SUPPORTING REPORT
4

CHONGQING 2035

A Green and Low-Carbon Growth Strategy to Decouple Economic Growth from Resource Use

WORLD BANK GROUP

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Photo: onlyyouqj.

1. Introduction

Chongqing is at a crossroads where its GDP per capita will reach a level at which cities typically decouple economic growth from energy and resource use, as well as associated carbon emissions and pollution. However, decoupling does not happen automatically. It requires cities to adopt green growth policies. For Chongqing to build a more innovative economy that increases its share of high-value activities, it is critical that it use resources more efficiently.

Chongqing Municipality's energy mix is dominated by coal at 60 percent and more generally by fossil fuels at 75 percent (Chongqing Municipal Bureau of Statistics and NBS Survey Office in Chongqing 2016). **Moreover, an inefficient urban form and an energy- and raw material-intensive economy have led to an overconsumption of resources, serious environmental damage, and high GHG emissions.** To produce one unit of GDP, Chongqing Municipality consumes 10 times more energy and emits eight times more CO_2 than the Greater Tokyo Area or Seoul Capital Area. High emissions have deteriorating effects on its environment and air quality, and they pose a significant danger to human health and risk exacerbating climate change.

BOX 1 Green Growth Strategy Key Messages

Current trends and key issues:

- Chongqing's manufacturing economy and superblock-driven expansion pattern are material- and energy-intensive.
- Chongqing's carbon emissions are high and air quality is low, partly due to the high share of coal in energy production and an urban form that encourages driving.

Benchmarking with global cities:

- Chongqing's energy use and greenhouse gas and CO_2 emissions are very high compared to global cities.
- While the development pathways of global cities suggest that resource use and economic growth can decouple, active policy measures are required to make this decoupling happen.

Recommendations:

- Reduce the energy intensity of the economy and decarbonize the energy mix by increasing the share of renewables.
- Plan for a compact urban form to decrease transportation energy use, emissions, pollution, and congestion, and become a car-light city.
- Improve the energy and resource efficiency of the built environment with efficient buildings and districts.
- Leverage Chongqing's automobile production base to develop the fast-growing electric mobility sector.

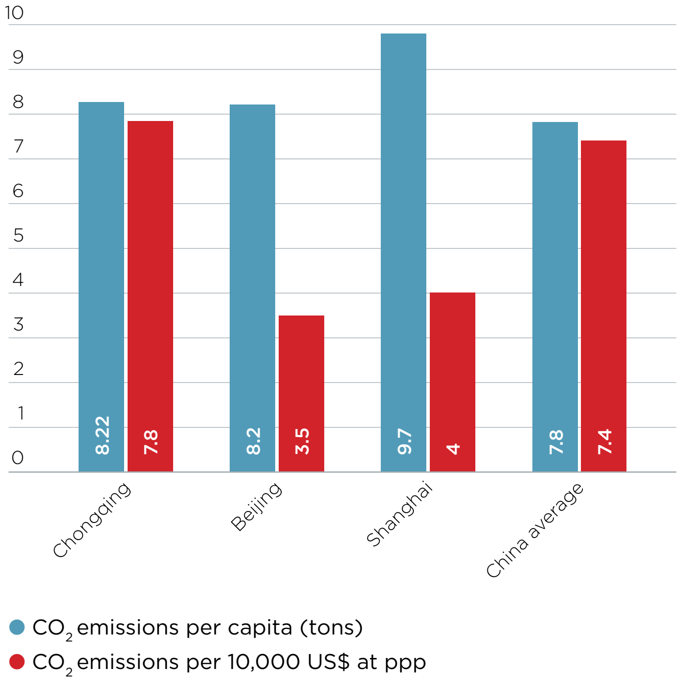
2. Current Trends and Key Issues

Chongqing's economic growth is energy intensive and its CO_2 emissions are very high; the city emits about double the CO_2 of Shanghai and Beijing to produce one unit of GDP. Between 1997 and 2015, energy consumption per capita has grown fourfold—from 0.66 tons of standard coal per inhabitant in 1997 to 2.39 tons in 2015. In 2014, Chongqing had very high CO_2 emissions, at 8.22 tCO_2e per capita and at 0.78 tCO_2e/US$1,000 at PPP per unit of GDP[1] (figure 1).

Chongqing's high carbon emissions per unit of GDP can be explained by two structural issues: an economy supported by heavy industries, and an energy mix dominated by fossil fuels, at 72 percent, with coal representing about 60 percent of its total energy consumption (figure 2 and figure 3).

Nevertheless, there are signs that Chongqing's GDP growth is decoupling from energy consumption. As shown in figure 4, its coal consumption has remained static and fallen slightly over the last few years, while the energy intensity per unit of GDP continues to decline significantly. Nonetheless, Chongqing's energy consumption remains high.

FIGURE 1 CO_2 Emissions Per Capita and CO_2 Emissions Per Unit of GDP in Chinese Cities



Source: Produced by the Urban Morphology and Complex Systems Institute for this report, based on Brookings Institution 2015, Economist Intelligence Unit 2011, and International Carbon Action Partnership 2014.

