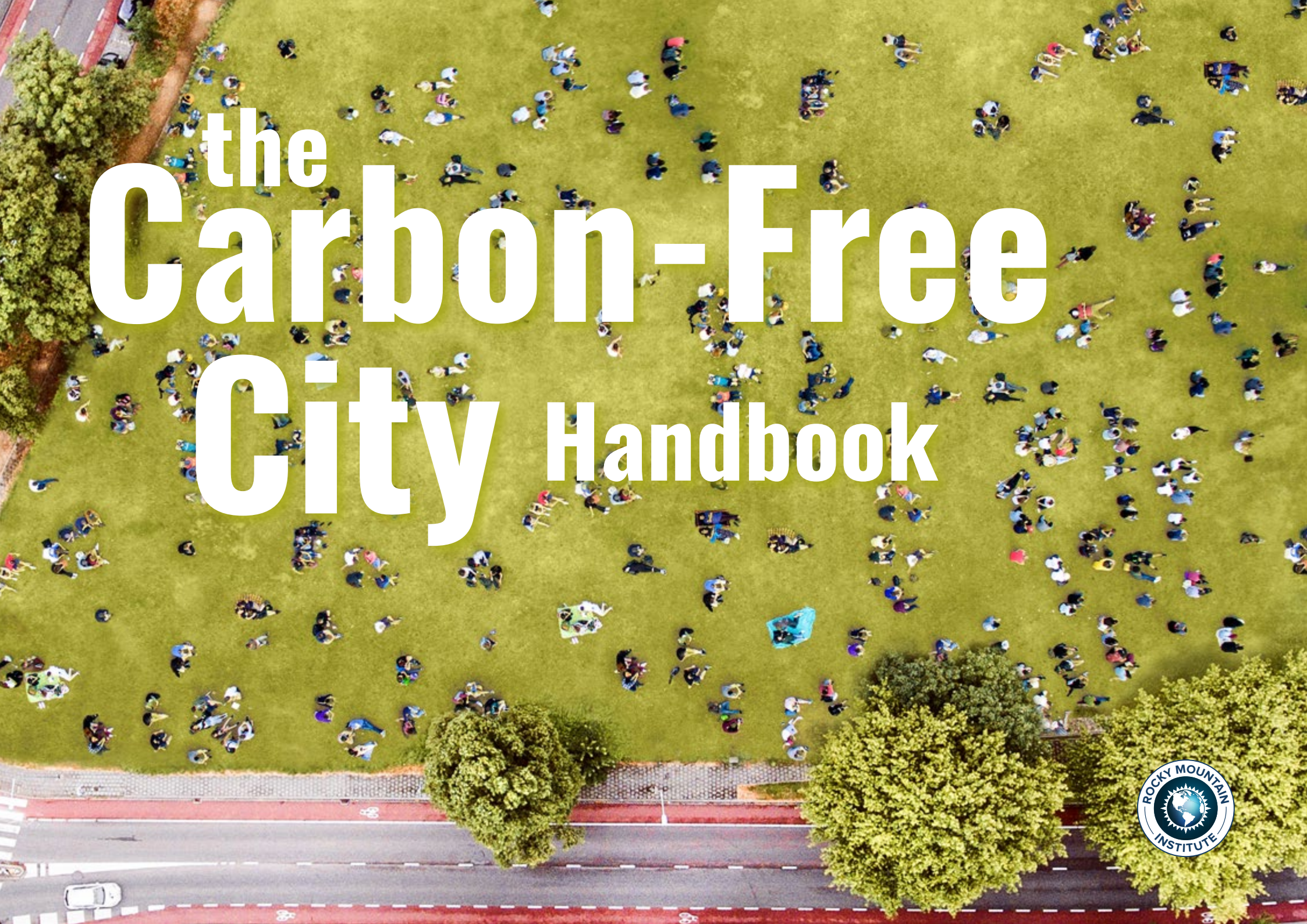

the Carbon-Free City Handbook

ROCKY MOUNTAIN INSTITUTE

about

Welcome to *The Carbon-Free City Handbook*

This handbook is organized around 22 recommendations for no-regrets actions that will help cities become carbon free. The recommendations are numbered continuously and are divided among five sections.

About Rocky Mountain Institute

Rocky Mountain Institute (RMI)—an independent nonprofit founded in 1982—transforms global energy use to create a clean, prosperous, and secure low-carbon future. It engages businesses, communities, institutions, and entrepreneurs to accelerate the adoption of market-based solutions that cost-effectively shift from fossil fuels to efficiency and renewables. RMI has offices in Basalt and Boulder, Colorado; New York City; Washington, D.C.; and Beijing.

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Letters from Leaders

Welcome to *The Carbon-Free City Handbook*. The next few years are the critical window for communities around the globe to take action and lead the world on a path that holds global warming below 2 degrees. It is our individual and collective responsibility—and opportunity—to be bold, to be ambitious, and to act faster. Cities are uniquely positioned to lead this transformation.

For cities, climate change brings economic, health, and stability threats to their communities. But immediate action tackling climate change also brings economic, health, and stability *opportunities* as well. City leaders can drive practical and transformative change that will improve their homes, businesses, neighborhoods, and local environment... and that will improve quality of life for their residents.

Rocky Mountain Institute (RMI) is proud to present this handbook to make it easier for cities around the world to take action. Almost any city can pursue these recommended actions and apply them locally, seeing results within a year. We've selected ideas that are, for the most part, universally applicable with compelling economics. In our experience, climate change solutions "done right" can stimulate growth, rather than be at odds with it. For more than 35 years, RMI has focused on practical solutions that justify optimism, rather than rely on it. We call this perspective "applied hope."

We do not have all of the answers yet. The recommendations here will not get you all the way to the carbon-free goal, but they will set you on a powerful economic pathway of transition. These are the first important steps. We will learn more as we continue the journey forward together.



Thank you for using this handbook. Thank you for taking action now. Thank you for embracing applied hope. And thank you for joining us in creating carbon-free cities and a low-carbon world, thriving, verdant, and secure, for all, for ever.

—Jules Kortenhorst, Chief Executive Officer and Trustee, Rocky Mountain Institute

In June 2017, a remarkable thing happened. Mayors from more than 7,400 cities around the world stepped up to lead local efforts to combat climate change as part of the Paris Climate Accord. I am incredibly proud that the City of Vancouver is among the nearly 6,400 cities that have joined the Global Covenant of Mayors for Climate & Energy.

Our city has already taken significant steps to encourage urban sustainability and help fight climate change. As part of our Greenest City Action Plan, we have committed to becoming the greenest city in the world by 2020. What does this mean for Vancouver? It means eliminating our city's reliance on fossil fuels and reaching our goal of 100% renewable energy by 2050, establishing Vancouver as a world leader in green building design and construction, reaching our goal of zero waste, and much more.

Transitioning towards a green future is also good for the local economy. We are on track not only to double the number of green jobs over 2010 levels by 2020, but to also double the number of companies that are actively engaged in greening their operations.

We are excited about the progress we've made, but this is just the start. We need to take bold action to tackle climate change.

This November, leaders from around the world will gather in Bonn, Germany, for the UN Climate Change Conference. This is an important opportunity for cities to have their voices heard and to take their seat at the international table.



In Vancouver, we are working harder than ever to take real action on climate change and I encourage other cities to join us in our ambitious path forward. Together, cities around the world can have a meaningful and substantial impact on one of the most pressing challenges—and opportunities—that we will face in our lifetime and for generations to come.

—Gregor Robertson, Mayor, City of Vancouver

Images courtesy left to right, RMI; Ariane Colenbrander; Jess Miller

We go by many job titles: chief sustainability officer, environment director, resilience officer, head of climate programs, energy efficiency manager, director of traffic management and operations, and so on. Yet while our titles vary, we share a common mission: to improve the quality of life for our city's citizens and the efficiency with which we run city government.

We are all people. We all live 'here.' And we are all deeply connected.

Now, more than ever, our quality of life depends on the well-being of our neighborhoods and parks, how much we sit in traffic, the food we eat, the quality of our air, and the energy we generate and consume. And these issues are inextricably tied to climate change.

It's impossible from 'un-know' or 'un-see' the floods, droughts, fires, blizzards, and suffering that result from a changing and increasingly volatile climate. While it may be a comfort to ignore this suffering (and many still do) it is our responsibility and moral obligation as leaders, parents, and decent human beings to do whatever we can to understand and deal with these impacts. Cities are responsible for up to 75% of all greenhouse gas emissions, which means they must play a critical and significant role in cutting emissions.

In 2004, the City of Sydney, under the leadership and foresight of our Lord Mayor Clover Moore, did exactly this. Sydney was the first Australian local government to become carbon neutral starting in 2007 by buying green power and carbon offsets, and to set a target of 70% renewables by 2030 based on 2006 levels. Since then, the City has completed 18 solar projects, reduced emissions by 180 tons, and established a $2 million-per-year renewable energy fund. Building retrofits have helped reduce emissions 17% across City-owned properties since 2006.

Sydney has achieved such progress despite relative inaction at other levels of Australian government. This underscores the importance of local government empowering everyday people at the local level. The evolving climate system will undoubtedly pose many challenges. The street trees that we plant now for our grandchildren, under current Mediterranean conditions, might not cope with a future of sub-tropical weather. Already, what we knew as urban heat 'islands' have turned into urban heat 'continents'—the homes built 50 years ago cannot cope with these conditions, but the ones we build now must.

The opportunity that we have now requires courage—to face the facts, to get on with the understanding and empathy to curb the suffering of others, and most importantly, to embrace the creativity necessary to reimagine alternatives, possibilities, and solutions that will protect ourselves and our ecosystem.

These efforts have become cornerstones for Sydney, both as one of Australia's largest cities and on the global stage. But they are cornerstones elsewhere, too. Climate and sustainability are now mainstream issues that permeate every corner of our cities, from municipal operations to businesses and the economy to everyday life.

Indeed, many cities around the world today have their first chief sustainability officer. Some progressive cities now have that person's successor. Some cities will someday soon establish such a role or such an office. Many cities share such responsibility across individuals, teams, and departments too numerous to list.

Regardless, we are a shared community of peers, separated by the geographic distance between our cities, yet tied together by shared vision and experience. Some of our cities are further along the journey than others. Yet we are all learning from each other and taking motivation from each other. And each in our own way, we are taking large steps toward becoming carbon-free cities. In many ways, achieving that goal is the highest aspiration of our office. We can do it. These recommendations help show where to start and how to proceed.



—Councillor Jess Miller, Deputy Lord Mayor, City of Sydney; *Deputy Chair of Sydney's Environment Committee; Member, Environment Panel for the Greater Sydney Commission*

About This Handbook

The Carbon-Free City Handbook helps city staff implement climate policies and actions that resolutely place their communities on an aggressive path toward sustainable, low-carbon economies. Although the focus is on immediate, no-regrets first steps, this handbook is not about slow, incremental change. It is about implementing policies and taking actions that yield bold, transformational outcomes.

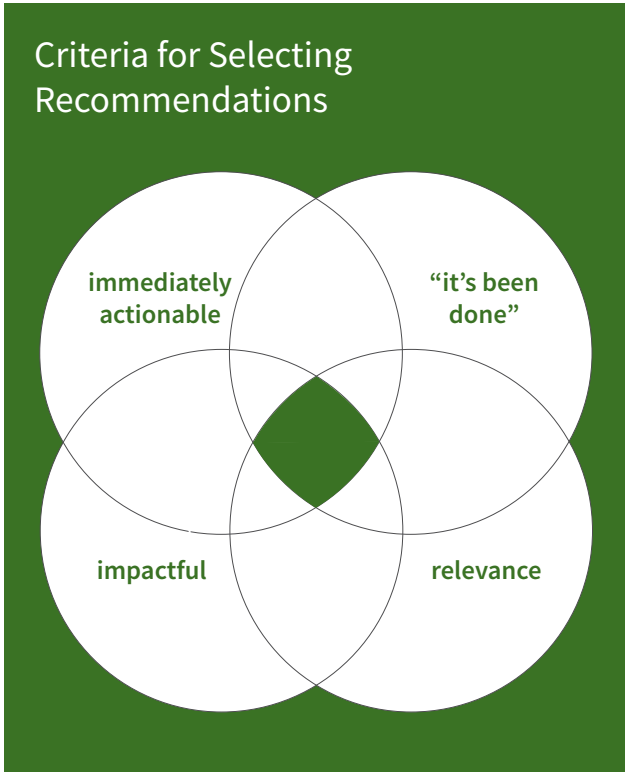
Yet while this handbook is a compass, pointing a direction for cities to move swiftly, this handbook is not a detailed map that enables full navigation. These resources do of course exist, and throughout the handbook we point to many of them. This handbook is a place to start.

Selection Criteria

At this book's core are 22 no-regrets actions that nearly every city should take to start the journey to becoming carbon-free. Disciplined application of four primary selection criteria helped cut through hundreds of possibilities to define a focused list for cities.

The selected recommendations are:

- **Immediately Actionable:** could be launched by city staff within one year
- **Achievable:** recently proven and economically viable, with compelling examples of successful city implementation
- **Impactful:** leading-edge solutions that either make immediate, significant impact or enable large, long-term carbon reductions
- **Broad Relevance:** applicable for most cities globally (population: 100,000+)



Many chapters begin with actions cities can take for their own assets and operations. These recommendations may not always have a dramatic direct impact on citywide carbon emissions (even if significant for the city government's footprint). However, they are often an important catalyst for others in the city and demonstrate municipal leadership. Several recommendations are based on examples that have been enacted at the state or provincial level. Such examples are included only where the powers exercised would typically be available for cities, too.



Format

The handbook's recommendations are categorized into five core chapters. For each recommendation you'll find:

Overview

Brief description of the recommendation

Action Documents

Specific policies, requests for proposals (RFPs), guides, ordinances, action plans, toolkits, and other examples from other cities ripe for inspiration and emulation

For more information on all action documents, recommended resources, and additional citations please visit rmi.org/carbonfreecities

Key Considerations

Must-know perspectives on a given recommendation, including:

- **Pitfalls:** potential challenges, caution flags, common mistakes
- **Best Practices:** how to do it well
- **Next Wave:** "extra credit" for cities contemplating progressive implementations of a given recommendation

Narrative City Vignette

A case study lite that spotlights a particularly noteworthy example of a city's successful implementation

Global City Spotlights

Other cities and governments around the world that are also leading by example for a given recommendation

Each chapter concludes with additional recommended resources relating to the chapter's recommendations

Benefits

Icons that indicate the recommendation's main benefits, including:



Carbon Emissions: all recommendations are included for their large potential positive climate impact, whether direct, indirect, ancillary, scope I-II-III, etc.



Economy: could include energy cost savings, avoided operations and maintenance costs, increased revenues through taxes or fees, job creation, real estate property value increases, business attraction, employee productivity gains, and other economic benefits



Health and Environment: could include improved air quality, better nutrition, greater opportunities for physical activity, and other health and environmental benefits



Safety and Resilience: could include improved street lighting, fewer pedestrian and traffic accidents, removal of combustion hazards, emergency backup power sources, and other public safety and community resilience benefits



Aesthetics: could include city beautification and greenscapes, cleaner streetscapes, architecturally refreshed building stock, and other aesthetic benefits that strengthen city pride and bolster resident happiness



Community Service and Equity: could include broader access to city services (especially for low-income residents), expanded options that empower residents with choices, and other benefits that serve the general public en masse

Toward Carbon-Free Cities

The Importance of 100% Goal Setting

Though the recommendations throughout this handbook are frequently specific, the diverse cities from around the world highlighted in these pages often share a common theme. They have each set a bold, aspirational 100% target, whether in the realm of renewable energy supply, net-zero energy buildings, electric vehicles on their roads and highways, or waste streams free of all organics.

Such aggressive goal setting—typically attached to a target date—is crucial. It offers visionary leadership, serves as a momentum-generating driving force for city efforts, and in the case of this handbook's recommendations, provides overarching context for particular, near-term actions. In other words, 100% goals bridge between immediate, discrete first actions (i.e., this handbook) and a city's ultimate carbon-free climate vision.

How cities choose to frame 100% goals varies, influenced largely by local context. To have a 100% goal related to one thing requires a 0% goal related to something else. Carbon-free cities are against one thing and for another thing; they are moving away from one reality and moving toward another reality.

