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

CNT
Sustainable Communities
Attainable Results

CHICAGO CLIMATE ACTION PLAN

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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.

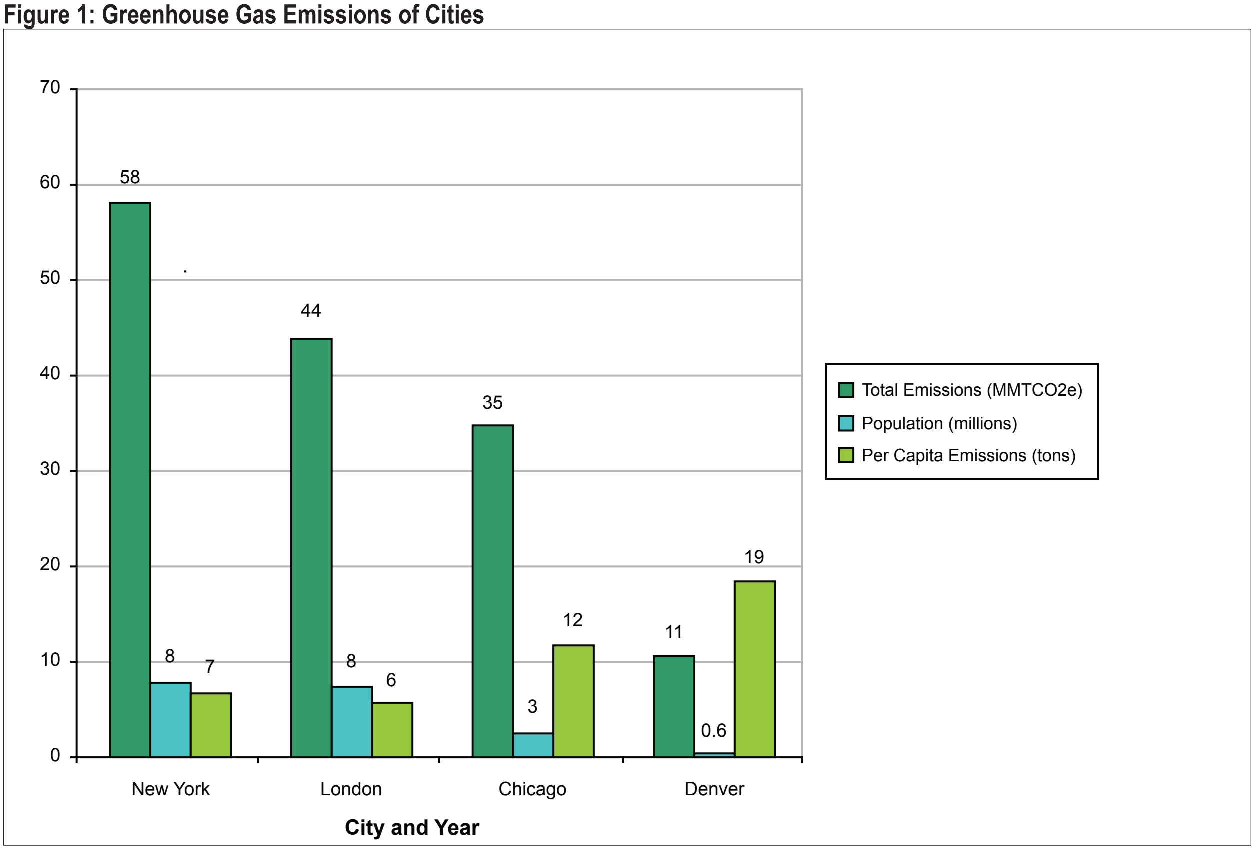
Chicago's Emissions

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.[1] 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).

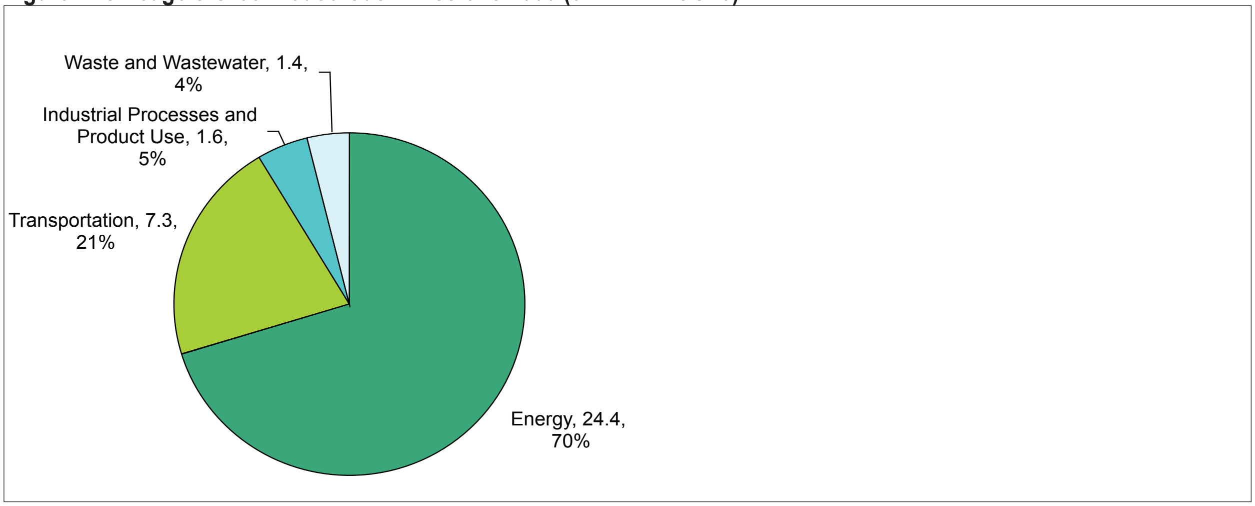
Figure 1: Greenhouse Gas Emissions of Cities



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.

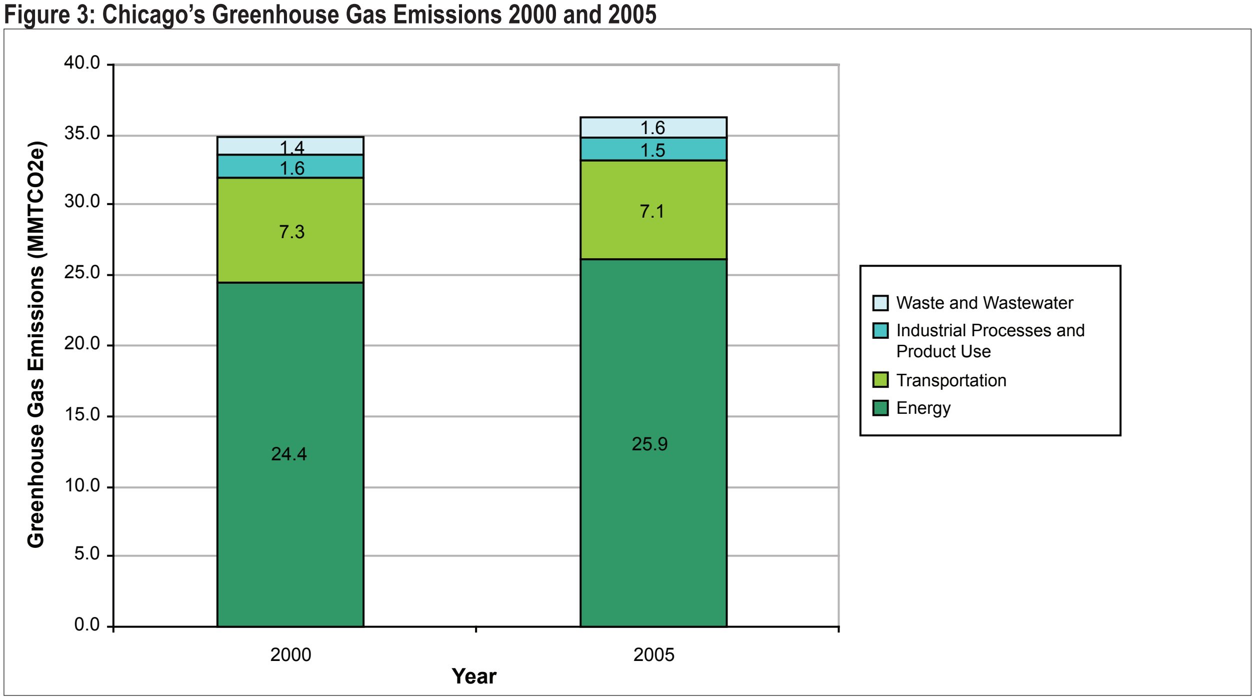
Figure 2: Chicago's Greenhouse Gas Emissions 2000 (34.7 MMT CO2e)



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



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.[3] 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.

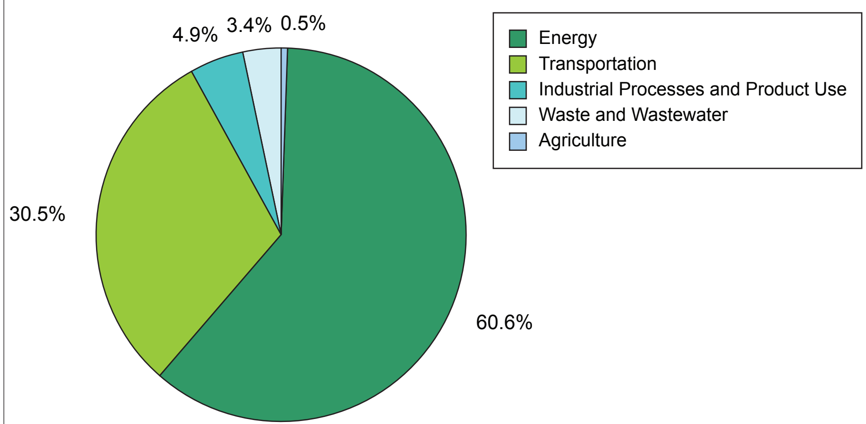
Transportation Greater Share of Total

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.

Figure 4: Chicago Region's Greenhouse Gas Emissions 2000 (105 MMT CO2e)



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

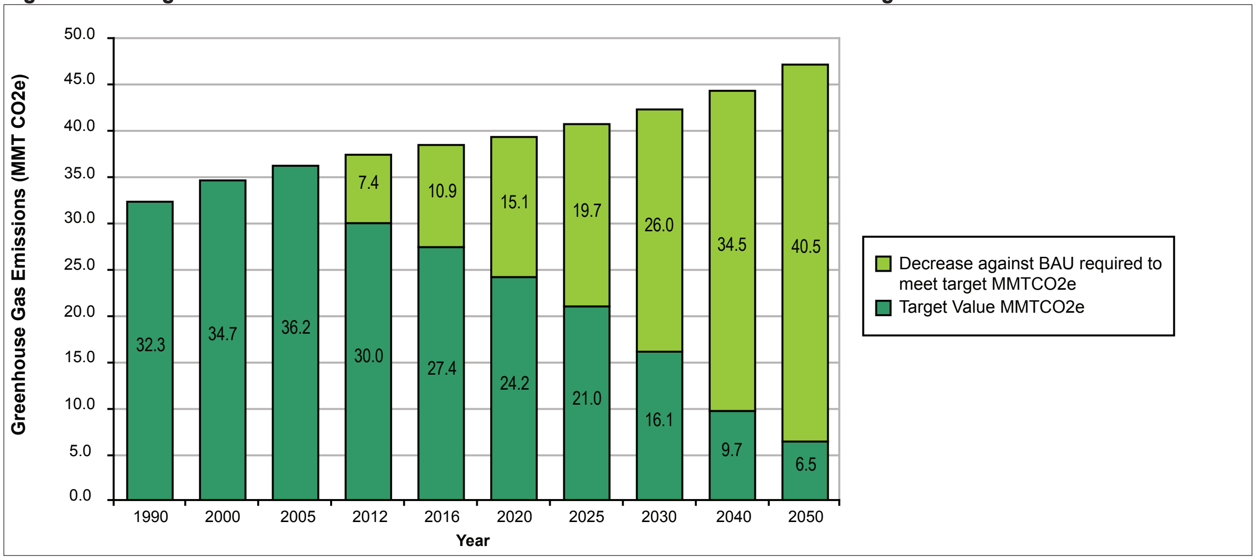
If Chicago continues on the path it is on, its GHG emissions are estimated to grow at an average rate of 0.7 percent annually to 39.3 MMTCO2e in 2020—a 13 percent increase over 2000 levels—and 47.0 MMTCO2e in 2050—a 35 percent increase over 2000 levels. This is a faster rate of growth than the 8 percent population increase that is forecasted for Chicago between 2000 and 2020.[4] 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.[5]

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.

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



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.

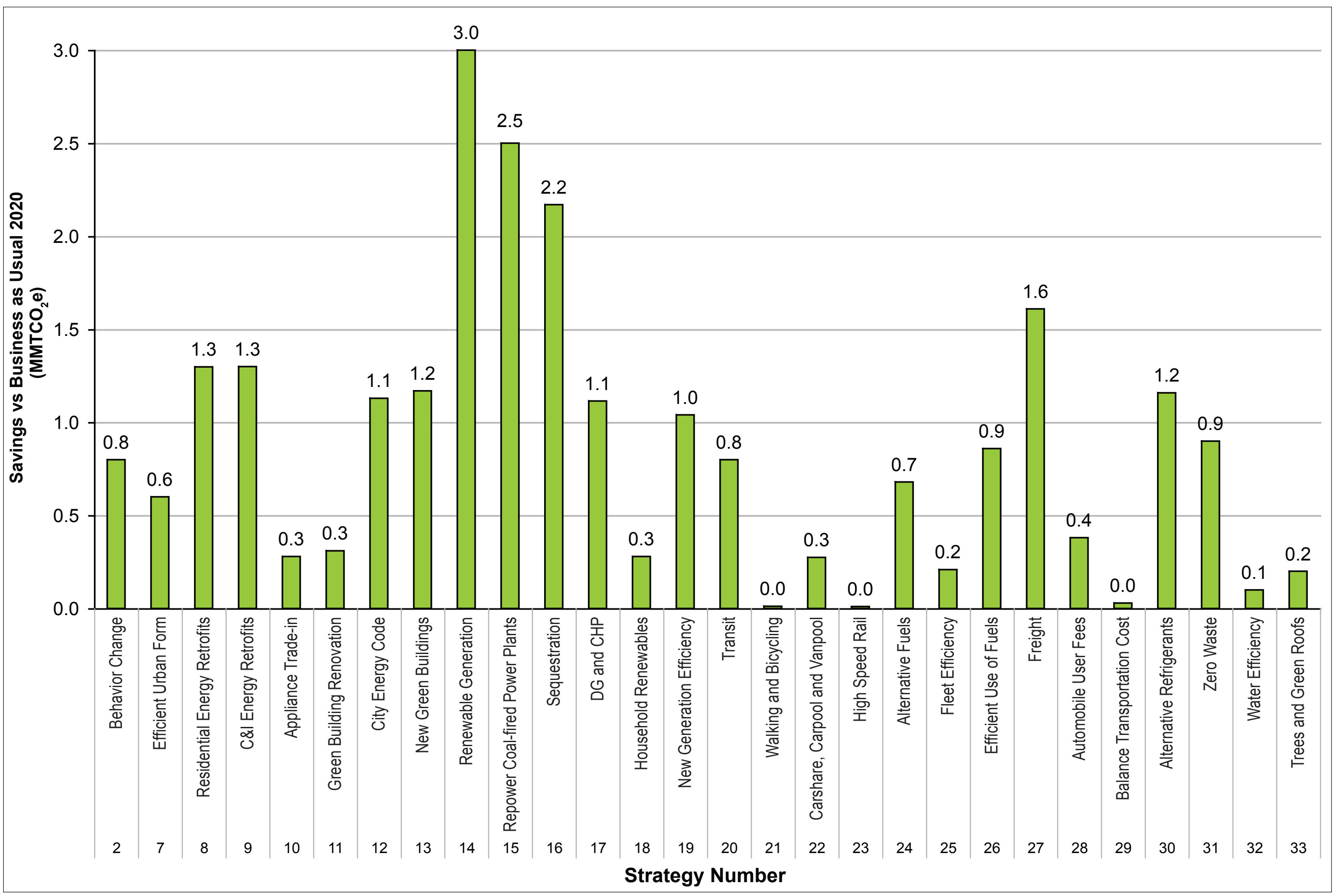
Demand side strategies are as critical as supply side strategies for reductions at the city and regional level. The energy saved in buildings and the miles not driven can together account for nearly half of the targeted reductions. They can take advantage of the inherent efficiency of urban areas, and 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 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

Category		Mitigation Strategy	Description	CO2e Reduction MMT
Framing	1	Provide leadership on climate issues	Continue and expand City leadership on climate strategy and implementation, including local leadership and strong advocacy in region, state, and federal legislation and policy.	Framing Strategy
	2	Promote behavioral change among residents and businesses that will elicit an ongoing response and action on climate change.	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").	0.80
	3	Use ongoing measurement, verification, data, and metrics to track and target actions, and to continuously improve performance	Develop, track, and share information on mitigation strategies and results.	Framing Strategy
	4	Encourage early action and rapid change	Ensure rapid implementation of mitigation strategies.	Framing Strategy
Cross-cutting	5	Enact a carbon tax	Put leadership capacities behind passing a nationwide carbon tax. Savings assume that a carbon tax would be enacted that reduced national and local emissions to meet target of 25 % reductions from 1990 levels by 2020.	15.10
	6	Enact a cap and trade system	Put leadership capacities behind passing a nationwide cap and trade system for greenhouse gases. Savings assume that a cap and trade system would be enacted that reduced national and local emissions to meet target of 25% reductions from 1990 levels by 2020.	15.10
	7	Implement efficient urban form	Promote transit oriented development. Calculates benefit from growth in population locating near transit.	0.159-0.623
Energy Demand	8	Energy retrofits in residential buildings	Retrofit 47% of existing residential building stock (400K units) by 2020, with 30% reduction in energy use/retrofited unit.	1.30
	9	Energy retrofits in commercial and industrial buildings	Retrofit 50% of the commercial and industrial building stock by 2020 resulting in a 30% reduction in energy use/retrofited building.	1.30
	10	Appliance trade-in	Supplement natural turnover of appliances and lightbulbs with targeted appliance trade-in and CFL replacement for low-income households.	0.28
	11	Green building renovation	Require all commercial (1K bldgs) and residential (60K units) renovations to meet Green Renovation Standards.	0.31
	12	Update and improve enforcement of City energy code	Update the City of Chicago's energy code to include more stringent conservation guidelines; and require compliance at the point of sale of all residential property.	1.13
	13	Provide permitting incentives to new construction green buildings	Require that all new residential (65K new homes) and commercial (4K new commercial buildings) construction be built to LEED or equivalent standards by 2020.	1.17
Energy Suppy	14	Build renewable electricity generation	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.	3.00
	15	Repower existing power plants	Repower 21 coal fired plants in the state of Illinois.	2.5
	16	Sequester carbon in new plants	New electricity generating plants use latest carbon sequestration technology.	2.17
	17	Distributed generation and combined heat and power projects	Adapt goals set in Chicago's 2001 Energy Plan to expand the use of Distributed Generation and Combined Heat and Power projects.	1.12
	18	Household renewable energy generation	Increase household scale renewable power (100% electric replacement) and solar domestic hot water (25% natural gas reduction) to 5% of the housing stock.	0.28
	19	Enforce efficency standards for new generation	Support policies for implementing energy efficiency standards for new and existing fossil fuel generation at the regional and national levels.	1.04

Transportation Mobility Options	20	Increase transit service	Ensuring stable funding for mass transit, and then increase ridership 30% above business as usual.	0.83
	21	Increase walking and bicycling mode share	Enact measures to double the pedestrian-bicycling mode share to one million trips/day.	0.01
	22	Increase the use of car sharing, carpooling and vanpooling	Car sharing vehicles increased by 10% annually, carpools by 10%, and vanpools by 20% over the Business As Usual (BAU) forecast.	0.30-0.51
	23	Develop intercity high speed rail network	Enact measures to generate regional high speed rail ridership of 13.6 million annually by 2025. Note: reductions represent only reduced driving by Chicago residents; the inclusion of reduced air travel will increase total reduction.	0.006
Transportation Petroleum Use	24	Increase supply and use of alternative fuels	Reduce CO2e per gallon of fuel by 10% through use of alternative fuels.	0.68
	25	Increase fleet efficiency	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.	0.21
	26	Enable more efficient use of fuels	4% annual increase in gas mileage starting in 2010, through measures such as user fees for vehicle ownership, feebates, increased gas taxes, and anti-idling ordinance.	0.51-0.86
Transportation Demand	27	Implement efficient freight movement	Increase freight by rail and waterborne modes; allow for swift movement of goods where mode shift cannot be accomplished; implement land use and planning practices to lower GHG impact from freight; make rail more efficient.	1.61
	28	Enact automobile user fees	Implement a congestion pricing system by 2020; phase in a market-based parking pricing system for 25 percent of all metered spaces over a five-year period.	0.02-0.38
	29	Balance the cost of transportation in proportion to GHG production	Mandate parking cash-outs; vary city vehicle sticker fees based on vehicle fuel efficiency; encourage employers to offer pre-tax transit passes.	0.03
Ind. Proc. & Prod. Use	30	Use of alternative refrigerants	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.	1.16
Waste and Water	31	Zero waste policy	Implement zero waste policy. Includes expanding recycling, requirements for City contracts, elimination of methane emissions.	0.92
	32	Water efficiency	Reduce water supply use and manage water and sewer effluents.	0.13
Land Cover and Forestry	33	Reduce emissions through tree planting & green roofs	Assumes 500 additional green roofs and a combined 83,333 public and private trees planted per year.	0.10 - 0.17

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.

