THE NEW CLIMATE ECONOMY
The Global Commission on the Economy and Climate

SEI STOCKHOLM ENVIRONMENT INSTITUTE

# WHAT IMPACT CAN LOCAL ECONOMIC DEVELOPMENT IN CITIES HAVE ON GLOBAL GHG EMISSIONS? ASSESSING THE EVIDENCE

Carrie M. Lee and Peter Erickson

## CONTENTS



## EXECUTIVE SUMMARY

City governments are increasingly taking an active role in economic development, working to attract and retain businesses. Urban leaders around the world have different resources, strengths and priorities, but cities' economic development and competitiveness efforts share many common elements. For example, they often focus on creating an attractive environment for residents to live and work, and to set up and grow businesses. Many cities invest in infrastructure enhancements (transport, telecommunications, water supply); they may also work to improve public services (parks, education), or provide support to businesses (e.g. tax incentives or promotion).

Nearly all of the world's net population growth over the next few decades is expected to occur in urban areas, and by 2030, the share of people living in urban areas is expected to rise to about 60%, from just over half today. City leaders' ability to build vibrant, prosperous communities will thus play a decisive role in the economic and social well-being of billions of people.

As economic hubs, cities also have a crucial role to play in mitigating global climate change. The Intergovernmental Panel on Climate Change (IPCC) has found particularly great opportunities in fast-growing urban centres in developing countries, but cities at all levels are pursuing climate action. Many of the measures they are choosing – e.g. retrofitting buildings to be more energy-efficient, improving public transit, promoting biking and walking, encouraging denser development – have also been shown to have broader economic and social benefits.

This paper looks at this issue in the other direction: how cities' economic development strategies are likely to affect global greenhouse gas (GHG) emissions. We examine policies and actions that are already widely used by cities to advance economic development and competitiveness, assess the evidence on their net GHG impact, and identify key issues that cities may want to address if they wish to align their climate and economic development goals.

Our key findings are:

- **By 2030, with a population of 5 billion people, cities could produce nearly 8 billion tonnes $CO_2$ from building heating and cooling and personal vehicle use alone. A shift to more compact, transit-oriented urban forms could have economic benefits and reduce emissions by about 0.6 billion tonnes $CO_2$ in 2030, and make subsequent GHG reductions more cost-effective and achievable.** In contrast, a continuation of car-centric, sprawling development could fail to realize the economic efficiency of compact forms and tend to lock in a higher trajectory for carbon emissions, rendering future mitigation more challenging and costly. The abatement potential is especially significant in fast-growing cities, which are concentrated in developing countries.
- **Attractive, well-functioning urban infrastructure and services are key enablers for delivering the GHG and economic benefits of a compact urban form.** For example, actions to improve the quality of life and local environment make living and working in urban centres more desirable. Improvements to information and communications technology can enhance the uptake of transport and building energy efficiency measures that rely on connectivity. Improvements in basic infrastructure, such as water supply and waste management, make urban environments more liveable and open up economic opportunities. This is especially the case in developing-country settings, where lack of functioning infrastructure has been a barrier to compact development and economic progress.
- **City-scale emission reductions will not always yield global-scale emission reductions.** Strategies that shift the location of energy-intensive industries beyond city borders, for example, will not eliminate related emissions, just change their location. And if businesses that relocate to, or expand in, a city use energy from higher-carbon sources than in other locations, global emissions could rise, regardless of what type of business they conduct. As a result, cities may be in a good position to help decrease the GHG-intensity of global business and industry if they can expand their low-carbon energy supplies. This could be accomplished by expanding utility-scale renewables (where cities have such influence, i.e. through public utilities), to creating local electricity grids that are ready for distributed solar power, to efficient district heating or cooling networks powered by renewable sources.
- **Several measures to reduce urban air pollution can also reduce global GHG emissions, particularly those that focus on energy efficiency, reducing coal use, and increasing renewable energy**. Actions that reduce urban air pollution through boiler, building, or vehicle efficiency will also tend to yield GHG benefits, as might actions to switch fuels from coal or oil to natural gas in power production. On the other hand, actions that tend to shift emissions either in location (in the case of industry) or from one type of greenhouse gas ($CO_2$) to another ($CH_4$, in the case of CNG vehicles), would do little to reduce global GHG emissions.
- **Cities wanting to maximize their contributions to global GHG emission reductions will need to address emissions associated with consumption of goods and services**. Current information suggests as much as 40% of city residents' GHG footprints in developed countries is related to food choice, long-distance (especially air) transport, and product purchases. Further work is needed to help policy-makers understand consumption patterns in their communities and identify effective measures to mainstream low-carbon consumption.

# 1. INTRODUCTION

City governments are increasingly taking an active role in economic development, working to attract and retain businesses. Urban leaders around the world have different resources, strengths and priorities, but cities' economic development and competitiveness efforts share many common elements. For example, they often focus on creating an attractive environment for residents to live and work, and to set up and grow businesses. Many cities invest in infrastructure enhancements (transport, telecommunications, water supply); they may also work to improve public services (parks, education), or provide support to businesses (e.g. tax incentives or promotion).

Nearly all of the world's net population growth over the next three decades is expected to occur in urban areas, and by 2030, the share of people living in urban areas is expected to rise to nearly two-thirds, from just over half today (UN 2014). With 1.4 billion new urban residents by 2030, cities have a tremendous opportunity to influence economic and social well-being around the world. How cities are built, rebuilt, maintained, and enhanced can create, or limit, the opportunities for residents. For example, cities that encourage in-migration, provide transportation services, support small-business development and clusters of key industries such as technology, finance, and business services, and offer cultural opportunities have tended to have greater income and employment growth than cities with fewer of these attributes (Kresl and Singh 2012; Ni 2012).

Research also suggests that cities can offer unique opportunities to reduce global greenhouse gas (GHG) emissions (Rosenzweig et al. 2011; Hoornweg et al. 2011; Erickson et al. 2013; Seto et al. 2013). For example, cities, perhaps even more so than national governments, can implement building energy codes and retrofit programs, develop public transport infrastructure, and steer development to lower-carbon practices. Many of these actions can have positive net economic returns for the community (CDP 2013; Gouldson et al. 2012).[1] If, as projected, cities are to house the majority of the world's new residents, their approaches to spatial development, transport infrastructure, and business and industry may substantially influence the GHG-intensity of the world's future population, as well as the costs of future GHG emission reductions. Faster-growing regions have a greater opportunity to influence how demand for growth is met and the associated GHG emissions. Cities in industrialized countries, though they may face much slower growth rates, still have substantial opportunities to affect GHG emissions intensity of their residents.

The goal of this paper is to assess the impact of urban economic development policies on global GHG emissions. We start with a set of policies or actions that cities already use to advance economic development and competitiveness, and then assess and characterize the global GHG implications of these actions. Several of the measures we examine, such as promoting a compact urban form, are already known to reduce GHG emissions. By looking at a broader array of economic strategies, however, we aim to gain new insights about how cities could better align their development and climate strategies.

Our findings may be of interest to a wide range of urban audiences, including policy-makers, researchers and civil society. They may be particularly useful to city planners and economic development agencies, who may use the information to identify strategies with climate co-benefits; refine and adjust practices with ambiguous GHG implications, and perhaps to find alternatives to economic development policies that increase and/or "lock in" GHG emissions in the long term.[2] Lastly, researchers may use this information to identify new avenues for research, as several of the practices identified could not be assessed due to lack of sufficient information.

1 The costs and benefits of GHG response measures has long been a focus of research at larger scales, and for which energy efficiency measures have continuously been recognized as providing economic benefits (Intergovernmental Panel on Climate Change 1991; Morris et al. 2008).

2 One might wonder whether similar research has been conducted at larger, i.e. national, scales. An emerging literature on "green growth" and "low emissions development strategies" is beginning to explore the intersection between economic development and GHG emission reductions at national scales (Clapp et al. 2010), but in general the focus of these efforts has tended to be on reducing emissions or emissions intensity, not on evaluating alternative growth trajectories.

