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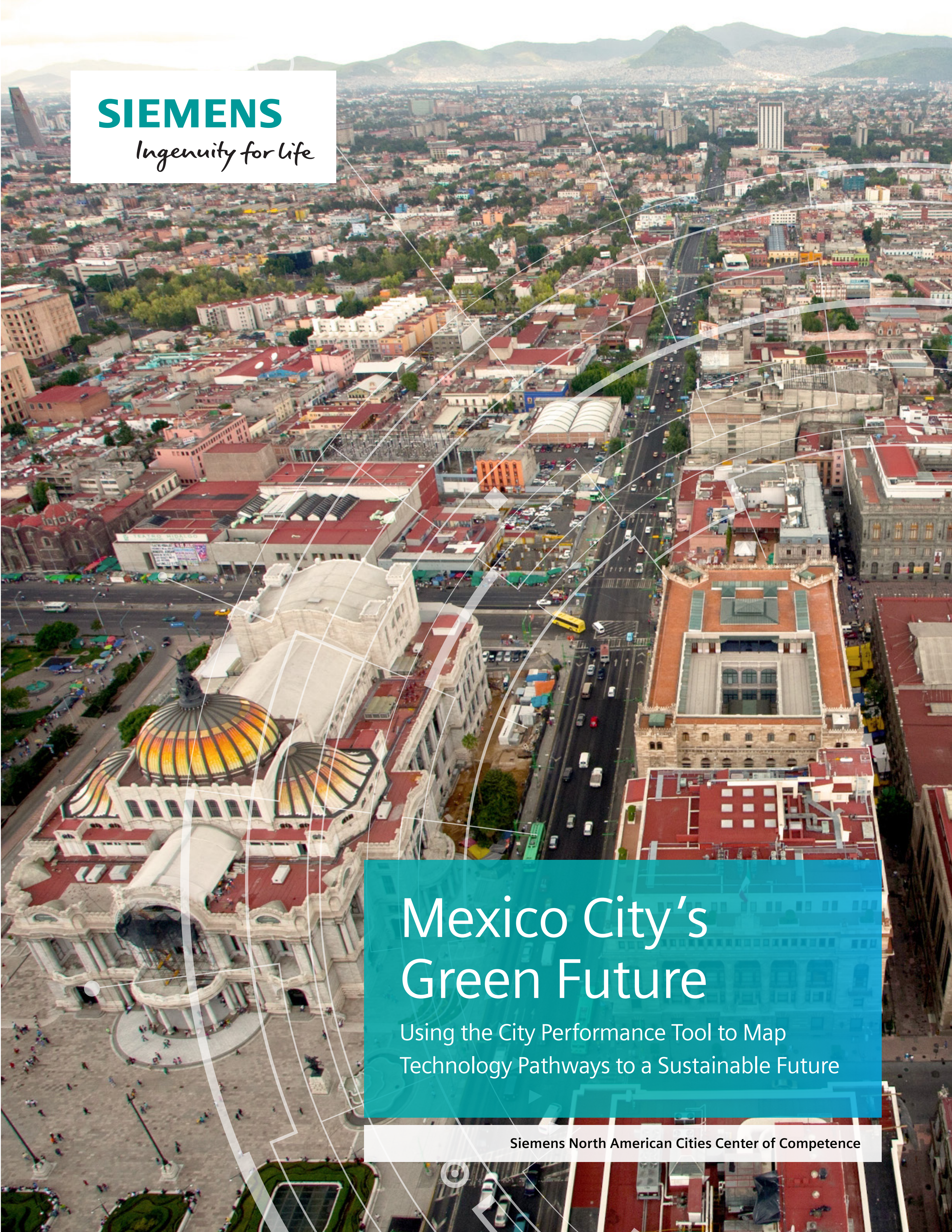


Mexico City's Green Future

Using the City Performance Tool to Map Technology Pathways to a Sustainable Future

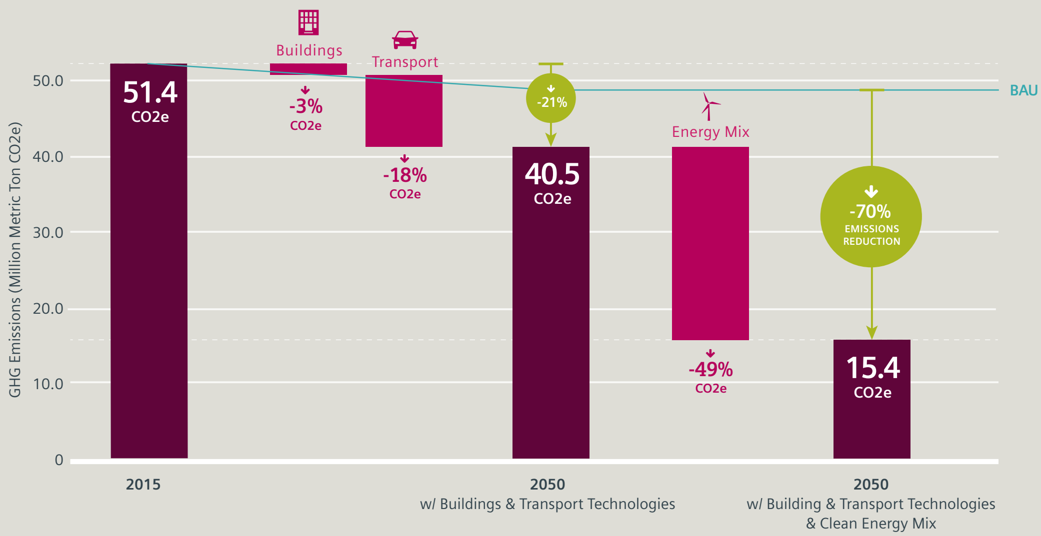
Siemens North American Cities Center of Competence

Resumen

Siemens City Performance Tool (CyPT) en la Ciudad de Mexico

La Ciudad de México es una potencia económica mundial y se encuentra entre las ciudades más importantes de la sostenibilidad en América Latina, de acuerdo con el Siemens Latin American Green City Index desde 2009. La adopción de políticas progresivas de sostenibilidad como *ProAire*, es un claro indicador de su esfuerzo por mejorar la calidad del aire. Sumando a esto la creación de áreas verdes, desarrollo de una robusta red de transporte multimodal, y reducción de los gases de efecto invernadero (GEI). El análisis de City Performance Tool (CyPT) de Siemens muestra que, la Ciudad de México ya está tomando decisiones importantes respecto a la sustentabilidad de su infraestructura, pero podría acelerar su progreso hacia objetivos más ambiciosos de sostenibilidad y mejorar la calidad de vida de sus ciudadanos adoptando 40 tecnologías para energía, edificios y transporte. Este reporte analiza las tecnologías en las que la Ciudad de México podría invertir para optimizar su mix energético, mejorar y ampliar su sistema de transporte público existente y dar ejemplo convirtiendo edificios públicos en construcciones sostenibles, teniendo en cuenta los impactos económicos y ambientales estimados que dichas tecnologías tendrían entre hoy y 2050.

Reducción Profunda Del Carbono



Si la Ciudad de México implementara las 40 tecnologías recomendadas en este reporte se podrían reducir las emisiones de CO2(e) anuales en casi un 70 por ciento desde hoy, pasando de 51 millones de toneladas métricas por año en 2015 hasta 15 millones en 2050.

Tecnologías de Alto Desempeño

De las 40 tecnologías recomendadas, las de mayor rendimiento en términos de reducción de carbono son: energía eólica terrestre y paneles fotovoltaicos (FV) de techo que reducirían las emisiones anuales de GEI en un 35 y un 14 por ciento, respectivamente.

Los Grandes Números

-70%
Reducción de emisiones por 2050

$300K
Costo por Persona (Mexican Pesos)

1.3M
Trabajos Creados (Medidos en Equilavalentes a Tiempo Completo)

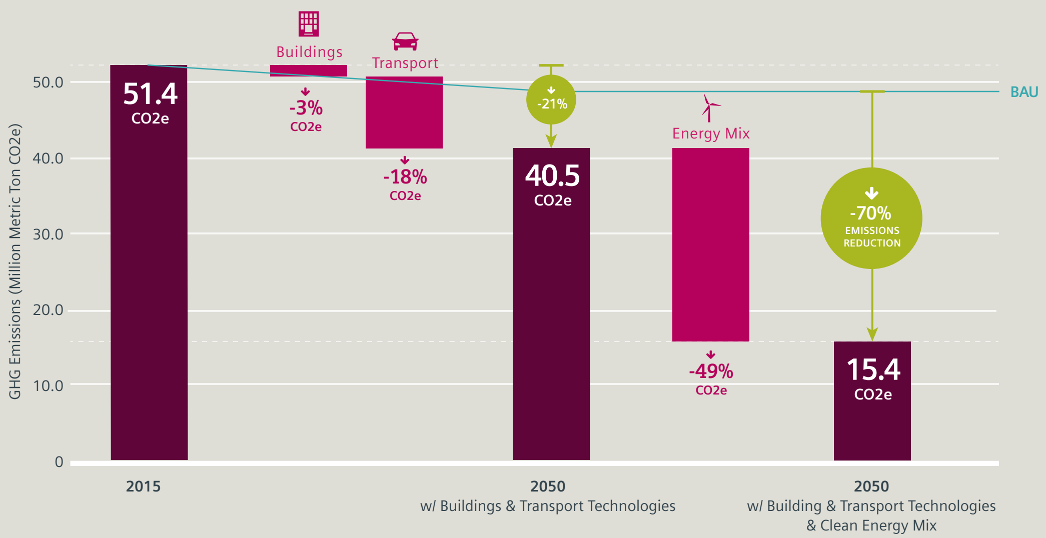
La implantación de estas 40 tecnologías entre hoy y 2050 costaría aproximadamente 2.6 billones de pesos mexicanos, o 300,000 pesos por habitante. La aplicación de las 12 tecnologías de edificios costarían aproximadamente 630 pesos por metro cuadrado de edificios residenciales y no residenciales; y la de las 22 tecnologías enfocadas al transporte costarían aproximadamente 15 pesos por kilómetro por pasajero. Con esta inversión, la Ciudad de México podría generar más de 1.3 millones de trabajos (medidos en equivalentes a tiempo completo) entre hoy y 2050.

