Chicago Greenhouse Gas Emissions: An Inventory, Forecast, and Mitigation Analysis for Chicago and the Metropolitan Region

An Assessment Prepared for the City of Chicago

Center for Neighborhood Technology
2008
Acknowledgements

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

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This research was commissioned to advise the Chicago Climate Task Force in the development of the Chicago Climate Action Plan. It does not represent official City of Chicago policy.

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Executive Summary

A Historic Challenge
Global climate change poses a challenge of historic proportions for Chicago and the world. This report provides a comprehensive analysis of the scope and scale of that challenge by offering a rigorous accounting of Chicago and the metropolitan region’s greenhouse gas (GHG) emissions, an in-depth investigation of the sources of those emissions, and a description of the likely trends if no action is taken. This report also offers a path forward in the form of a portfolio of emission reduction strategies designed specifically for Chicago. This research is intended to serve as a solid foundation which will enable Chicago to implement its commitment to reducing greenhouse gas 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 commission was to provide a rigorous accounting of the greenhouse gas emissions of the Chicago and the six county region, develop a forecast for future emissions, and research a set of 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 of Chicago to investigate the full ramifications of climate change on the City, both for its citizens and for City operations. In addition to CNT’s work on emissions and mitigation strategies, the City engaged several additional researchers to examine climate change adaptation, economic impacts, and ramifications of climate change for City departments and operations.

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—91 percent of Chicago’s emissions come from these three sectors, therefore most emission reductions must come from these areas as well.

2) **If no action is taken, Chicago’s GHG emissions will continue to grow.** Chicago’s emissions of 12 tons of carbon dioxide equivalent (CO2e) per capita in 2000 will 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 metropolitan region than in Chicago. Chicago’s efficient land use and transit assets can allow a household to own fewer autos and drive fewer miles than in other areas; encouraging development in location efficient areas and expanding transportation alternatives can reduce the impacts of growth on the region. Moreover, as Chicago takes action it will serve as a model for communities around the world.

4) **There is no one single cure, but many cures with many benefits.** CNT has identified 33 climate change mitigation strategies that, taken together, will allow Chicago to contribute its share to climate stabilization. With early, continuous, and aggressive action, these strategies will reduce Chicago’s GHG emissions and bring additional environmental and economic benefits to Chicago.
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 greenhouse gas reductions. America’s cities are already its most efficient places. At the same time, major additional improvements are possible. The 33 mitigation strategies identified by CNT can, when implemented, have dramatic impacts on GHG emissions in Chicago by using efficiency and innovation to reduce our 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 the existing emissions. To inform this discussion, CNT calculated a GHG emissions inventory for Chicago and the six-county metropolitan region for the years 2000 and 2005.

**Twelve Tons per Capita**

In the year 2000, Chicago emitted 34.7 million metric tons of carbon dioxide equivalents (MMTCO2e) of greenhouse gases (GHGs)—12 tons for each of Chicago’s 2.9 million residents, or 32 tons per household. Chicago’s per capita emissions, excluding air travel, are higher than New York (7 tons) and London (6 tons), but lower than Denver (19 tons).
Three Main Sources
The majority (91 percent) of Chicago’s emissions came from three main sources—the consumption of electricity, natural gas, and transportation. This is consistent with emission sources nationally and globally.

Figure 2: Chicago’s Greenhouse Gas Emissions 2000 (34.7 MMT CO2e)

A Growing Problem
Chicago’s greenhouse gas 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 MMTCO2e. US national emissions grew 1.6 percent over the same period.²

Figure 3: Chicago’s Greenhouse Gas Emissions 2000 and 2005
Chicago Climate Analysis

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 business 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 metropolitan 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 (CO2), methane (CH4), nitrous oxide (N2O), hydrofluorocarbons (HFCs), perfluorocarbons (PFCs), and sulfur hexafluoride (SF6). Emissions were converted into CO2e using global warming potentials from the IPCC Third Annual Assessment Report. CO2 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 clearly 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 of the mitigation strategies require regional cooperation for implementation, it is important to understand the regional footprint.

Suburban Growth
The six-county metro 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 from 2005 to 2006 by almost 2% to almost 2.8 million.

Transportation Greater Share of Total
The Chicago region emitted 105 MMTCO2e in 2000, or 12.9 tons per capita. As in Chicago, energy and transportation accounted for 91 percent of the regional emissions. However, transportation was a larger share of total emissions in the region—31 percent—than in Chicago—20 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 increased vehicle travel may have been due to trucking on the interstates, but CNT’s location efficiency research shows that the efficient land use and transportation alternatives in Chicago enable lower 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 ten percent growth between 2000 and 2005 to 116 MMTCO2e, or 13.8 tons per capita. The two main sources of this growth in GHG emissions were electricity use and solid waste generation. If the Chicago region continues on its current path, emissions are forecasted to grow to 125 MMTCO2e in 2020 and 169 MMTCO2e in 2050.
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Chicago Forecast
To understand the scale of action required to address GHG emissions in Chicago, the emissions likely to occur if no action is taken—under “business as usual”—must be forecasted. 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. In addition, an estimate of Chicago’s 1990 emissions was created, because 1990 is a common baseline year for emission reduction targets, yet data for 1990 are not easily available at the city scale.

This report uses the most recently available EIA data for forecasting at the time of writing. These numbers are revised annually, and future forecasts will include recent state and federal legislation, and may forecast a slower growth rate in energy consumption. 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.

More than Population Growth
If Chicago continues on the path it is on, its GHG emissions are estimated to grow at an average rate of 0.7 percent annually to 39.3 MMTCO2e in 2020—a 13 percent increase over 2000 levels—and 47.0 MMTCO2e in 2050—a 35 percent increase over 2000 levels. This is a faster rate of growth than the 8 percent population increase that is forecasted for Chicago between 2000 and 2020. By 2005, Chicago’s emissions had already grown 12 percent above the estimated 1990 level of 32.3 MMTCO2e.

Reduction Targets
Climate scientists estimate that a 50-85 percent reduction below 2000 global GHG emissions by 2050 is required to achieve an atmospheric concentration of GHGs at 445-490 ppm and stabilize the climate at 2.0-2.4 degrees Celsius above pre-industrial temperatures. For Chicago to achieve an 80 percent reduction below 1990 GHG emission levels by 2050 it must start to take action today. Moreover, the US has been the largest contributor of GHG emissions in the world to date, so it can be argued that US emission reductions should go beyond the global average required to achieve climate stabilization. Meeting an interim target of 25 percent below 1990 levels by 2020 would put Chicago on the path to this larger goal.
Fifteen Million Metric Tons
To meet a 2020 target of 25 percent below 1990 GHG emission levels will require a reduction of 15.1 MMTCO2e against business as usual levels to 24.2 MMTCO23—7.7 tons per capita.

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 feasible solutions that suit Chicago. Strategies were evaluated based 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 of the reductions needed.

Several community and stakeholder meetings informed the mitigation strategy research. These meetings included participation by architects, transportation officials, environmentalists, biking advocates, and concerned citizens. A website was developed to solicit ideas for greenhouse gas reductions in Chicago, and over 200 suggestions were submitted. After review of all mitigation ideas, 33 were selected for in-depth research based on their feasibility, potential for CO2e reductions, and capacity for rapid implementation.

Climate change is a global problem with many local solutions. Mitigating climate change is thus both a national and a local issue. Many strategies to reduce greenhouse gas 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 climate change solutions, with a focus on actions Chicago can take by 2020.
Thirty-Three Solutions
There is no one solution that will achieve Chicago’s GHG reduction goal; rather dozens of diverse solutions must be implemented simultaneously. CNT researched thirty three emission reduction strategies that, taken together, can meet the goal of reducing 15.1 MMTCO2e 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 the size of the whole.

The mitigation of climate change is a long term process that 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 in our urban environment - with less congestion, improved air quality, reduced energy costs for homeowners and businesses, and above all a cleaner, technologically advanced way of living. Chicago can be a model for the world to show that addressing climate change is not only necessary and possible, but can benefit its households, businesses, and communities.

CNT analyzed each of the 33 strategies both quantitatively and qualitatively to determine emission reduction potentials, the nature and scale of the programs and policies necessary, similar current activities underway in Chicago and the region that could be built on, examples of successful programs from other areas, and implementation opportunities and barriers.

The emission reduction 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 also presented that influence the implementation of all other strategies through leadership, education, behavior change, measurement, and early action.

Each of these strategies has a role to play in Chicago’s overall climate strategy. While they range widely in scale and scope, each of the strategies analyzed can make a significant contribution to Chicago’s greenhouse gas reduction effort. In some cases, such as building retrofits, the potential reductions are large and the value of implementation is clear. Some smaller strategies, however, 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% below 1990 levels by 2020 requires action in all sectors of Chicago. All the strategies framed here, taken together and deployed at scale, could reach Chicago’s overall reduction goal. Getting there is attainable, but will require action by every sector of Chicago.

Some of the strategies with the biggest reductions are also those that will bring the biggest economic benefits to Chicago residents and businesses. Energy and transportation efficiencies will save Chicago households hundreds, if not thousands, of dollars a year, and will bring substantial savings to Chicago businesses as well. Taken together, strategies to reduce energy in buildings account for approximately 30 percent of greenhouse gas reductions analyzed.

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

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Improving the energy efficiency of buildings is the biggest single opportunity for greenhouse gas reduction in Chicago. With 70 percent of Chicago’s greenhouse gas emissions generated by electricity and natural gas use, energy efficiency is a critical strategy. Because 80 percent of buildings that will exist in 2020 are already built, these strategies must focus on both existing and new buildings.

Expanding the opportunities for reduced auto travel will have a major contribution to greenhouse gas reduction as well as quality of life. Many of the 33 strategies will reduce energy used in transportation, both by residents and businesses. Together, transportation efficiency accounts for approximately 20% of greenhouse gas reductions analyzed.

The following chart summarizes the savings of individual 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 contribute to the implementation of the other strategies. The three framing strategies with indirect benefits are also excluded.

Figure 6: Chicago GHG Mitigation Strategies
## Mitigation Strategies

<table>
<thead>
<tr>
<th>Category</th>
<th>Mitigation Strategy</th>
<th>Description</th>
<th>CO2e Reduction MMT</th>
</tr>
</thead>
<tbody>
<tr>
<td>Framing</td>
<td>Provide leadership on climate issues</td>
<td>Continue and expand City leadership on climate strategy and implementation, including local leadership and strong advocacy in region, state, and federal legislation and policy.</td>
<td>Framing Strategy</td>
</tr>
<tr>
<td>2</td>
<td>Promote behavioral change among residents and businesses that will elicit an ongoing response and action on climate change.</td>
<td>Implement widespread educational and action-oriented programs. GHG reduction assumes half of all households and commercial buildings adopt 5 behavioral changes by 2020 (heating/cooling temperature adjustments, turning off light bulbs, replacing air conditioner filters, and reducing “phantom load”).</td>
<td>0.80</td>
</tr>
<tr>
<td>3</td>
<td>Use ongoing measurement, verification, data, and metrics to track and target actions, and to continuously improve performance</td>
<td>Develop, track, and share information on mitigation strategies and results.</td>
<td>Framing Strategy</td>
</tr>
<tr>
<td>4</td>
<td>Encourage early action and rapid change</td>
<td>Ensure rapid implementation of mitigation strategies.</td>
<td>Framing Strategy</td>
</tr>
<tr>
<td>Cross-cutting</td>
<td>Enact a carbon tax</td>
<td>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 % reductions from 1990 levels by 2020.</td>
<td>15.10</td>
</tr>
<tr>
<td>6</td>
<td>Enact a cap and trade system</td>
<td>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.</td>
<td>15.10</td>
</tr>
<tr>
<td></td>
<td>Implement efficient urban form</td>
<td>Promote transit oriented development. Calculates benefit from growth in population locating near transit.</td>
<td>0.159 - 0.623</td>
</tr>
<tr>
<td>Energy Demand</td>
<td>Energy retrofits in residential buildings</td>
<td>Retrofit 47% of existing residential building stock (400K units) by 2020, with 30% reduction in energy use/retrofitted unit.</td>
<td>1.30</td>
</tr>
<tr>
<td></td>
<td>Energy retrofits in commercial and industrial buildings</td>
<td>Retrofit 50% of the commercial and industrial building stock by 2020 resulting in a 30% reduction in energy use/retrofitted building.</td>
<td>1.30</td>
</tr>
<tr>
<td></td>
<td>Appliance trade-in</td>
<td>Supplement natural turnover of appliances and lightbulbs with targeted appliance trade-in and CFL replacement for low-income households.</td>
<td>0.28</td>
</tr>
<tr>
<td></td>
<td>Green building renovation</td>
<td>Require all commercial (1K bldgs) and residential (60K units) renovations to meet Green Renovation Standards.</td>
<td>0.31</td>
</tr>
<tr>
<td></td>
<td>Update and improve enforcement of City energy code</td>
<td>Update the City of Chicago’s energy code to include more stringent conservation guidelines; and require compliance at the point of sale of all residential property.</td>
<td>1.13</td>
</tr>
<tr>
<td></td>
<td>Provide permitting incentives to new construction green buildings</td>
<td>Require that all new residential (65K new homes) and commercial (4K new commercial buildings) construction be built to LEED or equivalent standards by 2020.</td>
<td>1.17</td>
</tr>
<tr>
<td></td>
<td>Build renewable electricity generation</td>
<td>Encourage the replacement of fossil fuel fired plants with renewable plants reducing emissions by 20%; 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 the Renewable Portfolio legislation in Congress.</td>
<td>3.00</td>
</tr>
<tr>
<td></td>
<td>Repower existing power plants</td>
<td>Repower 21 coal fired plants in the state of Illinois.</td>
<td>2.5</td>
</tr>
<tr>
<td></td>
<td>Sequester carbon in new plants</td>
<td>New electricity generating plants use latest carbon sequestration technology.</td>
<td>2.17</td>
</tr>
<tr>
<td></td>
<td>Distributed generation and combined heat and power projects</td>
<td>Adapt goals set in Chicago’s 2001 Energy Plan to expand the use of Distributed Generation and Combined Heat and Power projects.</td>
<td>1.12</td>
</tr>
<tr>
<td></td>
<td>Household renewable energy generation</td>
<td>Increase household scale renewable power (100% electric replacement) and solar domestic hot water (25% natural gas reduction) to 5% of the housing stock.</td>
<td>0.28</td>
</tr>
<tr>
<td></td>
<td>Enforce efficiency standards for new generation</td>
<td>Support policies for implementing energy efficiency standards for new and existing fossil fuel generation at the regional and national levels.</td>
<td>1.04</td>
</tr>
</tbody>
</table>

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<th>Description</th>
<th>Reduction (2010-2020)</th>
</tr>
</thead>
<tbody>
<tr>
<td>20</td>
<td>Transportation Mobility Options</td>
<td>Increase transit service by ensuring stable funding for mass transit, and then increase ridership 30% above business as usual.</td>
<td>0.83</td>
</tr>
<tr>
<td>21</td>
<td>Transportation Mobility Options</td>
<td>Increase walking and bicycling mode share by enacting measures to double the pedestrian-bicycling mode share to one million trips/day.</td>
<td>0.01</td>
</tr>
<tr>
<td>22</td>
<td>Transportation Mobility Options</td>
<td>Increase the use of car sharing, carpooling and vanpooling by car sharing vehicles increased by 10% annually, carpools by 10%, and vanpools by 20% over the Business As Usual (BAU) forecast.</td>
<td>0.30-0.51</td>
</tr>
<tr>
<td>23</td>
<td>Transportation Mobility Options</td>
<td>Develop intercity high speed rail network by enacting measures to generate regional high speed rail ridership of 13.6 million annually by 2025. Note: reductions represent only reduced driving by Chicago residents; the inclusion of reduced air travel will increase total reduction.</td>
<td>0.006</td>
</tr>
<tr>
<td>24</td>
<td>Transportation Petroleum Use</td>
<td>Increase supply and use of alternative fuels by reducing CO2e per gallon of fuel by 10% through use of alternative fuels.</td>
<td>0.68</td>
</tr>
<tr>
<td>25</td>
<td>Transportation Petroleum Use</td>
<td>Increase fleet efficiency by transitioning the entire fleet of taxis to electric hybrids by 2020; adopt B20 biodiesel for school buses and garbage trucks; hybrid buses for the CTA. Note: including all fleets will increase this number.</td>
<td>0.21</td>
</tr>
<tr>
<td>26</td>
<td>Transportation Petroleum Use</td>
<td>Enable more efficient use of fuels by increasing the mode share of electric and hybrid vehicles by 4% annually and reducing GHG impact from freight; make rail more efficient.</td>
<td>0.51-0.86</td>
</tr>
<tr>
<td>27</td>
<td>Transportation Demand</td>
<td>Implement efficient freight movement by increasing 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.</td>
<td>1.61</td>
</tr>
<tr>
<td>28</td>
<td>Transportation Demand</td>
<td>Enact automobile user fees by implementing 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.</td>
<td>0.02-0.38</td>
</tr>
<tr>
<td>29</td>
<td>Transportation Demand</td>
<td>Balance the cost of transportation in proportion to GHG production by mandating parking cash-outs; vary city vehicle sticker fees based on vehicle fuel efficiency; encourage employers to offer pre-tax transit passes.</td>
<td>0.03</td>
</tr>
<tr>
<td>30</td>
<td>Ind. Proc. &amp; Prod. Use</td>
<td>Use of alternative refrigerants by using influence with state and national leaders to begin a phase-out of HFCs following the model of the Montreal Protocol and achieve a 50% reduction from the BAU forecast for 2020.</td>
<td>1.16</td>
</tr>
<tr>
<td>31</td>
<td>Zero waste policy</td>
<td>Implement zero waste policy. Includes expanding recycling, requirements for City contracts, elimination of methane emissions.</td>
<td>0.92</td>
</tr>
<tr>
<td>32</td>
<td>Water efficiency</td>
<td>Reduce water supply use and manage water and sewer effluents.</td>
<td>0.13</td>
</tr>
<tr>
<td>33</td>
<td>Land Cover and Forestry</td>
<td>Reduce emissions through tree planting &amp; green roofs by assuming 500 additional green roofs and a combined 83,333 public and private trees planted per year.</td>
<td>0.10 - 0.17</td>
</tr>
</tbody>
</table>
Introduction

Global climate change poses a challenge of historic proportions for Chicago and the world. This report provides a comprehensive analysis of the scope and scale of that challenge by offering a rigorous accounting of Chicago and the metropolitan region’s greenhouse gas emissions, an in-depth investigation of the sources of those emissions, and a description of the likely trends if no action is taken. This report also offers a path forward in the form of a portfolio of emission reduction strategies designed specifically for Chicago. This research is intended to serve as a solid foundation which will enable Chicago to implement its commitment to reducing greenhouse gas 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 commission was to provide a rigorous accounting of the greenhouse gas emissions of the Chicago and the six county region, develop a forecast for future emissions, and research a set of 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 of Chicago to investigate the full ramifications of climate change on the City, both for its citizens and for City operations. In addition to CNT’s work on emissions and mitigation strategies, the City engaged several additional researchers to examine climate change adaptation, economic impacts, and ramifications of climate change for city departments and operations.

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—91 percent of Chicago’s emissions come from these three sectors, therefore most emission reductions must come from these areas as well.

2) **If no action is taken, Chicago’s GHG emissions will continue to grow.** Chicago’s emissions of 12 tons per capita in 2000 will grow 35 percent by 2050.

3) **Chicago is part of the regional solution. Emissions are growing at a faster rate in the six-county metropolitan region than in Chicago.** Chicago’s efficient land use and transit assets can 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.

4) **There is no one single cure, but many cures with many benefits.** CNT has identified 33 climate change mitigation strategies that, taken together, will allow Chicago to contribute its share to climate stabilization. With early, continuous, and aggressive action, these strategies will reduce Chicago’s GHG emission and bring additional environmental and economic benefits to Chicago.

Several community and stakeholder meetings informed the mitigation research that led to these conclusions. These meetings included participation by architects, transportation officials, environmentalists, biking advocates, and concerned citizens. A website was developed to solicit ideas for greenhouse gas reductions in Chicago, and over 200 suggestions were submitted. After review of all mitigation ideas, 33 were selected for in-depth research based on their feasibility, potential for CO2e reductions, and capacity for rapid implementation.
INTRODUCTION

Climate change is a global problem with many local solutions. Mitigating climate change is thus both a national and a local issue. Many strategies to reduce greenhouse gas 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 climate change solutions, with a focus on actions Chicago can take by 2020.

Cities are seen as both a cause of the 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 greenhouse gas reductions. America’s cities are already its most efficient places. At the same time, major additional improvements are possible. Widely implemented, these can have dramatic impacts on GHG emissions by using efficiency and innovation to reduce our consumption of fossil fuels—the primary source of GHGs in Chicago—and curtail other emission sources, such as waste.

The mitigation research presented in this report, along with adaptation and economic research developed by the other research partners in this project, was used to advise the City and Task Force as they created the Chicago Climate Action Plan. In order to develop a feasible implementation plan, the mitigation strategies were clustered into action plans for buildings and energy, transit and walkable neighborhoods, green business and industry, and other implementation actions. During this process, a few of the mitigation strategies in this report were adjusted to meet the goals of the action plan. Two of the strategies, a carbon tax and congestion pricing, were not selected for inclusion in the final action plan, but could be considered in future.

These strategies, when implemented simultaneously, can achieve the CO2e reduction target of 25 percent below 1990 levels by 2020. However, the mitigation of climate change is a long term process that 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 reduced GHG emissions, but a better way of living in our urban environment - with less congestion, improved air quality, reduced energy costs for homeowners and businesses, and above all a cleaner, technologically advanced way of living. Chicago can be a model for the world to show that addressing climate change is not only necessary and possible, but can benefit its households, businesses, and communities.
Where We Are Today

Chicago’s Emissions Inventory

Chicago Emissions 2000
In the year 2000, Chicago emitted 34.7 million metric tons of carbon dioxide equivalents (MMTCO2e) of greenhouse gases—12 tons for each of Chicago’s 2.9 million residents, or 32 tons per household.\(^6\) The majority—91 percent—of these emissions came from the consumption of electricity, natural gas, and transportation.

![Figure 7: Chicago’s Greenhouse Gas Emissions 2000 (34.7 MMT CO2e)](image)

Comparatively, the greenhouse gas emissions in the US in 2000 were 7,147 MMTCO2e.\(^7\) Chicago’s emissions inventory is thus just 0.5 percent of the national total, while Chicago is 1 percent of the national population. However, the emissions associated with living and working in Chicago are higher than this inventory would indicate, due to the upstream and lifecycle impacts of the goods and services Chicagoans consume that are produced outside of Chicago. Such lifecycle emissions are difficult to document, but are an important consideration in the overall sustainability of the city and warrant further study.

At 12 tons per capita, Chicago’s emissions are in the range of other large cities that have undertaken GHG emissions inventories. London’s reported 44 MMTCO2e 2006 emissions are six tons per person\(^8,9\); New York’s 58 MMTCO2e emissions in 2005 equate to seven tons per capita\(^10,11\); and the 11 MMTCO2e of similar emissions in Denver in 2005 were equivalent to 19 tons per person.\(^12,13\)

There are many variables affecting a city’s emissions inventory, including the accounting methodology used. Total energy use is key, as is the carbon intensity of that energy. For example, London reports that its electricity emits 0.52 kg CO2 per KWh in 2005\(^14\), while Chicago’s value was 0.609 kg per kWh in 2000.\(^15\) Chicago’s transportation system is another important factor—in 2000, 65 percent of Chicago’s workers used a car, truck, or van to travel to work, compared to 33 percent in New York and 80 percent in Los Angeles.\(^16\) Moreover, Chicago’s hot summers and cold winters require more energy for heating and cooling than is consumed by similar buildings in more moderate climates.
This research was commissioned to advise the Chicago Climate Task Force in the development of the Chicago Climate Action Plan. It does not represent official City of Chicago policy.

Chicago Emissions 2005
The emissions inventory for 2000 was prepared because it was the earliest year for which necessary data were readily available. An emissions inventory for 2005 was also created as the most recent year with complete data. Chicago’s greenhouse gas emissions grew in 2005 to 36.2 MMTCO2e. This was 4.2 percent higher than 2000 emissions levels. Comparatively, US national emissions grew 1.6 percent from 2000-2005 to 7,260.4 MMTCO2e. The relative proportion of Chicago’s emissions sources did not change greatly between 2000 and 2005—Electricity, Natural Gas, and Transportation were again 91 percent of emissions.
This research was commissioned to advise the Chicago Climate Task Force in the development of the Chicago Climate Action Plan. It does not represent official City of Chicago policy.
Methodology

Chicago’s greenhouse gas emissions footprint was calculated for the years 2000 and 2005 using United Nations Intergovernmental Panel on Climate Change (IPCC) methods and local data sources in combination with modeling of national data to local demographics. All data presented are measured in metric tons (tons) or million metric tons (MMT), to enable comparison internationally. Emissions were calculated for all direct sources within the geographical boundaries of the city of Chicago (“Chicago Inventory”) and the six county metropolitan region (“Regional Inventory”).

The inventory includes direct emissions for natural gas, transportation, and industrial process and product use. Indirect emissions were calculated for electricity and waste. Despite the fact that most electricity generation and waste handling facilities are located outside of city boundaries, emissions for the electricity consumed and waste generated by Chicagoans were included in the calculation. On-road transportation emissions were calculated using vehicle miles traveled data. Aircraft fuel consumption emissions for Chicago’s airports were documented, but are not included in Chicago inventory totals.

Emissions were calculated for the six major categories of greenhouse gases regulated under the Kyoto Protocol: carbon dioxide (CO2), methane (CH4), nitrous oxide (N2O), hydrofluorocarbons (HFCs), perfluorocarbons (PFCs), and sulfur hexafluoride (SF6). Emissions were converted into CO2e using global warming potentials from the IPCC Third Annual Assessment Report. CO2 formed the majority of Chicago’s GHG emissions in all study years.

Figure 11: Chicago’s Greenhouse Gas Emissions 2000 (34.7 MMT CO2e)
Energy Emissions
Chicago’s non-transportation energy use emitted 24.4 MMT CO2e in 2000, which was 71 percent of the total citywide emissions. By 2005, energy emissions grew by 6 percent to 25.9 MMT CO2e.

Figure 12: Chicago’s Greenhouse Gas Emissions 2000 (34.7 MMT CO2e) and 2005 (36.2 MMT CO2e)

Energy emissions in this report include emissions associated with electricity and natural gas consumption. Other non-transport energy sources (for example, kerosene and propane) were investigated and data for Chicago were unavailable. However, electricity and natural gas are 96 percent of the energy use in the area.¹⁹

Chicago’s greenhouse gas emissions from energy use were nearly evenly split between electricity and natural gas in 2000, but in 2005 electricity emissions grew while natural gas emissions shrunk.

Figure 13: Chicago’s Greenhouse Gas Emissions 2000 (34.7 MMT CO2e) and 2005 (36.2 MMT CO2e)
Electricity Emissions

Electricity emissions were calculated by gathering electricity consumption data from the local utility, Commonwealth Edison, and applying CO2 emissions factors associated with the local North American Electric Reliability Council region from the U.S. EPA’s Emissions & Generation Resource Integrated Database (eGRID) and other emissions factors from the California Climate Action Registry General Reporting Protocol. Electricity consumption, in terms of kilowatt hours (kWh), was measured based on user account data, and transmission and distribution losses were not included.

