reductions for spatial cooling in buildings of approximately 20 $MtCO_2e$ in 2030 under the 25% district cooling scenario, and approximately 40 $MtCO_2e$ in 2030 under the 50% district cooling scenario. This reduction would largely be due to a reduction in coal and gas consumption for electricity to power individual cooling appliances, which are replaced by district cooling plants powered by renewable energy sources and trigeneration.

6.4.2 Premature mortality from outdoor air pollution



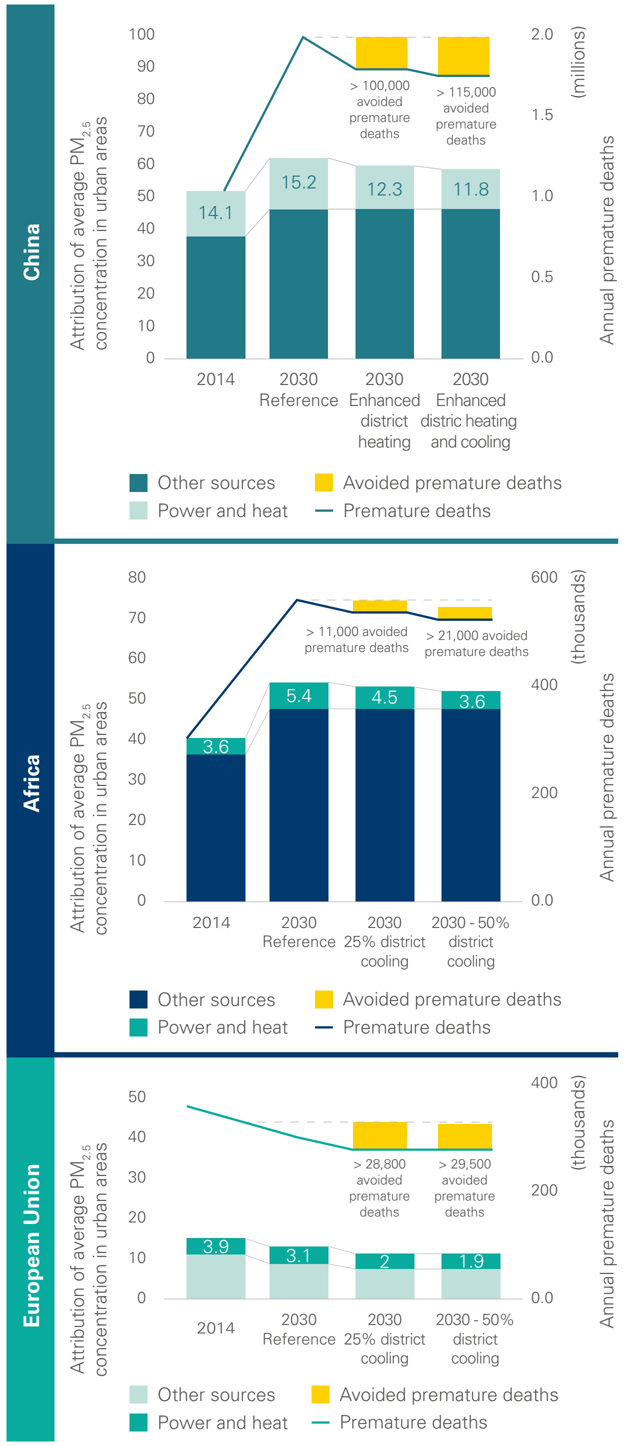
District scale renewable energy systems may contribute to significant reductions in outdoor air pollution from the energy sector in urban areas in several ways:

- District heat and cooling plants are often more efficient than individual building-scale technologies, requiring less primary energy, and subsequently generate lower emissions to deliver the same heating and cooling supply.
- District scale generation offers more potential for the integration of renewable technologies and the use of recovered waste heat in the supply of heating and cooling, thereby further reducing the need for the combustion of fossil fuels and air pollutant emissions usually associated with electricity generation or individual building-scale boilers.