This duality is evidenced in how cities communicate a ban vs. a target:

- Banning incandescent light bulbs vs. requiring 100% LEDs
- Banning internal combustion engine autos vs. targeting 100% electric vehicles
- Banning natural gas zones and designating cities free of fossil fuels vs. 100% renewable energy goals

Specific strategies for achieving these outcomes of course vary, but they largely fall into three interrelated categories:

- **Reduce:** decrease energy consumption (whether kilowatt-hours of electricity, vehicle miles traveled, building heating/cooling requirements, or other)
- **Electrify:** transition from primary burning of fossil fuels (e.g., natural gas for space heating, hot water, cooking; internal combustion engines for mobility) to electrified alternatives (e.g., heat pumps, electric stoves, electric vehicles)
- **Replace:** once electrified, replace fossil-fueled generation sources with carbon-free renewable energy sources (e.g., wind, solar, hydro, geothermal)

The end result of ambitious 100% goals paired with aggressive action is the same: transformational change mitigating climate impacts. It is about significant, rapid change on a short time frame, rather than slow, incremental change.





Global City Spotlights - 100% Renewable Energy/Electricity

Hundreds of cities across the world have made commitments to 100% renewable energy or electricity. Below is a sample of some cities with those commitments.





What makes a good 100% goal?

This handbook highlights high-impact, no-regrets actions every city should take today, regardless of longer-term, robust planning efforts. But when a city is ready to set ambitious climate targets and develop plans to reach them, there are a few critical elements of success:

- **Definition:** clearly define what is in and what is out of scope for the 100% goal
- **Deadline:** pair a 100% goal with a target date that is appropriately ambitious
- **Milestones:** set intermediate milestones that secure wins along the way and provide checkpoints to ensure progress is on track
- **Assessment:** back 100% goals with a robust techno-economic assessment that supports science-based targets and policies and provides a real, detailed understanding of what it will take to achieve those goals
- **Action Plan:** develop a supporting action plan with specific implementation strategies
- **Socialization:** cultivate broad support from throughout the city (e.g., general public, businesses, impacted stakeholder groups) to ensure that an effort isn't undermined by lack of political or community will

Financing Mechanisms

Access to capital and innovative financing mechanisms is often a critical enabler for initiatives. Cities have an important role to play creating or expanding financing options and improving access to such financing, both for city-led projects (i.e., public sector) and for those projects that initiate on the private sector side.

Financing Mechanisms for Public- and Private-Sector Projects:

- **Traditional Financing:** For cities, includes capital raised by issuing municipal bonds (including municipal green bonds) often underwritten by investment banks. For the private sector, includes access to capital via commercial bank loans.
- **Energy Performance Contracts (EPCs)**: Often utilized by energy service companies (ESCOs), which leverage third-party capital to finance turnkey energy improvements while the project's guaranteed energy savings cover the cost of financing.
- **Third-Party Ownership:** A third party invests in and owns the product or service and receives payments from the primary entity (i.e., city or constituent) to cover the full cost of the investment (capital, interest, operations and maintenance , etc.). Includes leases and service agreements.
- **Green Banks/Energy Efficiency Investment Corporations:** Quasi-public institutions dedicated to financing renewable energy, energy efficiency, and other clean energy and green infrastructure projects, often in partnership with private lenders.
- **On-Bill:** A utility or third-party lender extends financing to a utility customer (e.g., building owner-occupant) to undertake energy-efficiency upgrades. The utility collects regular monthly loan repayments through its normal billing platform.
- **City-Funded:** Cities use revenues from targeted programs in a given year to fund new investments (e.g., leveraging congestion pricing revenues for other transportation and mobility projects). Could include carbon taxes.

City-Initiated Financing Mechanisms for Private-Sector Projects:

- **Energy Loan:** Creation of a loan program targeting renewable energy and energy efficiency projects, such as a revolving loan structure in which proceeds from loan repayments are deployed for new loans.
- **Subsidized or Blended Loans:** A city provides low- or zero-interest loans that are blended with market rate loans from commercial banks that originate the loans.
- **Public-Private Partnership (PPP):** A city grants a designated private entity responsibility for combinations of infrastructure assets, project implementation, and ongoing services.
- **Credit Enhancement:** A city provides funds or assurance (e.g., loan loss reserve, loan guarantee) to a private lender to cover specified losses in the event a borrower defaults. As a result, lenders extend credit at lower rates than they would otherwise.
- **Property Assessed Clean Energy (PACE):** Financing tied to a property (vs. the owner) that can be transferred if a building is sold and that is repaid via an assessment on the property tax bill. Only available in the USA and through a similar program in Australia; PACE-like programs are being explored in Canada, China, Europe, and South Africa.



Important Considerations

- **Map Barriers and Align Financing Mechanism:** When evaluating potential financing mechanisms, consider current barriers to accessing capital, which are often specific to the sector and customer type. Consider directly engaging targeted stakeholders to fully understand the challenges they face and to identify an appropriate financing mechanism.
- **Evaluate Roles:** Prior to choosing a preferred financing approach, evaluate the roles and responsibilities for each stakeholder involved, including ownership, installation, risk mitigation, and operations and maintenance. A common evaluation approach is to map all relevant stakeholder roles, along with flows of capital, information, and services.
- **Assess Key Enablers:** Successful deployment of an innovative financing mechanism often requires attention to key enablers. For example, implementing a community-wide financing mechanism often requires a complementary initiative to educate the public about the opportunity and associated benefits.

Resources

- Institute for Market Transformation primer on local government role in energy project financing
- Summary of public-private financing solutions in the EU
- Energy Sector Management Assistance Program (World Bank)
- Green bond best practices
- Green bank resources
- Carbon Tax Center

For resources on these mechanisms go to **rmi.org/carbonfreecities**

Sustainable Melbourne Fund

Established in 2002 by the Melbourne City Council (AUS), the Sustainable Melbourne Fund (SMF) operates as a trust to support building owners, businesses, investors, and local councils to reduce their environmental footprint. SMF offers Environmental Upgrade Finance, which is a loan provided to support building improvements; repayments are administered through the local council.



Belo Horizonte Public-Private Partnership (PPP) for LED Lighting

In 2016, Belo Horizonte, the sixth-largest city in Brazil, put in place a public-private partnership to upgrade over 175,000 streetlights with efficient LEDs. The contract was executed for US$300 million over a 20-year time frame, and was the largest public street-lighting contract in Latin America.

Emissions and Recommendations

This chart shows two things: what percent of GHG emissions come from what sectors for a large, average, global city; and how those different sectors are addressed by the recommendations in this handbook.
(Data sources: C40 and Kennedy)



Note that a wide variety is possible, such as this chart of Lima's emissions, with a much larger proportion in Waste and Transport



Buildings
Buildings/Stationary, 48%

1 City Building Retrofits
2 Net-Zero Codes
3 Progressive Codes
4 Smart LED Lighting
5 Benchmarking and Transparency

Biological Resources
(Not included in standard emissions tracking)

22 Plant-Based Diets

Transportation and Mobility
Transport, 36%

6 Fleet Electrification
7 Combustion Vehicle Reduction
8 Freight Reduction
9 EV Charging
10 Car-Free Downtown
11 Mobility Alternatives
12 Public Transit

Electricity
Of emissions by energy source from all sectors, the average contribution from electricity is 25%

13 LED Smart Streetlights
14 Electric Districts
15 Municipal Solar Installations
16 Municipal Renewable Supply

Biological Resources
Waste, 7%

20 Organic Waste Diversion

Industry
Industry 7%

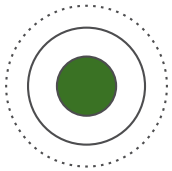
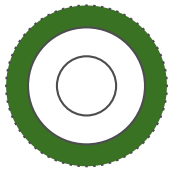
17 Clean Industrial Heat
18 Efficient Motors
19 Operator Training

Biological Resources
Agriculture, Forestry, and Other Land Use (AFOLU), 3%

21 Urban Forestry

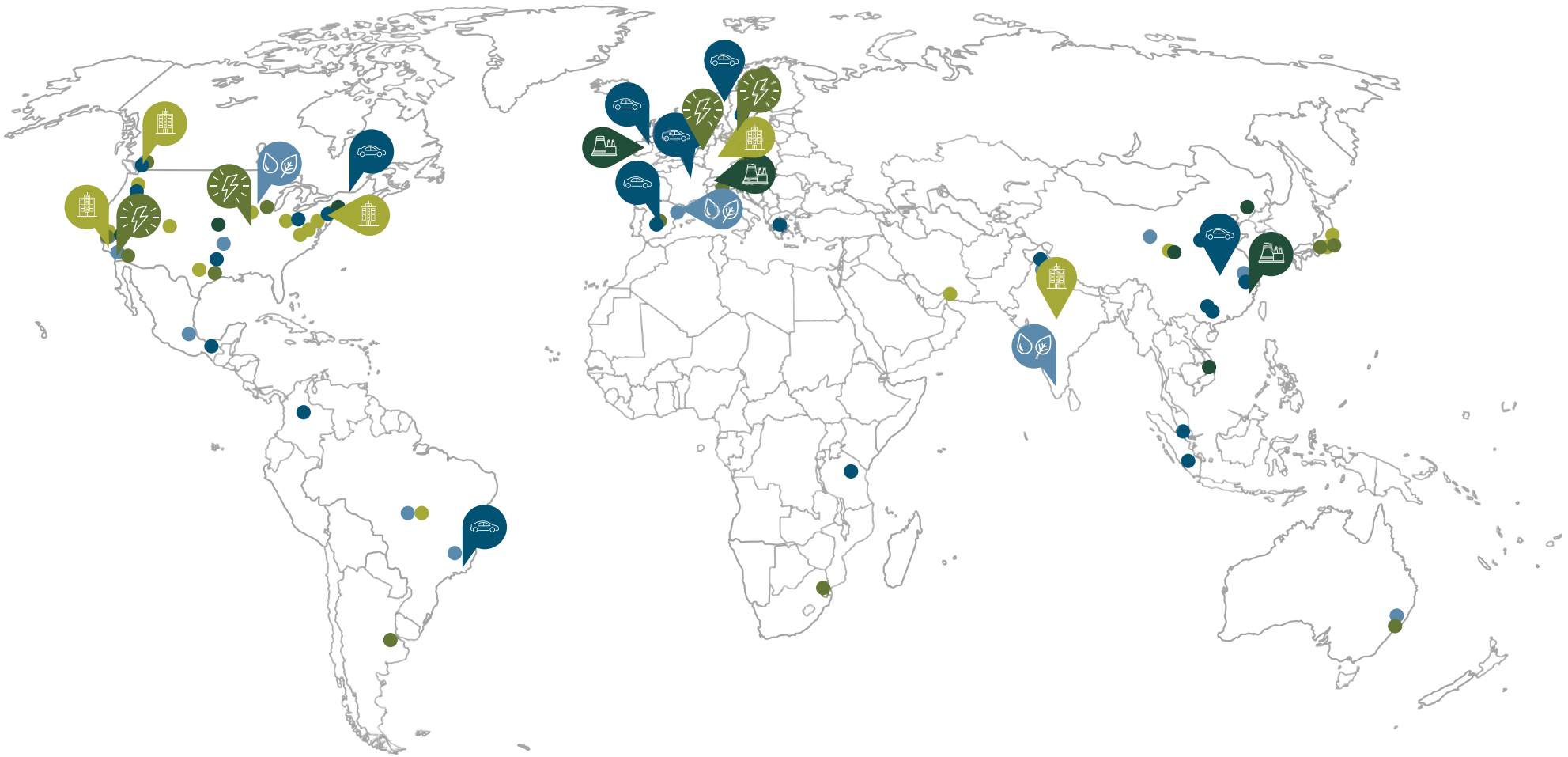
Types of Recommendations

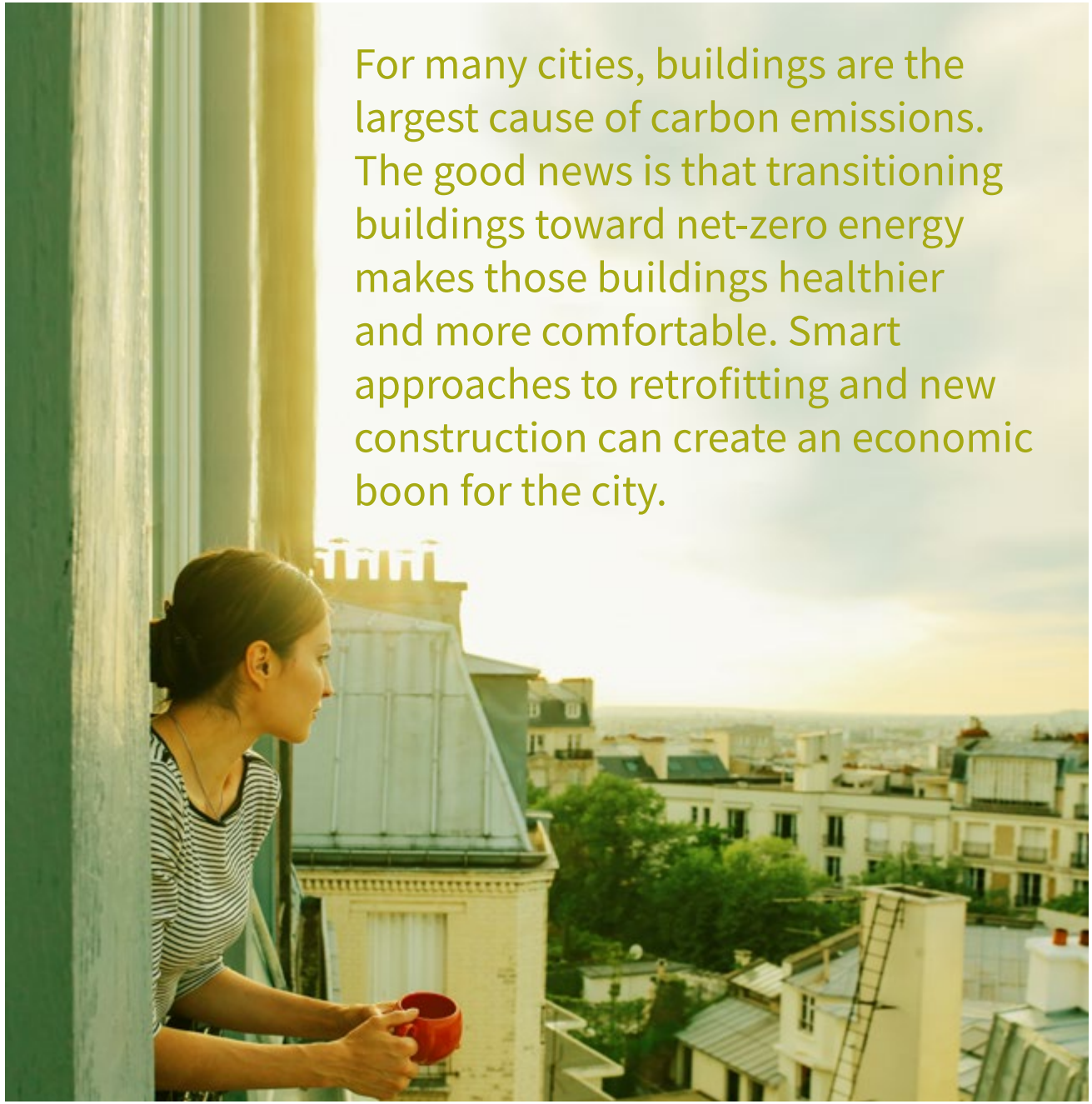
Handbook Recommendations

	City Area of Control	Size of Immediate Climate Impact	Buildings	Transportation and Mobility	Electricity	Industry	Biological Resources
Lead by Example Direct political control, important to kick-start local markets			1. City Building Retrofits	6. Fleet Electrification	13. LED Smart Streetlights 15. Municipal Solar Installations 16. Municipal Renewable Supply		21. Urban Forestry
Structural Citywide Change Within most cities' powers, and has citywide impact			2. Net-Zero Codes 3. Progressive Codes	7. Combustion Vehicle Reduction 8. Freight Reduction 10. Car-Free Downtown 11. Mobility Alternatives 12. Public Transit	14. Electric Districts	17. Clean Industrial Heat 18. Efficient Motors	20. Organic Waste Diversion
Enabling Mechanisms Create opportunities to make climate actions easier for others			4. Smart LED Lighting 5. Benchmarking and Transparency	9. EV Charging		19. Operator Training	22. Plant-Based Diets

Map of Recommendation Examples

This map shows the locations of the examples referenced throughout this handbook. The icons point to places with a narrative case vignette, while the dots refer to global city spotlights.