The 25 percent growth in electricity emissions was due in part to a 14 percent growth in non-transport electricity consumption from 21 billion kWh to 24 billion kWh. The emissions from electricity consumption are also calculated based on the average emissions from all power plants in the North American Electric Reliability Council region, or regional power pool. In addition to any real changes within the electric supply, the boundaries of the power pool that includes Chicago changed between 2000 and 2005. The resulting emissions factor for electricity grew nine percent from 2000 to 2005; in 2000 it was 0.609 kg per kWh and in 2005 it was 0.664 kg per kWh.

![Figure 14: Chicago's Greenhouse Gas Emissions 2000 (34.7 MMT CO2e) and 2005 (36.2 MMT CO2e)](image)

Electricity emissions in the residential sector grew 34 percent and electricity consumption grew from 5.5 to 6.8 billion kWh from 2000 to 2005. The commercial and industrial sector emissions also grew in that period, 36 percent, but this may be correlated with a drop by 53 percent in emissions in the “other” sector, which includes sales to public agencies and street lighting—the classification of accounts between these sectors may have changed between 2000 and 2005 creating an artificial shift in emissions. Taken together, these two non-residential sectors emissions grew 21 percent as electricity use increased from 15 to 17 billion kWh from 2000 to 2005.

**Crawford and Fisk**

While this study measured electricity consumption, there are two large electricity generation facilities in Chicago, the Crawford and Fisk coal fired power plants. These two plants are included in the regional power pool that makes up the GHG emissions factor for electricity, so their emissions impact is already included in this research, but it is worthwhile to discuss their individual impacts briefly as they are prominent features of Chicago’s energy landscape.

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The Crawford plant has a generating capacity of 805 MW and produced 2.8 billion kWh of net electricity and 2.9 MMTCO2 in 2000. It had an emissions factor of 1.04 kg per kWh—172 percent of the regional power pool average of 0.609. The Fisk plant is slightly smaller with a generating capacity of 663 MW in 2000. Fisk produced 1.5 kWh of net electricity and 1.63 MMTCO2 for an emissions factor of 1.06 kg per kWh. Taken together, these two plants produced 21 percent of the electricity consumed in Chicago, but their emissions were equivalent to 35 percent of the CO2 emissions from Chicago’s electricity consumption. These two plants make up approximately 1 percent of the electricity generated in the regional power pool. The link between these two generation facilities and Chicago’s GHG emissions inventory is complicated by the fact that the electricity produced is not sold to Chicago’s local utility, Commonwealth Edison (ComEd), so even though the electricity at the plants is generated in Chicago, from a contractual perspective it is not consumed in Chicago.

Figure 15: Crawford and Fisk Electricity Generation and Chicago Electricity Consumption

<table>
<thead>
<tr>
<th></th>
<th>2000</th>
<th>2004/2005a</th>
<th>Change in Generation</th>
<th>Change in CO2</th>
<th>Change in Emissions Factor</th>
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</thead>
<tbody>
<tr>
<td></td>
<td>Net kWh</td>
<td>CO2 MMT</td>
<td>kg CO2 per kWh</td>
<td>Net kWh</td>
<td>CO2 MMT</td>
</tr>
<tr>
<td>Crawford Generation</td>
<td>2,786,241,400</td>
<td>2.90</td>
<td>1.04</td>
<td>2,982,597,000</td>
<td>3.27</td>
</tr>
<tr>
<td>Fisk Generation</td>
<td>1,542,572,600</td>
<td>1.63</td>
<td>1.06</td>
<td>1,790,543,000</td>
<td>1.86</td>
</tr>
<tr>
<td>Total</td>
<td>4,328,814,000</td>
<td>4.53</td>
<td>1.05</td>
<td>4,773,140,000</td>
<td>5.13</td>
</tr>
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<td>Chicago Consumption</td>
<td>21,030,669,028b</td>
<td>12.86c</td>
<td>0.609c</td>
<td>24,028,494,904b</td>
<td>16.02</td>
</tr>
<tr>
<td>Total as Percent of Chicago Consumption</td>
<td>21% 35% 172%</td>
<td>20% 32% 162%</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

a. At the time of this research the most recent data year for eGRID was 2004 (V 2.0), so all generation information and emissions factors are 2004 data. Chicago’s electricity consumption is 2005 data.
b. Chicago’s electricity consumption discussed in this section is non-transport electricity. Transport electricity is discussed in the transportation section.
c. Total consumption including transport electricity was 21.4 million kWh in 2000 and 24.4 million kWh in 2005.

Nuclear Power

The contractual issues surrounding electricity generation and consumption further complicate Chicago’s emissions inventory, as the ComEd’s environmental disclosure statements show that its electricity supply was 75 percent nuclear power in 2000 and 89 percent nuclear power in 2005. Though nuclear power is not free from environmental impacts, it has no direct greenhouse gas emissions. As a result, ComEd reports CO2 emissions factors of 0.232 and 0.221 kg per kWh in 2000 and 2005 respectively—or about one third as carbon intensive as the regional power pool average.

After consulting with experts, the decision was made to use the regional power pool average emission factor rather than this utility reported factor for this research, because it is becoming more standard to look at the emissions associated with electricity consumption in the same way the market looks at electricity. Power plants take years to build and last decades, so a decrease in electricity demand in one location, like Chicago, does not generally result in a power plant shutting down. Most likely it means that the power generator will simply sell that electricity elsewhere. If demand is reduced system-wide, generators might reduce production. Over time, if there is less demand for electricity fewer new power plants might be built.

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The dynamic market for electricity makes the regional power pool—the grid-connected area over which electricity is likely to be traded—a better description of the electricity used any given area and its environmental impacts. Moreover, the nuclear generation facilities in the region are included in the regional power pool average emissions factors. Nevertheless, if one were to apply Commonwealth Edison’s emissions factors to Chicago’s non-transport electricity demand, the resulting emissions would be 4.94 MMTCO2e in 2000 and 5.36 MMTCO2e in 2005—7.91 and 10.7 MMTCO2e below the emissions levels presented in this study for those years respectively, a substantial portion (23 and 29 percent) of the total emissions inventory for the city.

One lesson to take from this discussion of nuclear power and Chicago’s coal plants is that reducing the GHGs associated with electricity consumption requires a two-pronged approach: the demand for electricity must be reduced through efficiency, conservation, and innovation—and demand reduction is often the most cost effective emission mitigation strategy; but the supply of electricity must also be sustainably decarbonized so that the production of power produces fewer emissions without producing any additional negative environmental consequences.

Natural Gas Emissions
Natural gas emissions were calculated by gathering natural gas consumption data from People’s Energy and from the ICC for the Nicor Gas service territory, and applying a natural gas emissions factors from the U.S. EPA’s Inventory of U.S. Greenhouse Gas Emissions and Sinks and the IPCC 2006 Guidelines for National Greenhouse Gas Inventories. In many ways the accounting of natural gas emissions is much more straightforward than that of electricity, because it is combusted on site, so the consumer of the energy is the same entity as the direct emitter of the greenhouse gases, making the allocation of emissions more clear.

Natural gas use in Chicago fell 14 percent from 2000 to 2005 with the largest drop—34 percent—in the industrial sector from 300 million to 200 million Therms. The residential sector fell 13 percent from 1.5 to 1.3 billion Therms, while the commercial sector stayed level at 350 million Therms. Some of the change can be attributed to variability in temperature and heating needs and there may be some variability from year to year as to how gas users are classified by sector. The emissions factors used for natural gas were the same in 2000 and 2005 at 5.31 kg CO2, 0.527 g CH4, and 0.0105 g N2O per Therm.

Since such a large portion of electricity and natural gas use in Chicago heats and cools our buildings, the use is very dependent on the weather. This trend is seen in the residential sector: the number of cooling degree days—a measure of how hot weather is and how much air conditioning might be used—was 52 percent higher in 2005 than in 2000, and the residential electricity usage was 23 percent higher. Similarly, the number of heating degree days—a measure of how cold weather is and building heating needs—was 3 percent lower in 2005 and residential natural gas use was 13 percent lower. Year-to-year variations in weather will always be a factor in Chicago’s energy use and GHG emissions inventories, and global warming may change those patterns over time by requiring more cooling in summer and less heating in winter. However, with better weatherization of buildings and cleaner energy sources Chicago can keep its buildings a comfortable temperature without increasing its emissions.
This research was commissioned to advise the Chicago Climate Task Force in the development of the Chicago Climate Action Plan. It does not represent official City of Chicago policy.
Chicago’s per household electricity usage is lower than that of the average U.S. household, the average household in the East North Central census region (Illinois, Wisconsin, Michigan, Indiana, and Ohio), or the average household in a U.S. city according to data from the U.S. Department of Energy’s Residential Energy Consumption Survey 2001. However, Chicago’s residential natural gas usage is higher on a per household basis than households in any of these regions.

It is more difficult to compare Chicago’s commercial and industrial energy use to national or regional averages. The U.S. Department of Energy’s Commercial Building Energy Consumption Survey (CBECS) does offer a point of reference, but because the size and use in commercial buildings varies so much, it’s difficult to make comparisons. However, the average electricity and natural gas usage among the 728,000 buildings in the East North Central region in the CBECS and the estimated 22,448 commercial buildings in Chicago were compared. It is estimated that Chicago’s commercial buildings use 93 percent of the electricity in the Commercial and Industrial Sectors (12 billion kWh) and the 250 million Therms of the natural gas in the Commercial Sector. This analysis shows that Chicago uses twice as much electricity and natural gas per building than in the average in the East North Central region—535,355 kWh and 15,573 Therms per commercial building in Chicago. It is unlikely that Chicago’s commercial buildings are simply half as efficient as other buildings in the region, therefore, this data requires further analysis using information on square footage, building age, building type, occupancy, and type of establishment.
Figure 20: Electricity and Natural Gas Use in Commercial Buildings

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**Transportation Emissions**

Transportation is the second largest source of GHG emissions in Chicago. Excluding the airports, transportation emitted 7.3 MMTCO2e in 2000 and 7.1 MMTCO2e in 2005. In 2000, transportation was 21 percent of Chicago’s GHG emissions.

**Figure 21: Chicago's Greenhouse Gas Emissions 2000 (34.7 MMT CO2e) and 2005 (36.2 MMT CO2e)**

Transportation emissions were developed using vehicle miles traveled data from the Illinois Department of Transportation and Amtrak\(^{30,31}\); fleet mix data from the Lake Michigan Air Directors Consortium (LADCO)\(^32\); vehicle efficiency data from the Federal Highway Administration\(^33\); and fuel sales and usage from the City of Chicago Department of Revenue, City of Chicago Department of Aviation, U.S. Department of Energy, and the National Transit Database.\(^{34-36}\) Emissions factors for transportation are from the U.S. EPA’s Inventory of U.S. Greenhouse Gas Emissions and Sinks and State Inventory Tool.\(^{37,38}\)

**Figure 22: Chicago Transportation Emissions 2000 (7.12 MMT CO2e) and 2005 (6.85 MMT CO2e)**
On road vehicles, including cars, trucks, and motorcycles, generated the majority of transportation GHGs in Chicago in 2000 and 2005—91 percent. The 3 percent decrease in total GHGs in this sector from 7.12 MMTCO2e in 2000 to 6.85 MMTCO2e in 2005 was largely due to an increase in the weighted average fuel economy for the vehicles on the road in Chicago from 16.5 miles per gallon (mpg) to 18.7 mpg, using Federal Highway Administration data. Vehicle efficiency increased between 2000 and 2005 for every vehicle type except light-duty gasoline, diesel trucks, and motorcycles.

The total vehicle miles traveled (VMT) in Chicago increased 3 percent between 2000 and 2005 from 12.2 billion to 12.6 billion miles per year. VMT in the U.S. grew 9 percent over the same period. The VMT in Chicago was 0.4 percent of the 2.7 trillion miles traveled by vehicles in the U.S. in 2000.

The vehicle mix and proportion of the total VMT traveled was obtained from LADCO for the Chicago Area Transportation Study (CATS) area in 2005 and assumed to be applicable for Chicago and in 2000. Annual data for Chicago only would improve the accuracy of these estimates. According to the LADCO data, the majority of VMT, 91 percent, were driven by gasoline passenger cars and light-duty trucks. Diesel heavy-duty vehicles were the third largest share of VMT at 7 percent, and they were the third largest share of GHG emissions as well. At an average of 5.8 miles per gallon in 2000, these trucks emitted 1.4 MMTCO2e over 893 million miles. As a share of total VMT, light and heavy-duty trucks are a higher proportion in Chicago than they are nationally—52 percent in Chicago versus 41 percent nationally in 2000. The share of passenger cars is lower at 48 percent versus 58 percent nationally. This impacts Chicago’s GHG emissions, as trucks generally have lower fuel economies and higher emissions than passenger cars.
Based on the vehicle miles traveled and vehicle mix, the fuel consumption of the on road vehicles in Chicago was calculated to be 741 million gallons of fuel in 2000, 80 percent of which was gasoline and 20 percent of which was diesel. In 2005 the on road fuel consumption was estimated at 755 million gallons, with 82 percent gasoline and the remainder diesel. The gasoline consumed was assumed to be 6.2 percent ethanol in 2000 and 9 percent in 2005 based on Illinois data from the U.S. Department of Energy, Energy Information Administration. Ethanol is added to gasoline in Chicago as an oxygenate to reduce air pollutant emissions. Because ethanol is derived from plants, which absorb CO2 from the atmosphere, rather than fossil fuels, the CO2 released upon combustion does not contribute to global warming. Therefore the ethanol portion of the estimate gasoline use is excluded from CO2 calculations.

The net result is that an average gasoline powered passenger car driven in Chicago emitted 0.39 kg CO2e per mile in 2000 while a light-duty gasoline truck, such as an SUV, emitted 0.49 kg Co2e per mile – 27 percent more.
This research was commissioned to advise the Chicago Climate Task Force in the development of the Chicago Climate Action Plan. It does not represent official City of Chicago policy.

Figure 26: Vehicle Emissions kg CO2e per Mile by Type

According to the U.S. Census, Chicago residents had 1.15 million personal vehicles in 2000—or 1.08 per household. CNT has found in its other research that access to transit and bikeable and walkable neighborhoods strongly influences not only vehicle ownership but the distance a vehicle is driven.

Fuel Method
In addition to estimating on road transportation emissions using VMT, data was gathered on fuel sales from the City of Chicago Department of Revenue. The on road portion of this fuel was estimated at 584 million gallons in 2000 and 529 million gallons in 2005, 21 percent and 30 percent below the fuel consumption estimated using VMT data. It was decided to base this emissions inventory on VMT rather than the fuel data for on road transportation because fuel sale data may exclude those who go outside city boundaries to purchase fuel, and the 9.5 percent drop in fuel sales between 2000 and 2005 could not be easily explained.

Off Road
Emissions associated with off road transportation were estimated based on fuel consumption and accounted for 10 percent of Chicago’s transportation emissions in 2000 and 2005—0.687 MMTCO2e and 0.657 MMTCO2e respectively. According to the National Transit Database, Metra, the Chicago regional commuter rail system, consumed 23.9 million gallons of diesel fuel in 2000, generating 0.244 MMTCO2e. In 2005, Metra’s fuel consumption increased to 24.1 million gallons and its emissions increased slightly to 0.247 MMTCO2e. At 1.6 billion reported passenger miles, Metra’s GHG emissions were 0.15 kg per passenger mile in 2000.

Based on data from the local utility, ComEd, electricity consumed by transportation in Chicago was 331 million kWh in 2000, generating 0.202 MMTCO2e. Most of this can be attributed to the Chicago Transit Authority (CTA), operators of Chicago’s “L”, elevated electric train system. The CTA reported consuming...
359 million kWh in 2000 in the National Transit Database. In 2005 electricity use associated with transportation increased 23 percent to 406 million kWh and the associated emissions increased to 0.271 MMTCO2e. The CTA’s reported electricity use in the National Transit Database was 409 million kWh in 2005. At a reported 1 billion passenger miles per year, the CTA’s GHG emissions were approximately 0.20 kg CO2e per passenger mile in 2000.

Emissions for Amtrak regional and long-distance rail emissions in Chicago were estimated at 0.01 MMTCO2e in 2000 and 2005 based on VMT and vehicle efficiency data in Chicago provided from Amtrak. Chicago was one of the nation’s busiest Amtrak locations with 2.5 million passengers riding Amtrak to or from Chicago in 2005. As with air travel and cargo, which are discussed further below, the total emissions associated with Chicago Amtrak passengers is much greater than what is emitted within Chicago boundaries, and for most purposes regional and long distance rail emissions should be examined at a geographic scale larger than a city.

Chicago is a major shipping hub, and cargo rail emissions in the city were 0.23 MMTCO2e in 2000 based on 22 million gallons of diesel fuel consumed as reported by the City of Chicago’s Department of Revenue. Cargo rail emissions fell to 0.13 MMTCO2e in 2005, as reported fuel consumption fell to 13 million gallons. It is not clear that this decrease is a trend however, as multimodal shipping using rail is gaining popularity in the U.S.

There are other off road transportation emissions sources that were not captured in this inventory, because data was unavailable. These sources include fuel consumed by marine transportation, construction equipment, business equipment (i.e. forklifts), recreational equipment (i.e. golf carts), and lawn and gardening equipment. None of these is likely to be significant for Chicago; marine transportation uses 5 percent of transportation energy nationally, and other off road sources not addressed here, including agricultural equipment, use 8 percent of the national total. Moreover, one would expect these off road emissions sources to be relatively small compared to the other sectors considered in this inventory.
uses of petroleum to be included in fuel sales data, but as is discussed above, the fuel sales data collected was lower than that estimated using VMT for on road transportation. Future research should investigate the off road uses of fossil fuels in Chicago in further detail.

Chicago's Aviation Emissions
The City of Chicago is concerned about greenhouse gas emissions from the operations at O'Hare and Midway Airports. However, there is currently no specific guidance or generally applied practice for computing airport-level GHG emission inventories. The Transportation Research Board (TRB) has commissioned a study to develop a guidebook to prepare airport source-specific inventories of greenhouse gas (GHG) emissions. When that guidebook is completed, the City will undertake that analysis.
Industrial Processes and Product Use

Industrial processes and product use generated 1.6 MMTCO2e in 2000, or 5 percent of the city total GHG emissions and 1.5 MMTCO2e in 2005, or 4 percent of the total. The activity data in this sector are very difficult to find on at the city level, so the emissions of this sector are estimated as a proportion of national emissions as reported by the U.S. EPA. Many of the emissions in this sector are compounds with high Global Warming Potentials (GWP)—they have relatively large impacts on global warming compared to CO2 over 100 years and the CO2e values shown reflect this.

Figure 28: Chicago’s Greenhouse Gas Emissions 2000 (34.7 MMT CO2e) and 2005 (36.2 MMT CO2e)

Industrial Processes

The industrial processes sector includes all non-energy related GHG emissions, such as those generated in the process of cement or zinc manufacturing. The US Census Bureau’s Economic Census and Annual Survey of Manufacturers was used to determine the proportion of US GHG producing industrial activity in Chicago. First, GHG producing industries located in Chicago were identified by North American Industry Classification System (NAICS) code. The relevant industries in Chicago were found to be Iron and Steel Production and Integrated Circuit or Semiconductor manufacturing. The employment in these sectors in Chicago was then calculated as a percentage of national employment by sector, and used to prorate the national GHG emissions in that sector. The potential for error in this method is substantial, but until better data are available for industrial processes at the city scale, it is a fair approximation. The result was that industrial processes were found to emit 0.433 MMTCO2e in 2000 and 0.0443 MMTCO2e in 2005.

The decline in Chicago’s industrial process emissions is directly related to the decline in employment in Chicago as a share of national employment in these industries. This is not meant to promote employment decline as a GHG reduction strategy. The pursuit of growth by cleaner industries and enabling manufacturer innovation will allow Chicago’s economy to grow with less global warming impact.

Figure 29: Employment in Non-Energy GHG Emitting Industries

<table>
<thead>
<tr>
<th>NAICS</th>
<th>Category</th>
<th>2000 Employmenta</th>
<th>2005 Employmenta</th>
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<td>Chicago</td>
<td>United States</td>
<td>Chicago Share of U.S.</td>
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<tr>
<td>3311</td>
<td>Iron and Steel Production</td>
<td>904</td>
<td>144,091</td>
</tr>
<tr>
<td>3344</td>
<td>Integrated Circuit or Semiconductor</td>
<td>1,333</td>
<td>620,927</td>
</tr>
</tbody>
</table>

a. 2000 and 2005 employment in Chicago are estimates extrapolated from 1997 and 2002 Economic Census data.

This research was commissioned to advise the Chicago Climate Task Force in the development of the Chicago Climate Action Plan. It does not represent official City of Chicago policy.
Product Use
In addition to these industrial activities, there are a number of products used in Chicago that generate GHG emissions. These include the sulfur hexafluoride (SF6) used as an insulator in electrical equipment and the nitrous oxide (N2O) used as an anesthetic by dentists. Again, local data on these emissions were unavailable, so a similar method as the industrial process emissions was employed —national emissions were prorated by Chicago’s share of the national population using US EPA National Inventory and US Census data. The result was emissions of 1.19 MMTCO2e in 2000 and 1.53 MMTCO2e in 2005 in Chicago.

The primary reason for the increase in product use emissions from 2000 to 2005 is an artifact of GHG accounting methods. Some greenhouse gases are also the substances that were found to be destroying the ozone layer in the 1980’s. They are being phased out as part of the Montreal Protocol on Substances that Deplete the Ozone Layer and are therefore not regulated by the Kyoto Protocol, nor are they reported in this inventory.\textsuperscript{14} Many of these “Ozone Depleting Substances” have been replaced with other greenhouse gases that fulfill the same needs, such as refrigeration, but are regulated by the Kyoto Protocol. These substances are meant to be transitional—fulfilling our needs while more environmentally benign compounds and processes are invented and adopted—so tracking their use can be important in the effort to promote alternatives.
Waste and Wastewater
Chicago’s waste and wastewater emitted 1.37 MMTCO2e in 2000 growing 15 percent to 1.58 MMTCO2e in 2005. Emissions in this sector were 4 percent of Chicago’s total GHG inventory. Nationally, waste emissions at 166 MMTCO2e in 2000 were 2 percent of total U.S. GHG emissions.

Figure 31: Chicago's Greenhouse Gas Emissions 2000 (34.7 MMT CO2e) and 2005 (36.2 MMT CO2e)

Solid Waste
Chicagoans generated 4.3 million metric tons of solid waste in 2000—1.5 metric tons per person. Waste generation grew by 16 percent to 5.0 million tons in 2005—1.77 metric tons per person. According to the City of Chicago, 56 percent of the waste generated was sent to landfills in 2000 and 2005. Data provided by the City of Chicago enabled the calculation of the portion of waste composed of degradable organic content, and national data was used to estimate the portion of methane emissions that is recovered at the landfill sites. The result was emissions of 1.06 MMTCO2e in 2000 and 1.23 MMTCO2e in 2005. Solid waste made up 77 percent of the emissions in this sector in 2000. All of the GHG emissions associated with solid waste are methane (CH4). Solid waste also produces CO2 as it decomposes, but as the carbon stored in decomposing food, paper, and paper products is biogenic in origin—it was absorbed from the atmosphere by plants in recent history—it’s release does not contribute to global warming, and therefore is not counted in this inventory.

All of the landfills used by Chicago in 2000 and 2005 were located outside of the city, so the emissions associated with waste disposal are considered indirect emissions. Chicago has a number of closed landfills within its city boundaries. Solid waste takes decades to decompose, so closed landfills continue to generate methane emissions. The IPCC uses a first order decay method to account for current year emissions from historic waste disposal, but data were unavailable at the time of this study to estimate these emissions for Chicago. This is an area that should continue to be investigated.

Wastewater
Fugitive methane emissions from water reclamation plants were estimated to be 0.352 MMTCO2e in 2000 and 0.346 MMTCO2e in 2005. The estimate was conducted by the Metropolitan Water Reclamation District (MWRD) using the methodology detailed in the 2006 IPCC guidelines. It was assumed that all sewer discharge was delivered to the MWRD plants via a covered sewer collection system. The MWRD estimate of the fugitive methane emissions for the entire district (which is larger than Chicago) was then scaled to represent the water treatment associated only with the Chicago population. Chicago accounted for 57% of the MWRD population in 2000 and 54% of the MWRD population in 2005.
Water reclamation plants recover methane during the water treatment process. This recovered methane is used on site for heating and/or electricity generation. There is no data available on the amount of methane that is recovered by MWRD annually. This is an area for further research. CO2 emissions associated with the consumption of the recovered methane were not included in this analysis, as the carbon is biogenic in origin and does not contribute to global climate change.
Agriculture, Forestry, and Other Land Use

Deforestation and changes in land use contributed 18 percent of global GHGs in 2000. Plants take in CO2 and store it as they grow, so deforestation releases the carbon stored in trees and stops their uptake of CO2. Deforestation has other climate impacts as well because it changes the albedo—or reflectivity—of the surface of the earth and the storage and release of water by plants. Recent deforestation has taken place mainly in the tropics and less developed regions of the world. Settlement resulted in deforestation in the US many years ago. More recently some of those forests have been growing back as land uses change and farm fields go fallow. The net emissions from land use, land use change, and forestry in the US in 2000 was a 756.7 MMTCO2e reduction.

Urban forestry—the planting of trees on settled land—can result in carbon uptake. Chicago’s trees had a crown cover of 8,350 hectares in 2000. Thus, trees covered 14.2 percent of Chicago’s land area—greater tree cover than the average desert (10 percent), but less than the average grassland (20 percent). The IPCC 2006 Guidelines for National Greenhouse Gas Inventories provides an estimated annual carbon accumulation value per hectare of tree crown cover in settled areas of 2.9 tons carbon per hectare (10.6 tons CO2). The result is that Chicago’s trees absorbed 0.0888 MMTCO2e in 2000. This was 0.3% of the total citywide emissions. Ensuring the long term benefit of the emissions reduction from trees in Chicago will require maintaining and replacing these trees.

Chicago may have benefited from additional carbon uptake from the growth of other plants such as shrubbery and grasses, but this would be negligible at the city scale and was not measured. Trees and other plants have additional climate benefits in settled areas, including Chicago, by providing shade for buildings and reducing the need for air conditioning. This is discussed further in the mitigation section of this report.

Agriculture in the US emitted 547.4 MMTCO2e in 2000 through livestock, crop, and soil activities. Some of these agricultural emissions are associated with the food and goods Chicagoans consume, however, from a direct emissions accounting perspective there is little agricultural activity within Chicago’s borders, so no agricultural emissions are included in Chicago’s emissions inventory. The lifecycle and indirect emissions associated with goods and services is an issue of importance to long term climate stability and should be further studied. As a rough indicator of the scale of these upstream impacts in the agricultural sector, Chicago was 1.03 percent of the US population in 2000, so if it was proportionately responsible for the agriculture emissions in the country that would be 5.63 MMTCO2e. The actual emissions associated with Chicago’s demand for agricultural products is more complicated due to international trade and local manufacturing trends.