FIGURE 2 Chongqing's Energy Mix

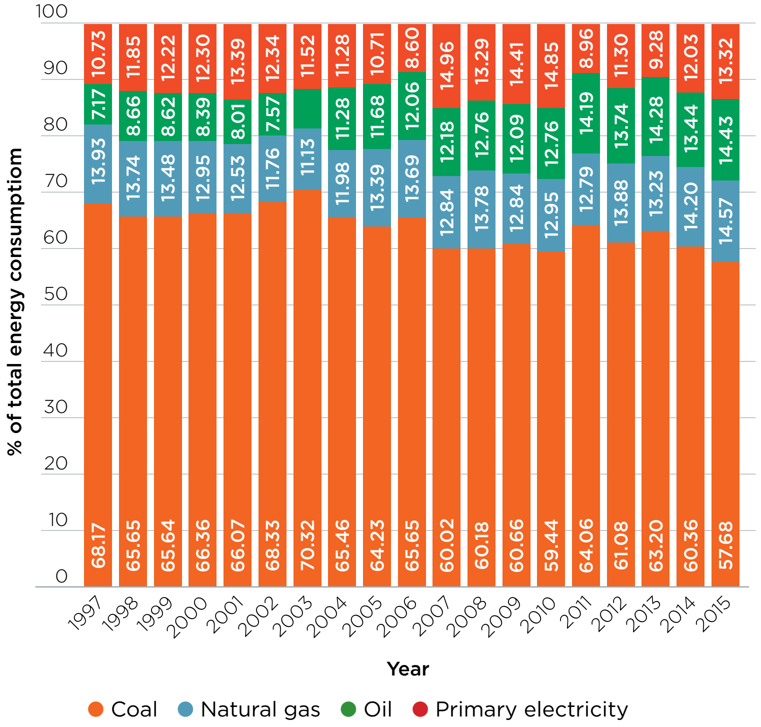
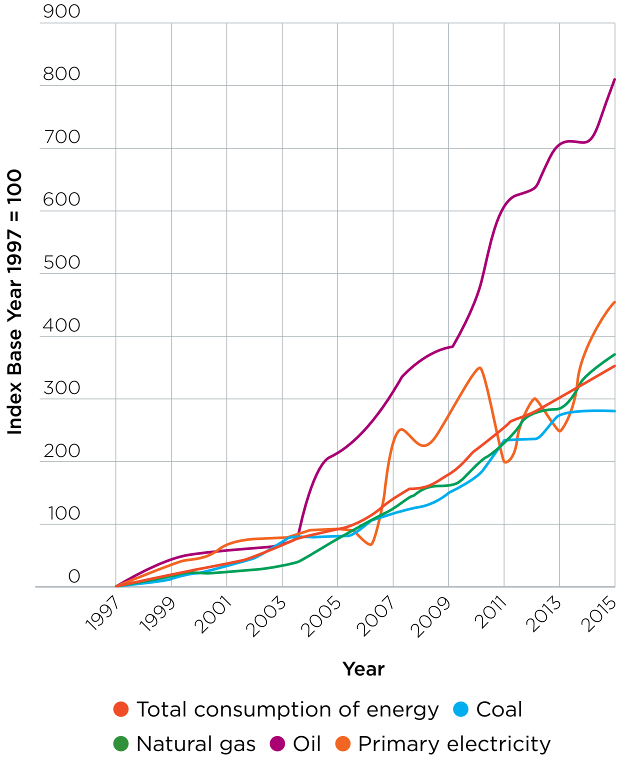
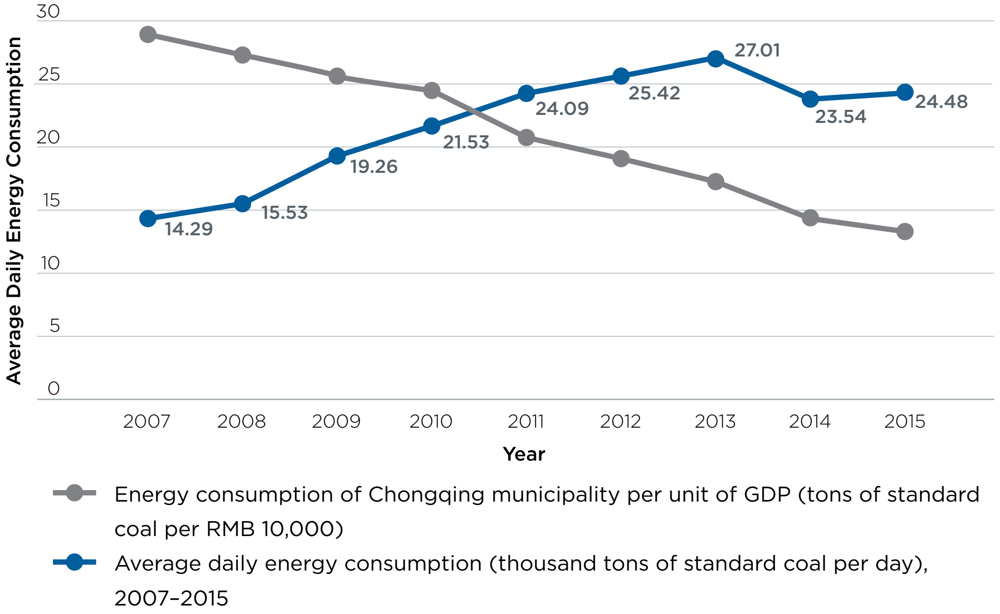


FIGURE 3 Energy Consumption Trend by Type of Energy for Chongqing



Source: Produced by the Urban Morphology and Complex Systems Institute for this report, based on Chongqing Municipal Bureau of Statistics and NBS Survey Office in Chongqing 2016.

FIGURE 4 Energy Consumption of Chongqing Municipality Per Unit of GDP and Average Daily Energy Consumption in 2007–2015



Source: Chongqing Municipal Bureau of Statistics and NBS Survey Office in Chongqing 2016.

Chongqing's urban expansion patterns are both material and energy intensive. A significant decline in population density of almost 50 percent in the last two decades has had a significant impact on energy use, infrastructure costs, and CO_2 emissions, increasing resource consumption and infrastructure costs per capita. Network costs per capita increase with lower densities, as these reduce economies of scale.[2] For example, a 50 percent fall in population density increases water network costs by 72 percent per capita and street networks costs by 117 percent per capita (Salat, Bourdic, and Kamiya 2017).

Chongqing's superblock patterns are energy intensive. Chongqing's growth in the last two decades has taken place in the form of residential superblocks that now cover three-quarters of the central city's built-up area, and are home to 35 percent of its population and 15 percent of its jobs.[3] Residential and commercial superblocks together represent 86 percent of the urban area and are mainly located in the city's fragmented outskirts. This form has been one of the main drivers of the increase in energy consumption, as suggested by empirical evidence from a comparative study carried out in Jinan focusing on 27 neighborhoods that represent four urban typologies commonly found in Chinese cities—traditional, grid, enclave, and superblock (box 2) (Massachusetts Institute of Technology and Tsinghua University 2010).

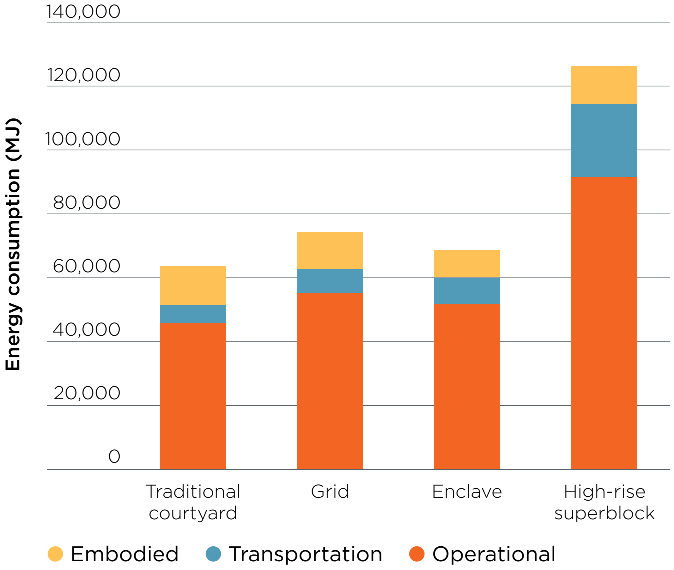
BOX 2 Energy Use of Urban Structures in China