Figure 8 shows that the enhanced district heating scenario may prevent around 100,000 annual premature deaths in 2030, compared to the reference scenario, by reducing emissions from power and heat used in buildings in China. Including the use of renewable energy powered district cooling technologies would lead to the prevention of a total of over 115,000 deaths per year in China, by reducing emissions from electricity generation. Almost 29,000 annual premature deaths could be avoided by increasing the use of district heating, or district heating and cooling, in the European Union. District cooling could also have a major impact on reducing premature deaths in Africa. The use of renewable energy powered district cooling technologies to supply 25% of cooling demand in 2030 could prevent more than 10,000 premature deaths in Africa, while a 50% supply scenario could prevent more than 21,000 premature deaths.

If the actions in the regions are scaled up to the rest of the world over 300,000 premature deaths could be avoided in an enhanced scenario using either district heating or district heating and cooling.

Figure 8: Impact of district scale energy for preventing premature deaths from outdoor air pollution in the European Union, China and Africa.



6.4.3 Job creation

District scale systems may reduce investments and jobs in sectors associated with the installation and maintenance of building-scale heaters and coolers, but will increase investments and jobs in the construction, operation and maintenance of centralised generation capacity, as well as the construction and maintenance of district pipeline networks and building scale connectivity and metering.

Significant expansions of China's and European Union's urban energy infrastructure are expected between 2015 and 2030. Accumulated investments of more than EUR 200 billion in China and EUR 900 billion in the European Union in the installation of new infrastructure for heating will be required between 2015 and 2030, to meet projected demand. The realisation of these scenarios will also require highly significant increases in the number of workers within the energy and construction industries, as indicated in Figure 9 and Figure 10. Whilst the reference scenario will require an additional 480,000 workers in China and 1.3 million in the European Union by 2030, compared to 2014, the enhanced district heating scenario will employ 235,000 more people in China and over 850,000 in the European Union, mostly due to increased employment for installation and operation and maintenance of clean technologies for district heat generation. These figures show the net impact for direct and indirect job creation in the sector accounting for the replacement of jobs on individual boilers. The construction and maintenance of a distribution network for district cooling would employ a further 150,000 people still in China and almost 600,000 in the European Union, by 2030. At the global scale, an enhanced district heating scenario will employ 3.8 million workers, while an enhanced district heating and cooling scenario will employ over twice that number, 8.3 million workers by 2030, when compared to 2014.

Figure 9: Employment impacts of district scale energy scenarios in China.