From a greenhouse gas accounting perspective, land use is studied mainly in terms of its flora and physical characteristics. In cities, land use is usually associated with planning, transportation, and building activities. Urban land use planning is an important element in both GHG emissions and climate change mitigation strategies for Chicago, as it shapes the way Chicagoans travel, live, and conduct business. However, these elements will be covered in the other sectors of this document.
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 the GHG emissions associated with its business operations each year. These emissions are also included in Chicago’s communitywide emissions inventory. In 2005, Chicago reported emitting 0.346 MMTCO2e for its municipal operations. The City of Chicago has also opted-in to report the emissions associated with electricity consumption. Chicago reported purchasing one billion kWh in 2005. Using the same regional power pool emissions factor applied to electricity in the Chicago community emissions inventory, the City’s electricity would generate 0.725 MMTCO2e, making the total emissions for the City’s operations 1.07 MMTCO2e, or three percent of the community-wide total in 2005. This is in keeping with most other cities—municipal operations are generally three to five percent of communitywide emissions. Chicago’s baseline emissions for CCX, an average of 1998-2001 usage, are 0.377 MMTCO2e and 892 million kWh, or a total of 0.922 MMTCO2e using the regional power pool emission factor for electricity. This baseline value is three percent of the communitywide total in 2000. Chicago has met its commitments as a CCX member by lowering emissions and purchasing carbon credits each year.

This research was commissioned to advise the Chicago Climate Task Force in the development of the Chicago Climate Action Plan. It does not represent official City of Chicago policy.
Regional Emissions Inventory

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 clearly 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. As is discussed further in the mitigation strategies section, many efforts to reduce GHG emissions in Chicago will need to be regional in nature, so a regional inventory can serve as the basis for many innovative GHG mitigation efforts.

For the purposes of this research the Chicago region is defined as the 6 county metro area—Cook, Will, DuPage, Kane, McHenry and Lake counties. This area had a population of 8.1 million in 2000; Chicago’s 2.9 million residents made up 36 percent of the region. The region’s population grew two percent between 2000 and 2005 to 8.2 million, while Chicago’s population fell seven percent over that period to 2.7 million. As is discussed in the mitigation section, this trend has implications for the region’s overall GHG emissions growth, because Chicago’s transit infrastructure allows residents drive fewer miles and emit fewer GHGs than residents in other parts of the region.

The Chicago region emitted 105 MMTCO2e in 2000, or 12.9 tons per capita. As in Chicago, energy and transportation accounted for 91 percent of the regional emissions. However, transportation was a larger share of emissions in the region—31 percent—than in Chicago—20 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 increased vehicle travel may have been due to trucking on the interstates, but CNT’s location efficiency research shows that the efficient land use and transportation alternatives in Chicago enables lower auto ownership and reduced driving in the city.

Emissions in all sectors grew at a faster rate in the region than in Chicago, resulting in ten percent growth between 2000 and 2005 to 116 MMTCO2e, or 13.8 tons per capita. The two main sources of this growth in GHG emissions were electricity use and solid waste generation. If the Chicago region continues on its current path, emissions are forecasted to grow to 125 MMTCO2e in 2020 and 169 MMTCO2e in 2050. Encouraging development in location efficient areas and expanding transportation alternatives can reduce the impacts of growth on the region.

Figure 32: Chicago Region’s Greenhouse Gas Emissions 2000 (105 MMT CO2e)
Regional electricity emissions in 2000 were 39.7 MMTCO2e based on 65 billion kWh consumption. Electricity use grew at approximately the same rate regionally (15 percent) as in Chicago (14 percent). Residential electricity use made up a slightly higher proportion of total electricity use in the areas outside Chicago (31 percent) as in Chicago (26 percent). The same method was used to calculate electricity emissions in the metropolitan region as was used in the Chicago inventory.

Regionally, natural gas consumption resulted in 23.8 MMTCO2e in GHG emissions. The Chicago region used 4.5 billion therms of natural gas in 2000. Consumption in the region fell nine percent between 2000 and 2005, to 4.1 billion therms. The portion of the region outside Chicago saw a 5 percent decrease in natural gas consumption over that period, while Chicago’s natural gas use fell 14 percent.

In addition to using data on Chicago’s usage from People’s Gas, this regional analysis uses Illinois Commerce Commission data for natural gas use by North Shore Gas and Nicor Gas customers. Because Nicor Gas serves customers both inside and outside the six county region, CNT used a geographic analysis to determine that 77 percent of the population in the Nicor Gas territory was in the six county region, and this value was used to apportion the Nicor Gas consumption data.

Vehicles in the Chicago region traveled 56 billion miles in 2000, generating 30.4 MMTCO2e. Chicago’s vehicle miles traveled (VMT) was 22 percent of this regional total—a much lower portion than Chicago’s share of the regional population (36 percent). Vehicle miles traveled increased 7 percent in the region from 2000 to 2005 to 60 billion miles. Emissions grew just 1 percent over that period to 30.7 MMTOC2e due to improvements in the average vehicle efficiency of vehicles on the road. The method and sources used to calculate on road transportation in the Chicago region were the same as those applied to Chicago.

Off road vehicles in the region generated 1.56 MMTCO2e in GHG emissions in 2000 and grew four percent to 1.62 MMTCO2e in 2005. The largest source of emissions in this area was cargo rail, which accounted for 1.05 MMTCO2e emissions in 2000 based on fuel use data from LADCO. Chicago’s portion of the cargo rail emissions was just 22 percent of this.

Total GHG emissions from industrial processes and product use in the region were 5.09 MMTCO2e in 2000 and 5.49 MMTCO2e in 2005—an eight percent increase. The six county region contains a greater variety
of GHG producing industries than Chicago. The U.S. Census Bureau’s Economic Census and Annual Survey of Manufacturers shows the following relevant industries in the region: cement production; lime production; glass manufacturing; iron and steel production; and integrated circuit or semiconductor manufacturing. As in Chicago, the largest source of growth in the industrial processes and product use segment was due to the increased use of products as substitutes for ozone depleting substances.

The regional emissions from waste were 3.61 MMTCO2e in 2000, growing 62 percent to 5.85 MMTCO2e in 2005. The major source of this growth was a growth in solid waste from an estimated 10 million tons to 19 million tons, which was estimated based on data from the Illinois Environmental Protection Agency. In addition, the regional recycling rate, 38 percent, is lower than Chicago’s 44 percent rate in 2000.

Agriculture accounted for 0.510 MMTCO2e emissions in 2000 and fell 17 percent to 0.424 in 2005. Unlike Chicago, agriculture accounts for a substantial portion of the land use in the six county region—37 percent in 1997 and 33 percent in 2002. Therefore, data from the Census of Agriculture were used to determine emissions from crops, grassland, livestock and manure as a portion of the national total.

State of Illinois Emissions
Illinois emitted 276.6 MMTOC2e in 2000, according to the World Resources Institutes’ Climate Analysis Indicators Tool. Land use change and forestry resulted in a 5.4 MMTCO2e reduction in GHG emissions statewide in 2000. In 2000, 36 percent of the 12.4 million residents of Illinois lived in Chicago, and 65 percent lived in the six county Chicago metropolitan region. Yet, the emissions of Chicago and the region that year represented just 13 percent and 38 percent of the state total respectively. Chicago’s transit system and efficient land use are part of the explanation for this variance; however, there are several other reasons as well.

The emissions inventory for Illinois looks at electricity from a generation perspective, rather than the consumption perspective used for Chicago’s inventory. Illinois exported 28 percent of the electricity generated in the state in 2003. Assuming similar portion was exported in 2000, that would account for 23.6 MMTOCO2e of the 84.2 MMTCO2e generated by electric utilities in Illinois that year.

Agriculture is another major source of variance between state and local emissions in Illinois; agricultural emissions were 16.4 MMTCO2e in 2000—six percent of the state total. Comparatively, agricultural emissions in the Chicago region were just 0.5 MMTCO2e, or 0.5 percent of the regional inventory in 2000. Industrial energy use (excluding electricity) was also higher in the state than locally at 44.5 MMTCO2e—16 percent of the state total. Agricultural and industrial emissions in other parts of Illinois may be linked to consumption of goods and services in the Chicago area, as so much of what is consumed in the city and metro region is not produced in the area. This is worthy of further exploration.

The final major source of variance between the state and local inventories is the inclusion of aircraft fuel. Aviation fuel sales associated with O’Hare and Midway airports are included in statewide emission totals. This is not included in Chicago’s city or regional inventory.
Chicago Business as Usual GHG Forecast

If Chicago continues on the path it is on, its GHG emissions are estimate to grow at an average rate of 0.7 percent annually to 39.3 MMTCO2e in 2020—a 13 percent increase over 2000 levels—and 47.0 MMTCO2e in 2050—a 35 percent increase over 2000 levels. This is a faster rate of growth than the 8 percent population increase that is forecasted for Chicago between 2000 and 2020, but a slower rate than the 1.09 percent annual growth seen in US national emissions between 1990 and 2005.\(^7\)

Chicago’s emission forecast was developed using federal government forecasts and data on historic emission trends. Local historic trends for emission generating activities, such as energy use and vehicle miles traveled were also examined.

This study used the most recently available EIA data for forecasting. However, EIA data is revised annually and the 2008 forecast due in mid 2008 will include recent state and federal legislation which is likely to forecast a slower growth rate in energy consumption. The anticipated new data would have some impact on the total forecasted emissions by 2020. They will not have a material impact on the nature of the strategies that have been proposed for City action or the magnitude of the programs that need to be implemented to achieve the target goals.
**Energy**

In order to forecast emissions from energy consumption in Chicago, the 2000 baseline was used for each sector and an annual growth rate was applied. The annual energy consumption rates used were from the 2007 Energy Outlook Report published by the Energy Information Administration.\(^7\) The values based on the forecast from 2005 to 2030 were used for the East North Central region which includes Illinois, Wisconsin, Indiana, Ohio, and Michigan. The combined annual growth rate in electricity consumption is 1%. The combined annual growth rate in natural gas consumption is 0.2%.

![Figure 35: Annual Rate Change in Energy Use (by Sector)](image)

<table>
<thead>
<tr>
<th>Sector</th>
<th>Annual Change</th>
</tr>
</thead>
<tbody>
<tr>
<td>Residential Electricity</td>
<td>0.87166%</td>
</tr>
<tr>
<td>Small Commercial and Industrial Electricity</td>
<td>1.44721%</td>
</tr>
<tr>
<td>Large Commercial and Industrial Electricity</td>
<td>0.40727%</td>
</tr>
<tr>
<td>Other Electricity</td>
<td>1.26079%</td>
</tr>
<tr>
<td>Residential Energy (Natural Gas)</td>
<td>-0.05760%</td>
</tr>
<tr>
<td>Commercial Energy (Natural Gas)</td>
<td>0.87265%</td>
</tr>
<tr>
<td>Industrial Energy (Natural Gas)</td>
<td>1.02994%</td>
</tr>
</tbody>
</table>

These growth rates were compared with the historical utility data reported on the ICC website from 1990 to 2004 showing energy sales per year.\(^7\) ComEd’s annual growth rate for all electricity consumption was 2.4% during this period. People’s Energy’s annual growth rate for all natural gas consumption was -0.02%. These data are not weather adjusted.

**Transportation**

The transportation forecast used three elements to determine the GHG emissions from on road transportation in 2020 and 2050. Historic vehicle miles traveled trends in Chicago from 1990 to 2000 using data from the Illinois Department of Transportation were projected forward—a growth rate of 0.61 percent in Chicago (1.98 in the region).\(^8\) Vehicle efficiency improvements and ethanol blending rates were also projected from 2000 Chicago levels based on national trends. The vehicle miles traveled was multiplied by the vehicle efficiency in miles per gallon to get a total fuel use in 2000, the portion of ethanol was netted out from this total, and GHG emission factors were applied. The result is that on road transportation emissions are projected to rise slightly through 2020 to 6.8 MMTCO2e and then fall to 5.1 MMTCO2e 2050 as vehicle efficiency improvements overtake increased VMT. Transportation electricity use was forecasted to increase at a rate of 1.26 percent using the electricity forecast methods described above. Other off road transportation sources were forecasted to grow at a rate of 1.9 percent annually.

**Other Sectors**

Emissions from industrial processes were forecasted to decrease to zero by 2020 based on the historic trends in local employment in these sectors.\(^8\) Product use emissions were forecasted to increase 1.37 percent annually based on national emission trends\(^8\) and local population forecasts from the Northeastern Illinois Planning Commission (now CMAP).\(^8\) National emission trends were used to project waste and wastewater emissions; combined emissions in this sector are expected to fall 0.4 percent annually to 1.1 MMTCO2e in 2050.
Where We Need to Go

Chicago Reduction Targets
Climate scientists estimate that a 50-85 percent reduction below 2000 global GHG emissions by 2050 is required to achieve an atmospheric concentration of GHGs at 445-490 ppm and stabilize the climate at 2.0-2.4 degrees Celsius above pre-industrial temperatures. Moreover, the US has been the largest contributor of GHG emissions in the world to date, so it can be argued that US emission reductions should go beyond the global average required to achieve climate stabilization.

For the purpose of this research, we have selected several targets to forecast.

- **The most immediate target is a 7% reduction in emissions below 2010 levels by 2012.** That is the target the US would have committed to if it had ratified the Kyoto Protocol, and by signing the US Conference of Mayors Climate Protection Agreement, Chicago has said it will strive to meet this goal. Chicago will need to reduce emissions by 7.4 MMTCO2e against business as usual levels in 2012 to meet this goal. This target is also 6.1 MMTCO2e below 2005 levels.

- **The longest-term target is a 2050 goal of 80 percent below 1990 levels**—which would put Chicago on the path to contributing to global climate stabilization. This target, of just 6.5 MMTCO2e citywide, would require a 40.5 MMTCO2e decrease in emissions against business as usual levels.

- **Intermediate targets were chosen to demonstrate a steady path to the 2050 goal.** The 2020 target of 25% below 1990 levels became the focus of the mitigation research in this report as it presented a mid-term goal that was far enough out to allow time for major infrastructure changes without being so long range as to seem intangible or be beyond the scope of most governmental planning exercises. This 2020 target will require a reduction of 15.1 MMTCO2e against business as usual levels.

![Figure 36: Chicago Business as Usual Greenhouse Gas Emissions and Reduction Targets](image)
The Scale of What it Will Take
The emissions reduction of 15.1 MMTCO2e against business as usual in 2020 is a somewhat abstract goal. Borrowing from the work of Pacala and Scolow, the reduction needed can be considered as six “wedges” of 2.5 MMTCO2e each. Using 2000 values and assuming no growth, for the purpose of discussion, below is a set of examples of actions that are the size of one wedge (2.5 MMTCO2e).

- **Cut residential electricity use by 75%**. Eliminate the demand for 4 billion kWh—2.5 MMTCO2e.

- **Replace 20 percent of all electricity with renewables**. Use solar, wind, or hydropower in place of grid average electricity for 4 billion kWh—2.5 MMTCO2e.

- **Increase vehicle efficiency by 10 mpg** to an average of 26.5 miles per gallon for all vehicles on the road, including heavy duty trucks and buses. Eliminate demand for 280 million gallons of fuel—2.5 MMTCO2e.

- **Eliminate 3 out of every 8 vehicle trips taken**. Eliminate demand for 280 million gallons of fuel—2.5 MMTCO2e.

- **Replace 3 out of every 8 gallons of fuel with alternatives**. Eliminate demand for 280 million gallons of fossil fuel—2.5 MMTCO2e.

- **Cut natural gas use by 22% in all buildings**. Eliminate 475 million Therms—2.5 MMTCO2e.

The examples above are simply meant to demonstrate the scale of action required. Their total impact implemented together would be less than their sum, as several of the GHG sources addressed, such as residential electricity use and electricity supply, overlap. Nevertheless, it demonstrates that an emission reduction goal of 15.1 MMTCO2e will take a substantial effort. The next section of this report details a portfolio of aggressive but feasible climate change mitigation strategies specifically designed for Chicago that when implemented together could meet Chicago’s emission reduction goal for 2020.
Meeting the Reduction Goals

Mitigation Strategies
The previous sections of this report document the sources of Chicago’s global warming impact and the greenhouse gas emissions likely in future years if no action is taken. This section presents a set of actions that can change the emission trajectory Chicago is on, reducing its global climate change footprint while bringing additional economic and environmental benefits to the city. This analysis of climate change mitigation strategies was designed to address two key questions for Chicago:

• What are the most promising strategies for substantially reducing Chicago’s greenhouse gas emissions?

• What scale of deployment of these strategies is necessary to achieve the goal of 25% reduction in greenhouse gas emissions between 1990 and 2020?

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 feasible solutions that suit Chicago. Identification of potential strategies included a participatory process. Several community and stakeholder meetings were held to gather proposed strategies for consideration. Participants included architects, transportation officials, environmentalists, biking advocates, other professional organizations, community groups, the business community, and concerned citizens. A website was developed to solicit ideas for mitigation research, and over 200 suggestions were submitted.

There is no one solution that will achieve Chicago’s GHG reduction goal, rather dozens of diverse solutions must be implemented simultaneously. After review of all mitigation ideas, 33 were selected for in-depth research based on their feasibility, potential for CO2e reductions, and capacity for rapid implementation at the city and regional level. Many programs with smaller emission reduction potentials were combined into larger strategies that met the scale of the reductions needed. It should be noted that virtually all of these strategies utilize currently available technology, and therefore, from a technical standpoint, could begin to be implemented immediately. Taken together, the emission reduction strategies can meet the goal of reducing Chicago’s emissions by 15.1 MMTCO2e 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 the size of the whole.

The Strategies
Each of the 33 strategies were analyzed both quantitatively and qualitatively to determine emission reduction potentials, the nature and scale of the programs and policies necessary, similar current activities underway in Chicago and the region that could be built on, examples of successful programs from other areas, and implementation opportunities and barriers.

Each detailed strategy description begins with a summary assessment of the strategy in terms of six criteria:

• Reduction potential: Total annual greenhouse gas emissions achievable, and the scale of activity necessary to achieve them.

• Cost-Effectiveness: Cost of implementation and potential financial savings generated relative to the emissions reductions achieved.

• Feasibility: Ability to implement at scale; identification of critical barriers to deployment.

• Additional Benefits and Burdens: Cost savings to residents and businesses, job creation, other environmental and quality of life benefits as compared to any negative effects of the strategy.

• Regional Impact: Level of opportunity for Chicago region.

• Opportunity for Rapid Deployment: Whether strategy can be implemented quickly.
The 33 strategies developed fall into nine categories:

1) **Framing/Leadership:** These strategies influence the implementation of all other strategies. While they may not be individually measurable, deploying them effectively is essential for the success of the overall plan. Framing strategies include ongoing City and civic leadership and advocacy, early action, developing measurement and evaluation mechanisms, and promoting education and behavior change of Chicagoans.

2) **Energy Demand:** Reducing the amount of energy used in Chicago buildings, both existing and new.

3) **Energy Supply:** Decarbonizing Chicago’s energy sources by expanding the supply of renewable energy and reducing the greenhouse gas emissions of conventional fuels.

4) **Transportation Demand:** Reducing vehicle miles traveled by vehicles in Chicago through promotion of alternative means of transportation, including walking, bicycling, and public transportation; transit-oriented development; and efficient freight movement.

5) **Transportation Petroleum Use:** Lowering petroleum use by increasing number of fuel-efficient vehicles, utilizing alternative fuels.

6) **Land Cover and Forestry:** Expanding trees, green spaces, and green roofs.

7) **Waste and Water:** Increasing water efficiency and reducing waste generated.

8) **Industrial Processes and Product Use:** Altering use of materials to reduce greenhouse gas emissions.

9) **Cross-cutting Strategies:** Two wide-ranging strategies were analyzed: creation of a carbon tax, and creation of a cap and trade system. In both cases, the role of the City could be to advocate for implementation of the strategy at a national level. Because of the nature of these strategies, they were not included in the Chicago greenhouse gas reduction totals. They do, however, provide a framework to understand their potential impact in the Chicago market, as well as implementation issues.

The individual strategy descriptions provide considerable detail to quantify the reduction potentials for each in the Chicago market. For many strategies, a range of deployment scales are included, as well as a timeframe for ramping up deployment.

While each strategy description stands on its own and is individually analyzed, there are number of key findings should be noted from this set of analyses:

**Each of these strategies has a role to play in Chicago’s overall climate strategy.** While they range widely in scale and scope, each of the strategies analyzed can make a significant contribution to Chicago’s greenhouse gas reduction effort. In some cases, such as building retrofits, the potential reductions are large and the value of implementation is clear. Some smaller strategies, however, 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% below 1990 levels by 2020 requires action across all strategies, and in all sectors of Chicago.** All the strategies framed here, taken together and deployed at scale, could reach Chicago’s overall reduction goal. Getting there is attainable, but will require action by every sector of Chicago.

**Some of the strategies with the biggest reductions are also those that will bring the biggest economic benefits to Chicago residents and businesses.** Energy and transportation efficiencies will save Chicago households hundreds, if not thousands, of dollars a year, and will bring substantial
savings to Chicago businesses as well. Taken together, strategies to reduce energy in buildings accounts for approximately 30 percent of greenhouse gas reductions analyzed.

**Demand side strategies are as critical as supply side strategies for reductions at the city and regional level.** The energy saved in buildings and the miles not driven can together account for nearly half of the targeted reductions. They can take advantage of the inherent efficiency of urban areas, and the extraordinary resources represented by our public transportation network. Having implemented efficiency measures wherever possible, renewable sources of energy and more efficient vehicles can ensure that the energy we do use is as clean as possible.

**Improving the energy efficiency of buildings is the biggest single opportunity for greenhouse gas reduction in Chicago.** With 70 percent of Chicago’s greenhouse gas emissions generate by electricity and natural gas use, energy efficiency is a critical strategy. Because 80 percent of buildings that will exist in 2020 are already built, these strategies must focus on both existing and new buildings.

**Expanding the opportunities for reduced auto travel will make a major contribution to greenhouse gas reduction as well as quality of life.** Many of the 33 strategies will reduce energy used in transportation, both by residents and businesses. Together, transportation efficiency accounts for approximately 20% of greenhouse gas reductions analyzed.

The following chart summarizes the savings of individual 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 37: Chicago GHG Mitigation Strategies**
**Mitigation Strategies**

<table>
<thead>
<tr>
<th>Category</th>
<th>Mitigation Strategy</th>
<th>Description</th>
<th>CO2e Reduction MMT</th>
</tr>
</thead>
<tbody>
<tr>
<td>Framing</td>
<td>Provide leadership on climate issues</td>
<td>Continue and expand City leadership on climate strategy and implementation, including local leadership and strong advocacy in region, state, and federal legislation and policy.</td>
<td>Framing Strategy</td>
</tr>
<tr>
<td></td>
<td>Promote behavioral change among residents and businesses that will elicit an ongoing response and action on climate change.</td>
<td>Implement widespread educational and action-oriented programs. GHG reduction assumes half of all households and commercial buildings adopt 5 behavioral changes by 2020 (heating/cooling temperature adjustments, turning off light bulbs, replacing air conditioner filters, and reducing “phantom load”)</td>
<td>0.80</td>
</tr>
<tr>
<td></td>
<td>Use ongoing measurement, verification, data, and metrics to track and target actions, and to continuously improve performance</td>
<td>Develop, track, and share information on mitigation strategies and results.</td>
<td>Framing Strategy</td>
</tr>
<tr>
<td></td>
<td>Encourage early action and rapid change</td>
<td>Ensure rapid implementation of mitigation strategies.</td>
<td>Framing Strategy</td>
</tr>
<tr>
<td>Cross-cutting</td>
<td>Enact a carbon tax</td>
<td>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% reductions from 1990 levels by 2020.</td>
<td>15.10</td>
</tr>
<tr>
<td></td>
<td>Enact a cap and trade system</td>
<td>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.</td>
<td>15.10</td>
</tr>
<tr>
<td></td>
<td>Implement efficient urban form</td>
<td>Promote transit oriented development. Calculates benefit from growth in population locating near transit.</td>
<td>0.159-0.623</td>
</tr>
<tr>
<td>Energy Demand</td>
<td>Energy retrofits in residential buildings</td>
<td>Retrofit 47% of existing residential building stock (400K units) by 2020, with 30% reduction in energy use/retrofitted unit.</td>
<td>1.30</td>
</tr>
<tr>
<td></td>
<td>Energy retrofits in commercial and industrial buildings</td>
<td>Retrofit 50% of the commercial and industrial building stock by 2020 resulting in a 30% reduction in energy use/retrofitted building.</td>
<td>1.30</td>
</tr>
<tr>
<td></td>
<td>Appliance trade-in</td>
<td>Supplement natural turnover of appliances and lightbulbs with targeted appliance trade-in and CFL replacement for low-income households.</td>
<td>0.28</td>
</tr>
<tr>
<td></td>
<td>Green building renovation</td>
<td>Require all commercial (1K bldgs) and residential (60K units) renovations to meet Green Renovation Standards.</td>
<td>0.31</td>
</tr>
<tr>
<td></td>
<td>Update and improve enforcement of City energy code</td>
<td>Update the City of Chicago’s energy code to include more stringent conservation guidelines; and require compliance at the point of sale of all residential property.</td>
<td>1.13</td>
</tr>
<tr>
<td></td>
<td>Provide permitting incentives to new construction green buildings</td>
<td>Require that all new residential (65K new homes) and commercial (4K new commercial buildings) construction be built to LEED or equivalent standards by 2020.</td>
<td>1.17</td>
</tr>
<tr>
<td></td>
<td>Build renewable electricity generation</td>
<td>Encourage the replacement of fossil fuel fired plants with renewable plants reducing emissions by 20%; 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 the Renewable Portfolio legislation in Congress.</td>
<td>3.00</td>
</tr>
<tr>
<td></td>
<td>Repower existing power plants</td>
<td>Convert two power plants located in city limits from coal to natural gas.</td>
<td>1.92</td>
</tr>
<tr>
<td></td>
<td>Sequester carbon in new plants</td>
<td>New electricity generating plants use latest carbon sequestration technology.</td>
<td>2.17</td>
</tr>
<tr>
<td></td>
<td>Distributed generation and combined heat and power projects</td>
<td>Adapt goals set in Chicago’s 2001 Energy Plan to expand the use of Distributed Generation and Combined Heat and Power projects.</td>
<td>1.12</td>
</tr>
<tr>
<td></td>
<td>Household renewable energy generation</td>
<td>Increase household scale renewable power (100% electric replacement) and solar domestic hot water (25% natural gas reduction) to 5% of the housing stock.</td>
<td>0.28</td>
</tr>
<tr>
<td></td>
<td>Enforce efficiency standards for new generation</td>
<td>Support policies for implementing energy efficiency standards for new and existing fossil fuel generation at the regional and national levels.</td>
<td>1.04</td>
</tr>
</tbody>
</table>

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<table>
<thead>
<tr>
<th>No.</th>
<th>Category</th>
<th>Action</th>
<th>Description</th>
<th>Reduction</th>
</tr>
</thead>
<tbody>
<tr>
<td>20</td>
<td>Transportation Mobility Options</td>
<td>Increase transit service</td>
<td>Ensuring stable funding for mass transit, and then increase ridership 30% above business as usual.</td>
<td>0.83</td>
</tr>
<tr>
<td>21</td>
<td>Transportation Mobility Options</td>
<td>Increase walking and bicycling mode share</td>
<td>Enact measures to double the pedestrian-bicycling mode share to one million trips/day.</td>
<td>0.01</td>
</tr>
<tr>
<td>22</td>
<td>Transportation Mobility Options</td>
<td>Increase the use of car sharing, carpooling and vanpooling</td>
<td>Car sharing vehicles increased by 10% annually, carpools by 10%, and vanpools by 20% over the Business As Usual (BAU) forecast.</td>
<td>0.30-0.51</td>
</tr>
<tr>
<td>23</td>
<td>Transportation Mobility Options</td>
<td>Develop intercity high speed rail network</td>
<td>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; the inclusion of reduced air travel will increase total reduction.</td>
<td>0.006</td>
</tr>
<tr>
<td>24</td>
<td>Transportation Petroleum Use</td>
<td>Increase supply and use of alternative fuels</td>
<td>Reduce CO2e per gallon of fuel by 10% through use of alternative fuels.</td>
<td>0.68</td>
</tr>
<tr>
<td>25</td>
<td>Transportation Petroleum Use</td>
<td>Increase fleet efficiency</td>
<td>Transition the entire fleet of taxis to electric hybrids by 2020; adopt B20 biodiesel for school buses and garbage trucks; hybrid buses for the CTA. Note: including all fleets will increase this number.</td>
<td>0.21</td>
</tr>
<tr>
<td>26</td>
<td>Transportation Petroleum Use</td>
<td>Enable more efficient use of fuels</td>
<td>4% annual increase in gas mileage starting in 2010, through measures such as user fees for vehicle ownership, freebates, increased gas taxes, and anti-idling ordinance.</td>
<td>0.51-0.86</td>
</tr>
<tr>
<td>27</td>
<td>Transportation Demand</td>
<td>Implement efficient freight movement</td>
<td>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.</td>
<td>1.61</td>
</tr>
<tr>
<td>28</td>
<td>Transportation Demand</td>
<td>Enact automobile user fees</td>
<td>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.</td>
<td>0.02-0.38</td>
</tr>
<tr>
<td>29</td>
<td>Transportation Demand</td>
<td>Balance the cost of transportation in proportion to GHG production</td>
<td>Mandate parking cash-outs; vary city vehicle sticker fees based on vehicle fuel efficiency; encourage employers to offer pre-tax transit passes.</td>
<td>0.03</td>
</tr>
<tr>
<td>30</td>
<td>Ind. Proc. &amp; Prod. Use</td>
<td>Use of alternative refrigerants</td>
<td>Use influence with state and national leaders to begin a phase-out of HFCs following the model of the Montreal Protocol and achieve a 50% reduction from the BAU forecast for 2020.</td>
<td>1.16</td>
</tr>
<tr>
<td>31</td>
<td>Waste and Water</td>
<td>Zero waste policy</td>
<td>Implement zero waste policy. Includes expanding recycling, requirements for City contracts, elimination of methane emissions.</td>
<td>0.92</td>
</tr>
<tr>
<td>32</td>
<td>Waste and Water</td>
<td>Water efficiency</td>
<td>Reduce water supply use and manage water and sewer effluents.</td>
<td>0.13</td>
</tr>
<tr>
<td>33</td>
<td>Land Cover and Forestry</td>
<td>Reduce emissions through tree planting &amp; green roofs</td>
<td>Assumes 500 additional green roofs and a combined 83,333 public and private trees planted per year.</td>
<td>0.10 - 0.17</td>
</tr>
</tbody>
</table>

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References

22. U.S. Environmental Protection Agency, “Emissions & Generation Resource Integrated Database (eGRID),” http://www.epa.gov/cleanenergy/egrid/index.htm. 2004 was the latest eGRID year available at time of this research, and thus the 2004 eGRID v.2.0 emissions factor was used in place of 2005.