We focus our analysis on economic development strategies in five categories:

- Promoting compact urban development;
- Enhancing transportation infrastructure and public transit;
- Maintaining and improving utility infrastructure;
- Attracting and promoting business and industry; and
- Improving quality of life and local environment.

The strategies assessed under each category were selected based on a review of local economic development toolkits, including those published by UN Habitat (2005) and the American Planning Association (Moore et al. 2006), and a review of the academic literature about practices proven to boost economic development in cities (Kresl 2013). Thus, unlike measures that start with a climate goal and *may also* support development, these activities are already considered good practice for urban economic development – and the question is whether they also might yield climate benefits.

Our analysis is not exhaustive, however; the categories we chose involve measures with significant implications for energy use and overall consumption, which are closely linked with GHG emissions. Many other practices, such as improving local governance and providing clear, consistent effectively enforced business policies and regulations, are also vital for economic development, but are less likely to have direct GHG implications.

Finally, we should note that because GHG emissions have global impacts, we evaluate economic strategies in terms of their net impact on global GHGs, not local emissions. For example, activities that simply shift the location of emissions – such as by moving energy-intensive industries out of cities – may have local, but not as likely global, GHG emissions benefits.

## 2. METHODOLOGY

This paper assesses the GHG implications of practices that cities employ for economic development and competitiveness. In each category, we begin by identifying widely used strategies, and then for each, we:

- Describe the potential outcomes, or changes, that the practice may achieve. For example, promoting compact and mixed-use development could reduce average travel distances and average dwelling sizes.
- Describe how those outcomes might *decrease* global GHG emissions, and under what conditions. For example, reduced average travel distances would likely mean less overall transport energy use, and smaller average dwelling sizes could lead to reduced per-person energy use and consumption of home furnishings.
- Describe how those outcomes might *increase* global GHG emissions, and under what conditions. For example, in regions where houses are typically built with wood framing, the development of large, mixed-use buildings and multi-family dwellings – which typically require the use of concrete, steel, and other GHG-intensive materials – could mean greater GHG construction emissions per resident, depending on the relative unit sizes.[3]
- Assess the net GHG impact, considering both the potential increases and decreases identified. In the example above, research indicates that the GHG reductions from lower building and transport energy use likely outweigh the higher construction-related emissions when compared with scattered, car-dependent development. The methodology for estimating net change in GHG emissions is described further below.

We present the results in a series of tables, one for each category, accompanied by a discussion of the overall findings and points of particular interest.

3 This would not be the case in regions where cement and steel are the dominant building materials for all construction types. In those regions, the GHG emissions associated with building materials would depend on the relative size of dwellings and the amount of materials required.

The GHG analysis relied primarily on the existing literature on the GHG abatement potential of different urban measures, including the authors' own prior work (see, e.g., Erickson et al. 2013). For actions not covered by that research, we relied on other literature, and in some cases performed new calculations. We present the assessment of change in GHG emissions using ranges, and on a relative (rather than absolute) basis, to address uncertainty and because cities around the world have dramatically different emissions profiles, owing especially to different stages of development. Table 1 below shows the colour-coded ratings we use.

**Table 1: Scale for rating the net GHG impact of urban-scale economic development practices**

| Rating symbol | Increase (+) or decrease (-), as fraction of average resident's carbon footprint | Equivalent GHG emissions increase or decrease for a world average resident (tonnes $CO_2$e per resident per year) |
|---|---|---|
| ● | >+5% | >0.3 |
| ◉ | +1% to +5% | 0.06 to 0.3 |
| ○ | -1% to +1 % | -0.06 to 0.06 |
| ◉ | -1% to -5% | -0.06 to -0.3 |
| ● | <-5% | <-0.3 |

# 3. ANALYSIS

## 3.1 Promoting compact urban development

The shape of cities can influence their economic performance and GHG emissions intensity. City shape, or urban form, influences both proximity (among residents and the services they desire) and the population densities needed to support certain amenities, such as public transit. Compact urban forms can locate residences, businesses, schools, and other amenities closer to each other than can lower-density development, creating what some call "agglomeration effects".

The economic benefits of compact urban form arise from this proximity and efficiency. For example, public infrastructure costs (e.g. construction of roads, sewer, water) can be lower than for scattered development (Camagni et al. 2002; Ewing et al. 2014). Compact development can also support clustering, where businesses involved in similar or related activities are located in close proximity (UN Habitat and Ecoplan International, Inc. 2005). Clustering can contribute to economic development by facilitating the exchange of services and products between companies, potentially leading to greater local expansion of the particular business sector. Clustering can allow businesses to take advantage of economies of scale and skilled labour recruitment, and facilitate the provision of needed infrastructure and support services for businesses.

Compact development can reduce transportation emissions by enabling a wider range of activities within a given area, reducing the need for people to travel long distances from home, to work, to school, to stores, etc., and thus reducing the need for cars (UN Habitat 2012). There is evidence of a clear, inverse relationship between compact communities and per capita GHG emissions associated with transport, both when comparing cities, and when comparing neighbourhoods within a given metropolitan area. For example, Kennedy et al. (2009) found per capita transport emissions ranging from more than 6 tonnes $CO_2$ in Denver (density <2,500 people/km$^2$) to less than 1 tonne $CO_2$e per capita in Barcelona (density >19,000 people/km$^2$).

A meta-analysis of regional simulation studies of urban densification scenarios for urban areas in the U.S. found both centralized development/infill and support for mixed land uses to have a significant influence on vehicle travel per person (Ewing et al 2008). Though relatively few such studies have been conducted for developing countries, one scenario study found that urban planning and related measures could reduce vehicle travel and associated emissions in Delhi by nearly 20% by 2030 compared with business as usual (Hickman et al. 2011).

In addition to reducing transportation emissions, compact development has been shown to be associated with smaller average dwelling size and reduced clearing of natural lands at the urban fringe. For example, Camagni et al. (2002) found that in Milan, the average unit size for new infill developments was 450 $m^2$, while in sprawling or linear development along transport lines/roadways, it exceeded 600 $m^2$. Smaller dwelling size, even in multi-family structures that are more GHG-intensive to construct, is likely to lead to net GHG reductions through reductions in per-person energy use (Chester et al. 2013; Norman et al. 2006). Smaller home size can also reduce emissions associated with home furnishings, since they have less space to fill (Oregon DEQ 2010). Lastly, compact and infill development can avoid the clearing of forest and agricultural land, avoiding GHG emissions from losses in carbon stocks. However, a study in Washington State, an area with high carbon stocks, found the GHG emissions associated with land-use change were small compared with energy-related GHGs (Erickson et al. 2012).

One important issue to note here – which we discuss again later in this paper – is that these factors do not necessarily assure that compact-city residents' emissions will be lower than those of their rural or suburban counterparts. How people choose to spend their money – including any savings from lower energy and transportation costs – can make a big difference; if they consume more goods and services, especially GHG-intensive ones such as air travel, that extra consumption can shrink the differences between urban and car-dependent, generally "suburban" lifestyles (Hertwich 2008; Girod and de Haan 2009; Jones and Kammen 2014).

Furthermore, to the extent that increased density contributes to other economic effects, such as higher housing prices that force subsequent new development and transport activity in the outlying region that, on balance, increase transport-related emissions, then some of the global benefits may be muted (Gaigné et al. 2012; Ewing et al. 2014). This suggests that for the GHG benefits of compact urban development to be maintained, metro areas must continue to accommodate new growth in compact urban forms (perhaps by increasing housing supply, and lowering prices), rather than in a sprawling periphery.

Table 2 summarizes the findings on how compact urban form can affect global GHG emissions. We find that, overall, compact urban form has a strong potential to reduce GHG emissions. Several actions discussed in other sections below also serve to promote compact urban form, such as infrastructure improvements to support higher densities, development of public transit and non-motorized transport options, and enhancing the built environment (UN Habitat 2012). Public transit improvements are also likelier to be efficient and competitive in more compact urban areas (Camagni et al. 2002).