Households living in high-rise superblocks in Jinan consume up to double the energy of households in any other residential type (figure 5). Energy consumption can be divided into three general categories:

1. **Operational energy: Operational consumption (at home and in common areas) accounts for the largest share, about 71–79 percent of the estimated total household energy consumption. The high level of operational energy consumption in superblocks is mainly due to the need for the vertical transport of people, water, and goods, but also for the operation of car parks (lighting, ventilation) and large underutilized spaces. In contrast, medium-height and high-density urban fabrics consume the least energy.**
2. **Transportation energy: Transportation energy is the second most important factor in household energy use. Superblocks consume on average two to three times more transportation energy than other types of neighborhoods, as these developments have few services within walking distance and usually require the use of a car for daily activities. In other urban structures, transportation energy is reduced by the presence of retail, schools, services, and accessible jobs in pedestrian environments.**
3. **Embodied energy: This is the amount of energy required during the life cycle of a material or product—production, extraction, processing, manufacturing, transportation, implementation, maintenance, and recycling, with the notable exception of use. Superblocks have the highest embodied energy use because of their peripheral locations that require new infrastructure and land development. A superblock in Jinan has the highest embodied energy per household, reaching a maximum of more than 12,000 MJ/household per year, compared to the minimum of less than 6,000 MJ/household per year.**

Source: Massachusetts Institute of Technology and Tsinghua University 2010.

FIGURE 5 **Energy Consumption in Typical Chinese Urban Structures**



Source: Massachusetts Institute of Technology and Tsinghua University 2010.

An urban form that encourages the use of private cars generates more GHG emissions and lowers air quality. Urban sprawl and superblocks increase the dependence on private vehicles. Households living in single-use superblocks are highly dependent on cars to accomplish their daily activities and they consume two to three times more transportation-related energy than those in other neighborhood types on average (Massachusetts Institute of Technology and Tsinghua University 2010). Increasing congestion resulting from car dependence has become one of the most serious threats to air quality. The high reliance on cars and the activities that form the basis of Chongqing's economy result in the city's high level of sulfur dioxide and particulate matter (PM), which are produced by combustion engines, solid fuel, road use, and a variety of industrial processes (WHO 2013). The burning of fossil fuels in power plants, industrial plants, and vehicles, while necessary for industrial growth, has been the main cause of air pollution.

Photo: gyn9038.

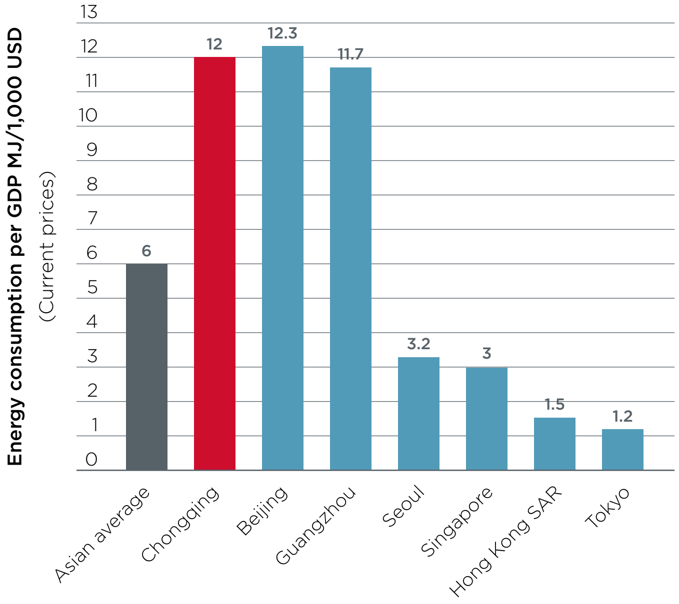
3. Benchmarking and Lessons from Global Cities

Chongqing's energy intensity and greenhouse gas and CO_2 emissions are very high compared to global cities. To produce one unit of GDP, Chongqing uses 10 times more energy than Tokyo, eight times more energy than Hong Kong SAR, and four times more energy than Seoul or Singapore. The higher energy efficiency of Tokyo and Hong Kong SAR is due to a more compact urban form, the higher penetration of energy-efficient technologies, and an economic structure oriented towards services (figure 6).

Compared to other Asian megacities such as Seoul and Tokyo, Chongqing has double the emissions per capita and about eight times higher emissions per unit of GDP. Chongqing emits 20 times more CO_2 to create one unit of GDP than a highly efficient European city such as Oslo, which uses the highest share of renewable energy among world cities, at 65 percent (figure 7).

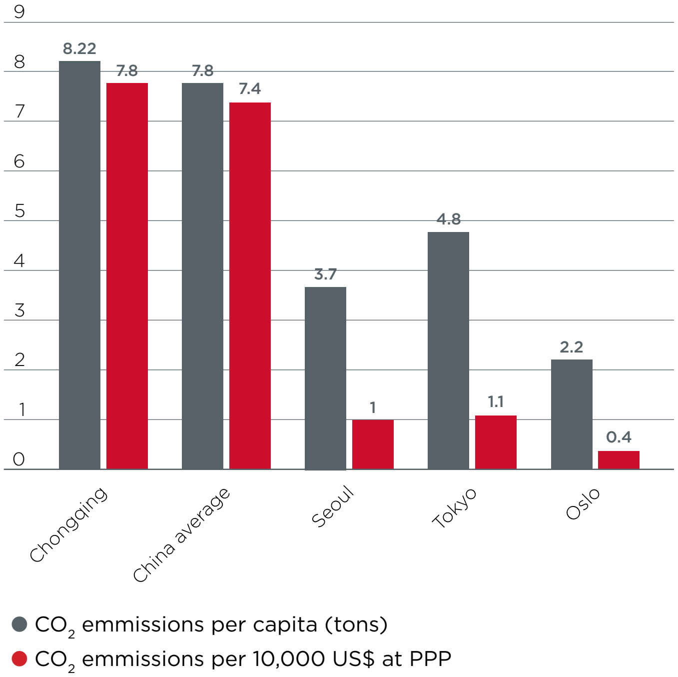
The air quality in Chongqing is significantly poorer than in global cities. Chongqing's urban air pollution, which has accompanied its rapid economic development and urbanization, has caused a growing number of air quality problems. Chongqing's residents are exposed to levels of pollutants in the air that far exceed World Health Organization (WHO) limits and levels in other Chinese provincial-level cities (figure 8).