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REFERENCES

Amtrak Data for Chicago from Chicago Department of the Environment
Fuel data from City of Chicago Department of Revenue, City of Chicago Department of Aviation, in possession of Author.
In possession of authors.
Intergovernmental Panel on Climate Change. 2006 IPCC Guidelines for National Greenhouse Gas Inventories. 2006,
This research was commissioned to advise the Chicago Climate Task Force in the development of the Chicago Climate Action Plan. It does not represent official City of Chicago policy.
Overview
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 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 of Chicago can continue to serve as a national example of a green, healthy, and sustainable place to live and work.

The City can expand its role as a leader at the municipal, state, and federal level in order to promote and encourage behavioral change from citizens and the business community in Chicago. It can further change on the federal level by working as a leader of large cities 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 resources to fund energy efficiency and transit infrastructure. Finally, the City can leverage its role as a tourist attraction, freight center, and city of neighborhoods to inspire a commitment among its residents to work towards reducing GHG emissions.

Qualitative Results

Program Elements
The City has provided leadership as a green city by establishing effective green building and parks initiatives, and building a strong and effective Department of Environment. The City of Chicago is likely to expand its green approaches and programs that will result in greenhouse gas (GHG) reductions. The City could continue to build on its reputation as green by setting aggressive GHG reduction goals, reporting regularly on progress, committing resources to meeting the set targets, and serving as a state and national leader on bold climate change strategies. Through the creation of a cohesive city-wide strategy, the City can have a great impact via the 40-plus city departments that provide and impact city services for residents and businesses.

The proactive Chicago Department of Environment (DOE) runs a multitude of programs and initiatives that support climate change mitigation. DOE staffs the Chicago Climate Task Force, which is charged with the development of a plan of GHG mitigation strategies. DOE’s leadership in convening the Task Forces and leaders is critical for developing and implementing a comprehensive action plan. There is also a role for DOE in the oversight of the climate action plan. For each of the mitigation strategies researched for this report, municipal GHG reduction potential is calculated (if applicable) and possible implementation mechanisms are detailed. The City, in reviewing the action plan developed from these reports can identify specific roles and reduction goals. The City could also serve as a national leader by including climate change initiatives in the Consolidated Plan and other long-range planning documents.

The City of Chicago has served as a leader through its voluntary participation in the Chicago Climate Exchange (CCX). This leadership could be continued and serve as encouragement for the participation of partners and vendors. The City of Chicago could widely circulate its measured GHG emissions—346,000 metric tons CO2 and 1,086,700 MWh of electricity use reported in 2005—and reduction goals for each year—currently set at 1% annual reduction.1 The City already provides a baseline for climate change challenges and could promote regional change by challenging regional municipalities to set a GHG reduction goal.

Mitigation Strategy #1
The City of Chicago provides exemplary leadership on climate change action resulting in affordable solutions for residents, businesses and institutions.
The City could maximize its visibility throughout Chicago, including events held at Daley Plaza, Grant Park, Millennium Park; neighborhood festivals; Taste of Chicago and more, to distribute information on climate change mitigation strategies and to sign up City residents for specific personal reduction goals and programs. The City can characterize and promote climate change mitigation as the way of doing business in Chicago.

The City has a number of existing initiatives, including green roofs, SmartBulbs, and pilot recycling programs, which can be expanded and marketed to more residents. An expansion of existing programs will lead to additional CO2e savings. Leadership on new initiatives aimed at reducing energy consumption and emissions in buildings, and promoting transit options, will establish the City as an innovator on climate change.

**Benefits and Burdens**

Showing leadership in climate change mitigation will strengthen the City’s position as a world class city, drawing more tourists and the corresponding investment, and effectively influencing state and national policies. As a climate change leader, the City of Chicago would be supporting mitigation strategies that reduce pollution, strengthen communities, and lower costs for households from increased efficiencies.

The City’s active participation in climate change mitigation will have ripple effects that lead to resident involvement. One researcher looking at the power of social norms and sustainable behavior noted that when people feel that a desired behavior is the norm in their communities, they are more likely to adopt that behavior themselves. For example, when people see their neighbors recycling, they are more likely to recycle in their own households.

A focus on climate change mitigation is sometimes viewed as a contrasting effort to that of the environmental justice community. The City’s approach to climate change can be as inclusive of all environmental concerns as possible. The City can also be inclusive in its targeted strategies—identifying programs that people from different cultures and socioeconomic backgrounds can participate in, contribute to, and benefit from.

**Current Initiatives and Models**

The City of Chicago is already recognized as an environmentally-friendly city. In a May 2006 Time Magazine article, Chicago’s 2 million square feet of planted or planned rooftop gardens were recognized as being more than all other U.S. cities combined. In the fall of 2003, Chicago won first place in the “Nations in Bloom” competition, an international competition that rates cities on their livability. This award noted the planting of 400,000 new trees, 62 miles of new median planters, and the renovation of 30 boulevards.

As of October 2006, there were over 250 green roofs in Chicago, including the city’s Center for Green Technology, Soldier Field’s parking garage, and Millennium Park. Green roofs add millions in open space square footage, and help the environment by reducing a building’s heating and cooling efforts, and absorbing rainwater that would normally enter the city’s aging sewer system.

Chicago is a leader in many other ways as well, most notably in its voluntary involvement in the Chicago Climate Exchange (CCX). The Chicago Climate Exchange “is North America’s only and the world’s first global marketplace for integrating voluntary legally binding emissions reductions with emissions trading and offsets for all six greenhouse gases.” The City has committed to reducing its emissions. According to Chicago’s CCX submissions, the municipal operations baseline was set at 377 thousand metric tons of CO2e. Emissions in 2005 were 346 thousand metric tons of CO2e. In order to reduce emissions to 25 percent below the baseline Chicago will have to reduce emissions to 283 thousand tons of CO2e by 2020, which is within reach of annual goals to reduce fuel and electricity consumption. Meeting these targets will enhance Chicago’s reputation as a leader on climate change.
Implementation Mechanisms

Chicago Climate Action Plan
After the Chicago Climate Action Plan is finalized, the City could hold a press conference to announce the GHG reduction potential and Chicago’s goals—encouraging Chicago businesses and residents to take ownership of the plan. The Plan could be made widely available in multiple languages with contact information prominently posted so that Chicago residents can follow up with questions and comments, with a specific emphasis on how to get involved. The Plan could be made available at all City locations—libraries, schools and offices—and online.

City’s Adoption
The City could adopt the Climate Action Plan by incorporating its recommendations into City operations. In addition to adopting recommendations, the City could change job descriptions to reflect the climate change mitigation component of each position.

Measuring and Reporting Results
The City CO2e baseline, projections, and reduction goals could be publicly shared. Annual updates to these figures, with emphasis on progress towards the reduction goal could be posted. Besides having measurements, mitigation strategies, program lists and online involvement opportunities, the City might consider a large visual display which shows the latest results.

Public Participation
The City can encourage residents’ active participation in the Climate Action Plan by promoting mitigation strategies and programs in all of its capacities—to its staff and partners, through existing community outreach events and offices, and at press conferences. The City might even start a climate challenge, perhaps as the next step of the 2007 Earth Month Pledge announced by the City. A climate challenge could have neighborhoods, or other city units, compete in reducing GHGs. By making climate change mitigation participatory, inclusive and accessible, the City will have done its job in leading the area to GHG reduction goals.

Feasibility

Financial
Climate change mitigation leadership will require resources for City staff training and education, marketing materials or plan dissemination, Climate Action Plan implementation and management, data collection and analysis, technical assistance for residents and businesses, and program promotion and expansion. The City could investigate funding opportunities, including grants, financing, and public/private partnerships, to be able to meet the aforementioned costs.

The City, in reducing municipal GHGs, may also realize cost savings—in areas of fuel and electricity consumption—that can be invested in climate change leadership activities.

Finally, Chicago will become a more affordable place to live and do business as a result of implementing the climate strategies that reduce operating costs and energy consumption in buildings and transportation costs in the city.

Technical
The City of Chicago has the tools it needs to serve as a climate change mitigation leader at the state and federal level.
Political
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, lobbying for regulations and incentives that will reduce GHG, and applying for funding sources to implement programs that will result in GHG reductions. The complexity and enormity of climate change will necessitate debate, political negotiation, dialogue, and sharing of best practices and transparency.

The City could create a Climate Change City Council committee that would be in charge of agenda items—ordinances, hearings and budget allocations—related to the Climate Action Plan. In order for the City of Chicago to be a climate change leader, the City could coordinate support and alignment of business leaders, Aldermen, and Cook County officials. Acting as an entity rather than divergent departments or standalone wards, the City could stress the importance of unity in accepting the challenge of implementing the Climate Action Plan at all levels (and region, as many strategies are related to the larger geographic area and population). There are many issues competing for the time, attention, and resources of Chicago’s leaders. Climate Change need not be separate from issues such as public health, job creation or housing affordability. Indeed, to succeed at reducing Chicago’s climate impact the city must make climate action a central feature of all its efforts.

References

1 City of Chicago Department of Environment, “Calendar Year 2005, CCX Emissions and Electricity Purchase Reporting Form”, http://egov.cityofchicago.org/city/webportal/portalContentItemAction.do?BV_SessionID=@@@@1957088613.1193936468@@@&BV_EngineID=ccceadmglijkececelldffhdffhg.0&contentOID=536925381&contentTypeName=COC_ED ITORIAL&topChannelName=HomePage.
5 City of Chicago, “Green Roofs Open to the Public,” http://egov.cityofchicago.org/city/webportal/portalContentItemAction.do?BV_SessionID=@@@@1957088613.1193936468@@@&BV_EngineID=ccceadmglijkececelldffhdffhg.0&contentOId=536912340&contentTypeName=COC_EDITORIAL&topChannelName=HomePage&blockName=See+Also
8 City of Chicago Department of Environment, “Calendar Year 2005, CCX Emissions and Electricity Purchase Reporting Form,” http://egov.cityofchicago.org/city/webportal/portalContentItemAction.do?BV_SessionID=@@@@1957088613.1193936468@@@&BV_EngineID=ccceadmglijkececelldffhdffhg.0&contentOId=536912340&contentTypeName=COC_EDITORIAL&topChannelName=HomePage.
Mitigation Strategy #2
Promote behavioral change among residents and businesses that will elicit an ongoing response and action on climate change.

<table>
<thead>
<tr>
<th>Strategy Summary</th>
<th>Scale</th>
<th>Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>CO2e Savings Against BAU</td>
<td>++</td>
<td>0.801 MMT CO2e</td>
</tr>
<tr>
<td>Scale of deployment</td>
<td>+++</td>
<td>50% of households and commercial entities</td>
</tr>
<tr>
<td>Timing</td>
<td>+++</td>
<td>People can start immediately</td>
</tr>
<tr>
<td>Regional Impact</td>
<td>++</td>
<td></td>
</tr>
<tr>
<td>Financial Savings in relation to Cost</td>
<td>+++</td>
<td>Little to no costs associated</td>
</tr>
<tr>
<td>Additional Benefits in relation to Burdens</td>
<td>+++</td>
<td>There are little to no burdens</td>
</tr>
<tr>
<td>Feasibility assessment</td>
<td>+++</td>
<td>Can begin immediately</td>
</tr>
</tbody>
</table>

Overview
In an April 2007 survey of adults nationwide, 52% of those polled said that the issue of global warming was either extremely or very important to them personally, with another 30% ranking it somewhat important. Despite the rising concern about climate change, our actions do not yet come near to reflecting the scale of change that needs to happen to solve the problem. Small but significant behavioral changes—turning off appliances and lights, reducing cooling temperatures and heating temperatures by 3 degrees in residential properties, and using programmable thermostats to control temperatures in commercial spaces—have the capacity to significantly impact CO2e savings. Translating concern about climate change into personal behavioral change would have substantial impact in greenhouse gas reduction.

Quantitative Results
GHG Reduction Potential: 0.801 MMT CO2e
Of the 0.801 MMT CO2e saved, 0.606 MMT CO2e are from residences and 0.195 MMT CO2e are from commercial properties.

Scale Assumed
This reduction potential assumes that 50% or 585,000 households adopt five behavior change strategies, and 50% or 11,200 commercial buildings adopt heating and cooling behavior change strategies. This is an illustrative, and not a comprehensive, list of practical behavior changes.

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Timeline
The strategies are readily available and fairly easy to adopt. The mitigation strategy and reduction potential can begin immediately, assuming that the number of households and businesses that adopt strategies will grow incrementally over time to reach 50% penetration of both types of places by 2020.

Per-Unit Reduction Potential
With this set of behavior changes, each household has the potential to reduce 1.034 metric tons CO2e annually. Each commercial entity has the potential to reduce 17.3 metric tons CO2e.

Activity Savings
Figure 1 shows the savings potential of the five household strategies. Commercial facilities have the potential to save 9% of heating and cooling energy by changing heating and cooling temperatures 3 degrees.

<table>
<thead>
<tr>
<th>Activity</th>
<th>Energy Savings</th>
<th>GHG Savings (metric tons CO2e/year)</th>
<th>Annual cost savings (in 2007 prices)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Eliminate one ten-mile car trip per week a</td>
<td>520 Vehicle Miles</td>
<td>0.223</td>
<td>$76.00</td>
</tr>
<tr>
<td>Reducing heating temperature by 3 degrees:</td>
<td></td>
<td>98 therms</td>
<td>$129.00</td>
</tr>
<tr>
<td>reduces gas use by 9% b</td>
<td></td>
<td>0.522</td>
<td></td>
</tr>
<tr>
<td>Increasing cooling temperature by 3 degrees:</td>
<td></td>
<td>122 kWh</td>
<td>$13.00</td>
</tr>
<tr>
<td>reduces cooling electric use by 9% c</td>
<td></td>
<td>0.075</td>
<td></td>
</tr>
<tr>
<td>Turning off 3 sixty watt bulbs 2 hours per day</td>
<td>131 kWh</td>
<td>0.080</td>
<td>$14.00</td>
</tr>
<tr>
<td>Replacing air conditioner filters d</td>
<td>136 kWh</td>
<td>0.083</td>
<td>$15.00</td>
</tr>
<tr>
<td>Turning off appliances with a “phantom load”</td>
<td>209 kWh</td>
<td>0.128</td>
<td>$23.00</td>
</tr>
<tr>
<td>Total</td>
<td>1,110</td>
<td>1.110</td>
<td>$270.00</td>
</tr>
</tbody>
</table>


Life cycle GHG Impacts
The GHG reductions of this strategy will go beyond the emissions from electricity production and natural gas combustion alone. The strategy will have upstream GHG benefits as well.

Regional GHG Reduction Potential
The GHG reduction potential of a regional behavior change strategy could be 2.4 MMTCO2e.

Economic Profile

Costs
The costs of this mitigation strategy are minimal and may include a programmable thermostat which ranges from $40-160. Depending on the type of thermostat purchased, it may be beneficial to have a professional install it at an additional service fee. Air conditioner filters start at about $2 each.
Savings
Both households and commercial entities will save on their heating and cooling bills by employing this strategy. Households will additionally save on the cost of electricity for lighting and phantom appliances. Cost savings depend on the size of units and could range from a couple dollars per month upwards.

Qualitative Results

Program Elements
Behavioral change most often happens when people realize they have something to gain from making a change. In this case, cost savings from reducing utility bills will be the driving factor that encourages people to adopt this mitigation strategy. Cost savings can be highlighted for any educational programs, workshops, etc. developed to forward the strategy.

The illustrated program elements for households include: 1) reducing heating temperature by 3 degrees; 2) increasing cooling temperature by 3 degrees; 3) turning off 3 sixty watt bulbs 2 hours per day; 4) replacing air conditioner filters; and 5) 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 the thermostat to a programmable thermostat that adjusts temperatures during work and nonwork hours.

This is one of the easier strategies, which can be quickly adopted by a large number of people for significant reduction impact. Facilitating behavioral change will entail outreach, education, information dissemination and technical assistance.

Benefits and Burdens
The benefits of these behavioral changes include reduced household expenses, and reducing pollution which leads to increased health benefits. Additionally, behavioral change starting with minor, easy changes can develop awareness and willingness to change that grows to embrace larger changes. Implementing behavioral changes lays the groundwork for other mitigation strategies that might include changes in car ownership or travel patterns.

One of the only burdens for this strategy is the cost of a programmable thermostat (for those households that don’t have one already), which has a relatively short payback period. This investment aside, the other changes proposed in this strategy do not involve costs or other burdens. Expanding behavioral change to other activities will result in other benefits and burdens.

Current Initiatives and Models
Energy efficiency workshops, such as those hosted in past years by the CNT Energy (formerly the Community Energy Cooperative), provide information about these cost and energy savings strategies providing tips on the best programmable thermostats and their installation. Energy efficiency information is also distributed by utilities with billing statements and at large festivals like the Taste of Chicago. Web resources encouraging behavioral change in the areas of heating, cooling, lighting and unplugging appliances abound with some of the best information available on the EnergyStar.gov web site. The City of Chicago can link to existing web resources from its Department of Environment site.

Implementation Mechanisms
The City of Chicago could incorporate these behavioral change strategies into the environmental curriculum for Chicago Public School students — emphasizing cost savings potential in materials the students can share with their parents. Public service announcements can be made on public access TV and on local radio
stations, again highlighting the cost savings associated with these strategies. The City of Chicago can help advertise energy efficiency programs and provide grants to agencies to offer energy efficiency sessions at community centers, churches and other local places. Chicago’s Department of Human Services can also add energy efficiency materials to its clients to encourage behavioral change among lower income populations who could most benefit from the savings potential of this strategy.

**Feasibility**

**Financial**
The particular actions advocated for in this strategy have minimal to no costs. Savings will be realized by households and commercial properties who adopt these actions.

**Technical**
These strategies are technically feasible. There are existing mechanisms for distributing the information, and provide the assistance and support that could result in behavioral change.

**Political**
It is hard to imagine major political objection to this strategy, which if introduced and adopted, can lead to more significant behavioral changes in the future.

**References**

Overview
Data informs policies and programs and could be more effectively used in Chicago and the region to identify the best opportunities to mitigate climate change. For instance, data reveals that the energy sector is the biggest source of emissions in Chicago and the region, and that transportation emissions will grow significantly under business as usual in the next decade. This information helps to frame where resources could be directed to mitigate climate change. Ongoing data collection and evaluation will provide the information required to identify the mitigation programs with the most impact, and evaluate if limited resources are being directed to the most cost effective strategies.

Qualitative Results

Program Elements
The City of Chicago and regional CO2e emissions baselines could be established and reduction goals set and, in fact, both of these activities are underway. The baseline, drafted by the Center for Neighborhood Technology (CNT) using sources discussed earlier in this report, was difficult to establish with the divergent data sets available, as well as lack of access to data in some cases. Datasets such as those provided by the energy companies, even if accessible to the public, are not easily digestible and necessitate a certain amount of analysis and level of expertise. Data that is relevant to individuals and collectives, such as real-time electricity usage on household and block levels, helps consumers make informed choices about electricity usage patterns, behavior changes and potential investments in efficiency measures. Therefore, in addition to establishing a baseline, it is important to make data more readily available in standard formats that can be accessed and utilized by a wider audience of interested parties including policymakers, community organizations, and the general public. The public, like policymakers and community organizations, needs access to data to inform choices and participation.

Transportation data, another key set of information for establishing a CO2e baseline, was also difficult to secure at various points during the project. The issues surrounding data collection for the purpose of establishing a baseline reinforces the important role the City of Chicago can play in ensuring that data is readily available and usable.

In order to track progress on emission reduction goals, it is important to regularly collect data on vehicle miles traveled over time, for example, and to track changes and continuously improve performance. Moreover, understanding such data geospatially will help target emission reduction efforts in areas of the city that with the highest emissions or the greatest potential for cost effective reductions. The City of Chicago could mandate the collection of data from City government agencies. The City could also use its position to leverage access to private data sources—used anonymously—and encourage other government entities in the surrounding area to participate in a regional data exchange.

The City of Chicago, since it has a relationship with various philanthropic funders, can also play a role in encouraging funders to mandate that their grantees collect program-level data related to climate change in standard formats. The most beneficial program result would be established, standardized GHG accounting methods across a broad scope. As noted earlier in this section, the City of Chicago is in the process of developing its baseline, as are cities, states, countries, industries and businesses worldwide. As noted in Greenhouse Gas Emissions: a Case Study of Development of Data Collection Tool, “accurate quantification and detailed documentation of GHG emissions data enables a company to demonstrate transparency and enhance the credibility of its corporate climate change strategy.” The City of Chicago could stay active in talking with other cities and entities about standardizing GHG accounting and incorporating standards into its own accounting system as they become available.
Benefits and Burdens
The benefit of establishing a GHG baseline is to develop capacity to make comparisons over time and to set and measure reduction goals. Measurement and data make climate change mitigation strategies concrete and provide information from which people can become active. Data collection, measurements, verification, and metrics to change and target actions are the basis of identifying and evaluating results, and continuously improving performance.

Standardized data collection and dissemination can be used to spark more community involvement and better choices, though there may be concerns regarding the anonymity of data. While it useful to have very specific information regarding the performance of one’s building or block or neighborhood, it is important to be cognizant of confidential information like account numbers to protect people’s privacy. Data tells a story and provides knowledge, knowledge in turn shapes choices. Data-informed choices are likely to be ones that result in cost savings and increased efficiency.

There are costs associated with the analysis of data, evaluation of reduction programs, and ongoing quality improvement programs. These costs, or burdens, include staff time, training on data collection, and dissemination and technology costs which may include software packages or web programming. The City of Chicago can work to minimize these costs by integrating data collection into existing jobs and identifying efficient technology, software packages and support that help to fulfill multiple objectives, rather than duplicating efforts.

Implementation Mechanisms
The City of Chicago can make collection of data relevant to GHG emissions, climate change mitigation efforts, and global warming adaptation compulsory for City agencies. The mandate, besides detailing what could be collected, can also formalize reporting standards for purposes of consistency and ease of use. Further, the City of Chicago can set a data sharing policy that guarantees public access to baseline and benchmark measures. The data sharing policy can include a pledge from the City of Chicago to actively seek data exchanges with entities in the region to ensure that climate change mitigation strategies are being coordinated throughout the area.

Current Initiatives and Models
There are several current initiatives related to data collection and reporting. First, as mentioned earlier, CNT is developing baseline CO2e measures for the Chicago Climate Change Task Force to consider. The calculations undertaken for this research effort—both baseline and forecasts—will be provided to the City of Chicago’s Department of Environment. The data has been structured so that it can be easily updated annually. Second, the Clinton Climate Initiative is developing a suite of tools for the purpose of reporting CO2e baselines and to monitor emissions—and savings—over time in its 40 partner cities. The City of Chicago and the Clinton Climate Initiative are active partners in this and other climate change mitigation endeavors. Third, the City of Chicago is already reporting its emissions as a participant in the Chicago Climate Exchange (CCX). Specifically, the City of Chicago as a member of CCX has to track direct emissions which “result from the on-site combustion of fossil fuels, such as natural gas to power industrial operations and gasoline to operate vehicle fleets.”

Additionally, the City of Chicago is a participant in the Illinois Data Exchange Affiliates (IDEA), a voluntary group of nonprofit organizations and civic entities that strive to make data more readily available. The IDEA recognizes that “good decisions require accurate, up-to-date information about the region, in all its dynamic and multi-faceted complexity.” The IDEA’s focus on the region, not just the City, broadens the scope to how municipalities interact with each other as well as other entities.
Feasibility

Financial
Data collection is already happening at the City level. Additional funds may be needed to expand analysis and evaluation functions that are directly tied to program performance and quality. The Clinton Climate Initiative is negotiating the development of software and hardware capacity for a web-based GHG data tool that the City of Chicago will have access to, so no substantial costs will be incurred by the City.