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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.

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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.

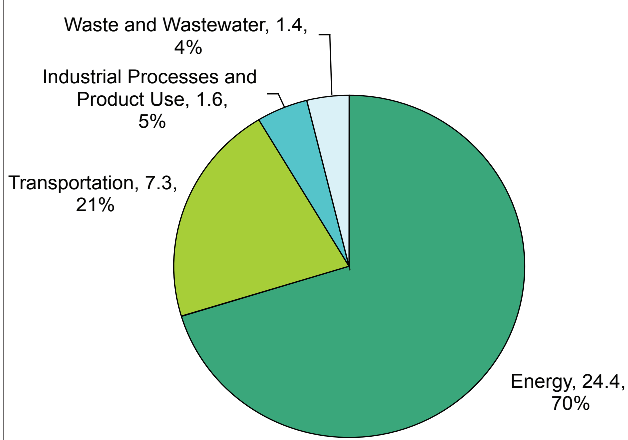
These strategies, when implemented simultaneously, can achieve the CO2e reduction target of 25 percent below 1990 levels by 2020. However, the mitigation of climate change is a long term process that will continue well beyond 2020, and will require the participation of all Chicagoans - renters, homeowners, 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.

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)

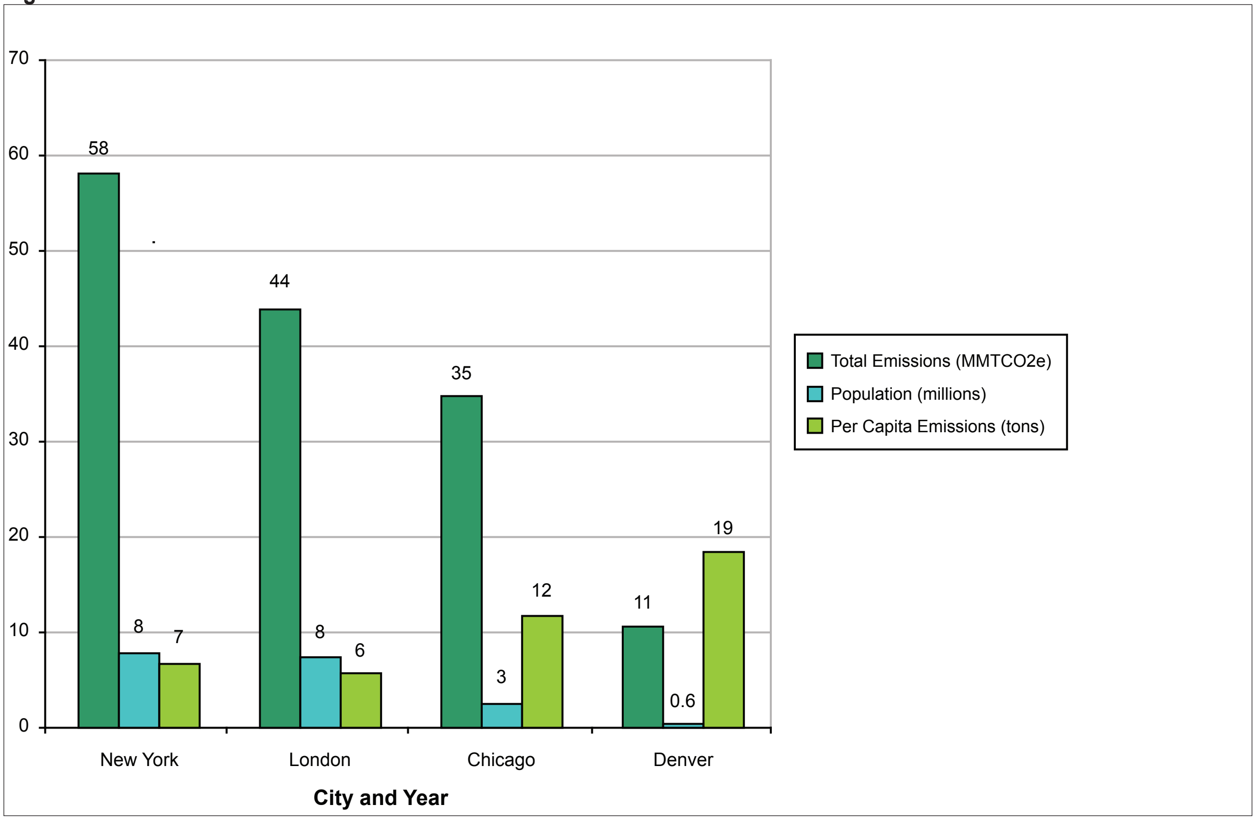


Comparatively, the greenhouse gas emissions in the US in 2000 were 7,147 MMTCO2e.[7] Chicago's emissions inventory is thus just 0.5 percent of the national total, while Chicago is 1 percent of the national population. However, the emissions associated with living and working in Chicago are higher than 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.

Figure 8: Greenhouse Gas Emissions of Cities



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.[17] 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.

Figure 9: Chicago's Greenhouse Gas Emissions 2005 (36.2 MMT CO2e)

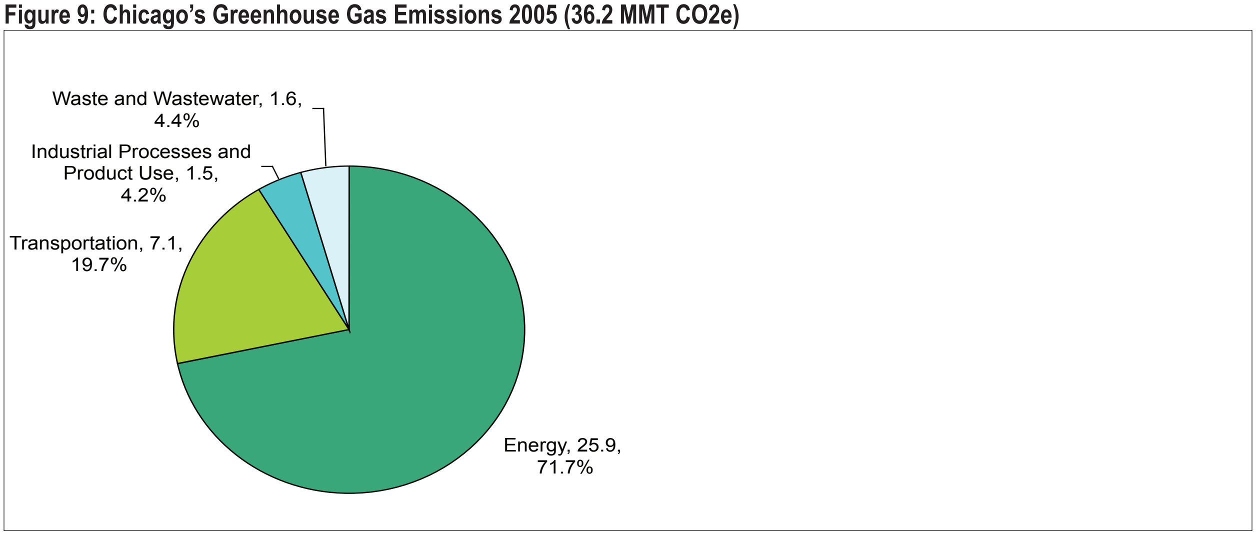
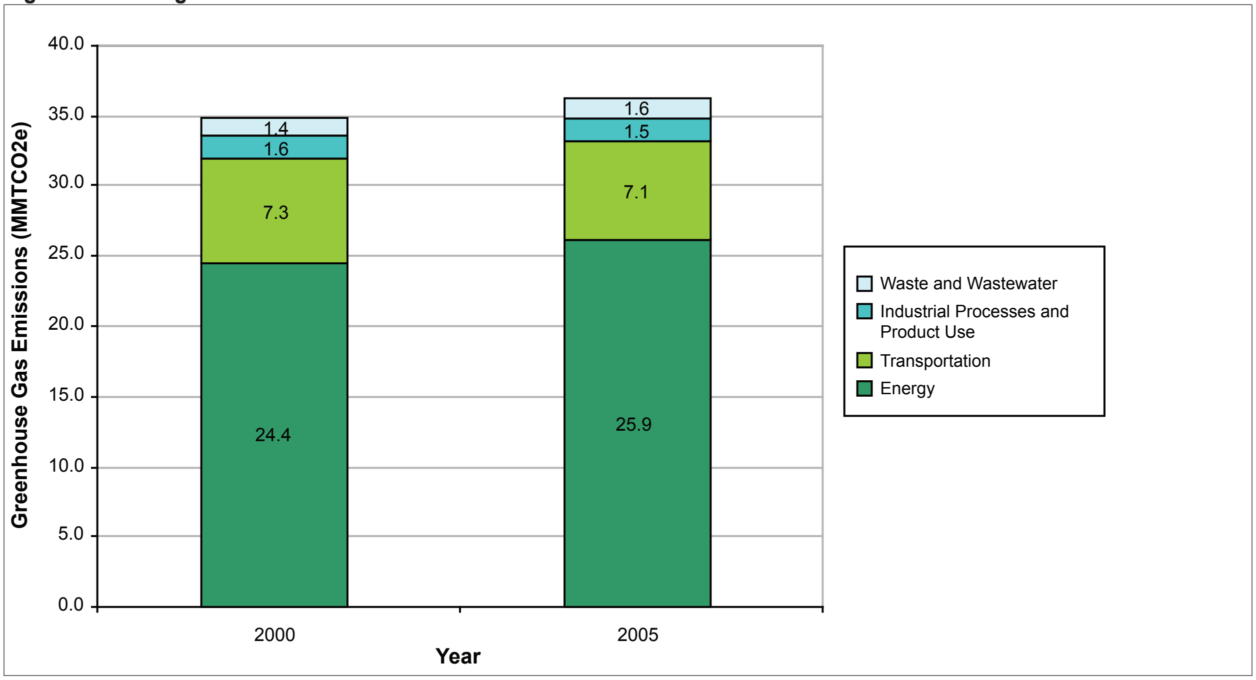


Figure 10: Chicago's Greenhouse Gas Emissions 2000 and 2005



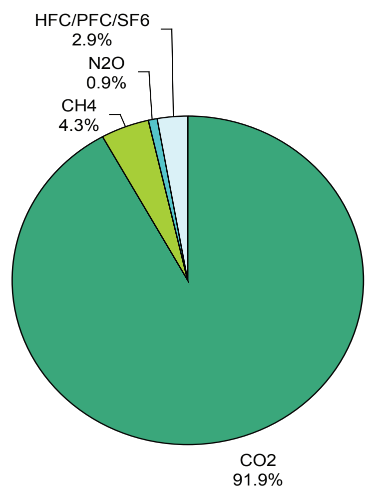
Methodology

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.[18] CO2 formed the majority of Chicago's GHG emissions in all study years.

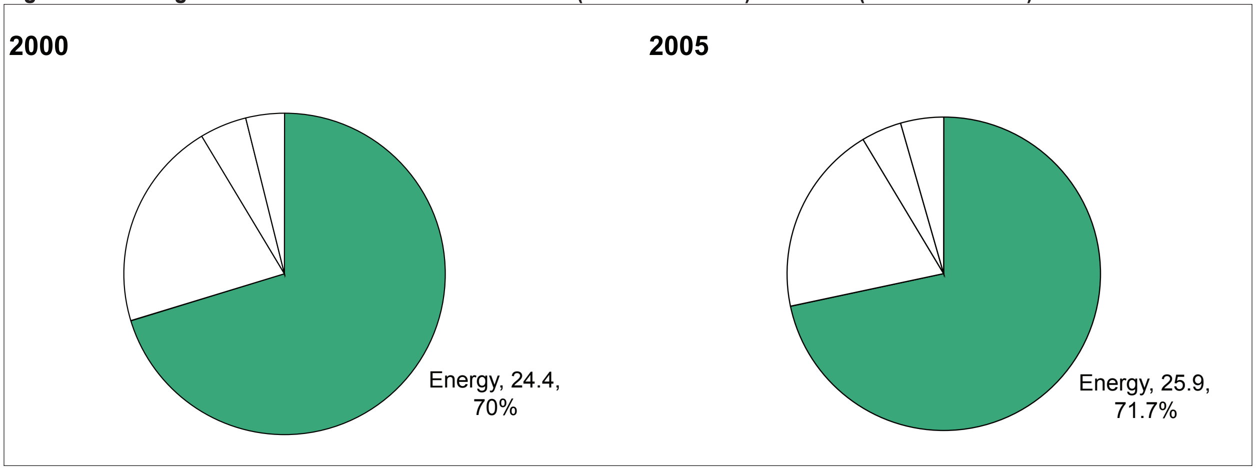
Figure 11: Chicago's Greenhouse Gas Emissions 2000 (34.7 MMT CO2e)



Energy Emissions

Chicago's non-transportation energy use emitted 24.4 MMTCO2e in 2000, which was 71 percent of the total citywide emissions. By 2005, energy emissions grew by 6 percent to 25.9 MMTCO2e.

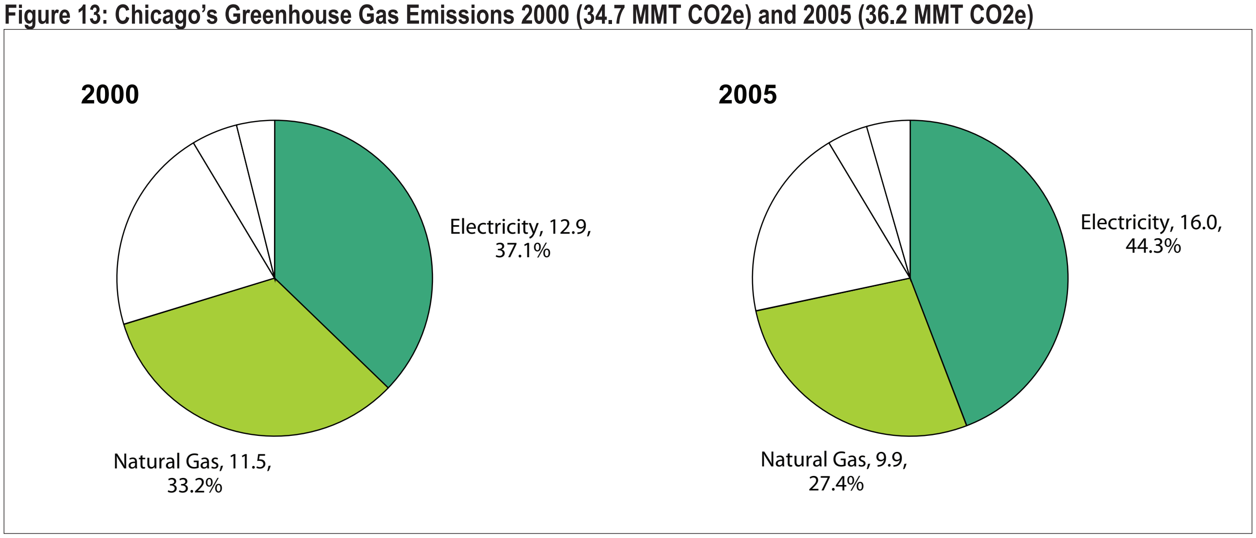
Figure 12: Chicago's Greenhouse Gas Emissions 2000 (34.7 MMT CO2e) and 2005 (36.2 MMT CO2e)



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 shrank.

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

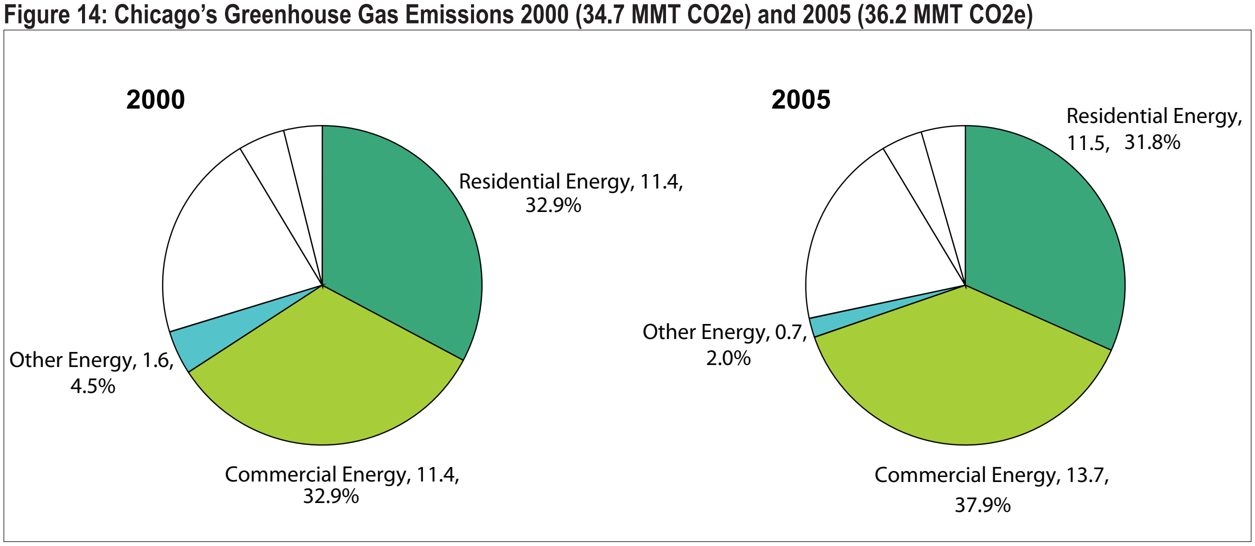


Electricity Emissions

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)[20] and other emissions factors from the California Climate Action Registry General Reporting Protocol.[21] 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.[22]

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



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.

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 MMTCO2e 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, Commonweath 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

	2000			2004/2005[a]			Change in Generation	Change in CO2	Change in Emissions Factor
	Net kWh	CO2 MMT	kg CO2 per kWh	Net kWh	CO2 MMT	kg CO2 per kWh			
Crawford Generation	2,786,241,400	2.90	1.04	2,982,597,000	3.27	1.10	7%	13%	5%
Fisk Generation	1,542,572,600	1.63	1.06	1,790,543,000	1.86	1.04	16%	14%	-2%
Total	4,328,814,000	4.53	1.05	4,773,140,000	5.13	1.08	10%	13%	3%
Chicago Consumption	21,030,669,028[b]	12.86[c]	0.609[c]	24,028,494,904[b]	16.02	0.664	14%	25%	9%
Total as Percent of Chicago Consumption	21%	35%	172%	20%	32%	162%			

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. Total consumption including transport electricity was 21.4 million kWh in 2000 and 24.4 million kWh in 2005.
c. Chicago consumption values in CO2e

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.[23,24] 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.

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[25] and the IPCC 2006 Guidelines for National Greenhouse Gas Inventories.[26] 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.[27] 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.