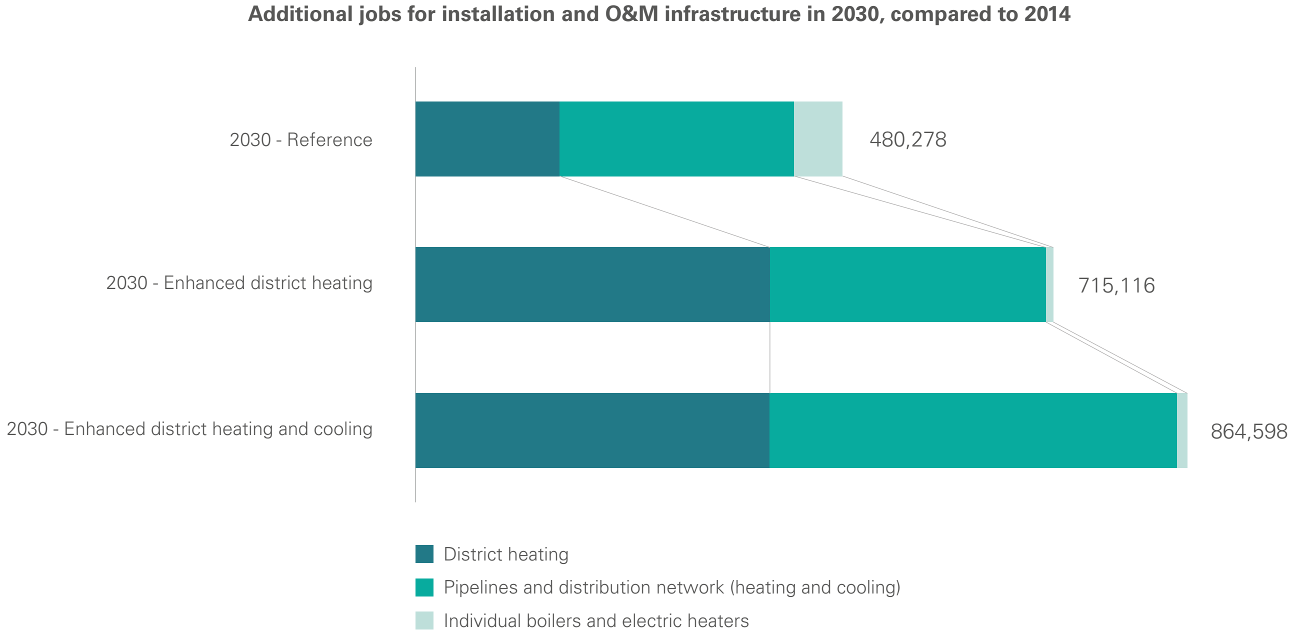
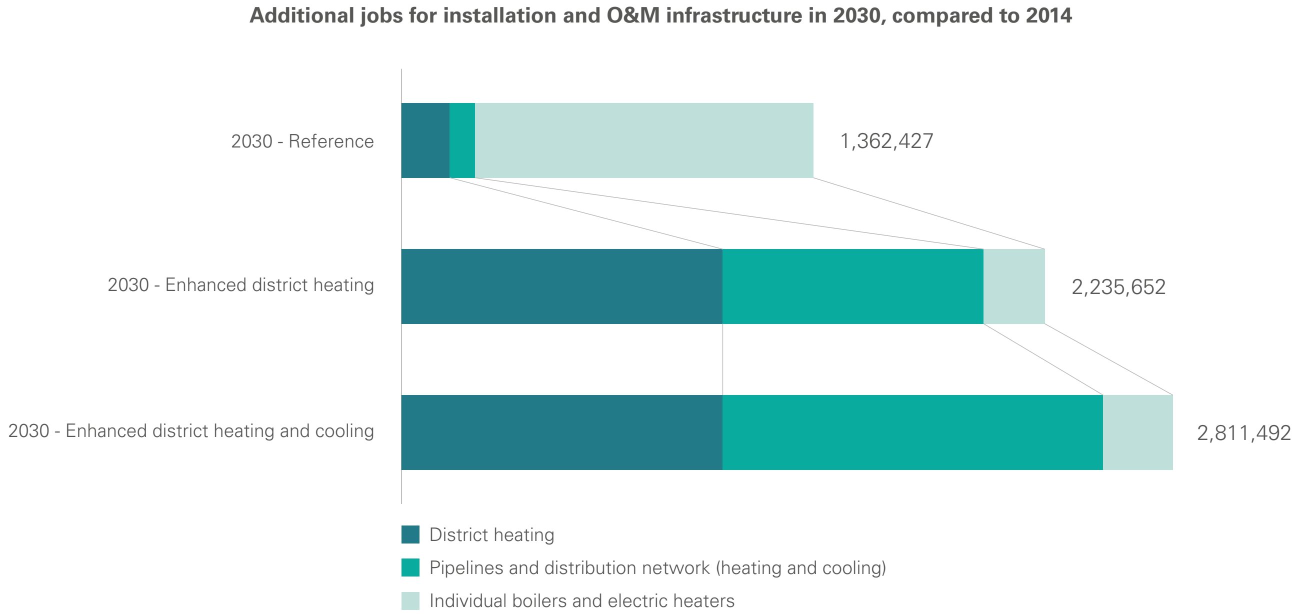
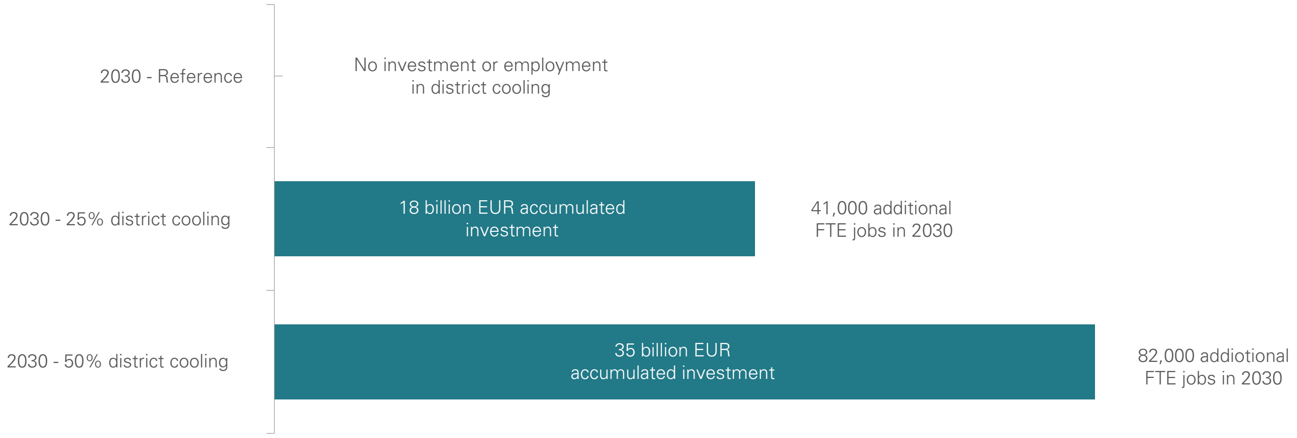


