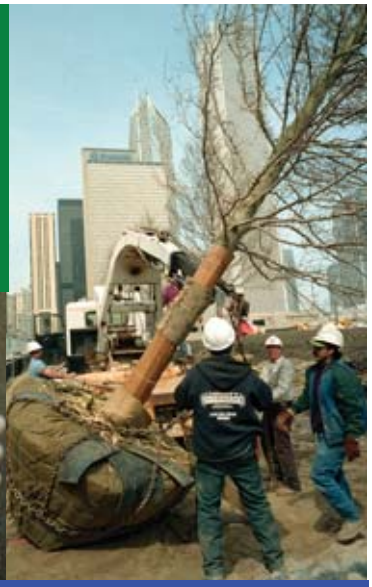
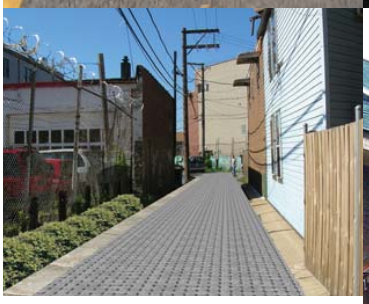
Chicago's Greenhouse Gas Emissions:





An Inventory, Forecast and Mitigation Analysis for Chicago and the Metropolitan Region

CHICAGO CLIMATE ACTION PLAN

Research Summary

The Center for Neighborhood Technology

CNT

Acknowledgments

This research and report are a result of collaboration between many people and organizations.

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A Historic Challenge

Global climate change poses a challenge of historic proportions for Chicago and the world. This summary provides a comprehensive analysis of the scope and scale of that challenge by offering a rigorous accounting of greenhouse gas (GHG) emissions in Chicago and the metropolitan region, an in-depth investigation of their sources, and a description of the likely trends if they are not reduced. This summary also offers a path forward in the form of a portfolio of emission-reduction strategies designed for Chicago. This research is intended to serve as a foundation that will enable Chicago to implement its commitment to reducing GHG emissions.

The Center for Neighborhood Technology (CNT) was commissioned to conduct this research to advise the City of Chicago and the Chicago Climate Change Task Force in their work to create a climate action plan for Chicago. CNT's task was to provide a rigorous accounting of GHG emissions in Chicago and the surrounding six counties, develop a forecast for future emissions, and research mitigation strategies that, when taken to scale and implemented together, could reduce the city's emissions to 25 percent below 1990 levels by 2020.

This research was part of a broader effort by the City to determine the local ramifications of climate change, for its citizens and for City operations. In addition to CNT's work on emissions and mitigation strategies, the City engaged researchers to examine climate-change adaptation, economic impacts, and the effects of climate change on City departments.

There are four main lessons to take away from the research presented here:

1) **Electricity, natural gas, and transportation are the main sources of Chicago's global warming impact**. Ninety-one percent of Chicago's emissions come from these three sectors—therefore most emission reductions must come from these areas.
2) **If no action is taken, Chicago's GHG emissions will continue to grow.** Without mitigation, Chicago's emissions of 12 tons of carbon dioxide equivalent (CO_2e) per capita in 2000 would be expected to grow 35 percent by 2050.
3) **Chicago is part of the solution regionally and globally.** Emissions are growing at a faster rate in the six-county region than in Chicago. Chicago's efficient land use and transit assets allow a household to own fewer autos and drive less than in other areas; encouraging development in location-efficient areas and expanding transportation alternatives can reduce the impacts of growth on the region's emissions. Moreover, as Chicago takes action it will serve as a model for communities around the world.
4) **There is no single cure, but many cures with many benefits.** CNT has identified 33 climate-change-mitigation strategies that, taken together, would allow Chicago to contribute its share to climate stabilization. With early, continuous, and aggressive action, these strategies would reduce Chicago's GHG emissions and bring additional environmental and economic benefits to Chicago.

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Cities are seen as both a cause of global warming and part of the solution. CNT's research over the past decade demonstrates that cities—because of their inherent efficiencies in transportation, communication, and networks—represent a major resource for GHG reduction. But while America's cities are already its most efficient places, major improvements are possible. The 33 mitigation strategies identified by CNT could dramatically reduce GHG emissions in Chicago by using efficiency and innovation to reduce consumption of fossil fuels—the primary source of GHGs in Chicago—and curtail other emission sources, such as waste.

Chicago's Emissions

The first step in addressing Chicago's contribution to global warming is understanding the scope, scale, and source of emissions. To inform this discussion, CNT calculated a GHG emissions inventory for Chicago and the six-county region for 2000 and 2005.

Twelve Tons per Capita

In 2000, Chicago emitted 34.7 million metric tons of carbon dioxide equivalents ($MMTCO_2e$) of greenhouse gases—12 tons for each of Chicago's 2.9 million residents, or 32 tons per household.[1] **Figure 1** shows that Chicago's per capita emissions, excluding air travel, are greater than New York's (7 tons) and London's (6 tons), but less than Denver's (19 tons).

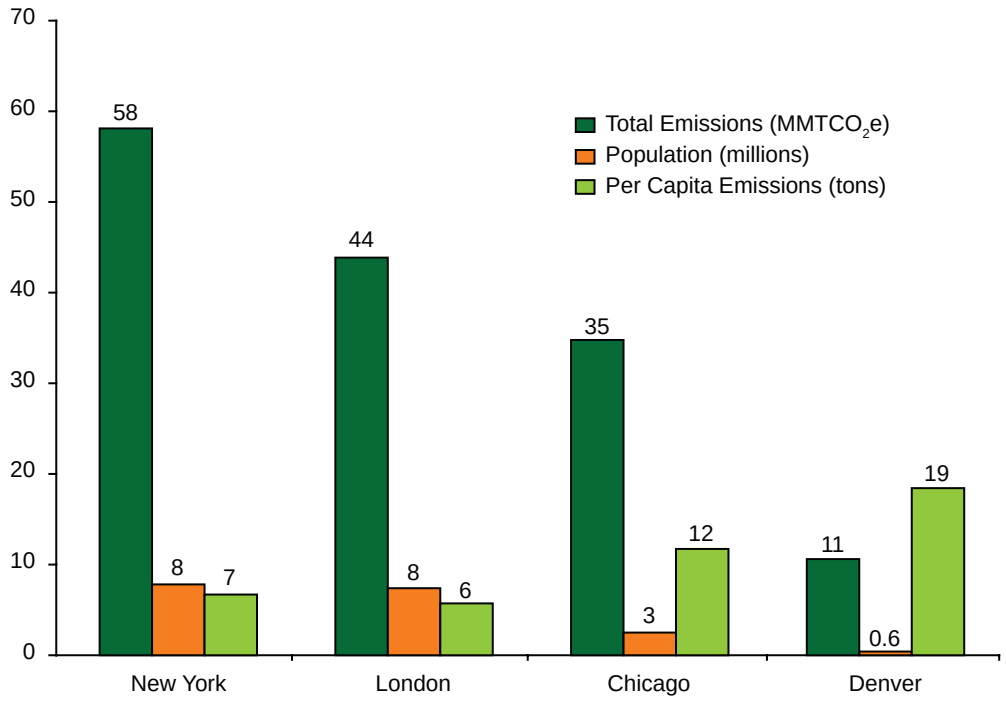

Figure 1 Greenhouse gas emissions of cities.

1 U.S. Census Bureau, "U.S. Decennial Census 2000," www.census.gov.

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Three Main Sources

The majority (91 percent) of Chicago's emissions came from three sources—the consumption of electricity, natural gas, and transportation (**Figure 2**). This is consistent with emission sources nationally and globally.

A Growing Problem

Chicago's GHG emissions are growing rapidly; if no changes are made they are likely to continue to do so for years to come. Emissions grew 4.2 percent between 2000 and 2005 to 36.2 $MMTCO_2e$ (**Figure 3**). U.S. emissions grew 1.6 percent over the same period.[2]

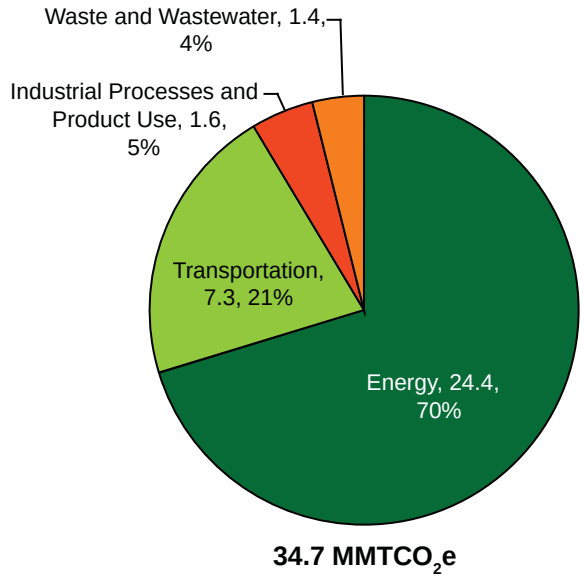

Figure 2: Chicago's Greenhouse Gas Emissions 2000

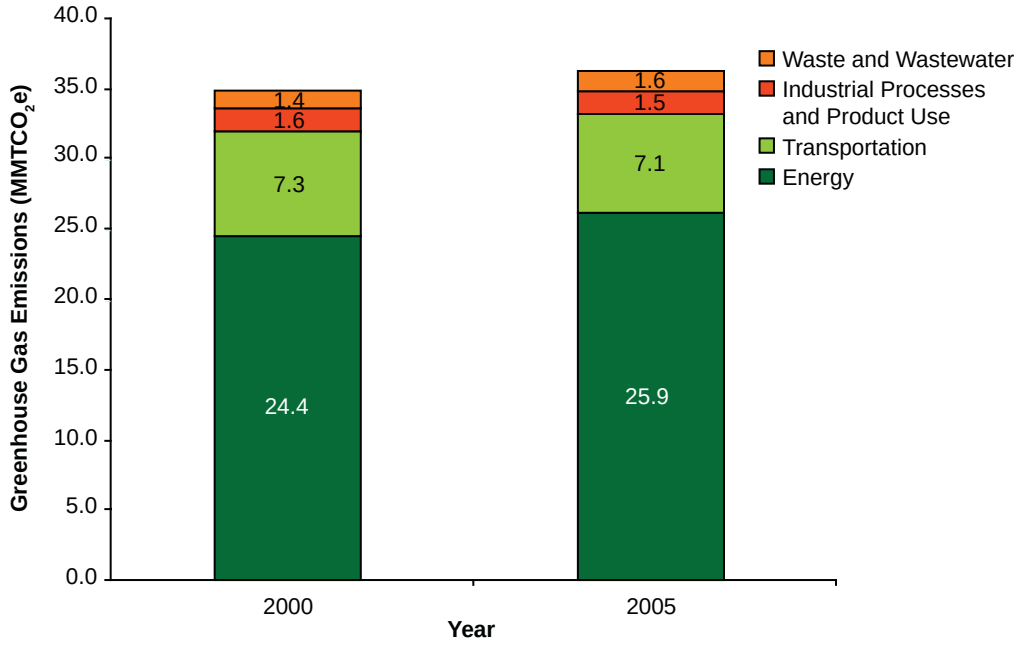

Figure 3: Chicago's Greenhouse Gas Emissions 2000 and 2005

2 U.S. Environmental Protection Agency. Inventory Of U.S. Greenhouse Gas Emissions And Sinks: 1990-2005. April 2007, http://www.epa.gov/climatechange/emissions/downloads06/07CR.pdf.

Local Government Emissions

The City of Chicago is a member of the Chicago Climate Exchange (CCX), a voluntary, legally binding emissions reduction and trading program. As part of its membership, the City reports GHG emissions associated with its operations each year. These emissions are included in Chicago's communitywide inventory and represent approximately three percent of the total. Chicago has met its commitments as a CCX member by lowering emissions and purchasing carbon credits each year.

Rigorous Accounting

CNT used Intergovernmental Panel on Climate Change (IPCC) methods and local data sources, in combination with modeling of national data to local demographics, to document all direct sources of GHG emissions in Chicago and the six-county region, as well as indirect emissions from electricity consumption and waste.

Emissions were calculated for the six major categories of greenhouse gases regulated under the Kyoto Protocol—carbon dioxide (CO_2), methane (CH_4), nitrous oxide (N_2O), hydrofluorocarbons (HFCs), perfluorocarbons (PFCs), and sulfur hexafluoride (SF_6). Emissions were converted into CO_2e using global warming potentials from the IPCC Third Annual Assessment Report.[3] CO_2 formed the majority of Chicago's GHG emissions in all study years.