Summary

Siemens City Performance Tool (CyPT) in Mexico City

Mexico City is a global economic powerhouse, and ranks among the top cities in sustainability in Latin America, according to Siemens Latin American Green City Index from 2009. Its adoption of progressive sustainability policies, like *ProAire*, indicate its dedication towards improving air quality, establishing more green space, building out a robust and multi-modal transport network, and reducing greenhouse gas (GHG) emissions. Siemens City Performance Tool (CyPT) analysis shows that while Mexico City is already making "green" decisions with regards to infrastructure, it could accelerate its progress towards ambitious sustainability targets and towards improved quality of life for its citizens by adopting 40 market-ready buildings, energy, and transport technologies. This report discusses the technologies in which Mexico City could invest to clean its energy mix, improve and expand its existing public transit system, and lead by example through greening publicly owned buildings, given the estimated economic and environmental impacts those technologies would have between today and 2050.

Deep Carbon Reduction



If Mexico City implemented all 40 technologies recommended by this CyPT analysis, it could reduce annual CO2(e) emissions by nearly 70 percent from today, from 51 million metric tons per year in 2015 to 15 million in 2050.

High Performing Technologies

Of the 40 technologies recommended, the highest performing in terms of carbon reductions are the two renewable energy levers: onshore wind power and rooftop photovoltaic (PV) panels. In combination with the buildings and transport levers, increasing the percentage of wind and solar power in the electricity mix to 70 percent by 2050 reduces annual emissions by 49 percent.

The Big Numbers

-70%
Emissions Reduction by 2050

$300K
Cost Per Person (Mexican Pesos)

1.3M
Jobs Generated (Full-Time Equivalents)

Installing and operating the recommended 40 technologies between today and 2050 would cost roughly 2.6 trillion Mexican pesos, or 300,000 pesos per city inhabitant. The 12 building technologies would cost approximately 630 pesos per square meter of residential and non-residential space, and the 22 transport technologies would cost about 15 pesos per passenger kilometer. With this investment, Mexico City could generate more than 1.3 million jobs (measured in direct, indirect, and induced full-time equivalents) between today and 2050.

Acknowledgements

Siemens would like to thank Mexico City's Secretaría de Desarrollo Economico and Secretaría de Medioambiente for their support of the CyPT analysis, including providing data and lending expertise on Mexico City's energy, buildings, and transport networks.

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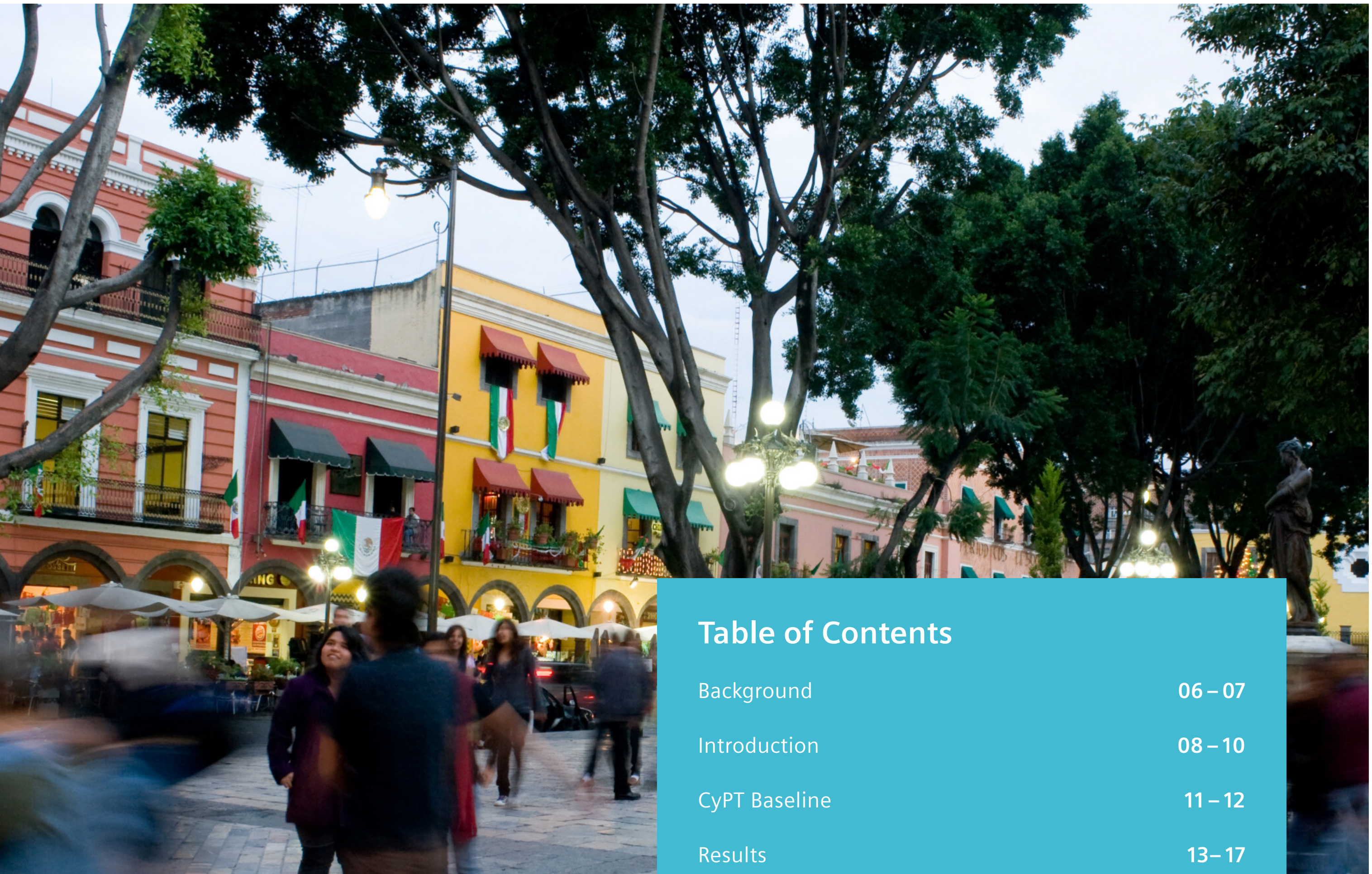

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Background

Over the last few decades, Mexico City ("CDMX") has seen incredible growth – the population has increased from 3 million to nearly 9 million people in 50 years, and the city's GDP has increased to about $182.8 billion, or 17% of Mexico's total GDP.[1] That not only positions Mexico City as the economic hub of Latin America, but also as a key economic power globally. Ample connections through trade, investment and cultural centers – such as the world's largest university, the National Autonomous University of Mexico (UNAM) – that have been fostered by Mexico City's government and commercial sector have helped the city attain international stature. On top of that, Mexico City has 147 museums, 136 theaters, 408 libraries, and four archaeological sites. And Mexico City's Benito Juarez International Airport connects travelers directly to 50 Mexican cities and 44 international cities.

But explosive growth has also brought some tough challenges to the city. Air quality and transportation issues have accompanied the city's expansion, and the government has been working to implement policies and programs to eradicate pollution and congestion. In the 1980s, the City mandated reformulated gasoline, closed or moved toxic factories, and implemented a "no driving day" (*Hoy No Circula*) policy that only permitted vehicles on the road every other day.[2] Then in the 1990s, the City further intensified its efforts and launched a series of comprehensive programs known as "*ProAire*." *ProAire* targets more than 80 indicators affecting transportation, health and education, energy consumption, green areas and reforestation as well as capacity building and scientific research. The focus is on reducing ozone and particulate matter and emphasizing environmental education and citizen participation.[3]

ProAire is working. Launched under the program in 2005, the new Bus Rapid Transit (BRT) Metrobús has resulted in a 15 percent modal shift from cars to public transit and an estimated 110,000 ton reduction in annual CO_2(e) emissions. The Ecobici bikesharing program has grown from 1,000 initial bicycles to more than 6,000 within six years, with daily ridership increasing from an average of 25,000 to 400,000 riders per day. Further expanded public transport includes an electric suburban rail system (*Tren Suburbano de la Zona Metropolitana del Valle de México*) and additional metro stations and lines, resulting in daily ridership amounting to more than 4 million people.[4]

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The success of these programs is mirrored in environmental indicators. Lead levels in the air have dropped by 90 percent since 1990. Suspended particles – tiny particles of dust, soot or chemicals that can lodge in the lungs – have gone down 70 percent.[5] Between 2008 and 2012, carbon emissions were reduced 7.7 million tons, exceeding the City's own 7 million ton target.[6] And thanks to its efforts, Mexico City has now attained roughly the same level of air quality as Los Angeles.[7] With population growth leveling off and even predicted to decline over the next few decades, these numbers can be expected to continue on a positive trend.

Nevertheless, policy implementation is not always easy given Mexico City's diverse social and economic fabric. For example, while the population of CDMX itself is projected to decrease over time, the areas surrounding Mexico City are projected to grow by 4 to 10 percent annually.[8] Many of the people from the surrounding areas will continue to commute in to Mexico City for work, exerting additional pressure on Mexico City's public transit system and road network to accommodate congestion.