## 3.2 Enhancing transportation infrastructure and public transit

Effective transportation infrastructure is crucial for economic growth and development. It enables people and goods to move across the city (e.g. on roads, public transit, or non-motorized transport), and in and out of the city (e.g. highways, airports, rail and ports). Traffic congestion, often associated with severe air pollution, is a problem in cities in developed and developing countries alike, and many city governments have made addressing it a priority. Economic development strategies also often prioritize expanding and improving airports, shipping ports and rail systems.

Improvements in transportation infrastructure can reduce GHG emissions if they avoid or reduce personal vehicle use and freight trips – for example, by shifting a portion of that travel to lower-GHG options (e.g. from cars to public transit, or to walking or biking). Actions that increase the use of high-GHG travel modes, such as expanding roads or airports, will increase global GHG emissions. Table 3 summarizes how economic development practices related to transportation infrastructure effect GHG emissions.

## 3.3 Attracting and promoting business and industry

A key objective of economic development for cities is attracting businesses and industries and encouraging them to expand locally. Businesses provide jobs for residents and a tax base for municipalities, and city governments work hard to attract and keep them, and to help them thrive. Common approaches include adopting favourable land-use policies, improving transportation systems and overall infrastructure, and improving the quality of life for residents (Zhang 2008). Cities can also support business development by

## Table 2. GHG impact of measures to promote compact urban form

(See Table 1 for rating scale of relative change in net GHG emissions)

| Practice | Potential outcome | Conditions that decrease global GHG emissions | Conditions that increase global GHG emissions | Relative change in net GHG emissions (per person) | Notes |
|---|---|---|---|---|---|
| Promote compact and mixed-use development, with mix of residential and commercial uses in urban centre(s) rather than extending development at urban fringe | Reduced average travel distances | Less overall transport energy use (Kennedy et al. 2009; Ewing and Cervero 2010) | None identified | ● | Reductions in vehicle travel can be enhanced through urban design and public transport (Ewing and Cervero 2010) |
| | Smaller average dwelling size | Reduced per-person energy use | Increased use of cement and steel for higher occupancy multi-story residential buildings relative to single story development (Chester et al. 2013; Norman et al. 2006) | **○** | |
| | | Reduced per-person consumption of some types of goods, such as furnishings (Oregon DEQ 2010) | None identified | **○** | |
| | Reduced clearing of agricultural and/or forest land for development | Reduced pressure at urban fringe reduces clearing of agricultural and/or forest land for development | None identified | ○ | |

building networks, facilitating knowledge-sharing (e.g. via forums to share best practices), and through marketing and promotion of the local area (including "buy local" campaigns), business development organizations, skills training centres, support for financing, and partnership development (UN Habitat and Ecoplan International, Inc. 2005).

Research has shown that actions taken by cities can have a significant impact on the location of a particular business or industry, but limited impact on the overall growth of that industry (Peters and Fisher, 2004). As a result, in most cases, efforts to attract industry – even low-carbon industry – to a community has no clear impact on global GHG emissions. This is because even as shifts in the type of industries that establish and grow locally will affect local GHG emissions and emissions intensity (per unit of economic output), unless there is a significant difference in the GHG-intensity of energy or other feedstocks available locally compared to in other areas, global emissions will remain largely unaffected. This is true for both GHG-intensive (e.g. steel) and non-GHG-intensive (e.g. finance) industries.

If, however, as part of its efforts to grow a particular sector, the city also expands its low-carbon energy supply, providing a lower-GHG source of energy for the business than it would have had in alternative locations, then global GHG emissions may be reduced. From that perspective, a city could provide significant global GHG benefits by providing low-carbon energy for energy-intensive (and thus GHG-intensive) industry (Erickson, van Asselt, et al. 2013).

## Table 3. GHG impact of transportation infrastructure and public transit improvements

(See Table 1 for rating scale of relative change in net GHG emissions)

| Practice | Potential outcome | Conditions that decrease global GHG emissions | Conditions that increase global GHG emissions | Relative change in net GHG emissions (per person) | Notes |
|---|---|---|---|---|---|
| Road / travel pricing, such as tolls or congestion pricing | Lower per-person vehicle travel; increased mode share of public transport | Reduction in net vehicle travel (Cambridge Systematics 2009) | None identified | ○ | These practices can be complementary with centralized and mixed use development |
| Expand mass-transit | Increased share of travel occurs on public transit | Reduction in net transport energy use (if sufficient transit ridership) | Emissions associated with construction of mass transit infrastructure (Chester and Horvath 2009) | ○ | |
| Improve non-motorized infrastructure (e.g. bike paths, sidewalks) | Increased share of non-motorized travel | Reduction in vehicle travel due to increase in walking or biking | Emissions associated with construction of transport infrastructure (Chester and Horvath 2009) | ○ | |
| Improving or expanding airport facilities | Increased air travel | None; air travel is the most GHG-intensive travel mode (IEA 2009) | Emissions associated with construction; residents and visitors increase travel by air relative to car or bus/train | Insufficient information to assess | |
| Improve freight rail infrastructure | Increased share of freight moving by rail instead of by truck | Reduction in net freight transport energy use, as rail is more efficient than trucks (IEA 2009) | None identified | Insufficient information to assess | |
| Improve marine port infrastructure | Increase share of local port in global trade (at expense of another port) | If marginal sources of energy to support port are lower-GHG than in alternative regions | If marginal sources of energy to support local port infrastructure are higher-GHG than alternative regions | ○ | |
| | Allow for expanded trade in fossil fuels | If fossil fuel traded is less GHG-intensive than fuel it displaces and does not lead to increased consumption | If fossil fuel traded is more GHG-intensive than fuel it displaces or leads to increased consumption | Insufficient information to assess | |
| Improving road infrastructure, (i.e. expanding roads or adding lanes) | Increase fraction of trips taken in private cars; reduced travel times from reduced congestion | Emissions reductions from reduced congestion and higher average vehicle speeds | New, induced vehicle trips; emissions associated with roadway construction | ○ | Risk of lock-in if fossil-fuel-based cars maintain significant market share |
| | Encourages low-density development | Where wood is used for home construction, may decrease cement/steel use in single-family construction over multi-family | Increased average dwelling size and energy use; increased average vehicle distances; increased clearing of agricultural and/or forest land for development | ● | |

Another strategy with potential economic and climate benefits is to encourage low-carbon technology suppliers or service providers (which offer a product or service that helps other companies, or individuals, reduce energy compared to an alternative technology or practice) to establish locally. Common types of businesses include energy service companies (ESCOs), solar or wind power equipment manufacturers, energy efficiency equipment providers, or any of a host of other "clean tech" companies (Arup and C40 Cities 2014; CDP 2013). These businesses may mostly help energy and emissions locally (e.g. ESCOs that assist local businesses, rooftop solar PV panel providers), or the emission reductions occur elsewhere, if markets for the technology (e.g. wind turbines) are largely regional or national.

Growth in these types of businesses may or may not help reduce a city's own GHG emissions inventory, depending on whether the companies' markets are primarily local, or national or international. Reductions in global GHG emissions would occur if growth of these businesses speeds the uptake of these low-carbon technologies beyond what would have occurred otherwise, e.g. by reducing the costs of low-GHG technologies or services in the broader marketplace. Reductions could also occur if such services shifted local consumption from higher-GHG alternatives – whether by substituting services (e.g. car-sharing) for products (individually owned cars) or by introducing new services (such as entertainment, or personal care services) that displace consumption of higher-GHG goods and services (e.g., long-distance travel).

Lastly some cities seek to grow tourism as a means to economic development. Though we do not specifically assess tourism here, the net GHG emissions effects would depend, like the other types of business and industry considered here, on what activities are being displaced elsewhere (and especially on the relative travel distance from the tourists' home to the travel destination).

Table 4 summarizes the GHG impacts of efforts to attract and promote local industry. In general, expanding local industry has little GHG effect, though, as noted above, expanding business and industry concurrently with low-GHG energy could yield net benefits.