For many cities, buildings are the largest cause of carbon emissions. The good news is that transitioning buildings toward net-zero energy makes those buildings healthier and more comfortable. Smart approaches to retrofitting and new construction can create an economic boon for the city.

section

1

Buildings

Eliminate carbon emissions associated with buildings

1 City Building Retrofits 14
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City Building Retrofits

Moving to net-zero energy-ready buildings

Perform deep energy retrofits on all existing city-owned buildings, including affordable housing, to make municipal facilities ultraefficient and net-zero energy ready. Such buildings would achieve net-zero or nearly net-zero energy if equipped with on-site renewable energy generation.

Action Documents

Find documents at **rmi.org/carbonfreecities**

- European Union website highlighting nearly zero-energy buildings goals, including public buildings goals, links to the original policy directive (Energy Performance of Buildings Directive), national plans, and progress reports by country **source**

Key Considerations

- ! Performance contracting and other mechanisms can mitigate lack of capital available for building improvements
- ! Invasive energy upgrades (e.g., building envelope upgrades) may displace occupants or disrupt operations; phasing can help mitigate impacts
- ☆ Set a clear time horizon (e.g., deadline, target date) for retrofitting existing buildings and communicate it broadly
- ☆ When possible, time deep energy retrofits to coincide with planned building upgrades
- ☆ Include on-site renewable energy in long-term planning to achieve net-zero energy over time





← Frankfurt, Germany

In 2010, the City of Frankfurt (DEU), required that all city-owned buildings—including municipal facilities and affordable housing—would meet the Passive House standard, a rigorous metric of building energy efficiency. The commitment built upon Frankfurt's earlier 2007 requirement that all new buildings meet Passive House standards, earning it the title of "Passive House Capital" at the 13th annual Passive House conference in 2009. In addition to its municipal leadership, Frankfurt developed a Passive House incentive program for property developers. Today Frankfurt boasts more than 300,000 m^2 of Passive House floor area, as well as more than 50 planned Passive House development projects, including the world's first Passive House hospital.

Global City Spotlights

California (USA) | All new state buildings and major renovations shall be net-zero energy (NZE) by 2025; 50% of existing state-owned building area shall be NZE by 2025

European Union (EU) | All new public buildings to achieve nearly net-zero energy by 2018

Japan (JPN) | All new public buildings will be zero emissions by 2030

United States Federal Government (USA) | All new federal buildings greater than 5,000 ft^2 gross will achieve NZE by 2030



Net-Zero Codes

Phase in net-zero energy requirements for new construction citywide

Phase in requirements for all new buildings to achieve net-zero energy or net-zero energy ready (deep efficiency without renewable energy on site) status using building code requirements. Establish target years after which all new buildings that enter the planning and permitting process will be designed to achieve net-zero energy. Making a building net-zero energy ready at the point of construction is very cost-effective. All new municipal buildings should be required to achieve net-zero energy.

Action Documents

Find documents at **rmi.org/carbonfreecities**

- City of Santa Monica (USA) Green Building Energy Reach Code, including code overview, language, and requirements **source**
- New Buildings Institute *Residential Zero Net Energy Guide for New Construction*, developed to assist builders/developers with code compliance **source**

Residential and commercial code cycle updates have resulted in greater than 40% efficiency gains since international model codes became widely adopted in 1980.



Santa Monica, California, USA

The City Council of Santa Monica, California (USA), approved the world's first ordinance requiring all new single-family homes be built to achieve net-zero energy, beginning in the year 2017. The city's ordinance localizes and accelerates California's Energy Efficiency Strategic Plan. The plan requires all new residential and commercial construction to achieve net-zero energy by 2020 and 2030, respectively. Santa Monica staff developed the city's ordinance in collaboration with Southern California Edison, a major investor-owned utility, with a focus on combining cost-effective, energy-efficient design with affordable renewable energy. The ordinance calls for single-family residences, duplexes, and low-rise multifamily residences to use 15% less energy than that allowed in the 2016 California Energy Code and to achieve net-zero energy.





Key Considerations

- Many builders/developers believe new net-zero energy buildings have a substantial up-front cost premium, which can be mitigated through training and education
- Establish financing mechanisms that unlock low-cost capital and reduce the up-front costs of efficient buildings (e.g., property assessed clean energy [PACE])
- Build political support among city legislators and key players in the real estate and construction industries
- Create local job market training for advanced construction practices
- Establish priority permitting (e.g., accelerated approval, fee reduction) and/or other incentives for net-zero energy projects to encourage early adoption ahead of mandates

Global City Spotlights

California (USA) | All new homes to be net-zero energy by 2020; all new commercial buildings to be net-zero energy by 2030

European Union (EU) | All new construction to be nearly net-zero energy by 2021; individual countries such as Germany have developed policies to carry out these goals

Japan (JPN) | Various net-zero energy building and net-zero energy home policies come into effect in 2020 and 2030

Progressive Codes

Adopt progressive codes for existing buildings

Require existing buildings to meet a specified energy-efficiency metric based on whole-building energy consumption per unit area after a "trigger" event, such as a sale, a building refinancing, or a major renovation, or in tandem with life safety upgrades.

Action Documents

Find documents at rmi.org/carbonfreecities

- City of Vancouver (CAN) Energy Trigger Process source
- City of Vancouver (CAN) Energy Requirements, Forms, and Checklists source

Key Considerations

- ! Resistance from real estate and construction industries could slow adoption
- ☆ Choose an appropriate timing trigger that will affect the greatest percentage of the building stock over the next 10–20 years
- ☆ Reduce the burden on small-building owners through tiered/incremental phasing, focusing first on larger buildings with a greater ability to implement
- ☆ Develop financing mechanisms to help small-building owners and homeowners reduce any up-front cost burdens, including provisions for assistance to low-income housing
- ☆ Work with city leadership, real estate market, construction market, and commercial and residential owners/tenants to understand risks, reduce market disruption, and build support
- ⇨ Code becomes more stringent over time, moving toward net-zero energy ready



Vancouver, British Columbia, Canada

The City of Vancouver, British Columbia (CAN), introduced Canada's first energy code/bylaw for existing large buildings. The code triggers an energy-efficiency upgrade—as well as upgrades for life safety, structural integrity, and accessibility—when a building undergoes rehabilitation, tenant improvements, additions, or a change of major occupancy classification. Prior to issuing a building permit, the City requires a completed "energy package" (i.e., documentation that the project will meet the city's energy requirements), including several energy-related criteria of the ASHRAE 90.1-2010 standard. This energy code for existing buildings complements an update to Vancouver's new construction building code. The city invested in developing new processes, creating compliance tools, and then training city staff and industry, including forming a partnership with the Greater Vancouver Home Builders Association.

» 20% greenhouse gas (GHG) reduction target for existing buildings by 2020 (vs. 2007 levels)

"Building owners in Vancouver are going above and beyond the energy upgrades required because of the clear benefits that these upgrades deliver."

—Doug Smith, Director, Sustainability Group, City of Vancouver





Left image courtesy of Green Energy Futures - David Dodge; right top image courtesy of Doug Smith

Global City Spotlights

Seattle, Washington (USA) | Energy code requires compliance with the most up-to-date International Energy Conservation Code (IECC) for the "alteration, repair, addition, and change of occupancy of existing buildings and structures"

San Francisco, California (USA) | San Francisco's Residential Energy Conservation Ordinance requires residences to undergo an energy inspection and upgrade with basic energy- and water-efficiency measures prior to the point of sale, up to a capped price

Sweden (SWE) | Buildings undergoing renovation must meet new construction building code for the section of the building being modified

Tokyo (JAP) | Cap-and-trade program focused on urban buildings deepened over time and achieved greater emissions reductions than the cap required, while most buildings did not rely on trading

Buildings contribute an average 50% to GHG emissions in large cities.

Smart LED Lighting

Replace all lighting with smart LEDs

Create policies to support interior lighting upgrades to LED technology citywide. Provide focused buy-down programs for low-income residents, with graduated approaches for individuals and institutions able to better afford the up-front costs required to secure long-term savings. In addition to energy cost savings, maintenance costs are greatly reduced.

Action Documents

Find documents at **rmi.org/carbonfreecities**

- Energy Service Agreement for the organization that procured and distributed LEDs through India's program **source**
- Technical specifications utilized for preferred LED technologies under India's program **source**
- New York City Local Law 88, which features energy-efficient lighting upgrade requirements **source**



India

Prime Minister of India Narendra Modi launched the "*domestic efficient lighting programme*" (UJALA) in 2015 to drive adoption of long-lasting, energy-efficient LED lighting. While costs have come down sharply as performance has continued improving, LED up-front cost premiums vs. traditional bulbs still hinder faster adoption. Modi's program thus established Energy Efficiency Services Limited (EESL), a state-run organization under India's Ministry of Power, to procure in bulk and then economically distribute LED bulbs. The program targets replacement of 770 million incandescent bulbs in India. With nearly 270 million LEDs distributed as of mid-October 2017, it has become the largest lighting initiative in the world. These replacements are expected to save India $5.9 billion in utility bills and an annual savings of 100 million kWh of energy. Through the program to date, LED prices have fallen 88% and the country has reduced CO_2 emissions by more than 28 million tons annually.

» LED replacements could save India $5.9 billion and 100 million kWh of energy annually





Right top image courtesy of Saurabh Kumar

Key Considerations

- Long-term buy-down of a specific technology could be construed as the government supporting that technology; include flexibility to support new, efficient lighting technologies as they become available
- Adopt the most-recent International Energy Conservation Code (IECC) standards for lighting whenever a new standard is released
- Make efficient lighting technologies, which typically have a higher up-front cost, accessible to low-income residents
- Phase out outdated and inefficient lighting technologies (e.g., incandescent and compact fluorescent)
- Develop a "stretch" lighting code requirement that goes beyond the IECC standard

Global City Spotlights

Dubai (UAE) | Launched a public-private partnership to develop a new high-efficiency LED, and is now preparing to replace 10 million lights by 2021

Massachusetts and California (USA) | Instituted building codes with more aggressive lighting standards than the IECC 2015 standard

New York, New York (USA) | Requires large nonresidential buildings to upgrade interior lighting to meet New York City's Energy Conservation Code, necessitating high-efficiency fixtures

Sri Lanka (LKA) | Is providing 1 million LED lights to low-income customers with zero-interest financing

Benchmarking and Transparency

Require building energy-use benchmarking and transparency

Require benchmarking for all buildings citywide, which necessitates reporting annual building energy use. This should be paired with a transparency policy that requires commercial and large residential building types to publicly disclose energy use.

Action Documents

Find documents at **rmi.org/carbonfreecities**

- New York City Local Law 84, the city's building energy benchmarking law **source**
- *State and Local Energy Benchmarking and Disclosure Policy*, U.S. Department of Energy, a comprehensive guide including policy, design, data collection, and quality assurance **source**
- ENERGY STAR Portfolio Manager, U.S. Environmental Protection Agency, an online tool for measuring and tracking energy, water, and GHG data **source**



New York, New York, USA

New York City, New York (USA), has required building owners to annually record energy and water use for their buildings since 2010 via Local Law 84, known as the NYC Benchmarking Law. Passed in 2009, the law requires all buildings greater than 50,000 ft^2 to report energy and water use data to the city, which then publicly discloses that information; midsize buildings of 25,000–50,000 ft^2 will be required to also benchmark starting in 2018. Leveraging the U.S. Environmental Protection Agency's online tool, the ENERGY STAR Portfolio Manager, New York City has achieved greater than 90% compliance across affected properties. The result has been actionable intelligence for owners, service providers, and consumers, as well as energy and emissions tracking over time, informing policies that enable the City to reach aggressive emissions reductions goals.

» **During the period 2010–2015, emissions and energy use at 4,200 regularly benchmarked properties fell by nearly 14% and more than 10%, respectively.**





Right top image courtesy of Dan Zarrilli

Key Considerations

- Benchmarking can be a challenge from the start in cities with poor or inconsistent utility metering practices
- Lack of enforcement mechanisms and/or transparency incentives can make policy ineffective
- Cities need plans to collect, analyze, publicly report, and act on data
- Phase requirements, affecting larger commercial buildings first (which have a greater ability to implement) and ultimately including small commercial and residential buildings
- Develop and implement policies that directly address highest-energy consumers
- Lead by example by disclosing energy use for city-owned buildings
- Implement benchmarking and transparency for all buildings immediately without a phase-in period

Global City Spotlights

Brazil (BRA) | A national benchmarking tool is available for buildings, while the country plans to make its use mandatory

China (CHN) | Beijing and Shanghai led China in developing benchmarking and transparency legislation, which was superseded by a national program that affected all Chinese cities in 2008

Various Cities (USA) | Cities such as Boston, MA; Philadelphia and Pittsburgh, PA; Washington, DC; Chicago, IL; Denver, CO; Austin, TX; and Seattle, WA have adopted similar benchmarking and transparency policies

Recommended Resources for Action

1. City Building Retrofits - Moving to net-zero energy-ready buildings

- New Buildings Institute *Getting To Zero: ZNE Project Guide* **source**

2. Net-Zero Codes - Phase in net-zero energy requirements for new construction citywide

- New Buildings Institute Zero *Net Energy Communications Toolkit* **source**

3. Progressive Codes - Adopt progressive codes for existing buildings

- New Buildings Institute *Zero Net Energy Policies*, including model energy and green codes, outcome-based energy codes, and stretch codes **source**
- ASHRAE 90.1-2010 *Energy Standard for Buildings Except Low-Rise Residential Buildings* **source**
- International Code Council 2015 *International Energy Conservation Code* **source**

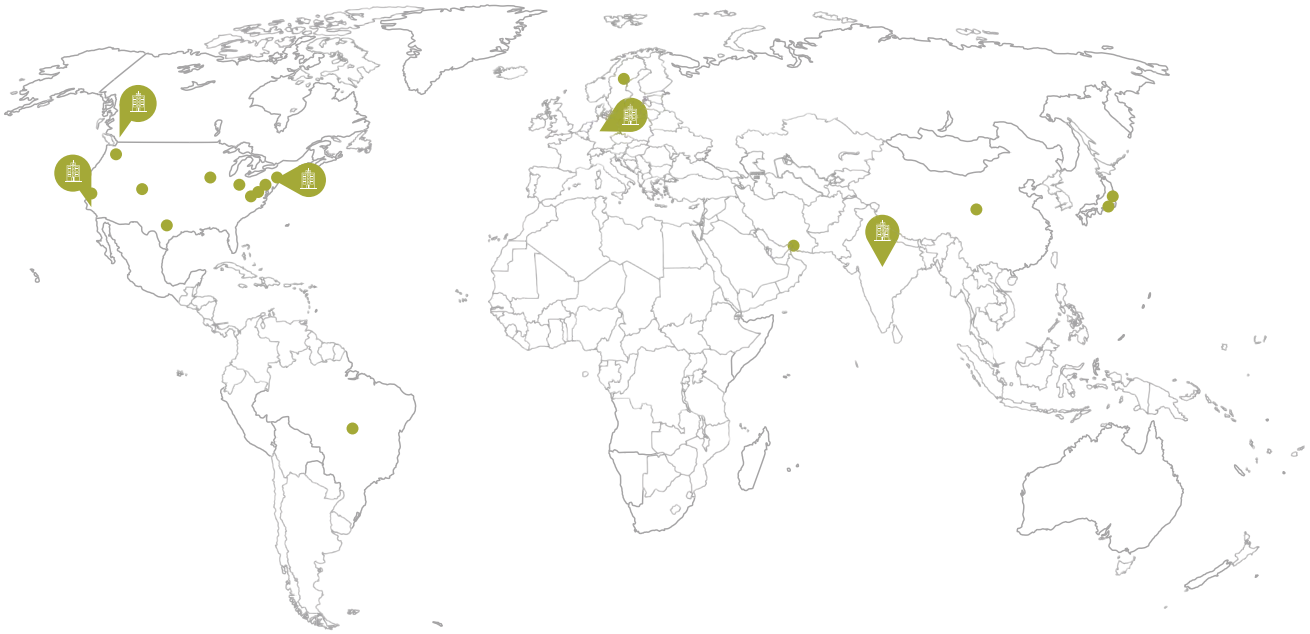
4. Smart LED Lighting - Replace all lighting with smart LEDs

- An explanation of India's program for driving cost-effective LED distribution **source**

5. Benchmarking and Transparency - Require building energy-use benchmarking and transparency

- *Benchmarking and Disclosure: State and Local Policy Design Guide and Sample Policy Language* (SEE Action) **source**

To find these Recommended Resources and additional citations from this chapter, please visit **rmi.org/carbonfreecities**





Movement of people, services, and goods is essential to a thriving city. Current transportation options often force a one-size-fits-all solution for that mobility: cars and trucks, and the streets designed to serve them. Carbon-free cities can provide more efficient and economic options that are tailored to different transportation needs—with no emissions—and that create vibrant urban spaces.