Figure 10: Employment impacts of district scale energy scenarios in the European Union.



District cooling systems could also have a major impact for employment in Africa. Figure 11 shows that the use of renewable energy powered district cooling for 25% of cooling demand in Africa in 2030 will require accumulated investments of approximately EUR 18 billion between 2015 and 2030, with more than 40,000 people employed in pipeline installation and maintenance in 2030. In the scenario where district cooling supplies 50% of cooling demand, these investments and employment rates double.

Figure 11: Investments and employment impacts for district cooling pipeline installation and maintenance in Africa.



6.4.4 Fossil fuel import dependency and import cost savings for imports

Through increased efficiency and the relative ease of integrating renewable energy technologies, district energy systems may offer the ability to enhance energy security through reducing reliance on imports of fossil fuels, thereby also accruing cost savings at the national level.

In the European Union, natural gas imports are projected to slightly increase over the next years, partly due to the decline of domestic production (Széles 2017). The enhanced district energy scenario would reduce natural gas consumption in the European Union by 22%, reducing the need for imports by 28%.

Assuming a natural gas import price in 2030 of 7 EUR/MBtu (IEA 2017b), this would result in approximate savings of EUR 20 billion in 2030.

Across the Africa region, the reduction in the primary demand for coal and gas through the measures for district cooling in 2030 (compared to the reference scenario) is estimated to account for less than 1% of fossil fuel imports in 2014. For China, the greatest impact in the reduction of fossil fuel consumption is in coal, but this has a limited impact for energy security in China from an import dependency perspective, due to the scale of coal production in China.