### 3.4 Maintaining and improving basic municipal services

Although the population of urban areas continues to increase, cities have become less dense in recent decades (Angel 2011). In developing-country cities, lack of infrastructure is a key barrier to densification, leading to sprawl, because infrastructure in the inner city is insufficient to meet basic needs (Burgess and Jenks 2002). Actions taken to improve urban infrastructure can make urban areas more liveable. Basic infrastructure, including access to clean water, electricity supply, waste management and transportation are prerequisites to many economic development actions considered here. Investment in infrastructure provides direct economic benefits through job creation, improves liveability for local residents, and is a key enabler for business and industry development (UN Habitat and Ecoplan International, Inc. 2005). Infrastructure investments, such as in water supply and stormwater infrastructure, may also help urban areas become more resilient to climate changes already expected to occur.

Information, communication, and technology (ICT) infrastructure serves as a building block for technology-centred businesses and participation in global economy. ICT infrastructure can reduce GHG emissions by limiting the need to travel or commute long distances, by promoting internet-based information-sharing and communication (e.g. video conferencing). ICT is also a key enabler for the deployment of systems to enhance the energy efficiency of homes and commercial buildings, as well as for web- and mobile-based car, ride and bike-sharing services, public transit information systems, and other applications (Arup and C40 Cities 2014). As the demand and use of ICT increases, the associated energy consumption is expected to grow as well, leading to increases in GHG emissions (ibid.).

Solid waste management is a significant expenditure for municipalities. In developing countries, municipalities often spend 20-50% of their available budget on solid waste management, even though less than 50% of the population is served and open dumping and burning are common (Le Courtois 2012). Increasingly local governments are looking to develop new markets for waste streams, such as extracting resources that can be used again as inputs for new products and reduce production costs (UNEP 2009). Increased waste management, including recycling collection and processing, wastewater treatment plants, landfill gas capture and flaring can reduce GHG emissions.

## Table 4. GHG emissions impact of strategies to attract and grow businesses

(See Table 1 for rating scale of relative change in net GHG emissions)

| Practice | Potential outcome | Conditions that decrease global GHG emissions | Conditions that increase global GHG emissions | Relative change in net GHG emissions (per person) | Notes |
|---|---|---|---|---|---|
| Encourage industries and businesses to establish and expand locally | Low-$CO_2$ sector companies establish/ expand locally instead of elsewhere | If this decreases the costs of low-GHG technologies or services in the broader marketplace, it could help speed uptake | None identified | ○ | Research indicates that economic development incentives have little impact on overall growth of an industry (International Economic Development Council 2014) |
| | High-$CO_2$ sector companies locate/ expand locally instead of elsewhere | If local energy supply or feedstock is lower-GHG than in alternative locations | If local energy supply or feedstock is higher-GHG than in alternative locations (Erickson et al. 2012) | ○ | |
| | Low-$CO_2$ intensity services establish locally (e.g. entertainment) | If residents spend money on these services instead of on higher-GHG goods and services | None identified | Insufficient information to assess | |
| | Businesses that help others reduce emissions establish/ expand locally (e.g. ESCO companies) | If business facilitate increase in energy efficiency retrofits and use of renewable energy | None identified | Insufficient information to assess | |
| Encourage local purchasing, e.g. "buy local" campaigns, to support local businesses | More of the goods purchased by residents are locally manufactured or grown | If GHG-intensity of production is lower locally than in alternative source regions; may also reduce emissions related to transportation of goods (Weber and Matthews 2008) | If GHG-intensity of production is higher locally than in alternative source regions | ○ | |

## Table 5. GHG impacts of utility infrastructure and public service improvements

(See Table 1 for rating scale of relative change in net GHG emissions)

| Practice | Potential outcome | Conditions that decrease global GHG emissions | Conditions that increase global GHG emissions | Relative change in net GHG emissions (per person) | Notes |
|---|---|---|---|---|---|
| Improve information and communi-cations technology | Increase in telecommuting and use of internet conferencing instead of long-distance travel | Less commuting by car and long-distance air travel | Increased electricity use associated with internet usage | Impact would be high for each flight avoided, but little information available to assess community-wide potential | |
| | Enhance uptake of internet-enabled transport and energy efficiency related measures that rely on internet connectivity | Reduced energy use associated with transport, home and commercial building energy | Increased electricity use associated with internet usage | Insufficient information to assess | Can relate to other practices, e.g. encourage industries and businesses to establish and expand locally Encourages mass transit use |
| Improve energy utility infrastructure | Reliability and access to centralized energy (electricity, gas) increases | Encourage switching from higher carbon fuels (coal, oil products); Reduce use of less efficient, higher-GHG energy sources (e.g. diesel generators, traditional biomass); Reduce transmission and distribution losses; Reduce fugitive methane emissions (for gas service) | Increased energy demand and use with expanded customer base for residential and industrial users | Insufficient information to assess | |
| | Increased access to distributed renewables | If distributed renewables substitute for fossil fuel-based power | None identified | ● | |
| Improvements to water supply infrastructure | Reliability and access to safe drinking water supply improves. Water losses in infrastructure are reduced | Improve energy efficiency of water supply system due to reduced losses; Reduce use of off-grid pumps | Expansion of system could increase energy demand for pumping | **○** | Could also help water supply be more resilient to climate change |
| Improve solid waste collection and management | Reduce waste production through composting and recycling efforts. New markets for waste streams develop | Increase recycling and composting, reduce landfilling of waste Further reductions if capture gas and/or energy from waste | None identified | **○** | |
| Improved sewer infrastructure and sewage management | Sewage is transported and treated at municipal facility instead of being disposed of in water systems | Would only reduce emissions if reference case practice involved methane generation | Could increase emissions if reference case practice (e.g. disposal in water system) did not involve | ○ | Could also help stormwater infrastructure be more resilient to climate change |

### 3.5 Improving quality of life and local environment

Quality of life refers to a range of factors, often intangible, that make a place appealing to live in. Strategies led by city governments can influence these factors and improve them over time; they are economic development strategies because they help attract and retain residents and businesses. Quality-of-life factors that support economic development include employment opportunities, low cost of living, public health and safety, environmental quality, educational resources, health care, recreational opportunities, and climate (Moore et al. 2006). Several quality-of-life factors have been discussed in previous sections.

Quality-of-life improvements can play a key role in promoting compact urban form, by drawing business and residents to downtown areas or neighbourhood hubs. Relevant measures can range from small scale actions that improve the streetscape and physical exterior of businesses, to large-scale redevelopment and rezoning efforts (often including public transit enhancements). In the longer term, the improvements can serve as a focal point for economic development and revitalization (UN Habitat and Ecoplan International, Inc. 2005).

Cultural institutions have been found to be a significant determinant of urban competitiveness, both because they bring visitors to the city, and because they play an important role in attracting and retaining workers that are skilled and educated (Kresl and Singh 2012; Strom 2003). Arts have a larger indirect, rather than direct, impact on economic development (Strom 2003). The role of art and cultural sector is linked to economic development at the regional and neighbourhood levels. In the U.S., many communities have invested in the arts for the dual purpose of neighbourhood revitalization and expanding cultural attractions (Markusen and Gadwa 2010; Strom 2003). A survey of economic development organizations in the U.S. focused on downtown revitalization found that an overwhelming majority feature arts and cultural information as a central part of their promotional effort (Strom 2003). As a tool for neighbourhood and city centre revitalization, cultural institutions can support concentrated development and associated GHG reductions. If local residents spend more of their income on these cultural attractions, instead of higher-GHG goods and services (e.g. air travel), this may lead to an emissions decrease (Girod and de Haan 2009). Any change in net GHG emissions associated with an increase in tourists traveling to the city to experience the attractions will depend on whether travel to the local area is closer (lower GHG) or farther (higher GHG) than their alternative vacation destination.

Table 6 summarizes the GHG effects of efforts to improve quality of life and local environment.

## 4. DISCUSSION AND CONCLUSIONS

This study has assessed the GHG emissions implications of city practices focused on economic development and competitiveness. It finds that there are several instances where local economic development practices can also reduce global GHG emissions, including compact development, mass transit and non-motorized infrastructure, expansion of renewable electricity access, and improvements to waste and water utility infrastructure, under certain conditions. Furthermore, the potential combined impact of the various actions discussed here could well be greater than the sum of its parts as, for example, efforts to improve local quality of life, if combined with compact urban form, could help draw new residents to urban areas with inherently low-carbon lifestyles.