Image courtesy of David van der Mark, adjustements were made

section

2

Transportation and Mobility

Providing mobility options for carbon-free transportation

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Fleet Electrification

Electrify the municipal vehicle fleet

Replace city-owned fossil-fuel vehicles (e.g., automobiles, light- and heavy-duty trucks, public buses, police vehicles) with vehicles that fully or partially run on electricity, such as battery electric vehicles (BEVs) or plug-in hybrid electric vehicles (PHEVs).

Action Documents

Find documents at **rmi.org/carbonfreecities**

- City of Seattle Fleet Action Plan, *A Clean Green Fleet* **source**
- New York City's *Clean Fleet Plan* **source**
- City of Montréal *Rolling Stock Green Policy* **source**

Key Considerations

- ! High up-front costs can limit vehicle purchases. This can be addressed with a lease-to-own model or by right-timing purchases with a planned vehicle-replacement schedule
- ☆ Pair this initiative with city EV charging-infrastructure expansion to make operating EVs easier for both the municipality and its residents
- ⇨ Convert to all-electric vehicles (vs. a mix of alternative fuel, hybrid, and pure electric)
- ⇨ Include high-mileage taxi and limousine fleets in city efforts





Left image courtesy of the Association of Electric Vehicles of Quebec

← Montréal, Quebec, Canada

With public transportation dating back more than 150 years to 1861, Montréal, Quebec (CAN), has long been a mobility leader. Now, the city is leading again, utilizing hybrid and electric vehicles in its municipal fleet. Montréal is converting 30% of its bus fleet to hybrids and 230 of its municipal fleet vehicles to electric by 2020, the latter with the help of an agreement with a major auto manufacturer to supply short-range electric vehicles. Longer term, the city is targeting a broader conversion of its municipal fleet from internal combustion engine vehicles to electric, and has set a number of bold goals for city-owned and private vehicle fleets (e.g., taxis) in its *Transportation Electrification Strategy 2016–2020*.

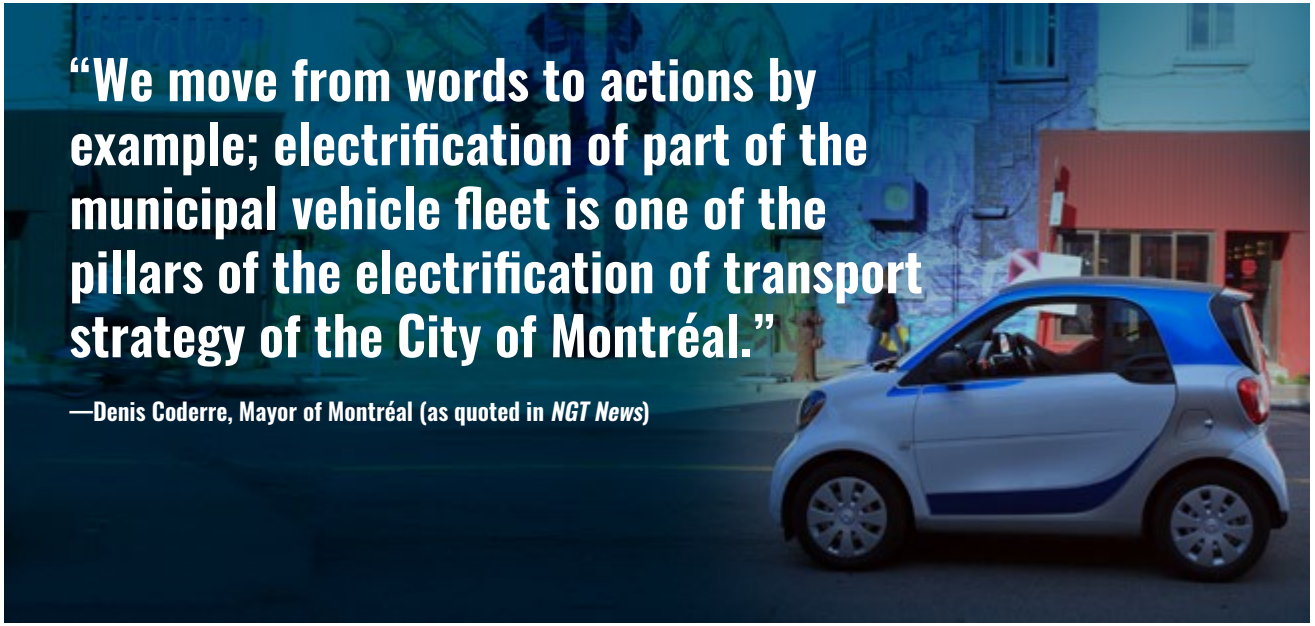
Global City Spotlights

Austin, Texas (USA) | Adding 330 BEVs and PHEVs to its fleet by 2020, which will save $3.5 million over the 10-year life of those vehicles

Copenhagen (DNK) | Since 2011, all new city-purchased vehicles have been zero emissions (BEV or hydrogen fuel cell); municipal bus fleet converting to electric starting in 2019

Oslo (NOR) | Municipal vehicle fleet and transportation systems must be zero emissions by 2020; the city is halfway to replacing its municipal fleet of 1,100 vehicles with EVs

Taiyuan (CHN) | First city globally to electrify its municipal taxi fleet, with supporting EV charging and a battery replacement program



"We move from words to actions by example; electrification of part of the municipal vehicle fleet is one of the pillars of the electrification of transport strategy of the City of Montréal."

—Denis Coderre, Mayor of Montréal (as quoted in *NGT News*)

Combustion Vehicle Reduction

Phase out internal combustion engine automobiles

Develop policies that limit internal combustion engine (ICE) vehicles in city centers, penalize "dirtier" vehicles more for driving or parking in the city, and develop long-term plans to ban diesel vehicles and ultimately all ICE vehicles in cities.

Action Documents

Find documents at **rmi.org/carbonfreecities**

- Paris phase-out law ***(in French)*** **source**
- Other information about the Paris phase-out law implementation ***(in French)*** **source**

Key Considerations

- ! Programs targeting cars based on their age and emissions levels can have a higher impact on lower-income residents, who often drive older, less-efficient vehicles
- ☆ Ban ICE vehicles on poor air quality days
- ☆ Support car-sharing programs with electric vehicles
- ⇨ Ban all ICE vehicles from city centers and/or ban the sale of ICE vehicles in the city outright





← Paris, France

In 2016, Paris (FRA), Mayor and Chair of C40 Cities Anne Hidalgo announced the city would completely phase out diesel cars by 2025, citing pollution and public health concerns. In October 2017, that deadline moved to 2024, when the French capital hosts the Olympics. The city also recently announced it intends to phase out all internal combustion vehicles by the year 2030. These ambitious plans have some describing Paris's aspiration to be "the post-car city." Already, Paris has banned diesel autos produced from 1997 to 2000, and all ICE autos registered before 1997 face extensive restrictions as well. In addition, a "pollution ticket" replaces an earlier system of alternating restrictions for other vehicles based on their license plate number.

» **On October 1, 2017, Paris held "a day without cars," with the goal of making the city "less polluted, more pleasant, and more peaceful." Nitrogen dioxide levels dropped 25% and noise levels dropped an average 20% (and an incredible 54% on the busy Champs-Élysées)**

Global City Spotlights

Athens (GRC) | Since 1982, has restricted vehicles via license plate rotation in central Athens to control traffic congestion and pollution; in 2012, began restrictions-free exemption for "green cars" (e.g., EVs); by 2025 will ban all diesel cars in the city center

London (GBR) | Has implemented an emissions surcharge (i.e., Toxicity T-Charge) of £10 for cars that do not meet Euro 4 emissions standards, which include most pre-2006 diesel cars

Madrid (ESP) | Parking charges vary based on a car's nitrogen dioxide emissions and engine type

Mexico City (MEX) | Since 1989, has restricted vehicles via license plate rotation; by 2025 will ban all diesel cars in the city center.



Freight Reduction

Phase out high-emissions urban freight

Reduce urban freight emissions through various regulatory and voluntary programs, including mandatory freight emissions standards, designated truck routes, stopping and standing laws, and off-peak delivery programs.

Action Documents

Find documents at **rmi.org/carbonfreecities**

- *Dublin City Council Heavy Goods Vehicles (HGVs) Management Strategy*, including maps, regulations, and user manuals **source**

Key Considerations

- ! Off-peak delivery has the potential to disrupt residents' sleep with noise
- ! Off-peak delivery can be more expensive for goods receivers who need staff on-site outside normal business hours
- ☆ Pair freight emissions policies with infrastructure improvements such as designated unloading docks
- ⇨ Require electrification of all urban freight vehicles (or electric-only operation in cities)





Left image courtesy of Daimler

← Dublin, Ireland

Dublin (IRL), has instituted a permitting requirement that bans most freight vehicles with five or more axles from the city center between 7:00 and 19:00 (7 a.m. and 7 p.m.) without a permit. The Dublin City Council introduced the *Heavy Goods Vehicles (HGVs) Management Strategy* in 2007 to manage freight vehicle traffic and enhance the city center environment, including alleviating traffic congestion and improving air quality. City officials chose an axle-based rather than weight-based restriction to make it easier to enforce. The City Council's actions have reduced freight vehicle traffic near the city center by an incredible 80–94%, removing an average 4,000+ heavy goods vehicles from Dublin's roads each day. The council is now looking to introduce emissions restrictions on the types of trucks that can apply for a permit.

Global City Spotlights

Amsterdam (NLD) | Environmental Zone (*Milieuzone*) imposes a fee on trucks heavier than 3,500 kg that do not meet Euronorm IV when they enter the city center ***(in Dutch and in English)***

London (GBR) | Low Emission Zone, introduced in 2008, charges trucks that do not meet Euronorm IV each day they enter the city center

Shenzhen (CHN) | Launched a program to electrify the city's 65,000 delivery vehicles. 12,000 have been electrified in only three years



EV Charging

Deploy electric vehicle charging infrastructure

Expand electric vehicle (EV) charging infrastructure by directly installing public charging stations and/or incentivizing the private sector to do so.

Action Documents

Find documents at **rmi.org/carbonfreecities**

- City of London Policy 6.13 Parking, which requires EV charging stations at one in five parking spots at London developments **source**
- *EV Charging Points in Oslo* draws lessons from the first four years of the city's EV charging strategy **source**

Key Considerations

- ! Charging station hardware costs vary widely, from $1,000 for Level 1 AC charging stations up to $90,000 for Level 3 DC fast charging stations
- ☆ Coordinate urban electric vehicle charging plans with utility infrastructure systems
- ☆ Provide transparent pricing signals that are consistent across all charging points citywide
- ☆ Locate charging stations to provide EVs priority parking on city streets or in public garages
- ⇨ Initially offer free EV charging to encourage early adoption
- ⇨ Provide taxi-only fast charging stations





← Oslo, Norway

Known as the Electric Vehicle Capital of the World, Oslo (NOR), boasts nearly 3,000 EV charging stations. With a population of ~630,000, that gives Oslo more than three times as many charging stations per capita than any other city. The city spends ~12 million kroner per year building new charging stations and an additional 4 million kroner per year to operate them. The city has made standard public EV charging free to date, which has led to substantial electric vehicle uptake in the city. Electric vehicles account for 40% of all new vehicles sold in Oslo. The city also works with the private sector to further expand charging infrastructure, including quick chargers, and with the taxi industry to build quick and semi-quick charging stations for dedicated taxi use.

Global City Spotlights

Amsterdam (NLD) | 2,000+ public charge points, with plans for 4,000 by 2018; residents can recommend charge point locations and leverage incentives

Beijing (CHN) | 6,700+ public charging stations, with upper limits for charging cost rates based on fossil-fuel market costs

London (GBR) | 1,600+ charging stations available to residents for a small annual fee; charging stations required in all new developments

Portland, Oregon (USA) | Doubling the number of publicly accessible Level 2 and DC fast chargers by 2020, including leveraging public property; funding to make affordable housing projects EV ready



Right image courtesy of Lan Marie Nguyen Berg

Car-Free Downtown

Eliminate cars from high-density districts

Eliminate cars from high-density districts by creating car-free pedestrian zones, limiting vehicles on certain days of the week, and implementing congestion pricing.

Action Documents

Find documents at **rmi.org/carbonfreecities**

- Singapore's Road Traffic Act, which describes its electronic road pricing system **source**
- Madrid's *Plan A: Air Quality and Climate Change Plan*, which features goals, an action plan, and data analysis ***(in Spanish)*** **source**

Key Considerations

- ! Some local businesses fear that less vehicular traffic will decrease customer access
- ! Limiting vehicle entrance based on license plates has shown to not decrease congestion significantly and may cause additional car purchases to get around the bans
- ☆ Electronic, automatic congestion pricing, which tracks cars and charges them a fee for entering high-congestion areas during certain hours
- ⇨ Ban cars altogether from high-density zones, including the city center



← Madrid, Spain

Madrid (ESP), is on a mission to reduce daily car usage from 29% to 23%. For the city center, cars will be banned altogether. Urban planners are redesigning 24 of the city's busiest streets to be car free and pedestrian focused, encompassing 500 acres when fully implemented by 2020. The Gran Vía, Madrid's most famous thoroughfare, is one of the roads set to allow only bikes, buses, and taxis, following a nine-day pilot in December 2016. During that pilot, revenue for local businesses was up 15% compared to the same time frame the previous year, demonstrating that these pedestrian zones could strengthen businesses. Meanwhile, Madrid is taking other measures to reduce air pollution, including alternating license plate restrictions when harmful nitrogen dioxide levels exceed specified thresholds.



Global City Spotlights

Jakarta (IND) | Mandates car-free days twice a month on key roads, which inspired another 34 cities to replicate the policy

New York, New York (USA) | Pavement to Plazas Program accepts applications from local residents to transform streets into plazas; converted world-famous Times Square (110,000 ft^2) to a pedestrian zone in 2016

Oslo (NOR) | Removed 300 parking spaces in the city center in 2017; currently bans diesel vehicles on high-pollution days; banning all cars by 2019

Singapore (SGP) | Fully automated electronic road pricing with rates reviewed quarterly and adjusted to maintain acceptable average speeds; also offers financial incentives to those who choose not to use their cars during peak hours

Stockholm (SWE) | Since 2007, charges drivers a congestion tax based on the time of day they enter the city, with no charges for the very early morning or late night

Three years after a portion of Willoughby Street in Brooklyn was transformed into a car-free pedestrian plaza, businesses along the plaza saw their revenues increase 47%. For comparison, businesses on nearby streets saw their revenues rise an average of 8%.

Mobility Alternatives

Create mobility alternatives in high-density districts

Introduce mobility alternatives to high-density areas to reduce single-occupancy vehicle traffic and enhance movement throughout the city, including bikeshare programs, expanded public transit, cyclist- and pedestrian-friendly streets, and integration between transit options.

Action Documents

Find documents at **rmi.org/carbonfreecities**

- Wuhan's proposed bikeshare policy improvements ***(in Chinese)*** **source**
- Vancouver's *Transportation 2040* plan, which details specific policies related to walking, cycling, transit-oriented mobility, and other solutions **source**

Key Considerations

- ! Alongside significant use rates, dockless bikeshare programs in China have had significant issues with obstructive parking, bike management, vandalism, and theft
- ☆ Integrated multi-modal mobility solutions that seamlessly/conveniently connect all segments of a trip (e.g., public transit stations with adjacent bikeshare stations)
- ☆ Require dockless bikeshare companies to develop electronic bike parking areas based on GPS, and to ensure operational staff of at least five people per 1,000 bikes





← Wuhan, China

Wuhan (CHN), the most populous city in central China, with more than 10 million residents, developed one of the largest bikesharing programs in the world to address “last-mile” transportation issues, or the connection between certain areas in the city and nearby public transit. Wuhan is about to introduce a novel approach to engage bikeshare riders by providing them with carbon credits based on their personal riding statistics, which riders can keep to offset their other carbon emissions or redeem for small personal prizes like movie tickets. In addition, the city constructed a 2,455 km nonmotorized network.