6.5/ EXPERIENCES FROM QINGDAO, PORT LOUIS AND IZMIR

Qingdao, China

Qingdao is one of China's low-carbon pilot cities, leading the transition towards low-carbon development. It has established a close connection between its economic development target and mitigation and adaptation targets (C40 Cities & Sustainia 2017). Up to 2020, one of the its main focus areas is to improve energy efficiency and optimise industry (Sustainia 2017). The city of Qingdao aims to adopt a non-coal-based energy system with a low-temperature heat distribution network. Instead of coal, Qingdao will use natural gas, solar thermal, shallow ground geothermal and excess heat recovered from industrial plants to power its district heating, cooling and power production and distribution systems. It will provide a population of more than 400,000 in eight locations in the city with access to clean and highly efficient district energy including 18.3 million m^2 of heating area, 1.7 million m^2 of cooling area, and 107.9 MWh of electricity. Compared to the equivalent production of energy through traditional coal-fired sources, the project will: a) result in annual energy savings equivalent to 537,900 tons of standard coal, thereby avoiding the annual emission of 1.4 $MtCO_2e$; b) improve local air quality through the estimated annual reduction of emissions of sulphur dioxide, nitrogen oxides and particulate matter; and c) eliminate the negative impacts of coal transportation through urban areas by truck or train (ADB 2015; C40 Cities & Sustainia 2017). This is expected to have significant impact on preventing respiratory and heart diseases.

Port Louis

The first district cooling system in Africa, using sea water for air- conditioning (SWAC), is being developed in Port Louis, the capital city of Mauritius island. Port Louis Central Business District, the targeted area for the first phase of the project, is one of the hottest places on the island, combining the subtropical climate with the natural urban heat island effect created by the concentration of buildings and human activities. Air conditioning is an essential year-round requirement for any business in the capital (Urban Cooling 2018a). And this is particularly key since electricity is the main source of greenhouse gases emission (45%), due to the island's high dependence on imported fossil fuel for its electricity generation (Stats Maritius 2016). Cold seawater (5°C) from the Indian Ocean will be pumped to cool buildings in Port Louis central business district and nearby locations (UNEP 2017; Urban Cooling 2018c). When completed, the project will replace traditional air conditioning systems in buildings currently powered through fossil fuel-based plants, enabling to reduce the power supply peak load by about 26 MW. The project is expected to create 40 direct green jobs for skilled local engineers and technicians, and potentially create many more indirect jobs in downstream businesses such as aquaculture and pharmaceutical (AfDB 2014; AfDB 2016). It will increase energy security, enhancing the reliability of power supply while providing savings of around USD 5 million per year on fossil imports, as well as reduce GHG emissions by approximately 40 tCO_2e per year (Urban Cooling 2018b).

Izmir, Turkey

Izmir, Turkey's third-most populous city, faces average wintertime lows downwards of 10oC for at least six months every year. To meet the heating needs of residents, while minimizing operating costs, the city has maintained the Balçova-Narlidere geothermal district heating systems (GDHS) since 1996. By April 2010, the equivalent number of subscribers to the GDHS reached 30,500 dwellings (Özmen, 2010) and, as of 2015, Balçova-Narlidere provided 72 MW of district heat (Danish Board of District Heating, 2015). In using Izmir's strategic proximity to geothermal sources, Balçova-Narlidere already limits GHG emissions significantly, compared to traditional heating methods, with CO_2 reductions reaching upwards of 120,400 tons per year (Özmen, 2010). The system's wider benefits are just as critical, particularly the positive effect on the city's air quality. During the heating season, district heating has reduced the levels of potent sulfur dioxide (SO_2) by at least 1,100 tons per year, fostering cleaner air for citizens of the ever-growing city Özmen (2010). Moreover, city residents are able to reduce heating costs by 35% compared to traditional residential gas consumption, saving the consumer money. As the project has required extensive operational support and maintenance over its 22-year lifespan, the Balçova-Narlidere GDHS has also proven to be a job creator and capacity-builder, increasing local opportunities and incentivizing the development of technical expertise in the fields of district heating and, more broadly, engineering.