In particular, the role of compact, transit-oriented development warrants special attention, as how the next 2 billion urban residents are accommodated, and how existing cities are rebuilt, may have dramatic influence over the quality of life and local environment, economic performance, and GHG emissions footprints of the world's cities.

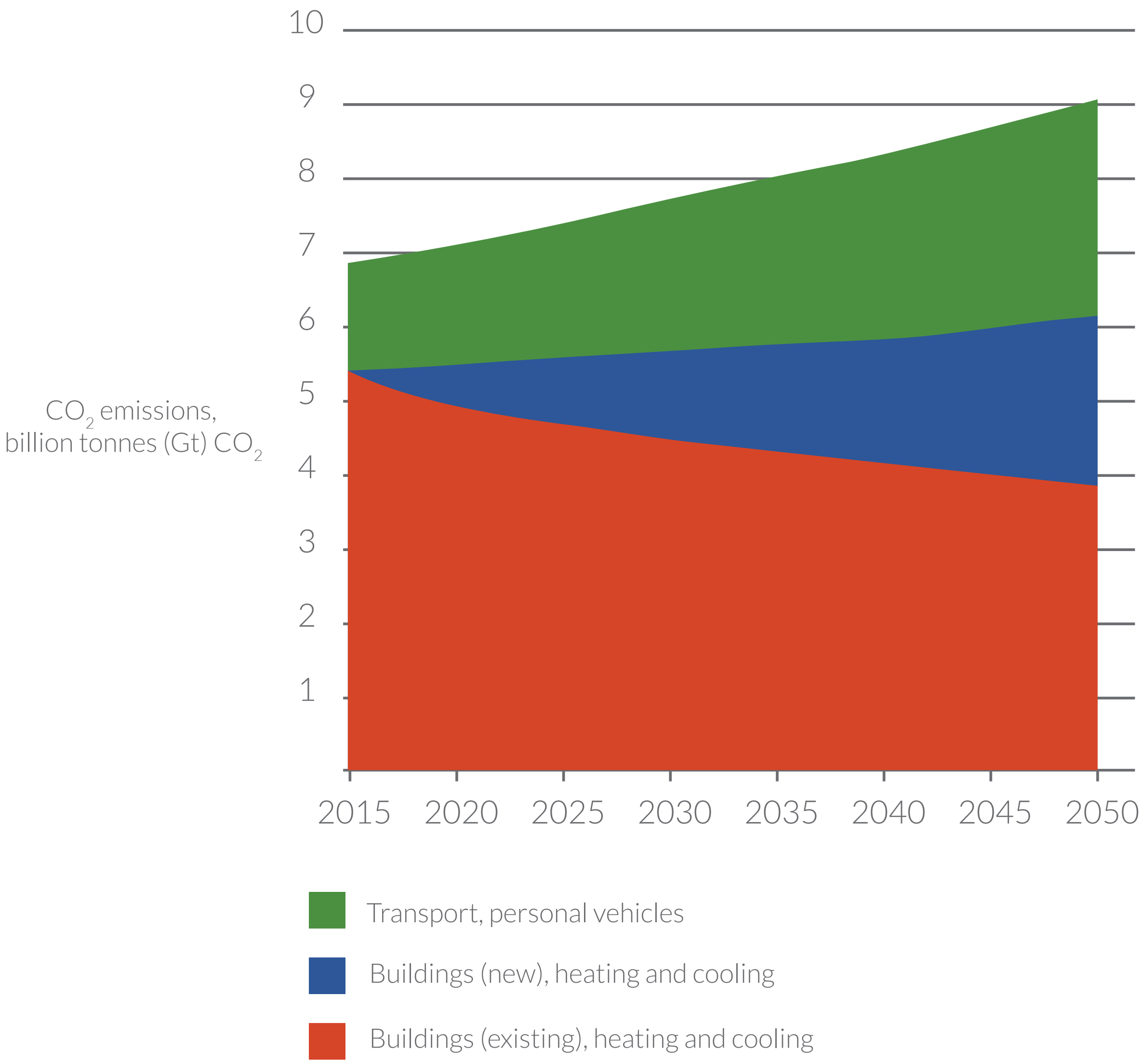
To help understand the scale of emissions associated with urban form, Figure 1 presents a reference case forecast, compiled from separate forecasts by the International Energy Agency (IEA 2013b; 2012) and the Global Buildings Performance Network (Ürge-Vorsatz et al. 2012), of emissions associated with urban building heating and cooling (both residential and commercial) as well as urban personal vehicles. Emissions associated with these sources are expected to rise from roughly 7 billion tonnes $CO_2$ in 2015 to over 9 billion tonnes $CO_2$ by 2050, or 290 billion tonnes $CO_2$ cumulatively over the period.

## Table 6. GHG impact of measures to improve quality of life and local environment

(See Table 1 for rating scale of relative change in net GHG emissions)

| Practice | Potential outcome | Conditions that decrease global GHG emissions | Conditions that increase global GHG emissions | Relative change in net GHG emissions (per person) | Notes |
|---|---|---|---|---|---|
| Enhance downtown core and neighbourhood hubs | Encourages residents and business to live and work in compact, transit-oriented urban centres | Same as compact urban form | None identified | Not quantified because is an enabling condition for compact development | |
| Enhance cultural attractions | Local residents spend more of their income on these attractions | May decrease emissions if shifts spending from higher-GHG goods and services (e.g. air travel) | None identified | Insufficient information available to assess | |
| | Tourists travel to city to experience these attractions | If local area is closer to the tourist's home than their alternative vacation destination | If local area is farther from the tourist's home than their alternative vacation destination | Insufficient information available to assess | |
| Improve air quality, via regulations to reduce particulate and other sources | Industry relocates to meet emissions limits | If marginal source of energy in alternative location is less GHG-intensive | If marginal source of energy in alternative location is more GHG-intensive | ○ | |
| | Industry installs emissions control equipment (e.g., scrubbers) | Reduced black carbon emissions and ozone precursors | Increased energy use for emission control equipment | ○ | |
| | Diesel vehicles convert to CNG | Combustion emissions of $CO_2$ are lower than for diesel; Reduced black carbon emissions | Methane leakage associated with CNG supply and use | ○ | At current estimated leakage rates, methane emissions associated with CNG are greater on a GWP basis than $CO_2$ savings |
| Improve quality and quantity of urban parks and street trees | Creates larger areas for vegetation growth; Encourages residents and business to be located near parks and within urban core | Can encourage compact urban form; increases carbon storage from vegetation growth | Additional parks reduce land area available for infilling development | Insufficient information available to assess | |
| Protection of nearby natural areas (e.g. greenbelt or conservation easements) | Nearby areas left in natural state rather than developed; development steered elsewhere | If steers development to urban core, can decrease vehicle travel compared to developing outlying areas | If unmet demand for land is met by growth beyond greenbelt or conservation area, vehicle travel could increase | Insufficient information available to assess | |

**Figure 1. Global urban $CO_2$ emissions associated with urban form, reference case, with detail by building vintage**




Based on the research reviewed above, compact, transit-oriented urban forms could reduce these emissions by close to a billion tonnes $CO_2$ annually in 2030 and close to 2 billion tonnes $CO_2$ annually in 2050. (For details of this estimate, please see the Appendix.) Cities and urban areas have unique influence over these emissions, as they tend to have much more influence over the measures, such as local land use and transportation planning, than do national governments. Furthermore, building local low-carbon infrastructure now, when urban areas are expanding rapidly, may help decrease the cost of future climate change mitigation, to the extent that doing so helps avoid expensive retrofits in the future (to transport or building systems). Urban action on transport systems and buildings also helps target GHG emission reduction opportunities that may be less directly influenced by carbon pricing, and therefore further complement national action. The potential for long-term GHG reductions and cost avoidance is particularly noteworthy in fast-growing cities, especially in developing countries, as these areas are rapidly locking in future transportation patterns.