Figure 16: Cooling Degree Days and Residential Electricity Use in Chicago

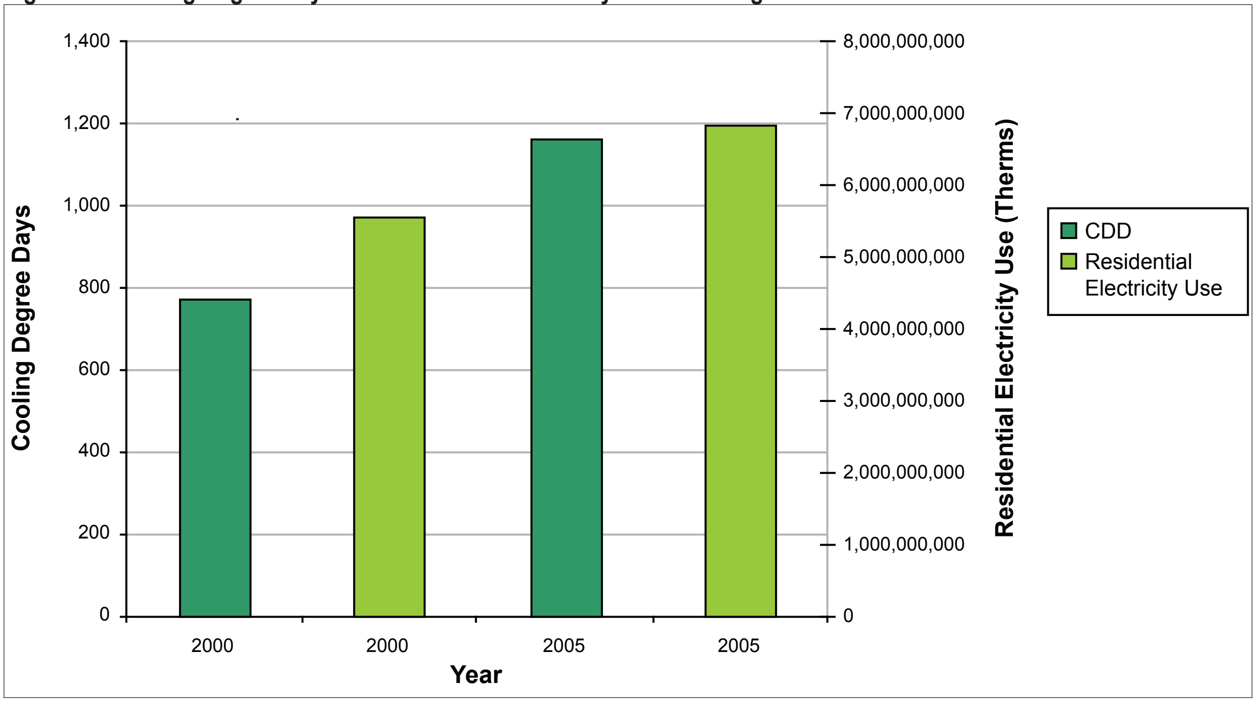
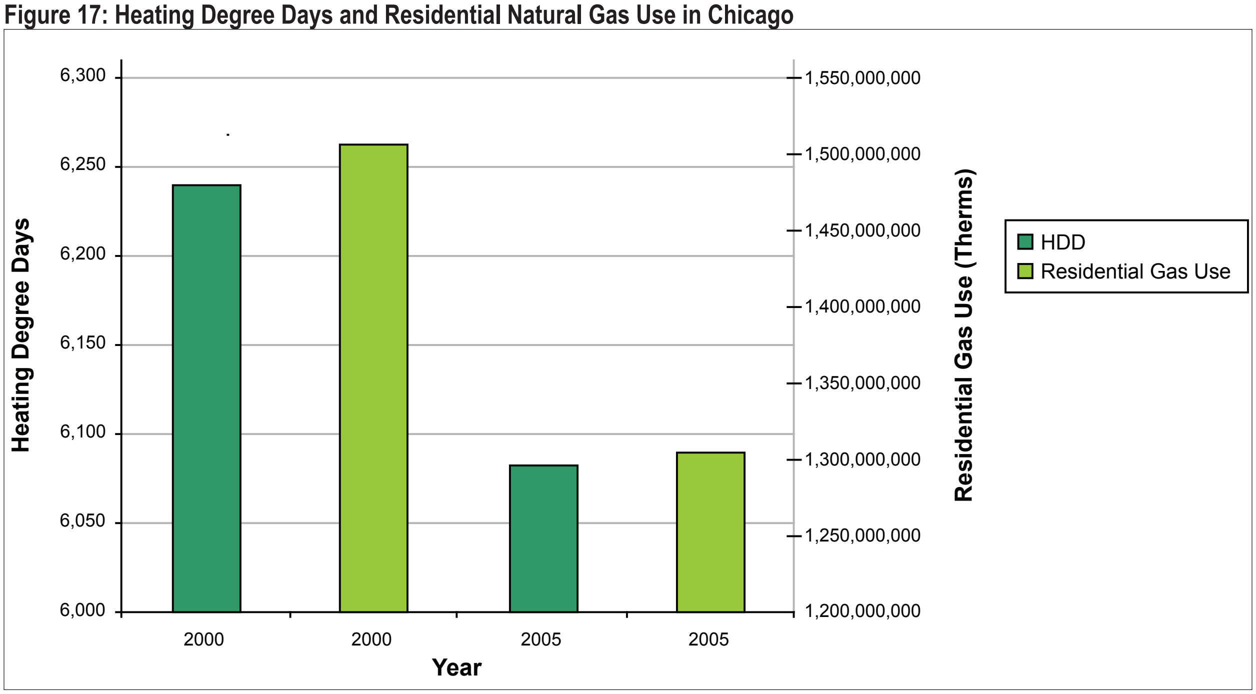
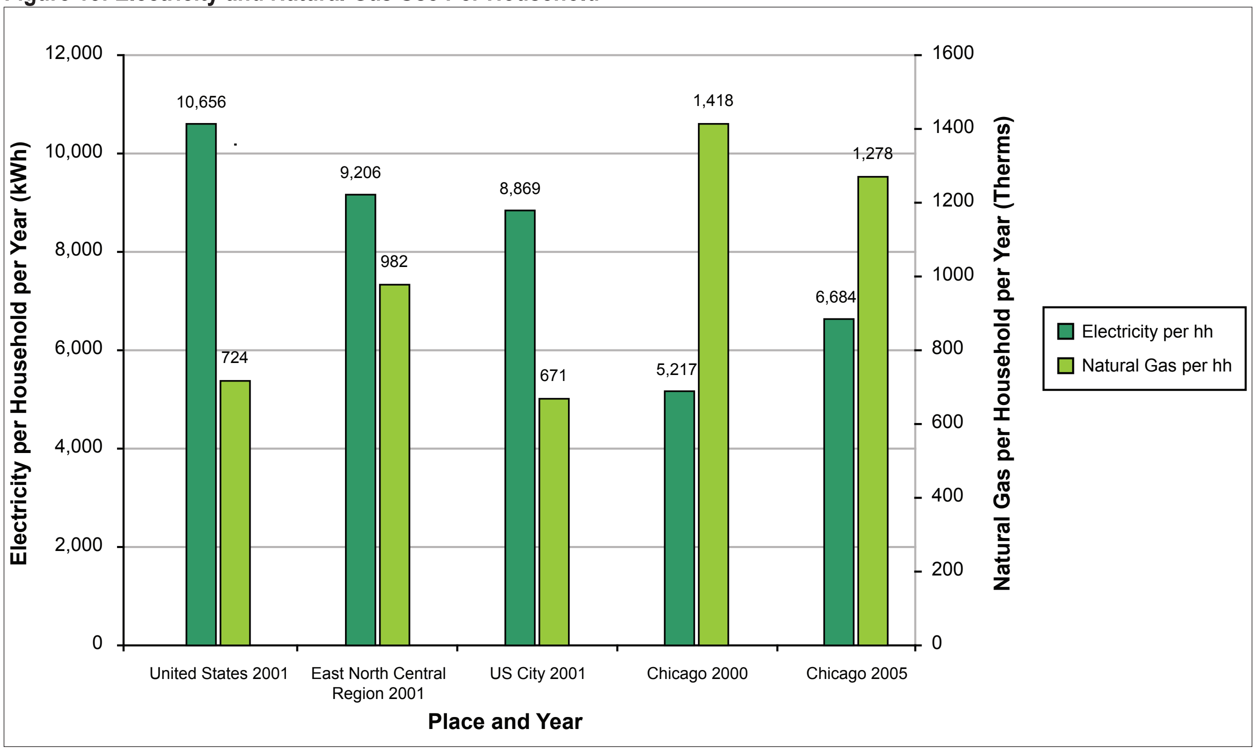


Figure 17: Heating Degree Days and Residential Natural Gas Use in Chicago



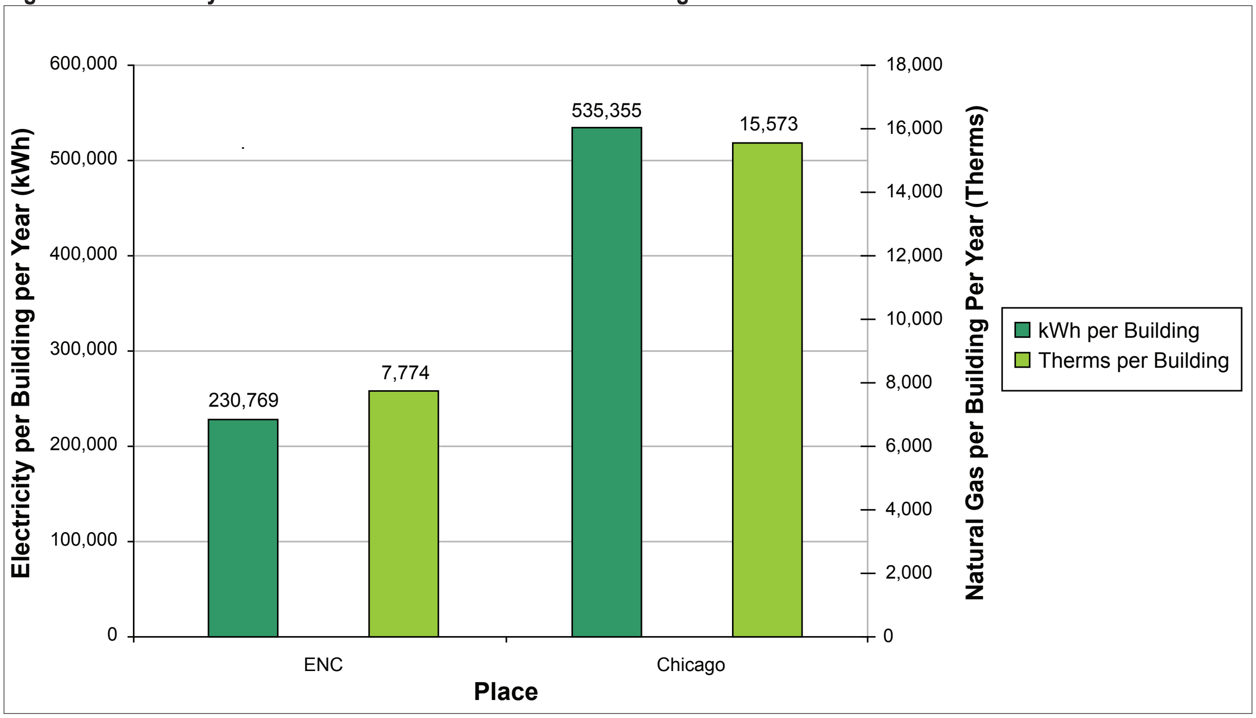
Chicago's per household electricity usage is lower than that of the average U.S. household, the average household in the East North Central census region (Illinois, Wisconsin, Michigan, Indiana, and Ohio), or the average household in a U.S. city according to data from the U.S. Department of Energy's 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.

Figure 18: Electricity and Natural Gas Use Per Household



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.[28] 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. [29] 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.

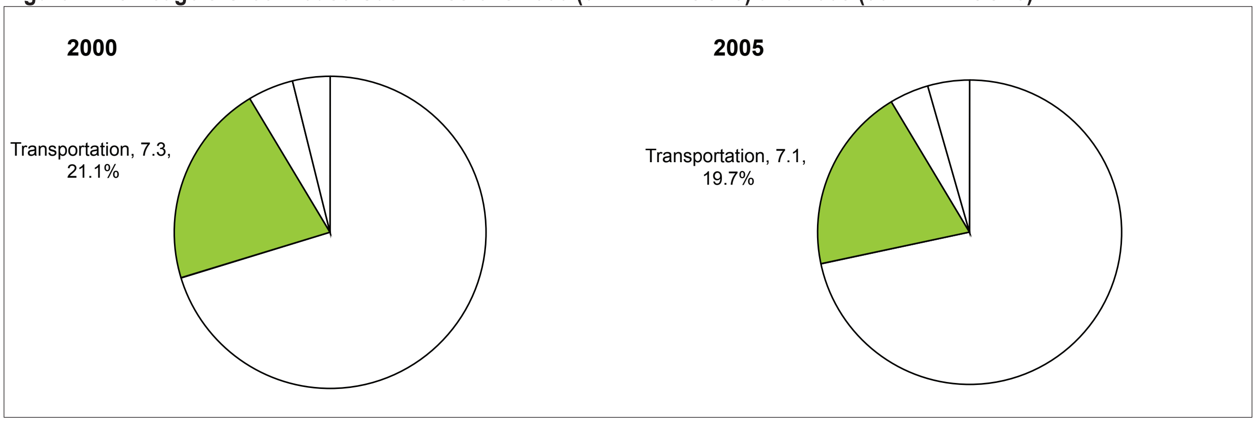
Figure 20: Electricity and Natural Gas Use in Commercial Buildings



Transportation Emissions

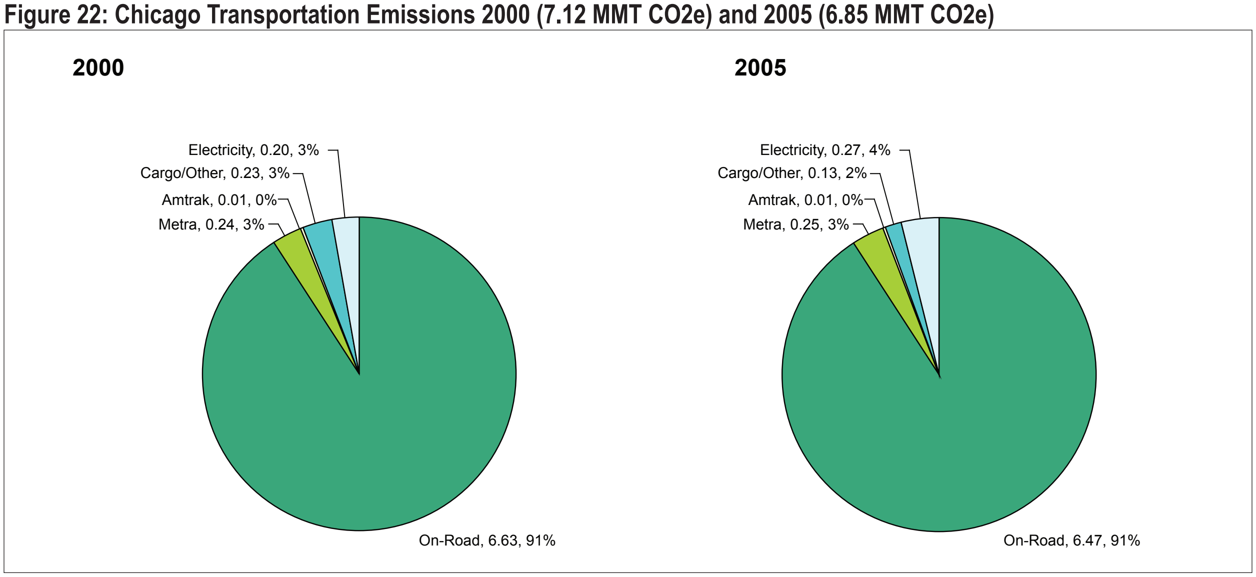
Transportation is the second largest source of GHG emissions in Chicago. Excluding the airports, transportation emitted 7.3 MMTCO2e in 2000 and 7.1 MMTCO2e in 2005. In 2000, transportation was 21 percent of Chicago's GHG emissions.

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



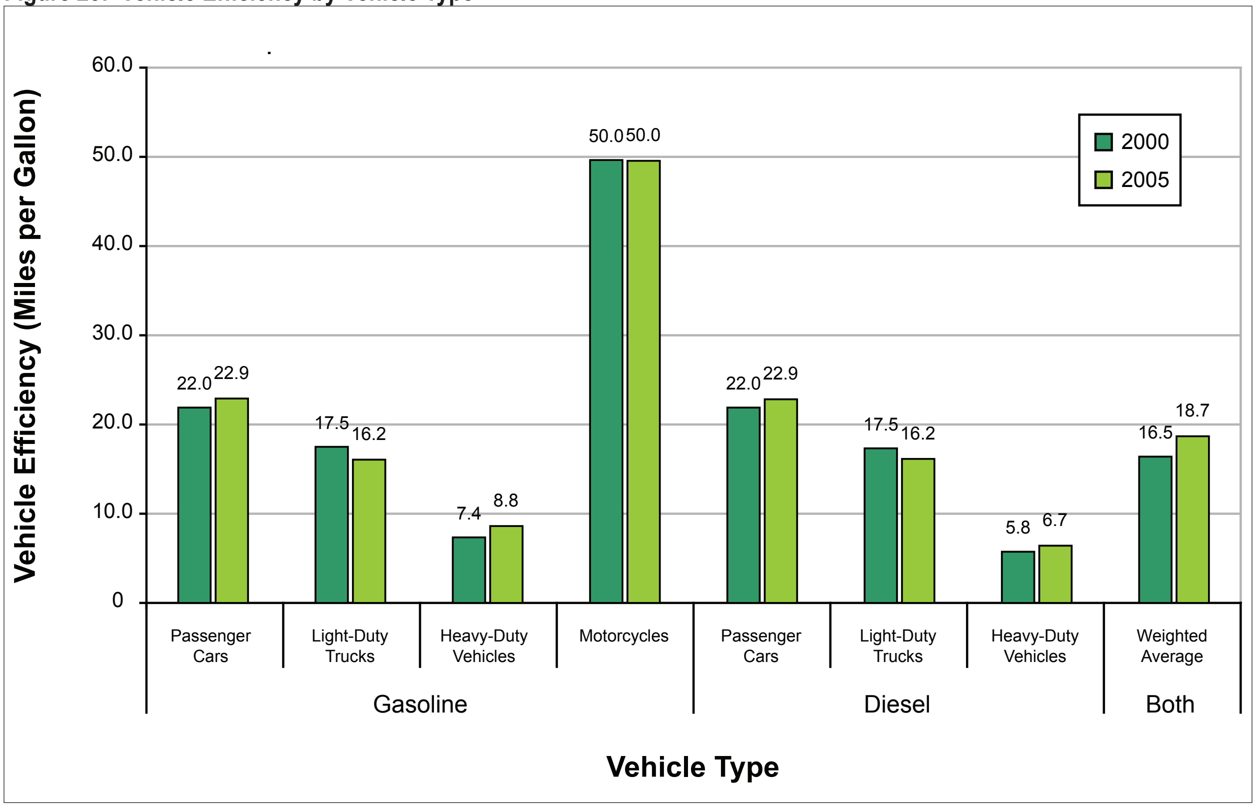
Transportation emissions were developed using vehicle miles traveled data from the Illinois Department of Transportation and Amtrak[30,31]; fleet mix data from the Lake Michigan Air Directors Consortium (LADCO)[32]; vehicle efficiency data from the Federal Highway Administration[33]; and fuel sales and 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.[34,35,36] 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.

Figure 23: Vehicle Efficiency by Vehicle Type



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.[39] VMT in the U.S. grew 9 percent over the same period.[40] The VMT in Chicago was 0.4 percent of the 2.7 trillion miles traveled by vehicles in the U.S. in 2000.[41]

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.[42] This impacts Chicago's GHG emissions, as trucks generally have lower fuel economies and higher emissions than passenger cars.

Figure 24: Share of Vehicle Miles Traveled by Vehicle Type 2000 and 2005

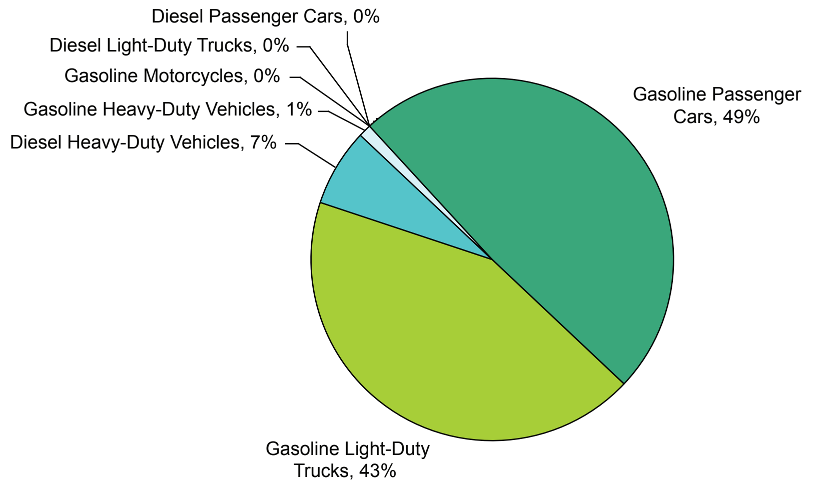
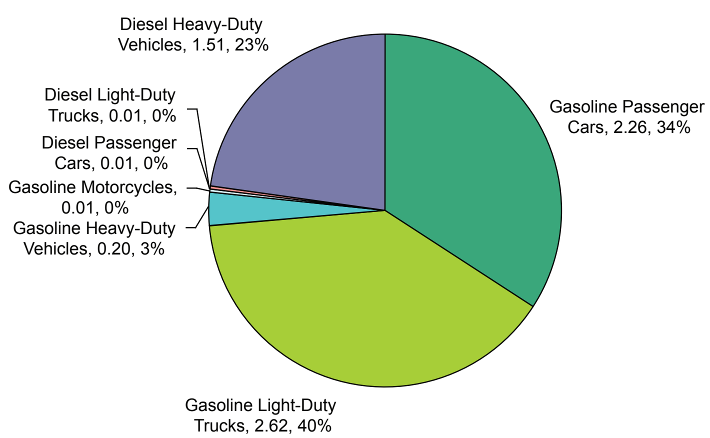


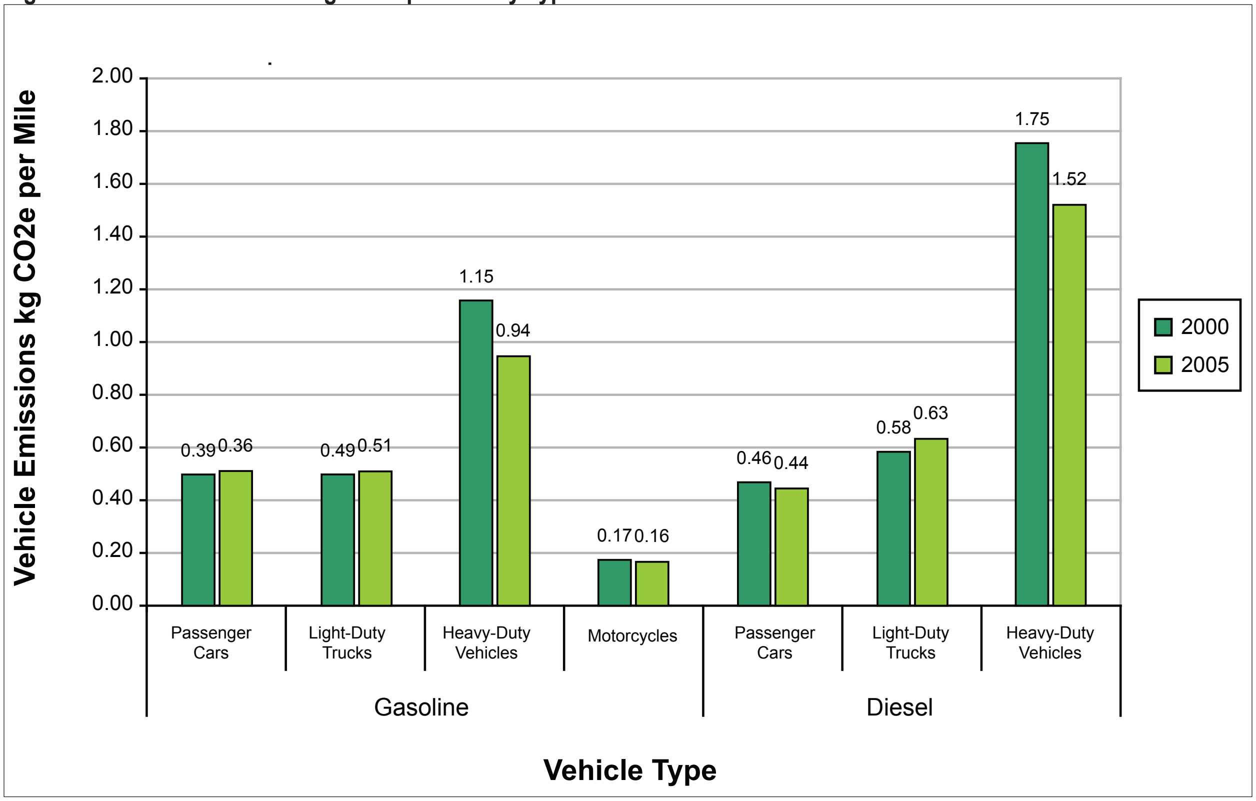
Figure 25: 2000 On Road Transportation GHG Emission by Vehicle Type



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.[43] 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.