Metropolitan Region

The geographic boundaries of Chicago are porous. Chicago's economy is regional—every minute of every day, individuals and goods travel in and out of the city. A regional inventory of GHG emissions documents these activities and puts Chicago's emissions inventory in context. A regional inventory also helps document real changes in emissions values, as opposed to shifts in emission sources from city to city. Finally, because many mitigation strategies require regional cooperation, it is important to understand the regional footprint.

Suburban Growth

The six-county area—Cook, Will, DuPage, Kane, McHenry, and Lake counties—had a population of 8.1 million as of the 2000 census. Chicago's 2.9 million residents made up 36 percent of the region. According to the American Community Survey, the region's population grew two percent between 2000 and 2005 to 8.2 million, while Chicago's population fell by almost seven percent over that period to 2.7 million. However, Chicago's population increased about two percent from 2005 to 2006, to almost 2.8 million.

Transportation Greater Share of Total

The Chicago region emitted 105 $MMTCO_2e$ in 2000, or 12.9 tons per capita. As in Chicago, energy and transportation accounted for 91 percent of the regional emissions (**Figure 4**, next page). However, transportation was a larger share of total emissions in the region—31 percent— than in Chicago—21 percent. The 56 million vehicle miles traveled in the region in 2000 was 6,894 miles per capita, 64 percent higher than the 4,214 miles per capita in Chicago. Some of this greater vehicle travel may have been due

3 J. T. Houghton, et. al. (Eds.), Climate Change 2001: The Scientific Basis Contribution of Working Group I to the Third Assessment Report, Intergovernmental Panel on Climate Change, 2001.

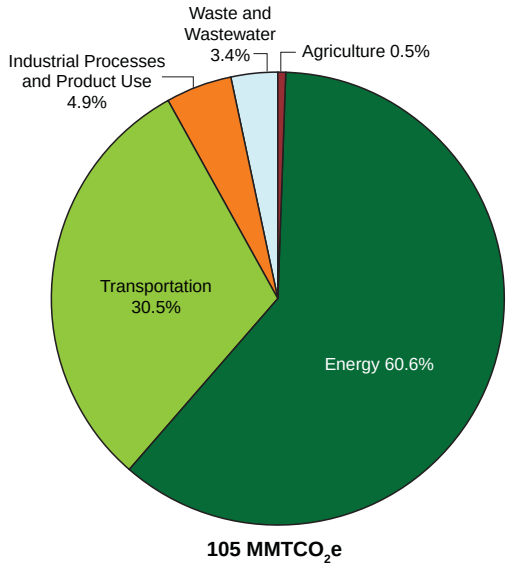

Figure 4: Chicago Region's Greenhouse Gas Emissions 2000

to trucking on the interstates, but CNT's location-efficiency research shows that the efficient land use and transportation alternatives in Chicago enable less auto ownership and reduced driving in the city.

All Regional Sectors Growing Faster than in Chicago

Emissions in all sectors grew at a faster rate in the region than in Chicago, resulting in 10 percent growth between 2000 and 2005 to 116 $MMTCO_2e$, or 13.8 tons per capita. The two main sources of this growth were electricity use and solid-waste generation. If the Chicago region continues on its current path, emissions are expected to grow to 125 $MMTCO_2e$ in 2020 and 169 $MMTCO_2e$ in 2050.

Chicago Forecast

To understand the scale of action required to address GHG emissions in Chicago, CNT needed to determine the emissions likely to occur if no action is taken—"business as usual." CNT analyzed regional and national forecasts and historic trends for GHG emissions and the underlying conditions and activities that generate those emissions, such as vehicle efficiency and natural gas use, to forecast Chicago's emissions through 2050.[4] In addition, an estimate of Chicago's 1990 emissions was created, because 1990 is a common baseline year for emission-reduction targets, but data for 1990 are not easily available at the city scale.

More than Population Growth

If Chicago continues on its current path, its GHG emissions are estimated to grow at an average rate of 0.7 percent annually to 39.3 $MMTCO_2e$ in 2020—a 13 percent increase over 2000 levels—and 47.0 $MMTCO_2e$ in 2050—a 35 percent increase over 2000 levels. This is a faster rate of growth than the eight percent population increase that is forecasted for Chicago between 2000 and 2020.[5] By 2005, Chicago's emissions had already grown 12 percent above the estimated 1990 level of 32.3 $MMTCO_2e$.

4 The forecast was developed using the best available data at the time of the analysis. As discussed on page 46 of the full report, future forecasts will take into account the impact of Illinois Energy Efficiency programs and the 2007 Energy Act and will likely lower the annual growth rates.

5 2030 forecast value of 3,260,897 extrapolated to 2020. Source: Northeastern Illinois Planning Commission. 2030 Forecasts of Population, Households and Employment by County and Municipality. September 27, 2006, http://www.chicagoareaplanning.org/data/forecast/2030_revised/ENDORSED_2030_forecasts_9-27-06.pdf.

Reduction Targets

Climate scientists estimate that a 50-85 percent reduction below 2000 global GHG emissions by 2050 is needed to reach an atmospheric concentration of GHGs at 445-490 ppm and stabilize the climate at 2.0-2.4 degrees Celsius above pre-industrial temperatures.[6]

For Chicago to achieve an 80 percent reduction below 1990 GHG emission levels by 2050, it must start to take action today. Because the United States has been the largest contributor of GHG emissions in the world to date, it can be argued that U.S. emission reductions should go beyond the global average required for climate stabilization. Meeting an interim target of 25 percent below 1990 levels by 2020 would move Chicago toward this larger goal.

Fifteen Million Metric Tons

To meet a 2020 target of 25 percent below 1990 GHG emission levels would require a reduction of 15.1 $MMTCO_2e$ against business-as-usual levels to 24.2 $MMTCO_2e$—7.7 tons per capita (**Figure 5**).

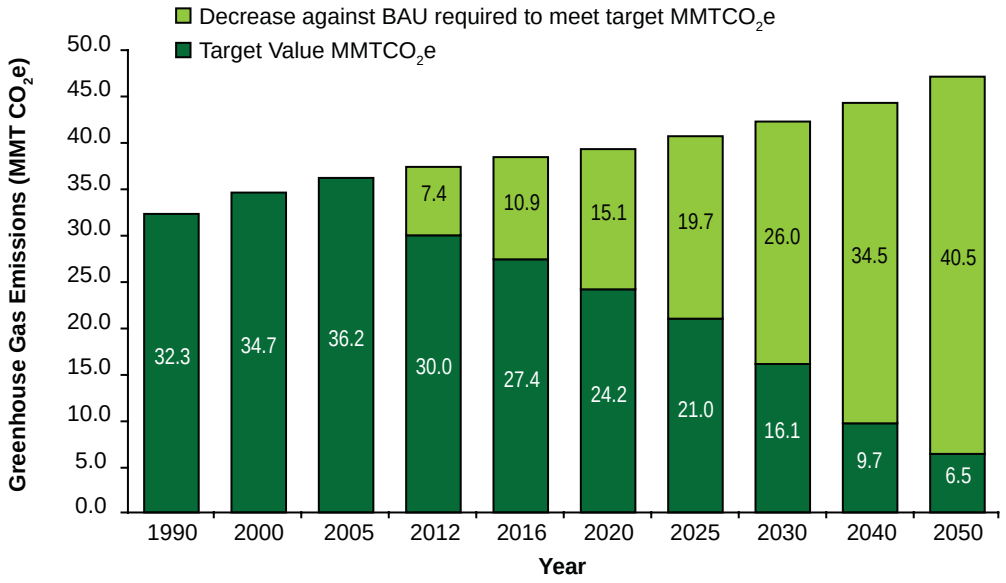

Figure 5: Chicago Business as Usual Greenhouse Gas Emissions and Reduction Targets

6 B. Metz, et. al. (Eds.), Climate Change 2007: Mitigation. Contribution of Working Group III to the Fourth Assessment Report of the Intergovernmental Panel on Climate Change, Intergovernmental Panel on Climate Change, 2007.

Mitigation Strategies

CNT conducted a broad survey of projects and programs that can reduce GHG emissions, soliciting input from stakeholders and researching best practices in communities around the world to identify solutions that suit Chicago. Strategies were evaluated on reduction potential, cost-effectiveness, feasibility, additional benefits, regional impact, and opportunity for rapid deployment. Many programs with smaller emission-reduction potentials were combined into larger strategies that met the scale needed.

Several community and stakeholder meetings informed the research. These meetings included participation by architects, transportation officials, environmentalists, biking advocates, and concerned citizens. A website was developed to solicit ideas for GHG reductions in Chicago, and more than 200 suggestions were submitted. After review of all mitigation ideas, 33 were selected for in-depth research.

Climate change is a global problem; mitigating it is both a national and a local issue. Many strategies to reduce GHG emissions are large-scale, such as changing our electricity infrastructure. But many others, such as residential energy efficiency, are inherently local. This report examines both types of solutions, with a focus on actions Chicago can take by 2020.

Thirty-Three Solutions

No one solution will achieve Chicago's GHG reduction goal; rather, dozens must be implemented simultaneously. CNT researched 33 emission-reduction strategies that, taken together, can meet the goal of reducing 15.1 MMTCO_2e against business as usual by 2020. Two of the strategies, Cap and Trade and Carbon Tax, were researched as umbrella strategies that could enable all of the others; thus, their emissions savings are equal to that of the whole.

The mitigation of climate change will continue well beyond 2020, and will require the participation of all Chicagoans—renters, homeowners, business leaders, educators, investors, and policymakers. The results will be not only fewer GHG emissions, but a better way of living—with less congestion, improved air quality, reduced energy costs for homeowners and businesses, and a cleaner, technologically advanced lifestyle. Chicago can show the world that addressing climate change is not only necessary and possible, but it can also benefit households, businesses, and communities.

CNT analyzed each of the 33 strategies to determine emission-reduction potentials, the nature and scale of the programs and policies necessary, similar activities underway in Chicago and the region that could be built upon, examples of successful programs from other areas, and implementation opportunities and barriers. The complete text of this analysis can be found in the full report, "Chicago's Greenhouse Gas Emissions: An Inventory, Forecast and Mitigation Analysis for Chicago and the Metropolitan Region."

The strategies address every sector of Chicago's emissions inventory. They include strategies to reduce emissions from energy demand and supply; transportation; land cover and forestry; waste and water; and industrial processes and product use. Four framing strategies are presented that influence the implementation of all other strategies through leadership, education and behavior change, measurement, and early action.

Each of these strategies has a role in Chicago's overall climate strategy. While

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they range widely in scale and scope, each one can make a significant contribution to Chicago's GHG reduction effort. In some cases, such as building retrofits, the potential reductions are large and the value of implementation is clear. Some smaller strategies, such as the planting of trees, are valuable components of a broader sustainable strategy because they bring significant additional benefits, or can be relatively easily deployed.

Reaching the ambitious but critical goal of reducing Chicago's emissions 25 percent below 1990 levels by 2020 requires action in all sectors. All the strategies framed here, taken together and deployed at scale, could reach Chicago's overall reduction goal.

Some strategies with the biggest reductions also would bring the biggest economic benefits to residents and businesses. Energy and transportation efficiencies would save Chicago households hundreds or thousands of dollars a year, and would bring substantial savings to Chicago businesses as well. Strategies to reduce energy use in buildings account for approximately 30 percent of GHG reductions analyzed.

Demand-reduction strategies are as critical as supply side strategies for reductions at the city and regional level. Energy savings in buildings and automobile miles not driven can account for nearly half of the targeted emissions reductions. They can take advantage of the inherent efficiency of urban areas, and the extraordinary resources represented by our public transportation network. Employing renewable sources of energy and more efficient vehicles can ensure that the energy we do use is as clean as possible.

Improving energy efficiency of buildings (by increasing insulation, for example) is the biggest single opportunity for greenhouse gas reduction in Chicago.

Improving energy efficiency of buildings is the biggest single opportunity for GHG reduction in Chicago, because 70 percent of Chicago's emissions are generated by electricity and natural gas use. Since 80 percent of the buildings that will exist in 2020 are already built, these strategies must apply to both existing and new structures.

Strategies that expand the opportunities to reduce auto travel will reduce greenhouse gases and improve quality of life. Transportation efficiency accounts for approximately 20 percent of GHG reductions analyzed.

Figure 6 (next page) summarizes the savings of mitigation strategies examined for this analysis. The two umbrella strategies of Cap and Trade and Carbon Tax are not displayed because they are policies that could enable the other strategies. The three framing strategies with indirect benefits are also excluded.