FIGURE 6 **Energy Consumption Per Unit of GDP**



Source: Produced by the Urban Morphology and Complex Systems Institute for this report, based on Economist Intelligence Unit 2011.

FIGURE 7 **CO_2 Emissions Per Capita and Per Unit of GDP**



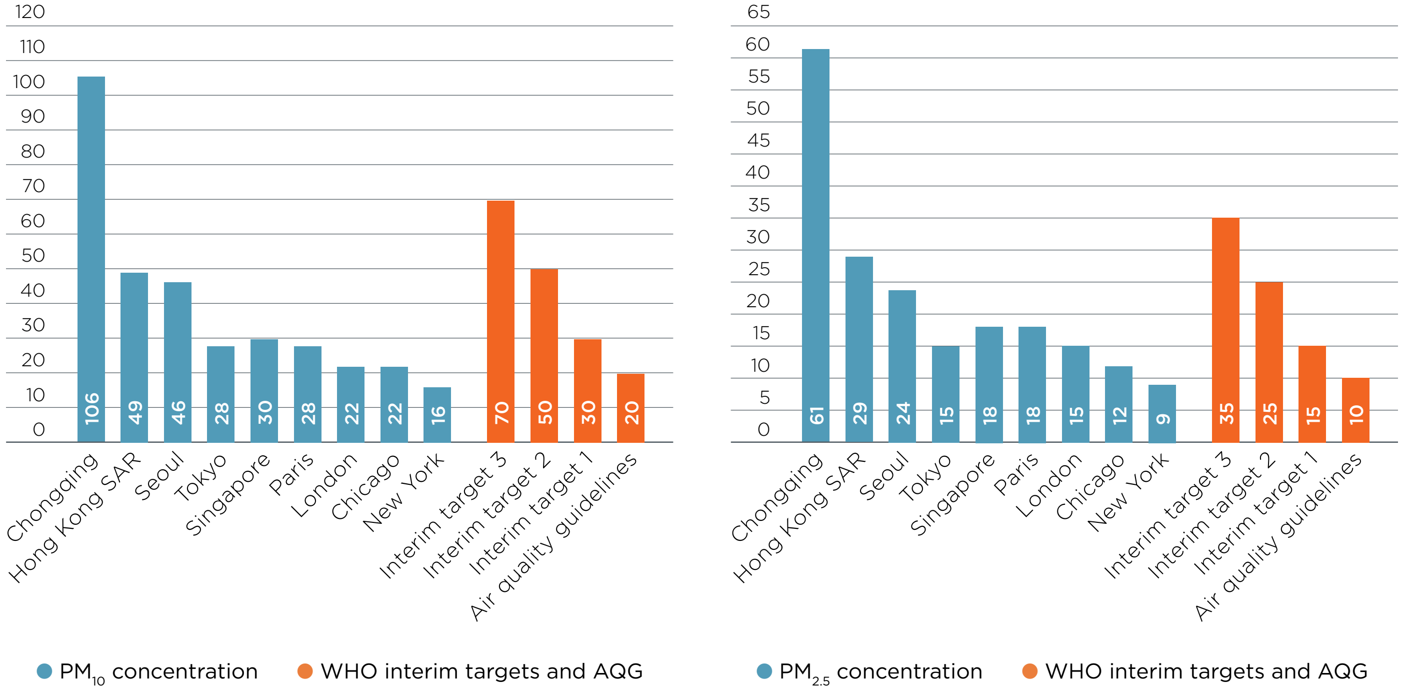
Source: Produced by the Urban Morphology and Complex Systems Institute for this report, based on Brookings Institution 2015, Economist Intelligence Unit 2011, and International Carbon Action Partnership 2014.

FIGURE 8 Atmospheric Sulfur Dioxide Emissions in 2004–2015

Source: National Bureau of Statistics of China 2016.

Global cities have a higher share of services in their economies and a lower share of heavy industry, and they have stringent regulations to decouple energy consumption and PM emissions from GDP growth. Falling energy demand, an increase in the uptake of low-carbon alternatives, and increasingly stringent air quality regulations are resulting in lower emissions of most major pollutants in many OECD cities. PM_{10} and $PM_{2.5}$ levels in Chongqing are more than twice those in Hong Kong SAR and Seoul, more than three times higher than in Tokyo and Singapore, and more than six times higher than in New York (figure 9). New York has excellent air quality, with particulate concentration below the long-term levels recommended by the WHO. This is due to the high modal share of transit in New York and two decades of increasingly stringent air quality standards, with numerous actions taken to reduce emissions from local sources of pollution.

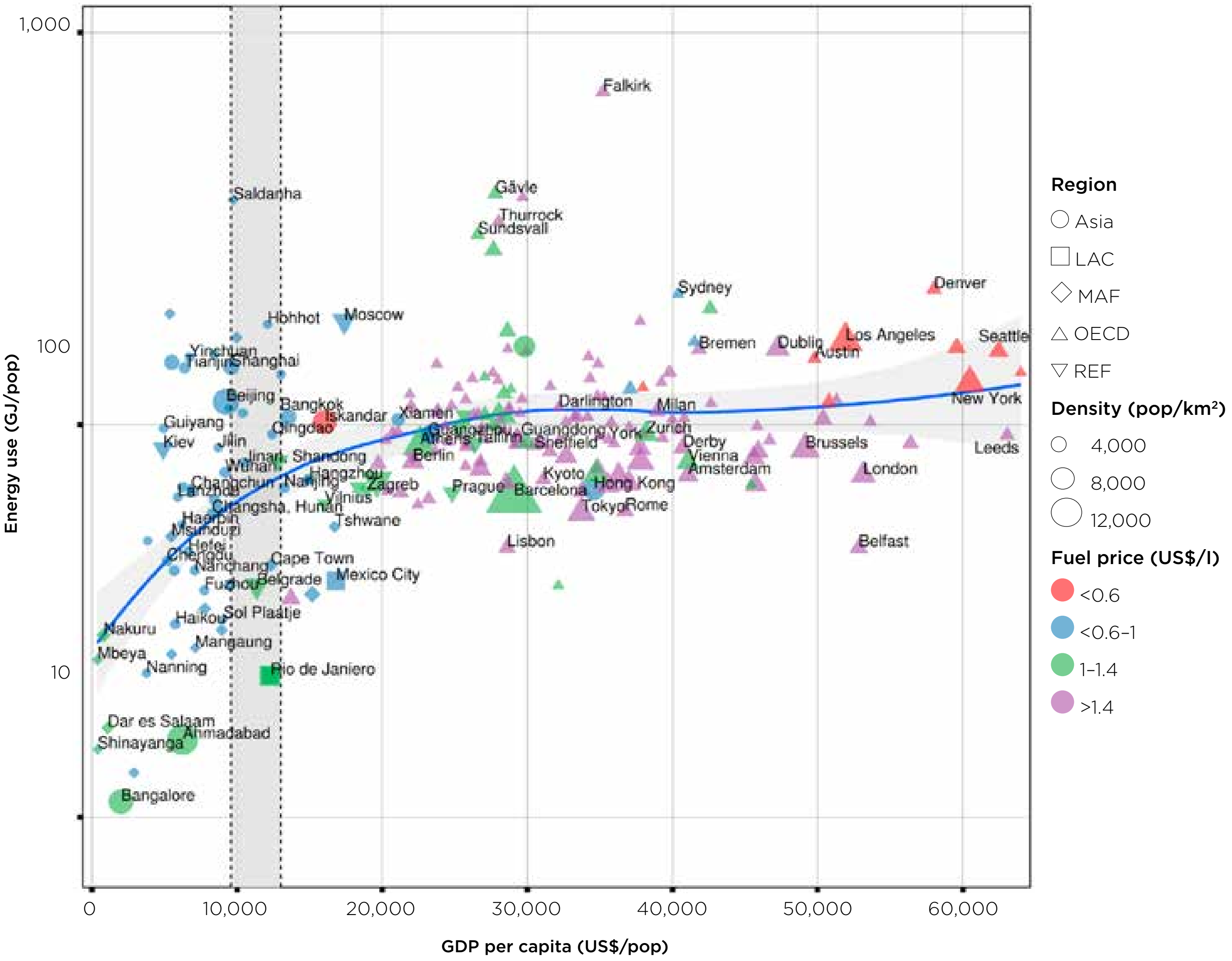
FIGURE 9 Annual Mean PM_{10} (Left) and $PM_{2.5}$ (Right) Concentrations Compared to WHO Interim Targets and WHO Air Quality Guidelines (AQG)[4]