Mexico City's government, however, has navigated these challenges well and has continued to implement environmental policies that have a positive impact on the city and its residents. In 2007, the City introduced its Green Plan (*Plan*

[1] http://www.brookings.edu/~/media/Multimedia/Interactives/2013/ten-traits/Mexico_City.pdf; Secretaría de Desarrollo Economico

[2] http://www.nytimes.com/2012/04/10/world/americas/vertical-gardens-in-mexico-a-symbol-of-progress.html?_r=0

[3] http://projects.wri.org/sd-pams-database/mexico/program-improve-air-quality-mexico-city-metropolitan-area-proaire

[4] http://www.metro.df.gob.mx/operacion/afluencia.html

[5] http://www.washingtonpost.com/wp-dyn/content/article/2010/03/31/AR2010033103614_2.html?sid=ST2010033103622

[6] http://www.siemens.com/press/pool/de/events/2014/infrastructure-cities/2014-06-CCLA/mexico-climate-close-up.pdf

[7] http://www.nytimes.com/2012/04/10/world/americas/vertical-gardens-in-mexico-a-symbol-of-progress.html?_r=0

[8] http://www.conapo.gob.mx/es/CONAPO/Proyecciones_Datos

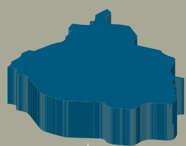
» The Ecobici bikesharing program has grown from 1,000 initial bicycles to more than 6,000 within six years, with daily ridership increasing from an average of 25,000 to 400,000 riders per day. «

Verde). Well aware of the fact that urban green spaces help to purify air and water, to manage storm water, to sequester carbon and to reduce heat-island effects, the City has revitalized many green spaces. In fact, green spaces have grown to about 5.4 m2 per capita today – up considerably from only 1.94 m2 in the early 1990s, especially considering the increase in population. But the imperative for green spaces continues to grow in parallel to the city's expansion. As the government continues to work towards environmental sustainability, the targeted range of 9-16 m2 of green space per inhabitant should continue to guide policy decisions.[9]

[9] http://www.transparenciamedioambiente.df.gob.mx/index.php?option=com_content&view=article&id=134%3Aicuales-son-los-principales-problemas-sobre-espacio-publico-y-areas-verdes-en-la-ciudad-de-mexico&catid=53%3Ahabitabilidad&Itemid=431

Introduction

Mexico City



Geographical Area
1,495 km²

Population
8.9M

Energy (% of Electricity Mix)

Hardcoal	9%
Hydro	22%
Natural Gas	34%
Nuclear	3%
Heavy Fuel Oil	25%
Other	3%
Geothermal	2%
Wind	2%

Buildings (Area per Capita)

30.7 (m²/ person) Residential
14.3 (m²/ person) Non-Residential

Passenger Miles
15.5 (PMI / person / day)

Seoul

Geographical Area
605 km²

Population
10.4M

Energy (% of Electricity Mix)

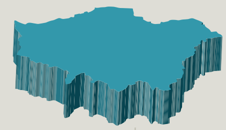
Hardcoal	1%
Lignite	38%
Hydro	2%
Natural Gas	24%
Nuclear	27%
Heavy Fuel Oil	3%
Other	3%
Waste	2%

Buildings (Area per Capita)

27.0 (m²/ person) Residential
21.0 (m²/ person) Non-Residential

Passenger Miles
15.5 (PMI / person / day)

London



Geographical Area
1,572 km²

Population
8.5M

Energy (% of Electricity Mix)

Biomass	12%
Hardcoal	31%
Hydro	2%
Natural Gas	26%
Nuclear	18%
Photovoltaic	1%
Wind	10%

Buildings (Area per Capita)

19.3 (m²/ person) Residential
11.6 (m²/ person) Non-Residential

Passenger Miles
14.0 (PMI / person / day)

Mexico City's desire not just for growth, but for green growth, is one of the many reasons why Siemens worked with the Secretary for the Environment and the Secretary for Economic Development to perform a City Performance Tool (CyPT) analysis of Mexico's capital city.

Siemens designed the CyPT to help city governments prioritize infrastructure investments to align with their estimated environmental and economic impacts. Based on more than 350 data points, the CyPT model calculates city-specific estimates of technologies' impacts on reducing CO2(e) emissions, improving air quality, and adding new jobs in the local economy. Siemens decision to focus on those three indicators was deliberate: cities today are leading the world in sustainability efforts, matching efforts to "go green" with efforts to foster green economies. Results from CyPT analyses have aided city-decision makers around the world in developing long-term strategic plans for meeting those ambitious sustainability targets, as well as informing

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Like in London, another of Mexico City's goals for the CyPT analysis is to find ways to optimize its multi-modal transport system, perhaps further electrifying and automating transport.

short-term actions to boost local growth.

By using the CyPT, Mexico City joins cities such as Copenhagen, London, Berlin, San Francisco, Shenzhen, Nanjing, Vienna, Munich, and Seoul in establishing technology pathways for a green future.

- **Like in San Francisco**, one of Mexico City's goals for the CyPT analysis is to test which technologies will enable deep carbon reduction. These technologies would support not only Mexico's bold "80x50" target (reducing GHG emissions by 80 percent by 2050), but also Mexico City's goal of 8-million ton reduction by 2020.[1,2]
- **Like in London**, another of Mexico City's goals for the CyPT analysis is to find ways to optimize its multi-modal transport system, perhaps further electrifying and automating transport. Although Mexico City has made great strides in terms of steering people towards formalized public transit options, cars and taxis, powered by diesel or gas, still constitute more than 40 percent of passenger miles traveled in Mexico City.[3]
- **Like in Seoul**, one of Mexico City's goals for the CyPT analysis is to understand how incorporating additional solar power into the grid mix has ripple effects on reducing GHG emissions from buildings and electric transport.

But unlike any other CyPT city, Mexico City is the first to use the CyPT directly to identify areas in which further data collection could assist with capital and operational planning. It is also the first city in Latin America to use the CyPT and to receive a CyPT report. The Mayor of Mexico City recently announced the launch of *Oficina Virtual de Información Económica (OVIE)*, an advisory service for decision-making on investment, and some of the main insights from this CyPT analysis center on which data would be helpful to collect as Mexico City adapts to a changing climate, while growing economically.

» By using the CyPT, Mexico City joins cities such as Copenhagen, London, Berlin, San Francisco, Shenzhen, Nanjing, Vienna, Munich, and Seoul in establishing technology pathways for a green future. «

[1] http://www.nrdc.org/international/copenhagenaccords/

[2] http://www.sedema.df.gob.mx/sedema/images/archivos/temas-ambientales/cambio-climatico/executive-summary-PACCM.pdf

[3] According to Siemens calculations.

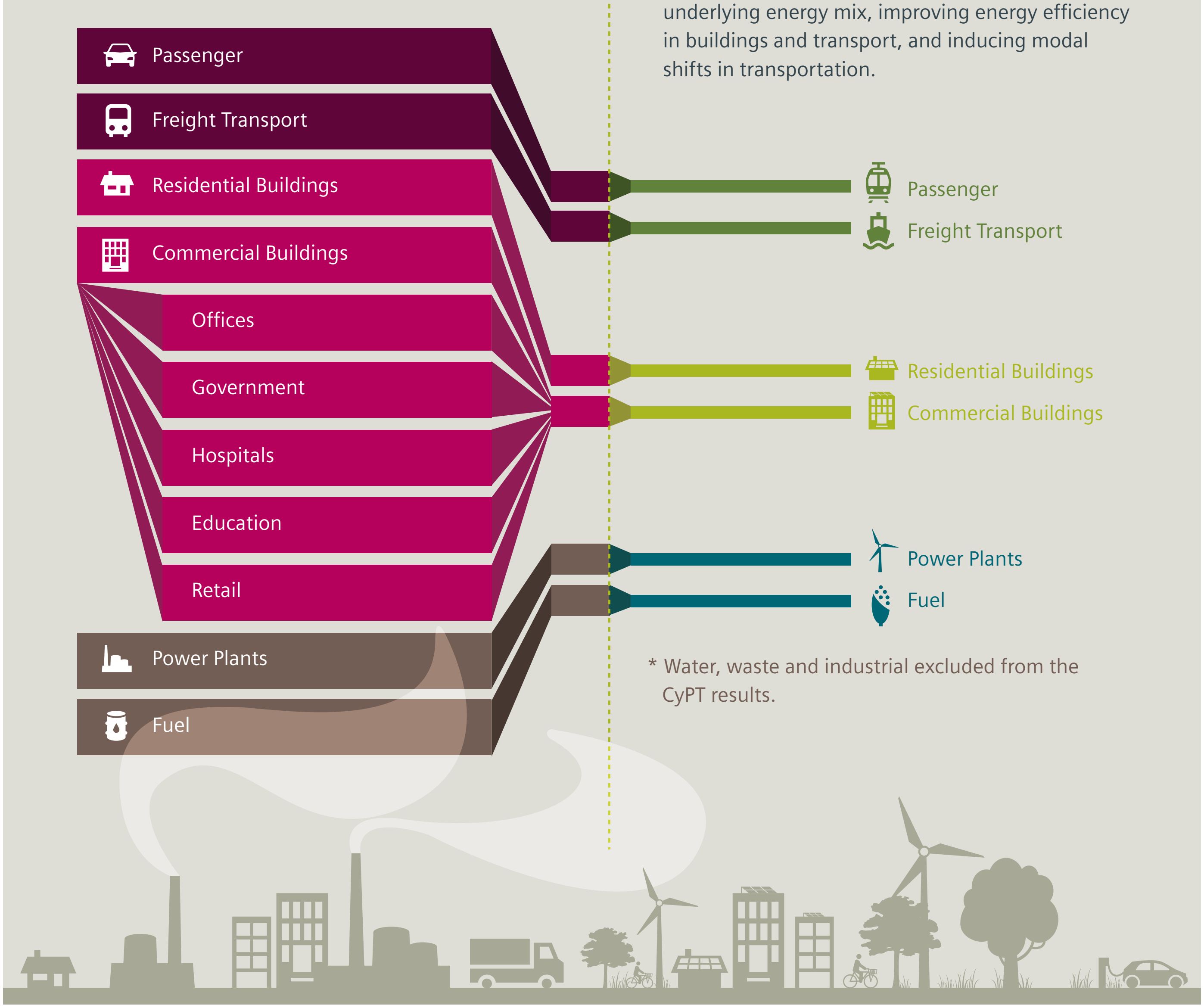
How the CyPT Model Works

STEP 1

Energy Mix Analysis
The CyPT works by using 350 city-specific data points to build an emissions baseline based on activities occurring within the city boundaries. It uses the 2012 GPC Protocol for Community-Wide Emissions to estimate emissions from residential and commercial buildings, passenger and freight transport, and energy consumption.