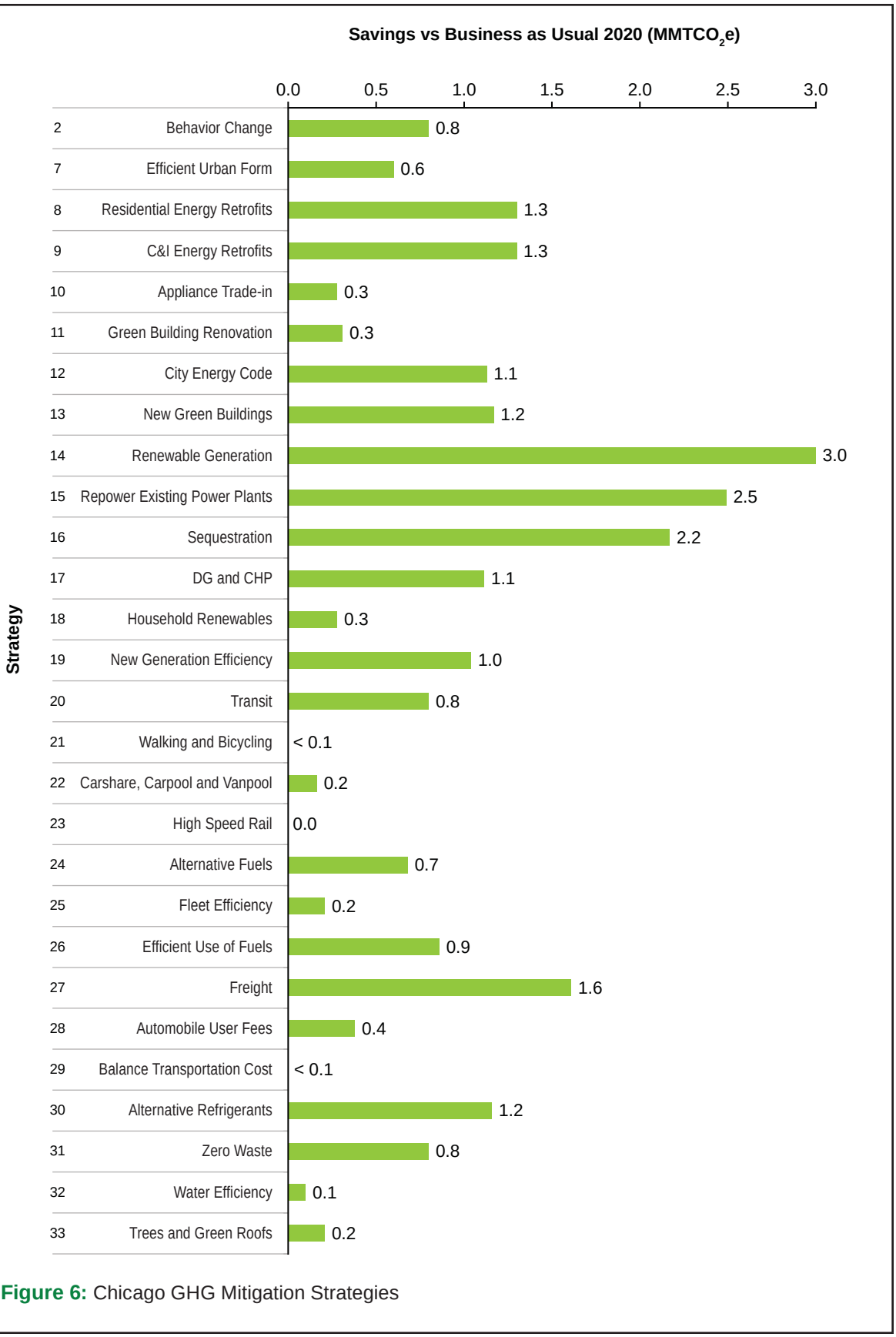

Figure 6: Chicago GHG Mitigation Strategies

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Framing

There are dozens of programs Chicago can implement to reduce its GHG emissions, but several overarching changes are needed to ensure the effectiveness of any emission-reduction strategy. These framing strategies, discussed below as #1-#4, include strong leadership and incentives from the City of Chicago, promotion of behavior change by residents and businesses, measurement and verification, and early aggressive action to reduce emissions.

Mitigation Strategy #1: The City of Chicago Provides Exemplary Leadership on Climate Change Action, Resulting in Affordable Solutions.

The City of Chicago has emerged as a national leader in environmental programs and policies, and is strategically positioned to provide the leadership required to establish a climate action plan and implement mitigation strategies to reduce Chicago's carbon emissions. The City has a number of tools at its disposal—incentives, regulations, financing, high public profile, access to buildings, relationships with state and federal legislators—and can effectively combat climate change while maintaining the city's character and propelling it forward economically.

The City can build on its role as a leader at the municipal, state, and federal level to encourage Chicago residents and businesses to take action. It can foster change on the federal level by leading large cities in an effort to promote supply-side changes in electricity generation and advances in transportation efficiency. The City can also continue to provide leadership in state energy and transportation policy by advocating for funding for energy efficiency and transit infrastructure.

The City has a number of initiatives, including green roofs, SmartBulbs, and pilot recycling programs, that can be expanded and marketed to more residents and would lead to additional GHG savings. Leadership on new initiatives aimed at reducing energy consumption and emissions in buildings, and promoting transit options, would establish the City as an innovator on climate change.

The Chicago Climate Action Plan will not be successful or viable without the City's leadership—from elected officials to department leaders and staff. The City of Chicago could leverage its political weight on the regional, state, national and international levels—developing standardized GHG accounting, streamlining data access, lobbying for regulations and incentives that will reduce GHGs, and applying for funding to implement programs that will result in GHG reductions. The complexity and scale of climate change necessitates debate, political negotiation, dialogue, and sharing of best practices and transparency.

Mitigation Strategy #2: Promote Behavioral Change among Residents and Businesses that Will Elicit Ongoing Response and Action on Climate Change.

GHG Reduction Potential: 0.801 MMTCO$_2$e

In an April 2007 survey of adults nationwide, 52 percent said the issue of global warming was extremely or very important to them personally, with another 30 percent ranking it somewhat important.[7] Despite the rising concern about climate change, our actions do not yet reflect the change needed to solve the problem. Small but significant behavioral

7 ABC News/Washington Post/Stanford University Poll. April 5-10, 2007. N=1,002 adults nationwide. MoE ± 3. Fieldwork by TNS.

Data must be readily available in standard formats that can be accessed by a wide audience to enable informed choices and broad participation in climate action.

changes—turning off appliances and lights, increasing cooling temperatures and reducing heating temperatures by 3 degrees in residential properties, and using programmable thermostats in commercial spaces—can significantly impact CO_2e savings. Translating concern about climate change into personal behavioral change would substantially reduce greenhouse gases.

This strategy could save 0.801 $MMTCO_2e$, of which 0.606 $MMTCO_2e$ are from residences and 0.195 $MMTCO_2e$ are from commercial properties. This assumes that 50 percent of residences (585,000 households) adopt five behavior changes, and 50 percent of commercial buildings (11,200) adopt heating and cooling behavior changes.

An illustrative, not a comprehensive, list of practical behavior changes for residences includes: 1) eliminating one 10-mile car trip per week; 2) reducing heating temperature by 3 degrees; 3) increasing cooling temperature by 3 degrees; 4) turning off three 60-watt bulbs two hours per day; 5) replacing air conditioner filters; and 6) turning off appliances with a ”phantom load,” such as video equipment and electronics.

The program elements for commercial properties include: 1) reducing heating temperatures by 3 degrees and increasing cooling temperatures by 3 degrees; and 2) changing to a programmable thermostat that adjusts temperatures during work and nonwork hours.

Additional benefits of these changes include reduced household expenses (will vary by household, but could be up to $250), and reduced pollution, which leads to increased health benefits. Additionally, making minor, easy changes can develop awareness and willingness that grows to embrace larger changes.

Mitigation Strategy #3: Use Measurement, Verification, Data, and Metrics to Track and Target Actions, and to Continuously Improve Performance.

To monitor progress on emissions reduction goals, it is important to collect data regularly, record changes and strive to improve performance continuously. Moreover, understanding such data geospatially will help target emissions reduction efforts in areas of the city with the highest emissions or the greatest potential for cost-effective reductions. Besides providing the basis for policies and programs, data could be used more effectively in Chicago and the region to identify the best opportunities to mitigate climate change. Ongoing data collection and evaluation will help identify mitigation programs with the most impact, and help evaluate whether limited resources are directed to the most cost-effective strategies.

Data must be readily available in standard formats that can be accessed by a wide audience—including policymakers, community organizations, and the general public—to enable informed choices and broad participation in climate action.

Establishing a GHG baseline not only allows Chicago to understand its emissions sources, but also enables the city to make comparisons over time and to set and measure reduction goals. Measurement and data make mitigation strategies concrete and provide information upon which people can act.

Standardized data collection and dissemination can spark more community involvement and better choices, though there may be concerns about anonymity. While it is useful to have very specific information regarding one’s building or block or neighborhood, it is important to protect the confidentiality of information such as account numbers. Data tells a story and provides knowledge; knowledge shapes choices. Data-informed choices result in cost savings and increased efficiency.

There are costs associated with the analysis of data, evaluation of reduction programs,

and ongoing quality improvement. These include staff time, training on data collection, and dissemination and technology costs, including software packages and web programming. The City of Chicago can minimize these costs by integrating data collection into existing jobs and identifying efficient technology, software packages and support that help fulfill multiple objectives, rather than duplicating efforts.

Framing Strategy #4: Encourage Early Action and Rapid Change.

The greenhouse gases we emit today can last decades, centuries, or even millennia in the atmosphere.[8] With each day that we delay action on GHG mitigation, the problem compounds. In many sectors, solutions are already being implemented, if slowly, using existing technologies. In those areas, increasing the rate of adoption can be just as important as major innovation. This is especially true in situations involving large capital investments and equipment or facilities with long lifetimes. A power plant or skyscraper built today is going to last decades. To reduce the emissions profile of our community in 10 or 20 years, we need to change the decisions being made today.

To spur change, which the market alone is not doing fast enough, the City of Chicago could consider measures that support climate-change mitigation such as implementing incentives, changing regulations and providing financing. For example, through the zoning code, the City can reduce the "off-street parking ratio" while increasing the "minimum bicycle parking ratio"[9] and plan for alternative transportation modes. Changes to the zoning code could also increase tree-planting requirements for parkways and encourage compact development, which results in reduced automobile travel. The City could also offer financing through its Emergency Housing Assistance Program to facilitate weatherization for low-income households.

Early action and rapid change that leads to GHG reductions will also reduce pollution and contribute to improved health outcomes. Other benefits could include increased efficiencies, because people are acting collectively, and job creation, as new industries and practices emerge. Incentives, regulations, and financing could help support change in all households—not just those that can afford purchases such as new hybrid vehicles.

Crosscutting

Strategies #5, 6 and 7 could affect emissions in all sectors of Chicago by changing the economics of GHG emissions through a cap-and-trade or carbon tax, and by changing the land-use patterns that shape our community and its transportation demand.

Mitigation Strategy #5: Enact a Carbon Tax.

GHG Reduction Potential- 15.1 MMTCO$_2$e

A carbon tax could use market forces to reduce emissions of carbon dioxide and other GHGs by internalizing their true social cost, and would tax energy sources that emit GHGs into the atmosphere. A properly executed national carbon tax would place the country, and therefore Chicago, on the way toward achieving the long-term goal of 80 percent reductions from the 1990 level by 2050.

8 Intergovernmental Panel on Climate Change, http://ipcc-wg1.ucar.edu/wg1/Report/AR4WG1_Pub_Ch02.pdf.

9 City of Chicago Department of Zoning. *Ordinance Text, Chapter 10: Parking and Loading.* July 18, 2007. http://egov.cityofchicago.org/city/webportal.

An effective, nationwide carbon tax would reduce the full lifecycle of GHG emissions since it would tax all energy sources emitting GHGs. A local carbon tax would not create as many lifecycle benefits since it would tax users of energy but not suppliers—demand would be affected but not production.

As behavior changed due to rising costs, the result would likely be more efficiency, more conservation, and decreased consumption. A carbon tax would encourage companies to become more efficient and reduce their GHGs, gaining a strategic advantage over competitors. Energy conservation can also offset the energy-price increases to those individuals and businesses that adapt to the changing marketplace.

To be truly effective, a carbon tax must be levied nationally or even globally. It can also be issued at the state or local levels of government. A national carbon tax would have a much greater effect on reducing GHGs than a local one, since energy production creates such a large share of GHGs and energy rarely is generated in the jurisdiction where it is consumed. The biggest benefit of a carbon tax is simplicity, especially when compared to "cap and trade" systems that must be fine-tuned to ensure that the correct amount of emissions—not too high or too low—are factored in from the start.

Mitigation Strategy #6: Enact a Cap and Trade System.