» Wuhan has 600,000 shared bikes as of October 2017

Left image courtesy of Szabolcs Horvát



Global City Spotlights

Chandigarh (IND) | Dial-a-rickshaw program to increase the reliability of bicycle-driven rickshaws to increase the use of nonmotorized transport options

Hangzhou (CHN) | Hangzhou Public Bicycle launched in 2008 and is the second-largest bikeshare program in the world

Singapore (SGP) | Becoming a bike-friendly city by constructing bike parking facilities at mass-rapid-transit facilities, enhancing connectivity for cyclists and pedestrians

Vancouver (CAN) | Comprehensive mobility alternatives plan addresses walking, biking, and public transportation

Public Transit

Prioritize rapid deployment of public transit to city hot spots

Rapidly deploy public transit solutions such as bus rapid transit (BRT) or light rail to city hot spots, which could be areas with high congestion, populous areas with currently limited access to public transit, or areas with issues that increase single-occupancy vehicle (SOV) use within the city.

Action Documents

Find documents at **rmi.org/carbonfreecities**

- *Bus Rapid Transit Planning Guide*, Institute for Transportation and Development Policy ***(in Chinese, English, Portuguese, Russian, or Spanish)*** **source**
- City resolutions, technical specifications for BRT buses and technical analyses of public transportation needs ***(in Portuguese)*** **source**



Rio de Janeiro, Brazil

Rio de Janeiro (BRA), partnered with EMBARQ Brazil (now WRI Sustainable Cities) to develop a bus rapid transit (BRT) network responsible for substantially decreasing the city's carbon emissions while providing a healthier and more-efficient system for commuters. The BRT network's first line, TransOeste, was operational just one year after its public announcement in 2011. The line operates on a dedicated BRT corridor and cuts the duration of inner-city trips by about half for approximately 185,000 passengers per day, while saving 107,000 tons of CO_2 equivalent over a 20-year period. The BRT system has since expanded to three lines operating on both dedicated and shared/public roads, with capacity to serve 2 million customers daily. Fuel-efficient buses classified as Euronorm V help reduce emissions further.

» **Due to its faster travel times, the total value of time saved on TransOeste BRT corridor trips averages $23 million per year**



Right image courtesy of Marcos Tognozzi

Key Considerations

- A well-designed rapid transit plan can fail without a full rollout plan that includes effective marketing of the benefits to city residents
- Plan rapid transit to serve all segments of the community, with a focus on underserved populations that could benefit from connectivity and affordable transit options
- Develop BRT-only corridors where possible, to reduce travel times
- Integrate BRT with other means of public transport and urban planning
- Utilize innovative financing mechanisms such as government grants, loans, revenues from fuel tariffs, fares, or other sources
- Use rapid transit as a short-term piece of a larger plan to deploy permanent clean-energy transit solutions

Global City Spotlights

Bogotá (COL) | Transmilenio BRT has dedicated lanes responsible for moving 2.4 million people per day and delivered about 50 billion pesos over three years in taxes that were not paid under the previous informal bus system

Cleveland, Ohio (USA) | HealthLine BRT line opened in 2008; by 2014, it served 5 million customers annually and reduced travel times by 30%

Dar es Salaam (TZA) | East Africa's first city to implement a BRT system; first phase spans 21 km and serves 160,000 passengers per day on 140 buses, reducing commute times by half for some residents

Guangzhou (CHN) | BRT opened in 2010 and now carries 850,000 passengers per day (28,000 per hour)

Recommended Resources for Action

6. Fleet Electrification - Electrify the municipal vehicle fleet

- *Cities and Climate Leadership Buy 100% Electric Vehicles for City Fleets* (U.S. ELPC) **source**
- *Plug-In Electric Vehicle Handbook for Fleet Managers* (U.S. DOE) **source**
- Sustainable Montréal report **source**
- Electrifying Montréal report **source**

7. Combustion Vehicle Reduction - Phase out internal combustion engine automobiles

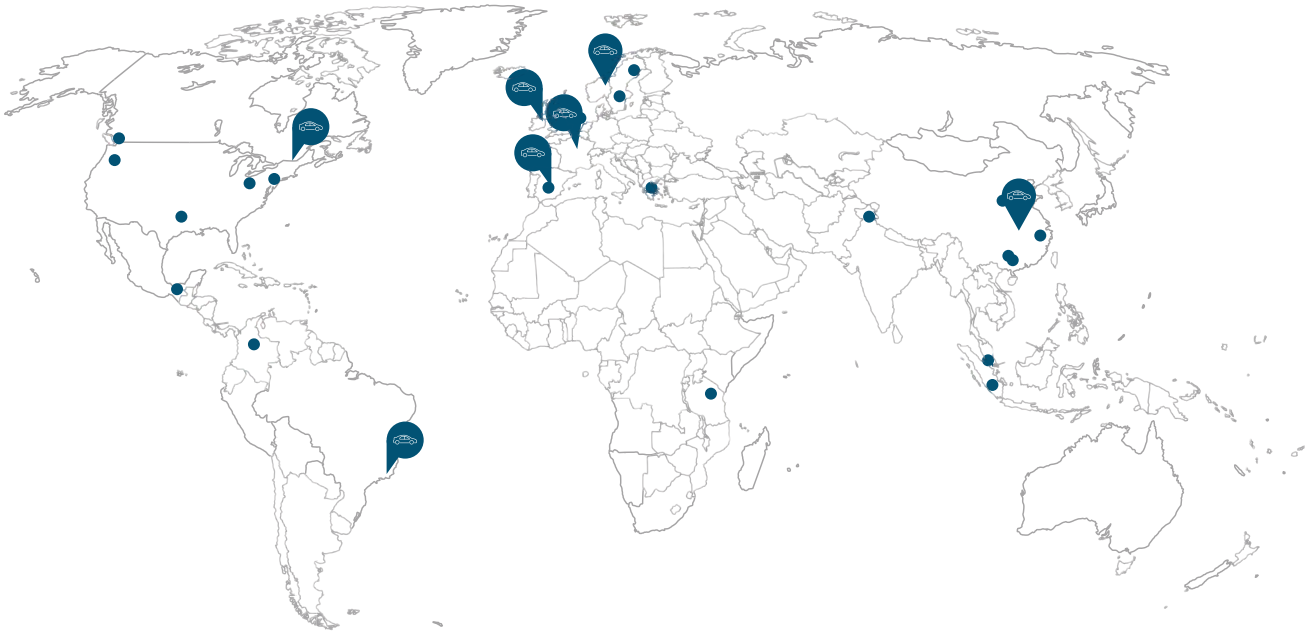
- *ZCR, vignettes Crit'Air... Comment Paris lutte contre la pollution de l'air* (Title in English: *ZCR, Crit'Air vignettes... How Paris fights against air pollution*) **source**

8. Freight Reduction - Phase out high-emissions urban freight

- *How to Develop a Green Freight Program: A Comprehensive Guide and Resource Manual* (U.S. EPA) **source**
- Initiative Selector Tool for Improving Freight System Performance (Rensselaer Polytechnic Institute)
- Global Green Freight **source**
- Bestfact, a portal for freight transport policies, contacts, and best practices **source**

9. EV Charging - Deploy electric vehicle charging infrastructure

- *Electric Vehicle Capitals of the World* (icct) **source**
- *Electric vehicles in Europe: Gearing up for a new phase?* (McKinsey) **source**
- *Plugging Away: How to Boost Electric Vehicle Charging Infrastructur*e (BoA, UCLA, UC Berkeley) **source**



10. Car-Free Downtown - Eliminate cars from high-density districts

- *Congestion Charging: Challenges and Opportunities* (icct) **source**
- *Singapore's Electronic Road Pricing* (ERP) **source**
- *Study on International Practices for Low Emission Zone and Congestion Charging* (WRI) **source**

11. Mobility Alternatives - Create mobility alternatives in high-density districts

- *Best Complete Street Policies of 2016* (Smart Growth America) **source**
- *Promoting Non-Motorized Transport in Asian Cities: Policymakers' Toolbox* (UN Habitat, Clean Air Asia, Shakti) **source**

12. Public Transit - Prioritize rapid deployment of public transit to city hot spots

- *Good Practice Guide Bus Rapid Transit* (C40 Cities) **source**
- *The BRT Planning Guide* (ITDP) **source**
- *Social, Environmental and Economic Impacts of BRT Systems* (WRI) **source**
- Global BRT Data source

To find these Recommended Resources and additional citations from this chapter, please visit **rmi.org/carbonfreecities**

As cities reduce their energy consumption and switch from direct fossil-fuel consumption to electrification, the remaining challenge then becomes how to transform electricity generation to carbon-free renewable energy. Leading cities are doing so by first committing to bold 100% renewable energy targets, then implementing comprehensive action plans.

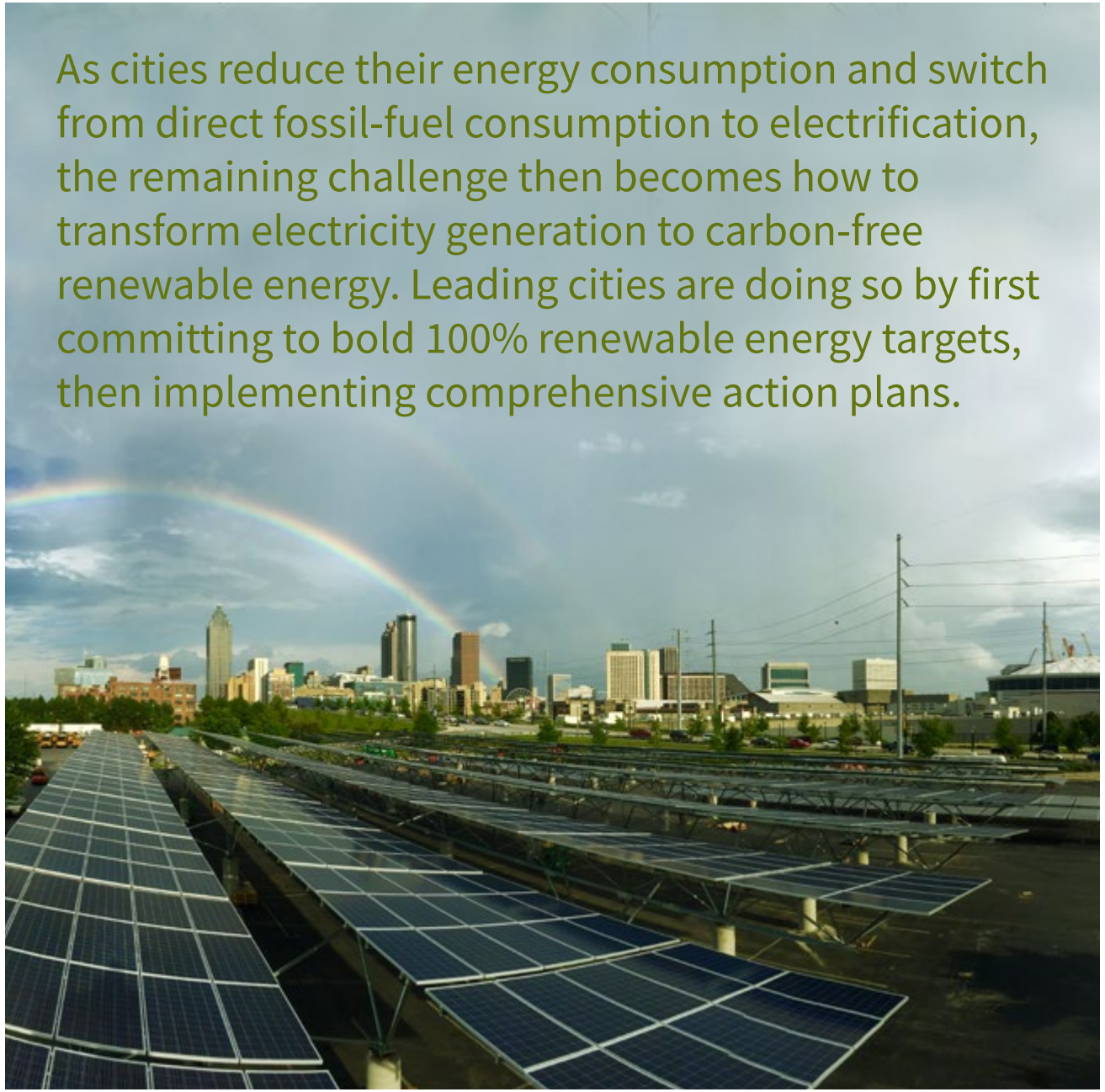


Image courtesy of Quest Renewables, Inc - Quadpod™ Solar Canopy

section

3

Electricity

Achieving 100% renewable energy

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LED Smart Streetlights

Replace streetlights and other infrastructure lighting with smart-control LEDs

Replace traditional lights (e.g., high-pressure sodium) with energy-efficient, smart LED luminaires and networked control (for real-time monitoring, on/off, dimming). Further use the streetlight network—both the physical poles and digital communications backbone—for additional sensors, cameras, and intelligent automation of city services.

Action Documents

Find documents at **rmi.org/carbonfreecities**

- Chicago Smart Lighting Project RFP **source**
- San Diego Streetlight Conversion Project RFP **source**

Key Considerations

- ! Ownership, operation, and/or maintenance can vary widely across municipalities, utilities, and third parties
- ! With networked control, infrastructure cybersecurity is critical
- ! Despite strong return on investment, up-front capital requirements can necessitate creative financing
- ☆ With pole-mounted technologies, streetscape aesthetics become relevant for urban designers and planners
- ☆ Be wary of closed/proprietary systems that "lock" a city into a dead-end investment and/or stifle innovation from the city, app developers, and technology companies
- ☆ Assess timing opportunities for planned investments and infrastructure upgrades



San Diego, California, USA

In February 2017, the City of San Diego, California (USA), announced deployment of what it called the "world's largest city-based 'Internet of Things' platform using smart streetlights." The city upgraded to 14,000 smart, network-connected LEDs, coupled with 3,200 sensor nodes. The controllable smart LEDs will save the city an estimated $2.4 million annually on energy costs, while the associated sensor network will yield many additional benefits. Real-time sensor data can optimize parking and traffic, enhance public safety, monitor air quality, and more. "Fostering innovation and improving infrastructure are important to enhancing the lives of all San Diegans. This new technology will give the City and developers the opportunity to make our neighborhoods safer and smarter," explained Mayor Kevin Faulconer.

- **60% LED streetlight energy cost savings**
- **50% GHG emissions reduction target by 2035 (vs. 2010)**
- **100% renewable energy target**



Street lighting can account for up to 40% of a municipality's electricity costs (not including maintenance).

Left and top middle images courtesy of Cody Hooven

Global City Spotlights

Chicago, Illinois (USA) | 250,000 streetlights (85% of network)—50–75% savings through efficiency enhanced by intelligent dimming

Buenos Aires (ARG) | 1,000 streetlights (70% of network) with centralized network—50% energy savings

Jakarta (IDN) | 90,000 streetlights installed in only 7 months, with smart monitoring and control

Madrid (ESP) | 225,000 streetlights (including 84,000 LED)—44% energy savings

Milan (ITA) | 140,000 streetlights—50% energy savings and 31% energy cost savings (€10 million) annually: 23,650 tons of CO_2 emissions savings annually



Electric Districts

Electrify districts to replace fossil-fuel infrastructure

Avoid and/or eliminate/replace fossil-fuel infrastructure (i.e., natural gas for heating, cooking, hot water) in favor of electric-only buildings and infrastructure, ranging from individual buildings to entire developments, neighborhoods, and districts.