STEP 2

CyPT Results*
Once that emissions baseline is established, Siemens collaborates with a city to determine which of the 73 technologies and policy levers in the CyPT apply and at which implementation rates. Scenarios of infrastructure technologies at various implementation rates are then run through the CyPT model. Results of the model demonstrate how the CyPT levers reduce emissions by cleaning the underlying energy mix, improving energy efficiency in buildings and transport, and inducing modal shifts in transportation.



* Water, waste and industrial excluded from the CyPT results.

CyPT Baseline

The CyPT model estimates today's CO2(e) emissions from buildings and transport in Mexico City to be 51 million metric tons, of which 62 percent is from buildings and 38 percent is from transport. Non-residential buildings constitute 36 percent of emissions overall; freight transport, 25 percent; residential buildings, 23 percent; and passenger transport, 15 percent. These numbers can be explained by buildings' large footprint in Mexico City; Mexico City's position as a global and local hub for freight; and the 60 percent passenger modal share for motorized forms of transport.

Under business-as-usual conditions, in which the electricity mix remains the same and energy consumption per capita is constant, the CyPT model estimates that CO2(e) emissions decrease to 47 million metric tons by 2050, with 68 percent of emissions coming from buildings and 32 percent from transport. The decline in transport emissions explains the decrease in emissions, and is a result of two factors: Mexico City's projected decrease in population, as the City attempts to reduce the number of people living within its boundaries from 8.9 million today to 7.8 million in 2050; and the CyPT model's assumption that transport technologies increase in efficiency over time due to replacement of existing vehicles at the end of their useful life.

The CyPT model's estimate of 51 million metric tons of GHG emissions conflicts with Mexico City's official estimate of 24.08 million, of which the City attributes 22 percent to commercial and residential buildings and 52 percent to transport.[1] This large difference is likely due to the differing approaches between how the CyPT model estimates emissions versus how Mexico City does, as well as the availability of Mexico City-specific data on buildings and transport.

To calculate any city's energy and emissions footprint, the CyPT model considers how travel, electricity, and heating demand are structured, as well as the make-up of the energy supply that feeds this demand. This "bottom-up" approach calculates emissions based on individual activities occurring within the city. For example, Siemens would estimate the emissions generated by a woman's daily commute by car by multiplying her miles traveled to work by the emissions factor for her car. Then, the CyPT model would aggregate emissions from individual activities to generate an overall estimate that could be broken down into its component parts. The CyPT model utilizes this approach in order to understand the behaviors and infrastructure causing city emissions, because each of the 73 technologies in the CyPT model will affect either behavior or infrastructure. By contrast, Mexico City, like many other cities across the world, follows a "top-down" approach for calculating emissions. This top-down approach looks at the amount of fuel consumed in each sector (e.g., the electricity consumed by buildings, the gas and diesel consumed in transport), assigns an emissions factor to each of those fuels, then multiplies fuel consumption by those factors. Both of these approaches can lead to accurate estimates, but they rely on different types of data.

In the case of Mexico City, Siemens worked closely with the Secretaries for Economic Development and for the Environment, conferred internally, and performed external research to source city-specific data.

To complete all the required data for the CyPT, Siemens also compared Mexico City's urban fabric to other CyPT cities. In particular, the most challenging tasks were to investigate energy consumption by buildings, including breakdowns between electricity, heating, and cooling, and source estimates for passenger miles traveled or freight-ton miles traveled to customize the CyPT transport model.

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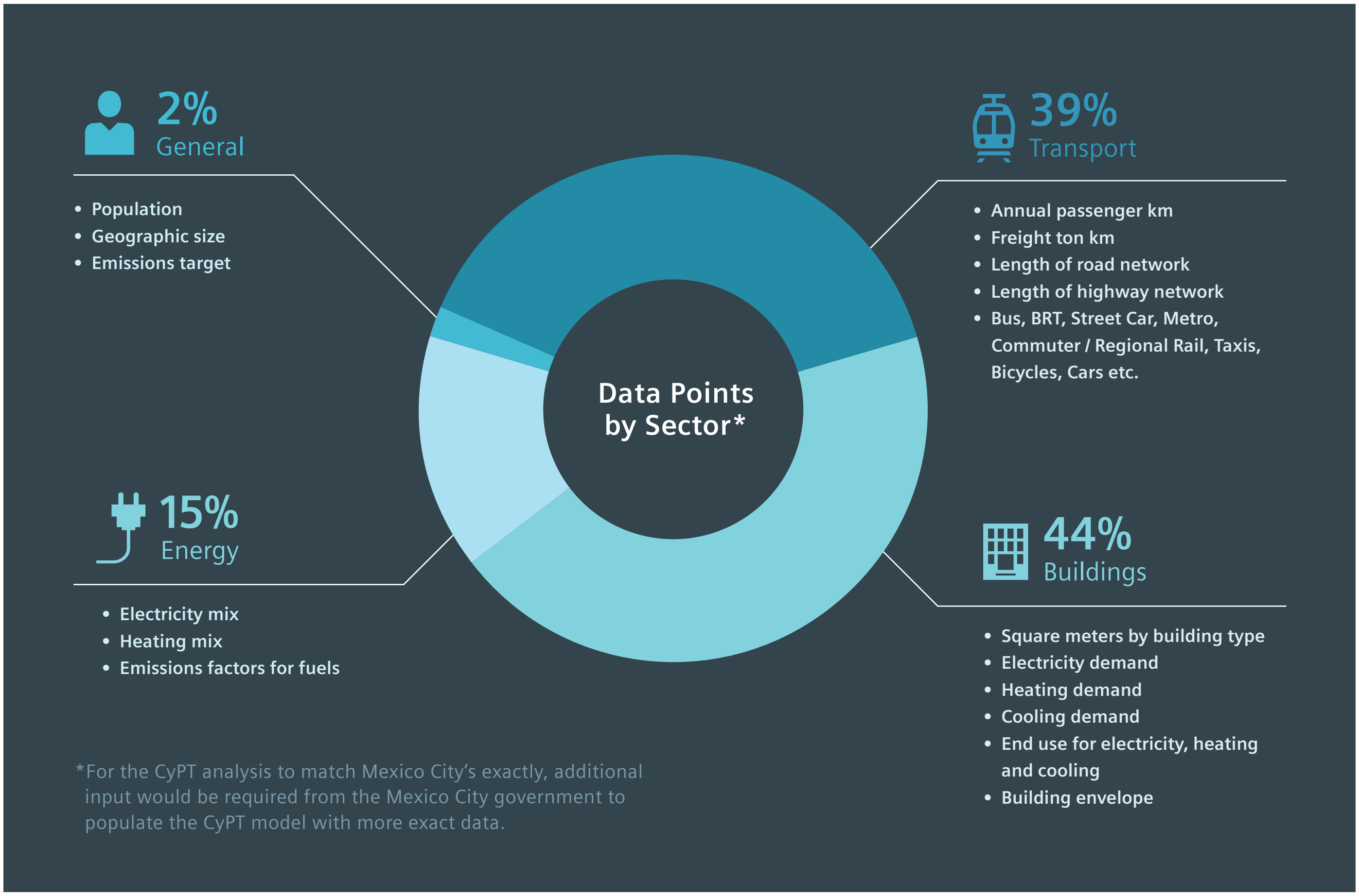
In these cases, Siemens compared data from other CyPT city sources to verify its estimations and finalize the Mexico City data template. Due to Mexico City and San Francisco's similar climates, Siemens referenced building energy consumption

[1] http://www.c40.org/cities/mexico-city



Percent of data points by sector used in the CyPT model. The model has so far been used in cities such as Munich, Vienna, London and Nanjing with each city identifying solutions that best fit the city's energy demand and production characteristics.

data from this city. Due to Mexico City, Seoul, and Nanjing's similar transport networks, Siemens compared passenger and freight transport data from these two Asian cities to Mexico City.

Going forward in this report, Siemens grounds its analysis in the CyPT model estimates for Mexico City's GHG emissions. Any estimates Siemens makes may not be 100 percent correct in absolute terms, but the analysis certainly provides insight on the technologies' relative values. For the CyPT analysis to match Mexico City's exactly, additional input would be required from the Mexico City government to populate the CyPT model with more exact data.

Results

For the CyPT analysis of Mexico City, Siemens modeled 40 of the 73 available levers in the Tool – 12 building technologies, 22 transport levers, and six energy levers.

Siemens chose levers and implementation rates in consultation with the Secretaries for the Environment and Economic Development and based on its own investigation and experience in Mexico City and expertise in energy, buildings, and transport infrastructure. The implementation rates are intentionally aggressive, based on the expectation that Mexico City has invested, and will continue to invest, in cleaner energy and a more robust multi-modal transport network.

The results of the analysis are astounding. If Mexico City implemented all 40 technologies recommended by the CyPT, it could reduce annual CO2(e) emissions by nearly 70 percent from today, from 51 million metric tons in 2015 to 15 million in 2050. Installing and operating these 40 technologies between today and 2050 would cost roughly 300,000 Mexican pesos (USD$17,000) per city inhabitant. The 12 building technologies would total approximately 630 pesos per square meter of residential and non-residential building stock, and the 22 transport technologies would total about 15 pesos per passenger kilometer. With this investment, Mexico City could generate more than 1.3 million jobs (measured in full-time equivalents) between today and 2050.