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[44], 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.

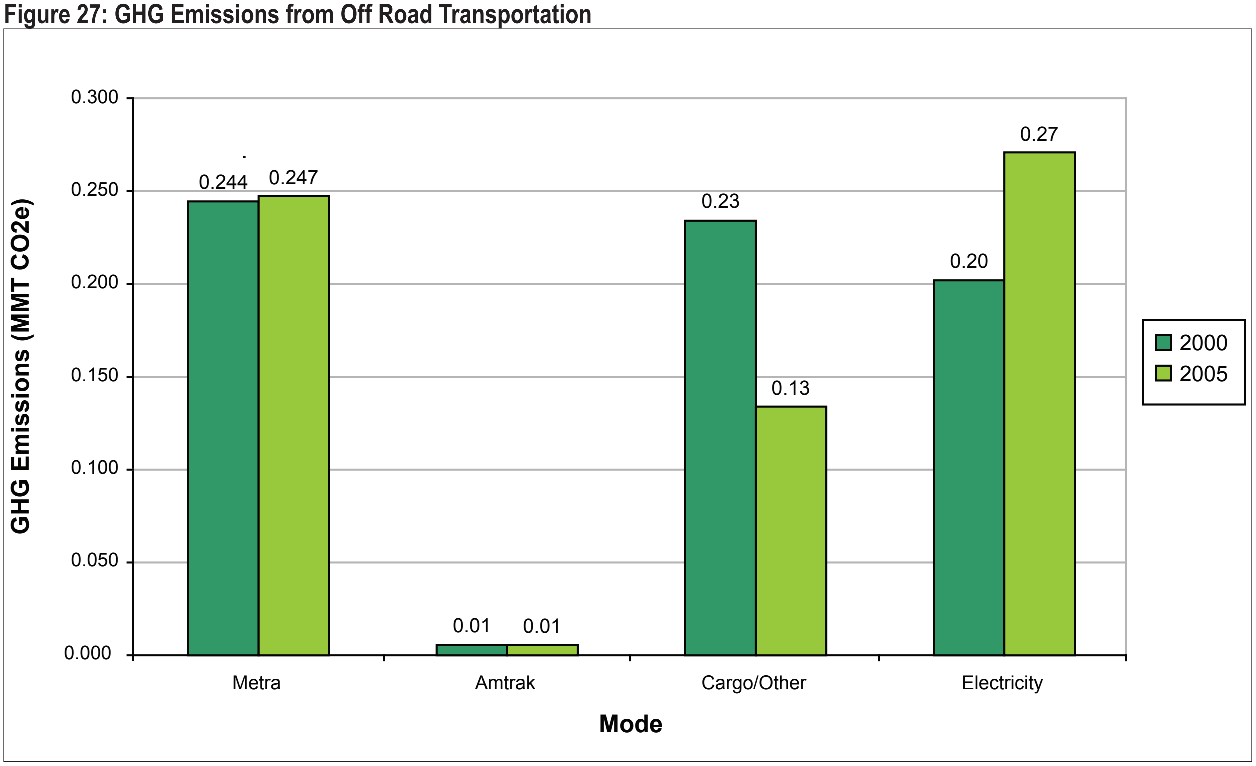
Based on data from the local utility, ComEd, electricity consumed by transportation in Chicago was 331 million kWh in 2000, generating 0.202 MMTCO2e. Most of this can be attributed to the Chicago Transit Authority (CTA), operators of Chicago's "L", elevated electric train system. The CTA reported consuming

359 million kWh in 2000 in the National Transit Database.[45] 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.[46] 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.[47] Chicago was one of the nation's busiest Amtrak locations with 2.5 million passengers riding Amtrak to or from Chicago in 2005.[48] 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.[49]

Figure 27: GHG Emissions from Off Road Transportation



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.[50] Moreover, one would expect these off road 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.

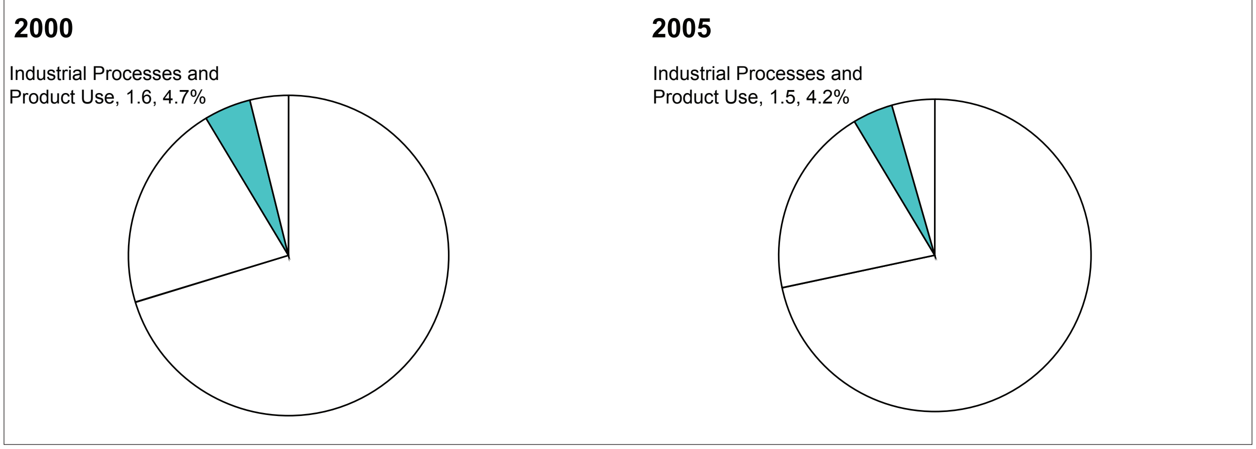
Chicago's Aviation Emissions

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.[60] 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[61] 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 MMMTCO2e 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.

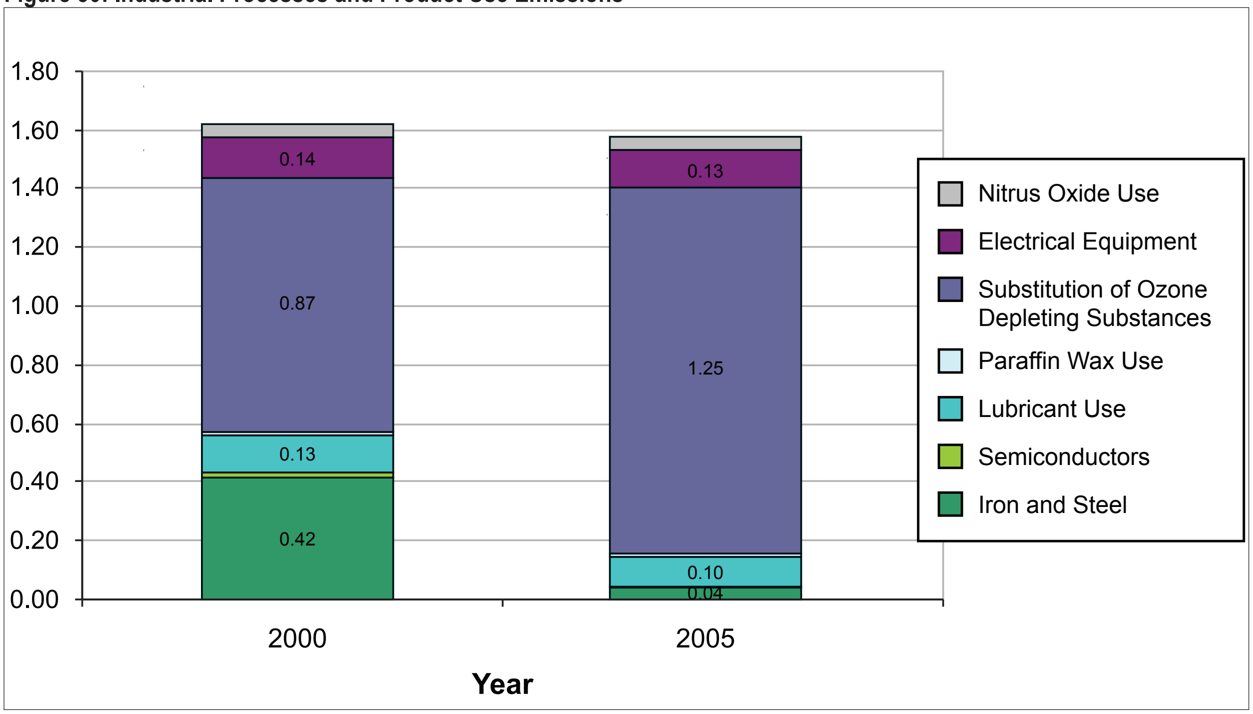
Figure 29: Employment in Non-Energy GHG Emitting Industries

		2000 Employment[a]			2005 Employment[a]		
NAICS	Category	Chicago	United States	Chicago Share of U.S.	Chicago	United States	Chicago Share of U.S.
3311	Iron and Steel Production	904	144,091	0.63%	91	102,422	0.09%
3344	Integrated Circuit or Semiconductor	1,333	620,927	0.21%	246	348,153	0.07%
a. 2000 and 2005 employment in Chicago are estimates extrapolated from 1997 and 2002 Economic Census data.							

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.

Figure 30: Industrial Processes and Product Use Emissions

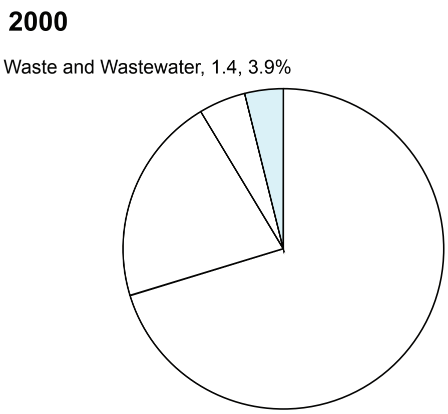


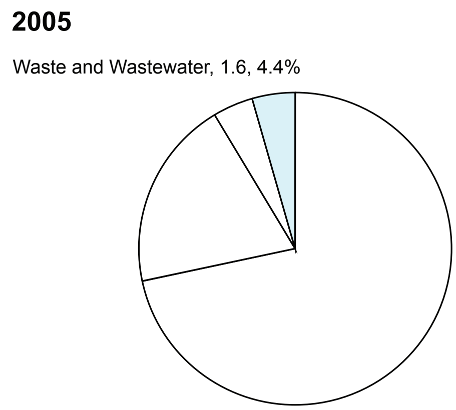
The primary reason for the increase in product use emissions from 2000 to 2005 is an artifact of GHG accounting methods. Some greenhouse gases are also the substances that were found to be destroying the ozone layer in the 1980's. They are being phased out as part of the Montreal Protocol on Substances that Deplete the Ozone Layer and are therefore not regulated by the Kyoto Protocol, nor are they reported in this inventory.[62] 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.[63]

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—its release does not contribute to global warming, and there for 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.[64] 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.[65] 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.[66] 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.[67] 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.[68]

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.[69] 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).[70] 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.[71] 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.

Regional Emissions Inventory

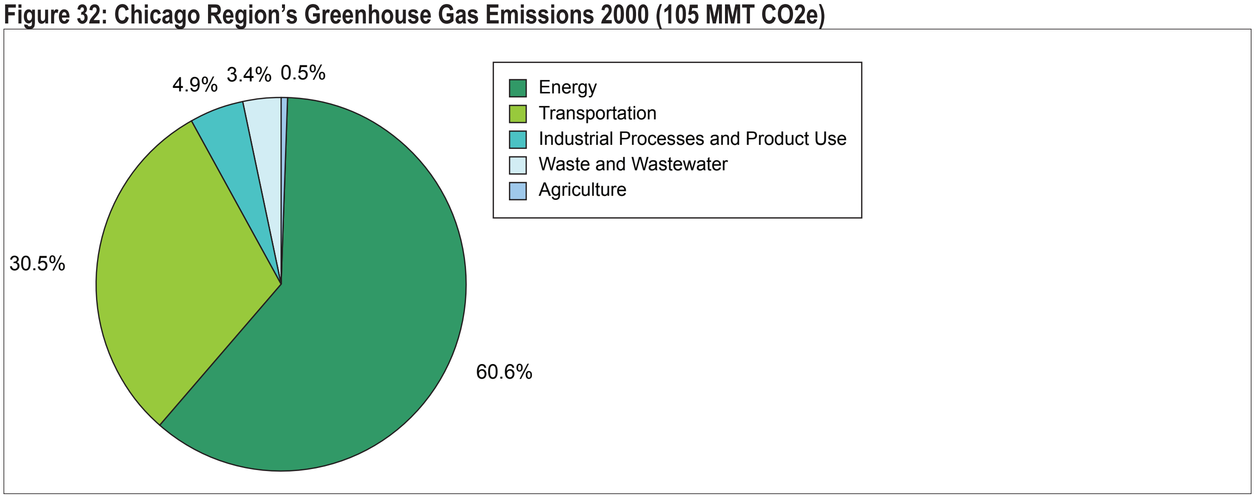
The geographic boundaries of Chicago are porous. Chicago's economy is regional—every minute of every day, individuals and goods travel in and out of the city. A regional inventory of GHG emissions documents these activities and clearly puts Chicago's emissions inventory in context. A regional inventory 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.

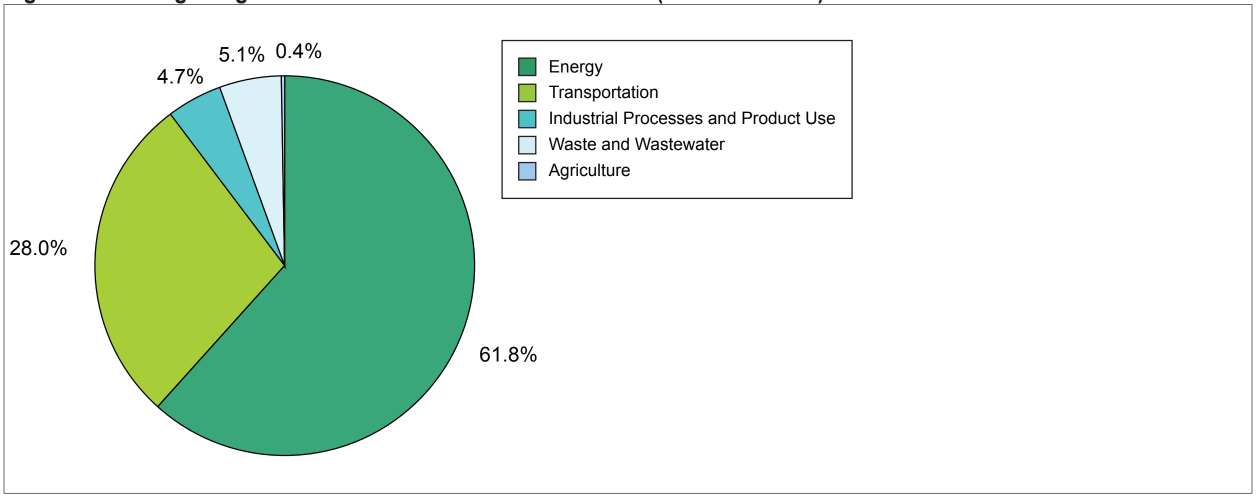
Emissions in all sectors grew at a faster rate in the region than in Chicago, resulting in ten percent growth between 2000 and 2005 to 116 MMTCO2e, or 13.8 tons per capita. The two main sources of this growth in GHG emissions were electricity use and solid waste generation. If the Chicago region continues 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)



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 33: Chicago Region's Greenhouse Gas Emissions 2005 (116 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.[72] 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.[73] 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[74] 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.[75] 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.[76] 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.

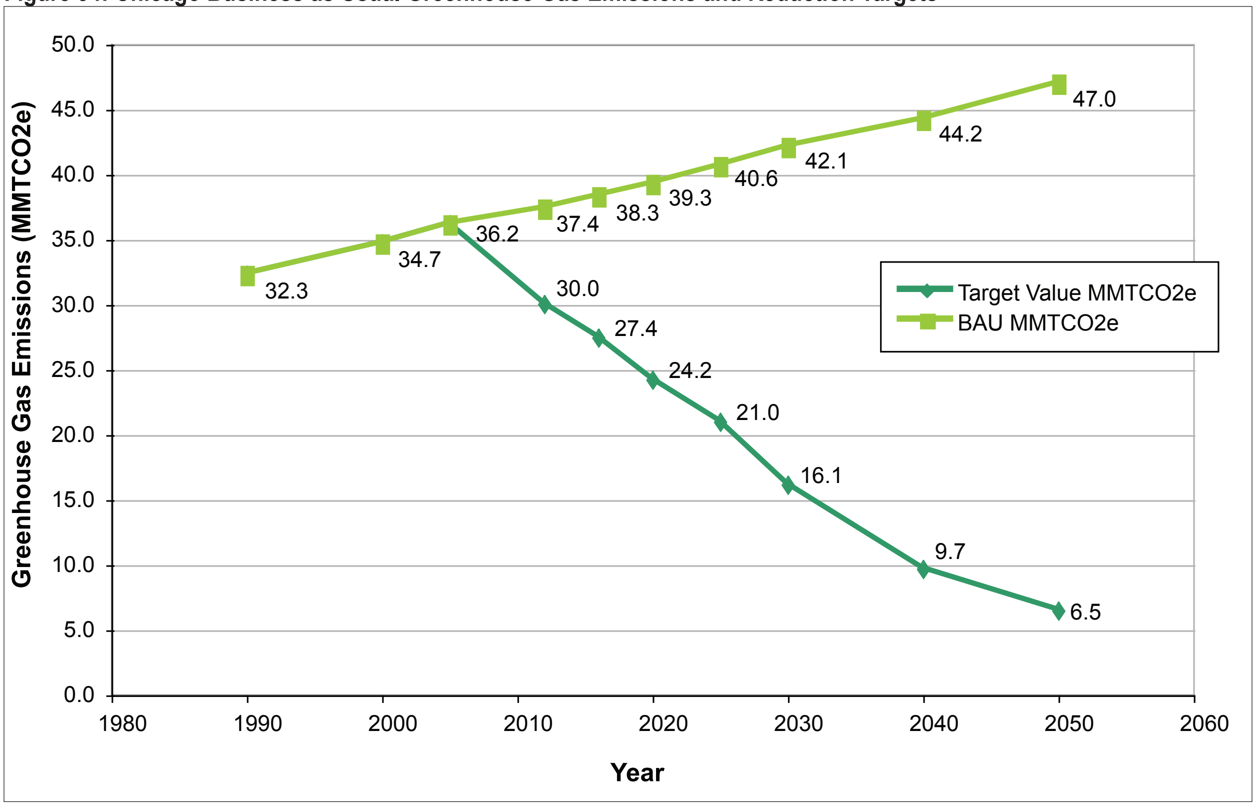
Agriculture is another major source of variance between state and local emissions in Illinois; agricultural emissions were 16.4 MMTCO2e in 2000—six percent of the state total. Comparatively, agricultural emissions in the Chicago region were just 0.5 MMTCO2e, or 0.5 percent of the regional inventory in 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.[77]

Figure 34: Chicago Business as Usual Greenhouse Gas Emissions and Reduction Targets



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 was from the 2007 Energy Outlook Report published by the Energy Information Administration.[78] The values based on the forecast from 2005 to 2030 used were 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)

Sector	Annual Change
Residential Electricity	0.87166%
Small Commercial and Industrial Electricity	1.44721%
Large Commercial and Industrial Electricity	0.40727%
Other Electricity	1.26079%
Residential Energy (Natural Gas)	-0.05760%
Commerical Energy (Natural Gas)	0.87265%
Industrial Energy (Natural Gas)	1.02994%

These growth rates were compared with the historical utility data reported on the ICC website from 1990 to 2004 showing energy sales per year.[79] 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).[80] 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 MMTOC2e 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.[81] Product use emissions were forecasted to increase 1.37 percent annually based on national emission trends[82] and local population forecasts from the Northeastern Illinois Planning Commission (now CMAP)[83]. 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.