Action Documents

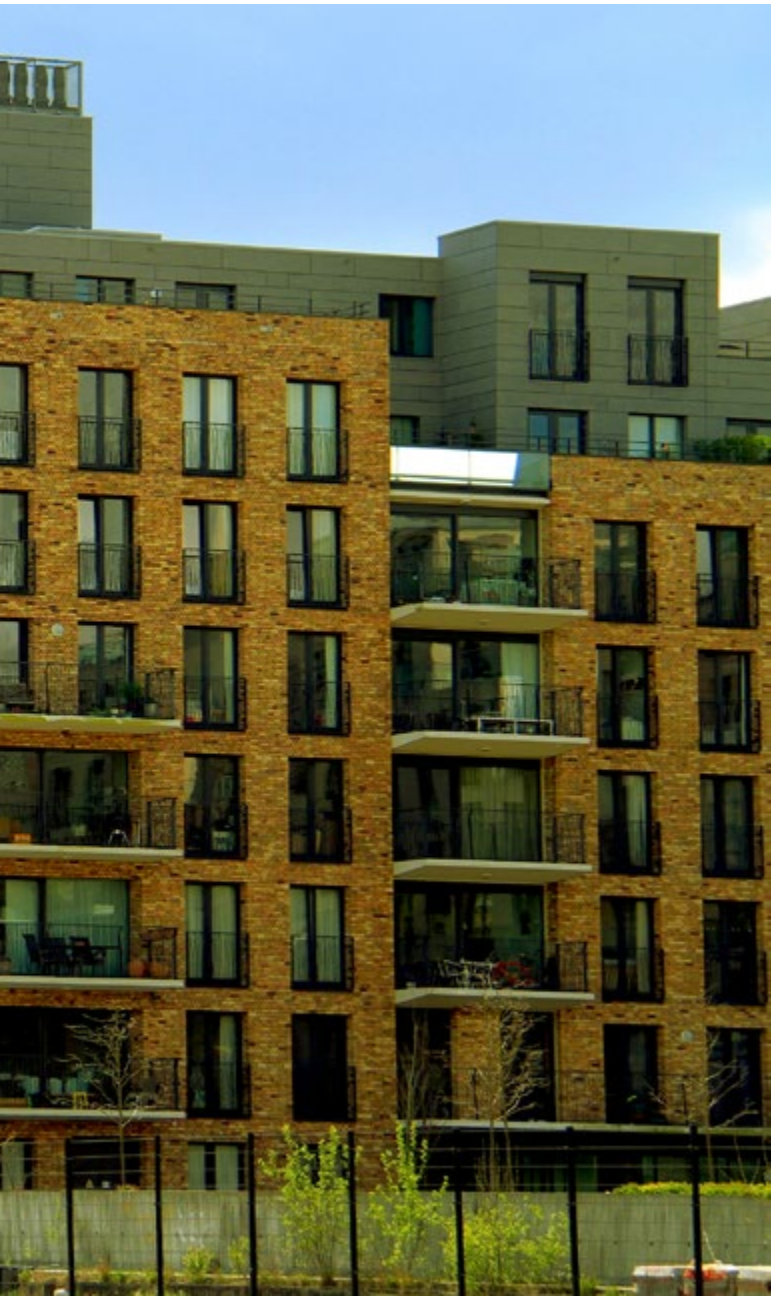
Find documents at **rmi.org/carbonfreecities**

- The Netherlands *Energy Agenda* natural gas policy, pp. 64–65 **source**
- Amsterdam's *To a City Without Natural Gas Plan* ***(in Dutch)*** **source**

Key Considerations

- ! Ownership, operation, and maintenance of legacy and new centralized infrastructure, such as district heating systems as an alternative to natural gas, is a critical issue. Carefully consider vested interests, regulatory implications, and other factors
- ! Legal and economic barriers must be carefully evaluated in a wholesale infrastructure shift
- ☆ Building a diverse coalition across many stakeholders is necessary to make it work
- ☆ Don't neglect builders and homeowners; build support for project buy-in
- ☆ Expert technological assessments to determine appropriate suite of solutions to reliably/confidently replace natural gas are a must





Left image courtesy of Thomas van Mens; right image courtesy of Abdeluheb Choho

← Amsterdam, The Netherlands

In Amsterdam (NLD), today, natural gas heats 90% of homes, contributing 30% of the city's carbon emissions. By 2050, the city plans for that number to be zero, in a dramatic shift away from natural gas. New neighborhoods in the city are being built without natural gas infrastructure. Existing neighborhoods are having natural gas removed, including 10,000 public-housing units that had their gas supplies removed in 2017. Starting September 1, 2017, the city also began offering homeowners incentives to offset the cost of removing natural gas from their homes. By 2020, more than 100,000 Amsterdam homes are expected to have transitioned from natural gas to district heat. Meanwhile, Amsterdam is also pursuing solutions beyond district energy, including distributed geothermal heat pumps and solar thermal.

- **90% of homes heated with natural gas**
- **30% of city carbon emissions contributed by home heating**
- **10,000 housing units' natural gas removed in 2017**
- **0% target for natural gas home heating in 2050**

Global City Spotlights

Chula Vista, California (USA) | Homebuilder City Ventures building electric-only green subdivisions

Hyogo Prefecture (JAP) | At Smart City Shioashiya, partners including local government moving away from natural gas toward solar-plus-storage residential microgrids to supply >80% of community energy needs

Palo Alto, California (USA) | City and its municipal utility running a program to encourage all-electric homes in a switch from natural gas

Stockholm (SWE) | Phasing out fossil fuels by 2050, including for buildings (e.g., Stockholm's extensive district-heating system, which is switching to renewables)

Vancouver (CAN) | Updated city building codes and city-approved *Zero Emissions Building Plan*, coupled with Vancouver's *Renewable City Strategy*, to phase out fossil-fuel-derived natural gas in new construction (and eventually existing construction, by 2050)



Municipal Solar Installations

Install solar PV on all available municipal sites

Install solar photovoltaics (PV) on all available municipal sites, including building rooftops (e.g., city hall, schools, police/fire, community centers, transit depots), carports, and other structures, and ground mount solar PV on appropriate land (e.g., rights of way, infill, brownfields). Make available for community solar projects.

Action Documents

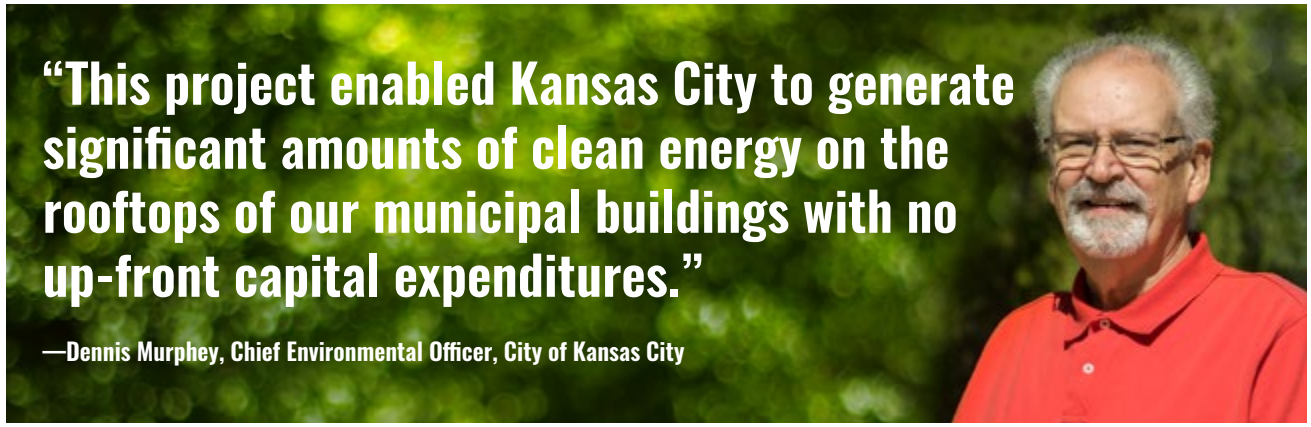
Find documents at **rmi.org/carbonfreecities**

- City of Kansas City Missouri, City-Wide Solar Energy Project RFP **source**
- City of Kansas City, Missouri, Master Solar Lease and Access Agreement (between city and vendor) **source**
- City of Kansas City, Missouri, Solar Services and Access Agreement (between city and utility) **source**



Kansas City, Missouri, USA

In 2013, the City of Kansas City, Missouri (USA), installed leased 25 kW solar PV systems on more than 60 municipal buildings, including police and fire stations, community centers, city office buildings, traffic operations center, and many others. The systems saved the city an estimated $40,000 in electricity costs their first year of operation, while the lease arrangement meant zero up-front costs for the city. The 1.45 MW of city rooftop solar arrays generate 1.5 million kWh of carbon-free electricity each year, and this is potentially just the beginning. A 2015 study from the Institute for Local Self-Reliance in cooperation with the Mid-America Regional Council—a regional council of governments and the metropolitan planning organization for the Kansas City region—identified 70 MW of rooftop solar opportunity across some 2,000 city-owned buildings, not including schools.



Left image courtesy of Kansas City; Middle image courtesy of Dennis Murphey

Global City Spotlights

Denver, Colorado (USA) | 14 MW of solar across airport, convention center, museums, affordable housing units; neighboring Jefferson County Public Schools has installed 100 kW solar PV arrays on 30 schools across the county

Durban, eThekwini Municipality (ZAF) | Established Energy Office Solar, and installed 300 kW solar on 5 municipal rooftops, including police and water and sanitation

Sydney (AUS) | Renewable energy master plan includes much in-city solar, including 40 municipal sites (and counting) to date, such as town halls, community centers, library, depots, pavilions, aquatic center, plus Environmental Innovation grants to spur community solar

Tokyo (JAP) | Using land along railways lines for large-scale solar installations, among other solar efforts

Yokohama (JAP) | Among other in-city renewable energy efforts, installed solar PV at nearly 200 schools

Key Considerations

- Understand solar export compensation (e.g., net energy metering, feed-in tariffs), regulatory-defined system size limitations, and availability of various ownership options (e.g., city-owned, third-party owned, or leased)
- Carefully evaluate ownership and finance options, considering both first costs and net present value over anticipated life of the PV systems
- Inventory rooftop suitability of city facilities (e.g., rooftop age, structure, warranty, shading)
- As a publicly visible demonstration of city renewable energy commitment and investment, communicate proactively and regularly to residents, businesses, etc.
- Carefully vet vendors with an RFP-driven process
- Consider pairing on-site solar with storage for microgrid backup power resilience, especially for critical facilities



Municipal Renewable Supply

Secure renewable energy supply for all municipal energy use

Leverage various mechanisms (e.g., utility green tariff programs, direct supply, power purchase agreements [PPAs], city ownership of utility-scale renewable generation) to secure renewable energy supply—often from beyond the city's borders—to meet all energy use not covered by on-site renewables.

Action Documents

Find documents at **rmi.org/carbonfreecities**

- Houston strategic renewable energy procurement RFP **source**
- Philadelphia renewable energy procurement RFP **source**

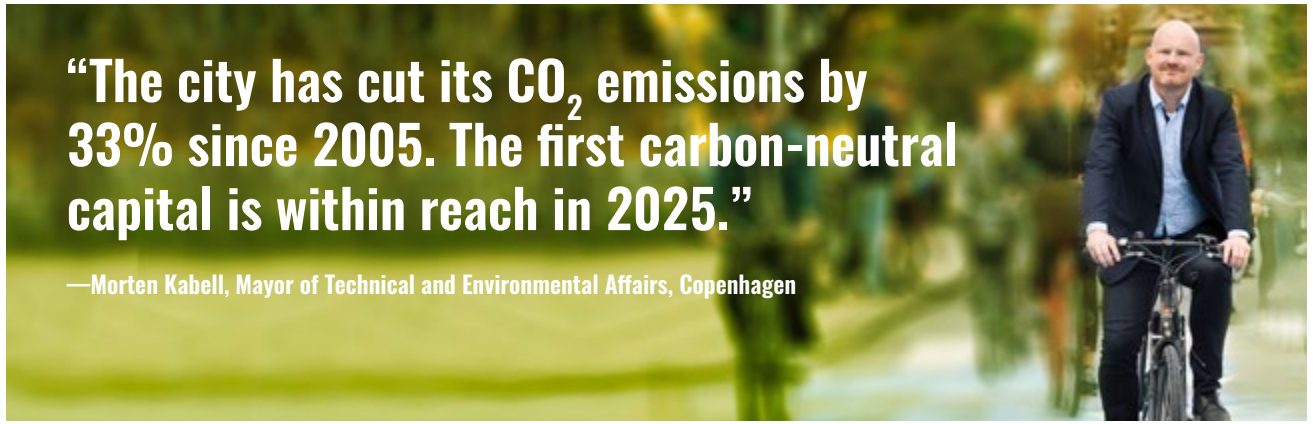
Key Considerations

- ! Financial hedges such as a virtual power purchase agreement bundled with renewable energy credits might expose a city to downside financial risk, and must be carefully evaluated
- ! Complex contractual structures can impede quick adoptions. Brokers/consultants/advisories specializing in utility-scale renewable energy procurement can help navigate these contracts.
- ☆ A competitive RFP process for procuring utility-scale renewable energy can unlock the most financially attractive opportunities
- ☆ Establish clear, detailed criteria for renewable supply
- ☆ Clearly identify city priorities such as acceptable locations/proximity for renewable supply, generation types (e.g., wind, solar PV, hydro, geothermal), additionality claims, etc.



Copenhagen, Denmark

By 2025 Copenhagen (DNK), Denmark's capital, is targeting carbon-neutral district heating and renewable energy supplying at least 100% of the city's electricity consumption, the latter with a heavy emphasis on wind. The city plans to install 100 new wind turbines, both inside and outside the city boundary, and both onshore and offshore, and including the close involvement of local communities and citizens. It is a massive leap beyond existing efforts, such as Copenhagen's famous and often-photographed in-harbor wind farm, *Middelgrunden*. Copenhagen Energy, an entity owned by the city, is charged with building the wind farms, with a city mandate to pursue loans, external funding, and joint ventures that make projects eligible for government tenders, all in order to finance the ambitious effort. The city is also negotiating with landowners in other municipalities for additional wind turbine sites.





Top middle image courtesy of Morten Kabell

Global City Spotlights

Bristol (GBR) | Municipalizing its electricity service, in part to achieve aggressive renewable energy goals, including owning several wind turbines, a large "solar for schools" program, and plans for district heating

Houston, Texas (USA) | Largest municipal purchaser of green energy in the United States

Sunnyvale, California (USA) | City council voted unanimously to "upgrade" to GreenPrime purchase option from Silicon Valley Clean Energy Authority to procure 100% renewable energy through the city's utility electric bill

Tokyo (JAP) | Interregional governmental efforts to connect urban load centers (e.g., Tokyo) with regions that have abundant renewable energy sources (e.g., large-scale wind, solar)



Recommended Resources for Action

100% Renewable Energy Targets and Action Plans

- Sydney's *Renewable Energy Master Plan* **source**
- Go 100% Renewable Energy **source**
- Ready for 100, Sierra Club **source**
- Renewable Cities **source**
- *Pathways to 100: An Energy Supply Transformation Primer for U.S. Cities* **source**

13. LED Smart Streetlights - Replace streetlights and other infrastructure lighting with smart-control LEDs

- *Smart Street Lighting as a Smart City Platform* **source**
- *GSMA Smart Cities Guide: Street Lighting* **source**
- U.S. Department of Energy Municipal Solid-State Street Lighting Consortium **source**

14. Electric Districts - Electrify districts to replace fossil-fuel infrastructure

- Vancouver *Zero Emissions Building Plan* **source**
- Palo Alto *Sustainability and Climate Action Plan* electrification fuel-switching levers **source**

15. Municipal Solar Installations - Install solar PV on all available municipal sites

- *Public Rooftop Revolution* (ILSR) **source**
- *Solar Powering Your Community Guide for Local Governments* (U.S. DOE) **source**
- U.S. Department of Energy, Office of Energy Efficiency & Renewable Energy. *Solar Powering Your Community: A Guide for Local Governments.* 2011 **source**

16. Municipal Renewable Supply - Secure renewable energy supply for all municipal energy use

- *Renewable Energy in Cities* (IRENA) **source**
- *Green Power Partnership Top 30 Local Government* (U.S. EPA) **source**



To find these Recommended Resources and additional citations from this chapter, please visit **rmi.org/carbonfreecities**



Industry is a major employer and economic driver in many global cities, significantly shaping a city's carbon emissions. Limited jurisdictional control means that cities frequently must partner strategically with these corporate residents to achieve economic and environmental solutions that benefit everyone.

section

4

Industry

Partnering with large energy users to improve their impacts

17 Clean Industrial Heat 52
18 Efficient Motors 54
19 Operator Training 56
Recommended Resources 58

Clean Industrial Heat

Reduce emissions from process heat loads

Develop industrial programs that reduce emissions from process heat loads. This can be accomplished many ways, including conversion to low-carbon fuels, making process heat generation more efficient, repairing heat-distribution infrastructure, and making productive use of waste heat.