Technology and Implementation Rates

	Buildings	Technology	Implementation Rate by 2050	Unit
Buildings	Residential	Efficient lighting technology	0.3%	stock/year
	Non-Residential	Wall insulation	0.6%	stock/year
	Non-Residential	Glazing	0.4%	stock/year
	Non-Residential	Efficient lighting technology	0.6%	stock/year
	Non-Residential	Demand oriented lighting	0.4%	stock/year
	Non-Residential	Building Efficiency Monitoring (BEM)	0.6%	stock/year
	Non-Residential	Building Performance Optimization (BPO)	0.4%	stock/year
	Non-Residential	Demand controlled ventilation	0.4%	stock/year
	Non-Residential	Building Automation, BACS B	0.1%	stock/year
	Non-Residential	Efficient Motors	0.2%	stock/year
	Non-Residential	Room Automation, HVAC+lighting	0.4%	stock/year
	Non-Residential	Building Remote Monitoring (BRM)	0.6%	stock/year
Transport		Automated train operation (ATO) Metro	100%	lines
		Hybrid electric buses	40%	fleet
		Electric buses	25%	fleet
		Metro - new line	6	lines
		E-Highways	50%	highways
		LED Street lighting	100%	street lights
		Intelligent traffic light management	70%	traffic lights
		Electric cars	42%	car fleet
		Hybrid electric cars	8%	car fleet
		Plug-in hybrid electric cars	5%	car fleet
		Electric taxis	30%	car fleet
		Electric car sharing	5	cars/1000 inhabitants
		Intermodal traffic management	100%	users
		Bikeshare	20	bikes/1000 inhabitants
		e-BRT (Bus Rapid Transit) - New line	8	lines
		Car - Eco-Driver Training and consumption awareness	8%	drivers trained
		Metro - Reduced headway	120	seconds
		BRT (Bus Rapid Transit) - Electrification	100%	lines
		Cycle highway	2.71	km/100.000 inhabitants
		Lorries/Trucks - Low emission zone	6	EURO class
		Car & Motorcycle - City tolling	20%	road traffic reduction
		Public Transport - E-ticketing	100%	users
Energy		Wind	50%	energy generation
		PV	20%	energy generation
		Network Optimization	70%	grid
		Smart Grid for Monitoring and Control	100%	grid
		Power System Automation	100%	grid
		Smart Metering	75%	housing connections

Buildings:
- Residential
- Non-Residential

Levers with the Highest Impacts

By far, the levers with the highest individual impacts on CO2(e) emissions are the energy levers: onshore wind power, rooftop photovoltaic (PV) panels, power system automation, smart grid for monitoring and control, and network optimization. Increasing wind energy from 2 percent of the grid mix today to 50 percent of the grid mix in 2050 alone accounts for 19.5 million metric tons (or 47.1 percent) of annual CO2(e) reductions from business-as-usual conditions. The next highest lever in terms of emissions impact is rooftop PV panels: shifting the grid mix from almost no solar energy today to 20 percent in 2050 would decrease emissions by 7.8 million metric tons (or 18.9 percent) of annual CO2(e) reductions

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from business-as-usual conditions. Implementing automation, control, and monitoring services for the grid, which would lower technical and non-technical transmission and distribution losses for low and medium-voltage, also show promise in terms of reducing emissions. In addition, they would have the corollary benefit of ameliorating electricity reliability for consumers.

Next in order of impact are the transport levers. Improving service on existing transit lines and expanding the public transport network, limiting the number of cars on the road, and making freight transport more efficient are key themes in reducing emissions.

- **By improving service on Metro,** building new Metro and BRT lines (Metrobus), and continuing to incentivize the use of EcoBici, Mexico City could reduce annual emissions by 2 million metric tons. Improving service could mean decreasing peak-time headway between Metro trains from 160 seconds today to 120 seconds in 2050. According to CyPT estimates, this would reduce overall emissions by 2 percent or 880 kilotons CO2(e) – savings equivalent to removing 185,000 cars from the road. Increasing the number of Metro lines from 12 lines today to 18 in 2050 could reduce emissions by another 2 percent – savings equivalent to planting 22 million trees.[1]
- **With regards to car transport,** measures to reduce the number of cars on the road and to ease the flow of traffic could reduce emissions by almost 3 percent. A city tolling or congestion charging system, aimed at reducing the number of cars on the road by 10 percent, and an intelligent traffic light system, which would increase the number of model-based adaptive control lights to 70 percent of the total, account for 1.5 percent and 1.6 percent of the reductions, respectively.
- **Equipping 50 percent of the highways in Mexico City with eHighway** could reduce GHG emissions by another

[1] U.S. Environmental Protection Agency, Greenhouse Gas Equivalencies Calculator, https://www.epa.gov/energy/greenhouse-gas-equivalencies-calculator

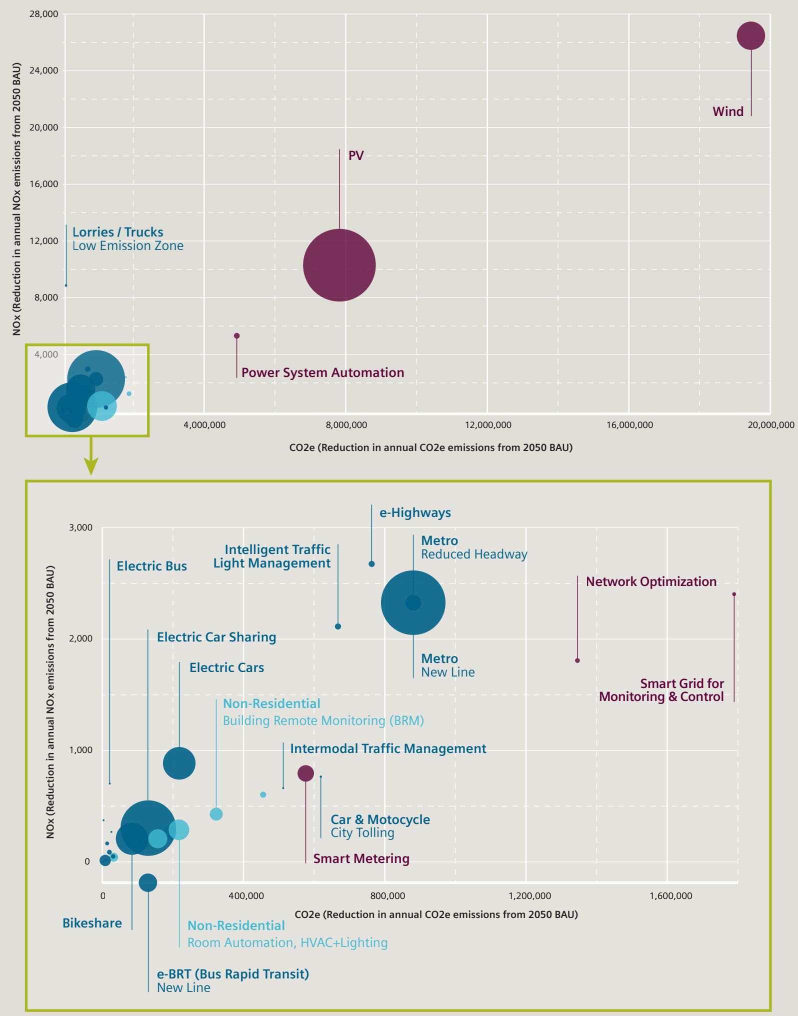
- 1.6 percent. eHighways consist of an electric catenary system running along a highway to which hybrid or fully electric trucks can connect or disconnect as they drive. If the grid mix has a lower emissions factor than diesel or gas does, eHighways can greatly improve the efficiency of short- or long-haul freight transport. They can also greatly improve local air quality. NOx and PM levels surrounding logistics areas are often the highest within city boundaries, and are generally located near the lowest-income neighborhoods. Technologies like eHighway therefore not only reduce emissions, but also serve environmental justice purposes, ensuring that air quality throughout the city is clean. The CyPT estimates that eHighway would reduce PM10 and NOx levels in Mexico City by 5.3 percent and 5.8 percent, respectively.

Less impactful but also very significant levers are in the buildings sector, with the highest impacts coming from efficient lighting technology in the residential sector (0.9 percent) and building performance optimization (1.39 percent) and building remote monitoring (1 percent) in the non-residential sector. Siemens took Mayoral powers into consideration as we were setting implementation rates, so implementation rates for buildings vary between 0.3 percent and 0.6 percent of the existing building stock being retrofitted every year between today and 2050.

» In the buildings sector, with the highest impacts coming from efficient lighting technology in the residential sector (0.9 percent) and building performance optimization (1.39 percent) and building remote monitoring (1 percent) in the non-residential sector. «

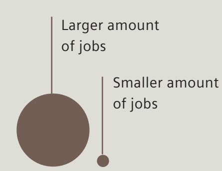
A few technologies emerge as having the highest impacts in terms of reducing emissions, improving air quality, and creating jobs. Adopting onshore wind power and solar PV panels, automating the power system and optimizing the electricity network, adding new Metro lines and reducing headway, and building eHighways are some of the highest performing technologies in all categories. When looking across indicators, though, low emissions zones for trucks, electric carsharing, and bikeshare also stand

Technology Results: CO2e, NOx, and Jobs



Levers	100's of Jobs*
Non-Residential - Wall insulation	67
Non-Residential - Glazing	155
Non-Residential - Efficient lighting technology	115
Non-Residential - Demand oriented lighting	46
Non-Residential - Building Efficiency Monitoring (BEM)	86
Non-Residential - Building Performance Optimization (BPO)	27
Non-Residential - Demand controlled ventilation	3
Non-Residential - Building Automation, BACS B	24
Non-Residential - Efficient Motors	1
Non-Residential - Room Automation, HVAC+lighting	297
Non-Residential - Building Remote Monitoring (BRM)	138
Automated train operation (ATO) Metro	1
Electric buses	0
Metro - new line	3,488
E-Highways	27
LED Street lighting	3
Intelligent traffic light management	28
Electric cars	894
Plug-in hybrid electric cars	18
Electric taxis	9
Electric car sharing	2,591
Intermodal traffic management	1
Bikeshare	869
e-BRT (Bus Rapid Transit) - New line	284
Car - Eco-Driver Training and consumption awareness	15
Metro - Reduced headway	204
Cycle highway	4
Lorries/Trucks - Low emission zone	2
Car & Motorcycle - City tolling	1
Public Transport - E-ticketing	104
Wind	830
PV	5,512
Network Optimization	18
Smart Grid for Monitoring and Control	9
Power System Automation	32
Smart Metering	228