Of course, many other opportunities to reduce urban GHG emissions exist, including some of the practices discussed above.  However, the focus of this paper has been on economic development practices that have

GHG implications, not to catalogue all the options for reducing urban-scale GHG emissions.[4] That said, this research has identified the possibility that increased local service provision – such as sharing of cars or other goods, or provision of local entertainment services, may be uniquely available in urban areas and also, to the extent it displaces consumption of high-GHG goods (e.g. purchasing new cars, or long-distance travel), may also reduce GHG emissions. This and other opportunities for cities to contribute to low-carbon consumption deserve further research.

In summary, key findings of this research are as follows:

- **By 2030, with a population of 5 billion people, cities could produce nearly 8 billion tonnes $CO_2$ from building heating and cooling and personal vehicle use alone. A shift to more compact, transit-oriented urban forms could have economic benefits and reduce emissions by about 0.6 billion tonnes $CO_2$ in 2030, and make subsequent GHG reductions more cost-effective and achievable.** In contrast, a continuation of car-centric, sprawling development could fail to realize the economic efficiency of compact forms and tend to lock in a higher trajectory for carbon emissions, rendering future mitigation more challenging and costly. The abatement potential is especially significant in fast-growing cities, which are concentrated in developing countries.
- **Attractive, well-functioning urban infrastructure and services are key enablers for delivering the GHG and economic benefits of a compact urban form.** For example, actions to improve the quality of life and local environment make living and working in urban centres more desirable. Improvements to information and communications technology can enhance the uptake of transport and building energy efficiency measures that rely on connectivity. Improvements in basic infrastructure, such as water supply and waste management, make urban environments more livable and open up economic opportunities. This is especially the case in developing-country settings, where lack of functioning infrastructure has been a barrier to compact development and economic progress.
- **City-scale emission reductions will not always yield global-scale emission reductions.** Strategies that shift the location of energy-intensive industries beyond city borders, for example, will not eliminate related emissions, just change their location. And if businesses that relocate to, or expand in, a city use energy from higher-carbon sources than in other locations, global emissions could rise, regardless of what type of business they conduct. As a result, cities may be in a good position to help decrease the GHG-intensity of global business and industry if they can expand their low-carbon energy supplies. This could be accomplished by expanding utility-scale renewables (where cities have such influence, i.e. through public utilities), to creating local electricity grids that are ready for distributed solar power, to efficient district heating or cooling networks powered by renewable sources.
- **Several measures to reduce urban air pollution can also reduce global GHG emissions, particularly those that focus on energy efficiency, reducing coal use, and increasing renewable energy.** Actions that reduce urban air pollution through boiler, building, or vehicle efficiency will also tend to yield GHG benefits, as might actions to switch fuels from coal or oil to natural gas in power production. On the other hand, actions that tend to shift emissions either in location (in the case of industry) or from one type of greenhouse gas ($CO_2$) to another ($CH_4$, in the case of CNG vehicles), would do little to reduce global GHG emissions.
- **Cities wanting to maximize their contributions to global GHG emission reductions will need to address emissions associated with consumption of goods and services-based emissions.** Current information suggests as much as 40% of city residents' GHG footprints in developed countries are related to food choice, long-distance (especially air) transport, and product purchases. Further work is needed to help policy-makers understand consumption patterns in their communities and identify effective measures to mainstream low carbon consumption.

4 For a typology of urban-scale GHG abatement practices, see Erickson et al. (2013).

## References

Angel, S. (2011). *Making Room for a Planet of Cities*. Lincoln Institute of Land Policy, Cambridge, MA. http://www.lincolninst.edu/pubs/1880_Making-Room-for-a-Planet-of-Cities-urban-expansion.

Arup and C40 Cities (2014). *Climate Action in Megacities: C40 Cities Baseline and Opportunities: Version 2.0*. Arup for C40 Cities, London and New York.

Burgess, R. and Jenks, M. (2002). *Compact Cities: Sustainable Urban Forms for Developing Countries*. Routledge.

Camagni, R., Gibelli, M. C. and Rigamonti, P. (2002). Urban mobility and urban form: the social and environmental costs of different patterns of urban expansion. *Ecological Economics*, 40(2). 199–216. DOI:10.1016/S0921-8009(01)00254-3.

Cambridge Systematics (2009). *Moving Cooler: An Analysis of Transportation Strategies for Reducing Greenhouse Gas Emissions*. Urban Land Institute, Washington, DC.

CDP (2013). *Wealthier, Healthier Cities: How Climate Change Action Is Giving Us Wealthier, Healthier Cities*. Carbon Disclosure Project with C40 Cities and AECOM, London.

Chester, M. V. and Horvath, A. (2009). Environmental assessment of passenger transportation should include infrastructure and supply chains. *Environmental Research Letters*, 4(2). 024008. DOI:10.1088/1748-9326/4/2/024008.

Chester, M. V., Nahlik, M. J., Fraser, A. M., Kimball, M. A. and Garikapati, V. M. (2013). Integrating Life-cycle Environmental and Economic Assessment with Transportation and Land Use Planning. *Environmental Science & Technology*, 47(21). 12020–28. DOI:10.1021/es402985g.

Clapp, C., Briner, G. and Karousakis, K. (2010). *Low-Emission Development Strategies (LEDS): Technical, Institutional and Policy Lessons*. OECD/IEA Climate Change Expert Group Papers. Organisation for Economic Co-operation and Development, Paris. http://dx.doi.org/10.1787/2227779x.

Erickson, P. A., Lazarus, M., Chandler, C. and Schultz, S. (2013). Technologies, policies, and measures for GHG abatement at the urban scale. *Greenhouse Gas Measurement and Management*, DOI:10.1080/20430779.2013.806866.

Erickson, P. A., Stanton, E. A., Chandler, C., Lazarus, M., Bueno, R., et al. (2012). *Greenhouse Gas Emissions in King County*. Report commissioned by King County, Wash. Stockholm Environment Institute, http://www.sei-international.org/publications?pid=2026.

Erickson, P. A., van Asselt, H., Kemp-Benedict, E. and Lazarus, M. (2013). *International Trade and Global Greenhouse Gas Emissions: Could Shifting the Location of Production Bring GHG Benefits?* SEI project report, Stockholm Environment Institute, Stockholm. http://www.sei-international.org/publications?pid=2296.

Ewing, R., Bartholomew, K., Winkelman, S., Walters, J. and Chen, D. (2008). *Growing Cooler: The Evidence on Urban Development and Climate Change*. Urban Land Institute, Washington, DC. http://www.smartgrowthamerica.org/growing-cooler.

Ewing, R. and Cervero, R. (2010). Travel and the Built Environment: A Meta-Analysis. *Journal of the American Planning Association*, 76(3). 265–94.

Ewing, R., Richardson, H. W., Bartholomew, K., Nelson, A. C. and Bae, C.-H. C. (2014). *Compactness vs. Sprawl Revisited: Converging Views*. 4571. CESifo Working Paper. http://www.econstor.eu/handle/10419/89650.

Gaigné, C., Riou, S. and Thisse, J.-F. (2012). Are compact cities environmentally friendly? *Journal of Urban Economics*, 72(2–3). 123–36. DOI:10.1016/j.jue.2012.04.001.

GEA (2012). *Global Energy Assessment – Toward a Sustainable Future*. Cambridge University Press, Cambridge, UK and New York, and the International Institute for Applied Systems Analysis, Laxenburg, Austria. http://www.globalenergyassessment.org.

Girod, B. and de Haan, P. (2009). GHG reduction potential of changes in consumption patterns and higher quality levels: Evidence from Swiss household consumption survey. *Energy Policy*, 37(12). 5650–61. DOI:16/j.enpol.2009.08.026.

Gouldson, A., Kerr, N., Topi, C., Dawkins, E., Kuylenstierna, J. and Pearce, R. (2012). *The Economics of Low Carbon Cities: A Mini-Stern Review for the Leeds City Region*. Centre for Low Carbon Futures.

Hertwich, E. G. (2008). Consumption and the Rebound Effect: An Industrial Ecology Perspective. *Journal of Industrial Ecology*, 9(1-2). 85–98. DOI:10.1162/1088198054084635.