GHG Reduction Potential- 15.1 MMTCO$_2$e

The City of Chicago could realize significant CO_2e savings through support of a cap and trade system, which sets the amount of emissions allowed for different GHG producers (cap) and allows the price of emissions to fluctuate with the market (trade). Cap and trade is considered an effective market solution to curb GHG emissions, since businesses can sell excess polluting credits when they reduce emissions. Companies that reduce emissions have more credits to sell, while larger polluters are forced to buy the credits from them at market rates. To be most effective, a cap and trade system must be implemented across industries on a large scale, or nationally or worldwide, which adds to its complexity.

A properly executed national cap and trade program would place the country, and therefore Chicago, toward the goal of achieving a 25 percent GHG reduction from 1990 levels by 2020 and an 80 percent reduction from 1990 levels by 2050. To effectively reduce GHG in 2020 and beyond, such a system would need to be implemented very soon. The cap would be lowered steadily over time and by 2020 would reach the target of 25 percent reduction from 1990 levels. Like a national carbon tax, a national cap and trade system would reduce the full life cycle of GHG emissions since it would be a limit on all U.S. emissions producers.

With a cap and trade system, the initial allotment of credits must be considered carefully to ensure the market will function correctly. Too many or too few available credits could hamper the system. Also, a system could be set up that would not reward heavy polluters by assigning them more credits than companies that have curbed emissions recently.

Mitigation Strategy #7: Implement Efficient Urban Form.

GHG Reduction Potential: 0.159 to 0.623 MMTCO$_2$e

The nature and form of the built environment contribute to GHG-producing activities that occur in a community, particularly in the energy and transportation sectors. Residents of dispersed, sprawling communities may travel long distances to reach work, school or shopping, most likely in automobiles. In contrast, those who live in compact, dense,

Those who live in compact, dense, transit-rich communities use less energy for travel, heating and cooling.

transit-rich communities make shorter commutes to destinations that are close by. The dense building forms of compact communities—condos, townhouses, and attached housing—use fewer exterior walls and are inherently more energy-efficient than stand-alone buildings.

Efficient urban form is as important as technology and fuel management in reducing GHG emissions, and a directed approach to future development can contribute to carbon reductions. “Smart growth” principles encourage dense, mixed-use, and pedestrian-oriented development. They promote mobility choices—such as transit, car sharing, walking and biking—that reduce reliance on automobiles. The strategy of transit-oriented design (TOD) promotes smart-growth principles by locating compact, mixed-use, walkable development within a half-mile of transit stations, decreasing auto dependency.

In its 2030 plan, the Northeastern Illinois Planning Commission (now part of Chicago Metropolitan Agency for Planning [CMAP]) projects household growth of 106,243[10] for the city and 480,614 in the six-county region by 2020. Thus, the suburbs will add 374,372 households. The business-as-usual growth scenario assumes households will establish themselves evenly across the region, in areas NIPC designated residential in 2001. If smart growth and TOD principles were employed, and the same households were developed within a half-mile of fixed-guide-way transit stations (transit zones) in Chicago and the region, there would be a reduction of 0.159 to 0.623 $MMTCO_2e$ in Chicago. This range of reductions was calculated using the household transportation model published by the Brookings Institution[11] to calculate total driving associated with household location.

10 Chicago Metropolitan Agency for Planning, “Original NIPC 2030 Forecasts,” http://www.cmap.illinois.gov/2030_forecasts_ORIGINAL.aspx.

11 Shelley Poticha, Peter Haas, et. al., “The Affordability Index: A New Tool for Measuring True

Residents of smart-growth communities could see considerable savings due to decreased energy costs and less reliance on automobiles. Research has shown that Chicago-area households in transit-rich neighborhoods pay 15 percent of their income for transportation, as opposed to 23 percent in communities with no transit.[12] Large savings also can be had by making more efficient use of existing infrastructure, such as transportation and energy systems, rather than developing in new areas.

Energy Demand

The majority of Chicago's GHG emissions—70 percent—came from electricity and natural gas use in 2000. That makes energy use the largest target for emission-reduction strategies. Strategies #8-#13 focus on reducing the demand for energy in Chicago's buildings, which will cut energy bills for residents and businesses.

Mitigation Strategy #8: Energy Retrofits in Residential Buildings.

GHG Reduction Potential: 1.80 MMTCO$_2$e

Energy retrofits in existing residential buildings are critical to climate mitigation because 80 percent of the buildings existing today will still be standing in 2020.[13] Residential energy efficiency programs can reduce electricity and natural gas consumption an average of 30 percent by retrofitting homes using existing technologies.[14] Energy-conservation measures (ECMs) address building envelopes, heating, cooling, hot water, lighting systems, and appliances. They do so using insulation, energy-efficient windows, high-efficiency boilers and furnaces, programmable thermostats or energy-management systems, solar or tankless hot water systems, and compact fluorescent bulbs. Technical and financial assistance can help property owners make the best choices and provide them with access to capital to achieve the most savings and best return on their investments.

Residential energy-conservation measures include use of compact fluorescent light bulbs.

It is possible to reduce emissions by 1.3 MMTCO$_2$e in Chicago by implementing energy retrofits in about half of existing residential buildings, assuming an average of 30 percent energy savings per unit. That average is based on a national evaluation of weatherization programs, assuming comprehensive energy retrofits are

Affordability of Housing Choice," The Brookings Institution, http://www.brookings.edu/reports/2006/01communitydevelopment_the-center-for-transit-oriented-development.aspx.

12 Peter M. Haas, Ph.D., et. al., "Housing & Transportation Cost Trade-offs and Burdens of Working Households in 28 Metros," Center for Neighborhood Technology and Virginia Tech, http://www.cnt.org/repository/H-T-Tradeoffs-for-Working-Families-n-28-Metros-FULL.pdf.

13 Pew Center on Global Climate Change, "Working Together … Because Climate Change is Serious Business," http://www.pewclimate.org/global-warming-in-depth/all_reports/buildings/ex__summary.cfm.

14 Martin Schweitzer, "Estimating the National Effects of The U.S. Department of Energy's Weatherization Assistance Program with State-Level Data: A Meta Evaluation Using Studies from 1993 to 2005," Oak Ridge National Labs, http://www.osti.gov/bridge.

implemented and equipment is maintained.[15]

To achieve this reduction, a large-scale energy efficiency initiative must be launched building from Chicago's existing programs (which serve 7,000 units annually in targeted markets), identifying new initiatives for underserved markets, and taking these programs to a much larger scale. The goal is to retrofit 400,000 residential units by 2020.

Residential energy efficiency programs are cost-effective, provide excellent return on investment, and can provide benefits for households and the economy. Chicago could implement innovative and broad strategies to make its housing stock more efficient and make the city a more affordable place to live and work.

Mitigation Strategy #9: Energy Retrofits in Commercial and Industrial Buildings.

GHG Reduction Potential: 1.30 MMTCO$_2$e

Energy retrofits in commercial and industrial buildings could save 1.3 MMTCO$_2$e in 2020. Commercial and industrial energy efficiency programs could achieve an average of 30 percent savings by using existing technologies.[16] The retrofits address building envelopes, heating, cooling, hot water, lighting systems, and plug load. Technologies and strategies used include lighting retrofits, passive day-lighting, recommissioning of buildings, super insulation, energy-efficient windows, high-efficiency boilers and furnaces, heat- recovery systems, energy-management systems, solar or tankless hot-water systems, and high-efficiency equipment to reduce plug load. Technical and financial assistance can help property owners achieve the most savings and best return on their investments.

Emissions could be reduced by 1.11 MMTCO$_2$e by retrofitting 50 percent of existing commercial buildings (9,000) by 2020. Emissions could be further reduced by 0.19 MMTCO$_2$e by retrofitting 50 percent of existing industrial buildings (200) over the same period.

By reducing operating costs, energy efficiency programs provide substantial benefits for commercial-building owners. These programs also have a positive impact on individual buildings. The Building Owners and Managers Association (BOMA) states that commercial office managers in Chicago offer competitive rents and cite reduced operating costs through energy efficiency improvements when competing for tenants. Additionally, tenants often seek "greener office space" to improve employee comfort and meet company goals.[17]

Mitigation Strategy #10: Appliance Trade-in.

GHG Reduction Potential: 0.28 MMTCO$_2$e

Energy-efficient home appliances—primarily air conditioners and refrigerators—cut down on energy use, resulting in GHG reductions. This mitigation opportunity promotes appli-

15 Martin Schweitzer, "Estimating the National Effects of The U.S. Department of Energy's Weatherization Assistance Program with State-Level Data: A Meta Evaluation Using Studies from 1993 to 2005," Oak Ridge National Labs, http://www.osti.gov/bridge.

16 Pew Center on Global Climate Change, "Working Together … Because Climate Change is Serious Business," http://www.pewclimate.org/global-warming-in-depth/all_reports/buildings/ex__summary.cfm.

17 Midwest Energy Efficiency Alliance. *Illinois Residential Market Analysis, Final Report.* May 12, 2003

ance trade-in programs that lower energy consumption. Appliances typically use electricity and are products with relatively short life cycles. In the same vein, changing lighting from incandescent bulbs to compact fluorescent bulbs (CFLs) reduces GHGs. A variety of trade-in programs allow people to replace older and less-efficient appliances or lighting with new and more efficient ones.

This strategy calls for speeding up replacement and more aggressively targeting trade-ins for energy-efficient appliances in low-income communities where residents cannot readily afford new refrigerators and air conditioners. Without aggressive action, pockets of old, inefficient appliances will remain in lower-income households and in rental units regardless of natural turnover, largely due to affordability. For refrigerators, old models are sometimes placed in a basement or garage when a new one is purchased—increasing energy use instead of capturing the energy savings of the new unit.

A potential 0.284 $MMTCO_2e$ could be saved through an appliance trade-in and CFL program that targets 10 to 20 percent of the one million households in Chicago. Beyond the value of reduced energy consumption (e.g., reductions in emissions of CO_2 and other pollutants such as mercury and particulate matter), benefits of replacement programs include better appliances for recipients, reduced electricity costs for households, and increased awareness of energy efficiency.

Mitigation Strategy #11: Green Building Renovation.

GHG Reduction Potential: 0.31 $MMTCO_2e$

The City of Chicago could require that all commercial and residential renovations be rated "green." Green building is defined as a way to "significantly reduce or eliminate the negative impact of buildings on the environment and on the building occupants through sustainable site planning, safeguarding water and water efficiency, energy efficiency, conservation of materials and resources, and indoor environmental quality."[18] The U.S. Green Building Council (USGBC) developed a rating system for green buildings and is considered the country's leading authority on the topic. The USGBC asserts that, in addition to the obvious environmental benefits to building green, there are economic, health and community benefits.[19]

While much media focus regarding green buildings is on new construction, existing buildings also can be renovated to green standards. Renovation typically involves upgrading building systems by insulating walls and the roof, sealing air leaks, replacing windows, upgrading HVAC hot-water systems, replacing appliances with higher-efficiency models, recommissioning building systems to assure they are operated properly, and upgrading lighting systems.

To maximize the energy savings of existing buildings, the City of Chicago could mandate green-building standards for all substantial renovations of residential and commercial buildings in Chicago. The residential sector could adhere to the newly established guidelines of the Chicago Green Homes Program, while the commercial sector could benefit from a similarly structured rating program. The green-building program should include training for involved parties, including industry, tradespeople and homeowners.

Implementing energy retrofits that adhere to green building standards could reduce

18 U.S. Green Building Council, Atlanta Chapter web site, U. S. Green Building Council, http://www.southface.org/web/resources&services/USGBC-atlanta/USGBC-atlanta.htm.

19 U.S. Green Building Council, http://www.usgbc.org/.

While much discussion of green buildings focuses on new construction, existing buildings also can be renovated to green standards.

emissions by 0.31 $MMTCO_2e$. Reductions could amount to 0.19 $MMTCO_2e$ in residential buildings and 0.12 $MMTCO_2e$ in commercial buildings.

According to building permit data, there are an average of 6,000 residential renovations and 100 commercial building renovations each year in Chicago. This strategy proposes retrofitting 60,000 residential units and 1,000 commercial buildings by 2020. It assumes that all residential and commercial renovations beginning in 2010 will be retrofitted to green-building standards.

Mitigation Strategy #12: Update Chicago's Energy Code.

GHG Reduction Potential: 1.13 $MMTCO_2e$

Updating the City of Chicago's energy code to strengthen conservation guidelines and require compliance at the point of property sale could save 1.13 $MMTCO_2e$ in 2020.