There is also more attention at local and state levels, in addition to the national level, on comprehensive and standard data collection which may result in grant opportunities for municipalities to expand their efforts in this area. The City of Chicago can pursue funding to supplement existing data work.

Technical
GHG accounting standards are being formulated and debated. There are no set data collection and report standards related to GHGs at this time. The City of Chicago is setting its own baseline, forecasts and reduction goals that could be fed into a widely used GHG accounting system when available.

Political
As noted under Current Initiatives and Models, there is already a commitment from the City of Chicago to monitor GHG emissions through its participation in CCX and as one of the 40 cities of the Clinton Climate Initiative. CNT and the Global Philanthropy Partnerships’ work, which will be used by the Chicago Climate Change Task Force, will also help further the progress of this framing mitigation strategy. The City could increase its mandate to City departments and funded agencies to ensure that the data being collected is available in a more comprehensive and standardized way for more entities and people moving forward. The City could also stay active in the IDEA and other partnerships to expand data collection and the use of metrics.

References

Overview
The greenhouse gases we emit today can last decades, centuries, or even millennia in the atmosphere. Thus, with each day that we delay action on greenhouse gas 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, perhaps more, as major innovation. This is especially true in situations involving large capital investments and equipment or facilities with long lifetimes. A power plant built or skyscraper built today is going to last decades. To impact the emissions profile of our community in 10 or 20 years, we need to change the decisions being made today.

Qualitative Results

Program Elements
In order to spur change, which the market alone is not doing fast enough, the City of Chicago could consider taking measures such as implementing incentives, making regulatory changes and providing financing that support climate change mitigation. Incentives can be used in any number of ways—from offering rebates to consumers who buy vehicles with the highest fuel economy to expedited permitting to developers building green. The City of Chicago has recently implemented a Green Permit Program through the Department of Construction and Permits (DCAP). A marketing brochure for the program explicitly states that “the DCAP Green Permit Program provides developers and owners with an incentive to build green by streamlining the permit process timeline for their projects.” The Green Permit Program was designed to encourage more green building and development than would happen without the incentive. The City of Chicago could explore other opportunities to develop incentives that encourage participation in climate change mitigation strategies.

The City of Chicago could regulate GHG producing activities and practices to bring about reductions. For example, through the zoning code, the City can reduce the “off-street parking ratio” while increasing the “minimum bicycle parking ratio” and planning for alternative transportation modes, not just automobile traffic. Changes to the zoning code can also increase tree planting requirements for parkways, and increase density requirements to encourage compact development often accompanied by reduced automobile travel. The zoning code can be updated with the goal, among others, of specifically addressing climate change mitigation.

The City of Chicago could offer financing through its Emergency Housing Assistance Program, for example, to facilitate proactive weatherization among low-income households. Weatherization saves energy and, subsequently, GHG. Low-income households are in particular need for financial support in increasing the efficiency of their homes. The City could explore other financing mechanisms, like the Tax Increment Financing (TIF), which could be used to support rapid change in GHG emissions.

Benefits and Burdens
Early action and rapid change that leads to GHG reductions will also result in pollution reduction and increased health benefits. Other benefits include increased efficiencies, as people are collectively acting, and possibly job creation as new industries and practices emerge.

Early action and rapid change can come at a financial cost that makes it difficult for low-income households to participate. Incentives, regulations, and financing could address how to be most inclusive and support the change of all households— not just those that can afford things like new hybrid vehicles. Delayed action will only lead to greater expense and challenges related to climate change mitigation.
While many people feel the urgency of climate change, there are also many who do not prioritize it. Climate change, to some, can be a nebulous and distant prospect that is far below concerns of health care, employment and housing. Climate change, therefore, must be addressed in ways that are relevant for diverse populations with varying interests so that people rally behind mitigation strategies. Early action and rapid change also necessitates a certain amount of investment which may manifest as a diversion of existing funds from one program to another, an investment in training people to work in a new way, or the purchase of technology tools.

Implementation Mechanisms
Early action and rapid change can be encouraged in many ways, as noted under Program Elements. For Chicago to reduce its GHG emissions substantially and do its part to address global warming a sense of urgency must be raised among the residents and businesses of Chicago. As Socolow and Pacala have pointed out, the path to climate stabilization can be achieved with existing technologies. The City could work to find the barriers to action in Chicago, whether financial, regulatory, cultural, or technical and use its substantial authority and leadership to create the solutions to overcome them. This is not a problem that the city government can solve on its own, but the City has the capacity to encourage and mandate change by those that live and work in Chicago, and the sooner those changes are made the more impact they will have on the fight against global warming.

Tools that Chicago can use to drive rapid change include strong, mandatory targets, dedicated leadership, knowledgeable staff that are focused on the issue, transparency, clear communication, and bold initiatives. In addition, Chicago could pursue the integration of a global warming mandate into every feasible job description, city budgeting decision, and regulatory program. Finally, Chicago could structure its GHG initiatives to reward those who act early, whether with incentives for early movers or additional requirements for those who wait. For example, the California Global Warming Solutions Act of 2006 encouraged and achieved early action on GHG accounting by enacting the following requirement:

“Entities that voluntarily participated in the California Climate Action Registry prior to December 31, 2006, and have developed a greenhouse gas emission reporting program, shall not be required to significantly alter their reporting or verification program except as necessary to ensure that reporting is complete and verifiable for the purposes of compliance with this division as determined by the state board.”

Current Initiatives and Models
Chicago already has some programs designed to spur action on climate change mitigation. For example, “if every household in the U.S. replaced just ONE incandescent light bulb with an energy efficient compact fluorescent light bulb (CFL), it would eliminate the equivalent of the emissions created by one million cars.” CFLs are an available technology that can be implemented on a wide-scale now. It is an easy change that makes a big impact. The City of Chicago’s Energy-Efficient Light Bulb Giveaway of 500,000 compact fluorescent bulbs (CFLs) took advantage of the potential of a City-wide CFL replacement program. Chicago can take the lessons from its CFL program and use them to help implement other large-scale programs to encourage rapid change in the sectors with the largest GHG emissions, such as energy demand and transportation.

In Boulder, Colorado, a carbon tax was instituted that is being collected by utility companies and is based on home energy use. The proceeds from this tax are being directed into a fund that will support the City of Boulder’s Climate Action Plan. Boulder’s implementation of a carbon tax and use of its proceeds will support additional mitigation strategies. Having dedicated resources for mitigation strategies supports early action and rapid change. One of Los Angeles’s rapid change proposals includes the distribution of “two CFLs to each of the 1.4 million households in the City.” Other cities climate action plans similarly call for big actions that can lead to significant CO2e savings. While the reduction of CO2e from a single CFL is not huge, the impact is remarkable (and relatively low-cost) at a much larger scale.

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Feasibility

Financial
Reducing GHG emissions is a large task that requires big solutions. The changes and costs need to reach the required reductions are also very large. Changes needed are global, national, statewide and local in scope and include all industries, transportation sectors and consumers. Costs are relative to this scale of change. There is savings potential that could be realized by making investments in new technologies, systems and practices that result in GHG reductions. The sooner changes are made and climate change is addressed, the better costs can be kept under control.

Technical
There are existing technologies to significantly reduce GHG emissions. These existing technologies can be employed today, and be used to leverage rapid change.

Political
Early action and rapid change necessitate partnerships and collaborations that include private and public entities. To achieve early action and rapid deployment, stakeholders must act in concert. There is existing alignment of public and private entities on the City of Chicago’s Climate Change Task Force. This group of leaders will serve as an example of the collaborations that are necessary to realize mitigation strategies. In Green LA: An Action Plan to Lead the Nation In Fighting Global Warming, environmental leadership that resulted in change is attributed to “environmental consensus” among civic leaders, community organizations, nonprofits, and the business community.”

Determining what needs to be done, and when and how is highly politically charged. There are many stakeholders and interests to consider. Early action and rapid change is critical for the success of climate change mitigation, yet there is still consensus being sought in some arenas as to whether climate change exists or what the extent of the problem is. Moving from basic questions, which are time-consuming and hard to answer, such as what the baseline GHG is from the energy sector, to what the solutions are is a long road. The City of Chicago’s commitment to climate change mitigation will need to include a commitment to early action and rapid change for climate change mitigation strategies to be successful in reducing large quantities of CO2e.

References

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2. This is known as a feebate. For more information, see Center for Clean Air Policy’s Transportation Guidebook, http://www.ccap.org/guidebook.
7. CFLBulbs.com
Mitigation Strategy #5
Enact a Carbon Tax

<table>
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<tr>
<th>Strategy Summary</th>
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<td>15.1 MMT CO2e</td>
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<td>Feasibility assessment</td>
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Overview
A carbon tax would tax energy sources that emit greenhouse gases (GHGs) into the atmosphere. A carbon tax has the potential to use market forces to reduce the emissions of carbon dioxide and other GHGs by internalizing their true social cost.

Quantitative Results

GHG Reduction Potential- 15.1 MMT CO2e
A properly executed national carbon tax would place the country, and therefore Chicago, on the way to achieving the long-term goal of 80 percent reductions from the 1990 level by 2050.

Scale Assumed
This would assume a properly priced carbon tax was placed nationally across all six major GHG sources.

Timeline
The sooner a carbon tax is instituted, the more quickly savings would be realized, although a significant period of time after implementation is necessary to affect long-term decisions and demonstrate progress towards reducing emissions. A carbon tax would need much less startup time to implement than a “cap and trade” program. A carbon tax could be instituted within six months to a year of its passage.

Per-unit GHG Savings
The elasticities of demand for products and activities with associated GHG emissions vary, and further research will need to be conducted to determine the GHG savings per dollar of tax in Chicago.
Activity Savings
The activity savings—e.g. electricity, natural gas, petroleum use—associated with a carbon tax will vary based on how the tax is applied and how the associated reductions are achieved.

Lifecycle GHG impacts
An effective carbon tax would reduce the full lifecycle of GHG emissions since it would be a nationwide tax of all energy sources emitting GHGs. Ideally, all emitters would be covered by the tax.

A more local carbon tax would not create as many lifecycle benefits since those taxes are merely on users of energy and not the suppliers—one demand is affected and not production.

Regional GHG Reduction Potential
The region would save GHGs from a carbon tax. A properly priced carbon tax could meet the Chicago CO2e savings goals set for 2020 and 2050 respectively. Similar reduction rates region-wide could result in 59.4 MMTCO2e saved in 2020.

Municipal GHG Reduction Potential
The City could save in municipal operations as well. According to the Chicago Climate Exchange reporting Chicago’s municipal operations baseline is set at 0.377 MMTCO2e of direct emissions and 892 GWh of electricity use (0.58 MTTCO2e at regional power pool average emission rates). Chicago’s direct emissions in 2005 were 0.346 MMTCO2e. In order to reduce emissions to 25 percent below their baseline Chicago will have to reduce direct emissions to 0.283 MMTCO2e by 2020. A cap and trade system will help reduce Chicago’s emissions and achieve its goal as emissions are cut across all of their sectors.

Economic Profile

Costs
According to Richard Newell of Duke University, economists estimate that to reduce CO2 concentrations to the safe level of 550 parts per million, the price of carbon would need to be $5 to $30 per metric ton by 2025 and $20 to $90 per metric ton by 2050. These values are based on the projected average costs of mitigation. A lower target or faster timeline would require higher prices and faster implementation. A carbon tax of $20 per metric ton would translate to 18 cents per gallon of gas, a six percent increase in national gas prices, and a 14 percent increase in electric prices over the national average. A $50 per metric ton tax would raise gas prices by 45 cents, a 15 percent increase in the national average, and electric rates by 35 percent of the national average. A tax in this range could raise approximately $1.3 billion per year in revenue from Chicago.

This additional $1.3 billion in revenue could be used for any number of initiatives such as an income tax rebate, new emission reduction technology, transit projects, or other related priorities.

Savings
Savings would come as behavior changes due to rising costs and would result in efficiency, conservation, and decreased consumption. A carbon tax would incentivize some companies to become more efficient and reduce their GHGs produced, thereby gaining a strategic advantage over competitors. Energy conservation can also offset the increases in energy prices to those individuals and businesses that adapt to the changing marketplace.
Qualitative Results

Program Elements
To be truly effective, a carbon tax must be levied at a national, or even global, level. It can also be issued at state or local levels of government. A national carbon tax will have a much greater effect on reducing GHGs since energy production creates such a large share of GHGs, and energy is rarely generated in the jurisdiction where it is consumed. The City of Chicago could put its leadership and lobbying capacities behind passing a nationwide carbon tax and review opportunities to implement a city-based carbon tax.

Benefits and Burdens
The biggest benefit of a carbon tax is its simplicity, especially when compared to “cap and trade” systems which must be fine tuned to ensure that the correct amount of emissions—not too high or too low—are factored in from the start. A carbon tax can reduce emissions in a more efficient and less bureaucratic manner. There is a transparency to a carbon tax that does not exist with other systems. The public and private sectors both know what the cost of carbon is at all times and there is less of a chance that the system would be exploited by special interests.

Economists appreciate the nature of a carbon tax in that it penalizes a “negative” producing GHGs. By assigning a value to carbon based on its harmful impacts on climate, it is believed that the market will begin to move away from carbon-intensive industries. A carbon tax would provide an incentive to invest in alternative, non-GHG producing fuel sources and provide industry a rational basis for making long-term decisions about their energy sources. Revenue from a carbon tax could be used for a variety of programs. The revenue could be used for research and development of alternative fuels or for investment in transit systems. It could simply be redistributed throughout the country on a per capita basis thereby rewarding those who use the least carbon in their lives, similar to the benefit that Alaskans receive from their gas and oil royalties.

One of the challenges of a carbon tax is understanding the actual elasticity of energy use. In short, there is no guarantee that a carbon tax will actually reduce emissions both in the short and long term. The structure of the energy creation system in the United States is rather inflexible in the short term. It is unclear how quickly industry will be able to respond to a carbon tax before long term solutions will start to work to reduce emissions. This is especially the case in our transportation network where decades of land use decisions have fed urban sprawl, making any large decline in transportation emissions based on a carbon tax less likely in the short run as we have planned for driving. The carbon tax in absence of other policy changes may not produce significant CO2e savings. However, a carbon tax can serve to shape future transportation priorities and land use decisions.

Another concern is the issue of equity among households from different income levels. While a carbon tax by itself would more heavily burden individuals in lower economic classes, this can be offset with a proportional redistribution of the tax among all citizens. This would actually reward individuals who used less carbon in their daily lives by paying out more than they paid into the carbon tax system, and could negate any issues of economic equality associated with a carbon tax.

Another debate is whether and, if yes, how much the economy would suffer if a carbon tax were implemented. While studies have shown various amounts of gross domestic product (GDP) losses and slight GDP gains due to a carbon tax, one opinion on this debate is from Michael Canes, a private consultant and former chief economist for the American Petroleum Institute, who led a Capitol Hill briefing on the subject earlier in 2007, and who said if “we want to do the least damage to the growth of GDP, a carbon tax will be the much more cost-effective way to go.”

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Current Initiatives and Models
Quebec: Quebec has plans to begin a carbon tax on energy producers beginning in October 2007. The rate will be $\text{C}\$50 per metric ton with plans to double that by 2020.\textsuperscript{7} This rate could raise approximately $\text{C}\$200 million ($\text{US}\$188 million) per year with $\text{C}\$69 million coming from gasoline, $\text{C}\$36 million from diesel fuel, and $\text{C}\$43 million from home heating oil.\textsuperscript{8} Additionally, natural gas distributors will pay about $\text{C}\$39 million while electricity distributor Hydro-Quebec will contribute $\text{C}\$4.5 million for its thermal energy plant in Tracy, Quebec.\textsuperscript{9} This tax is expected to raise the price of gasoline 0.8 Canadian cents per liter (2.8 U.S. cents per gallon).\textsuperscript{10} Approximately 50 companies will be affected by the carbon tax that is aimed at reducing GHG emissions and using revenues to improve public transportation.\textsuperscript{11}

Boulder: In November 2006, Boulder, Colorado passed the first carbon tax in the U.S. as part of its Climate Action Plan. This carbon tax is different than most that are proposed in that the tax is applied at the consumer level.\textsuperscript{12} According to a Boulder press release:

“The average household will pay $1.33 per month and an average business will pay $3.80 per month. The tax will generate about $1 million annually through 2012 when the tax is set to expire. Estimated energy cost savings from implementing the Climate Action Plan are $63 million over the long term.”\textsuperscript{13}

Implementation Mechanisms
The City of Chicago can advocate the Illinois congressional delegation to propose and support carbon tax legislation at the federal level. The City can start a public awareness campaign and ask Chicago residents to contact their legislators about passing a carbon tax to reduce GHGs.

The City can pursue a carbon tax strategy similar to what is being done in Boulder. However, this tax would only change demand and would not have the larger benefit of directly altering the production of energy.

Feasibility

Financial
A carbon tax would generate revenue while encouraging reduced carbon emissions. The revenue generated could be used, in part, to support the operation and oversight of the tax.

Technical
There is some level of confidence that a carbon tax would be fairly easy to implement. Additional research and models would be needed to determine the best way to systemize a carbon tax.

Political
The largest obstacle in enacting a carbon tax is the political one. As a recent Los Angeles Times editorial wrote, “taxes are radioactive, while carbon trading sounds like something that just affects utilities and big corporations.”\textsuperscript{15} Even with support from environmental voices such as Al Gore, Sierra Club head Carl Pope, and economists such as N. Gregory Mankiw, former chairman of the Bush administration’s Council on Economic Advisors, and former Federal Reserve Chairman Alan Greenspan, a carbon tax has little leverage in Congress. There are five current bills dealing with a “cap and trade” system while only one that proposes a carbon tax. The fact that a carbon tax proposes a direct cost on carbon, while a “cap and trade” masks the extra cost to the public makes a “cap and trade” an easier pill to swallow in Congress. The long-term future of a carbon tax depends on the success of its proponents in showing how its transparent nature is a strength and not a weakness and that it is a better choice in reducing GHGs more quickly and more efficiently than a “cap and trade” system.
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References

Mitigation Strategy #6
Enact a Cap and Trade System

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Overview
Through support of a cap and trade system, which sets the amount of emissions allowed for different greenhouse gas (GHG) producers—allowing the price of emissions to fluctuate with the market, the City of Chicago could realize very significant CO₂e savings. Many people believe cap and trade to be an effective market solution to curb GHG emissions since businesses can sell their excess polluting credit when they reduce emissions. Therefore, companies that reduce emissions are rewarded by having more credits to sell, while larger polluters are forced to buy emissions credits from them at market rates. To be truly effective, a cap and trade must be implemented across industries on a large scale, nation or worldwide, which adds to the complexity of this strategy. There are many cap and trade proposals currently being evaluated, and there is much attention on this strategy which could help move it forward. Chicago, as one of the nation’s largest cities, could play an important role in advocating for a cap and trade system that would greatly benefit the region and beyond.

Quantitative Results
GHG Reduction Potential- 15.1 MMT CO₂e
A properly executed national cap and trade program would place the country, and therefore Chicago, on the way to achieving a 25 percent GHG reduction from 1990 levels by 2020 and an 80 percent reduction from 1990 levels by 2050.

Scale Assumed
The GHG reduction potential assumes a properly executed cap and trade program is implemented nationally across all 6 major GHG sources.

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Timeline
A cap and trade system, to effectively reduce GHG in 2020 and beyond, needs to be implemented in the very near term. The cap would be lowered steadily over time and by 2020 would reach a target of 25 percent reduction from 1990 levels.

Life cycle GHG impacts
A cap and trade program would reduce the full life cycle of greenhouse gas emissions since it would be a nationwide limit on emission producers. Ideally, all emitters would be covered by the trading system.

Regional GHG Reduction Potential
The region would save GHGs as well. A properly set up cap and trade system would meet the reduction goals set for Chicago for 2020 and by 2050. The region needs to eliminate 59.4 MMT CO2e by 2020 to meet the 25 percent below 1990 level goal. A successful cap and trade system would play a large role in reaching this goal.

Municipal GHG Reduction Potential
The City could save in municipal operations as well. According to the Chicago Climate Exchange reporting Chicago’s municipal operations baseline is set at 0.377 MMTCO2e of direct emissions and 892 GWh of electricity use (0.58 MTTCO2e at regional power pool average emission rates). Chicago’s direct emissions in 2005 were 0.346 MTTCO2e. In order to reduce emissions to 25 percent below their baseline Chicago will have to reduce direct emissions to 0.283 MMTCO2e by 2020. A cap and trade system will help reduce Chicago’s emissions and achieve its goal as emissions are cut across all of their sectors.

Economic Profile

Costs
A cap and trade system sets the emissions allowed under each phase of the plan with emissions slowly reduced over time. Carbon credits are traded in an open market. GHG producers are required to have enough carbon credits to cover their emissions. Under this system, the price of carbon emissions has a distinct cost associated with them. At the time of writing, carbon credits were trading at approximately $26 per ton in the European market. The extra cost of business associated with the purchase of carbon credits will most likely be passed on to the consumer but within the reigns of a competitive market. Companies which are able to produce an equal amount of energy while producing less GHGs will gain a competitive advantage over their competition, empowering them to offer cheaper prices for their services.

These credits could be purchased under an auction system, initially creating another cost for the program. An auction system would reward those firms who have been proactive in reducing GHG emissions since they would have to purchase less initial credits than firms that have not reduced GHG emissions.

Savings
The savings under a cap and trade system would go to the energy producers who are able to reduce greenhouse gas emissions and, therefore, trade their credits to heavy emitters. Under the traditional cap and trade system, credits accumulate by reducing emissions beyond the set acceptable level and are free, which can lead to large profits for firms with credits to sell.

The auction can also create a large pool of revenue when the system is put in place. This revenue can be used for any number of initiatives such as a federal income tax rebate, research into alternative fuels, or any number of conservation projects.
Qualitative Results

Program Elements
A cap and trade program takes longer to institute than a carbon tax (see Mitigation Strategy #5). A GHG baseline must be calculated in order to determine how many emission credits each existing company should be granted. Also, there is normally a reduction in credits that are offered at some regular interval in order to reduce emissions. “Setting up a market for greenhouse gases is tremendously tricky,” said Mark Trexler, Director of Global Consulting Services for EcoSecurities, a London consultancy and broker in carbon credits. If too many credits are offered, it keeps the price of credits low and provides no real incentive to the private sector to decrease emissions. If too few credits are offered, it could force reductions at too steep a pace and have severe economic ramifications. Clearly, setting the initial market in a cap and trade system will go a long way in determining the success of such a program.

Another aspect of a cap and trade system is setting price basements and ceilings. For example, if the price of carbon gets too high and reaches a certain point, it becomes more like a carbon tax and polluters can purchase as many credits as needed at the ceiling price. This safety valve is in place to prevent runaway prices if there is a carbon shortage in the system. A similar device would be in place if the price of carbon got too low as well. These strategies are fairly controversial as they tend to favor industry over reduction of emissions. They essentially blend the price certainty of a carbon tax on the high end while the price is allowed to vary on the low end.

A cap and trade system is favored because of the following three points:

1) By gradually reducing the credits available to trade in a cap and trade system, there is more of a certainty in reducing emissions than under a carbon tax.

2) The private sector is incentivized and rewarded for innovation. In theory, firms would seek to produce the most energy while generating the fewest GHG emissions in order to sell excess credits to other companies at a rate determined by a free market trading system. Those companies that can innovate quickly will receive compensation from the emissions market for doing so. The government will be involved in setting the initial parameters for the cap and trade system but, once installed, it will become a market system like any other.

3) The cap and trade system is politically palatable, especially in contrast to the carbon tax which, as its name suggests, introduces a new tax. Even if costs under a cap and trade system are the same as a carbon tax, the cap and trade system has a layer of complexity that makes it function unlike a traditional tax system. This provides enough political cover to garner more support from Congress for a cap and trade system than for a carbon tax.

There are many considerations to a cap and trade system. Much attention must be given to the initial allotment of credits to ensure the market will function correctly. As shown above, too many or too few available credits can severely 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.

The lack of a set, stable price is another shortcoming of a cap and trade system. The trading system by nature sets up a system with little price certainty. Prices should fluctuate based on supply and demand giving energy producers little idea of costs ahead of time. With this price uncertainty, it is more difficult to make long term planning decisions.
Another criticism of a cap and trade system is that the credits are initially given to companies for free. This indirectly rewards them for polluting in the first place. An alternative to this giveaway is an auction system. In this system, companies would need to bid against one another to receive their initial allotments of credits. According to Robert Reich, the former Secretary of Labor, “the auction market itself determines who can pollute and by how much. And since companies will inevitably want to reduce their bidding costs, they’ll search for new technologies that cut their emissions.” As part of this system the money raised in an auction would be returned to all citizens in the form of a dividend check similar to what Alaskans receive from their oil rights.

Benefits and Burdens

Benefits to a cap and trade system include increased efficiency across industries and ancillary environmental benefits—reduced pollution resulting in cleaner air, water and land. A cap and trade would have long-term impact on the way this country does business by fostering innovation and environmentally sound practices.

Consumers could end up absorbing additional burdensome costs that companies incur at some level to reach compliance with the program. Efforts should be made to incorporate small emitters and allow households and small businesses to benefit from pursuing efficiency. There is also concern in the Environmental Justice community that pollution will be geographically concentrated in lower income communities.

Current Initiatives and Models

Chicago Climate Exchange (CCX)
Chicago boasts “North America’s only and the world’s first global marketplace for integrating voluntary legally binding emissions reductions with emissions trading and offsets for all six greenhouse gases.” Members voluntarily commit to reduce emissions and can buy and sell emission credits through the exchange. Current members include Intel, Ford Motor Company, and Motorola in addition to the City of Chicago.

United States Sulfur Dioxide Trade
In what is considered the major success in cap and trade systems, the 1990 Clean Air Act set up such a system to reduce sulfur dioxide which is a major cause of acid rain. The plan was established by the U.S. Environmental Protection Agency (U.S. EPA). As of 2005, SO2 emissions have declined by 35 percent over 1990 levels and 41 percent from 1980 levels. A 2005 study in The Journal of Environmental Management estimates that in 2010, the Acid Rain Program’s annual benefits will be approximately $122 billion (2000$), at an annual cost of about $3 billion - a 40-to-1 benefit-to-cost ratio.

European Union
The largest cap and trade system is currently in place in the European Union (EU). It covers more than 11,500 energy intensive facilities across the 25 EU member countries, including oil refineries, power plants over 20 megawatts in capacity, coke ovens, and iron and steel plants, along with cement, glass, lime, brick, ceramics, and pulp and paper installations. Covered entities emit 45 percent of the EU’s carbon dioxide emissions. The trading program does not cover emissions from non-CO2 greenhouse gases, which account for about 20 percent of the EU’s total greenhouse gas emissions. The first trading began on January 1, 2005. A second trading period is expected to begin in 2008, with a third one planned for 2013.