Hickman, R., Ashiru, O. and Banister, D. (2011). Transitions to low carbon transport futures: strategic conversations from London and Delhi. *Journal of Transport Geography*, 19(6). 1553–62. DOI:10.1016/j.jtrangeo.2011.03.013.

Hoornweg, D., Sugar, L. and Trejos Gomez, C. L. (2011). Cities and greenhouse gas emissions: moving forward. *Environment and Urbanization*, 23(1). 207–27. DOI:10.1177/0956247810392270.

ICCT (2012). *Global Transportation Energy and Climate Roadmap: The Impact of Transportation Policies and Their Potential to Reduce Oil Consumption and Greenhouse Gas Emissions*. International Council on Clean Transportation, Washington, DC.

IEA (2013a). *World Energy Outlook 2013*. International Energy Agency, Paris. http://www.worldenergyoutlook.org

IEA (2013b). *A Tale of Renewed Cities: A Policy Guide on How to Transform Cities by Improving Energy Efficiency in Urban Transport Systems*. Policy Pathway. IEA/OECD, Paris.

IEA (2012). *Energy Technology Perspectives 2012: Pathways to a Clean Energy System*. International Energy Agency / OECD Publishing, Paris. http://dx.doi.org/10.1787/20792603.

IEA (2009). *Transport, Energy and $CO_2$: Moving towards Sustainability*. Paris.

Intergovernmental Panel on Climate Change (1991). *Climate Change: The IPCC Response Strategies*. Island Press.

International Economic Development Council (2014). *Economic Development Reference Guide*. International Economic Development Council. http://www.iedconline.org/clientuploads/Downloads/IEDC_ED_Reference_Guide.pdf.

Jones, C. and Kammen, D. M. (2014). Spatial Distribution of U.S. Household Carbon Footprints Reveals Suburbanization Undermines Greenhouse Gas Benefits of Urban Population Density. *Environmental Science & Technology*, 48(2). 895–902. DOI:10.1021/es4034364.

Kennedy, C., Steinberger, J., Gasson, B., Hansen, Y., Hillman, T., et al. (2009). Greenhouse Gas Emissions from Global Cities. *Environmental Science & Technology*, 43(19). 7297–7302. DOI:10.1021/es900213p.

Kresl, P. (2013). The Centrality of Urban Economies to the Study of Competitiveness. *Journal of CENTRUM Cathedra: The Business and Economics Research Journal*, 6(2). 219–34.

Kresl, P. and Singh, B. (2012). Urban Competitiveness and US Metropolitan Centres. *Urban Studies*, 49(2). 239–54. DOI:10.1177/0042098011399592.

Le Courtois, A. (2012). Municipal Solid Waste: turning a problem into resource. *Private Sector & Development* – PROPARCO blog, 22 October. http://blog.private-sector-and-development.com/archive/2012/10/29/municipal-solid-waste-turning-a-problem-into-resource.html.

Markusen, A. and Gadwa, A. (2010). Arts and Culture in Urban or Regional Planning: A Review and Research Agenda. *Journal of Planning Education and Research*, 29(3). 379–91. DOI:10.1177/0739456X09354380.

Moore, T., Meck, S. and Ebenhoh, J. (2006). *An Economic Development Toolbox (PAS 541)*. APA Planning Advisory Service.

Morris, J., Paltsev, S. and Reilly, J. M. (2008). *Marginal Abatement Costs and Marginal Welfare Costs for Greenhouse Gas Emissions Reductions: Results from the EPPA Model*. MIT Joint Program on the Science and Policy of Global Change.

Ni, P. (2012). *The Global Urban Competitiveness Report-2011*. Edward Elgar Publishing.

Norman, J., MacLean, H. and Kennedy, C. (2006). Comparing High and Low Residential Density: Life-Cycle Analysis of Energy Use and Greenhouse Gas Emissions. *Journal of Urban Planning and Development*, 132(1). 10–21. DOI:10.1061/(ASCE)0733-9488(2006)132:1(10).

Oregon Department of Environmental Quality (2010). *A Life Cycle Approach to Prioritizing Methods of Preventing Waste from the Residential Construction Sector in the State of Oregon: Phase II Report*. Quantis, Earth Advantage, and Oregon Home Builders Association for the Oregon DEQ, Portland.

Rosenzweig, C., Solecki, W. D., Hammer, S. A. and Mehrotra, S. eds. (2011). *Climate Change and Cities: First Assessment Report of the Urban Climate Change Research Network*. Cambridge University Press, Cambridge.

Seto, K. C. and Dhakal, S. (2014). Chapter 12: Human Settlements, Infrastructure, and Spatial Planning. *Climate Change 2014: Mitigation of Climate Change. Contribution of Working Group III to the Fifth Assessment Report of the Intergovernmental Panel on Climate Change*, O. Edenhofer, R. Pichs-Madruga, Y. Sokona, E. Farahani, S. Kadner, et al. (eds.). Cambridge University Press, Cambridge, UK, and New York. http://www.mitigation2014.org.

Strom, E. (2003). Cultural policy as development policy: evidence from the United States. *International Journal of Cultural Policy*, 9(3). 247–63. DOI:10.1080/1028663032000161687.

UN (2014). *World Urbanization Prospects: The 2014 Revision*. United Nations Department of Economic and Social Affairs, Population Division, New York. http://esa.un.org/unpd/wup/.

UN (2011). *World Urbanization Prospects: 2011 Edition*. United Nations Department of Economic and Social Affairs, Population Division, New York. http://esa.un.org/unpd/wup/unup/index_panel2.html.

UNEP (2009). *Developing Integrated Solid Waste Management Plan: Training Manual*. Nairobi, Kenya. http://www.unep.or.jp/ietc/Publications/spc/ISWMPlan_Vol1.pdf.

UN Habitat (2012). *Urban Patterns For A Green Economy: Leveraging Density*. United Nations, Nairobi, Kenya.

UN Habitat and Ecoplan International, Inc. (2005). *Promoting Local Economic Development through Strategic Planning: Volume 4: Action Guide*. The Local Economic Development Series. Nairobi, Kenya.

Ürge-Vorsatz, D., Petrichenko, K., Antal, M., Staniec, M., Ozden, E. and Labzina, E. (2012). *Best Practice Policies for Low Carbon & Energy Buildings: A Scenario Analysis. Research Report Prepared by the Center for Climate Change and Sustainable Policy (3CSEP) for the Global Buildings Performance Network*. Global Buildings Performance Network, Paris.

Weber, C. L. and Matthews, H. S. (2008). Food-miles and the relative climate impacts of food choices in the United States. *Environmental Science & Technology*, 42(10). 3508–13. DOI:10.1021/es702969f.

Zhang, M. (2008). *What Can Cities Do to Enhance Competitiveness? Local Policies and Actions for Innovation*. En breve. World Bank, Washington, DC. http://documents.worldbank.org/curated/en/2008/07/10133626/can-cities-enhance-competitiveness-local-policies-actions-innovation.

# APPENDIX

## QUANTIFYING THE GLOBAL GHG ABATEMENT POTENTIAL OF COMPACT, TRANSIT-ORIENTED URBAN AREAS

This appendix presents estimates of the global GHG abatement potential of compact, transit-oriented urban areas. Urban form and transit are most likely to affect GHG emissions, especially $CO_2$ emissions, associated with passenger travel and, to a lesser extent, building energy (ICCT 2012; Chester et al. 2013; Ewing et al. 2008; Ürge-Vorsatz et al. 2012). Few forecasts of these, or any, urban-scale GHG emissions exist, though some researchers have estimated global urban passenger travel (IEA 2013b) and global urban building heating and cooling energy and $CO_2$ emissions (Ürge-Vorsatz et al. 2012). Here, we combine and adapt those forecasts, both of which also relied on United Nations forecasts of urban population (UN 2011), to estimate these sources of urban $CO_2$ emissions through 2050. From that forecast, we then estimate the possible contribution of urban form and public transportation to reducing $CO_2$ emissions in each year. Research is ongoing to refine these estimates, and expand them to include additional measures of urban GHG abatement potential, such as building energy efficiency.