Building codes establish minimum standards for structural and mechanical safety of buildings and their systems to protect public health and sanitation. Energy codes have been added to basic building guidelines to make buildings more energy-efficient.[20] The implementation of energy codes can reduce energy use by 15 to 30 percent.[21] A local study of the impact of adopting the International Energy Conservation Code (IECC) found

20 R. Bartlett, M.A. Halverson, and D.L. Shankle, Pacific Northwest National Laboratory, U.S. Department of Energy. *Understanding Building Energy Codes and Standards.* Richland, Washington: 2003. www.energycodes.gov/implement/pdfs/codes101.pdf.

21 L. Kinney, "Energy Performance Workshops: Making the Integrated Design Process Fast and Effective," Boulder, Colorado: Platts.

Overall savings from green building design are more than ten times the initial investment.

that residential buildings in compliance with IECC have annual savings of 25 percent.[22] Chicago adopted its own energy code—the Chicago Energy Conservation Code, modeled after the International Code Council's (ICC) 2001 IECC—in 2003.[23] Full enforcement of the current energy code and any subsequent revisions is needed to realize the full GHG reduction potential of this strategy.

Reaching the full savings potential assumes energy-code compliance is required at the point of sale for residential housing in the City of Chicago, estimating conservatively that five percent of housing units are sold annually—421,000 units between 2010 and 2020. These units would be retrofitted as needed to meet the energy code. A 25 percent energy savings, and corresponding GHG reduction, is anticipated from these retrofits.[24]

The most significant benefit of this strategy is lowered household energy costs. There would be additional benefits to the local economy associated with investment in housing stock and job creation in the building trades.

Mitigation Strategy #13: Green Building for all New Construction.

GHG Reduction Potential: 1.17 MMTCO$_2$e

The City of Chicago could require that all *new* residential and commercial construction be built to green-building standards. If such a comprehensive policy began in 2010, a GHG reduction of 1.17 MMTCO$_2$e in 2020 would result.

Newly constructed residential and commercial buildings built to green-building standards would reduce energy consumption and emissions by 50 percent compared to existing consumption. Assuming all structures are built to the highest standards, the reduction potential would be 0.35 MMTCO$_2$e from residential green buildings and 0.82 MMTCO$_2$e from commercial green buildings—1.17 MMTCO$_2$e total. This assumes that all buildings—6,500 residential and 400 commercial buildings per year—would be built to LEED or equivalent standards.[25]

The costs and savings associated with green building have been well studied. The comprehensive report, "The Costs and Financial Benefits of Green Buildings,"[26] confirms that upfront costs to support green design are, on average, two percent higher than for typical buildings but result in life cycle savings of 20 percent of total construction costs. Overall savings are more than 10 times the initial investment.

Energy Supply

Strategies #8-#13 identify methods for Chicago to reduce emissions and wasted energy by increasing efficiency. Chicago can also reduce emissions by ensuring that the energy

22 R.G. Lucas, Pacific Northwest National Laboratory, U.S. Department of Energy, *Assessment of Impacts from Adopting the 2000 international Energy Conservation Code for Residential Buildings in Illinois.* Richland, Washington: February 2002. www.energycodes.gov/implement/pdfs/illinois_res_final.pdf.

23 Chicago Energy Conservation Code, www.cityofchicago.org.

24 R.G. Lucas, Pacific Northwest National Laboratory, U.S. Department of Energy, *Assessment of Impacts from Adopting the 2000 international Energy Conservation Code for Residential Buildings in Illinois.* Richland, Washington: February 2002. www.energycodes.gov/implement/pdfs/illinois_res_final.pdf.

25 U.S. Census Bureau, "U.S. Decennial Census 2000," www.census.gov.

26 Greg Kats, "The Costs and Financial Benefits of Green Buildings," www.usgbc.org.

it does use is cleaner. Strategies #14-#19 focus on creating a lower-GHG supply of energy. These supply strategies are strongly related to the demand strategies above—the more we can reduce demand, the less supply we will need to clean up.

Mitigation Strategy #14: Build Renewable Electricity Generation.

GHG Reduction Potential: 3.00 MMTCO$_2$e

Photovoltaic (PV) technology and wind power are two proven alternative clean energy sources for utility-scale electricity production. The emissions-reduction potential of this strategy is 3 MMTCO$_2$e and assumes that 20 percent of the emissions associated with fossil fuel-fired electricity plants in the regional power pool are replaced with renewable electricity generation.

In addition to PV and wind power, this strategy explores electricity production from biomass, wave or tidal power, and biogas. These sources are more experimental than PV and wind power, and are more expensive to implement now—expense being the largest barrier to renewable electricity generation. Traditional hydroelectric power has not been included in this analysis because there are only limited opportunities in the region.

Using renewable sources instead of fossil fuel plants will result in GHG savings and other benefits—including reducing air pollutants that harm public health, increasing opportunities for innovation, and creating new jobs. The decommissioning of existing plants and manufacturing of new technology has environmental burdens such as waste generation and material use. But the life-cycle benefits of clean generation outweigh those burdens from a GHG perspective and may do so by other measures as well.

Mitigation Strategy #15: Repower Existing Power Plants.

GHG Reduction Potential: 2.5 MMTCO$_2$e

Repowering existing power plants by moving from coal-powered to natural gas-powered generation can significantly reduce CO$_2$e emissions from electricity generation. Coal has high carbon content and, as a fuel source for electricity, is a large CO$_2$e emitter. Natural gas-fueled plants also emit CO$_2$e, but at a lower rate per kilowatt-hour of electricity.

Repowering a coal plant can be simple or complex. A simple transformation may only require adding new equipment to an existing plant, whereas a more complex model might require installing new, higher efficiency gas generators[27]—a substantial renovation that retools the whole plant and uses only the existing building shell and site. Costs, challenges and reduction potential vary according to the complexity of the transformation.

Repowering the 21 coal-fired power plants in Chicago's regional power pool that are located in Illinois could reduce emissions associated with Chicago's electricity consumption in the amount of 2.5 MMTCO$_2$e. This analytical model uses a consumption-based methodology that accounts for all the plants that make up the regional electricity supply, so Chicago's benefits are scaled in proportion to its share of regional electricity consumption (7.26 percent).

While repowering plants can provide significant environmental benefits, there are a number of challenges. First, yet-to-be-identified capital is needed to cover the implementation costs. Second, given current and projected coal and natural gas prices, and absent a cap and trade or equivalent financing mechanism that prices fuels based on

27 Lee, Henry and Shashi Kant Verma. Coal or Gas: The Cost of Cleaner Power in the Midwest. Cambridge: JFK School of Government, Harvard University, 2000. 31-32.

Incorporating carbon sequestration into all new coal power plants could significantly reduce emissions from power generation.

CO_2e, repowered coal plants would produce electricity that is significantly more expensive than what those plants produce today. Third, the increased consumption of natural gas would further tighten natural gas supplies and put more upward pressure on prices, affecting not just these plants, but the price of natural gas for home heating and for industry.

Mitigation Strategy #16: Sequester Carbon in New Plants.

GHG Reduction Potential: 2.17 $MMTCO_2e$

Incorporating carbon sequestration into all new coal power plants could significantly reduce CO_2e from power generation. Sequestration at all new coal-fired plants in the region would cut Chicago's emissions inventory by 2.17 $MMTCO_2e$.

Coal plants are the largest emitters of CO_2 in the electricity sector and, if new coal plants are built using current technologies, high emissions would continue over the life of those plants. Emerging carbon sequestration technology injects CO_2 from a power plant into underground geological formations. Carbon sequestration is similar in concept to natural gas storage and offers a model for coal-powered electricity generation that could have very low emissions. While coal plants with sequestration will never reach the zero direct GHG emissions of renewables and nuclear power, they could provide the lowest emitting use of fossil fuels.

As energy demand grows, new power plants will be built to serve that demand and to replace older plants that retire. While peak demand is likely to continue to be met with natural gas-fired peaker plants, the options for baseload generation are renewables (addressed in other mitigation strategies), coal and nuclear. Because of the long life—30 to 50 years[28]—of baseload plants, making the right decisions about power-plant construction would affect CO_2e emissions for decades.

Sequestration of carbon from coal-fired power plants is in its early research stages; it is not yet commercially available. Important considerations include: cost; the amount of additional energy required for sequestration; and the geological feasibility of sequestration. However, the high GHG reduction potential of sequestration makes it worth further investigation.

Mitigation Strategy #17: Distributed Generation and Combined Heat and Power Projects.

GHG Reduction Potential: 1.12 $MMTCO_2e$

Chicago can reduce its reliance on central station power plants and increase clean, efficient power generated onsite at local facilities by creating rules and incentives that promote distributed generation (DG) and combined heat and power (CHP) projects. This strategy focuses on the use of DG and CHP to reduce CO_2e from electricity generation.

During the past 100-plus years, the traditional model has been to produce electricity at large central station power plants and move it over electric wires to customers. The efficiency of large power plants was greater than that of small generators, and the structure of the electric industry favored this type of electric system. In the Midwest, it has led to reliance on nuclear power and coal-fired power plants.

With small-scale generation technologies improving and fuel options growing, the

28 Massachusetts Institute of Technology, *The Future of Coal: An Interdisciplinary MIT Study.* Cambridge, MA: 2007, http://web.mit.edu/coal/.

prospect of cleaner, cheaper and more reliable on-site generation that does not suffer losses in the transmission system inherent with central station power has created new interest in both DG and CHP. While on-site renewable energy sources are sometimes considered a form of DG, they are not included in this strategy because their intermittent availability (requiring sun or wind) does not usually provide the power needed for these applications with today's technologies.

DG is typically used when a customer wants to manage peak load for economic, reliability or other reasons. CHP is an extension of DG in which on-site generation balances electricity-generating capacity with recovery of heat from the system for uses such as industrial processes, heating or running cooling systems. It has additional value in terms of energy efficiency and emissions reductions. CHP is well suited to the food industry (manufacturing and retail), hospitals, and institutional campuses such as universities. DG and CHP also are being considered for new commercial, industrial, and large residential developments.

By adopting goals set by the City in its 2001 Energy Plan,[29] there is potential to reduce emissions by 0.685 $MMTCO_2e$ from cleaner electric generation and 0.430 $MMTCO_2e$ from reduced natural gas use for heat.

Mitigation Strategy #18: Household Renewable Energy Generation.

GHG Reduction Potential: 0.28 $MMTCO_2e$

By increasing the use of household-scale renewable power in the form of distributed generation, Chicago can increase clean, efficient power generated locally while reducing reliance on central station power plants. Renewable energy generation on the household level could reduce 0.28 $MMTCO_2e$.

Household DG is on-site generation of electricity that allows families to decrease or eliminate electricity purchased from the electricity grid. Household DG systems include photovoltaic (PV) panels or wind turbines that can be installed on roofs or in yards. Households in Chicago would likely interconnect their home DG systems to the citywide electric grid in order to sell excess power, as well as to purchase power when their home systems do not provide sufficient capacity.

Electricity supply in Illinois comes almost exclusively from large central station power plants that use coal or nuclear power. Natural gas, the primary source of space and water heating in Illinois, is also obtained via a delivery system from a central supply provided by a utility. In recent years, as more fuel options and improved technologies have come to market, generation of renewable household energy has become a viable option that can not only reduce GHGs, but could address supply problems (e.g., power quality and availability), and energy security (e.g., eliminate potential for centralized electricity failure). Proven DG technologies are available, but the adoption rate continues to be low; high initial investment cost is a major barrier.

This strategy assumes that 55,000 housing units would install renewable generation equivalent to 100-percent electricity replacement on each house. It is also assumed that 55,000 housing units would install solar domestic hot water, reducing natural gas consumption by 25 percent per household. Fifty-five thousand housing units represents five

29 City of Chicago Department of Energy, "Chicago's Energy Plan, 2001," egov.cityofchicago.org/webportal/COCWebPortal/COC_EDITORIAL/2001EnergyPlan.pdf.

Renewable energy generation in households (by using photovoltaic panels, for example) could help reduce emissions.

percent of Chicago housing stock.[30]

Mitigation Strategy #19: Establish Efficiency Standards for Electricity Generation.

GHG Reduction Potential: 1.04 MMTCO$_2$e

More efficient fossil fuel generation can contribute significantly to GHG emissions reductions. Strategies to replace fossil fuel generation with renewable generation are viable, but technology can improve the efficiency of existing and newly built fossil fuel generation. Fossil fuels are the energy source for about 70 percent of the nation's generation requirements.[31] Coal, petroleum, and gas are the dominant fossil fuels used by the industry.

30 An analysis of the permit data resulted in projections of 1.13 million housing units in Chicago by 2020 comprised of 842,000 existing units, 153,000 substantially rehabbed units and 137,000 new housing units. This information is from an analysis of permit data provided via the Greater Chicago Housing and Community Development Website, http://www.chicagoareahousing.org.