Source: Produced by the Urban Morphology and Complex Systems Institute for this report, based on WHO 2005, 2016.

An observation from the development of many global cities is that when urban wealth reaches a certain level, resource consumption does not necessarily continue to increase with increasing GDP per capita. For example, the Asian Green Cities Index shows a steady increase in resource consumption with GDP per capita only up to a certain level—when incomes exceed around US$20,000 per person, average consumption decreases (Economist Intelligence Unit 2011). In a study of 274 cities using data from the World Bank on 2009 GDP at PPP,[5] the Global Energy Assessment and the International Association of Public Transport suggested that energy use increases with economic activity, especially for cities with GDP per capita below US$10,000. This growth slows down when GDP per capita is above US$20,000, and decoupling occurs for cities with GDP per capita above US$30,000 (figure 10) (Creutzig, et al. 2014).

FIGURE 10 **Energy Use Correlation with Economic Activity in a Sample of 274 Cities Representative of World Cities**



Source: Creutzig, et al. 2014. © Creutzig, et al. Reproduced with permission from Creutzig and PNAS; further permission required for reuse.

LAC: Latin America and the Caribbean; MAF: Middle East and Africa; REF: Reforming economies of Eastern Europe and the former Soviet Union.

The most energy-efficient cities are in the cluster of European cities located in the middle of the graph. These cities are compact and have higher fuel prices, which shows that decoupling is quite effective across the European Union (EU), with London and Prague having similar levels of energy use per capita despite their differences in wealth. Among the wealthiest cities, those in the United States, except New York, are slightly above the general decoupling trend due to their sprawling urban form and low fuel prices. For carbon emissions, similar patterns of decoupling happen when cities become wealthier: the six richest Asian cities emit an average of 5.8 tons/person per year, compared to an overall average of 4.6 tons/person among Asian cities (Economist Intelligence Unit 2011). The five cities in the middle-income group produce an average of 7.6 tons/person per year.

However, decoupling does not happen automatically. Examples of global cities, such as Copenhagen, London, New York, and Hong Kong SAR, show that increased wealth creates the conditions for decoupling, but this must be bundled with integrated policies to achieve the desired outcome (box 3). Policies that should be put in place include a compact urban form, with densities aligned with transit, mixed-use developments, and a well-balanced job and housing ratio. Other policies include increasing the use of non-motorized transport and replacing coal with renewable energies. A good example is Copenhagen, which aims to become the first large carbon-neutral city by 2025. Copenhagen's GDP per capita has increased by 30 percent between 1993 and 2010, while its carbon emissions have halved since 1993 to 3.5 tons of CO_2 per capita, thus achieving an absolute decoupling of economic growth and carbon emissions. Copenhagen is well known for its "Finger Plan" model of urban development from 1947, which has channeled urban growth along rail corridors that radiate from the city center, while protecting "green wedges" from development. The city has achieved a high level of integration between land use and transit, with 57 percent of the population and 61 percent of the jobs located within walking distance of urban rail stations (Rode et al. 2013). Moreover, the city aims to have 50 percent of commuting trips made by bike. Replacing coal and biomass for heating and power generation, and the increased use of wind energy have also made a substantial contribution to reducing its overall emissions.

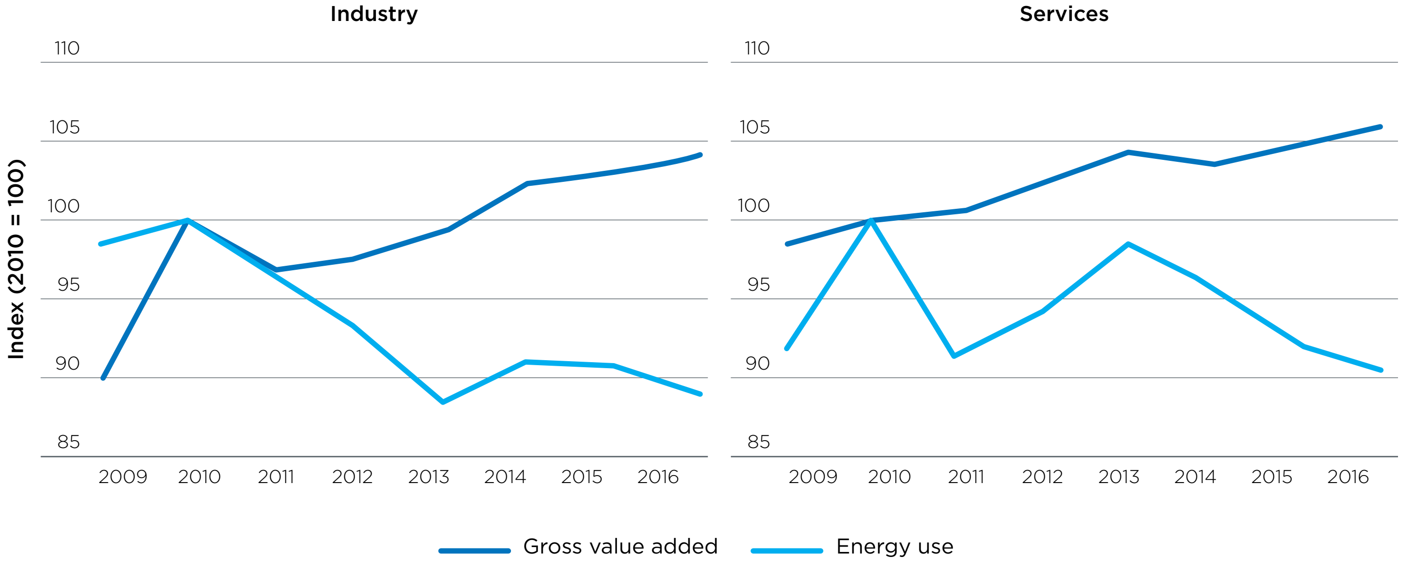
BOX 3 Energy Efficiency and Low-Carbon Performance in Tokyo and Hong Kong SAR