Dot Size = Jobs Generated



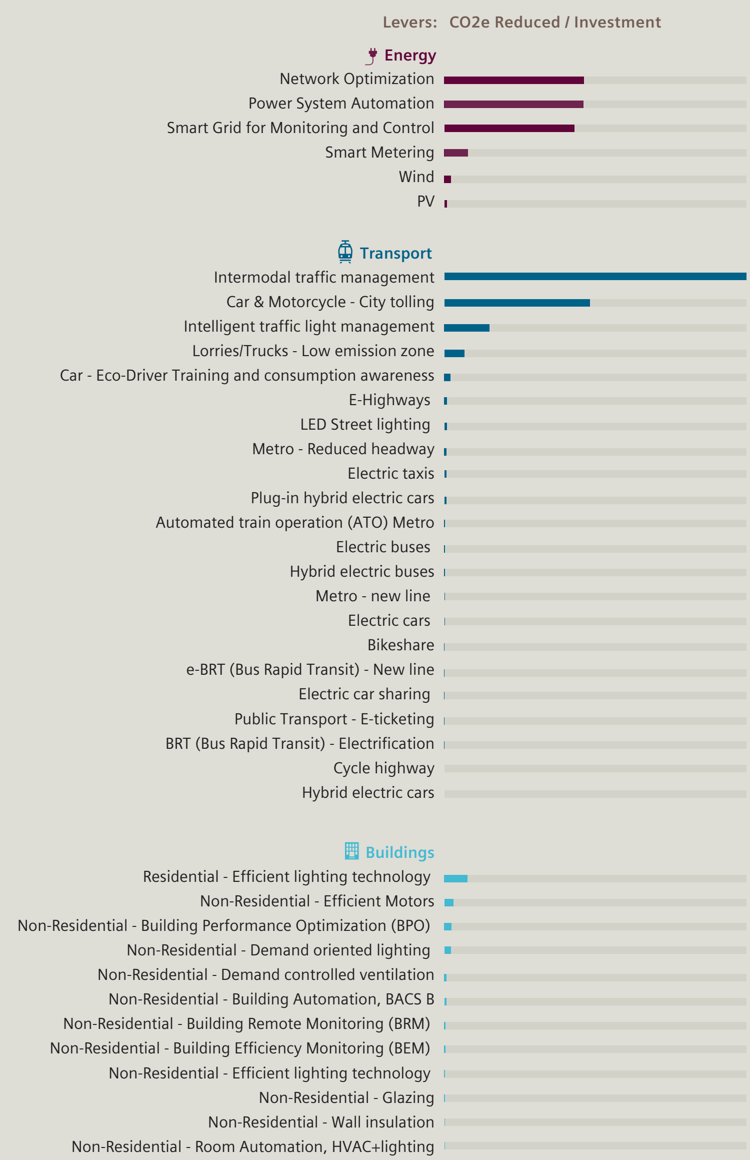
*** Siemens calculations:** Amount of direct, indirect, and induced Full-Time Equivalents generated between today and 2050.

out. These three levers have the additional benefit of reducing the number of cars and trucks on the road and shifting people towards no-emissions forms of transport. With regards to electric carsharing and bikeshare especially, there are also urban design implications: both rely on and encourage density, which has been shown to inherently reduce people's carbon footprints.

» Intermodal traffic management and city tolling (or congestion charging) are the two most cost efficient levers.«

Other technologies win out in terms of cost efficiency. Intermodal traffic management and city tolling (or congestion charging) are the two most cost efficient levers, as measured by the reduction in annual CO2(e) emissions over capital and operating expenses. Intermodal traffic management refers to an app, which provides real-time information to travelers to help them decide on the most efficient mode of transportation. Costs to develop and maintain apps are low, while the potential benefits of people switching modes based on efficiency and carbon footprint are relatively high. City tolling systems are also relatively inexpensive to install and have low operating expenses, especially considering their generation of revenue on an almost daily basis.

Technology Results: CO2e, NOx, and Jobs



The table above ranks the CyPT technologies by cost efficiency, measured as reductions in annual CO2e emissions over the value of investment.

Impactful Technology Synergies

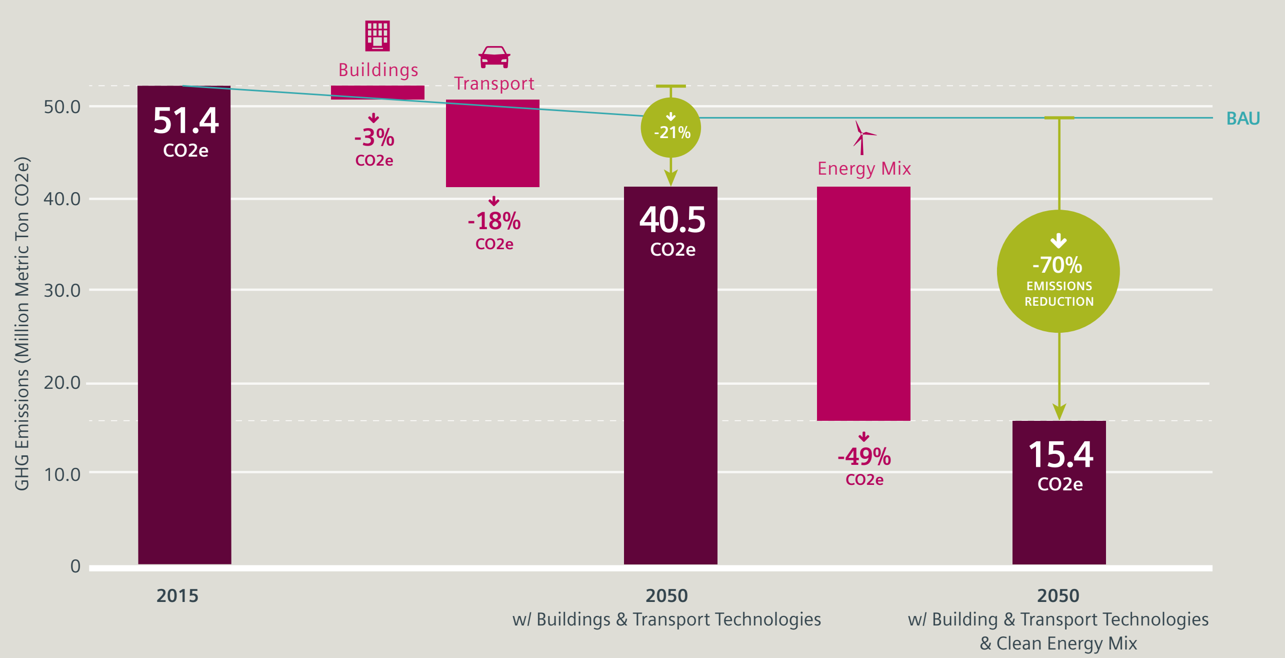
Moving beyond individual lever impacts, modeling the combined effects of all 40 energy, buildings, and transport levers on Mexico City's emissions baseline reveals considerable synergies among technologies.

Increasing the share of wind power to 50 percent and of solar power to 20 percent of the grid mix would bring the total clean energy percentage of Mexico's national grid mix to 95 percent (including hydropower and nuclear), almost completely removing coal, natural gas, and heavy fuel oil from the mix. This would reduce the emissions factor from today to 2050 by 90 percent, producing ripple effects felt throughout the buildings and transport networks. Because most buildings in Mexico City are powered by electricity, this decreased emissions factor compounds the effects of implementing energy efficiency technologies. For example, the impact of shifting 100 percent of residential lighting to efficient light technology increases by 80 times as the electricity mix moves from 29 percent clean energy to 95 percent. Implementing all 12 building technologies recommended by Siemens would reduce annual CO2(e) emissions from 32 million metric tons under business-as-usual conditions to just 5 million metric tons. Results from the transport sector are almost as impressive. Implementing all 22 transport technologies recommended by Siemens would reduce annual CO2(e) emissions from 15 million metric tons under BAU to 9.9 million. This includes adopting hybrid and fully electric buses (65 percent of the fleet), moving to hybrid and fully electric cars (50 percent of the fleet), installing 44,000 eCars in an eCarsharing program, and electrifying BRT routes.

» Modeling the combined effects of all 40 energy, buildings, and transport levers on Mexico City's emissions baseline reveals considerable synergies among technologies. «

Increasing the share of wind power to 50 percent and of solar power to 20 percent of the grid mix would bring the total clean energy percentage of Mexico's national grid mix to 95 percent (including hydropower and nuclear), almost completely removing coal, natural gas, and heavy fuel oil from the mix.

Deep Carbon Reduction



Conclusions

If Mexico City implemented all 40 technologies recommended by this CyPT analysis, it could reduce annual CO2(e) emissions by nearly 70 percent from today, from 51 million metric tons in 2015 to 15 million in 2050.

Carbon emission reduction of this magnitude would put Mexico City on par with leading cities in sustainability around the world, such as Copenhagen, San Francisco, London, Singapore, and Sydney. Although ambitious, implementation would cost roughly 300,000 Mexican pesos (~USD$17,000) per city inhabitant between today and 2050, while generating 1.3 million jobs (measured in full-time equivalents).

Cities that have successfully implemented cross-sector, large-scale infrastructure programs, such as the one recommended by this report, have divided implementation into short-, medium-, and long-term actions. They begin by investing in smaller projects, which not only save costs and generate revenue, but also build momentum for longer-term, bigger ticket items. Medium-term projects then focus on cementing systems that utilize cleaner sources of energy and more efficient forms of transport. These make way for ambitious long-term projects, which may cost more to implement or require significant behavioral change from consumers.