31 Energy Information Administration, "Electric Power Industry Overview," http://www.eia.doe.gov/cneaf/electricity/page/prim2/toc2.html.

The Energy Policy Act of 2005 (EPAct) encourages energy conservation and efficiency, improved electric reliability, and use of alternative energy sources. EPAct added five new federal standards to the Public Utility Regulatory Policy Act of 1978 (PURPA), one of which, Section 1251(a), sets a standard for fossil fuel generation efficiency. Specifically, "each electric utility shall develop and implement a 10-year plan to increase the efficiency of its fossil fuel generation."[32] These policies promote upgrades of existing plants and efficiency for new plants. Plant upgrades include replacement of equipment, modification of facilities or changes to operating and maintenance (O&M) practices. New plants could be built with the most-efficient-available technology. The policies provide no specific requirements or efficiency goals, and efficiency standards have not yet been implemented in the U.S. Owners of electric generation maintain that standards are not necessary, because electricity markets promote efficiency by creating competition among generators.[33]

Implementing the recommendations in EPAct could reduce Chicago's emissions inventory by 1.04 $MMTCO_2e$, assuming that the efficiency of existing fossil fuel generation improves by 5 percent, and new fossil fuel generation by 13 percent. This assumes that all of the savings result from a reduced plant heat rate in BTUs per kWh. It is based on information from the U.S. Department of Energy, which assumes the efficiency of new plants could be improved by 3 percent to 13 percent.[34]

As fossil fuel-powered plants are made more efficient, there are overall reductions in criteria pollutants.[35] Additionally, many of these plants are the major employers in small, rural communities, and continuing to upgrade and operate these plants benefits the local economy.

Transportation

The second largest source of GHG emissions in Chicago is transportation. The movement of people and goods contributed 7.3 $MMTCO_2e$, or 21 percent, to Chicago's 2000 emissions inventory. Strategies #20-#29 target transportation GHG emissions from three angles: first by increasing mobility options so people can travel by methods other than private vehicles (strategies #20-#23); second by reducing the petroleum used by vehicles (strategies #24-#26); and third by reducing the overall demand for travel (strategies #27-29). These three improvements are all necessary to reduce Chicago's climate-change impact, and each affects the other—as demand for auto travel decreases, demand for vehicle fuels will decrease as well.

Mitigation Strategy #20: Increase Transit Service.

GHG Reduction Potential: 0.83 $MMTCO_2e$

A comprehensive and accessible transit system is the linchpin to a wide network of strategies to reduce carbon emissions in the transportation sector. The key to reducing

32 Energy Policy Act 2005, PURPA Standards Fossil Fuel Generation Efficiency, www.tva.gov/purpa/pdf/efficiency-staff.pdf.

33 CPS Energy, "Preliminary Recommendation on EPACT's Fossil Fuel Generation Efficiency Standard," http://www.cpsenergy.com/files/customer_comment_and_input/EPAct%20Fossil%20Fuel%20Efficiency-PrelimRec(380707_1).pdf.

34 Energy Information Administration, "Annual Energy Outlook 2007 with Projections to 2030," http://www.eia.doe.gov/oiaf/aeo/electricity.html.

35 National Energy Technology Laboratory, http://www.netl.doe.gov.

A comprehensive and accessible transit system is the linchpin to a wide network of strategies to reduce carbon emissions in transportation.

reliance on carbon-intensive vehicle travel is to provide a wide choice of other transportation modes—walking, biking, car-sharing, car pooling, and transit. The potential success of other transportation sector strategies, such as parking cash-out programs and congestion pricing, also depend on convenient public transit.

To provide the comprehensive transit service required to create a system of transportation choices that reduce carbon emissions, the City and CTA could set a goal of increasing transit ridership by 30 percent over 2000 levels by 2020, adding 7.4 million trips per year (beginning in 2000). This would likely require increasing routes and frequency (days and hours of service), as well as a wholesale review of market incentives for various modal decisions, and consideration of priority use of public space by public vehicles.

A firm commitment, in both political will and dollars, is required to ensure that transit is a cornerstone mitigation strategy to reduce transportation-related emissions. Beyond a commitment to maintaining the system, Chicago's transit system can increase service and ridership by increasing bus routes, track miles, accessibility, and frequency. Coordination between transit providers and taxi and car-sharing companies, better signage and information about how to make connections, farecard coordination, and station transfer points can all increase transit use as well. The GHG benefit of increased transit ridership assumes a corresponding reduction of single-vehicle-occupancy use. Additional benefits from increased transit use include lower household transportation costs and improved air quality.

Mitigation Strategy #21: Increase Walking and Bicycling Mode Share.

GHG Reduction Potential: 0.012 MMTCO$_2$e

Walking and biking trips reduce GHG emissions by decreasing the number of auto trips. For the city of Chicago, almost one-third of all trips are one mile or less, and nearly half are shorter than two miles.[36] This strategy recommends doubling the number of total walking and biking trips in Chicago by 2020, by targeting those trip lengths with the most potential—biking trips less than five miles, and walking trips less than one mile.

Doubling bicycle and pedestrian trips in Chicago (adding 490,000 trips) would result in 105,000 fewer vehicle miles traveled per day--an annual GHG reduction of 0.012 MMTCO$_2$e.

Doubling bicycle and pedestrian trips in Chicago would result in 105,000 fewer vehicle miles traveled per day.

Walking offers great health benefits as the most accessible form of exercise, and is considered to be one of the key strategies to confronting the looming obesity epidemic. Additionally, a walkable, bikeable city relieves its residents of the financial burden of owning and operating a car. Other benefits include increased public safety through more “eyes on the street” and increased foot traffic for local businesses.

Mitigation Strategy #22: Increase the Use of Car Sharing, Carpooling and Vanpooling.

GHG Reduction Potential: 0.300-0.511 MMTCO$_2$e by 2020

Car sharing, carpooling and vanpooling can reduce GHG emissions as alternatives to single-occupancy-vehicle travel. The CO$_2$e savings potential ranges from 0.300 to 0.511 MMTCO$_2$e depending on how aggressively each program is implemented.

Car sharing is a program that offers an alternative to car ownership and provides its members access to a fleet of vehicles that can be reserved and paid for on an hourly basis. Insurance, maintenance and gas costs are covered with an hourly and per-mile rate.

Carpooling and vanpooling are based on the idea that, while it is difficult for some to reduce the trips or vehicle miles traveled (VMT) to work, it is quite feasible to double vehicle occupancy—or in the case of vanpooling, to increase occupancy up to 12 people.

The direct benefits of reduced vehicle travel, whether through car sharing, carpooling

36 “Soles and Spokes,” http://www.cmap.illinois.gov/bikeped/ssplandocs.aspx

A regional high speed rail service would provide a competitive travel alternative, especially for smaller cities underserved by airlines.

Car sharing offers an alternative to car ownership and provides its members access to a fleet of vehicles that can be reserved and paid for on an hourly basis.

or vanpooling, include reduced gasoline use, road congestion, criteria air pollution and parking needs for residents and businesses. Users can also see individual cost savings from lowering gasoline use, car maintenance and possibly fewer automobile purchases.

Mitigation Strategy #23: Develop An Intercity High-Speed Rail Network.

GHG Reduction Potential: .006 MMTCO$_2$e

High-speed rail could make intercity passenger travel more efficient—reducing high-emitting passenger-vehicle and air trips less than 500 miles in length. This strategy highlights the plan developed by The Midwest Regional Rail Initiative (MWRRI).[37] The MWRRI is a coalition of federal and state agencies formed in 1996 to identify rail connections, ways to use existing rail, and places to improve intermodal connections to enhance system access in the Midwest.

It is necessary to look at the reduction potential of an intercity high-speed rail network for the entire Midwest, then extrapolate the benefits to Chicago proportionately. For the region, there is a projected annual reduction of 0.09 MMTCO$_2$e. The Chicago portion of that, based on population, would be .006 MMTCO$_2$e (about 6 percent of the total). However, if emissions for air travel are included (they are not included in Chicago's emissions inventory), savings would be 0.19 MMTCO$_2$e in the Midwest, with Chicago's share being 0.012 MMTCO$_2$e.

There are nearly three million residents in Chicago who would have ready access to high-speed rail. The MWRRS assumes a 10-year phase-in from the start time. Corridors with the highest potential ridership would be developed first and may include Chicago-Detroit, Chicago-St. Louis, and Chicago-Twin Cities.[38]

37 Midwest Regional Rail Initiative. A Transportation Network for the 21st Century: Executive Report. February 2000, www.midwesthsr.org/pdfs/railmidwest.pdf.

38 Midwest Regional Rail Initiative. A Transportation Network for the 21st Century: Executive

The MWRRS would provide a competitive travel alternative, especially for smaller cities underserved by airlines. An economic analysis created for the MWRRS found that the system would generate a benefit of $1.80 for each $1 of cost. But the initial cost and time to build the high-speed rail system in this region are challenges. Moreover, while trains in general offer net GHG benefits, the health impacts associated with diesel combustion must be examined more closely to understand their implications. Finally, any expansion in rail corridors must carefully manage wildlife habitat impacts, safety, noise pollution, and traffic congestion at crossings.

Mitigation Strategy #24: Increase Supply and Use of Alternative Fuels.

GHG Reduction Potential: 0.675 MMTCO$_2$e in 2020

Replacing a portion of gasoline with cleaner, alternative fuels can generate moderate savings in Chicago's GHG emissions. Reducing CO_2e per unit of energy—in this case, gallon of fuel—by at least 6.5 percent by 2020 through use of alternative fuels, with a corresponding reduction in gasoline use, would save 440,000 metric tons of CO_2e annually by 2020. A more aggressive, but still feasible, goal would be to reduce emissions through use of alternative fuels by 10 percent by 2020, to save 675,000 metric tons of CO_2e annually by that year.

Current technology permits the use of ethanol, primarily from corn, biodiesel, electricity, and compressed natural gas, as alternatives to petroleum. This strategy examines the emission-reduction potential of an alternative fuel, such as ethanol or biodiesel, that has zero anthropogenic CO_2 emissions at the tailpipe. In the near future, the use of even lower life-cycle GHG forms of ethanol, such as cellulosic ethanol,[39] and greater use of hydrogen and plug-in electric cars could reduce emissions even further. Advanced technologies and alternative fuels are being researched by national laboratories and universities and they are expected to become more financially and technically feasible soon.

Increasing the use of alternative fuels reduces our reliance on oil imports. Other benefits include potential U.S. job creation tied to all aspects of alternative-fuel production and use. Alternative fuels, with low tailpipe emissions, can also reduce criterion pollutants that are direct causes or irritants of asthma.

Challenges need to be overcome to advance this strategy, including the tendency for ethanol and biodiesel blends to get lower gas mileage due to lower energy content than diesel fuels. Also, some alternative fuels cost more than gasoline and most are not yet available for mass consumption. According to the U.S. EPA, not all alternative fuels emit less GHGs during their full life cycle than gasoline.

Mitigation Strategy #25: Increase Fleet Efficiency.

GHG Reduction Potential: 0.209 MMTCO$_2$e in 2020

Vehicle fleets operating in the city of Chicago—commercial, personal, City-owned and operated, Chicago Transit Authority, and car sharing—account for a large portion of vehicle miles traveled within the city and the corresponding GHG emissions. Strategies that require greater fuel efficiency or alternative-fuel use in the fleets the City controls or operates could reduce emissions by 209,000 metric tons of CO_2e annually.

Report. February 2000, www.midwesthsr.org/pdfs/railmidwest.pdf.

39 Cellulosic ethanol is "derived from a wide variety of sources of cellulose (cell wall) plant fiber. These range from stalks and grain straw to switchgrass and quick-growing trees (poplar and willow)—and even municipal waste." Source: About.com, http://alternativefuels.about.com.

Increasing vehicle fleet fuel efficiency would not only help reduce emissions, it would also have other environmental and health benefits.

- By switching 100 percent of the taxi fleet to hybrid electric vehicles with better fuel efficiency, 129,000 tons CO_2e could be reduced annually.[40] [41]
- Assuming each of the 2,600 school buses in the City averages 13,000 miles per year while operating at seven miles per gallon of diesel fuel, replacing current fuel with B20 gasoline could reduce emissions by up to 9,800 metric tons CO_2e annually.[42] [43]
- CTA buses traveled 66.2 million miles in 2000 while getting 3.1 miles per gallon of diesel fuel.[44] Switching to diesel hybrids would save 30 percent of the gas consumed and nearly 70,000 tons CO_2e annually.