### Reference case forecast

Table 1 presents urban $CO_2$ emissions in the reference case. The estimates for $CO_2$ emissions associated with building energy use for heating and cooling are adapted from estimates by the Global Buildings Performance Network (Ürge-Vorsatz et al. 2012).[5] Estimates for $CO_2$ emissions associated with personal vehicles start with a forecast of urban vehicle travel by the International Energy Agency (IEA 2013b) and apply estimates, also by the International Energy Agency, of the energy-intensity of future vehicles (IEA 2012) and $CO_2$ intensity of future transportation fuels (IEA 2013a).[6]

**Table 7. Global urban $CO_2$ emissions, reference case, Gt $CO_2$**

| | 2015 | 2020 | 2025 | 2030 | 2035 | 2040 | 2045 | 2050 |
|---|---|---|---|---|---|---|---|---|
| Buildings, heating and cooling | 5.4 | 5.5 | 5.6 | 5.7 | 5.7 | 5.8 | 6.0 | 6.1 |
| Transport, personal vehicles | 1.5 | 1.6 | 1.8 | 2.0 | 2.2 | 2.5 | 2.6 | 2.9 |
| **Sum*** | **6.8** | **7.0** | **7.4** | **7.7** | **8.0** | **8.3** | **8.6** | **9.0** |
| Urban population (billions) | 3.9 | 4.3 | 4.6 | 5.0 | 5.3 | 5.6 | 5.9 | 6.3 |
| Emissions per person (t $CO_2$) | 1.7 | 1.6 | 1.6 | 1.5 | 1.5 | 1.5 | 1.4 | 1.4 |

*Numbers may not add up, due to rounding

Figure 1 on page 14 presents these estimates, with emissions associated with building heating and cooling separated into existing (through 2014) and new (built 2015 and beyond) buildings.[7]

5 We start with their Moderate Efficiency scenario of global $CO_2$ emissions associated with building heating and cooling energy (Figure 23); and then apply their estimate of urban share of global building heating and cooling energy (Figure 16). This assumes that the $CO_2$ intensity of energy is the same in urban and non-urban areas, which may not be the case (GEA 2012).

6 For countries where the IEA does not estimate future urban vehicle travel (IEA 2013b), we apply the average, in passenger-kilometers per person, of all other areas. For reference case energy intensity of vehicles (in MJ per passenger-km), we apply the global average for passenger road travel across all (urban and non-urban) areas in the 4DS case of Energy Technology Perspectives 2012. For reference case $CO_2$ intensity of transportation fuels, we apply the average for oil (non bunker fuel) used in the transport sector from the New Policies case of World Energy Outlook 2013 (IEA 2013a).

7 Split of new and existing buildings based on the share of energy from buildings, by vintage, in the GBPN study (Ürge-Vorsatz et al. 2012, fig.11).

## Abatement potential of compact, transit-oriented urban form

Compact, transit-oriented urban form can reduce $CO_2$ emissions by avoiding and reducing the length of personal vehicle trips, shifting a portion of those trips to other modes (including public transportation and non-motorized modes), and reducing building energy demands to the extent that urban dwellings are smaller or better insulated (since multi-family dwellings share walls with other units and have fewer exterior walls). Here we estimate the combined $CO_2$ abatement potential of these practices relative to the reference case above. Compact urban form may also affect other sources of emissions, such as offering the possibility to reduce the need for home furnishings and equipment and the "embedded" emissions associated with their production (ODEQ 2010); these emission-reduction opportunities are not considered here.

We estimate the potential of reduced building energy resulting from smaller average units (both residential and commercial) as 20%.[8] Applying this to the reference new buildings emissions calculated above results in a $CO_2$ abatement potential of 0.1 Gt $CO_2$ in 2020 rising to 0.5 Gt $CO_2$ in 2050.

We estimate the potential of compact urban form and expanded public transportation as about 40% in 2050 relative to the reference case, based on results from the IEA's "avoid/shift" scenario.[9] This translates to a $CO_2$ abatement potential of 0.1 Gt $CO_2$ in 2020 rising to 1.3 Gt $CO_2$ in 2050 (Table 8).

### Table 8. Urban $CO_2$ emissions abatement potential, relative to reference case, Gt $CO_2$

| | 2015 | 2020 | 2025 | 2030 | 2035 | 2040 | 2045 | 2050 |
|---|---|---|---|---|---|---|---|---|
| Buildings, heating and cooling | - | 0.1 | 0.2 | 0.2 | 0.3 | 0.3 | 0.4 | 0.5 |
| Transport, personal vehicles | - | 0.1 | 0.2 | 0.4 | 0.6 | 0.8 | 1.0 | 1.3 |
| **Sum** | | **0.2** | **0.4** | **0.6** | **0.9** | **1.1** | **1.4** | **1.8** |

In summary, we estimate the $CO_2$ abatement potential of compact, transit-oriented urban form as approaching one gigatonne $CO_2$ in 2030. Although these opportunities are unique to the urban environment, many other additional abatement opportunities also exist (Erickson et al. 2013), such as building energy retrofits, even as they are not unique to urban areas. As a result, the overall GHG emissions abatement potential of city and urban policies and measures is higher than listed in Table 8 and is the subject of ongoing research.

## Acknowledgements

We thank Bill Tompson, of the Organisation for Economic Co-operation and Development (OECD) and Gulelat Kebede of the United Nations Human Settlements Programme (UN-Habitat) for helpful comments. Thanks also to SEI colleagues Marion Davis and Michael Lazarus for suggestions and contributions. This paper was prepared with funding from the Swedish International Development Cooperation Agency (Sida) as a contribution to the New Climate Economy project.

8 This is roughly consistent with the reduced floor area scenarios in the GBPN study (Ürge-Vorsatz et al. 2012) and slightly higher than the 10% energy savings potential found in a comparative study of low- and high-density residential structures in the Phoenix area of the United States (Chester et al. 2013)

9 We assume that all reduction in $CO_2$ emissions due to avoided trips and shifts to public transport in this case occur in passenger travel in urban areas. Applying these reductions to the reference case urban emissions estimated above yields an abatement potential of 42% in 2050.

# ABOUT THE NEW CLIMATE ECONOMY

The Global Commission on the Economy and Climate is a major new international initiative to examine the economic benefits and costs of acting on climate change. Chaired by former President of Mexico Felipe Calderón, the Commission comprises former heads of government and finance ministers, and leaders in the fields of economics, business and finance.

The New Climate Economy (NCE) is the Commission's flagship project. It provides independent and authoritative evidence on the relationship between actions which can strengthen economic performance and those which reduce the risk of climate change. It will report in September 2014 in advance of the UN Climate Summit. It aims to influence global debate about the future of economic growth and climate action.

## About the authors

**Carrie M. Lee** is a staff scientist in SEI's U.S. Centre, in Seattle. Her research focuses on climate change mitigation.

**Peter Erickson** is a senior scientist in SEI's U.S. Centre, in Seattle. He works on a wide range of climate mitigation issues, with a growing focus on cities.

SEI STOCKHOLM ENVIRONMENT INSTITUTE

The Stockholm Environment Institute is an independent international research institute that has been engaged in environment and development issues at local, national, regional and global policy levels for more than 25 years. SEI supports decision-making for sustainable development by bridging science and policy.

## How to cite

Lee, C.M., and Erickson, P. 2014. *What impact can local economic development in cities have on global GHG emissions? Assessing the evidence*. New Climate Economy contributing paper. Stockholm Environment Institute, Seattle, WA, US. Available at: http://newclimateeconomy.report.

## Disclaimer

This paper was commissioned by the New Climate Economy project as part of the research conducted for the Global Commission on the Economy and Climate. The New Climate Economy project is pleased to co-publish it as part of its commitment to provide further evidence on and stimulate debate about the issues covered in the main Global Commission report. However neither the project nor the Commission should be taken as endorsing the paper or the conclusions it reaches. The views expressed are those of the authors.

Copyright TBD. This work is licensed under the Creative Commons Attribution-NonCommercial-NoDerivative Works 3.0 License. To view a copy of the license, visit https://creativecommons.org/licenses/by/3.0/us