Action Documents

Find documents at **rmi.org/carbonfreecities**

- *Energy Efficiency Trends and Policies in Industry* features a number of industrial energy efficiency policies in the EU, including incentives for industrial processes (Page 49) **source**
- *Handbook on Codes, Covenants, Conditions, and Restrictions for Eco-Industrial Parks* includes some draft language used in codes and covenants to encourage clean district heating **source**





← Jinhua, Zhejiang, China

In Jinhua, Zhejiang Province (CHN), the city established the *Jinhua Upgrade Plan for High-Polluting Boilers* to replace nearly 1,500 coal-fired boilers with new, efficient boilers by the end of 2016. According to the Jinhua City Development and Reform Commission, retrofitting those boilers would eliminate 780,000 tons of coal consumption, 15,200 tons of dust emissions, 9,900 tons of sulfur dioxide, and 2.18 million tons of carbon dioxide. Jinhua offered incentives to companies that performed boiler retrofits early (by the end of 2015). Companies that missed the 2016 deadline would not receive any financial subsidy and be subject to doubled pollution fines from the provincial government's environmental protection department. By 2016, the city had far exceeded its target, retiring 2,665 coal-fired boilers and measuring substantial improvements in the city's air quality.

Global City Spotlights

Qinhuangdao (CHN) | Developed a circular-economy district through the city's EcoPartnership program, whereby industrial partners exchanged a number of resources, including process heat

Sweden (SWE) | Developed industrial tax-relief program for 180 partners in power-intensive industries that agreed to reduce energy use, saving 1.45 TWh energy per year, including process-heating reductions

Vietnam (VNM) | Developing ecoindustrial zones in three provinces with over 300 enterprises

Key Considerations

- City zoning laws and other ordinances can prevent industrial buildings from sharing heating, cooling, or waste heat with nearby residential and commercial buildings
- Make process heat-distribution systems more efficient; distribution-system retrofits often lead to immediate, quick-payback, low-cost energy savings
- Repurpose waste heat within a facility to heat a nearby facility, to generate electricity, or for another use
- Plan for ecoindustrial parks, which make more efficient use of many resources (including process heat)
- Retrofit city-owned heating infrastructure (e.g., steam-generation and -distribution systems) and move toward 100% clean energy sources before policy implementation

The typical industrial facility can reduce its energy use 20% simply by insulating steam and condensate return lines, stopping steam leakage, and maintaining steam traps.

Efficient Motors

Replace energy-intensive motors with efficient and variable-speed models

Develop a program to replace inefficient motors with high-efficiency models through codes, standards, rebates, incentives, audit programs, and other strategies.

Action Documents

Find documents at **rmi.org/carbonfreecities**

- Topmotors, supported by the Swiss Federal Office of Energy, which includes documents, tools, and processes related to industrial motor audits and improvements ***(in English, French, or German)*** ***source***
- *Energy Conservation Standards for Commercial and Industrial Electric Motors*, U.S. Department of Energy **source**

Key Considerations

- ! Private industrial corporate forces can move slowly and may require additional incentives or penalties to accelerate motor replacement
- ☆ Incorporate continuous commissioning plan so that motors operate most efficiently
- ☆ Incentivize redesign of overall industrial processes to reconfigure motors, controls, and other components to maximize efficiency
- ⇨ Set motor efficiency standards into industrial building code, preventing low-efficiency models from being used
- ⇨ Adopt motor upgrade requirement for industrial energy users with existing motors





← Switzerland

In 2010, the Swiss Federal Office of Energy financed the EASY program, a pilot program to stimulate electricity savings in the industrial sector in Switzerland (CHE). It focused on auditing and retrofitting motor systems. The EASY program subsidized each step of the process, with the heaviest subsidies applied to early steps to encourage action and lesser subsidies for later steps thanks to rapid economic payback (i.e., in one to three years). As part of the program, energy management personnel at the participating businesses were trained to continue implementing systematic improvements to their motor systems. EASY found that 56% of all audited motors were older than their expected operating lifetime and most did not include variable-speed (or variable-frequency) control, identifying 73.7 GWh of potential energy savings over the expected lifetime of newly installed equipment. The EASY audit pilot program concluded in 2014, but the Swiss Federal Office of Energy's Topmotors program continues the effort.

Electric motor-driven systems represent around 70% of electric energy consumption in the industrial and service sectors.

Global City Spotlights

California (USA) | Sets standards for many nonresidential fan and pump motors to be high-efficiency and variable speed

China (CHN) | The *Twelfth Five-Year Comprehensive Work Plan of Energy Conservation and Emission Reduction* included motor system energy conservation

New York, New York (USA) | Requires variable-frequency drives for fan motors greater than 10 horsepower

USA | The Integral Horsepower Amended Motor Rule sets standards for motor efficiency, including a ban on selling new motors that don't meet efficiency standards



Operator Training

Establish a local industrial energy management training center for plant/energy operators

Develop a voluntary energy management program that recognizes industry for committing to energy management systems, energy audits, and continual energy reductions in their facilities, which will build local capacity for energy managers. Provide resources, including training, for energy management personnel to achieve continuous improvement.

Action Documents

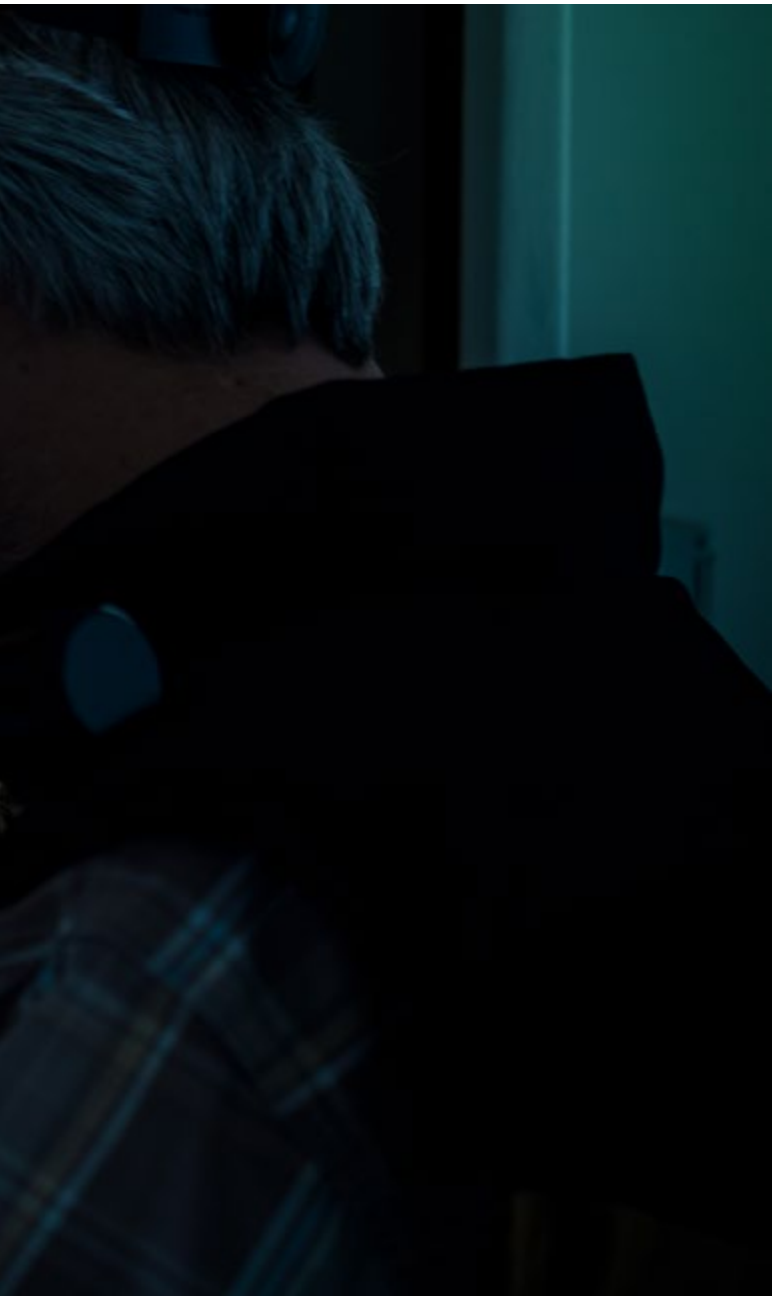
Find documents at **rmi.org/carbonfreecities**

- Ireland's Large Industry Energy Network **source**
- U.S. Department of Energy's Superior Energy Performance Program **source**

Key Considerations

- ! Without strong industry participation from the start, savings and program momentum may be slow to build
- ☆ Utilize universal standards developed by the International Standards Organization (ISO)
- ⇨ Require industrial partners commit to specific energy-reduction targets (e.g., 30% within three years)
- ⇨ Make energy management programs a requirement rather than voluntary
- ⇨ While these efforts have been made by countries, it is within a city's power to launch a similar program





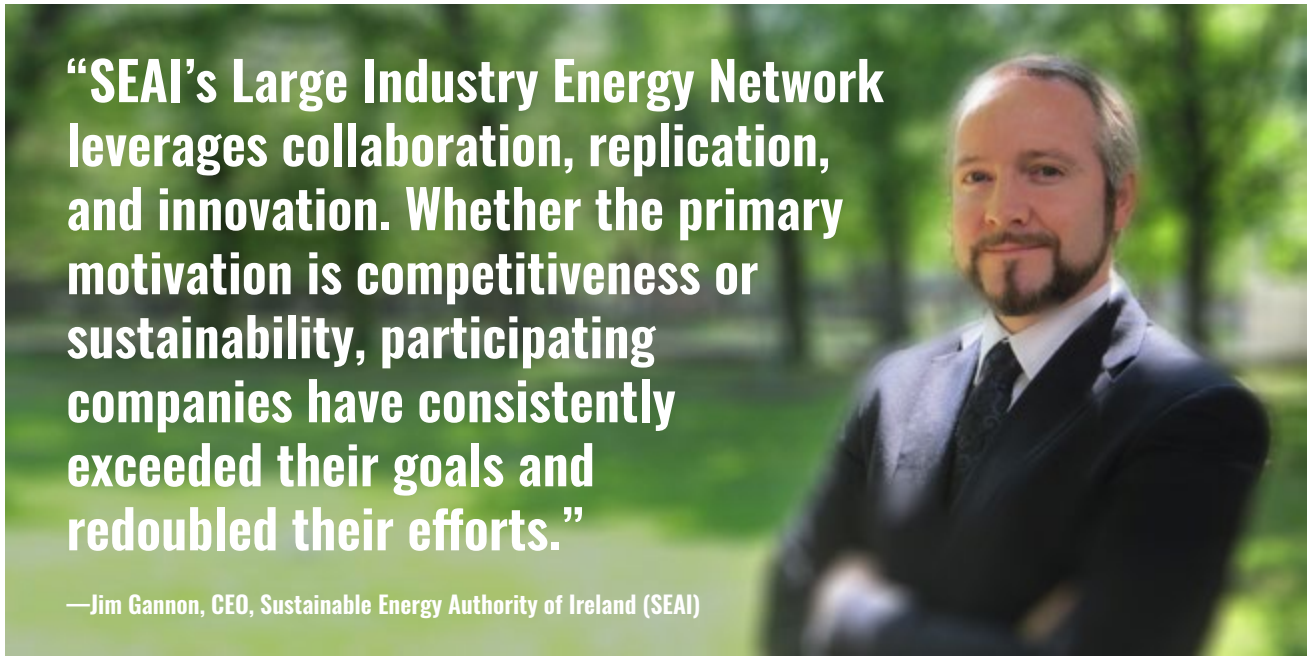
← Ireland

The Large Industry Energy Network (LIEN)—an initiative of the Sustainable Energy Authority (SEAI) of Ireland (IRL)—has provided energy management support and direction to Ireland's largest energy users for more than 20 years. The network's 200 industrial partners each have annual energy bills in excess of €1 million and collectively account for 55% of the nation's industrial primary energy use. They share and replicate energy-efficiency best practices between members and with the wider business community. Members commit to improving or establishing an energy management plan, setting energy efficiency targets, and reporting annually, all based on the ISO 50001 standard, a proven framework for industrial energy management. Network members have improved their energy efficiency 30% over the past 20 years.

Global City Spotlights

Sweden (SWE) | Runs a voluntary program requiring companies to perform an energy audit and engage in an energy management system

USA | The U.S. Department of Energy's (DOE's) Superior Energy Performance Program certifies industrial facilities for energy management excellence and demonstrated savings. The DOE's Industrial Assessment Centers are university partnerships that train the next generation of energy engineers through actual industrial energy assessments that typically identify over $130,000 in annual savings opportunities



Right image courtesy of Jim Gannon

Recommended Resources for Action

17. Clean Industrial Heat - Reduce emissions from process heat loads

- Jinhua City Environmental Protection Bureau, work summary and plan for 2017 ***(in Chinese)*** **source**
- "Zhejiang Jinhua start 'coal to gas' to gradually eliminate high-polluting boiler government subsidies" ***(in Chinese)*** **source**

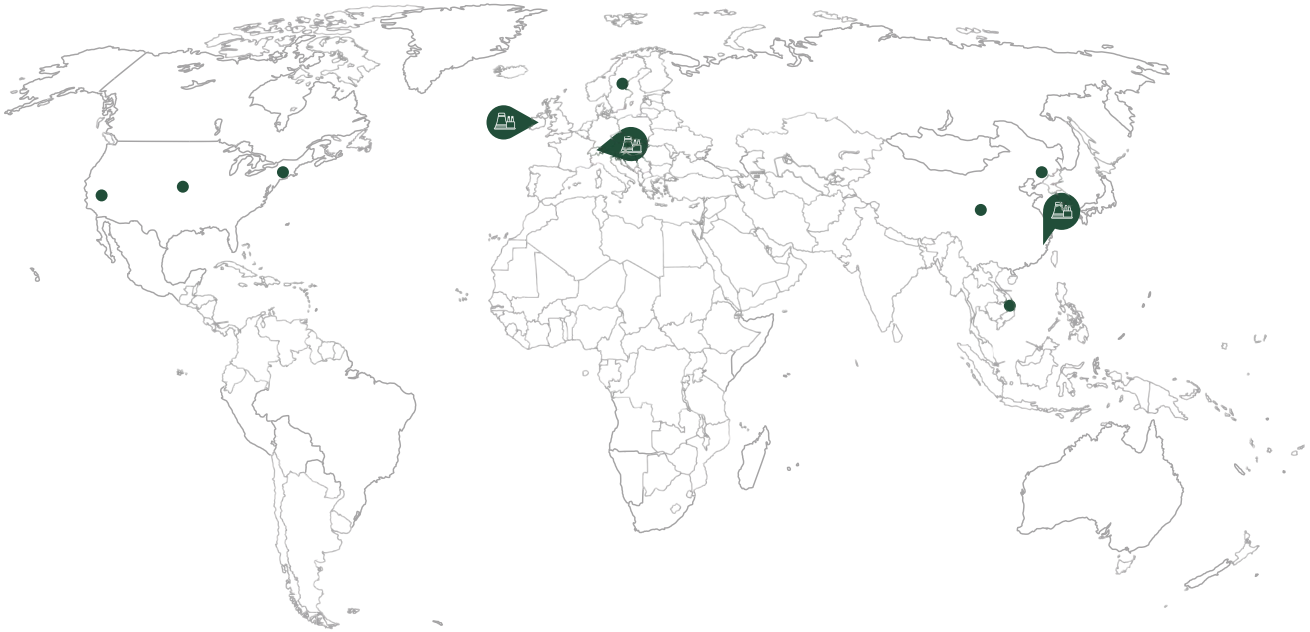
18. Efficient Motors - Replace energy-intensive motors with efficient and variable-speed models

- *Swiss motor efficiency program EASY: results 2010–2014* (ACEEE) **source**

19. Operator Training - Establish a local industrial energy management training center for plant/energy operators

- *ISO 50001 Energy Management Standard* (U.S. DOE) **source**
- *Superior Energy Performance: Certifying Increased Energy Productivity Under ISO 50001* (U.S. DOE) **source**

To find these Recommended Resources and additional citations from this chapter, please visit **rmi.org/carbonfreecities**





Human technologies are not the only sources of low-carbon solutions. Cities can also shift the flow and management of their biological resources to reduce emissions, capture carbon, and provide numerous other benefits to a city.

section

5

Biological Resources

Managing biological resources to reduce carbon dioxide emissions

20 Organic Waste Diversion 60
21 Urban Forestry 62
22 Plant-Based Diets..... 64
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Organic Waste Diversion

Divert all organic waste from landfills

Divert organic waste—including food waste, landscaping debris, and paper and cardboard packaging—from landfills. Organic materials anaerobically decompose in landfills and produce methane, one of the most potent greenhouse gases. Diversion from the landfill waste stream and subsequent proper composting can greatly reduce GHG impacts while producing a valuable landscaping and agriculture resource.