Increasing fleet efficiency would have the additional environmental benefit of reducing criteria air pollutants that contribute to smog and harm public health, and would also reduce our dependence on foreign oil. The sustainability of biodiesel at a large scale warrants further research and is of great interest as the market for alternative fuels grows. The use of biodiesel in Chicago also might support agriculture in Illinois. But the growth of biodiesel crops faces the same sustainability concerns as does the current agricultural system in issues such as water quality, wetland protection and pesticide risks.[45]

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40 Unknown Author, "N.Y. Has a Good Taxi Idea—Let's Go Green with Envy," *Chicago Sun Times,* May 25, 2007.

41 Jim Travers, "Rally Cry for a Taxi Revolution," Consumer Reports Cars Blog, http://blogs.consumerreports.org/cars/2007/05/nyc_taxi_gas_re.html.

42 California Environmental Protection Agency. *On Road Motor Vehicle Activity.* May 1995, http://www.arb.ca.gov/research/resnotes/notes/95-9.htm.

43 Mark Clayton, "It's a Plug-in Hybrid—and It's a School Bus," *The Christian Science Monitor,* April 2, 2007.

44 Chicago Transit Authority. *2001 Annual Budget Summary.* http://www.transitchicago.com/downloads/budget/2001sum.pdf.

45 U.S. Environmental Protection Agency. *EPA's National Strategy for Agriculture.* April 25, 2006, http://www.epa.gov/agriculture/agstrategy.html.

Mitigation Strategy #26: Enable More Efficient Use of Fuels.

GHG Reduction Potential: 0.512-0.858 MMTCO$_2$e in 2020

Increasing gas mileage in vehicles can dramatically reduce GHG emissions. Fuel economy standards have been set since 1975 through the Corporate Average Fuel Economy (CAFE), administered by the National Highway Traffic Safety Administration (NHTSA). CAFE standards now require new passenger vehicles to average 27.5 miles per gallon (MPG) of fuel, and new light trucks 22 MPG, for an overall average of 24.7 MPG.[46]

With passage of the Energy Independence and Security Act of 2007, fuel-economy standards are required to be raised to an average of 35 mpg by 2020—the first time the CAFE average has been raised since the 1970s. The bill calls for increasing CAFE standards every year starting in 2011, and raising it to a "maximum feasible rate" between 2021 and 2030.

The City of Chicago could advocate for rapid implementation of the CAFE standards nationally, and implement local policies (such as user fees on auto purchases) that accelerate the use of more fuel-efficient vehicles. A "feebate"—"a tax on vehicle purchases or a rebate given to buyers of new vehicles based on fuel economy"[47]—could be applied to vehicles purchased within the City limits. The City can also encourage more efficient fuel use by applying its Vehicle Idling Management Policy[48] (which limits idling for City vehicles to five minutes per hour while not in traffic) to private vehicles, including trucks and buses.

The goals are viable from both a business and technological point of view. European and Asian countries have standards that are much higher than the standard proposed for the United States by 2020.

Mitigation Strategy #27: Implement Efficient Freight Movement.

GHG Savings Potential: 1.61 MMTCO$_2$e by 2020

The freight industry is a major economic force for Chicago and the region. On rail alone, $350 million worth of goods move to, from and through the region annually.[49] GHG emissions reductions in the city of Chicago could be realized by implementing one or more of these suggestions: 1) moving as much freight by rail and waterborne modes as possible; 2) allowing for swift movement of goods—avoiding as much congestion as possible—where mode shift cannot be accomplished; 3) implementing land use and planning practices that allow the region to lower its GHG impact from freight, encouraging development around this historically valuable asset; and 4) making rail more efficient.

The freight-related GHG reduction potential for Chicago was determined by calculat-

46 National Highway Traffic Safety Administration, "CAFE Overview—Frequently Asked Questions," http://www.nhtsa.dot.gov/cars/rules/cafe/overview.htm.

47 Center for Clean Air Policy, "Transportation Guidebook," http://www.ccap.org/guidebook.

48 City of Chicago Department of Fleet Management, "Vehicle Idling Management Policy," http://egov.cityofchicago.org/city/webportal/portalContentItemAction.do?BV_SessionID=@@@@16577662921182191232@@@@&BV_EngineID=cccfaddlelhgjgjcefecelldffhdfgm.0&contentOID=536929856&contenTypeName=COC_EDITORIAL&topChannelName=Dept&blockName=Fleet+Management%2F2005%2FI+Want+To&context=dept&channelId=0&programId=0&entityName=Fleet+Management&deptMainCategoryOID=-536895658

49 Chicago Metropolis 2020. *The Metropolis Freight Plan: Delivering the Goods.* December 2004, http://www.chicagometropolis2020.org/documents/MetropolisFreightPlan.pdf.

User fees such as congestion pricing and an enhanced parking-pricing system could reduce automobile use.

ing a proportion of the estimated national potential, using the ratio of Chicago's estimated population in 2020 to the national estimate. For every ton-mile of freight moved from truck to rail, emissions would be reduced to 10.3 percent. Therefore, in 2020, if 25 percent of the freight moved by truck could be moved by train instead, the savings would be 124.7 $MMTCO_2e$—and 1.16 $MMTCO_2e$ would be Chicago's share. For every percent of ton-miles of freight moved from truck to rail, there would be a national savings of 5.0 $MMTCO_2e$; Chicago's fraction is 0.047 $MMTCO_2e$.

Strategies to lower GHGs from the freight sector are to move freight by the lowest-impact mode available, or to not move the freight at all. Changing as much freight movement from truck to rail as possible would provide the largest GHG reduction. Implementing the Chicago Region Environmental and Transportation Efficiency Program (CREATE)[50] quickly could reduce congestion on the Chicago regional rail network, reduce shipping delays and avoid idling trains and backups at congested grade crossings. The direct reductions come from reducing the diesel fuel used in moving every ton-mile of freight.

The CREATE Program estimates that the Chicago region would generate $595 million for improved efficiencies for rail passengers and motorists. The CREATE Program also values air-quality improvements at $1.1 billion and construction-related benefits at $2.2 billion.[51]

Mitigation Strategy #28: Enact Automobile User Fees.

GHG Reduction Potential: 0.021-0.381 $MMTCO_2e$ in 2020

User fees such as congestion pricing and an enhanced parking-pricing system could reduce automobile use, resulting in CO_2e savings. Congestion pricing is a user fee to motorists using public roadways, with the goal of reducing congestion and raising revenue. "Congestion pricing" throughout this report refers to "cordon pricing"—charging a fee to enter or drive within a congested area.[52] This approach has been implemented in London, Singapore, and Stockholm and has been considered recently for New York City.

Enhanced parking pricing corrects for the low cost of curbside parking. It raises the cost of parking enough so that parking districts are nearly full—but not completely—so that parkers will be able to find a space in commercial and retail districts without too much driving around, consuming fuel and contributing more to CO_2e emissions.

The Pew Center for Climate Change cites studies that show congestion pricing can reduce vehicle miles traveled VMT from 0.2 percent to 5.7 percent. Applying these findings to Chicago, GHG reductions for city traffic could be between 13,000 and 373,000 metric tons annually in 2020.[53]

Following a methodology and test case laid out by Donald Shoup in "The High Cost of

50 Chicago Region Environmental and Transportation Efficiency Program, http://www.createprogram.org/.

51 Chicago Region Environmental and Transportation Efficiency Program. *CREATE Program Final Feasibility Plan.* August 2005, http://www.createprogram.org/.

52 Federal Highway Administration, U.S. Department of Transportation. *Congestion Pricing: A Primer.* December 2006.

53 David L. Greene and Andreas Schafer, Pew Center for Global Climate Change, "Reducing Greenhouse Gas Emissions from U.S Transportation," www.pewclimate.org/docUploads/ustransp.pdf.

Free Parking,"[54] annual GHG savings in Chicago from an enhanced parking system could be 8,300 metric tons CO_2e. This assumes that parking pricing would be "enhanced" at 25 percent of the City's 28,000 parking meters (based on parking spaces in 2000).[55]

Many congestion pricing systems started as unpopular policies.[56] However, most of the current projects are moving forward, and none would be considered failures by the general populace. Many details would need to be worked out before any system could even be evaluated. When congestion pricing was introduced in London, for example, an extensive transit system was in place that offers viable alternatives to paying the congestion fee. Enhancing public transit would be a critical component of successful congestion pricing in Chicago.

Acceptance of changed meter-pricing mechanisms is more politically feasible than congestion pricing, because its localized revenues could be dedicated to improving the metered area. Outreach to the business community to demonstrate the success of these technologies in other cities could help alleviate fears about the concept.

Mitigation Strategy #29: Balance the Cost of Transportation in Proportion to GHG Production.

GHG Reduction Potential 0.0291 $MMTCO_2e$

Programs that normalize the costs of transportation based on GHG emissions, such as parking cash-out options, city-sticker price variations based on fuel efficiency, and pre-tax transit passes could change the price signals that influence transportation choices and reduce emissions.

The current transportation system benefits automobiles over other means of travel. In Chicago, gas is relatively affordable compared to other nations, roads are mostly free with some inexpensive toll roads, and free parking is supplied by many employers. These costs (or lack thereof), combined with the ease of getting into a car and traveling on one's own schedule, make automobiles the preferred travel method of travel for most people—as shown by the fact that the average Chicago household owned 1.08 cars in 2000.[57]

According to national parking-cost expert Donald Shoup, offering parking cash-outs to six million commuters nationally would reduce commuter travel by 3.9 billion vehicle miles traveled, save 156 million gallons of gasoline, and reduce 2.2 $MMTCO_2e$ per year.[58] Assigning Chicago's savings based on population would yield approximately 20,600 metric tons of CO_2 in savings.

As of October 2003, the CTA and RTA have 1,800 enrolled businesses and 40,000 participating employees in the pre-tax transit program. If this program was expanded by 25 percent, emissions could be cut by 8,480 metric tons of CO_2e.

Parking cash-outs and pre-tax transit passes are recruiting and retention tools for companies. The programs outlined could reduce costs to employers and employees,

54 Donald Shoup, "The High Cost of Free Parking," *American Planning Association* (2005): 351-369.

55 Chicago Public Library, "Facts About Chicago," http://www.chipublib.org/004chicago/chifacts.html.

56 Unknown Author, "A Capital Idea," *The Economist,* February 22, 2007.

57 U.S. Census Bureau, "U.S. Decennial Census 2000," www.census.gov.

58 Donald Shoup, "Parking Cash Out," *American Planning Association* (2005): 104-108.

lessen congestion, lower travel times and improve quality of life. Linking the cost of City stickers to vehicle fuel economy may disproportionately affect low-income households, which typically own and operate older cars that are not as fuel efficient as newer models, but this could be ameliorated through transit passes or rebates for low-income residents.

Industrial Processes and Product Use

Industrial processes and product use accounted for 4.7 percent of Chicago's GHG emissions in 2000. These emissions arise from the manufacturing processes for iron, steel, and electronics and the use of high global-warming-impact gases such as refrigerants by residents and businesses. Mitigation strategy #30 examines the emission-reduction potential of alternative refrigerants in Chicago.

Mitigation Strategy #30: Use Alternative Refrigerants.

GHG Reduction Potential: 1.159 MMTCO$_2$e in 2020

HydroFluoroCarbons (HFCs) have a proportionately larger impact on global warming than more common greenhouse gases, such as carbon dioxide. One ton of HFC-134a has the same global-warming impact over 100 years as 1,300 tons of CO_2, according to the IPCC's Third Assessment Report. This strategy proposes to replace HFCs, used primarily in air conditioners, refrigerators and freezers, with alternative refrigerants.

HFCs are substitutes for the ozone-depleting hydrochlorofluorocarbons (HCFCs) that are being phased out as part of the Montreal Protocol.[59] The end-use sectors emitting the most HFCs are refrigeration and air conditioning (87 percent of the national total), aerosols (9 percent of the national total), and solvents (1 percent of the national total). Motor vehicle air conditioning makes up approximately 43 percent of HFC emissions in refrigeration and air conditioning.[60]

Reducing the business-as-usual forecast for ozone-depleting substitutes in Chicago by 50 percent would reduce emissions by 1.159 MMTCO$_2$e in 2020. The City of Chicago could join the worldwide effort to ban HFCs, since phasing out HFCs would be most effective if done internationally. While California has banned the sale of HFC-134a, it has also been investigating the ban of HFCs altogether, an action taken by the European Union.

Due to the global-warming potential of HFCs and their tremendous growth over the past 15 years, something must be done to curb their use. Although this GHG sector has not received much national attention, it is growing so rapidly that alternatives must be found soon. While manufacturers would likely pass research and production costs to consumers, overall cost is not expected to change much and alternatives should be affordable. But no suitable alternative has yet been agreed to in the European Union, even though its phase-out begins in just four years. Honeywell, DuPont, and other major chemical manufacturers are researching alternatives.