The table below sets out a possible technology pathway for Mexico City to pursue, in which 14 of the 40 key CyPT technologies are divided into short-, medium-, and long-term buckets, with each technology building on the effects of the last.

Technology Pathway for Mexico City

Term	Strategy	CyPT Levers	Potential CO2e Reduction (in metric tons)
Short-Term: 1,595,595 Potential CO2e Reduction (in metric tons)	**Short-Term Strategy** — Focus on improving the quality of existing public transit infrastructure.	Metro - Reduced Headway	880,602
	Use "early wins," which improve local air quality, generate revenue, or create green space, to support these improvements.	Cars & Motorcycle - City tolling	619,053
		Lorries / Trucks - Low Emission zone	85,595
		LED Street Lighting	10,345
		Substation Undergrounding*	
Medium-Term: 28,375,664 Potential CO2e Reduction (in metric tons)	**Medium-Term Strategy** — Green the electricity supply.	Wind	19,459,130
		PV	7,822,452
	Expand the reach of public transit.	Metro - new lines	880,602
		e-BRT (Bus Rapid Transit) - new line	129,293
	Continue the shift to non-emitting transport modes.	Bikeshare	84,187
Long-Term: 1,036,222 Potential CO2e Reduction (in metric tons)	**Long-Term Strategy** — Electrify transport modes.	Electric buses	21,133
		Electric cars	218,015
		Electric car sharing	116,391
		Electric taxis	13,259
	Install a multi-modal, intelligent traffic system center.	Intelligent traffic light management	667,424

By 2050
31,007,482
Total Potential CO2e Reduction (in metric tons)

* See breakout box on page 20 for more information on substation undergrounding.

Most of the technologies listed in the table above stem from energy and transport sectors, because, based on Siemens analysis, they yield the largest results in terms of CO2(e) reduction. But that does not mean that the Government of Mexico City should ignore altogether the buildings sector or building technologies. As evidenced by combining the impacts of all 40 technologies, cleaning the electricity mix has huge effects on reducing emissions from buildings. However, in the interim period before cleaner energy sources come online, the public sector could take a leading role in demonstrating how energy efficiency technologies—from lower-hanging fruit technologies, such as wall insulation and window glazing, to smart city technologies, such as building automation—diminish electricity consumption in buildings.

Adopting smart technologies in public buildings could also be an opportunity for the public sector to kick-start projects in local energy generation and distribution in Mexico City. For example, this CyPT analysis demonstrates the high emissions impact of adopting rooftop solar panels; public sector policies could support PV adoption for both residential and non-residential buildings. The local government could also work to link these panels to microgrids in downtown business districts or other dense areas. District cooling systems could provide cooling to nearby buildings. If Mexico City's climate changes, and if Mexico City moves towards electrified transport, district heating systems could be implemented alongside district cooling systems, and microgrids could be adapted to included electric car chargers - all powered by renewable energy.

Adopting smart technologies in public building and linking them to smart, local energy systems would also enable the public sector to collect data on how and when energy is being consumed. Building and grid automation technologies rely on understanding these patterns of usage, as well as identifying possible gaps in electricity provision or points where electricity consumption could be optimized, would allow for building and grid automation, and once implemented, can greatly reduce emissions from energy consumption.

Just as the public sector uses data to understand energy consumption in buildings, it can also draw data from the transport sector to comprehend, and even shape, travel patterns. Mexico City has already shown significant progress in this area. A partnership between the World Bank's Latin America and Caribbean Transport Unit and Mexico City's public transit authority, SETRAVI, served to collect and disseminate data that will help the government consolidate transit

London's Example

London has set the example in tackling challenges posed by congestion through an integrated approach towards transportation.

In 2000, the Mayor of London created an aggressive transit strategy that addressed decades-long under-investment in existing or new infrastructure, congestion and air pollution mitigation. A series of short-term actions built momentum for larger transit investments.

Beginning in 2003, the Congestion Charge (CCZ) charged passenger cars for entering Central London. Since 2008, the Low Emissions Zone (LEZ) also deterred polluting vehicles from driving in Greater London. Both the CCZ's and the LEZ's camera systems check registered vehicles and their respective payment and exemption statuses against a database via a central IT enforcement system. Since the inception of London's CCZ, traffic entering the original charging zone has remained at 27 percent below pre-charging levels in 2002. To date, 99 percent of larger vans and 96 percent of heavy goods vehicles (HGVs) and coach buses are meeting their respective emissions standards thanks to the LEZ. [1]

While the CCZ and LEZ were implemented, the City also created the London Cycle Hire Scheme, which now has 10,000 bicycles, and rolled out separated Cycling Superhighways to help protect cyclists. Since 2003, cycling levels have risen 66 percent.[2] The City also used revenue streams from the CCZ and LES to gradually replace its outdated bus fleet with hybrid buses. TfL also designed Crossrail, an ambitious rail project that would set up London for a bigger and brighter future, increasing capacity on existing Underground lines and connecting outer boroughs of the city. In short, London bet big that building a transport network that connected the city both internally and to the rest of the world would pay off.

[1] https://www.london.gov.uk/sites/default/files/gla_migrate_files_destination/MAQS%202015%20Progress%20Report%20FINAL%20FOR%20PUBLICATION_0.pdf

[2] http://content.tfl.gov.uk/congestion-charge-factsheet.pdf

Type of Data to Collect by Implementing Smart CyPT Technologies

This table goes into more detail about the types of data Mexico City could collect by implementing smart CyPT technologies.

Data Point	CyPT Levers or Other Data Collection Method
• Energy consumption for lighting, cooling, and appliances by building category • Characteristics of the building envelope	Energy Audit, Building Performance Services, Building Optimization, Building Efficiency Monitoring, Building Remote Monitoring
• Energy losses through the building envelope • Market penetration of wall insulation, high-efficient lighting, window glazing	Building Performance Services, Building Optimization, Building Efficiency Monitoring, Building Remote Monitoring Commissioned Research, Energy Audit
• Passenger miles traveled by mode • Freight ton miles traveled by mode	Intelligent traffic light system, Intermodal traffic management, Electric carsharing, New Metro Vehicles, City Tolling, e-Ticketing Low Emissions Zone, eHighway

routes and better serve supply and demand, while riders plan more easily thanks to real-time transit updates.[1] Drawing data from proposed CyPT technologies (e-ticketing, a congestion charge, intelligent traffic light management, a low emissions zone) would add to this transport data store, bolstering the development of an intermodal traffic management app.

Overall, Siemens applauds the government and the residents of Mexico City for crafting and executing policies and programs that are steering the city well towards sustainability. There is still a long way to go – the air can become cleaner, the roads less congested, and the city greener – but the foundation is laid and the steps taken so far have been successful. Together, the 40 technologies Siemens has analyzed through this CyPT report will help improve air quality, decrease congestion, and revitalize green spaces throughout the city. They will increase accessibility, connecting more people to jobs and services – and eventually, helping to bridge the economic divide. Because the objective of investing in infrastructure technologies is not only to help Mexico City make smarter decisions, but also to support its goal of becoming the best, most liveable city for all of its inhabitants.

Beyond CyPT Technologies

The CyPT contains 73 of the leading infrastructure technologies for city sustainability, but there are still others on the market that can assist cities with becoming greener, reducing carbon emissions, and increasing the amount of green space available to citizens.

One such technology is gas-insulated switchgear (GIS). Because GIS is one-third the size of traditional switchgear systems, it allows for above-ground and industrial-looking high-voltage substations to be replaced with substations located fully or partially underground. This is especially helpful in urban settings, where GIS enables substations to become virtually invisible and noise-free, while still transmitting reliable, high-voltage energy to densely populated, growing areas.

In a suburb of Los Angeles, California, for example, a GIS substation lies below a neighborhood park. Increasing load demand, both current and future, and the requirement that it be both reliable and economical, meant that the local utility needed to put a substation in the area. However, there was also a strong desire to create additional green spaces in the neighborhood, so the utility mandated the substation be situated below ground. Given Anaheim's location in earthquake-prone Southern California, it also was critical that the equipment be able to withstand seismic events. As the turnkey provider, Siemens not only constructed the substation but also laid soil and landscaped it with terracing, grass and foliage to create a new park for the community. The compact and reliable switchgear was a key component of this space-constrained solution that included a Siemens 69-kV GIS with eight bays, two 56-MVA transformers and a 12-kV medium voltage system with 20 panels. Only a single, partially exposed section of wall at one side of the park terracing provides access to the substation.

[1] http://www.worldbank.org/en/news/feature/2013/11/05/mexico-city-open-database-improves-transit-efficiency-helps-commuters

Appendix I: List of Data Sources

Mexico City, Secretaría de Desarrollo Economico

Mexico City, Secretaría de Medioambiente

Brookings Institution

BRTData

C40 Cities

Center for Energy and the Environment

City of Ningbo, China

City of San Francisco, CA, USA

Comisión Federal de Electricidad

National Resources Defense Council

Seoul Metropolitan Government

Siemens AG

The New York Times

The Washington Post

Tom-Tom Traffic Index

Transport for London

UNHABITAT

U.S. Department of Energy

U.S. Environmental Protection Agency

World Bank

Appendix II: CyPT Indicators

The CyPT tracks technologies' impact of four indicators

1. CO_2(e) Emissions

CO_2(e) stands for a carbon dioxide equivalency measure that allows for various greenhouse gasses (GHGs) to be expressed in terms of CO_2 as a common unit. Equivalency is determined by multiplying the amount of the GHG by its global warming potential (GWP), where GWP indicates how much warming a given GHG would cause in the atmosphere over a certain period of time (usually 100 years). For example, CO_2 has a GWP of 1, whereas methane (CH_4) has a GWP of 25. Therefore, 1kg CH_4 * 25 = 25kg CO_2e.