Stringent national regulations on emissions, a comprehensive energy policy, investments in renewable energy and energy efficiency, and a compact urban form with the most extensive urban rail network contribute to making Tokyo the city with the world's highest energy productivity (ratio of energy consumption to value added) at nearly three times the global average. Japan has successfully decoupled its industry and services sectors as well, as shown in figure 11.

Hong Kong SAR's compact development model has also led to a decoupling of economic growth and gasoline consumption. Gross value added per capita increased by 50 percent between 1993 and 2011, while per capita CO_2 emissions and gasoline consumption fell by about 10 percent each. Total annual carbon emissions from passenger transport in Hong Kong SAR are 378 kg/person, compared to around 1,000 kg/person in European cities and more than 5,000 kg/person in Houston, Texas. Hong Kong SAR spends only around 5 percent of its GDP on motorized travel compared to 12–14 percent in cities like Melbourne and Houston.

Source: Rode, et al. 2013..

FIGURE 11 Changes in Gross Value Added and Energy Use in Japan's Industry and Service Sectors in 2009–2016



Source: International Energy Agency 2017.

Photo: Pengpeng

4. Recommendations:

Chongqing's Green Growth Transformation

Compared to cities with higher GDP per capita, Chongqing is in a state of transition: its nominal GDP per capita in 2016 was US$8,908, and it will soon reach a stage where its economic growth may begin to decouple from energy and resource use. To accelerate the process of decoupling, lessons from other more developed cities show that Chongqing should change the course of its spatial development and make its industry and economy more energy efficient to ensure that additional economic growth does not come with an environmental cost. A green growth strategy will help Chongqing climb the value chain by boosting efficiency and fostering the growth of clusters of expertise in the knowledge-intensive green production sector. Chongqing can become a laboratory for the green economy in which learning and experience inspire innovation and reduce the cost of implementing new technologies.

A green growth strategy requires Chongqing to adopt an integrated approach that combines policy, regulations, and spatial considerations. This strategic direction will require green growth transformations for the main sectors that contribute to emissions—energy, buildings, transport, and urban form.

Green growth transformation I

Reduce the energy intensity of the economy and decarbonize the energy mix by increasing the share of renewables

Chongqing's poor air quality and high level of carbon emissions per capita and per unit of GDP derive primarily from an economy that is highly resource-intensive and from an energy mix dominated by coal and fossil fuels. Reducing the energy intensity of the economy includes two key actions: one is technological and implies improving the technological efficiency of energy conversion and use; the other is structural and requires improving Chongqing's industrial structure by moving up the value chain towards high-end manufacturing. The share of renewables in Chongqing's energy mix is currently far below China's average of 11.2 percent in 2014, and Chongqing should strive to achieve China's national goals. China's goal of increasing its use of non-fossil energy in primary energy consumption to about 20 percent by 2030 means that by 2030, its non-fossil energy supplies will have to be seven or eight times their 2005 level. Simultaneously, the CO_2 intensity of energy consumption will fall by 20 percent compared with 2005 levels, which will play a key role in significantly reducing the CO_2 intensity of GDP (Cheng and Tong 2017).

Green growth transformation II

Plan for a compact urban form to decrease transportation energy use, pollution, and congestion, and become a car-light city

Urban compactness, increased walkability, public transportation, and concentrating people, jobs, and amenities near mass transit stations reduce transportation energy consumption and emissions, as well as the resources embodied in transportation infrastructure. Compact city policies are the first lever to reduce mobility environmental impacts and reduce carbon and pollutant emissions. In the Compact Growth scenario modeling conducted for this report, the GHG and pollutant emissions associated with automobile use are reduced by 40 percent compared to the Trend scenario (box 4). Following Singapore, Chongqing should systematically move towards becoming a car-light city. This would require

BOX 4 Urban Growth Scenario Modeling of the Impact on the The Environment and GHGs

Urban development patterns have substantial effects on climate change mitigation and environmental sustainability. While policies that address the technical aspects of vehicle efficiency, building performance, and energy supply play important roles in conserving resources and reducing emissions, the impacts of land use and strategic development are even more crucial to sustainable growth.

Compact growth induces a modal shift towards walking and public transportation

Modal share is an indicator of the extent to which the local urban environment and regional land use patterns support non-auto alternatives. The walking and transit shares of trips are 5 percent and 4 percent higher in the Compact Growth scenario than in the Trend scenario, while the auto share is 9 percent lower. The mode shares for the scenarios are summarized in figure 12.

Compact growth reduces vehicle kilometers traveled (VKT) by household automobiles and daily average travel time per capita

Through lower automobile use and shorter travel distances, the Compact Growth scenario results in 18.7 billion VKT annually in 2035, or 39 percent less than the 30.6 billion VKT in the Trend scenario. The average VKT per capita is 2,320 km per year in the Trend scenario compared to 1,420 km in the Compact Growth scenario. Figure 13 and figure 14 illustrate the annual VKT results per capita. Cumulative to 2035, the VKT difference between the Trend and Compact Growth scenarios is significant. While VKT in the Trend scenario totals 410 billion km, VKT in the Compact Growth scenario totals 311 billion km. The difference of 99 billion km is equivalent to over seven years of driving at current levels.

Additionally, as illustrated in figure 15, commuters in the Trend scenario spend an extra five minutes per day traveling on average across all modes.[7]

Compact growth reduces GHG and air pollutant emissions associated with transportation and improves air quality

The difference in VKT between the scenarios corresponds to a similar difference in GHG emissions, with the Compact Growth scenario having 2.6 MMT less CO_2 emissions per year in 2035 compared to the Trend scenario. These emissions savings exceed current annual CO_2 emissions from auto travel within the regional study area. These figures are based on current vehicle performance, and the uptake of newer, more energy-efficient vehicle technologies in the future could lower emissions even further (figure 16 and figure 17).