The first trading period was plagued with problems as the governments gave away too many emission credits to the most polluting companies. Once this was realized, the price of carbon dropped sixty percent and gave little incentive to lower source emissions. One of the reasons behind this was that each country was allowed to assign its own emission goals and only a handful of countries—Britain, Denmark, Ireland, and Spain—issued fewer credits than the industry wanted. The result is that emissions have actually increased between 1 and 1.5 percent in 2006.
The next trading period is believed to be the most important because it covers 2012, the target of the Kyoto Protocol. Many countries have significantly cut their credits for the next phase in an attempt to reign in emissions. Poland has cut its permit total by 26% and Latvia and Lithuania by half.14

**Implementation Mechanisms**

There are currently 6 pieces of pending federal legislation that would begin a national cap and trade program for carbon. The City of Chicago can review proposed legislation and determine which aspects of the legislation that it will support with its lobbying power and leadership influence.

The City of Chicago, which is a participant in the Chicago Climate Exchange, can encourage its partners to participate in this voluntary system and hope to spark more interest a national effort.

**Feasibility**

**Financial**

The cost of implementing a cap and trade system and regulating it will be high, as will the cost to some industries in revamping systems to reduce GHGs and/or purchase credits. These costs could be transferred to consumers who will then also experience a financial burden.

**Technical**

There are some relevant experiences to draw from for the creation of a national cap and trade program. One mandatory cap and trade system is currently in the planning stages in the U.S. California passed AB32 in 2006 which attempts to cap 2020 emissions at 1990 levels. The bill allows market based approaches for achieving this goal.15 Work will need to be done to make sure the problems that have severely crippled the first stage of the EU trading system do not happen in the U.S. The system must be kept as transparent as possible and special interests should not shape the plan created here.

The technology to reduce GHGs from the largest producing sectors exists.

**Political**

The City of Chicago as a member of the Chicago Climate Exchange has relevant experience to share in shaping a larger scale and mandatory cap and trade program. Also, as mentioned under Implementation Mechanisms, the City could bring pressure to its partners and vendors to participate in the CCX.

Existing debate and proposed legislation at the federal level suggests a deep interest in pursuing a large scale GHG reduction program such as a cap and trade. However, the savings discussed here are not achievable under cap and trade policies currently being considered at the Federal level, where the strictest cap proposed would reduce 2020 emissions to 1990 levels. In order for a Federal cap and trade to be enacted that would meet Chicago’s reduction target, Chicago and other stakeholders would need to advocate for stricter Federal policies, which may or may not be feasible.
References


This research was commissioned to advise the Chicago Climate Task Force in the development of the Chicago Climate Action Plan. It does not represent official City of Chicago policy.
Mitigation Strategy #7
Implement Efficient Urban Form

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<td>Scale of deployment</td>
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<td>Regional</td>
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<td>Long Term</td>
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<td>Regional Impact</td>
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<td>Financial Savings in relation to Cost</td>
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<td>Household cost of living</td>
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<td>Additional Benefits in relation to Burdens</td>
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<td>Feasibility assessment</td>
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Figure 1 Two Views of Cities

Overview

The nature and form of the built environment contribute to the greenhouse gas (GHG) producing activities that occur in a community, particularly in the energy and transportation sectors. Residents of disperse, sprawling communities may travel long distances to reach work, school and shopping destinations, often in automobiles. In comparison, those who live in compact, dense, transit-rich communities make shorter commutes to destinations and amenities that are close by. The dense building forms of compact communities—condos, townhouses, and attached housing—utilize less 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 development that is dense, mixed use and pedestrian-oriented. It promotes increased mobility choices—such as transit, car sharing, walking and biking—that lead to reduced reliance on automobiles. Transit-oriented design (TOD) is one strategy that promotes smart growth principles by centering compact, mixed-use, walkable development within a half-mile of transit stations, resulting in decreased auto dependency.

Figure 1 illustrates that, on a per household basis, there are considerably less GHG emissions related to vehicle travel in the compactly developed City of Chicago than in the dispersed six-county suburban area.¹ Similar patterns are seen in other U.S. metropolitan areas.²

Car ownership and driving distances are largely determined by residential density, household income, household size, and availability of public transit.³ As the population has increased, so too has the rate of developed land and vehicle miles traveled (VMT) — “for every 1% in population increase, developed land increases about 1.2%-1.3% and VMT increases by about 2.3%.”⁴ Smart growth and TOD produce compact development that reduces the high VMT that often accompanies urban sprawl.

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Figure 1

Source: CNT, Travel Matters, 2003
Quantitative Results

GHG Reduction Potential: 0.159 to 0.623 MMT CO2e

As part of its 2030 plan, the Northeastern Illinois Planning Commission (currently part of Chicago Metropolitan Agency for Planning, CMAP) projects household growth of 106,243\textsuperscript{5} for the City and 480,614 in the six-county region by 2020. Thus, the suburbs, less Chicago, 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 the fixed guide way transit stations (transit zones) in Chicago and the six-county region, there would be a reduction in a range of 0.159 to 0.623 MMT CO2e in Chicago. This range of reductions was calculated using the household transportation model published by the Brookings Institution\textsuperscript{6} to calculate the total driving associated with household location. Figure 2 summarizes these results.

Figure 2 shows three smart growth scenarios and their associated GHG reductions. Scenario 1 allows for new households to locate in transit zones so that the minimum residential in these zones is 18 HH per residential acre (a typical density for efficient zones, similar to the Damen stop on the Blue line), and a residential density of 30\% (this is the current ratio of suburban to city transit zones) in the suburbs. Note that scenario 1 has more new households in Chicago that the NIPC’s projections because to find the reduction relative to the BAU it was assumed that some suburban households would have to relocate to the city and their GHG reductions are credited. Scenario 2 uses these same residential densities in the transit zone but moves households from the non transit areas of the city and the suburbs so that the net household increases align with NIPC’s projections of city and suburbs.\textsuperscript{7} Finally, scenario 3 distributes the new households in the transit zones evenly but constrains the total number to NIPC’s city versus suburban projections.

**Figure 2 VMT, Gasoline, and CO2e Growth by Location of Population Growth**

<table>
<thead>
<tr>
<th>Scenario</th>
<th>HH Added by 2020</th>
<th>VMT (Million Miles Added)</th>
<th>MMTCO2e Added from new HH</th>
<th>HH Added by 2020</th>
<th>VMT (Million Miles Added)</th>
<th>MMTCO2e Added from new HH</th>
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<td>New region’s hh locate across whole region (BAU)</td>
<td>480,615</td>
<td>5,680</td>
<td>2.460</td>
<td>106,243</td>
<td>830</td>
<td>0.359</td>
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<td>Region New HH locate so as to make transit zones have minimum density (Scenario 1)</td>
<td>480,615</td>
<td>4,109</td>
<td>1.780</td>
<td>308,048</td>
<td>2,106</td>
<td>0.912</td>
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<td>Extra HH in Suburbs that will move to city under scenario 1</td>
<td>201,805</td>
<td>1,668</td>
<td>0.289</td>
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<td>Relative savings</td>
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<td>0.681</td>
<td>1.438</td>
<td></td>
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<tr>
<td>Region New HH locate in transit zones in city to minimum density but relocate others in non-transit area (Scenario 2)</td>
<td>480,615</td>
<td>4,852</td>
<td>2.101</td>
<td>106,243</td>
<td>152</td>
<td>0.066</td>
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<tr>
<td>Relative savings</td>
<td>829</td>
<td>0.359</td>
<td>678</td>
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<tr>
<td>Region New HH locate in transit zones allocation following NIPC projections for city vs. suburbs</td>
<td>480,615</td>
<td>4,186</td>
<td>1.813</td>
<td>106,805</td>
<td>463</td>
<td>0.200</td>
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<tr>
<td>Relative savings</td>
<td>1,494</td>
<td>0.647</td>
<td>367</td>
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Chicago’s proportion of the household growth is 22%, yet even under the BAU accounts for 15% of the regions’ GHG reduction potential (0.359 vs. 2.460 MMTCO₂e). This underscores the already efficient nature of the city in regards to VMT-related emissions, and the enormous potential for the suburbs to realize significant GHG reductions by implementing efficient urban form through smart growth and TOD. Additionally, these calculations assume that suburban growth will occur in areas currently designated residential. If projections were to assume new development in exurban areas, which is currently underway, there would be even more savings potential. As discussed in the overview, there are additional GHG savings in the energy use sector that can result from pursuing efficient urban form; this is an area ripe for further research.

**Scale Assumed**

Smart growth can be employed in Chicago through infill development. The six-county region offers abundant opportunities to channel efficient growth into compact dense communities along Metra lines and other efficient transportation assets, while preserving open space and farmland.

**Timeline**

Over the last several decades, “existing tools such as land use planning, zoning and transportation infrastructure investments have been primarily made to enhance the mobility provided by motor vehicles.”

Decisions made about the built environment and infrastructure will have an impact on climate change for decades to come. Smart growth planning tools could be developed and adopted now in order to guide new development patterns that will affect carbon emissions for decades.

**Per-unit Reduction Potential**

2.4 metric tons CO₂e of transportation emissions will be reduced per household per year for every household that moves into a smart growth area versus the region at large.

**Activity Savings**

The reduction in VMT regionally will be from .9 to 1.6 billion miles, or 400 million to 1.4 billion miles for Chicago.

**Life cycle GHG Impacts**

The emission factor used in the above analysis for gasoline is 0.0089 MT CO₂e/gallon gas. This accounts for only the direct emissions from burning gasoline in cars, but the full life cycle emission factor is higher. An additional consideration in a full life cycle analysis would be to calculate the full GHG input from building and maintaining the new infrastructure required for greenfield development in the suburbs; this savings is difficult to estimate.

**Regional GHG Reduction Potential: 0.359 to 0.681 MMT CO₂e**

Significant capacity for reducing regional CO₂e reductions can be achieved through smart growth development. The BAU development scenario in the six-county region is a continuation of sprawling, dispersed communities reliant upon the automobile. Over 380 fixed rail transit stations exist in the six-county region—140,500 acres within a half mile of these stations, with 937,173 households. These transit zones could easily accommodate the 480,614 projected households by 2020, and still have only 10 households per acre on average in these zones. There is a projected growth of 374,372 households in the six-county region, less Chicago, by 2020. If all of those households were built within a half a mile of those stations instead of spread out across the six-county region, there is a potential to reduce related thus greenhouse gases.

**Municipal GHG Reduction Potential**

No significant municipal CO₂e savings is anticipated.
Economic Profile

Financial costs
Financial incentives may be offered to attract developers to employ smart growth principles, and could include low interest loans, tax deferrals and infrastructure improvements. However, these initial public investments will realize a return on investment due to increased tax revenue from rising property values and increased sales.

Financial Savings
Considerable savings are available to residents of smart growth communities, due to decreased energy costs and less reliance on automobiles. Research has shown that Chicago metropolitan households in transit-rich neighborhoods pay 15% of their income for transportation, as opposed to 23% in communities with no transit. There are also large savings to be had by making more efficient use of existing infrastructure, such as transportation and energy systems, rather than developing in new areas.

Qualitative Results

Program Elements
Smart growth encourages location efficiency, which is a function of access to necessities and amenities, such as employment, shopping, schools and recreational facilities; of traveler choice, ranging from good pedestrian environment to mass transportation to newer forms of transit such as car sharing; and of the density of the built environment. The U.S. EPA has developed the following Smart Growth Principles:

- Mix land uses;
- Take advantage of compact building design;
- Create housing opportunities and choices for a range of household types, family sizes, and incomes;
- Create walkable neighborhoods;
- Foster distinctive, attractive communities with a strong sense of place;
- Preserve open space, farmland, natural beauty, and critical environmental areas;
- Strengthen and direct development towards existing communities;
- Provide a variety of transportation choices;
- Make development decisions predictable, fair, and cost-effective; and
- Encourage community and stakeholder collaboration in development decisions.

TOD employs many of these principles in compact, mixed-use developments within a half-mile of transit. Successful TOD can employ a variety of creative tools to incorporate decreased reliance on the automobile, such as lower per-unit parking ratios and transit passes for residents.

Both cities and states have adopted smart growth incentive programs. The City of Austin has developed a point-based performance evaluation system for redevelopment projects. Incentives such as density bonuses, fee reductions or infrastructure financing can be leveraged to encourage “smart features.” The State of New Jersey developed a scorecard to identify smart growth strengths and weaknesses.

Other governments have moved to incorporate smart growth principles into their climate plans. The mayor of Vancouver, Canada has made compact, dense development the cornerstone of the city’s development and climate mitigation plan, coining a term for this strategy—“ecodensity.” Some states in the U.S. are incorporating smart growth and transit strategy into climate policy, including Connecticut, Massachusetts, and New York.
Benefits and Burdens
Benefits include increased quality of life for residents who can walk and use transit to travel to work, retail and other amenities. Residents also realize significant cost of living savings associated with reduced auto travel and building energy use. A 2006 study concluded that households living close to transit spend 15% on transportation costs as opposed to those without access to transit spending 23%.10

Other benefits include reduced road congestion; increased air quality; preservation of open space, park land, and farmland; and less need for sprawling infrastructure investment and maintenance. There is also less electricity line loss that occurs when energy is delivered to distant locations.

Burdens may include increased regulation, a prolonged political process to adopt smart growth principles and increased time required to build regional cooperation.

Implementation Mechanisms
Smart growth, and in particular compact, dense TOD, can be promoted through comprehensive plans, zoning, density bonuses and other planning tools. Zoning practices could include zoning overlays, interim zoning and floating zones. Financing mechanisms such as federal grants, low interest loans and local tax incentives would make TOD attractive to developers.

An initiative to create state and city TOD plans would necessitate the inclusion of local planning agencies, transit agencies, and community stakeholders in order to target where TOD initiatives should be focused and how they should be implemented.11 Successful implementation requires comprehensive regional planning, regional cooperation, funding for efficient transportation alternatives, and targeted infrastructure spending.

A key component of smart growth is the provision of a wide variety of transportation choices to transplant the need for an automobile. Access to reliable and frequent transit, pedestrian-friendly design, bike path and parking, as well as new transportation alternatives such as car-sharing, are necessary elements of a smart growth development.

Current Initiatives and Models
The City of Chicago has incorporated some smart growth principles into its planning and development. Chicago currently has density bonus zoning which provides incentives for increased density in exchange for other development concessions. This zoning option could be amended to provide additional focus on areas close to transit. The Planned Development District Ordinance could also be enhanced to specifically incorporate TOD, including reduced parking ratio requirements and deeded transit passes.

Several recent Chicago development activities incorporate smart growth and TOD principles. Chicago Sun Times housing observer David Mack writes:

“Chicago’s South Loop … ‘a multitude of loft and other condominium and town-house complexes reflect a number of ‘smart growth’ principles,’ including brownfield redevelopment, historic preservation and warehouse conversion”.12

In Chicago’s Austin neighborhood, Bethel New Life collaborated with residents, churches, public officials, public school principals, the Garfield Park Conservatory, and local organizations to develop the Transit Village Plan. The plan focuses on improving quality of life by addressing residents’ needs for a walkable neighborhood and better community services. The plan received the U.S. EPA 2006 National Award for Smart Growth Achievement.
The suburb of La Grange “joined the trend by using a former retail site for a mid-rise condominium and an old lumberyard for a town-house project a few years ago, and is now facilitating redevelopment north of the main business district, where a high-rise condo complex will include retail space.” Several other suburbs have focused on mixed use development near transit stations, notably Evanston and Oak Park. However, a coordinated regional plan and vision has not been adopted.

In Austin, Texas the Smart Growth Matrix is a tool to analyze development proposals within the Desired Development Zone. It is designed to measure how well a development project meets the City’s Smart Growth goals. If a proposed development project advances the city’s smart growth goals, financial incentives such as waiver of development fees, infrastructure investment, or streetscape improvements may be made available.

**Feasibility**

Implementation of efficient urban form principles is feasible in both city and the region. Smart growth initiatives have begun to be implemented piecemeal in selected suburbs, but the most comprehensive CO2e reductions could be realized through a coordinated regional approach that includes the City of Chicago.

**Financial**

Financing tools such as tax incentives and low interest loans are required, but entirely feasible due to the return on investment that results from this type of development. Demand for TOD has been documented. “There are ……more households who want shorter and more convenient commutes and who want to live in neighborhoods where the grocery store, park, library and school are within walking distance.” The demand for housing near transit is projected to reach 9 million households nationally by 2020.

**Technical**

The technical expertise to implement smart growth and TOD exists, the next step is to educate more planners and municipalities of it benefits. Implementation tools and financing tools also exist, but could be improved by developing models that meet the needs of individual communities.

**Political**

Political will is required to fully embrace smart growth principles so they become an integral aspect of planning efforts rather than just another zoning option. This is particularly true in the regional setting, where the most potential lays for reduced VMT and related carbon emissions. Support and cooperation from CMAP, the Regional Transportation Authority (RTA), and the City of Chicago could significantly move this effort forward and realize dramatic results in CO2 savings and related benefits.
This research was commissioned to advise the Chicago Climate Task Force in the development of the Chicago Climate Action Plan. It does not represent official City of Chicago policy.

References

7. This projection assumes 2000 and 2020 the transit network does not change, the distribution of jobs remains the same, residential land use will remain the same as 2001 (Note that this is very conservative since we know that farmland has already been converted to residential land, and that will only make the BAU growth more diffuse and generate more transportation demand), a conservative 18.6 miles/gallon is assumed as the average auto gas mileage, the average household’s income of the new households is the current regional average of $68,967/year, and the average household size is the same as the current one of 2.73 people per household.
**Mitigation Strategy #8**
Energy Retrofits in Residential Buildings

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<td>proven models</td>
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**Figure 1: Residential Energy Consumption by End Use**


**Overview**

According to the Pew Center on Global Climate Change, “Given the durable nature of buildings, the potential for GHG reductions resides mostly with the existing building stock for some time to come.” Furthermore, to maximize potential for greenhouse gas (GHG) emissions reductions, it is important to address the existing building stock because 80% of the buildings existing today will still be standing in 2020. Residential energy efficiency programs can reduce electricity and natural gas consumption thereby reducing greenhouse gas emissions. These programs can achieve an average of 30 percent reduction in energy consumption by comprehensively retrofitting homes using existing appropriate technologies. Energy conservation measures (ECMs) address building envelopes, heating, cooling, hot water, lighting systems and appliances. Technologies used are 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. Effective programs combine technical, financial and educational assistance to help property owners make the best choices and provide them with access to capital in order to achieve the highest savings and return on their investments.

**Quantitative Results**

**GHG Reduction Potential: 1.3 MMT CO2e in 2020**

It is possible to reduce emissions by 1.3 MMT CO2e in Chicago by implementing energy retrofits in roughly half of the existing residential building stock assuming an average of 30 percent energy savings per unit. A national evaluation of weatherization programs has shown that energy consumption can be reduced by 30 percent on average in existing residential buildings if comprehensive energy retrofits are implemented and equipment is maintained.
The impact of this strategy is determined by estimating the number of existing residential housing units through 2020. This estimate is based on the number of buildings reported in the 2000 census minus the estimated annual number of demolished and substantially rehabbed units. Buildings that are substantially rehabbed (defined as renovation of all building systems to the building shell) can achieve higher energy savings and are therefore addressed on the Green Buildings section for new and substantially rehabbed units.

The number of existing buildings in 2020 was estimated as follows. According to the 2000 census, there were 1,061,928 housing units in Chicago. An average of 3,000 units have been demolished and 8,000 units substantially rehabbed annually. These estimates are based on ten years of permit data (1994-2003) from the Chicago Department of Construction and Permitting. By removing the annual number of demolished and substantially rehabbed units from the 2000 baseline through 2020, there will be 842,000 existing housing units in 2020. The average emissions per housing unit in 2000 were 10.7 metric tons CO2e. Assuming that an energy retrofit program began in 2008 with 6,000 units and that the program increased as shown in Figure 5, to a total of 400,000 units (47% of existing stock) could be retrofitted by 2020 resulting in a potential savings of 1.3 MMT CO2e by 2020. This calculation assumes a flat rate of per household consumption over this period.

Figure 2: Chicago Housing Stock by Year Built and Ownership


Scale
The potential emissions reduction of 1.3 MMT CO2e assumes that retrofits begin with 6,000 units in 2008 with a scaled-up program implementation to reach a total of 400,000 housing by 2020.

Timeline
The scale of GHG emissions reductions proposed (1.3 MMT CO2e) assumes a ramp up of program deployment beginning with 6,000 retrofits in 2008. It assumes a ramp-up schedule shown in Figure 5 to 400,000 units by 2020. Currently, the weatherization program in Cook County retrofits 2,500 units annually indicating the need for significant investment and resource deployment.
Per-unit GHG Reduction Potential
The proposed energy retrofit strategy holds the potential to reduce an average of 3.2 metric tons CO2e per housing unit annually.

Activity Savings
Employing this strategy can result in savings of 863 gigawatt hours of electricity and 235 million therms of natural gas.

Lifecycle GHG Impacts
Energy retrofit programs for residential buildings should be designed to reduce the impacts of upstream and downstream processes (including manufacturing, transportation and decommissioning of materials) by using locally manufactured materials and assuring appropriate reuse of building materials. However, further research is needed to quantify and appropriately account for the lifecycle GHG impacts of the installation of more efficient heating and cooling equipment, as well as for the use of energy efficient building materials. Because energy retrofit programs for existing buildings reduce the consumption of fossil fuels, they are likely to result in net CO2e savings globally.

Regional GHG Reduction Potential
There is the potential to save 2.5 MMT CO2e in the region in 2020 by conducting energy retrofits of residential buildings. Typically, energy efficiency programs correspond to utility service areas or units of government, such as wards or counties. In 2000, there were 3,065,091 housing units in the six county metropolitan area. Assuming the same scale of implementation (6,000 units in 2008 with an annual increase through 2020) and that 80 percent of existing housing is standing in 2020, the GHG emissions reduction potential for the region is 2.5 MMT CO2e.

Municipal GHG Reduction Potential
Under the Chicago Housing Authority’s Plan for Transformation, the City will own and operate 25,000 units by 2010. Under this plan, old units have been demolished and replaced with new construction. In addition, some existing units will undergo substantial renovation and are addressed under the Green Building section. Strategies that the City can adopt to promote energy retrofits in existing housing are described below in the Program Elements section.

Economic Profile
The typical cost of retrofits for multi-family units is $2,500 to $5,000 per unit and $5,000 for single family units. Multi-family units are less costly per unit because the expenses incurred to address whole building systems (e.g., insulation, heating system) are spread across a larger number of units and because the units are smaller in size. The length of time for payback of energy efficiency retrofits to be realized ranges from three to eight years, translating to a return on investment (ROI) of 12.5 percent to 30 percent. Typically the homeowner bears the initial capital costs and takes advantage of the energy savings; however, many owners lack the financial resources, information and access to incentives to take advantage of this cost effective investment. In rental units, a split incentive often exists where building owners incur the retrofit costs and the savings are realized on the renters’ utility bills. Figure 3 shows the level of investment that would be required to achieve the respective emissions reductions targets.

This research was commissioned to advise the Chicago Climate Task Force in the development of the Chicago Climate Action Plan. It does not represent official City of Chicago policy.
Qualitative Results

Program Elements

Residential energy retrofit programs are most effective when they combine technical assistance, financial assistance and ongoing monitoring and maintenance. Programs designed to address all building systems (envelope, heating/cooling, and lighting) most effectively reduce overall consumption. An energy performance standard measured in energy consumption per square foot per year can be established for each residential building type and serve as a target for building performance. For example, an achievable performance standard for multi-family buildings in Chicago is one therm/sq. ft/year.12

Typical energy retrofit program elements include roof insulation, energy efficient windows, sealing air leaks, programmable thermostats, energy management systems, high efficiency boilers, flue dampers, tankless or solar hot water heaters, water saving technologies like low-flow showerheads, compact fluorescent light bulbs (CFLs) and lighting controls. In order to effectively reach property owners, technical recommendations should be partnered with financing assistance. Energy efficiency financing programs include matching grant programs and low-interest financing. Alternative financing strategies include programs that use energy savings to payback the initial capital expenditures through utility bill financing, “pay as you save” programs or through energy service companies. A typical package of energy efficiency improvements for a multifamily building in Chicago is shown below in Figure 4. It should be noted that energy savings are interrelated; the savings shown below result from the complete package of energy conservation improvements listed.

Figure 4 Sample Energy Efficiency Recommendations - Costs and Benefits

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This research was commissioned to advise the Chicago Climate Task Force in the development of the Chicago Climate Action Plan. It does not represent official City of Chicago policy.

Chicago Climate Analysis
This research was commissioned to advise the Chicago Climate Task Force in the development of the Chicago Climate Action Plan. It does not represent official City of Chicago policy.

<table>
<thead>
<tr>
<th>Building Envelope</th>
<th>Cost</th>
<th>Savings</th>
<th>Simple Payback (Yrs)</th>
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</thead>
<tbody>
<tr>
<td>Ceiling Cavity Insulation</td>
<td>$7,049</td>
<td>$1,531</td>
<td>4.6</td>
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<tr>
<td>Seal Air Leaks</td>
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<td>$70</td>
<td>5.7</td>
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<table>
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<th>Mechanical Systems</th>
<th>Cost</th>
<th>Savings</th>
<th>Simple Payback (Yrs)</th>
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<td>Replacement Hi-Efficiency Boiler</td>
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<td>$4,542</td>
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<td>Boiler Controls</td>
<td>$4,500</td>
<td>$901</td>
<td>5.0</td>
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<tr>
<td>Outdoor Reset Control</td>
<td>$2,000</td>
<td>$1,770</td>
<td>1.1</td>
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<tr>
<td>Repipe Leaking Condensate Return Lines</td>
<td>$2,000</td>
<td>$460</td>
<td>4.3</td>
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<tr>
<td>Replace Radiator &amp; Line Vents</td>
<td>$1,270</td>
<td>$755</td>
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</table>

<table>
<thead>
<tr>
<th>Electrical/Lighting</th>
<th>Cost</th>
<th>Savings</th>
<th>Simple Payback (Yrs)</th>
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<tr>
<td>Compact Fluorescent Lamps in Common Areas</td>
<td>$152</td>
<td>$55</td>
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</table>

<table>
<thead>
<tr>
<th>Total for all Measures</th>
<th>Cost</th>
<th>Savings</th>
<th>Simple Payback (Yrs)</th>
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</thead>
<tbody>
<tr>
<td></td>
<td>$41,371</td>
<td>$10,084</td>
<td>4.1</td>
</tr>
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</table>

* Based on a typical three-story, 24-unit masonry structure with 24,000 square feet of heated space.

Pricing programs can also be used to change energy conservation behaviors by providing reduced prices to encourage lower consumption, especially during high peak electricity periods. An example is the Energy-Smart Pricing PlanSM which used real-time electricity price signals and consumer education and resulted in a 10 percent peak demand reduction and a 4 percent reduction in electricity consumption.33

In order to achieve substantial greenhouse gas emissions reductions, this energy efficiency retrofit program must be implemented in a substantial proportion of the existing residential housing stock. Figure 5 below shows the annual number of housing units by sub-sector to be retrofitted beginning with a ramp-up period in 2008 and 2009, with full scale implementation from 2010 through 2020, that allows the city to reach 400,000 units and 1.3 MMT CO2e by 2020.