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.[84] 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.

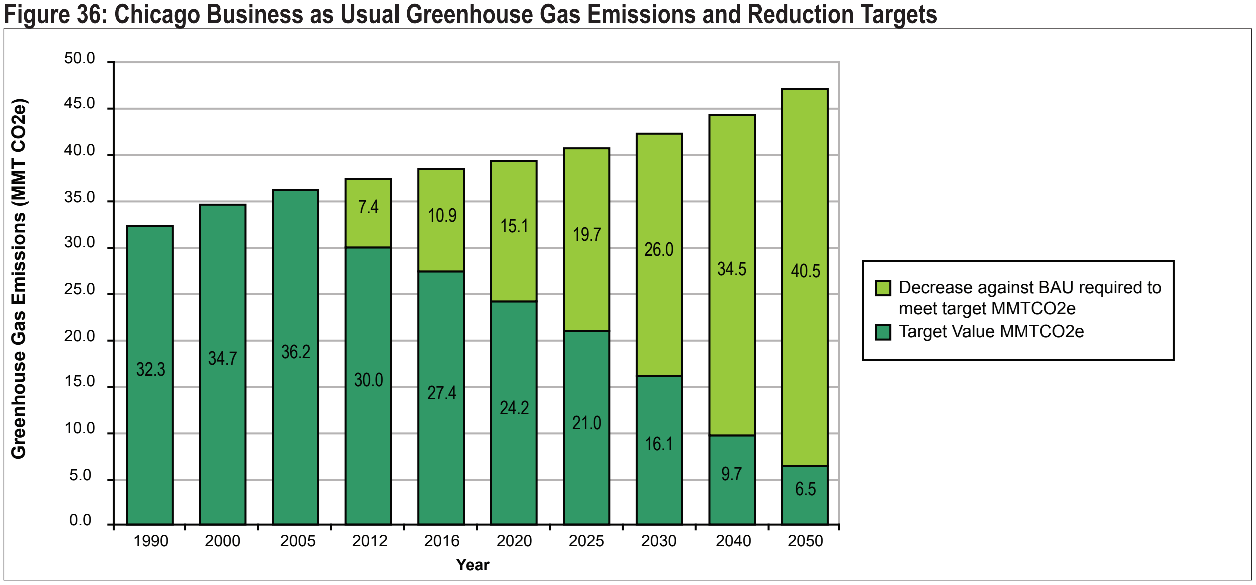
For the purpose of this research, we have selected several targets to forecast.

- **The most immediate target is a 7% reduction in emissions below 1990 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.[85] 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



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.[86] 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.

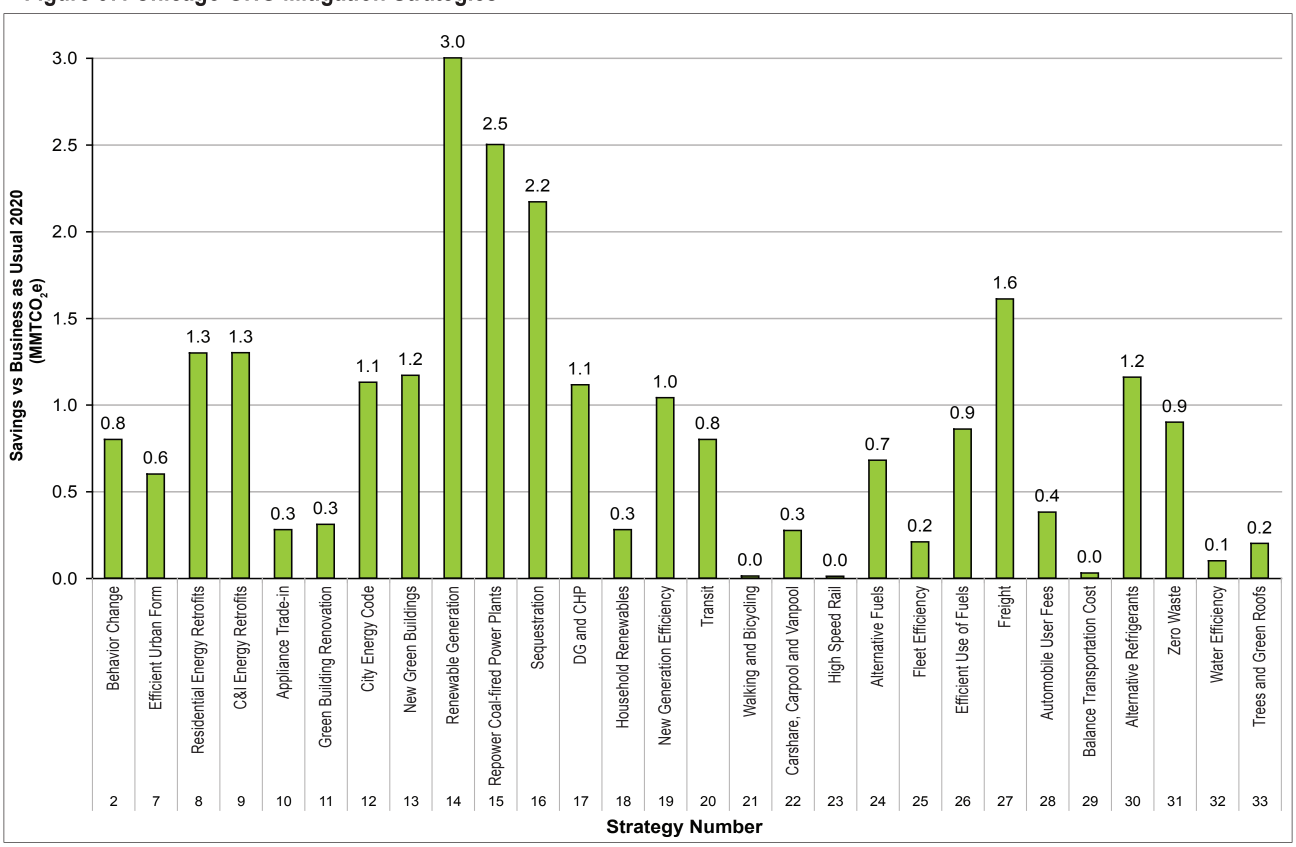
Demand side strategies are as critical as supply side strategies for reductions at the city and regional level. The energy saved in buildings and the miles not driven can together account for nearly half of the targeted reductions. They can take advantage of the inherent efficiency of urban areas, and 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

Category		Mitigation Strategy	Description	CO2e Reduction MMT
Framing	1	Provide leadership on climate issues	Continue and expand City leadership on climate strategy and implementation, including local leadership and strong advocacy in region, state, and federal legislation and policy.	Framing Strategy
	2	Promote behavioral change among residents and businesses that will elicit an ongoing response and action on climate change.	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")	0.80
	3	Use ongoing measurement, verification, data, and metrics to track and target actions, and to continuously improve performance	Develop, track, and share information on mitigation strategies and results.	Framing Strategy
	4	Encourage early action and rapid change	Ensure rapid implementation of mitigation strategies.	Framing Strategy
Cross-cutting	5	Enact a carbon tax	Put leadership capacities behind passing a nationwide carbon tax. Savings assume that a carbon tax would be enacted that reduced national and local emissions to meet target of 25 % reductions from 1990 levels by 2020.	15.10
	6	Enact a cap and trade system	Put leadership capacities behind passing a nationwide cap and trade system for greenhouse gases. Savings assume that a cap and trade system would be enacted that reduced national and local emissions to meet target of 25% reductions from 1990 levels by 2020.	15.10
	7	Implement efficient urban form	Promote transit oriented development. Calculates benefit from growth in population locating near transit.	0.159-0.623
Energy Demand	8	Energy retrofits in residential buildings	Retrofit 47% of existing residential building stock (400K units) by 2020, with 30% reduction in energy use/retrofited unit	1.30
	9	Energy retrofits in commercial and industrial buildings	Retrofit 50% of the commercial and industrial building stock by 2020 resulting in a 30% reduction in energy use/retrofited building.	1.30
	10	Appliance trade-in	Supplement natural turnover of appliances and lightbulbs with targeted appliance trade-in and CFL replacement for low-income households.	0.28
	11	Green building renovation	Require all commercial (1K bldgs) and residential (60K units) renovations to meet Green Renovation Standards.	0.31
	12	Update and improve enforcement of City energy code	Update the City of Chicago's energy code to include more stringent conservation guidelines; and require compliance at the point of sale of all residential property.	1.13
	13	Provide permitting incentives to new construction green buildings	Require that all new residential (65K new homes) and commercial (4K new commercial buildings) construction be built to LEED or equivalent standards by 2020.	1.17
Energy Suppy	14	Build renewable electricity generation	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.	3.00
	15	Repower existing power plants	Convert two power plants located in city limits from coal to natural gas.	1.92
	16	Sequester carbon in new plants	New electricity generating plants use latest carbon sequestration technology.	2.17
	17	Distributed generation and combined heat and power projects	Adapt goals set in Chicago's 2001 Energy Plan to expand the use of Distributed Generation and Combined Heat and Power projects.	1.12
	18	Household renewable energy generation	Increase household scale renewable power (100% electric replacement) and solar domestic hot water (25% natural gas reduction) to 5% of the housing stock.	0.28
	19	Enforce efficency standards for new generation	Support policies for implementing energy efficiency standards for new and existing fossil fuel generation at the regional and national levels	1.04

Transportation Mobility Options	20	Increase transit service	Ensuring stable funding for mass transit, and then increase ridership 30% above business as usual.	0.83
	21	Increase walking and bicycling mode share	Enact measures to double the pedestrian-bicycling mode share to one million trips/day.	0.01
	22	Increase the use of car sharing, carpooling and vanpooling	Car sharing vehicles increased by 10% annually, carpools by 10%, and vanpools by 20% over the Business As Usual (BAU) forecast.	0.30-0.51
	23	Develop intercity high speed rail network	Enact measures to generate regional high speed rail ridership of 13.6 million annually by 2025. Note: reductions represent only reduced driving by Chicago residents; the inclusion of reduced air travel will increase total reduction.	0.006
Transportation Petroleum Use	24	Increase supply and use of alternative fuels	Reduce CO2e per gallon of fuel by 10% through use of alternative fuels.	0.68
	25	Increase fleet efficiency	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.	0.21
	26	Enable more efficient use of fuels	4% annual increase in gas mileage starting in 2010, through measures such as user fees for vehicle ownership, feebates, increased gas taxes, and anti-idling ordinance.	0.51-0.86
Transportation Demand	27	Implement efficient freight movement	Increase freight by rail and waterborne modes; allow for swift movement of goods where mode shift cannot be accomplished; implement land use and planning practices to lower GHG impact from freight; make rail more efficient.	1.61
	28	Enact automobile user fees	Implement a congestion pricing system by 2020; phase in a market-based parking pricing system for 25 percent of all metered spaces over a five-year period.	0.02-0.38
	29	Balance the cost of transportation in proportion to GHG production	Mandate parking cash-outs; vary city vehicle sticker fees based on vehicle fuel efficiency; encourage employers to offer pre-tax transit passes.	0.03
Ind. Proc. & Prod. Use	30	Use of alternative refrigerants	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.	1.16
Waste and Water	31	Zero waste policy	Implement zero waste policy. Includes expanding recycling, requirements for City contracts, elimination of methane emissions.	0.92
	32	Water efficiency	Reduce water supply use and manage water and sewer effluents.	0.13
Land Cover and Forestry	33	Reduce emissions through tree planting & green roofs	Assumes 500 additional green roofs and a combined 83,333 public and private trees planted per year.	0.10 - 0.17

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Mitigation Strategy #1

The City of Chicago provides exemplary leadership on climate change action resulting in affordable solutions for residents, businesses and institutions.

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.

The City could maximize its visibility throughout Chicago, including events held at Daley Plaza, Grant Park, Millenium 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.[2] 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.[3] 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.[4]

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.[5] 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.[6]

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.[8] 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.[9] 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.

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Mitigation Strategy #2
Promote behavioral change among residents and businesses that will elicit an ongoing response and action on climate change.

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

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.[1] 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.

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.

Figure 1 Household Behavior Change Savings

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

a. Assuming average Chicago vehicle efficiency of 19.2 miles per gallon based on CATS 7.15.05 Vehicle Mix Analysis (http://www.ladco.org/tech/emis/net05/index.html) and Illinois Department of Transportation, Illinois Travel Statistics, Table FC-4. http://www.dot.il.gov/travelstats/2005its.pdf
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c. Assumes phantom load is 4% of household electricity use. Joe Schwartz. "Finding the Phantoms: Eliminate Standby Energy Loss." Home Power Magazine. February/March 2007. http://www.homepower.com/view/?file=HP117_pg64_Schwartz

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.[2] 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.[3]

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.

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Mitigation Strategy #3
Use ongoing measurement, verification, data, and metrics to track and target actions, and to continuously improve performance.

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."[1] 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 be 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.[2] 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).[3] 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."[4]

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."[5] 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.

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Mitigation Strategy #4
Encourage early action and rapid change.

Overview

The greenhouse gases we emit today can last decades, centuries, or even millennia in the atmosphere.[1] 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[2] 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."[3] 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"[4] 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.[5] 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."*[6]

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."[7] 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.[8] 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.[9] 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."[10] 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.

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."[11]

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.

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Mitigation Strategy #5
Enact a Carbon Tax

Strategy Summary	Scale	Value
CO2e Savings Against BAU	+++	15.1 MMT CO2e
Scale of deployment	+++	Nationwide or worldwide to reach maximum effectiveness
Timing	++	Possibly phased in 2010
Regional Impact	+++	59.4 MMT CO2e
Financial Savings in relation to Cost	++	Costly, but incentives for efficiency.
Additional Benefits in relation to Burdens	++	Many environmental benefits, potential cost to consumers.
Feasibility assessment	++	Politically challenging, technically feasible

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—only 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.[1,2] 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.[3] A tax in this range could raise approximately $1.3 billion per year in revenue from Chicago.[4]

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.[5] 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."[6]

Current Initiatives and Models

Quebec: Quebec has plans to begin a carbon tax on energy producers beginning in October 2007. The rate will be C$50 per metric ton with plans to double that by 2020.[7] This rate could raise approximately C$200 million ($188 million) per year with C$69 million coming from gasoline, C$36 million from diesel fuel, and C$43 million from home heating oil.[8] Additionally, natural gas distributors will pay about C$39 million while electricity distributor Hydro-Quebec will contribute C$4.5 million for its thermal energy plant in Tracy, Quebec.[9] This tax is expected to raise the price of gasoline 0.8 Canadian cents per liter (2.8 U.S. cents per gallon).[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.[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.[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."*[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."[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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Mitigation Strategy #6
Enact a Cap and Trade System

Strategy Summary	Scale	Value
CO2e Savings Against BAU	+++	15.1 MMT CO2e
Scale of deployment	+++	Nationwide or worldwide to reach maximum effectiveness
Timing	++	Possibly phased in 2010
Regional Impact	+++	59.4 MMT CO2e
Financial Savings in relation to Cost	++	Costly, but incentives for efficiency.
Additional Benefits in relation to Burdens	++	Many environmental benefits, potential cost to consumers.
Feasibility assessment	++	Technically feasible, substantial political support, but a large and costly undertaking.

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.

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 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

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.[1] 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.[2] 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."[3] 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.[4]

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."[5] 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).[6] As of 2005, SO2 emissions have declined by 35 percent over 1990 levels and 41 percent from 1980 levels.[7] 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.[8]

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.[9] 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.[10]

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.[11] 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.[12] The result is that emissions have actually increased between 1 and 1.5 percent in 2006.[13]

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.

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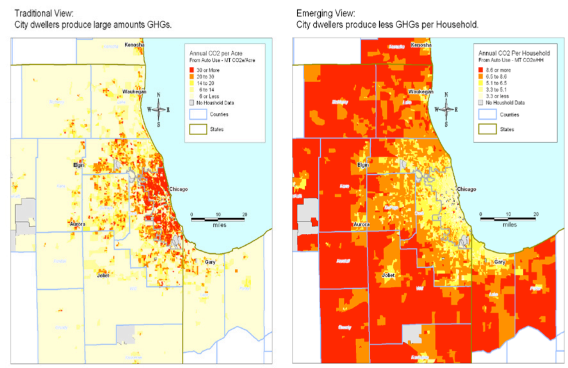
Mitigation Strategy #7
Implement Efficient Urban Form

Strategy Summary	Scale	Value
CO2e Savings Against BAU	+	: 0.159 to 0.623 MMT CO2e in Chicago
Scale of deployment	+++	Regional
Timing	+	Long Term
Regional Impact	+++	: 0.359 to 0.681 MMT CO2e
Financial Savings in relation to Cost	+++	Household cost of living
Additional Benefits in relation to Burdens	+++	Increased quality of life
Feasibility assessment	++	requires regional cooperation

Figure 1 Two Views of Cities



Source: CNT, Travel Matters, 2003

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.

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.

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[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[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.[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

				Chicago's Portion		
Scenario	**HH Added by 2020**	**VMT (Million Miles Added)**	**MMTCO2e Added from new HH**	**HH Added by 2020**	**VMT (Million Miles Added)**	**MMTCO2e Added from new HH**
New region's hh locate across whole region (BAU)	480,615	5,680	2.460	106,243	830	0.359
Region New HH locate so as to make transit zones have minimum density (Scenario 1)	480,615	4,109	1.780	308,048	2,106	0.912
Extra HH in Suburbs that will move to city under scenario 1				201,805	1,668	0.289
Relative savings		1,571	0.681		1,438	0.623
Region New HH locate in transit zones in city to minimum density but relocate others in non-transit area (Scenario 2)	480,615	4,852	2.101	106,243	152	0.066
Relative savings		829	0.359		678	0.293
Region New HH locate in transit zones allocation following NIPC projections for city vs. suburbs	480,615	4,186	1.813	106,805	463	0.200
Relative savings		1,494	0.647		367	0.159

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."[8] 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 CO2 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.[9] 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."[13] 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 CO_2e 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."[14] The demand for housing near transit is projected to reach 9 million households nationally by 2020.[15]

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 CO_2 savings and related benefits.

Doug Foy on Cities

"Cities are much more efficient in their use of energy, water, and land than suburbs…New York City, for example, turns out to be the most energy efficient place in America… Because the buildings are dense and thus more efficiently heated and cooled, and because 85 percent of all trips in Manhattan are on foot, bike, or transit, New York City uses dramatically less energy ...on a per capita basis, than any other state in America."