Waste and Water

Solid waste and wastewater treatment accounted for 3.9 percent of Chicago's emis-

59 Environmental Protection Agency, "HCFC Phaseout Schedule," http://www.epa.gov/ozone/title6/phaseout/hcfc.html.

60 Environmental Protection Agency. *2007 Draft U.S. Greenhouse Gas Inventory Report.* February 2007.

sions in 2000. Water use also accounted for some of the emissions in the energy category, due to the energy used to pump, treat, and heat water. Strategies #31 and #32 propose emissions reductions by eliminating landfilled solid waste and using water more efficiently.

Mitigation Strategy #31: Zero Waste Policy.

GHG Reduction Potential: 0.838 - 0.938 MMTCO$_2$e

Chicago and other cities are setting goals to eliminate municipal solid waste—taking steps towards a "zero waste" system, where each unit of energy and material would be somehow reused.[61]

Eliminting *all* waste emissions associated with methane production in Chicago landfills could reduce emissions by 0.809 MMTCO$_2$e by 2020. If 90 percent of all methane producing waste is eliminated, the reduction would be 0.728.

Restructuring the way garbage and recycling are collected offers additional opportunities. Many cities have begun to franchise the collection of waste from large residential and commercial sources. Currently, this waste is collected by private haulers hired by building owners of these buildings, and there is no coherent collection plan. Franchising this operation to a single hauler for each neighborhood would eliminate redundancies in waste collection and remove 2,000 heavy-duty diesel trucks from the streets each day. This would reduce an additional 0.110 MMTCO$_2$e from Chicago, making the total reduction from eliminating waste and reducing collection efforts 0.938 MMTCO$_2$e for a zero waste program, and 0.838 MMTCO$_2$e for a 90 percent program.

Behavior change is a key component of this strategy. Systems would have to be changed at manufacturing companies, and employees would have to be trained to learn how byproducts of processes should be used for non-waste activities. Consumer waste could be reduced significantly by cutting down on packaging materials—which represents a change for both consumers and manufacturers. By increasing public recycling bins and instituting a stronger residential-recycling program, the City could make recycling more widespread.

Mitigation Strategy #32: Reduce Water Supply Use and Manage Water and Sewer Effluents.

GHG Reduction Potential: 0.135 MMTCO$_2$e

In 2006, the City of Chicago purified more than one billion gallons of water per day for use by the residents of Chicago and 124 neighboring suburbs.[62] Emissions related to water are generated from the energy used in pumping, filtration and treatment, distribution, and heating for home use.

Programs that could reduce water-supply use and increase efficiency of stormwater management, which will result in CO$_2$e savings, include: 1) reducing leakage in the distribution system; 2) enhancing industrial efficiency; 3) supporting residential water conservation; 4) reducing turf-grass lawns; and 5) employing green infrastructure measures strategically to reduce CO$_2$e.

Reductions of 0.135 MMTCO$_2$e could result from aggressive water conservation.

61 Jessica Winter, "A World Without Waste," *Boston Globe,* March 11, 2007.

62 City of Chicago, "Chicago's Water Agenda 2003," http://egov.cityofchicago.org/webportal/COCWebPortal/COC_EDITORIAL/wateragenda_1.pdf.

Repairs to leaks in the distribution system, industrial water-efficiency measures, residential water conservation by metering, and reductions in turf-grass lawns that are watered can collectively cut emissions by 0.035 $MMTCO_2e$. Reductions due to green infrastructure could cut another 0.098 $MMTCO_2e$.

The City of Chicago has begun to incorporate green infrastructure in its Green Urban Design and Green Alley programs.

Green infrastructure employs natural systems such as native vegetation and landscape features that filter stormwater before it enters the sewers. A long-term campaign to establish green infrastructure throughout public and private lands in the Chicago region could result in fewer discharges to the tunnel and reservoir plan.

The City of Chicago has begun to incorporate green infrastructure in its Green Urban Design and Green Alley programs, and the recently implemented stormwater management ordinance. These programs reduce energy and water costs to the local government and consumers and help protect natural resources.

Land Cover and Forestry

Chicago's urban forest sequestered 0.0888 $MMTCO_2e$ in 2000, just 0.3 percent of the city's emissions that year. However, urban trees and green roofs provide additional benefits that reduce energy use for heating and cooling, and are examined in mitigation strategy #33.

Mitigation Strategy #33: Reduce Emissions through Tree Planting & Green Roofs.

GHG Reduction Potential: 0.100 - 0.170 $MMTCO_2e$

The City of Chicago is home to more than 200 green roofs totaling more than 2.5 million square feet—significantly more than any other city in the U.S.[63]—and is a leader in planting new trees. Additional trees and rooftop gardens in the city can lower the City's GHG emissions.

By shading and cooling buildings, trees reduce heating and cooling energy use. As trees grow, they take carbon dioxide out of the air and transform it into roots, leaves, bark, flowers, and wood. Through photosynthesis, they store—sequester—the carbon.[64] Protecting, preserving, and improving the life of existing trees is extremely important as older, mature trees have a higher potential for sequestration, especially in the near term.

63 City of Chicago, Department of Environment, *RFP Grant Administration Services,* May 21, 2007.

64 Gregory McPherson, "Urban Tree Planting and Greenhouse Gas Reductions," *Arborist News,* June 2007.

Chicago is a leader in planting new trees.

Green roofs—"roofs planted with vegetation"[65]—can moderate building heat gain and loss and decrease energy load for both heating and cooling. Green roofs absorb the sun's heat energy before it is transferred and absorbed into the building and results in more temperate surface that reduces air conditioning demand. In cold climates, the superior insulation provided by green roofs help reduce heat loss as well. Green roofs improve the efficiency of the roofing system and reduce energy demand in three ways: shading, evaportranspiration and improved insulation (r value).[66]

By increasing the city's tree canopy to 17 percent, and increasing green roof coverage to 7 million square feet by 2020 on a total of 6,000 buildings across Chicago, emissions could be reduced by 0.100 to 0.170 $MMTCO_2e$.

65 U.S. Environmental Protection Agency, "Heat Island Effect: Glossary," http://www.epa.gov/heatisland/resources/glossary.html.

66 Karen Liu, "Energy Efficiency and Environmental Benefits of Rooftop Gardens," *National Research Council Canada* 44, no. 2 (March 2002): 1-14.

Category	Mitigation Strategy		Description	CO_2e Reduction MMT
Framing	1	Provide leadership on climate issues.	Continue and expand City leadership on climate strategy and implementation, including local leadership and strong advocacy in regional, state, and federal legislation and policy.	Framing Strategy
	2	Promote behavioral change among residents and businesses that will elicit continuing response and action on climate change.	Implement widespread educational and action-oriented programs. GHG reduction assumes half of all households and commercial buildings adopt five behavioral changes by 2020 (heating/cooling temperature adjustments, turning off light bulbs, replacing air conditioner filters, and reducing "phantom load").	0.80
	3	Use measurement, verification, data, and metrics to track and target actions, and to continuously improve performance.	Develop, track, and share information on mitigation strategies and results.	Framing Strategy
	4	Encourage early action and rapid change.	Ensure rapid implementation of mitigation strategies.	Framing Strategy
Cross-cutting	5	Enact a carbon tax.	Put leadership capacities behind passing a nationwide carbon tax. Savings assume that a carbon tax would be enacted that reduced national and local emissions to meet target of 25 percent reductions from 1990 levels by 2020.	15.10
	6	Enact a cap and trade system.	Put leadership capacities behind passing a nationwide cap and trade system for greenhouse gases. Savings assume that a cap and trade system would be enacted that reduced national and local emissions to meet target of 25% reductions from 1990 levels by 2020.	15.10
	7	Implement efficient urban form.	Promote transit-oriented development. Calculates benefit from growth in population locating near transit.	0.159-0.623
Energy Demand	8	Energy retrofits in residential buildings.	Retrofit 47 percent of existing residential buildings (400,000 units) by 2020, with 30 percent reduction in energy use/unit.	1.30
	9	Energy retrofits in commercial and industrial buildings.	Retrofit 50 percent of commercial and industrial buildings by 2020 resulting in a 30 percent reduction in energy use/building.	1.30
	10	Appliance trade-in.	Supplement natural turnover of appliances and lightbulbs with targeted appliance trade-in and CFL replacement for low-income households.	0.28
	11	Green building renovation.	Require all commercial (1,000 buildings) and residential (60,000 units) renovations to meet Green Renovation Standards.	0.31
	12	Update and improve enforcement of City energy code.	Update the City of Chicago's energy code to include more stringent conservation guidelines; require compliance at the point of sale of all residential property.	1.13
	13	Provide permitting incentives to new construction green buildings.	Require that all new residential (65,000 new homes) and commercial (4,000 new commercial buildings) construction be built to LEED or equivalent standards by 2020.	1.17

Category		Mitigation Strategy	Description	CO_2e Reduction MMT
Energy Suppy	14	Build renewable electricity generation.	Encourage replacement of fossil fuel-fired plants with renewable plants reducing emissions by 20 percent; contract with alternative electricity generators to supply a portion of the City's power; create tax credits for purchasing energy from low-emitting alternative sources; support Renewable Portfolio legislation in Congress.	3.00
	15	Repower existing power plants.	Repower 21 coal-fired plants in Illinois.	2.5
	16	Sequester carbon in new plants.	New electricity-generating plants use latest carbon sequestration technology.	2.17
	17	Distributed generation and combined heat and power projects.	Adapt goals set in Chicago's 2001 Energy Plan to expand the use of Distributed Generation and Combined Heat and Power projects.	1.12
	18	Household renewable energy generation.	Increase household-scale renewable power (100 percent electric replacement) and solar domestic hot water (25 percent natural gas reduction) to 5 percent of the housing stock.	0.28
	19	Enforce efficency standards for new generation.	Support policies for implementing energy efficiency standards for new and existing fossil fuel generation regionally and nationally.	1.04
Transportation Mobility Options	20	Increase transit service.	Ensure stable funding for mass transit, then increase ridership 30 percent above business as usual.	0.83
	21	Increase walking and bicycling mode share.	Enact measures to double the pedestrian-bicycling mode share to one million trips/day.	0.01
	22	Increase car sharing, carpooling and vanpooling.	Increase car-sharing vehicles by 10 percent annually, carpools by 10 percent, and vanpools by 20 percent over business as usual.	0.30-0.51
	23	Develop intercity high-speed rail network.	Enact measures to generate regional high-speed rail ridership of 13.6 million annually by 2025. *Note: reductions represent only reduced driving by Chicago residents; inclusion of reduced air travel would increase total reduction.*	0.006
Transportation Petroleum	24	Increase supply and use of alternative fuels.	Reduce CO_2e per gallon of fuel by 10 percent through use of alternative fuels.	0.68
	25	Increase fleet efficiency.	Transition all taxis to electric hybrids by 2020; adopt B20 biodiesel for school buses and garbage trucks; use hybrid buses for the CTA. *Note: including all fleets would increase this number.*	0.21
	26	Enable more efficient use of fuels.	4 percent annual increase in gas mileage starting in 2010, through measures such as user fees for vehicle ownership, feebates, increased gas taxes, and anti-idling ordinance.	0.51-0.86
Transportation Demand	27	Implement efficient freight movement.	Increase freight by rail and waterborne modes; allow for swift movement of goods where mode shift cannot be accomplished; implement land use and planning practices to lower GHG impact from freight; make rail more efficient.	1.61
	28	Enact automobile user fees.	Implement a congestion-pricing system by 2020; phase in a market-based parking-pricing system for 25 percent of all metered spaces over a five-year period.	0.02-0.38
	29	Balance the cost of transportation in proportion to GHG production.	Mandate parking cash-outs; vary city-sticker fees based on vehicle fuel efficiency; encourage employers to offer pre-tax transit passes.	0.03

Category	Mitigation Strategy		Description	CO_2e Reduction MMT
Ind. Proc. & Prod.	30	Use of alternative refrigerants.	Influence state and national leaders to begin a phase-out of HFCs, following the model of the Montreal Protocol, and achieve a 50 percent reduction from the business-as-usual forecast for 2020.	1.16
Waste and Water	31	Zero-waste policy.	Implement zero-waste policy. Includes expansion of recycling, requirements for City contracts, elimination of methane emissions.	0.84
	32	Water efficiency.	Reduce water-supply use and manage water and sewer effluents.	0.13
Land Cover and Forestry	33	Reduce emissions through tree planting and green roofs.	Add 500 green roofs and 83,333 trees planted annually by the public and private sectors.	0.10 - 0.17