**Figure 5: Scale of Energy Retrofits for Existing Residential Buildings**

<table>
<thead>
<tr>
<th>Year</th>
<th>Single Family Low-Income</th>
<th>Single Family Moderate/Upper Income</th>
<th>Multi-Family Low-Income</th>
<th>Multi-Family Moderate/Upper Income</th>
<th>Total Annual Goal (Number of Housing Units)</th>
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</thead>
<tbody>
<tr>
<td>2008</td>
<td>2,500*</td>
<td>500</td>
<td>2,500*</td>
<td>500</td>
<td>6,000</td>
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<tr>
<td>2009</td>
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<td>2010</td>
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<td>3,500</td>
<td>2,500</td>
<td>11,500</td>
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<tr>
<td>2011</td>
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<td>5,000</td>
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<td>16,000</td>
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<tr>
<td>2012</td>
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<td>4,500</td>
<td>7,000</td>
<td>5,000</td>
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<td>2013</td>
<td>9,500</td>
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<td>6,000</td>
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<td>2014</td>
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<td>7,500</td>
<td>35,000</td>
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<tr>
<td>2015</td>
<td>11,500</td>
<td>8,500</td>
<td>11,500</td>
<td>8,500</td>
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<tr>
<td>2016</td>
<td>11,500</td>
<td>8,500</td>
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<td>8,500</td>
<td>40,000</td>
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<tr>
<td>2017</td>
<td>11,500</td>
<td>8,500</td>
<td>11,500</td>
<td>8,500</td>
<td>40,000</td>
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<tr>
<td>2018</td>
<td>15,000</td>
<td>10,000</td>
<td>15,000</td>
<td>10,000</td>
<td>50,000</td>
</tr>
<tr>
<td>2019</td>
<td>15,000</td>
<td>10,000</td>
<td>15,000</td>
<td>10,000</td>
<td>50,000</td>
</tr>
<tr>
<td>2020</td>
<td>15,000</td>
<td>10,000</td>
<td>15,000</td>
<td>10,000</td>
<td>50,000</td>
</tr>
<tr>
<td>Total</td>
<td>119,500</td>
<td>79,000</td>
<td>119,500</td>
<td>82,000</td>
<td>400,000</td>
</tr>
</tbody>
</table>

*GHG emissions are in metric tons of CO2e
Benefits and Burdens
Residential energy efficiency programs are cost-effective, providing an 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, thereby, make the city a more affordable place to live and work.

Energy efficiency programs are especially valuable for low-income households; yet they often do not reach the families that need them most—largely due to program design.\textsuperscript{14} Low-income families are spending up to 25\% of their incomes on energy costs.\textsuperscript{15} According to advocates for these types of families, implementing energy efficiency programs in low-income communities typically saves seven dollars for every one dollar invested over the lifetime of the energy efficiency measures.\textsuperscript{16} These programs also benefit utilities by lowering bad debt ratings. Unfortunately, low-income families have lower participation rates in energy efficiency programs.\textsuperscript{17}

Energy efficiency programs have a net positive impact on the economy. It is estimated that, if the Midwest region achieves a 1\% per year reduction in natural gas consumption for five years, wholesale natural gas prices could decrease by as much as 13\%.\textsuperscript{18} According to national energy experts, “Energy efficiency also puts downward pressure on natural gas prices, and consumers in Illinois could see an additional $907 million in savings by 2011. Energy efficiency also has the potential to create more than 6,400 new jobs and $220 million in net employee compensation in Illinois over the next five years.”\textsuperscript{19} Additional environmental benefits include reduced emissions of the criteria pollutants associated with the reductions in electricity consumption and natural gas production.

Utilities sometimes view energy efficiency programs as burdensome and as having a negative impact on revenue. This barrier can be minimized or removed by structuring programs to be revenue neutral from the standpoint of the utility. These “de-coupling” strategies are currently being implemented in several states.

Current Initiatives and Models
In order to effectively reach a broad section of the existing residential housing stock, strategies need to be structured by building and ownership type. For example, low-income single family home owners may need grants to implement energy retrofits but larger multi-family property owners may be able to finance energy retrofits as part of building acquisition. The goal for all program design should be to combine technical and financial assistance into a one-stop shop and combine incentives to promote the highest level of efficiency.

Funding mechanisms for energy efficiency retrofits include utility fees, matching grant programs, low-interest financing, re-financing of first mortgages, property tax incentives, utility bill financing programs, and energy service contracts (ESCOs). The ESCO model uses venture capital to finance the initial capital costs for energy retrofits which is re-paid through the energy savings. The ESCO model is currently used in commercial and industrial settings because it is more cost-effective for the contractors to achieve large savings with one large customer. To implement this strategy on the residential scale would require an innovative mechanism for aggregating large numbers of smaller retrofits in order to make it cost effective for the energy performance contractor.

On-Bill Financing is a newer concept for financing energy efficiency programs which has been piloted for small business customers in some areas of the nation. These programs finance the purchase of new appliances or energy efficient equipment with repayment through the utility bill.\textsuperscript{20} Building owners get easy access to financing and a convenient repayment system on their utility bills at the same time as they accrue the energy savings. Utilities have been hesitant to adopt On-Bill Financing programs for residential
customers because their customer billing systems must be upgraded to handle these options, however, there are some pilot residential programs currently being developed.

In Chicago, the majority of energy efficiency work currently done in existing residential buildings is through the weatherization program implemented by the Community and Economic Development Association of Cook County (CEDA). This program is excellent at reaching very low-income single family homes. However, this program currently reaches 2,500 households per year, is under-funded and maintains a long waiting list. The City of Chicago also has several grant programs implemented through various departments—Chicago Department of Housing (CDOH), Chicago Department of Environment (CDOE), Chicago Department of Human Services (CDHS), Mayor’s Office for People with Disabilities (MOPD), Chicago Department of Public Health (CDPH) — that fund energy efficiency as a stand-alone initiative or as a component of renovation work.

The Chicago Energy Savers Fund resulted in 30 percent savings in 12,500 housing units in the 1980s. This program was implemented by community-based agencies and provided low-interest loans to qualified housing units. This program is being reactivated in 2007 through foundation and City funding. The new program, the Cook County Energy Savers Program, will provide a one-stop shop combining technical assistance and matching grants to multi-family buildings and anticipates retrofitting 2,500 units in its first year.

Examples of successful energy efficiency programs in other parts of the U.S include Efficiency Vermont and the New York Energy Smart program. Administered by the New York State Energy Research and Development Authority (NYSERDA), New York Energy Smart has documented 30 percent savings in residential retrofits. The Efficiency Vermont program is modeled as an energy efficiency utility. The program is designed to obtain the most cost effective energy savings as measured by Btu/dollar. Efficiency Vermont has worked with 50 percent of Vermont residents since 2000.

Implementation Mechanisms
In addition to developing policies and programs to support the above activities, the City of Chicago has the opportunity to influence housing in innovative ways by integrating energy efficiency into all housing related programs administered by city agencies. Following are two examples:

- As part of the Housing Choice Voucher program, CHAC provides rental housing assistance to 35,369 households annually in Chicago. HUD subsidies are used to pay rent and utilities for families. A reduction in utility bills could result in an increased number of vouchers for Chicago residents. Chicago has the opportunity to pilot energy efficiency programs with HUD in Housing Choice Voucher units as a demonstration program. Targeting this group of property owners could result in a significant impact if programs were structured to retrofit entire buildings, not just the subsidized units.

- The Chicago Department of Housing (CDOH) serves as a housing financing agent. In this role, CDOH has the opportunity to promote energy efficient retrofits in the tens of thousands of housing units that it finances annually. By promoting energy efficiency and energy performance standards as part of every housing program administered by the City, large numbers of units could be affected annually.

Feasibility

Financial
Residential energy retrofits are cost-effective and provide a good return on investment. Financial assistance (grants, loans, “pay-as-you-save”) and incentives (rebates, property tax benefits) are needed to encourage
owners to make these investments now, instead of deferring them. Because energy prices are continuing to rise, now is a good time to get the attention of property owners. The total cost of retrofitting 47% of the existing housing stock is substantial—funding sources will include owners, public, and private/utility funds. Because investments can be repaid from savings, success will depend on development of appropriate-scaled financing opportunities.

**Technical**

The technology and technical assistance delivery systems are available with effective models in many states. The challenge is to provide the technical and financial assistance jointly to maximize the ease of program delivery and participation rates.

**Political**

Illinois has not funded energy efficiency work in any substantial way. There is support for a comprehensive energy bill currently among legislators, utilities and advocates. Implementation of a comprehensive residential energy retrofit program will substantially reduce emissions, improve the economy, and make Chicago a more affordable place to live.

**References**

7. U.S. Census Bureau, factfinder.census.gov.
9. U.S. Census Bureau, factfinder.census.gov.
12. CNT Analysis of Utility Bill Data, June 28, 2007
Mitigation Strategy #9
Energy Retrofits in Commercial and Industrial Buildings

<table>
<thead>
<tr>
<th>Summary Strategy</th>
<th>Rating</th>
<th>Value</th>
</tr>
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<tbody>
<tr>
<td>CO2e Savings Against BAU</td>
<td>+++</td>
<td>1.3 MMTCO2e</td>
</tr>
<tr>
<td>Scale of Deployment</td>
<td>+++</td>
<td>9,000 commercial and 200 industrial buildings</td>
</tr>
<tr>
<td>Timing</td>
<td>+++</td>
<td>Beginning with 5 commercial and 5 industrial buildings in 2008</td>
</tr>
<tr>
<td>Regional Impact</td>
<td>+++</td>
<td>3.5 MMTCO2e</td>
</tr>
<tr>
<td>Financial Savings in Relation to Cost</td>
<td>+++</td>
<td>25-40% ROI</td>
</tr>
<tr>
<td>Additional Benefits in Relation to Burdens</td>
<td>+++</td>
<td>Lowers cost of doing business</td>
</tr>
<tr>
<td>Feasibility Assessment</td>
<td>+++</td>
<td>Proven models</td>
</tr>
</tbody>
</table>

Figure 1 Energy Intensity in Midwest Commercial Buildings, 2003

Source: Energy Information Administration, Commercial Building Energy Consumption Survey <www.eia.doe.gov>

Overview

Energy retrofits in commercial and industrial buildings could result in savings of 1.3 MMT CO2e in 2020. Commercial and industrial energy efficiency programs are proven to be cost effective. These programs can achieve an average of 30 percent savings by retrofitting buildings using existing technologies. The retrofits address building envelopes, heating, cooling, hot water, lighting systems, and plug load. Technologies and strategies used include lighting retrofits, passive day-lighting, re-commissioning 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. Effective programs combine technical and financial assistance to help property owners make the best choices to achieve the highest savings and return on their investments. Large commercial and industrial customers may have energy managers on staff who are able to manage consumption and electricity and gas purchase contracts.

Chicago’s large and economically important commercial sector resides in more than 22,000 buildings varying in size from skyscrapers to corner grocery stores. The sector includes service businesses (e.g., retail stores, hotels, and restaurants), hospitals and health care providers, public and private schools, correctional institutions, museums, and religious organizations. Municipal buildings are also included in the commercial sector. The industrial and manufacturing sector, housed in more than 700 buildings, includes a variety of businesses including metal working, electronics manufacturing, construction and food processing. When looking at the combined energy consumption of the commercial and industrial sectors, commercial buildings account for 90 percent of electricity and 50 percent of natural gas consumption. This is, in part, because the commercial sector is so large and because many downtown office buildings are heated using electricity. Industrial users have a higher proportion of natural gas consumption related to...
industrial processes. The number of commercial buildings and the amount of commercial square footage in Chicago increased from 1979 to 1992, while total energy consumption remained flat, reflecting increased efficiency of newly constructed buildings. The number and energy consumption of industrial buildings has decreased as this sector has declined over the same period.

**Quantitative Results**

**GHG Reduction Potential: 1.3 MMT CO2e in 2020**

Energy consumption and emissions can realistically be reduced by 30 percent on average in existing commercial buildings if comprehensive energy retrofits are implemented and equipment is maintained. According to the 2000 tax assessor database, there are 22,448 commercial buildings and 734 industrial buildings currently in Chicago. Of these, 80 percent—assuming the same rate of demolition and substantial renovation that has been observed in the residential sector—or 18,000 will be standing in 2020. The industrial sector is shrinking at an annual rate of 3 percent according to the U.S. Census, therefore it is assumed that the rate of decrease in industrial buildings will also be 3 percent, resulting in 425 industrial buildings in 2020.

The average emission per commercial building in 2000 was 410 metric tons of CO2e. The average emission per industrial building in 2000 was 3,014 metric tons of CO2e. If 50% of the commercial and industrial building stock is retrofitted to reduce consumption by 30 percent, there is a potential savings of 1.3 MMT CO2e by 2020 from this sector.

**Scale**

There is a potential to reduce emissions by 1.11 MMT CO2e by retrofitting 50% of the existing commercial building stock, or 9,000 commercial buildings, by 2020. There is a potential to reduce emissions by 0.19 MMT CO2e by retrofitting 50% of the existing industrial building stock, or 200 industrial buildings, by 2020.

**Timeline**

The following chart shows the timeline for program implementation. A pilot scale program should be considered during the first two years of the program. If such a pilot is implemented, the number of commercial facilities included in the pilot should be between 40 and 50 facilities of varying sizes.

**Figure 2**

<table>
<thead>
<tr>
<th>Year</th>
<th>Industrial</th>
<th>Commercial</th>
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<tr>
<td>2008</td>
<td>5</td>
<td>5</td>
</tr>
<tr>
<td>2009</td>
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<td>2010</td>
<td>10</td>
<td>100</td>
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<tr>
<td>2011</td>
<td>10</td>
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<td>2012</td>
<td>15</td>
<td>475</td>
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<td>2013</td>
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<td>2014</td>
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<td>2016</td>
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<td>2017</td>
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<td>20</td>
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<td>2019</td>
<td>20</td>
<td>1,500</td>
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<tr>
<td>2020</td>
<td>20</td>
<td>1,500</td>
</tr>
<tr>
<td>Total</td>
<td>200</td>
<td>9,000</td>
</tr>
</tbody>
</table>
Per-unit GHG Reduction Potential
There is a potential to reduce an average of 123 metric tons CO2e annually per commercial building and 904 metric tons CO2e annually per industrial building. This is based on an average commercial or industrial building. This is a limitation because energy consumption clearly varies significantly by business type. To illustrate the variation among sectors, Figure 3 shows energy consumption by Standard Industrial Characterization (SIC) code for the forty largest users.⁶

Figure 3 Samples of Energy Consumption by SIC

<table>
<thead>
<tr>
<th>SIC_CODE_DESCRIPTION</th>
<th>Average Annual Consumption (kwh)</th>
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<tbody>
<tr>
<td>Electric, Gas, And Sanitary Services</td>
<td>2,484,498</td>
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<tr>
<td>Justice, Public Order, And Safety</td>
<td>2,119,197</td>
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<tr>
<td>Hotels And Other Lodging Places</td>
<td>1,769,420</td>
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<tr>
<td>Food And Kindred Products</td>
<td>1,215,575</td>
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<td>Primary Metal Industries</td>
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<td>Holding And Other Investment Offices</td>
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<tr>
<td>Rubber And Misc. Plastics Products</td>
<td>781,225</td>
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<tr>
<td>Paper And Allied Products</td>
<td>751,589</td>
</tr>
<tr>
<td>Museums, Botanical, Zoological Gardens</td>
<td>741,627</td>
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<td>Executive, Legislative, And General</td>
<td>732,787</td>
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<td>Educational Services</td>
<td>705,981</td>
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<td>Chemicals And Allied Products</td>
<td>651,668</td>
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<td>Fabricated Metal Products</td>
<td>576,021</td>
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<td>Electronic &amp; Other Electric Equipment</td>
<td>485,664</td>
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<td>Administration Of Human Resources</td>
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<td>Textile Mill Products</td>
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</tr>
<tr>
<td>Leather And Leather Products</td>
<td>389,791</td>
</tr>
<tr>
<td>Petroleum And Coal Products</td>
<td>382,089</td>
</tr>
<tr>
<td>Amusement &amp; Recreation Services</td>
<td>373,598</td>
</tr>
<tr>
<td>Wholesale Trade—Nondurable Goods</td>
<td>349,705</td>
</tr>
<tr>
<td>Wholesale Trade—Durable Goods</td>
<td>333,142</td>
</tr>
<tr>
<td>Metal Mining</td>
<td>315,956</td>
</tr>
<tr>
<td>General Merchandise Stores</td>
<td>313,960</td>
</tr>
<tr>
<td>Depository Institutions</td>
<td>312,661</td>
</tr>
<tr>
<td>Real Estate</td>
<td>289,669</td>
</tr>
<tr>
<td>Stone, Clay, And Glass Products</td>
<td>283,752</td>
</tr>
<tr>
<td>Communication</td>
<td>279,984</td>
</tr>
<tr>
<td>Transportation Equipment</td>
<td>268,084</td>
</tr>
<tr>
<td>Security And Commodity Brokers</td>
<td>263,734</td>
</tr>
<tr>
<td>Furniture And Fixtures</td>
<td>263,584</td>
</tr>
</tbody>
</table>
Activity Savings
The fuel savings associated with this mitigation strategy are 1,525 gigawatt-hours (GWH) of electricity and 69 million therms of natural gas.

Lifecycle GHG Impacts
Energy retrofit programs for commercial and industrial buildings could be designed to reduce the impacts of upstream and downstream processes—including manufacturing, transportation and decommissioning of materials—by using locally manufactured materials and assuring appropriate re-use of building materials. Further research is needed to quantify and appropriately account for the lifecycle greenhouse gas (GHG) impacts of the installation of more efficient heating and cooling equipment, as well as the use of energy efficient building materials such as insulation. Because energy retrofit programs for existing buildings reduce the consumption of fossil fuels, they have additional life cycle CO2e savings.

Regional GHG Reduction Potential
The estimated regional GHG reduction potential is 3.5 MMT CO2e. This strategy can be as effective throughout the region as in Chicago. Energy efficiency programs are typically employed according to utility service area or units of government background.

Municipal GHG Reduction Potential
The City of Chicago can make significant achievements towards emissions reductions by retrofitting all existing City-owned buildings. The potential reduction, assuming that all City buildings are retrofitted by 2020, is 0.12 MMT CO2e based on the energy consumption reported for buildings managed by the City of Chicago Department of General Services.

Economic Profile
The typical cost of retrofits for commercial and industrial buildings varies greatly depending on the building type and use. Costs for individual energy conservation measures are discussed below under the Program Elements section. For purposes of this analysis, the average cost, which ranges from $25 to $75 per square foot, was used. The return on investment (ROI) for energy retrofits in this sector ranges from 25% to 40%.

Energy efficiency retrofits in the commercial and industrial sectors are typically funded through energy performance contracts. Energy performance contracts use venture capital to fund the initial capital costs associated with energy retrofits and are repaid through the energy savings. There are also programs for specific building types including an Illinois Department of Commerce and Economic Opportunity (ILDCEO) program for small business and grant funding for non-profits.

Figure 4 shows the level of investment required to achieve the listed targets.
Figure 4 Costs and GHG Emissions Reductions

<table>
<thead>
<tr>
<th>Goal of Existing Units</th>
<th>Number of Buildings</th>
<th>Million Square Footage of Conditioned Space</th>
<th>MMTCO2e Reduction</th>
<th>Capital Costs (Million $)</th>
<th>Annual Goal (Bldgs)</th>
<th>Annual Cost (Million $)</th>
</tr>
</thead>
<tbody>
<tr>
<td>100%</td>
<td>18000</td>
<td>265</td>
<td>2.22</td>
<td>$13,230</td>
<td>1400</td>
<td>$1,018</td>
</tr>
<tr>
<td>75%</td>
<td>13500</td>
<td>198</td>
<td>1.67</td>
<td>$9,923</td>
<td>1000</td>
<td>$763</td>
</tr>
<tr>
<td>50%</td>
<td>9000</td>
<td>132</td>
<td>1.11</td>
<td>$6,615</td>
<td>700</td>
<td>$509</td>
</tr>
<tr>
<td>25%</td>
<td>4500</td>
<td>66</td>
<td>0.56</td>
<td>$3,308</td>
<td>350</td>
<td>$254</td>
</tr>
</tbody>
</table>

Qualitative Results

Program Elements
Commercial and industrial energy retrofit programs are most effective when they combine technical assistance, financial assistance, and ongoing monitoring and maintenance. Additionally, industrial retrofits should include an environmental assessment to address other environmental regulatory issues because, as building systems and processes are improved to reduce greenhouse gas emissions, other emissions may be impacted and should be considered. Programs are designed to address all building systems and business and manufacturing processes to most cost-effectively reduce overall consumption. The following program strategies are recommended by the Chicago Chapter of the American Institute of Architects, Committee on the Environment.

Lighting Retrofits
Lighting retrofits include improving the quality of the luminous environment and the lighting installation. They typically include retrofitting and replacing lighting equipment (lamps, ballasts, luminaries, etc), aligning lighting performance targets with building use, and installing lighting controls. The recent focus of lighting retrofits is energy savings, daylight use, individual control of light, quality of light, emissions during lifecycle, and total costs. Costs for lighting retrofits range from one to two dollars per square foot.8 Paybacks are quick, usually within one to two years, depending on the commercial building costs.

Building Envelopes
High performance thermal insulation uses new technologies and materials including vacuum insulation to provide higher insulation values in smaller spaces. This is particularly relevant in commercial retrofits where space is limited. In many situations, increasing wall volumes is too costly and may be technically infeasible. Costs per square foot range from two to five dollars and payback periods are usually three to five years depending on the installation.8

Higher energy costs have provided the incentive for introducing substantial technological improvements in window design, in order to minimize heat losses from the building while maintaining the multi-functional character of the window. Costs for windows range depending on opening and structural requirements. It is therefore difficult to provide a per square foot cost or savings estimate. Payback periods for windows, however, tend to be longer than for other energy conservation measures. Finally, reflective and thermal roof technologies should be considered to reduce heat gain and loss.10
Energy: Demand: EXISTING BUILDINGS

Heating and Cooling Systems
There are numerous technologies available for improving the heating and cooling equipments’ operating efficiencies. These technologies include installing energy management systems, controlling humidity, reducing duct losses, installing more efficient equipment and replacing over-sized equipment. Significant savings—15-30%—can be achieved through improvements to the HVAC systems.11

Hot Water
Hot water consumption can be a significant contributor to overall energy consumption in select commercial buildings including hospitals, restaurants and laundries. There are many applicable improvements for water heating including heat pump water heaters, water heating dehumidifiers, and heating water with waste heat. Other technologies include solar water heaters, gas condensing water heaters, and tankless, or instantaneous, water heaters.12 The costs and savings of these technologies range greatly depending on the water consumption pattern in each building.

Demand Controlled Ventilation
Demand Controlled Ventilation (DCV) is an effective part of commercial energy conservation strategies because it uses the ventilation system only when there is a need for it. In most cases, it is quite possible to achieve significant savings by using a DCV system. Large savings—up to 60 percent—can be shown for some ventilation systems that operate continuously. For typical commercial office space, there are investment costs of two to four dollars per square foot2 with payback periods of five to 10 years.13 Energy savings range from 20-30 percent.

Building Commissioning and Re-commissioning
David E. Claridge, Deputy Director of the Energy Systems Laboratory at Texas A&M University, has said:

“For existing buildings, we found median commissioning costs of $0.27/ft², whole-building energy savings of 15 percent, and payback times of 0.7 years. For new construction, median commissioning costs were $1.00/ft² (0.6 percent of total construction costs), yielding a median payback time of 4.8 years (excluding quantified non-energy impacts).”16

Benefits and Burdens
Energy efficiency programs have a positive impact on the environment and economy. This is discussed in detail in Mitigation Strategy #8.

Energy efficiency programs reduce operating costs by as much as 30 percent, providing substantial benefits for the owners of commercial buildings. Energy efficiency programs also have a positive impact on individual buildings. The Building Owners and Managers Association (BOMA) states that commercial office managers in Chicago compete for long-term lease agreements by offering competitive rents and cite the importance of reducing operating costs through energy efficiency improvements. Additionally, tenants are often seeking “greener office space” to improve employee comfort and meet company goals.17
Current Initiatives and Models

One of the current programs available to the commercial and industrial sector in Chicago is the Small Business Smart Energy (SB$E) program which provides energy efficiency technical services for small to medium-sized for-profit businesses. Financial assistance is not provided as part of this program. Another voluntary effort to improve energy efficiency among Chicago businesses is the Midwest Energy Efficiency Association’s Building Operator Certification (BOC) training program, a competency-based training and certification program for operations and maintenance staff working in institutional, commercial and industrial buildings. BOC achieves measurable energy savings by training individuals who are directly responsible for day-to-day building operations.

The City of Chicago has embarked on an ambitious energy efficiency program for all City buildings as part of their Climate Initiative. The Public Building Commission has successfully completed LEED certified building projects including police stations, libraries, schools, and fire stations.

Outside of Illinois, one model for small commercial and industrial customers is the National Grid Small Business Services program in Massachusetts which has served 35,000 out of 77,000 customers between 1990 and 2003, saving 2.5 million megawatt-hours (MWHs) during this time period. Another model is the Focus on Energy Commercial Program in Wisconsin, which works to establish relationships with businesses and business associations. The program includes education and training for the commercial sector in areas such as energy management, efficient swimming pools, and refrigeration. In 2006, 13,117 businesses participated in this program, resulting in an annual energy savings of 111.6 million kilowatt-hours (KWH) and 9.7 million therms.

Implementation Mechanisms

The most successful commercial and industrial (C&I) energy programs are comprehensive programs focused jointly on the business or manufacturing process and the building systems. Programs should be designed to meet the needs of each customer, and not simply target a set of energy end uses. Some commercial customers are not concerned about energy costs because they represent a small portion of total operating costs. The goal of commercial retrofit programs should be to identify those sectors that most benefit from energy retrofits.

Larger C&I customers may already have energy managers on staff and will have greater access to capital to make energy efficiency improvements. In order to spur change more quickly, it is important to provide price incentives for building operators. Given that energy costs and property taxes are among the highest building operating costs, providing property tax incentives for reducing greenhouse gas emissions is an attractive incentive for building owners. The City of Chicago can work with Cook County Assessor’s Office to determine baseline GHG emissions for buildings of a certain type, and appropriate incentives that correspond with baseline measures for reducing GHG emissions.

While payback and even savings are typically realized over a short period of time, retrofits can seem cost prohibitive, especially for smaller businesses. In order to effectively reach small commercial customers, technical recommendations must be partnered with financing (small grants, loans and tax credits). Energy performance contracting is an effective way to finance energy investments in the large commercial sector, while efficiency financing programs including matching grants and low interest financing are effective for smaller businesses. Alternative financing strategies include programs that use energy savings to pay back the initial capital expenditures through utility bill financing, “pay as you save” programs, or through energy service companies. Finally, utilities can benefit from peak shaving by funding peak demand and energy conservation programs for the commercial and industrial sectors.
Feasibility

Financial
The financial costs may be high for performing comprehensive energy retrofits in the commercial and industrial building stock, but the savings opportunities are large and examples from other states show that payback is possible.

Energy consumption in existing commercial and industrial buildings can be reduced significantly by providing incentives to large customers and technical and financial assistance to small customers. The Clinton Climate Initiative has announced a landmark program to reduce energy consumption in buildings using the energy performance contracting model. Chicago could make great strides by implementing this program on a large scale with the private building sector.24

Technical
Commercial energy technologies are currently available for commercial buildings.

Political
This program is politically feasible as long as the implementation schedule and financing are developed in conjunction with key stakeholders including the Building Owners and Managers Association (BOMA) and the Chamber of Commerce.