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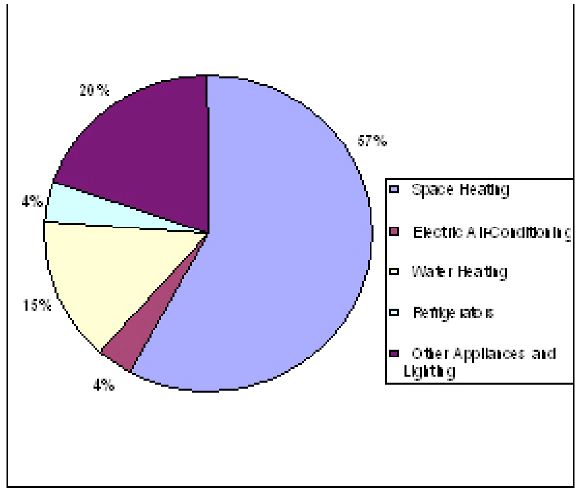
Mitigation Strategy #8
Energy Retrofits in Residential Buildings

Strategy Summary	Scale	Value
CO2e Savings Against BAU	+++	1.3 MMTCO2e
Scale of deployment	+++	400,000 homes
Timing	+++	beginning with 6,000 homes in 2008
Regional Impact	+++	2.5 MMTCO2e
Financial Savings in relation to Cost	+++	12.5 – 30% ROI
Additional Benefits in relation to Burdens	+++	affordable housing
Feasibility assessment	+++	proven models

Figure 1: Residential Energy Consumption by End Use



Source: Residential Energy Consumption Survey, North East Central Region (http://www.eia.doe.gov/emeu/recs/recs2001_ce/2001tblc)e.html)

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."[1] 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.[2] 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[3] 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

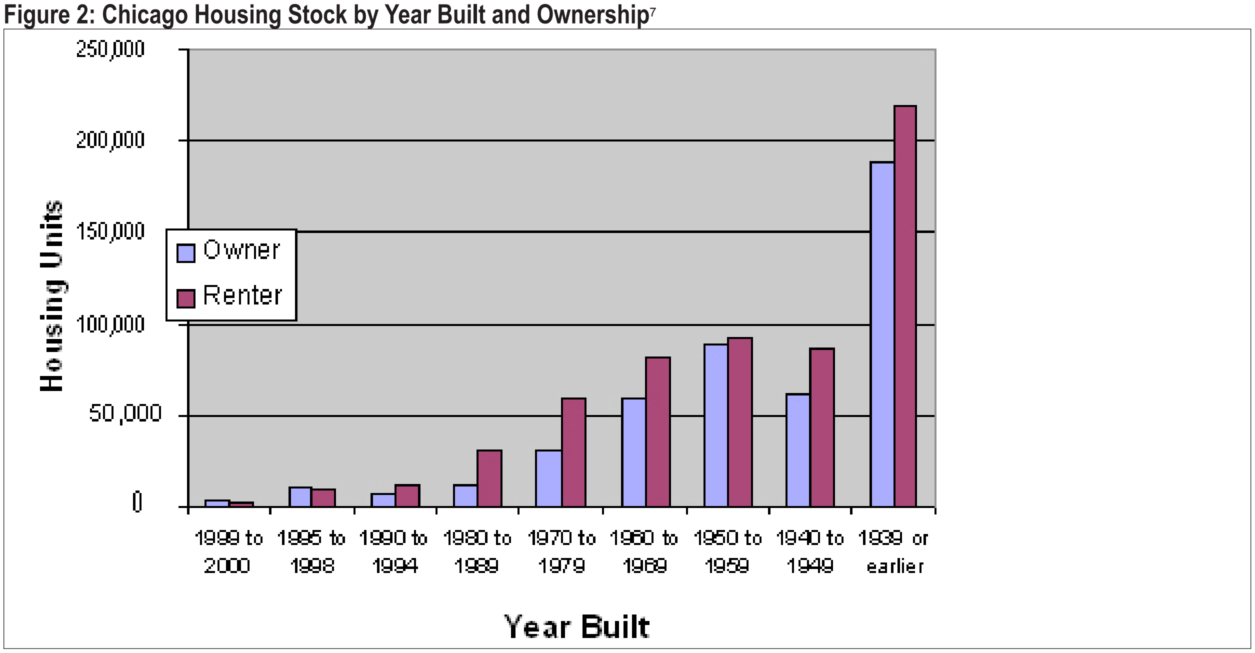
GHG Reduction Potential: 1.3 MMT CO2e in 2020

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.[4]

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.[5] 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.[6] 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[7]



Source: U.S. Census 2000, www.factfinder.gov

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.[8] 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[9] 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. (See Mitigation Strategy #13).[10] 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.[11] 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.

Figure 3 Scale, Costs and CO2 Savings from Energy Retrofits of Residential Buildings

TOTAL NUMBERS FOR PERIOD FROM 2008 - 2020				AVERAGE ANNUAL NUMBERS		
Goal of Existing Units	Total Number of Units	Total GHG Reduction (MMTCO2e)	Total Capital Costs (Million $)	Annual Number of Retrofitted Housing Units*	Average Annual GHG Reduction (MMTCO2e)	Annual Cost (Million $)
100 %	842,000	2.8	2,526	64,769	0.22	194
75%	631,500	2.1	1,895	48,577	0.16	146
65%	550,000	1.8	1,650	42,308	0.14	127
50%	421,000	1.4	1,263	32,385	0.11	97
25%	210,500	0.7	632	16,192	0.05	49

*The average annual number of retrofitted housing units is the average number of units over a thirteen year period from 2008 through 2020. For the goal of 47%, there is an assumption that 6,000 units will be retrofitted in 2008 gradually increasing each year to 50,000 units in 2020 for a total of 400,000 over the thirteen year period.

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

	Cost	Savings	Simple Payback (Yrs)
Building Envelope			
Ceiling Cavity Insulation	$ 7,049	$ 1,531	4.6
Seal Air Leaks	$ 400	$ 70	5.7
Mechanical Systems			
Replacement Hi-Efficiency Boiler	$ 24,000	$4,542	5.3
Boiler Controls	$ 4,500	$ 901	5.0
Outdoor Reset Control	$ 2,000	$ 1,770	1.1
Repipe Leaking Condensate Return Lines	$ 2,000	$ 460	4.3
Replace Radiator & Line Vents	$ 1,270	$ 755	1.7
Electrical/Lighting			
Compact Fluorescent Lamps in Common Areas	$ 152	$ 55	2.8
Total for all Measures	**$ 41,371**	**$ 10,084**	**4.1**
* 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.[13]

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

Year	Single Family Low-Income	Single Family Moderate/Upper Income	Multi-Family Low-Income	Multi-Family Moderate/Upper Income	Total Annual Goal (Number of Housing Units)
2008	2,500*	500	2,500*	500	6,000
2009	2,500	1,000	2,500	2,000	8,000
2010	3,500	2,000	3,500	2,500	11,500
2011	5,000	3,000	5,000	3,000	16,000
2012	7,000	4,500	7,000	5,000	23,500
2013	9,500	5,000	9,500	6,000	30,000
2014	10,000	7,500	10,000	7,500	35,000
2015	11,500	8,500	11,500	8,500	40,000
2016	11,500	8,500	11,500	8,500	40,000
2017	11,500	8,500	11,500	8,500	40,000
2018	15,000	10,000	15,000	10,000	50,000
2019	15,000	10,000	15,000	10,000	50,000
2020	15,000	10,000	15,000	10,000	50,000
Total	119,500	79,000	119,500	82,000	400,000
*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.[14] Low-income families are spending up to 25% of their incomes on energy costs.[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.[16] These programs also benefit utilities by lowering bad debt ratings. Unfortunately, low-income families have lower participation rates in energy efficiency programs.[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%.[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."[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.[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.[21]

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.

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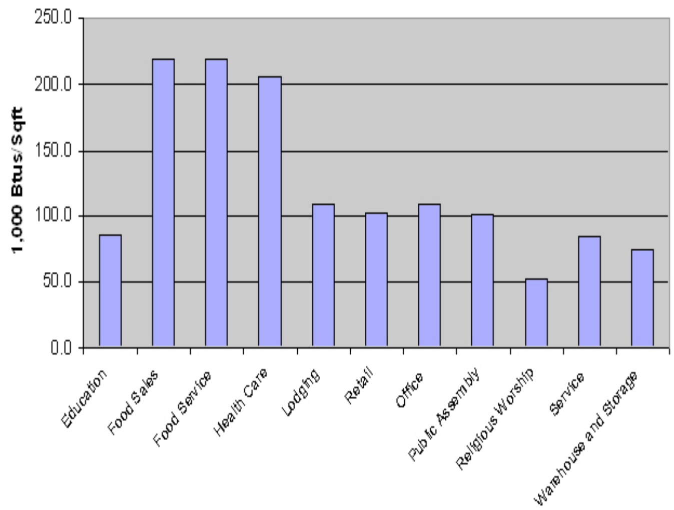
Mitigation Strategy #9
Energy Retrofits in Commercial and Industrial Buildings

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

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.[1] 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.[2] 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.[3] 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.[4,5] 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

Year	Industrial	Commercial
2008	5	5
2009	10	20
2010	10	100
2011	10	200
2012	15	475
2013	15	500
2014	15	500
2015	20	1,000
2016	20	1,000
2017	20	1,000
2018	20	1,200
2019	20	1,500
2020	20	1,500
Total	**200**	**9,000**

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

SIC_CODE_DESCRIPTION	Average Annual Consumption (kwh)
Electric, Gas, And Sanitary Services	2,484,498
Justice, Public Order, And Safety	2,119,197
Hotels And Other Lodging Places	1,769,420
Food And Kindred Products	1,215,575
Primary Metal Industries	988,867
Holding And Other Investment Offices	785,466
Rubber And Misc. Plastics Products	781,225
Paper And Allied Products	751,589
Museums, Botanical, Zoological Gardens	741,627
Executive, Legislative, And General	732,787
Educational Services	705,981
Chemicals And Allied Products	651,668
Fabricated Metal Products	576,021
Electronic & Other Electric Equipment	485,664
Administration Of Human Resources	457,174
Textile Mill Products	393,944
Leather And Leather Products	389,791
Petroleum And Coal Products	382,089
Amusement & Recreation Services	373,598
Wholesale Trade--Nondurable Goods	349,705
Wholesale Trade—Durable Goods	333,142
Metal Mining	315,956
General Merchandise Stores	313,960
Depository Institutions	312,661
Real Estate	289,669
Stone, Clay, And Glass Products	283,752
Communication	279,984
Transportation Equipment	268,084
Security And Commodity Brokers	263,734
Furniture And Fixtures	263,584

Insurance Carriers	257,243
Instruments And Related Products	237,575
Lumber And Wood Products	237,378
Trucking And Warehousing	236,493
Health Services	229,370
Food Stores	215,521
Water Transportation	208,468
Environmental Quality And Housing	193,780
Business Services	193,593

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.[7] 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

Total Period from 2008 - 2020						Average Annual Goal
Goal of Existing Units	Numberof Buildings	Million Square Footage of Conditioned Space	MMTCO2e Reduction	Capital Costs (Million $)	Annual Goal (Bldgs)	Annual Cost (Million $)
100%	18000	265	2.22	$ 13,230	1400	$ 1,018
75%	13500	198	1.67	$ 9,923	1000	$ 763
50%	9000	132	1.11	$ 6,615	700	$ 509
25%	4500	66	0.56	$ 3,308	350	$ 254

Qualitative Results

Program Elements

Commercial and industrial energy retrofit programs are most effective when they combine technical assistance, financial assistance, and on-going 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 are 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.[9]

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]

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:

> *"Commissioning is the process of ensuring systems are designed, installed, functionally tested, and operated in conformance with the design intent. Commissioning begins with planning and includes design, construction, start-up, acceptance, and training and can be applied throughout the life of the building. Furthermore, the commissioning process encompasses and coordinates the traditionally separate functions of systems documentation, equipment start-up, control system calibration, testing and balancing, and performance testing."*[14]

Building commissioning is frequently not done because of the financial pressures of handing over buildings quickly.[15] When building use is not understood, building systems may be functioning for significant periods when the building is not occupied. There is significant opportunity to save energy in some buildings by setting back temperatures appropriately during unoccupied periods. Evan Mills, in a report for the Lawrence Berkeley Labs, notes that,

> *"For existing buildings, we found median commissioning costs of \$0.27/ft^2, whole-building energy savings of 15 percent, and payback times of 0.7 years. For new construction, median commissioning costs were \$1.00/ft^2 (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 $mart Energy (SB$E) program which provides energy efficiency technical services for small to medium-sized for-profit businesses.[18] 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.[19]

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.[20] 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.[21]

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.[22] 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.[23]

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.

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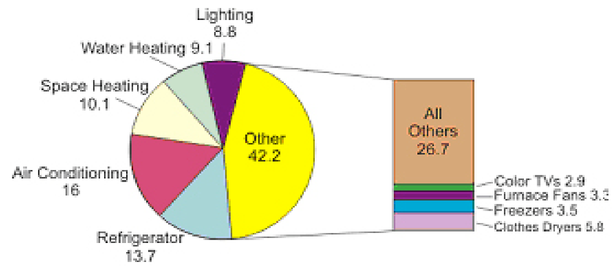
Mitigation Strategy #10
Appliance Trade-In

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

Figure 1 Percentages of United States residential electricity use by type



Source: Energy Information Administration, Form EIA-457A, B, C, E and H of the 2001 Residential Electricity Consumption Survey.

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[1] as well. As federal minimum energy standards have increased in recent years and are likely to continue to do so,[2] 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 this 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 turn-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,[3] 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.[14]

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[4]

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

Appliance	Action	Scale (Number of Appliances)	GHG Reduction per Year at Scale (MMTCO2e)
Room Air Conditioner	Trade-in: Replacing room air conditioners that would otherwise not be replaced by 2020	83,000	0.0111
	Creating incentives for the purchase of Energy Star rated room air conditioner units	216,000	0.009
Refrigerator	Trade-in: Replacing refrigerators that would not otherwise be replaced	104,000	0.031
	Increased purchases of Energy Star rated units	103,000	0.005
Light Bulb	Replacing incandescent bulbs with CFLs[5]	4,000,000	0.228
TOTAL			**0.284**

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

Appliance	Action	Electricity Savings per Year per Appliance (kWh)	GHG Savings per Year per Appliance (kg CO2e)
Room Air Conditioner	Trade-in: Upgrading from an 8 EER unit to a 9.8 EER	221	135
	Increased purchases of Energy Star rated units	72	44
Refrigerator	Trade-in	500[6]	304
	Increased purchases of Energy Star rated units	75	46
Light Bulb	Replacing incandescent bulbs with CFLs	93	57

Activity Savings

Total electricity savings from these strategies would be 467 gigawatt-hours per year. Detailed savings are provided in Figure 4.

Figure 4 Activity Savings by Action

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

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[7] and just over $100 for each room air conditioner.[8] 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.[9] 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.

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3 Ecos Consulting, Northwest Energy Efficiency Alliance. Energy Efficient Lighting in New Construction. Portland, Oregon: 2002.

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.

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8 New York State Energy Research and Development Authority, “Keep Cool New York,” www.aceee.org/utility/2bkpcoolrdnys.pdf.

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12 Citizens Utility Board, “About the Northern Illinois Energy Project,” http://www.citizensutilityboard.org/niep_aboutNEIP.html.

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Mitigation Strategy #11
Green Building Renovation

Strategy Summary	Rating	Value
CO2e Savings Against BAU	+	0.31 MMTCO2e
Scale of Deployment	++	60,000 homes & 1,000 commercial buildings
Timing	+++	Beginning in 2010
Regional Impact	+	0.93 MMTCO2e
Financial Savings in Relation to Cost	+++	$50-$65 per square foot (total 20-year Net Benefit)
Additional Benefits in Relation to Burdens	+++	Improves building sustainability
Feasibility Assessment	+++	Proven models

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."[1] 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.[2]

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 upgrading 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 MMTCO2e 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.[3]

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."[4] 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."[5] 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.[6]

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.[7]

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."[8] 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.[9]

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[10] to Novato, California[11] —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.

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Mitigation Strategy #12
Update Chicago's Energy Code

Strategy Summary	Rating	Value
CO2e Savings Against BAU	+++	1.13 MMTCO2e
Scale of deployment	+++	421,000 homes
Timing	+++	beginning in 2010
Regional Impact	+++	3.4 MMTCO2e
Financial Savings in relation to Cost	+++	12 – 30% ROI
Additional Benefits in relation to Burdens	+++	Reduced operating costs in housing
Feasibility assessment	++	Design program with stakeholder input

Overview

Updating the City of Chicago's energy code to include more stringent conservation guidelines and requiring compliance at the point of sale of property could result in CO2e savings of 1.13 MMT CO2e in 2020.

Building codes develop minimum standards for the structural and mechanical safety of buildings and their systems, developed to protect public health and sanitation. Energy codes have been added to basic building guidelines to make buildings more energy efficient.[1] The implementation of energy codes can reduce energy use from 15% to 30%.[2] In a local study assessing the impacts of adopting the International Energy Conservation Code (IECC), it was found that residential buildings in compliance with IECC have annual savings of 25%.[3] Chicago adopted its own energy code—the Chicago Energy Conservation Code, modeled after the International Code Council's (ICC) 2001 IECC—in 2003.[4] Full enforcement of the current energy code, and any subsequent revisions, is important for realizing the full GHG reduction potential of this mitigation strategy.

As noted in a Pacific Northwest National Laboratory report from 2003:

> *"The code must be one that is understood by all parties, adopted through at least a quasi-consensus process, enforced and, most importantly, exceeded by most builders… codes are arguably the most cost-effective tool available for raising the energy efficiency of new buildings."*[5]

In addition to new buildings, an updated energy code stands to raise energy efficiency of the more than one million existing housing units in Chicago.

One of the new opportunities identified in this mitigation strategy is taking advantage of the typical cycle of a building turnover by requiring energy code compliance at the "sale" stage. Donald Shoup (AICP) found in a 1996 study that about half of all owner-occupied housing units in the U.S. were sold at least once within ten years.[6] This presents a dependable cycle of turnover at 5 percent per year on which to structure enforcement, regulation and/or incentives, such as energy code compliance.

Quantitative Results

GHG Reduction Potential: 1.13 MMTCO2e

The GHG reduction potential assumes that energy code compliance is required at the point of sale for residential housing in the City of Chicago, estimating conservatively that 5 percent of housing units are sold annually for a total of 421,000 units between 2010 and 2020. These units would be retrofitted as needed to meet energy code requirements. A 25% energy savings, and corresponding GHG reduction, is anticipated from these retrofits.[7]

Figure 1, using 2000 U.S. Census data, shows the housing turnover rate in Chicago to demonstrate the applicability of this mitigation strategy, and the potential for GHG reductions.

Figure 1: Chicago Housing Unit Turnover

Length of residency in unit	% of total occupied units	Cumulative Percent
2 yrs or less	21.8%	21.8%
2 to 5 yrs	31.2%	53.0%
6 to 10 yrs	14.7%	67.7% 10 yrs or less
11-20 yrs	13.3%	81.0%
21 to 30 yrs	9.30%	90.3%
31 yrs+	9.70%	100.0%

Scale

The scale assumed is all housing units sold, or 5 percent of existing housing units annually—42,100 per year. Upon sale, homes would go through the Chicago Energy Conservation Code certification process, reaching a total of 421,000 units between 2010 and 2020.

Timeline

The mitigation strategy begins in 2010 with an equal number of housing units retrofitted to meet the Chicago Energy Conservation Code each year through 2020.

Per-unit GHG Reduction Potential

There is a potential to reduce an average of 2.68 metric tons CO2e annually per renovated housing unit.

Activity Savings

Employing this strategy can result in savings of 548 gigawatt-hours of electricity and 149 million therms of natural gas per year.

Lifecycle GHG Impacts

Programs that bring existing residential buildings up to code 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 life cycle greenhouse gas impacts of the installation of more efficient heating and cooling equipment, as well as the use of energy efficient building materials such as insulation.[8] Because energy retrofit programs for existing buildings reduce the consumption of fossil fuels, they have additional CO2e savings globally.

Regional GHG Reduction Potential

The greenhouse gas reduction potential is 3.4 MMT CO2e assuming the Chicago Energy Conservation Code is implemented at the same level across the six county region.

Municipal GHG Reduction Potential

Under the Chicago Housing Authority's Plan for Transformation, the City will own and operate 25,000 housing units by 2010. Under this plan, all units will either be newly constructed or substantially renovated and therefore should meet the current energy code requirements. There are no additional greenhouse gas emissions reductions that are assumed.

Economic Profile

The typical cost of retrofits for multi-family units is $2,500 to $5,000 per unit and $5,000 retrofits of single family units. Multi-family units are less costly per unit because the costs to address whole building systems—insulation and heating—are spread across a larger number of units and because they have a smaller square footage. Because the sole purpose of properties being brought to code is so they can be sold, the cost of upgrades and repairs can be rolled into the asking price for the home. However, many owners lack the capital, information and incentives to take advantage of this cost effective investment. As proposed, this program would require investment at the point of sale. For properties in disrepair, there may be a level of investment needed for structural repairs, e.g., roof replacement, before the energy work can be conducted. Significant repairs, in addition to retrofitting for compliance, will increase the investment per unit. Significant repair costs could potentially make it more difficult for low and moderate income families to sell or purchase property, unless energy subsidies are provided as part of the sale.

Qualitative Results

Program Elements

In order to make the City of Chicago's residential Energy Conservation Code more stringent, the City could consider the following:

1) **100% enforcement of existing code in new construction:** Ensure the implementation of the Chicago Energy Conservation Code (energy code) with 100% enforcement. A review of Chicago building code permits shows that, on average, there are 6,500 residential units built each year. Careful inspection of each unit during and after construction and before occupancy is important to determine energy code compliance. This requires focusing significant resources on inspection. It is currently unknown whether there are unrealized energy savings from insufficient levels of inspection or enforcement of the Chicago Energy Conservation Code; rather, for illustrative purposes, the impact or loss in potential savings if a certain percentage of these new units each year do not meet code, has been outlined in Figure 2. Even if just 10% of all new units do not meet code, there is significant energy savings lost.

Figure 2: Noncompliance for New Buildings

6500 new units/year, % not in compliance (scenario)	# Units not in compliance (scenario)	# Units not in compliance (2008-2020)	Greenhouse Gas Reductions lost (2008-2020) MMTCO2e
10%	650	8,450	0.02
20%	1300	16,900	0.05
30%	1950	25,350	0.07
40%	2600	33,800	0.09
50%	3250	42,250	0.11
This table is intended to illustrate the urgency of code enforcement from site plan review through construction and occupancy. Noncompliance, which is unknown, is not calculated in the quantitative section.			