Emissions of air pollutants from vehicles also decrease with VKT. The Compact Growth scenario has 293,000 MT less in total emissions of NOx, CO, THC, particulate matter, black carbon, and SO_2 by 2035 than the Trend scenario, accounting for a difference of 85 percent. This reduction in emissions exceeds the current annual emissions from automobile travel in the regional study area. As with GHGs, the adoption of newer and cleaner vehicle technologies would further reduce emissions.

Source: Produced by Calthorpe Associates for *Chongqing 2035: Urban Growth Scenarios*.

a combination of both carrot and stick approaches, where driving private vehicles is made more difficult through the reduction of parking facilities and increased toll charges, etc.; and public transit and active modes are encouraged or subsidized.

Green growth transformation III

Improve the energy and resource efficiency of the building sector with efficient buildings and districts

The building sector will have a strong impact on Chongqing's environmental performance. Construction projects have been a major engine of growth in Chongqing, representing three-quarters of the growth in fixed assets, and this trend is likely to continue. It is estimated that the building sector is responsible for 40 percent of global energy consumption and about 20 percent of global water consumption. Energy and water are sectors in which Chongqing needs to make significant reduction efforts and that offer the highest potential for mitigating GHG emissions, according to the Intergovernmental Panel on Climate Change (IPCC). In 2009, building heating accounted for 8 percent of Chongqing's emissions (Liu 2016). Energy efficiency measures such as insulation, renewable micro-generation, conversion of heating energy into electricity (through air and ground-source heat pumps), and district heating from renewable energy sources are already used in many cities around the world. Implementing such measures will ensure that Chongqing's growth is not accompanied by a significant jump in emissions from the construction and building sectors. These types of policies can have significant impacts. For example, Stockholm has experienced a 33 percent reduction in greenhouse gas emissions from heating and electricity in recent decades, with emissions falling from 3.8 tCO_2e to 2.3 tCO_2e per person between 1990 and 2010.

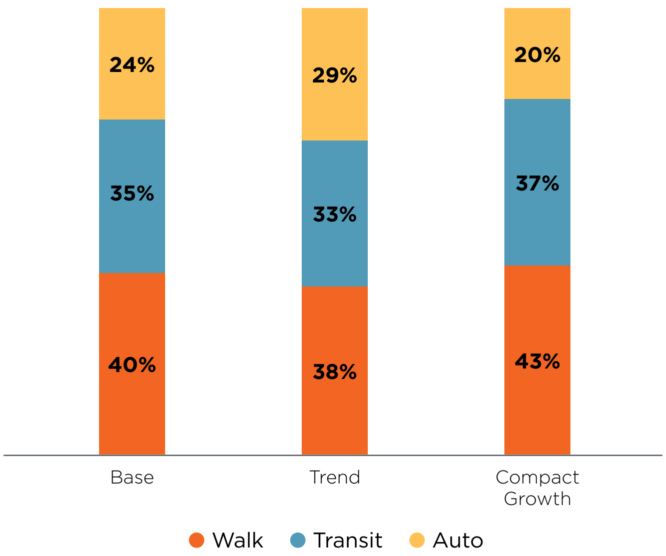
Chongqing can also innovate by creating eco-neighborhoods with integrated district-level solutions that increase energy efficiency in construction, heating, water and waste compared to building-specific solutions.

Green growth transformation IV

Leverage Chongqing's automobile production base to develop the fast-growing electric mobility sector

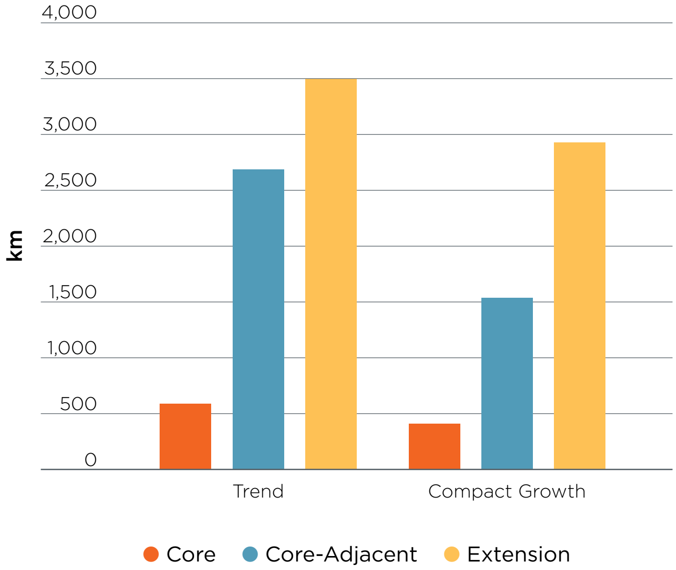
Globally, road transport is responsible for 16 percent of energy-related global carbon emissions (Herzog 2009). In 2009, this sector constituted 7 percent of emissions in Chongqing, compared to 18 percent in Shanghai (Liu 2016). There is a clear opportunity for Chongqing to limit any future growth in this area. Greening urban transport with innovative technologies is a win-win solution, that tackles pollution and GHG emissions and serves as a potential driver of growth in Chongqing, where automobile production is a leading manufacturing sector. Registrations of electric cars reached a new record in 2016, with more than 750,000 sales worldwide.[6] China has an electric car market share close to 1.5 percent and a strong potential for growth. In 2016, China was by far the largest market for electric cars globally, accounting for more than 40 percent of electric cars sold worldwide ; this figure represents more than double the volume sold in the United States. Chongqing can leverage its existing automobile production base to become a global leader in the production and use of electric cars.