Action Documents

Find documents at rmi.org/carbonfreecities

- Residential Source Separated Organics Collection Tool Kit source
- Vancouver's policy to limit organic waste in landfills source

Key Considerations

- ! Waste and recycling programs that don't focus on organics will have a minimal climate impact, even as they provide other benefits
- ☆ Diverting organic waste requires behavior changes, so a strong educational campaign can make a big difference to program success
- ☆ Capture biogases from composting to use on-site for heating and electricity generation (biogas, combined heat and power [CHP])
- ☆ Implement recycling requirements for construction and demolition (C&D) to keep lumber and other organics out of landfills
- ⇨ Establish a zero-waste goal backed up by a zero-waste action plan





← Alappuzha, India

Alappuzha, in the state of Kerala (IND), was facing a major problem when smelly garbage was clogging its beautiful canals and a neighboring community started protesting the disposal of Alappuzha's waste there. The city discontinued an unsuccessful door-to-door collection program and launched the Clean Home, Clean City (*Nirmala Bhavanam, Nirmala Nagaram*) program to install neighborhood- and home-composting and biogas systems. A close partnership with neighborhood and women's associations proved critical. The city started saving Rs10,000 a day in garbage truck fuel alone. In 2016, the Centre for Science and Environment declared Alappuzha one of the three cleanest cities in India.

Global City Spotlights

Linköping (SWE) | Only 1% of municipal solid waste goes to landfill, and the biogas from organics provides fuel for the transportation sector

São Paulo (BRA) | Seeking to divert 80% of organic waste

Sydney (AUS) | Between 2006 and 2012, increased diversion from landfill waste stream from 27% to 66%, two years ahead of provincial government's target

Vancouver (CAN) | Bans organic waste going into landfills, with associated tipping fees

Over 350 municipalities in Europe have made zero-waste commitments.



Urban Forestry

Invest in urban forestry, parks, and other "green infrastructure"

Well-designed urban forests can create powerful carbon sinks to remove carbon from the atmosphere and offset emissions. They can also reduce the urban heat-island effect, and therefore reduce energy use for cooling loads.

Action Documents

Find documents at rmi.org/carbonfreecities

- City of Minneapolis Urban Forest Policy source
- City of Minneapolis Site Plan Review, which includes landscaping requirements source
- City of Minneapolis tree-related ordinances/codes source
- City of Los Angeles Urban Forestry Policy source

Key Considerations

- ! Many urban trees have a high mortality rate. Be sure to support tree survival with ongoing maintenance. This practice can combine well with using compost from the "Organic Waste Diversion" recommendation
- ! Not all trees offer the same carbon sink benefits, so it is best to use native trees selected for carbon absorption
- ☆ Use public-private partnerships to accomplish plantings and maintenance, as Los Angeles does with City Plants, Detroit does with Greening of Detroit, and Chicago does with the Chicago Region Tree Initiative





← Minneapolis, Minnesota, USA

Minneapolis, Minnesota (USA), has a strong track record in urban forestry. The city has integrated its forestry policy throughout its ordinances and codes, and won accolades for this work. Research estimates that the city's trees provide $24.9 million worth of benefits annually, more than twice the amount of money the city spends maintaining that asset. $6.8 million of that benefit comes from reduced energy costs for buildings. Minneapolis's entire urban forest is valued as a $756 million asset. Through its Urban Forestry Project, the city offers trees to businesses and residences for a reduced price. Meanwhile, the city frequently ranks high on assessments of greenest cities, best places to live, and healthiest cities.

A variety of studies have found that having more trees by a building or neighborhood is linked to reduced property crimes and violent crimes.

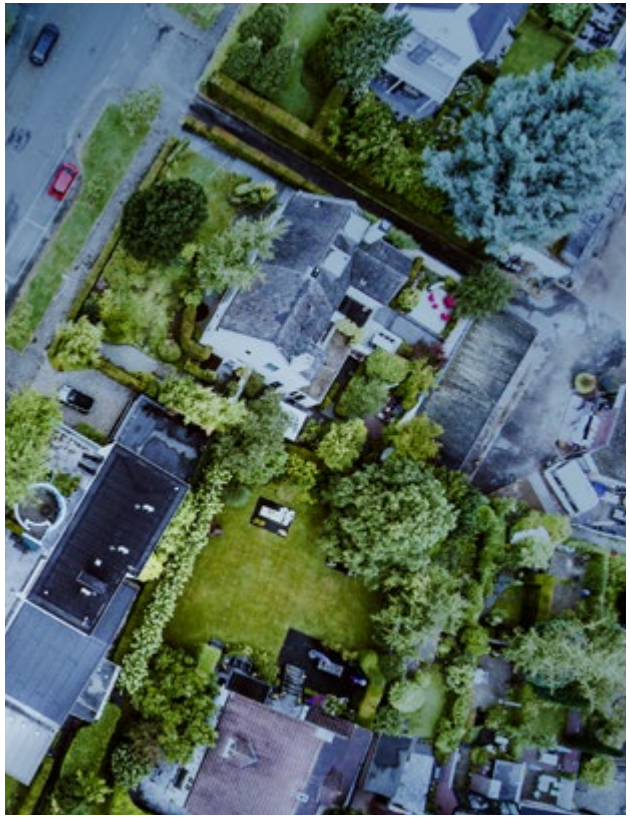
—Vibrant Cities Lab

Global City Spotlights

Chandigarh (IND) | Forests are part of Chandigarh's climate action plan, with a focus both on preservation and new plantings

Los Angeles, California (USA) | Provides free trees to residents in return for their maintenance of the trees; "green angels" program attracts support for tree planting from the real estate community

Shanghai (CHN) | Part of Million Trees program and annually works to add more trees to the city through extensive plantings



Plant-Based Diets

Shift menus to include more plant-based foods

Shift menus to include more plant-based foods, creating opportunities to promote food options that cause fewer climate-related emissions while offering other health and related benefits. Conversely, diets high in meats, especially beef and pork, result in a much higher carbon footprint.

Action Documents

Find documents at rmi.org/carbonfreecities

- Barcelona's "Veg Friendly" city proposal ***(in Catalan)*** source
- Cuiabá's "conscious eating" resolution ***(in Portuguese)*** source
- Two school meatless-meals toolkits ***(in English and in Portuguese)*** source, source

Key Considerations

- ! Food is highly personal and cultural, so cities generally avoid mandates and focus more on providing options
- ☆ Tie educational efforts to native and local foods to build on cultural and regional history
- ☆ Partner with nonprofit organizations to help launch programs
- ☆ Build on the foundation of other food-related commitments, such as Milan's (ITA) Urban Food Policy Pact
- ⇨ Consider plans to become a vegetarian city, such as the mayor of Turin (ITA) has announced



Barcelona, Spain

In 2016, Barcelona (ESP), officially declared itself a "veg-friendly" city and began promoting and supporting vegetarian and vegan diets. To provide more options for people interested in a plant-based diet, the city created a guide and app to help residents and visitors find local food options. Barcelona also created an incubator for entrepreneurs, investors, and consumers. Finally, the city led by example, introducing "meatless Mondays" at all city-owned food services and requiring vegetarian and vegan options at events promoted by the city.



Global City Spotlights

Cuiaba and Varzea Grande (BRA), Oakland and Los Angeles (USA), and Veracruz state (MEX) | Have all introduced a one-day-a-week plant-based diet in schools across the city. Oakland saved $42,000 by cutting animal products served in schools by 30%; the school district also saved 42 million gallons of water and reduced its carbon footprint by 14% annually

São Paulo (BRA) | Worked with a nonprofit partner to create the largest "meatless Monday" program in the world (*Segunda Sem Carne*), offering 1 million vegetarian meals twice a month

China (CHN) | Health ministry released dietary guidelines encouraging the country's population to cut meat consumption by 50%

Marshall, Texas (USA) | Mayor launched a nonprofit to promote a plant-based diet, after his own personal health scare and recovery

"We are proud that the municipality of Cuiabá is leading this important initiative to improve public health and develop more sustainable programs. We know that sustainability is the essential commitment for any serious political management today."

—Emanuel Pinheiro, Mayor of Cuiabá



Right bottom image courtesy of Emanuel Pinheiro

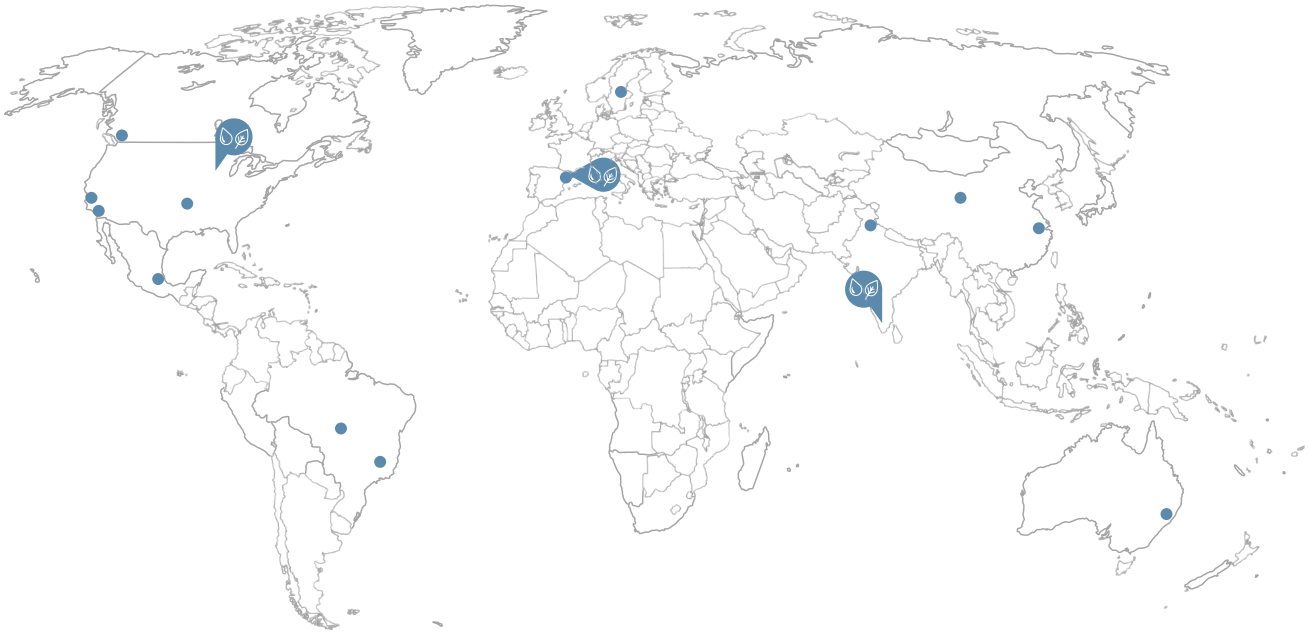
Recommended Resources for Action

20. Organic Waste Diversion - Divert all organic waste from landfills

- *The Polokwane Declaration On Waste Management* source
- *China Zero Waste Alliance* source
- *Managing and Transforming Waste Streams: A Tool for Communities* (U.S. EPA) source
- *Tackling Waste through Community-Based Composting: Bangladesh* (CCAP) source
- *Network of European Zero Waste Municipalities* source
- *European Compost Network* source
- *Zero Waste in Action* - Directory of Zero Waste Communities in U.S. and their policies source

21. Urban Forestry - Invest in urban forestry, parks, and other "green infrastructure"

- *Urban Forestry Toolkit* (U.S. Forest Service) source
- *Funding Trees for Health: An Analysis of Finance and Policy Actions to Enable Tree Planting for Public Health* (The Nature Conservancy) source
- *Carbon Dioxide Reduction Through Urban Forestry: A Guide for Professional and Volunteer Tree Planters* (USDA) source
- *The Sustainable Urban Forest: A Step-by-Step Approach* (USDA, Davey Institute) source
- Tree City's four standards (Arbor Day Foundation and National Association of State Foresters) source
- *i-Tree Tools for Assessing and Managing Forests and Community Trees* (USDA) source
- *inVest*, a tool for valuing ecosystem services (Natural Capital Project) source



22. Plant-Based Diets - Shift menus to include more plant-based foods

- *Milan Urban Food Policy Pact* source
- *The Good Food Institute* source
- *Conscious Eating Brazil* source
- *Conscious Eating Canada* source

To find these Recommended Resources and additional citations from this chapter, please visit rmi.org/carbonfreecities

These 22 recommendations, their action documents, and the additional resources are designed to remove barriers and make it easier for cities take immediate action. Best practices will help cities move from concept to impact.



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The Path Forward

The Carbon-Free City Handbook makes it easier to launch actions within this next year. It does that by removing some of the guesswork about the clear places to start, and by avoiding "analysis paralysis" that can delay action for years. Detailed planning is important, but the world cannot wait for every city to carefully craft its plans for years before taking action. The time to act is now. Still, you have work ahead before anything can be launched.

First, you must choose where to start. Begin with a clear understanding of your city's current priorities, so you can determine how these recommendations align with those priorities. The sector divisions and the benefits icons make it easier to identify which recommendations might best fit your city's current priorities. Then, you will have to "sell" each idea to the decision makers for your community, by recognizing how the various benefits will meet the current priorities.

Cities that have made less progress than their peers may have a great opportunity. Often these cities are better able to "leapfrog" current leaders in the field. The ambitious recommendations in this handbook make it possible to skip the long, arduous process of taking incremental steps, and instead realize the simplicity of moving much farther with a few key actions. By doing so, these cities can move to a leadership position.

You're Not Alone

One key to success is to realize that neither you nor your city has to rely solely on your own resources. Here are three opportunities to gain help in taking action faster:

- **Stakeholder Engagement:** The city can play an important role in inspiring and enabling the citywide community to take action by convening local gatherings to organize making changes. The city can be a catalyst for community-driven actions that have real impact. This engagement is also important to understand the opportunities and limitations within the wider community.

- **Regional Cooperation:** Many cities can achieve greater impact faster by sharing procurement, knowledge, and inspiration with their peers across the region. This approach can help overcome barriers for any single city, while achieving political and financial economies of scale. Some successful examples of this approach include China's Alliance of Pioneer Peaking Cities and Europe's SMARTMR: Sustainable Measures for Achieving Resilient Transportation in Metropolitan Regions, which is a collaboration among eight cities. Collaborating on a local scale is especially useful for finding efficiencies in delivering results. Examples of this approach include the Bay Area Regional Energy Network and the Southeast Michigan Regional Energy Office.

- **Peer Networks:** Many networks exist to help cities show their own leadership, learn from other cities, and accelerate broader solutions. Some of the leading networks for this purpose are C40 cities, ICLEI–Local Governments for Sustainability, and the Carbon Neutral Cities Alliance.

Future Strategies

This may be first of several editions of *The Carbon-Free City Handbook*. The entire community of practitioners is learning and innovating quickly. This book represents a snapshot of the high-impact, no-regrets actions of today, but these are the starting places to reach our goals. We welcome recommendations and suggestions, which we will endeavor to share back with the community.

New strategies are coming that weren't included in this handbook because of our focus on proven solutions. Forward-looking cities may pioneer these practices so that they can become proven strategies for other cities. These future strategies may include cost-effective net-zero energy building retrofits for homes and businesses, renewable approaches for heating and air conditioning, autonomous vehicle programs, local food productions, and demand-side flexibility programs.

We invite cities to reach out to us as they implement high-impact programs like these.

The World Is Moving

Momentum is building around the world. International cooperation sets the stage. Cities should lead the action. If they don't, then others will define the path for them, and a critical engine for growth will be forfeited.

It is no longer a question of whether these changes are coming. It is no longer a question of whether we can wait five years before acting. Don't wait to see what other cities can test; these actions are ready to launch now. Don't wait for other challenges; meeting this one will solve climate, energy, employment, and resiliency, all at the same time. Don't wait for someone else to lead the way; you are the champion the world needs.

Now is the time to move forward, joining in the momentum across the world and defining the path for your community. Show the world how your city makes each of these changes in its own style, building on the history, culture, and leadership that surrounds you. We are all looking forward to seeing what you do. We look forward to joining you to make this the great victory of this generation.

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