References

2 Center for Neighborhood Technology Analysis of utility bill data provided by ComEd and Peoples Energy.
5 Cook County Tax Assessor database, accessed on June 12, 2007.
6 CNT analysis of utility data, July 13, 2007
18 Small Business $mart Energy Program (SB$E) is a program of the IL DCEO. More information on providers, clients, and services offered is available at http://www.commerce.state.il.us/dceo/Bureaus/Energy_Recycling/Energy/ Energy+Efficiency/sbse_program.htm.
Energy: Demand: EXISTING BUILDINGS

Mitigation Strategy #10
Appliance Trade-In

<table>
<thead>
<tr>
<th>Strategy Summary</th>
<th>Scale</th>
<th>Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>CO2e Savings Against BAU</td>
<td>+</td>
<td>0.284 MMTCO2</td>
</tr>
<tr>
<td>Scale of Deployment</td>
<td>+++</td>
<td>Approximately 10-20% of households</td>
</tr>
<tr>
<td>Timing</td>
<td>+++</td>
<td>The sooner programs start, the greater the energy and financial savings for consumers</td>
</tr>
<tr>
<td>Regional Impact</td>
<td>+</td>
<td>Fewer room air conditioners in the suburbs; 0.792 MMTCO2 for just a light bulb and refrigerator program</td>
</tr>
<tr>
<td>Financial Savings in Relation to Cost</td>
<td>+++</td>
<td>Programs long proven cost effective</td>
</tr>
<tr>
<td>Additional Benefits in Relation to Burdens</td>
<td>+++</td>
<td>Improved comfort and quality of life</td>
</tr>
<tr>
<td>Feasibility Assessment</td>
<td>+++</td>
<td>Long track record of these programs across the country</td>
</tr>
</tbody>
</table>

**Figure 1 Percentages of United States residential electricity use by type**


**Overview**

Energy efficient home appliances—specifically air conditioners and refrigerators—cut down on energy use, resulting in greenhouse gas (GHG) reductions. This mitigation opportunity explores appliance trade-ins that have the potential to lower energy consumption. Appliances typically use electric energy exclusively and represent products with relatively short lifecycles that are replaced over time. In the same vein as refrigerators and air conditioners, changing lighting—from incandescent bulbs to compact fluorescent bulbs (CFLs)—results in GHG reductions. There are a variety of trade-in programs which allow people to replace older and less efficient appliances and/or lighting with new and more efficient appliances and lighting.

This mitigation opportunity calls for increasing the pace of replacement and more aggressively targeting trade-ins for energy-efficient appliances in low-income communities that cannot readily afford new refrigerators and air conditioners. Figure 1 describes the typical breakdown of a home’s electricity usage, showing that air conditioning and refrigeration are the two largest sources of consumption. The next largest—space heating and water heating—are largely addressed in Mitigation Strategy #8, which looks at the building envelope and mechanical systems of residential buildings.
Refrigerator and Air Conditioner Trade-in Programs
Trade-in programs for air conditioners and refrigerators, which make up approximately 30% of residential electric usage in the U.S., are highly effective tools to reduce electricity usage. Trade-in programs keep old units from remaining in use when cost-effective replacements can reduce consumption. Appropriate rebates can encourage the purchase of Energy Star rated appliances as well. As federal minimum energy standards have increased in recent years and are likely to continue to do so, the natural turnover of appliances—most have a life of twenty years or less—will mean that most appliances will be much more efficient than units in use today absent any special programs by 2020. Without aggressive action to replace older appliances, pockets of older, inefficient appliances will remain in lower income households and in rental units regardless of the natural turnover largely due to affordability issues. For refrigerators, older inefficient models are sometimes placed in a basement or garage when a new one is purchased, therefore increasing energy use, instead of capturing the energy savings of the new unit. A trade-in program can reduce this problem. Targeted trade-in programs provide the economic assistance necessary for overcoming lack of adoption of newer, more efficient technologies. Rebates, in conjunction with these proposed trade-in programs, can then encourage that more efficient appliances acquired are Energy Star rated.

Over time, the combination of the natural replacement rate with targeted programs to accelerate some replacements will reduce electric consumption from many household appliances, although electricity use will grow from other appliances and new uses (see sidebar on televisions).

While refrigerators are found in every home, room air conditioning is largely used as a cooling means in older buildings. Newer buildings almost exclusively have central air conditioning. Therefore, as older buildings are replaced by newer buildings through the natural replacement rate of the housing stock, the stock of room air conditioners in Chicago will decline somewhat. Though 20% of existing housing units will be replaced by new units by 2020, over the next several decades, room air conditioners will continue to represent a significant sector of energy use in the City and could be targeted for trade-in programs to get the oldest and worst units out of operation.

Room air conditioners are treated like a commodity in this mitigation opportunity because of their non-permanent installation, and programs can target both homeowners and renters. They can be installed and removed by the resident and are typically purchased at appliance stores or similar retailers much like other electronics. In contrast, central air conditioners are considered an inherent part of a building system. Refrigerators, unlike air conditioners, are a more permanent installation requiring a different program design. Also, refrigerators are typically a landlord’s responsibility to provide so programs may need to target different sectors.

Lighting: From Incandescent to CFL
Lighting represents approximately nine percent of home electric use. In newer homes the number of fixtures is greater than in older homes, meaning that absent any technological change in lighting, this sector of home energy use will grow as newer homes replace older homes. Reductions in emissions from lighting will be driven by the transition from incandescent lighting to CFL and other new technologies (e.g., LED lights). This transition is already beginning to take place and will continue to be driven by external market transformation forces. Programs designed with incentives for the adoption of CFLs are primarily effective as a means of building awareness of the improving options for CFLs. Longer term, substantial change-over of the lighting stock will come through more traditional retail channels.

A Note about TVs and Growing Energy Use
In contrast to increasing efficiency of many appliances, an area of increasing electric usage is TVs. Above and beyond the addition of new devices such as DVD players and DVR recorders, the proliferation of TVs and a new generation of high-definition televisions (HDTVs) are replacing the traditional cathode ray tube units of the past. Of the two most popular technologies for HDTVs—LCD and plasma—LCDs are fairly energy efficient and plasma televisions use much more energy than the TVs they replace. As HDTVs become more and more ubiquitous, consumer choices will have an impact on electricity consumption. If this trend continues, the three percent of home energy use by TVs and related appliances could grow to ten percent.
Quantitative Results

GHG Reduction Potential: 0.284 MMTCO2e

Energy consumption and emissions can be reduced by replacing old room air conditioners and refrigerators via an aggressive trade-in program and by replacing four million incandescent light bulbs with CFLs.

Scale

0.284MMT CO2e can be saved through the actions described in Figure 2. With approximately one million households in Chicago, the appliance programs would reach roughly 10 to 20% of households.

Figure 2: Scale and GHG Reduction by Action

<table>
<thead>
<tr>
<th>Appliance</th>
<th>Action</th>
<th>Scale (Number of Appliances)</th>
<th>GHG Reduction per Year at Scale (MMTCO2e)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Room Air Conditioner</td>
<td>Trade-in: Replacing room air conditioners that would otherwise not be replaced by 2020</td>
<td>83,000</td>
<td>0.0111</td>
</tr>
<tr>
<td></td>
<td>Creating incentives for the purchase of Energy Star rated room air conditioner units</td>
<td>216,000</td>
<td>0.009</td>
</tr>
<tr>
<td>Refrigerator</td>
<td>Trade-in: Replacing refrigerators that would not otherwise be replaced</td>
<td>104,000</td>
<td>0.031</td>
</tr>
<tr>
<td></td>
<td>Increased purchases of Energy Star rated units</td>
<td>103,000</td>
<td>0.005</td>
</tr>
<tr>
<td>Light Bulb</td>
<td>Replacing incandescent bulbs with CFLs</td>
<td>4,000,000</td>
<td>0.228</td>
</tr>
<tr>
<td><strong>TOTAL</strong></td>
<td></td>
<td></td>
<td><strong>0.284</strong></td>
</tr>
</tbody>
</table>

Timeline

Trade-in and rebate programs can be developed and implemented on a fairly short timeline: six months to a year. The earlier programs start, the earlier consumers will start seeing the financial savings coming from these energy efficiency measures.

Per-unit GHG Reduction Potential

The per-unit GHG reduction potential for appliances varies by model and usage conditions, but some averages are supplied in Figure 3.

Figure 3: Electricity and GHG Savings by Appliance

<table>
<thead>
<tr>
<th>Appliance</th>
<th>Action</th>
<th>Electricity Savings per Year per Appliance (kWh)</th>
<th>GHG Savings per Year per Appliance (kg CO2e)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Room Air Conditioner</td>
<td>Trade-in: Upgrading from an 8 EER unit to a 9.8 EER</td>
<td>221</td>
<td>135</td>
</tr>
<tr>
<td></td>
<td>Increased purchases of Energy Star rated units</td>
<td>72</td>
<td>44</td>
</tr>
<tr>
<td>Refrigerator</td>
<td>Trade-in</td>
<td>500*</td>
<td>304</td>
</tr>
<tr>
<td></td>
<td>Increased purchases of Energy Star rated units</td>
<td>75</td>
<td>46</td>
</tr>
<tr>
<td>Light Bulb</td>
<td>Replacing incandescent bulbs with CFLs</td>
<td>93</td>
<td>57</td>
</tr>
</tbody>
</table>

Activity Savings

Total electricity savings from these strategies would be 467 gigawatt-hours per year. Detailed savings are provided in Figure 4.
This research was commissioned to advise the Chicago Climate Task Force in the development of the Chicago Climate Action Plan. It does not represent official City of Chicago policy.

### Figure 4 Activity Savings by Action

<table>
<thead>
<tr>
<th>Appliance</th>
<th>Action</th>
<th>Electricity Savings per Year at Scale (MWh)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Room Air Conditioner</td>
<td>Trade-in</td>
<td>18,262</td>
</tr>
<tr>
<td></td>
<td>Increased purchases of Energy Star rated units</td>
<td>15,528</td>
</tr>
<tr>
<td>Refrigerator</td>
<td>Trade-in</td>
<td>51,978</td>
</tr>
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<td></td>
<td>Increased purchases of Energy Star rated units</td>
<td>7,719</td>
</tr>
<tr>
<td>Light Bulb</td>
<td>Replacing incandescent bulbs with CFLs</td>
<td>373,760</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td></td>
<td><strong>467,247</strong></td>
</tr>
</tbody>
</table>

### Lifecycle GHG Impacts

Because this mitigation opportunity would reduce the consumption of fossil fuels, it would have a net benefit globally in terms of the GHG emissions associated with processes such as, extraction, refinement, and transport. The emissions impacts related to the manufacturing of new appliances will be offset by ensuring that proper recycling of old units keeps the metals out of landfills and coolants from being off-gassed.

### Regional GHG Reduction Potential

The room air conditioner trade-in program would not be relevant in areas of the region where housing was built after 1990, and therefore, probably does not have room air conditioning. Refrigerator trade-in programs on a regional level would reduce CO2e by approximately 0.109 MMT. CFL replacements throughout the region could double the reduction potential of this aspect of the mitigation opportunity – 0.683 MMT CO2e, for a total of 0.792 MMT CO2e.

### Municipal GHG Reduction Potential

Many older City of Chicago buildings have room air conditioners, particularly older public schools buildings. While a full survey of the inventory of these room air conditioners has not been conducted, anecdotally it appears that these could be a clear early target of a replacement program for older room air conditioners. As part of the ongoing maintenance of City buildings, all screw-in incandescent bulbs could be replaced with CFLs.

### Economic Profile

#### Cost and Benefit of Appliance Trade-in

Effective appliance trade-in programs cost, including program administration and recycling, in the range of $100 to $200 for each refrigerator and just over $100 for each room air conditioner. A new Energy Star rated refrigerator can cost $400 or more today depending on the size. An Energy Star rated room air conditioner can cost $150 or more today. Replacing a 10 year old refrigerator can save $40 annually and each room air conditioner $25 annually.
Qualitative Results

Program Elements
Appliance trade-in programs are carried out in several ways including one-time events or as part of energy audit or home-based appliance assessment programs. For room air conditioners, a popular model is to hold limited time events. In this model, marketing efforts drive potential participants to pre-register for a weekend event where they bring in their old unit and receive a new one. This ensures that one old unit is collected for each new one deployed and that old units are properly recycled. Such events are best conducted in the spring prior to air conditioners being installed in windows for the summer. A trade-in program is preferable to a rebate program because a rebate program only gives incentives to purchase a new Energy Star rated appliance, it does not address the issue of the retirement of the old inefficient one. An older room air conditioner might just get moved to a different room and continue to be used, which would defeat the purpose of reducing energy use and GHG emissions.

Refrigerator replacements for low-income households are a more complex program undertaking. Many successful programs include program staff that conduct home visits to inspect the old refrigerators and measure their energy use. This approach can also serve as a basis for a wider energy audit to identify other energy saving measures and provide immediate low-cost measures such as installation of CFLs.

CFL programs can be designed as promotional giveaway programs, coupons or rebates, or write-downs of retailer costs.

Benefits and Burdens
Above and beyond the value of reduced energy consumption (e.g., reductions in emissions of both CO2 and other pollutants such as mercury and particulate matter), the benefits of appliance and lighting replacement programs include increased quality of appliances for recipients, reduced electricity costs for households, and increased attention to energy efficiency measures. For example, newer refrigerators keep temperature more consistent which can better ensure food safety, and new room air conditioners can be more effective in cooling than older units that are undercharged with coolant. While CFLs can produce a color of light that is unfavorable to some consumers, they do provide the benefit of reduced maintenance time, because they need to be replaced far less frequently than conventional incandescent bulbs.

It can be a challenge to reach the trade-in target and demonstrate actual savings. For example, a broken air conditioner bought at a thrift store and then turned in does not actually reduce energy use and emissions. For refrigerators—due to their large size—delivery, installation, and hauling away of the old unit can present logistical difficulties.

Appliance trade-in programs can be complex, requiring several types of partners. Typically, community based organizations assist with outreach, an energy efficiency program vendor provides turn-key event logistics (several national firms provide such services), a retailer provides the stock of appliances, and a dedicated appliance recycler handles the collected old units. Old appliances must also be properly recycled. Coolant, foam insulations, capacitors—often containing small amounts of PCBs—are all materials that must be handled by a proper, licensed recycling operation. And in Chicago, there are no dedicated appliance recycling facilities.

CFLs continue to cost more than incandescent bulbs and some consumers not like the light they produce, on account of the variance in CFL color temperature. CFLs do result in significant savings over time, as they last much longer and use less energy.
Current Initiatives and Models
Several pilot room air conditioner replacement programs have been conducted in Chicago over the past several years. CNT Energy (formerly known as the Community Energy Cooperative) ran programs in Pilsen and on the Northwest Side of Chicago in 2000 and 2001, replacing more than 5,000 units. More recently, the Midwest Energy Efficiency Alliance (MEEA) and ComEd have held trade-in events in eight City wards and five suburban communities in the summers of 2005 and 2006 for participants in the Low Income Home Energy Assistance Program. These events resulted in the replacement of 2,000 units. Perhaps the largest scale version of this type of model is the $20 million “Keep Cool, New York” program that created turn-in bounties for over 200,000 room air conditioners in 2001 and 2002.10

A recent study by the American Council for an Energy Efficient Economy (ACEEE) explored exemplary energy efficiency programs for low-income households that could serve as models for Chicago. One of several refrigerator programs highlighted in this report was the “Indiana Low-Income Weatherization and Refrigerator Replacement Program” run by the utility Cinergy, the state of Indiana Weatherization program and the Indiana Community Action program. This program included a home visit to measure the energy use of old refrigerators. ACEEE noted the sliding cost scale and a partnership with a major manufacturer to provide new units as keys to the success of the program. Fifty-seven percent of refrigerators tested were found to be inefficient enough that they were then replaced as a result of this program.11

CFL programs are already underway in Chicago, including those sponsored by the City of Chicago, ComEd, and the Northern Illinois Energy Project.12 The City can continue to support these and any other new efforts that encourage consumers to try new lighting technologies. With the relatively short lifespan of a traditional incandescent bulb—750 hours or so—the natural rate of turnover will give consumers many opportunities to replace them with longer lasting and more efficient alternatives.

Implementation Mechanisms
Appliance trade-in programs and lighting programs could be supported by the new Energy Efficiency Portfolio standard that was mandated by the Illinois General Assembly in the summer of 2007. ComEd and the Illinois Department of Commerce and Economic Opportunity are developing program implementation plans to meet this standard starting in 2008.

Feasibility

Financial
Funding is necessary to support trade-in programs. As the State of Illinois determines the structure and level of funding for future energy efficiency programs, the City of Chicago could actively advocate for the creation of robust programs to make energy efficiency a part of the culture of Illinois, much as it is in states that have led on this issue. For example, SB1184 (Harmon) that is currently in the Illinois General Assembly creates a funding mechanism for energy efficiency programs and specifically sets aside 10 percent of funding for programs run by municipalities.13

Technical
Appliance and light bulb replacement programs are the bread and butter of energy efficiency programs throughout the nation and have a long track record of success. Key partners include utilities, appliance manufacturers, retailers and local energy efficiency organizations; these groups work together to make such strategies very feasible.

Political
The only political issue for this mitigation opportunity is securing funding for trade-in and light bulb replacement programs.
References

4. This model counts only the incremental savings from programs that change that replacement rate or encourage increased purchases of Energy Star rated appliances; it does not count the GHG reduction potential from the natural replacement rate of the 935,000 refrigerators, and 734,000 room air conditioners in Chicago. In this section, replacement rates are from estimated life of appliances and energy savings are from calculators available on http://www.energystar.gov.
5. While this replacement may happen as part of the business as usual scenario, future market share estimates for CFLs are not available. This scale is based on replacing bulbs in low-income households with an average of 25 bulbs per household with 16% of households as low-income. The source for light bulbs per household is the Energy Information Agency, http://www.eia.doe.gov/emeu/lighting. Appliance figures are from the 2003 American Housing Survey, Washington DC: U.S. Census Bureau, www.census.gov.
6. For refrigerators older than 15 or 20 years, this number could be twice as high.
Mitigation Strategy #11
Green Building Renovation

<table>
<thead>
<tr>
<th>Strategy Summary</th>
<th>Rating</th>
<th>Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>CO2e Savings Against BAU</td>
<td>+</td>
<td>0.31 MMTCO2e</td>
</tr>
<tr>
<td>Scale of Deployment</td>
<td>++</td>
<td>60,000 homes &amp; 1,000 commercial buildings</td>
</tr>
<tr>
<td>Timing</td>
<td>+++</td>
<td>Beginning in 2010</td>
</tr>
<tr>
<td>Regional Impact</td>
<td>+</td>
<td>0.93 MMTCO2e</td>
</tr>
<tr>
<td>Financial Savings in Relation to Cost</td>
<td>+++</td>
<td>$50-$65 per square foot (total 20-year Net Benefit)</td>
</tr>
<tr>
<td>Additional Benefits in Relation to Burdens</td>
<td>+++</td>
<td>Improves building sustainability</td>
</tr>
<tr>
<td>Feasibility Assessment</td>
<td>+++</td>
<td>Proven models</td>
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Overview
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.” The U.S. Green Building Council (USGBC) developed a rating system, or standard, for green buildings and is considered the country’s leading authority on the topic. The USGBC cites that in addition to the obvious environmental benefits to building green, there are economic, health and community benefits.

While much of the focus of green buildings in the media is on new construction projects, existing buildings can also 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 high efficiency models, re-commissioning building systems to assure they are properly operated, and upgradng lighting systems.

According to building permit data, there are an average of 6,000 residential renovations and 100 commercial building renovations each year in Chicago. In order 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 green building rating program. The green building program should include a significant training component for involved parties, including industry and trades people and homeowners.
Quantitative Results

GHG Reduction Potential: 0.31 MMT CO2e in 2020
It is possible to reduce emissions by 0.31 MMT CO2e by implementing energy retrofits that adhere to green building standards. The emissions reductions are 0.19 MMT CO2e in residential buildings and 0.12 MMT CO2e for commercial buildings.

Scale
This strategy proposes retrofitting 60,000 residential units by 2020 and 1,000 commercial buildings. The scale assumes that all residential and commercial renovations beginning in 2010 will be retrofitted to green building standards.

Timeline
The timeline for this strategy assumes that the program will commence in 2010. It assumes that 6,000 housing units and 100 commercial properties are renovated each year from 2010 to 2020.

Per-unit GHG Reduction Potential
There is a potential to reduce an average of 3.2 metric tons CO2e annually per green residential unit renovated and 123 metric tons CO2e annually per green commercial building renovated.

Activity Savings
Employing this strategy can result in savings of 254 gigawatt-hours (GWH) of electricity and 30 million therms of natural gas.

Lifecycle GHG Impacts
Energy retrofit programs designed for green building renovations could be designed to reduce the impacts of upstream and downstream processes, including manufacturing, transportation and decommissioning of materials, by using locally manufactured materials and assuring appropriate re-use of building materials. However, further research is needed to quantify and appropriately account for the lifecycle greenhouse gas (GHG) impacts of the installation of more efficient heating and cooling equipment, as well as the use of energy efficient building materials such as insulation.

Regional GHG Reduction Potential
Assuming the same implementation scale for the region as proposed for the City, there is the potential to reduce 0.93 MMT CO2e in 2020 by mandating green building renovations in all residential and commercial building renovations.

Municipal GHG Reduction Potential
Under the Chicago Housing Authority’s Plan for Transformation, the City will own and operate 25,000 housing units in 2010. Under this Plan, some existing units will undergo substantial renovation and can be done so using green building techniques outlined in the new program. If all 25,000 units were renovated according to green building standards, the City could reduce GHG by 80,000 metric tons CO2e.

Economic Profile
The cost premium to perform green renovations can be only slightly over the cost of renovating buildings to-code. In a report by California’s Sustainable Buildings Task Force it was reported that “the average premium for all studied green buildings is slightly less than 2 percent or three dollars to five dollars per square foot.” The author of this study was later quoted that “more and more buildings can be built at the LEED-certified level for little or no cost premium. You can easily get at least half-way to certified at a zero-cost premium.” While the actual costs and benefits for each project will vary, national studies have identified total 20-year net benefits in the range of $50 to $65 per square foot.
Qualitative Results

Program Elements

Mandatory Chicago Green Homes Program
The City of Chicago could change its voluntary green homes program into a mandatory one that requires all residential renovations to be “green” under the prescribed requirements of the Chicago Green Homes Program. This would increase energy and water savings resulting in GHG reduction of 0.20 MMT CO2e.

Mandatory Chicago Green Commercial Building Program
The City of Chicago could develop and institute a green building program that requires all commercial renovations to be “green” based on a rating system similar or congruent to currently accepted LEED standards. This, too, would increase energy and water savings, resulting in GHG reduction of 0.12 MMT CO2e.

Promote training and education to building industry and general public
As with any newly-regulated mandatory program, the City must make a special effort to educate program participants: City staff, builders, developers, sub-contractors, and trade unions. In doing so, particular attention is necessary to target home remodeling contractors and agencies who will be most affected by this mandate. Green building practices will include new or different construction practices, installation and technologies. The City of Chicago can consider the implications of green building mandates and provide the necessary training it will require at all levels.

Furthermore, while green renovations of homes and businesses would be managed via permitting, there are other home repairs that are completely at the discretion of the building owner or tenant. Chicagoans could be made aware of the benefits of green renovation and maintenance, including energy savings and CO2e savings.

Other more targeted information could be supplied at various first points of contact, such as business license application and renewal, building permit application, and/or via issuance of property tax bills. The goals of the education component could be to: 1) make people aware of the new mandate, 2) convey the general program guidelines, and 3) demonstrate the benefits of green building renovation.

Benefits and Burdens
The benefits of green building are many. As stated in the Chicago Green Homes program guide, the benefits to the occupants include healthier indoor air, reduced water usage, and durable maintenance materials. Use of recycled materials contributes to societal benefits of reduced pollution and resource conservation.

Mandating green renovations through the Chicago Green Homes Program, and a similarly developed commercial program, necessitates hiring additional plan reviewers, permit processors and inspectors. Another challenge is garnering support for the measure from contractors and home re-modelers who currently do not perform renovations using green practices. There will be a cost involved with informing, educating and supporting parties affected by the mandate.
Current Initiatives and Models
Chicago is home to two outstanding examples of green building renovations, both platinum-rated LEED certified, which is the highest rating possible. Both the City, through its Chicago Center for Green Technology, and the nonprofit agency Center for Neighborhood Technology tie their green building certification into their organizational mission and work, by providing building tours, workshops, and access to information on green renovation and buildings.

Chicago Green Homes Program
In April 2007, the City of Chicago Department of Construction and Permits (DCAP) unveiled the Chicago Green Homes Program. The program applies to residential projects in four categories:

- Single-Family Homes (including town homes), New Construction
- Single-Family Homes (including town homes), Renovation
- Multi-Family Buildings (less than 80 feet in height), New Construction
- Multi-Family Buildings (less than 80 feet in height), Renovation

This voluntary, points-based rating system features three different levels of green building, one-star, two-star and three-star (highest), with ratings applied in seven different point categories: sustainable sites, energy efficiency, materials, health and safety, resource conservation, homeowner education, and innovation.

Green Permit Program
This program is billed by DCAP as “an expedited permit process for projects that incorporate innovative green building strategies.” Eligible projects can receive permits in less than 30 days (less than 15 days in some cases) and have consultant code review fees waived.

Other
In addition to residential projects, the Department of Planning and Development (DPD) requires varying levels of green standards and green roofs for any residential, institutional, industrial or commercial project that receives public funds, and even for certain projects that are located within planned developments or lakefront protection ordinance developments.

Nationwide Trend
In response to climate change and rising emissions, cities nationwide are in the process of legislating mandatory green building standards. Large and small cities alike—from Boston to Novato, California— are instituting mandatory green building measures.

Implementation Mechanisms
Changing the Chicago Green Homes Program from voluntary to mandatory requires careful analysis of the current program, as well as a proposal for how to modify current rules. A similar program that mandates green renovations for commercial buildings could also be implemented. Considerations include: staffing needs, including training and management; communication with builders, contractors and building owners; and any measures that will need to be reviewed by City Council and passed by a vote. Program performance could be monitored against energy demand reduction goals. The standards for such programs can also be periodically reviewed and updated to ensure that the program continues to achieve savings against “business as usual.” In order to ensure the adoption and usage of emerging technologies and improvements in the fast-growing green building industry, the City of Chicago could consider regularly updating its program and applicable codes to reflect the highest industry standards.
Feasibility

Financial
The City of Chicago will need to consider the permanent cost of additional staff and ongoing training, and equally as important, periodic evaluation of the program itself and the performance rate of Chicago’s green buildings. The cost differential between renovating green and renovating without green principals is minimal.

Technical
The City of Chicago is already building green, and it is not a new concept in the public and private realm in Chicago. The City has already proven to be a leader and, with key financial and political support, it can implement the technical aspects of ramping up its new voluntary program to a City-wide mandated program.

Political
The building industry, including developers, home remodeling contractors and trade unions, has a strong voice in local politics. Broad support, both internally with key department leaders, commissioners and aldermen, and externally with specific developers, unions and business associations, will be necessary to advance a proposed green building mandate and garner the approval required by City Council.

References