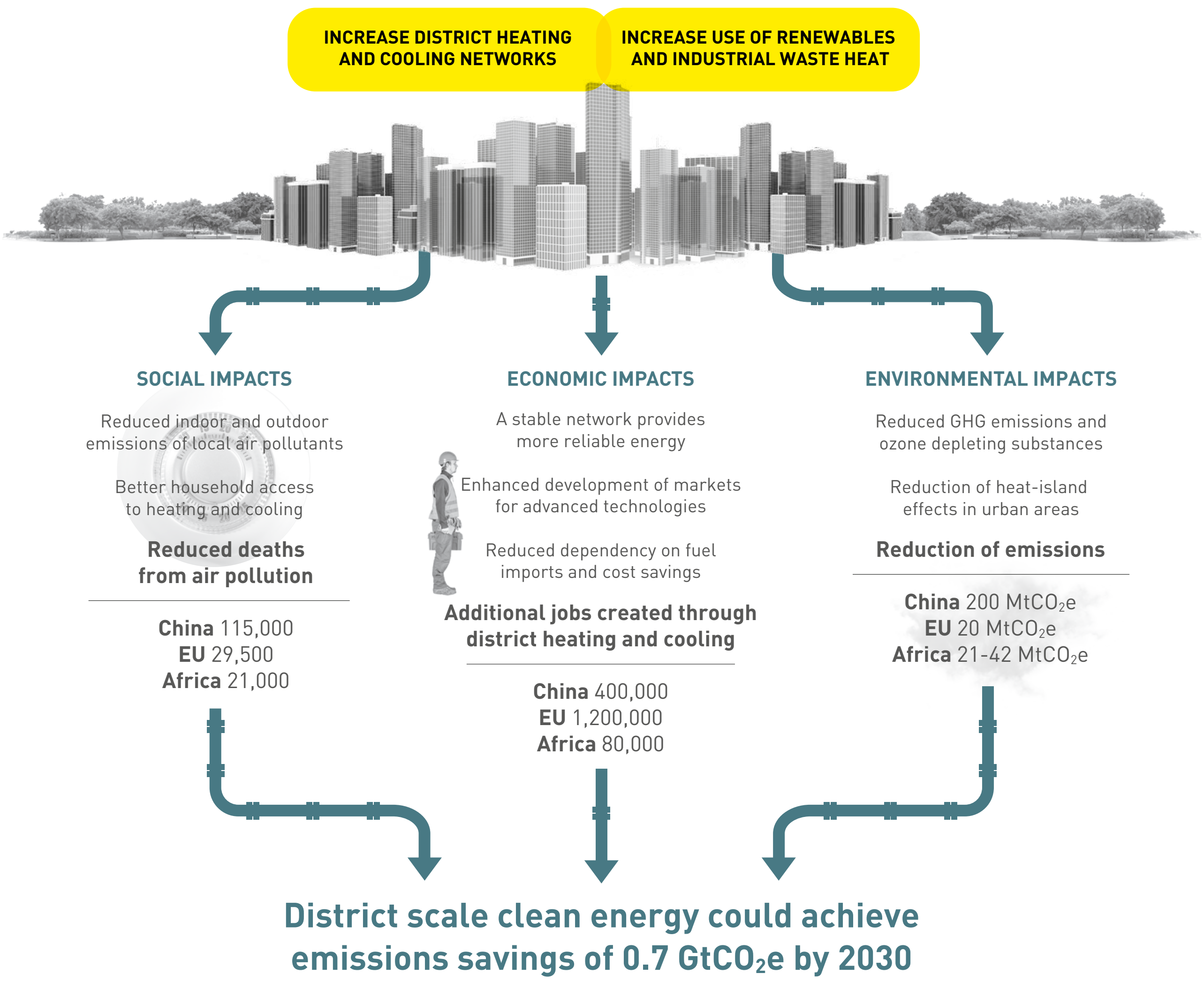
Sources

Danish Board of District Heating. (2015, January). Invitation: District Heating Sector Visit to Turkey. DBDH. Retrieved from https://dbdh.dk/download/event/Invitation%20Tyrkiet%20Maj%202015.pdf