2. NO_x

Nitrogen Oxides (NO_x) most commonly refer to nitric oxide (NO) and nitrogen dioxide (NO_2). Some level of NO_x occurs naturally in the air, but NO_x is predominantly caused by human activity that is harmful to the atmosphere, particularly the burning of fossil fuels. In urban settings especially, NO_x emitted from vehicle emissions can cause significant air pollution.

3. PM_{10}

Particulate matter 10 (PM_{10}) describes very small liquid and solid particles floating in the air that measure only 10 microns in diameter (about 1/7th the thickness of human hair). These particles are small enough to breathe into human lungs and among the most harmful of air pollutants. PM_{10} has many negative health impacts once lodged in the lungs, and can increase the severity of asthma attacks, cause or worsen bronchitis, and weaken the body's immune system. The most common sources of PM_{10} include vehicle emissions, wood burning stoves and fireplaces, and dust from construction, landfills and agriculture.

4. Jobs (Full-time equivalents)

The CyPT measures the gross number of direct, indirect, and induced jobs created in the local economy by investing in CyPT technologies. These include installation, operation and maintenance jobs, which are calculated as full time equivalent jobs of 2,080 hours per year. Manufacturing jobs are not accounted for, because some of these technologies may be produced outside the city's functional area, with no local benefits to the economy.

Appendix III: CyPT Technologies

Building Levers

Selected shortlisted technologies that can be added up into a comprehensive technology strategy for Mexico City.

Residential	Efficient lighting technology	Significant electrical energy can be saved by replacing conventional luminaires with more efficient lighting fixtures and/or changing magnetic ballasts to electronic ballasts. Further reductions in power consumption can be achieved with the use of light-emitting diodes (LEDs), which also have a far higher lifespan than conventional lighting. LED solutions combined with intelligent light management systems can lower lighting costs in a building by as much as 80%. Reduction of CO2e, PM10, NOx related due to electricity savings.
Non-Residential	Wall insulation	Solid wall insulation e.g. made of expanded polystyrene (EPS) can be applied to already existing buildings. Applying the rigid foams to exterior side of walls raises thermal resistance. The insulation reduces the heat gain/loss through the walls and thus minimizes the heating/cooling energy needed. Reduction of CO2e, PM10, NOx related due to energy savings.
Non-Residential	Glazing	Applying double/triple glazed window made of two or three panes of glass and a space between them filled with air or insulating gases reduces heat and noise transmission as well as solar gain from solar radiation through the window. Due to better window insulation less heating and cooling energy is needed inside the building. Reduction of CO2e, PM10, NOx related due to energy savings.
Non-Residential	Efficient lighting technology	Electricity can be saved by replacing conventional light bulbs for room lighting with more efficient light-emitting diodes (LEDs). LEDs consume up to 90% less energy and have a longer lasting in operation hours and turn off/on cycles. LED lamps are compatible with conventional lamps and can be substituted for them easily. LED provide an equal luminosity at lower specified power. Reduction of CO2e, PM10, NOx related due to electricity savings.
Non-Residential	Demand oriented lighting	Demand-oriented lighting is based upon presence (or motion) detection: Lighting is switched 'on' when someone enters a given area and deactivates after a pre-defined period of time without movement. It is usually combined with daylight measurement. The largest energy savings can be achieved in buildings with fluctuating occupancy, and when combined with other lighting technologies, it can reduce the lighting energy use within a building by 20 to 50%. Reduction of CO2e, PM10, NOx related due to electrical energy savings.
Non-Residential	Building Efficiency Monitoring (BEM)	Building Efficiency Monitoring provides real-time measurement of energy consumption and environmental conditions within an EXISTING building, via a centralized monitoring system connected to a network of field devices (such as meters, switches and sensing devices). Standard energy reports are created to allow benchmark comparison with similar buildings to assess performance and highlight problems (e.g. kWh, CO2, temperature). Offering monitoring services and performance reports creating awareness and transparency and enable continuous improvement and reduction of overall energy consumption. Reduction of CO2e, PM10, NOx related due to thermal and electrical energy savings.
Non-Residential	Building Performance Optimization (BPO)	Building Performance Optimization (BPO) is a range of services designed to increase the energy efficiency of an EXISTING building by implementing proven building control strategies otherwise known as Facility Improvement Measures (or FIMs). BPO can improve THERMAL and ELECTRICAL energy efficiency in a building in many ways; typically via improved HVAC technology, by adapting the building to suit usage profiles or providing information and analytics for operational personnel. Reduction of CO2e, PM10, NOx related due to energy savings.
Non-Residential	Demand controlled ventilation	With demand-controlled ventilation (DCV), the amount of air introduced into a space is matched to the actual demand and is ideal for areas with fluctuating occupancy such as open-offices, conference rooms and restaurants. CO2 levels measured by air quality detectors identify periods of low occupancy and cause the fans to stop or reduce speed (at 50% air volume, the fan power is reduced by a factor of 8!). DCV also provides savings in heating and cooling, by adjusting setpoint temperatures (economy mode). Reduction of CO2e, PM10, NOx related due to electrical electricity savings.

Selected shortlisted technologies that can be added up into a comprehensive technology strategy for Mexico City.

Building Levers (continued)

Non-Residential	BACS Class B	Energy-efficient building automation and control functions save building operating costs. The thermal and electrical energy usage is kept to a minimum. It is possible to estimate the efficiency of a building based on the type of operation and the efficiency class of the building automation and control systems (BACS) installed. Energy Class B includes advanced building automation and controls strategies, such as demand-based operation of HVAC plant, optimized control of motors and dedicated energy management reporting. Reduction of CO2e, PM10, NOx are related to thermal and electrical energy savings.
Non-Residential	Energy Efficient Motors and Drives	Analyzing the drive technology in your building (fans, pumps, compressors or process plant) can lead to significant cost- and energy-savings and help reduce emissions. As an example: changing a standard 30kW motor (IE1) to an equivalent energy efficient motor (IE3) can save 3,500 kWh per year, and 2,000kg of CO2 emissions. Adding variable speed drive technology will ensure motors only draw as much energy as is actually required. Reduction of CO2e, PM10, NOx are related to electrical energy savings.
Non-Residential	Room Automation HVAC+lighting	Room Automation provides control and monitoring of heating, ventilation, and air conditioning within individual zones based upon demand, with options for automatic lighting. A built-in energy efficiency function identifies unnecessary energy usage at the room operating units, encouraging room users to become involved in energy saving, and different lighting scenarios can be programmed. Reduction of CO2e, PM10, NOx are related to thermal and electrical energy savings.
Non-Residential	Remote Monitoring	Remote Monitoring allows individual building performance to be measured and compared against benchmark values for similar building types or sizes. Energy experts are able to remotely analyze building energy usage, to detect problems and make proposals for improvements. Reduction of CO2e, PM10, NOx related due to energy savings.

Transport Levers

Passenger	Automated train operation (ATO)	Share of lines operated with ATO at target year: ATO controls or guides optimal throttle of engines, moving at optimal speed while remaining on schedule. Reduced electricity demand per person km due to coasting. The saving potential correlates with the number of and distance between the stations. Reduction of CO2e, PM10, NOx related to lower electricity demand.
Passenger	Hybrid electric buses	Share of vehicle fleet operated by hybrid electric vehicles at target year. Small combustion engine for base energy demand combined with an electric drive for acceleration and for brake energy recuperation. Energy demand is reduced due to a higher efficiency of the combustion engine, operating at optimum and brake energy recuperation together with related emissions.
Passenger	Electric buses	Share of the vehicle fleet operated by battery electric vehicles. Battery electric vehicles are "zero" exhaust gas emission vehicles. Significant reduction of local emissions PM10, NOx. The electricity used for charging is generated according to the general local electricity mix.
Passenger	Metro - new line	Number of new metro lines of average metro length at target year, shifting passengers from all other mode according to the transportation performance of existing lines in the city. Public transport attractiveness is increased and energy demand per person kilometer is reduced together with related emissions.
Freight	E-Highways	Share of hybrid diesel-electric trucks and highways with overhead power lines at target year. As soon as trucks join the eHighway, they connect to the overhead power lines and switch into pure-electric mode. Leaving the eHighway, the trucks switch back to using hybrid mode. Energy demand is reduced due to shift of transport to hybrid electric truck and electric transport together with related emissions.
Infrastructure	LED Street lighting	Share of low efficient street light replaced by more efficient light-emitting diodes (LEDs). Saving electricity together with related emissions. Additionally high reduction in maintenance due to longer lifetime (10 years versus 6-12 month) and possibility to dim the light depending on the environmental conditions.

Transport Levers (continued)

Infrastructure	Low emission zone for vehicles	Share of the city's area, defined as a geographical area with restrictions for vehicles of certain off-gas emission standards .

Energy Levers

Generation	Windpower	Share of electricity provided by windpower at target year changing the energy mix and ist realted emissions provides cleaner electricity for buildings and electric powered transport modes.
Generation	Photovoltaic	Share of electricity provided by Photovoltaic at target year changing the energy mix and its related emissions provides cleaner electricity for buildings and electric powered transport modes
Transmission	Network Optimization	A well-structured, secure and highly available electricity supply infrastructure. Reduces grid losses; Resulting in less energy generation and related emissions to provide the demanded energy at customer side.
Distribution	Smart Grid for Monitoring and Automation	Increased network performance with intelligent control - Optimization of decentralized energy resources –economically and ecologically possibility for bidirectional energy flow, Reduces technical and non-technical grid losses in distribution and corresponding reduced energy generation and related emissions.
Transmission	Power System Automation and optimized network design	Optimal combination of substation automation and change of voltage levels, power system structures, equipment (lines, transformers), change of disconnecting points, etc. in order to reduce (non-) technical losses, guarantee fast power system restoration after a fault in the network and simplified network operations.
Distribution	Smart Metering and demand response	Implementing smart meter devices and a meter data management system providing detailed information about how much energy is consumed at which place , which allows demand response and reduction of non-technical losses.

Selected shortlisted technologies that can be added up into a comprehensive technology strategy for Mexico City.