2) **Enforce energy code compliance for all residential properties upon sale:** Regulate code compliance at the sale of every residential unit with a certification of energy code compliance required for every residential property sale. The GHG reduction potential in Quantitative Results is based on this strategy.

   The Chicago Energy Conservation Code regulates new residential construction and substantial rehabilitation of existing housing stock. This means that there is a large percentage of the housing stock that is not under the jurisdiction of the current energy code. Requiring compliance when ownership changes will substantially increase the energy efficiency of residential buildings in Chicago, thereby allowing more Chicagoans to benefit from energy savings and reducing the City's greenhouse gas emissions. Like other point-of-sale requirements, the costs associated with compliance can be rolled into the purchase price of the property or subsidized as part of first time home buyer programs or other programs intended to benefit low-income populations that might otherwise have a hard time meeting the requirements.

3) **Inform Chicago's residents about energy cost and energy use:** Require an Energy Efficiency Disclosure Statement from seller to buyer that outlines the efficiency ratings of systems and appliances within the property.

   The City of Chicago's Department of Consumer Services currently requires a "Heating Cost Disclosure" at the request of a residential buyer or renter. It focuses strictly on the heating energy costs over the past 12 months, and does not provide tools and information about how the home uses energy and where efficiency improvements could be made. An Energy Efficiency Disclosure Statement could provide this information in a statement required of the seller when the property is sold, much like other real estate disclosures. In addition to energy costs associated with each property, it could also outline the efficiency ratings of systems and appliances. The statement could also describe insulation R values when known, infiltration levels and barriers, e.g. weather-stripping and sealing, details on windows and doors, and the heating and cooling systems. The City of Chicago could pattern its statement after HUD's "home energy rating report," with requirements outlined in its 1993 Single Family Energy Efficient Mortgage Pilot Program[9] in a simple checklist form. The City could also opt for creating its own energy labeling system for disclosure at sale.

4) **Model code after other progressive codes:** The City of Chicago could consider updating its code to one that exceeds IECC standards, encourages and achieves performance, is flexible with emerging technologies, and provides training and technical support in all facets of code management and implementation. One such code is California's Title 24, which is considered the most stringent, best enforced and best performing in the United States.

   Title 24's standards exceed IECC efficiency standards and continually evolve to include new proven technologies. Performance studies have shown that nearly 90% of homes complied with code, compared to other states where less than half of all homes complied with local energy codes.

   Key to this rate of compliance is the fact that Title 24 allows for flexibility in a performance-based code that uses a menu approach which gives builders more choice than a prescriptive code. According to a paper by Prindle et al:

   "Most [California] builders use approved simulation software to find the most cost-effective set of efficiency features that meet the performance target. This has helped create a supportive industry of building energy consultants and home energy raters, who often give builders additional energy design advice, helping to further improve efficiency and field performance."[10]

All of the program elements described will require training and technical assistance for builders, contractors, code officials, and realtors. An updated energy code that is enforced for new and existing residential units gives Chicagoans the opportunity to take better control of managing their energy behavior and costs.

Benefits and Burdens

The most significant benefit of this mitigation strategy is lowered household energy costs. Additionally, there are economic benefits to the local economy associated with on-going investment in the housing stock, including job creation among the building trades.

An aggressive enforcement plan will necessitate hiring additional plan reviewers, permit processors and code inspectors. A strong training program focusing on inspectors issuing "Certificates of Occupancy" should also be implemented. Another major challenge will be initial resistance from realtors who may perceive the at-sale standards as a barrier to completing real estate transactions. Additionally, there may be concern among affordable housing advocates that this requirement causes more difficulty for low-income families to purchase property, further promoting gentrification in some neighborhoods. This last burden may be addressed through energy efficiency funding dedicated to low income programs.

Current Initiatives and Models

Currently, renovation is commonly performed at property turn-over, particularly to correct building code violations. Some California cities regulate energy and conservation improvements at sale. For example, the City of Berkeley requires owners to retrofit with insulation and water conservation devices, while outsourcing program compliance to a qualified local nonprofit agency. The City of Davis requires insulation and safety precautions like smoke alarms and exterior door deadbolts, and sellers must provide code inspection reports to buyers.[11] An energy performance standard is easier to comply with than programs that require specific energy conservation measures as found in California.[12]

Implementation Mechanisms

This program—energy code enforcement at point of sale—could be implemented by ordinance of the Chicago City Council. However, in order to alleviate the concerns of realtors, home owners, and affordable housing advocates, the program should include a funding source to assure that resources are available when they are needed. Additionally, there may be a need to exclude certain types of transactions and housing types to avoid delaying ownership transfer in an emergency. Conditions that are addressed through the City's Troubled Building Initiative related to criminal activity, no-heat situations, water or extreme structural damage, are examples of emergency situations.

Feasibility

Financial

Assuming that funds can be identified to assist low to moderate income home owners, this program is financially feasible. Property owners often invest in buildings prior to sale in order to increase the sale price, so this mitigation property harnesses an existing trend. This program would ensure that investment is targeted to energy saving improvements in addition to cosmetic improvements that are typically made. Any higher purchase price that results from this provision should be mitigated by reduced energy costs.

Technical

The building technologies currently exist to significantly reduce energy consumption in residential buildings.

Political

Possible opposition from realtors and the affordable housing community should be addressed to identify an implementation plan that is acceptable to these stakeholders.

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Mitigation Strategy #13
Green Building for All New Construction

Strategy Summary	Rating	Value
CO2e Savings Against BAU	+++	1.17 MMT CO2e
Scale of deployment	+++	All new construction: 4,000 commercial and 65,000 residential buildings
Timing	Now	Beginning in 2010
Regional Impact	+++	3.5 MMT CO2e
Financial Savings in relation to Cost	+++	Savings to exceed costs over the life of the building
Additional Benefits in relation to Burdens	+++	Lower pollution, increased health and other benefits
Feasibility assessment	++	There is the political will to make this happen; scale is high as are some initial costs. And there is a learning curve among some people in the building industry.

Overview

The City of Chicago could require that all new residential and commercial construction be built to green building standards. If a comprehensive green building policy for new construction began in 2010, a GHG reduction of 1.17 MMT CO2e in 2020 would result.

The U.S. Green Building Council (USGBC) defines green building 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."[1]

Green building is further described as "building responsibly," which requires a builder to address numerous design and construction issues. Below is a list of directives[2] for building green:

- Maximize energy efficiency of the finished structure;
- Minimize the depletion of natural resources, including timber and water;
- Decrease the amount of construction waste going to landfills ;
- Control erosion and minimize impact on natural areas;
- Increase energy efficiency and conserve water in construction and operations;
- Design and install landscape features, such as trees and shrubs, that minimize demand for water and synthetic chemicals and reduce the heat island effect;
- Reduce maintenance costs using innovative and durable materials;
- Improve indoor air quality;
- Control moisture and provides proper ventilation;
- Use more environmentally friendly materials;
- Ensure smart site planning and land use.

Quantitative Results

GHG Reduction Potential: 1.17MMT CO2e in 2020

Energy consumption and emissions can realistically be reduced by 50% over existing consumption levels in newly constructed residential and commercial buildings built to green building standards. Assuming that all newly constructed structures are built to the highest green standards, there will be a reduction potential of 0.35 MMT CO2e from residential green buildings and 0.82 MMT CO2e from commercial green buildings, resulting in 1.17 MMT CO2e total.

Scale

According to an analysis of permit data and census data, there will be 6,500 newly constructed homes[3] and 400 newly constructed commercial buildings[4] annually between 2010 and 2020. This strategy assumes that 100% of all newly constructed residential and commercial buildings will be built to LEED or equivalent standards.

Timeline

From 2010 to 2020, all new construction—4,000 commercial buildings and 65,000 housing units—will be built using established green building standards.

Per-unit Reduction Potential

The average emission per commercial building in 2000 was 410 metric tons of CO2e. The average emission per residential building in 2000 was 10.7 metric tons of CO2e. If new green buildings can reduce energy use by half, the annual emissions savings will be 205 metric tons of CO2e per commercial building and 5.35 metric tons CO2e per residential building.

Activity Savings

The fuel savings associated with this mitigation strategy are 1240 gigawatt-hours of electricity and 77 million therms of natural gas.

Life cycle GHG Impacts

The Pew Center for Climate Change states that there is insufficient research to quantify and appropriately account for the life cycle greenhouse gas impacts of new green buildings.[5] USGBC has also identified the need for life cycle costing analysis. The analysis needs to consider a number of site specific issues, including whether a new building is replacing a demolished building where materials are re-used. A simplified analysis would suggest that green buildings reduce the consumption of fossil fuels during the life cycle of the building and, therefore, are likely to result in net CO2e savings globally.

Regional GHG Reduction Potential

The estimated regional greenhouse gas emissions reductions are 3.5 MMT CO2e. This strategy can be implemented in Chicago as well as the region. Building construction is typically regulated on a local level; municipalities could share best practices for encouraging green building and CO2e reductions.

Municipal GHG Reduction Potential

The City of Chicago can make significant strides in reducing GHGs by building all new City-owned buildings to the highest green standard. The potential reduction, assuming that all new City buildings are built to the highest green energy efficiency standard, is 0.111 MMT CO2e.

Economic Profile

The financial costs and savings associated with green building have been well studied. The comprehensive report entitled, "The Costs and Financial Benefits of Green Buildings"[6] confirms that upfront costs to support green design are, on average, 2% higher than for typical buildings but result in life cycle savings of 20% of total construction costs. Overall savings are more than ten times the initial investment.

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 new construction to be "green" under the prescribed requirements of the Chicago Green Homes Program, with measurable energy efficiency performance targets added. This would increase energy savings and water savings.

For residential buildings, the City of Chicago already has established green guidelines to draw from. In April 2007, the City of Chicago introduced the Chicago Green Homes Program, a voluntary program for single-family and multi-family homes under 80 feet, for both new construction and renovation projects. Applicants to the program can earn Chicago Green Home (CGH) certification on a points rating scale at 1, 2 or 3 (highest) star rating.[7] There are seven point categories: sustainable sites, energy efficiency, materials, health and safety, resource conservation, homeowner education, and innovation. The guidelines should be refreshed periodically to continue to award performance that is well above business as usual. Guidelines should also be harmonized with other green building systems such as the U.S. Green Building Council's Leadership in Energy and Environmental Design (LEED) Green Building Rating System™.

Utilizing a categorical point system and awarding CGH-certification on a case-by-case basis makes broad participation possible, because it recognizes the many different ways a building can be "green." What is "green" for a single family home on the southeast side of Chicago in a new development may be very different than what "green" means for an infill two-flat on the near-west side. According to GreenBuildingSolutions.org,

> *"although there is no magic formula, success comes in the form [of] leaving a lighter footprint on the environment through conservation of resources, while at the same time balancing energy-efficient, cost-effective, low-maintenance products for our construction needs…[it] involves finding the delicate balance between homebuilding and the sustainable environment."*[8]

Energy efficiency is generally adhered to as the cornerstone of green building practices. The USGBC reports that 38% of CO2e in the United States comes from residential and commercial buildings:

> *"most of these emissions come from the combustion of fossil fuels to provide heating, cooling and lighting, and to power appliances and electrical equipment. By transforming the built environment to be more energy-efficient and climate-friendly, the building sector can play a major role in reducing the threat of climate change."*[9]

The CGH certification process is based on a point system—green certification for the three tiers requires 200 to 350 points—in seven different aforementioned categories. The largest point category, at 552 possible points, is Energy Efficiency (EE), and at least 90 of the overall points must come from EE. The 1-star, 2-star and 3-star certifications do not directly correspond with energy savings potential and GHG reduction potential. However, this can be ascertained if the buildings are awarded points in EE categories also addressed by the ENERGY STAR Index. The ENERGY STAR Index, much like the International Energy

Conservation Code (IECC) from 2004, applies energy savings to specific EE practices—savings which can be used to determine the corresponding GHG reduction potential. The City of Chicago can further integrate the ENERGY STAR Index, the IECC or a similar standard into the CGH point system so that energy savings and GHG reduction potential can be easily calculated. For example, a 1-star green building might represent a 10% energy savings while a 2-star green building represents a 25% energy savings.

After a review of building permit data and population projections,[10] it was estimated that approximately 6,500 new residential units and 400 new commercial[11] units will be built each year in Chicago between 2010 and 2020. In order to maximize the energy savings of these buildings, the City could mandate green building standards for new construction 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.

Mandatory Chicago Green Commercial Building Program

The City of Chicago could develop and institute a green building program that requires all new commercial construction to be "green" based on a rated system—LEED or similar standards. This, too, would increase energy savings and water savings.

The City of Chicago could consider using standards for commercial buildings established by the USGBC, "a non-profit organization dedicated to sustainable building design and construction."[12] USGBC developed the Leadership in Energy and Environmental Design (LEED) Green Building Rating System™ for commercial green building, and recently developed a LEED Homes program along the same scope for the residential sector. LEED has a rating system and criteria for the following five areas: sustainable site development, water savings, energy efficiency, materials selection, and indoor environmental quality.[13]

Promote training and education to building industry and general public

As with any newly-regulated mandatory program, the City should focus on training program participants: City staff, builders, developers, sub-contractors, and trade unions. Please refer to Mitigation Strategy #11 for more on training and education.

Benefits and Burdens

In addition to decreased energy consumption, greenhouse gas emissions and operating costs, other benefits from building green include increased occupant health, comfort, and productivity. Additionally, building green lowers pollution and landfill waste. Recent research has shown that buildings with good overall environmental quality can reduce the rate of respiratory disease, allergy, asthma and sick building symptoms while enhancing worker performance. Decreased absenteeism and increased productivity rates have potential financial benefits of improving indoor environments that exceed costs by factors of 8 and 14 respectively.[14] Additionally, a green-rating is added value for a building's sale price, especially if regulations are adopted that require certain building performance levels at the point of sale.

Mandating the Chicago Green Homes Program and a green commercial standard will require additional plan reviewers, permit processors and inspectors to track building design and implementation. Another challenge is facilitating buy-in from builders. Although the National Home Builders Association recently established its own green building guidelines, there are still many builders lacking familiarity with green building techniques.[15] This challenge can be met with training and education.

Current Initiatives and Models

This strategy would draw on a number of current initiatives in Chicago, including the Chicago Green Homes Program launched in April 2007 by City of Chicago Department of Construction and Permits (DCAP). Another DCAP initiative that could serve as a platform for this strategy is the Green Permit Program, "an expedited permit process for projects that incorporate innovative green building strategies."[16] Eligible projects can receive permits in less than 30 days (less than 15 days in some cases) and have consultant code review fees waived. 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.[17] Finally, as of July 2007, Chicago is already home to at least 24 USGBC LEED certified buildings.[18]

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[19] to Novato, California[20] —are instituting mandatory green building measures. At a minimum, Chicago could consider a requirement for all planned developments.

Implementation Mechanisms

The Chicago Green Homes Program and Chicago's green commercial building initiatives could be changed from a voluntary to a mandatory program. Measurable energy savings performance targets could be integrated into the point structure to ensure that energy savings and GHG reduction potential are measured in a standard way. A commercial green building program mirroring the CGHP could also be developed. In order to ensure that this strategy meets its GHG reduction goals, an ongoing measurement and evaluation effort should be implemented as part of this program.

Feasibility

Financial

Ongoing costs associated with mandatory green building include: cost of additional staff, ongoing training, and program evaluation. One-time costs include intensive training, education and marketing at the outset of the mandatory program. The capital costs to building developers may need financing, but will be more than returned in lowered operation costs over the lifetime of the building.

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 handle the technical aspects of ramping up its new voluntary program to include all new construction in a mandatory program.

Political

There is existing political support for green buildings, as evidenced by the City's investment in the Center for Green Technology and other green buildings. A mandatory green building program would necessitate much more political support as it would affect all building trades, developers, architects, mortgage brokers, prospective home buyers, management companies and building owners.

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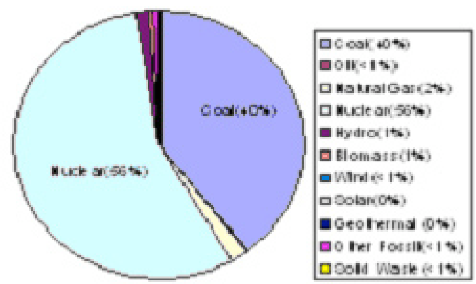
Mitigation Strategy #14
Build Renewable Electricity Generation

Strategy Summary	Rating	Value
CO2e Savings Against BAU	+++	3 MMTCO2e
Scale of Deployment	+++	Supply equal to 20% of electricity emissions
Timing	+	Start process immediately for long-term impact
Regional Impact	+++	9.24 MMTCO2e
Financial Savings in Relation to Cost	+	Renewable generation is not always competitive with traditional electricity generation, but as natural gas prices increase and carbon costing develops, they may become more cost-effective.
Additional Benefits in Relation to Burdens	+++	Meet standards and comply with regulations
Feasibility Assessment	++	Expensive; financial assistance and incentives needed

Figure 1 Electricity Generation by Fuel Type



Source: http://www.epa.gov/cleanenergy/egrid/index.htm

Overview

Photovoltaic (PV) technology and wind power are two proven alternative clean energy sources for utility-scale production of electricity. This strategy analyzes renewable electricity generation using these sources. Using renewable generation sources instead of fossil fuel plants will result in greenhouse gas (GHG) savings and many other benefits that include reducing air pollutants that damage public health, increasing opportunities for innovation, and new job creation.

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

Electricity supplied to the Chicago area via the ComEd distribution system or "grid" is supplied by several hundred plants across the Midwest. In 2000, the region that served Chicago included 380 plants across Wisconsin, Missouri, Michigan, Illinois, Indiana, and Iowa. This region was changed by the Federal Energy Regulatory Commission in 2004 to include some plants in eastern states.[1] For purposes of this analysis the generation plants in the year 2000 were used to estimate GHG emissions. In 2000, the 380 generation plants in the region supplying Chicago provided a net generation of 415 millions megawatt-hours (MWH). These plants supplied 56 percent of generation with nuclear power, 40 percent with coal, and two percent with natural gas.[2] Only two percent of the generation is supplied by renewable sources, not including nuclear.[3]

Most of the electricity in the area is generated by nuclear energy—a carbon-free, non-greenhouse generation source. However, the problems inherent in nuclear power, most notably high cost and the lack of environmentally benign options for the disposal and storage of nuclear waste, make expanding the role of nuclear generation problematic. Much of the Chicago-area nuclear-power infrastructure is also aging and will either require substantial re-investment to continue operations, or be retired. Coal-fired power plants provide nearly all the additional generating capacity and are responsible for the majority of the greenhouse gas emissions from the electricity sector. Natural gas plants provide a smaller amount of peaking capacity contributing a smaller proportion of greenhouse gas emissions.

Quantitative Results

GHG Reduction Potential: 3 MMT CO2e in 2020

The emissions reduction associated with this strategy of replacing supply associated with 20 percent of the emissions from electricity, or the four coal-fired electricity plants, is 3 MMT CO2e.

Scale

Emissions from electricity consumption are estimated by multiplying the total consumption for the city of Chicago by the emissions factor for the entire power pool that provides electricity to the ComEd service territory. For Chicago to claim 3 MMT of CO2e reductions from electricity generation, a 20 percent reduction in emissions from the entire power pool is required. Each plant has a different rate of emissions, so the number of plants that would need to be replaced depends on which plants were chosen to be replaced with renewable generation. One example is to look at the four plants with the largest annual emissions that are equal to the 20% emissions reduction goal. These four large coal-fired plants emit about 51 MMT CO2e and generate 41 million MWH representing about 10 percent of electricity generation in the region.[4]

Timeline

The deployment timeline for this strategy is long term. It can take several years to obtain permits and raise capital to build new generation. To achieve the emissions savings outlined in this strategy by 2020, a renewable generation program could begin immediately.

Per-unit GHG Reduction Potential

The per unit reduction potential based on the average emission rate for the entire region is 0.61 metric tons of CO2e per MWH of generation. The per unit reduction potential for the four coal fired plants described above is 1.1 metric tons of CO2e per MWH of generation.

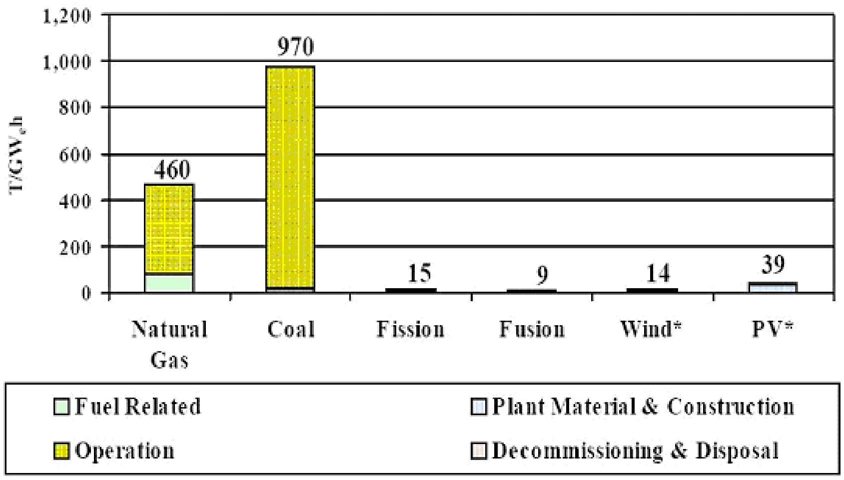
Activity Savings

In order to reduce 3 MMT CO2e, 82 million MWH of generation would have to be replaced assuming the average emission rates for the electricity pool. The example of replacing the four largest coal-fired plants would require 46 million MWH of coal-fired generation to be replaced.