Özmen, H. M. (2010). *A Case Study on the Balçova-Narlidere Geothermal District Heating System*. Dokuz Eylül University, Izmir, Turkey. Retrieved from http://acikerisim.deu.edu.tr/xmlui/bitstream/handle/12345/8132/283631.pdf?sequence=1&isAllowed=y

Riahi, L. (2015). *District Energy in Cities: Unlocking the Potential of Energy Efficiency and Renewable Energy*. UNEP. Retrieved from https://wedocs.unep.org/bitstream/handle/20.500.11822/9317/-District_energy_in_cities_unlocking_the_potential_of_energy_efficiency_and_renewable_ene.pdf?sequence=2&

DISTRICT HEATING & COOLING BENEFITS



07
FINDINGS AND CONCLUSIONS FOR FURTHER WORK

Climate action can be action for health, quality of life and prosperity. This analysis of measures for energy efficiency retrofit in the residential building sector, district-scale renewable energy, and enhanced bus networks for modal shift of urban transportation has found positive impacts for various regions and countries in different stages of economic development.

- **Residential energy efficiency retrofit** can lead to net job creation of over **5 million jobs in cities worldwide,** for regions where retrofit is an economically attractive climate change mitigation measure. For North America, the EU and China, the scale of job creation is equivalent to 4-12% of the unemployed population in 2017 and can **increase household annual saving rates by 10-60%**, with the lowest-income households benefiting the most.
- **Enhanced bus networks and bus services** could **prevent the premature deaths of nearly 1 million people per year** from air pollution related mortality and road traffic fatalities worldwide, **saving nearly 40 billion hours of commuter travel time each year** by 2030, equivalent to around 20 million additional full-time workers.
- **District-scale renewable energy** for heating and cooling in buildings could **prevent over 300,000 premature ambient air pollution related deaths per year** by 2030, whilst also creating **jobs for approximately 8.3 million** people, approximately 4.5 million more than in the reference scenario.

Climate action can have proportionally greater benefits for lower income groups. The findings of the analysis indicate that climate change action yields greater benefits in cities of developing countries. This is mainly due to the opportunity for significant infrastructure development as well as projected demographic shifts over the next 10 years. Together, these cities will have more people with the most to gain from newer construction, modern technologies, and cutting-edge practices. Additionally, lower-income groups in all regions are likely to accrue the most benefits from the assessed measures.

To realize the full extent of the opportunities available to cities, action must be integrated throughout all aspects of delivery in a city. For the measures assessed in this report, the scale of the benefits was usually substantially greater in the case of the Paris Agreement compatible pathways than under the reference scenario. Likewise, the Paris Agreement compatible pathways deviate substantially from the reference case in terms of the scale of action and investments needed in the sectors. The climate, health and prosperity opportunities available to cities depends on focused, deliberate action to introduce appropriate policy interventions and invest in the most cost-effective actions for multi-objective impact.

The opportunities available to cities depend on careful planning to avoid adverse outcomes. Since enhanced action in the sectors analysed requires a significant shift in investment patterns and policy signals, it is inevitable that the shift of investments away from older industries will result in winners and losers, as well as occasional job displacement. As with most large infrastructure investments, there are several potential negative impacts which could be incurred by the measures, unless sufficient planning is taken to mitigate these adverse outcomes. This is particularly relevant for lower-income and marginalised groups, who, despite having the most to gain from the benefits associated with the measures, are also often most vulnerable to the adverse impacts if not sufficiently controlled.

Increased collaboration can accelerate climate action. More work is needed to deepen the evidence base for impacts that can be realized through these measures, and for the many other measures that are vital to achieving the necessary emission reductions in cities in the short term. A great deal of fragmented research and information exists, from research institutions, civil society organisations and information collected by city-level and national governments. Enhanced collaboration between these groups to share information and better understand estimated and observed impacts can help to develop and deepen the case for action, empowering cities to make the necessary moves towards a climate safe, healthy and prosperous future.

References, methodologies and assumptions

See the full report and methodological document for a full list of references used in this research as well as details of the methodologies developed, and the assumptions contained.

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