FIGURE 12 **Transportation Mode Share under Different Scenarios**



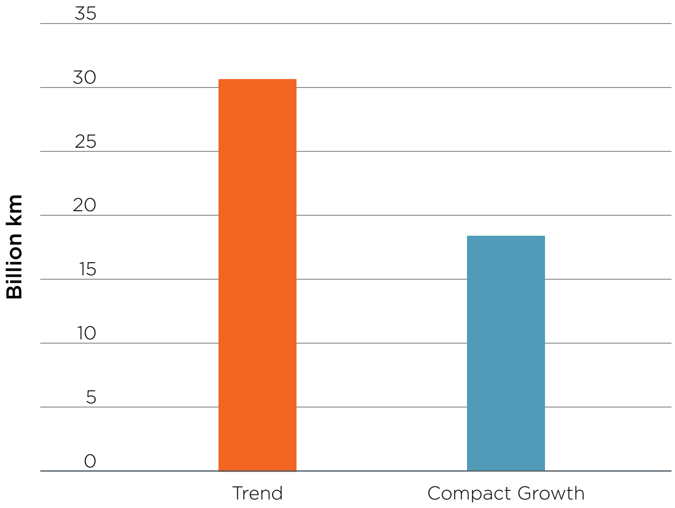
Source: Produced by Calthorpe Associates for *Chongqing 2035: Urban Growth Scenarios.*

FIGURE 13 **Automobile Vehicle Kilometers Traveled Per Regional Location under Different Scenarios**



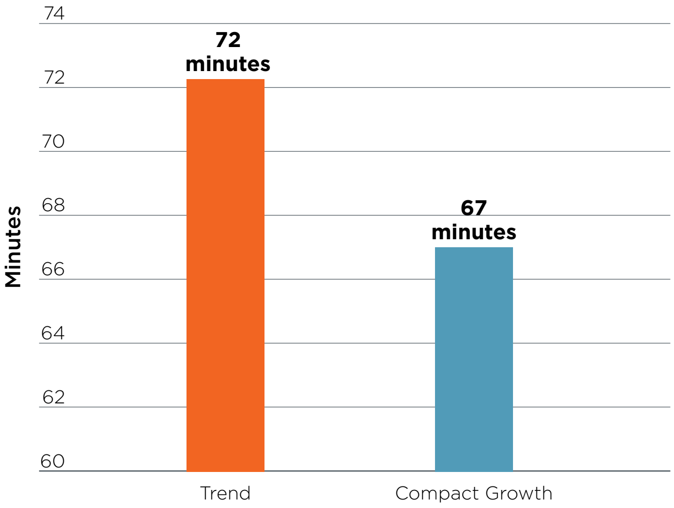
Source: Produced by Calthorpe Associates for *Chongqing 2035: Urban Growth Scenarios.*

FIGURE 14 **Automobile Vehicle Kilometers Traveled in 2035 under Different Scenarios**



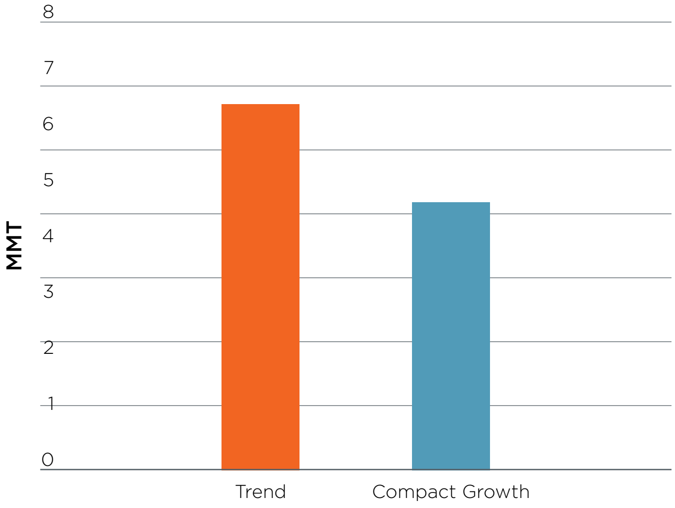
Source: Produced by Calthorpe Associates for *Chongqing 2035: Urban Growth Scenarios.*

FIGURE 15 **Daily Average Travel Time Per Capita under Different Scenarios**



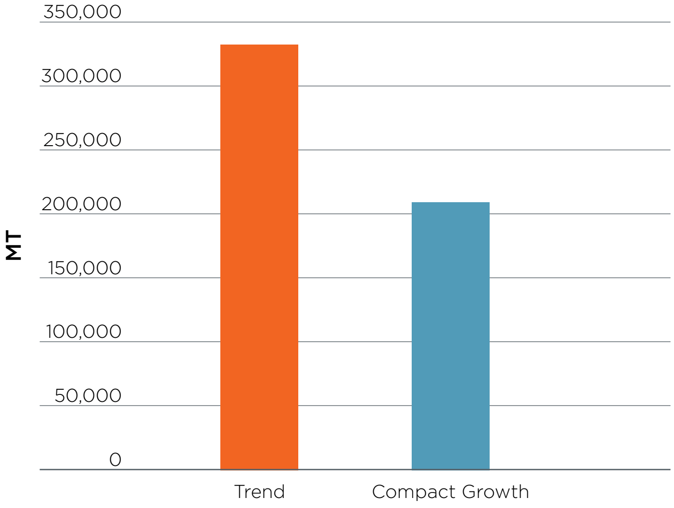
Source: Produced by Calthorpe Associates for *Chongqing 2035: Urban Growth Scenarios.*

FIGURE 16 Automobile GHG in 2035



Source: Produced by Calthorpe Associates for *Chongqing 2035: Urban Growth Scenarios.*

FIGURE 17 Automobile Air Pollutant Emissions in 2035



Source: Produced by Calthorpe Associates for *Chongqing 2035: Urban Growth Scenarios.*

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Endnotes

1. Overall GHG emissions in tCO_2e.
2. Studies on road networks (Ingram and Liu 1997) and urban water and wastewater networks (Müller, et al. 2013) suggest that per capita network length and material stocks tend to increase with declining urban density. Müller et al. (2013) have computed data on a representative sample of about 40 cities, which has been mathematically analyzed by the Urban Morphology and Complex Systems Institute. (Salat 2016; Salat, Bourdic, and Kamiya 2017). This statistical analysis allows for calculation of the elasticity of water, wastewater, and street network lengths and costs per capita with regard to average residential density.
3. Satellite picture analysis made for this report by Calthorpe Associates and China Sustainable Transportation Center (CSTC).
4. Hong Kong SAR and Seoul are close to the WHO Interim Target (IT) 2, where long-term risks of premature mortality are reduced by about 6 percent compared to IT 1. Paris and Tokyo are at IT 3, which indicates that risks of premature death are reduced by approximately another 6 percent compared to IT 2. For PM_{10}, Chicago and London are close to the long-term Air Quality Guideline (AQG) level but are still at IT 3 for $PM_{2.5}$.
5. This data set includes 274 cities from 60 countries with a combined population of 775 million, or 21 percent of the global urban population. While the GDP data date back to 2009, the thresholds and global clustering remain valid today.
6. With a market share of 29 percent, Norway has the most successful deployment of electric cars in the world.
7. Travel time is a function of accessibility, mobility, distance, and congestion. How much time people spend commuting or otherwise getting around to meet daily needs plays a big role in quality of life. Beyond the social dimensions, travel time also has an impact on economic productivity.

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