Lifecycle GHG Impacts

Lifecycle GHG impact from coal and gas-fired electricity generation is significantly higher than from renewable sources. Figure 2 shows the emissions associated with several different types of electricity generation in tones of CO2e per gigawatt-hour (GWH) of electricity generated. The emissions from operation (shown in yellow) are much higher than the plant materials, construction or decommissioning of each plant type.[5]

Figure 2: Emissions Comparisons in tones of CO2e per Gigawatt-hour



Source: P.J. Meier et al. “Life Cycle Energy Requirements and Greenhouse Gas Emissions.” University of Wisconsin. April 2002.

Regional GHG Reduction Potential

The regional emissions reduction associated with this strategy of replacing supply associated with 20 percent of the emissions from electricity, or the four coal-fired electricity plants, is 9.24 MMT CO2e. Because this strategy is implemented on the supply side, the emissions reduction is proportionate to the total electricity consumption. Regional electricity consumption is three times greater than electricity consumption in the city of Chicago.

Municipal GHG Reduction Potential

The GHG reductions related to municipal operation were calculated based on the City’s reported 2005 electricity consumption of 1,086,700 MWH, or five percent of the total electricity consumed within Chicago boundaries.[6] The municipal GHG reduction potential is 0.15 MMT CO2e.

Economic Profile

Figure 3 compares the levelized costs of new renewable generation with new natural gas generation. These costs can be interpreted as a constant level of revenue necessary each year to recover all the expenses over the life of a power plant. This data is from an analysis by the State of California. However, it should be noted that construction and operating costs continue to increase due to increases in the price of steel and natural gas.

Figure 3: Cost of Generation by Technology

Technology	Fuel	Operative Mode	Gross Capacity (MW)	Direct Cost Levelized (cents/kWh)
Combined Cycle	Natural Gas	Baseload	500	4.58
Simple Cycle	Natural Gas	Peaking	100	14.06
Wind	None	Variable	100	5.42
Hydropower	Water	Load-Following	100	6.58
PV	None	Load-Following	50	48.4

Source: California Electricity Analysis Office, “Comparative Cost Of California Central Station, Electricity Generation Technologies” Energy Policy Report Proceeding, Docket 02-IEP-01, Publication No. 100-03-001SD, February 2003

Qualitative Results

Program Elements

Replacing 6,480 MW of coal generation with cleaner fuel technologies is feasible. Replacing electricity supply equivalent to 20 percent of emissions at the average emissions rate is more challenging, as it would require approximately twice the generation of a strategy targeted specifically at coal. This strategy proposes implementing a mix of renewable technologies. Part of the reason a single fuel source should not be substituted is technology-specific, e.g., PV technology only provides direct power during daylight hours. In addition, the problems inherent in relying on a single energy source are alleviated. The following alternative energy sources are options for northern Illinois:

1) **Photovoltaic (PV):** PV technology is being deployed on a utility-size scale in numerous locations world-wide and in the U.S. The plants consist of multiple interconnected PV arrays. The U.S. Department of Energy (DOE) notes that, while the up-front costs of PV systems are relatively higher than both traditional and other alternative energy production operations, they provide unique benefits. PV arrays can be brought into production much more quickly than conventional plants and, due to their quiet, non-polluting operations, do not face siting objections as other plants do.

2) **Wind:** Illinois has substantial wind energy resources, with four wind farms in operation (production equals 305 MW) and 80 MW under construction.[7] Wind resource data from the DOE shows 9,000 MW of potential wind capacity.[8] Wind is a currently underutilized resource with capacity to expand.

3) **"Offshore" Wind Turbines:** Wind turbines are another option for wind energy. Offshore wind can be up to twice as powerful as land-based wind, and Lake Michigan's proximity to Chicago's population negates the problems of long distance transmission. Offshore wind projects have been proposed for Lake Michigan. However, the initial response has mirrored the reaction to the proposed Cape Wind projects in Massachusetts – public opinion supports on-shore rather than off-shore windmill siting.[9] Siting for both onshore and offshore wind turbines is contentious, as there are concerns about obstructed views, noise levels, and potential harm to birds (this last issue has largely been addressed with design changes). These concerns are often accompanied by a "Not In My Back Yard" reaction, as seen in the siting battle over windmills in Nantucket Sound, which needs to be addressed.

4) **Biomass**: Energy can be generated from burning carbon-based materials. Switchgrass is a perennial plant that can be burned to produce energy. Using plant materials has the additional benefit of providing a new crop for farmers to produce, with the potential for rural Illinois economic development. Biomass feedstock can also be mixed with coal in power plants, in a process called co-firing.[10]

5) **Wave or Tidal Power:** Large bodies of water contain great potential for power generation. Tidal power uses the gravitational pull of currents to produce energy and represents a more predictable source of energy than wind or solar energy. Wave power incorporates the influence of surface winds on water. No utility-scale projects are currently in operation in the U.S., although many projects are in the works, including a project in New York City's East River. The primary drawback to tidal power is financial; the costs of producing wave energy are substantial. There is intensive research and development activity underway in this area. Consequently, it would be most practical to delay pursing this technology until the industry matures.

6) **Biogas:** Biogas consists of methane (CH4) harvested from livestock or landfill sites. Sometimes

cited as a "clean" fuel source, the release of methane into the atmosphere is problematic. Methane is a GHG and its production should be minimized. However, when methane is present, utilizing these emissions is a way to reduce their impact. An example of the quandary is New Horizons Dairy in Elmwood, Illinois. Their 270-kilowatt (KW) methane conversion system was financed through a $380,000 grant from the Illinois Department of Commerce and Community Affairs and is regarded as a successful prototype. However, there are also other pollution concerns associated with factory farming.

Benefits and Burdens

Changing the fuel sources for electricity generation has the potential to reduce criteria air pollutants significantly, improve public health and reduce the air and water quality impacts of power generation on other species. The decommissioning of existing plants and manufacturing of new generation technology has environmental burdens such as waste generation and material use. But, as is shown in Figure 2, the benefits of clean generation outweigh those burdens from a GHG perspective and may do so by other measures as well.

Building new generation has the opportunity to create jobs in the Midwest and, if supplies are sourced locally, to support the growth in green energy technology manufacturing. To relieve economic distribution burdens for energy consumers, any renewable program should seek to offset the increased costs associated with clean generation for low income consumers through efficiency programs or other means.

Current Initiatives and Models

There are operational models for the first four alternative energy sources described under Program Elements. The Sacramento Municipal Utility District (SMUD) is currently operating a two MW PV power plant[11] in California. Wind farms currently operating in Illinois include Mendota Hills (50.4 MW) and Crescent Ridge (54.45 MW), as well as a number of other smaller projects. Alliant Energy-Interstate Power and Light[12] in Iowa completed a long-term test burn of biomass in 2006, where 19,600 MW of electricity was produced. Verdant Power's fleet of underwater power turbines in New York's East River went on-line in April 2007. In February 2007, Ocean Power Technologies (OPT) and PNGC Power signed an agreement to work cooperatively on OPT's development of the Reedsport OPT Wave Park. The first commercial wave farm is the Aguçadora Wave Park near Póvoa de Varzim, established in 2006; and numerous other projects are under construction.

Implementation Mechanisms

The City can encourage the replacement of coal-fired plants, particularly plants responsible for the greatest emissions, by providing or promoting tax incentives to alternative energy generation plants interested in locating in the Chicago area. Further, the City of Chicago can contract with alternative electricity generators to supply a portion of the City's power. Tax credits can be made available to businesses and residents who purchase electricity from a low-emitting alternative source. Finally, the City can support the Renewable Portfolio legislation that has been introduced in Congress.

The Illinois legislature recently passed a Renewable Portfolio Standard (RPS) that requires power utilities to obtain 25 percent of their power from wind, solar or biomass sources by June 2025.[13] Electricity generators are also under significant pressure to reduce coal-fired generation in order to comply with the Clean Air Act. The enforcement of the Criteria Pollutants standards will also motivate efforts to replace coal-fired generation with renewable sources.

Voluntary household purchase of "green tags" can be an important implementation strategy for promoting renewable electricity generation. Green tags, also called renewable energy certificates, are the property rights to the environmental benefits, including GHG reductions, from generating electricity from renewable energy sources. Currently in Chicago, only commercial and industrial customers can purchase renewable energy through Alternative Retail Electricity Suppliers (ARES). ComEd could provide a renewable purchase program for residential customers, providing additional benefits to locally produced renewable power. Although the price of renewable power may be higher, household customers have shown willingness to pay for the environmental benefits.

Feasibility

Financial

A growing public mandate for renewable energy in Illinois could help finance the transition to cleaner fuels. A study completed for the Illinois Clean Energy Community Foundation reports widespread public support for increasing the amount of electricity coming from renewable sources. Notably, 67 percent of the respondents stated they would pay more per month for electricity that was generated from wind or solar power.[14] Local suppliers of green power, including PEPCO, have reported that the demand for electricity generated from renewables exceeds the current supply.

Financial incentives that promote renewables are necessary to promote generation. Pending federal legislation to require a national-level Renewable Portfolio Standard could significantly improve the economic feasibility of this strategy.[15]

Technical

All of the technologies suggested exist today, but some are more tested than others. For example, wave or tidal power is relatively new. A portfolio of renewable generation must be developed that supports electricity reliability as well.

Political

Changing the fuel sources utilities use has the potential to reduce GHG emissions significantly, due to the sheer volume of generation involved. However, the process of promoting sufficient change in power production to meet this goal is difficult and will likely require federal and/or state mandates. Municipalities can have a significant impact on federal policy. The City could work with other municipalities to support the Renewable Portfolio Standards that are currently being considered by Congress.

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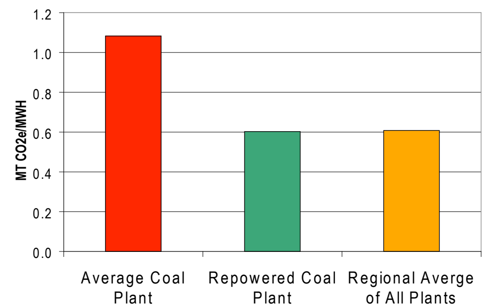
Mitigation Strategy #15
Repower Existing Power Plants

Strategy Summary	Rating	Value
CO2e Savings Against BAU	++	2.5 MMT CO2e
Scale of deployment	+	21 coal-fired power plants located in Illinois
Timing	+	Long lead time
Regional Impact	+	Would require repowering other plants, proportionate to population
Financial Savings in relation to Cost	+	High capital costs and natural gas costs
Additional Benefits in relation to Burdens	+++	Reduced emissions of other pollutants
Feasibility assessment	+	Technically feasible, financial and political feasibility much lower

Figure 1 Repowering Coal Plants Will Lower Regional Emisisons



Overview

Repowering existing power plants by moving from coal-powered to natural gas-powered generation can significantly reduce CO2e emissions from electricity generation. Coal has a high carbon content and therefore, as a fuel source for electricity, it is a large CO2e emitter. Natural gas-fueled power plants also emit CO2e, but at a lower rate per kilowatt-hour of electricity. Repowering is a strategy aimed at replacing existing consumption of electricity by rebuilding existing coal fired generation that serves current needs, rather than a mitigation strategy aimed at lowering emissions from new power generation that would serve future needs, as discussed in "*Mitigation Strategy #14: Build Renewable Electricity Generation*" and "*Mitigation Strategy #16: Sequester Carbon in New Plants*". Repowering a coal plant can range from simple to complex. A simple transformation may only require adding new equipment to an existing plant, whereas a more complex model might require installing more new, higher efficiency gas generators[1], a substantial renovation that retools the whole plant and basically only uses the existing building shell and site. Costs, challenges and reduction potential correspond to the range of repowering with simple renovations presenting modest costs, challenges, and reductions and complex renovations presenting significant costs, challenges and reductions.

This strategy focuses on the impact of repowering the twenty-one coal fired power plants in the state of Illinois.

Quantitative Results

GHG Reduction Potential: 2.5 MMTCO2e

Repowering the twenty-one coal fired power plants physically located in the state of Illinois could reduce emissions associated with Chicago's consumption in the amount of 2.5 MMT CO2e. The model used in this analysis uses a consumption based methodology which takes into account all the plants that make up the regional electricity supply so Chicago's benefits are scaled to be proportionate to its regional share of electricity consumption (7.26%).

Scale

In the year 2000, the 21 coal fired plants located in Illinois generated 78,863 GWh of electricity or 27% of all the electricity generated in the MAIN electric region used in this analysis.[2]

Timeline

Repowering a coal fired power plant requires an extensive planning timeline. Once all permits and regulatory processes are completed, construction could easily take between one and two years, during which time the plant is unavailable for power production.[3] A recent example of the length of a project like this is Dominion's proposal to repower a 240 mw power station from coal-fired to natural gas thus delivering more power to serve Virginia's growing needs and cutting air emissions. The station is the oldest coal-fired plant in Virginia but is not expected to be completed until 2012.[4]

Per-unit Reduction Potential

The coal fired power plants analyzed here vary greatly in size and CO2 output. Figure 2 provides an average of the 21 coal-fired plants in the region which are located in the state of Illinois.

Figure 2: Emissions Associated with the 21 Coal-Fired Plants Located in Illinois

Name	Capacity (MW)	2000 Net Generation (MWH)	2000 CO2 Emissions (metric tons)	2000 CO2 Emissions Rate (metric tons/ MWH)	Potential CO2 Emissions with Repowering (metric tons)	Potential Reductions (metric tons)
Average	856	3,755,362	3,920,016	1.044	2,263,823	**1,656,193**
Median	780	2,786,241	2,898,965	1.040	1,679,614	**1,219,351**
Min	230	1,058,409	1,004,921	0.949	638,035	**366,886**
Max	1786	10,228,675	9,978,201	0.976	6,166,093	**3,812,108**
Total	17,978	78,862,610	82,320,336	1.057	47,540,292	**34,780,044**

Repowering assumes using technology similar to that in use at the large gas fired Elwood plant near Joliet which has an emissions rate of 0.603 metric tons per MWh, significantly cleaner than the average coal plant which is over 1.049 metric tons per MWh coal plant as shown in figure 2. The most efficient new construction of natural gas combined cycle turbine plants can run as efficiently as 0.389 metric tons per MWh[5] but this level is unlikely to be reached from any conventional repowering of an existing plant.

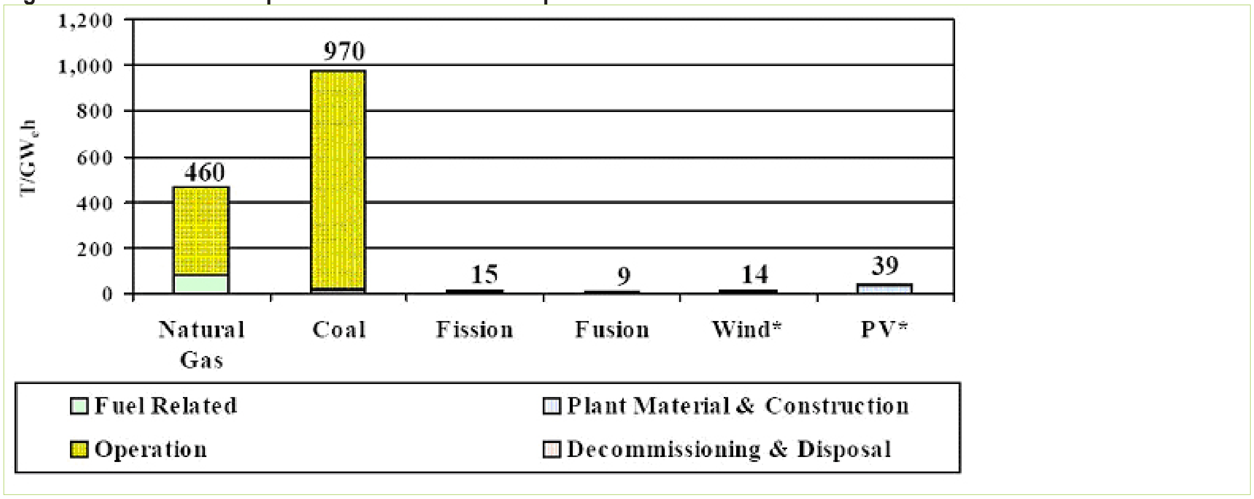
Activity Savings

Repowering the 21 plants located in Illinois would decrease coal consumption by 30 million short tons or 5% of US coal consumption while increasing natural gas usage by over 10,000 million therms or 4.2% of total United States gas use.

Lifecycle GHG impacts

Lifecycle GHG impact from traditional coal plants is higher than from natural gas-fired plants. Figure 3 shows the emissions associated with several different types of electricity generation in tons of CO2e per GWh of electricity generated. The emissions from operation (shown in yellow) are much higher than the plant materials, construction or decommissioning of each plant type.[6]

Figure 3: Emissions Comparisons in tones of CO2e per GWh



Regional GHG Reduction Potential

The regional impact would be proportionate to the energy consumption in the region or 7.5 MMTCO2e.

Municipal GHG Reduction Potential

Because this is a supply side strategy, there are no direct municipal operations savings other than the City's proportionate use of electricity.

Economic Profile

Assuming an installation cost of $666 per megawatt of capacity, repowering one typically sized plant comparable to an Illinois plant would cost approximately $977 million.[7] Each additional 800 MW plant would cost $532 million to repower. This estimate is conservative and costs could be significantly higher. Using even more advanced technologies to further lower emissions could be substantially more expensive.

Repowering coal fired plants to run on natural gas will create new costs. First, the power plant operators must recover the fixed costs of converting the plants. Unlike the construction of new plants, existing plants are already largely paid for; repowering is a new capital expenditure. Second, natural gas prices are currently higher than coal prices so the fuel costs of the repowered plants will be higher than before the repowering. Due to large fluctuations in the price of natural gas, an exact estimate of the difference is difficult to determine. Power prices in New England, where there are more natural gas fired plants than the Midwest, are approximately 50% higher.[8] At current prices, this is approximately two cents per kilowatt hour. At that level, Chicago homes and businesses would pay an additional $427 million per year for electricity, and the typical household, approximately $128 per year.

If a cap and trade, or similar mechanism, is imposed, the cost of coal fired generation will increase significantly and could potentially make plants that are repowered economically viable.

Qualitative Results

Program Elements

Emissions from coal-fired power plants are one of the most significant sources of air pollution. Repowering these plants to run on natural gas would be a key factor in improving emissions of priority air pollutants that goes beyond the value of CO2e reductions.

Benefits and Burdens

While repowering plants can provide significant environmental benefits, there are a number of challenges. First, an infusion of capital that has yet to be identified is needed to cover the implementation costs. Second, given current and projected future coal and natural gas prices, and absent a cap and trade or equivalent financing mechanism that prices fuels on CO2e, repowered coal plants will produce electricity that is significantly more expensive than what those same plants produce today. Third, the increased consumption of natural gas will further tighten natural gas supplies and provide an additional upward pressure on natural gas prices, impacting not just these plants, but the price of natural gas for home heating and for industrial processes.

Current Initiatives and Models

Utilities around the country have repowered coal fired power plants, typically on a case by case basis. There are no broad initiatives at the scale of repowering an entire region's plants. The typical reason to undertake a repowering initiative is to increase capacity at the plant because of local constraints. It should be noted that Midwest Generation ceased operations of their Collins gas and oil-fired generating station consisting of 2,698 MW since September 30, 2004 and decommissioned them by the fourth quarter of 2004. Midwest Generation cited the reason in part to higher long-term natural gas prices and the current generation overcapacity in the MAIN region.

Implementation Mechanisms

The State of Illinois could develop a plan to repower coal-fired plants located in the state particularly if a carbon cap and trade system was implemented. For the two plants located in Chicago, the City could use financial incentives, including tax breaks, to leverage negotiations with the owners, Edison Mission Energy. Both Fisk and Crawford generating stations are currently capable of using natural gas for full boiler operation, if desired. Permanent natural gas operation would require significant infrastructure changes. Because these plants do not sell power directly to end use customers, or even directly to ComEd, these incentives would likely need to be significant. Repowering could also be a component of discussions on other environmental issues in relation to these plants. The city could work with the state to plan for the repowering of the coal-fired plants located across the state.

Feasibility

Financial

At current natural gas and coal prices, and with uncertainty regarding how to finance the capital costs of repowering, the financial feasibility of repowering is low. If a cap and trade program was implemented, either at the federal or state level, it would greatly increase the feasibility of this strategy, as power plants that reduce emissions could potentially receive financial compensation, thereby partially alleviating the costs of repowering.

Technical

At a purely technical level, repowering is very feasible and could have significant impacts on carbon emissions.

Political

Issues of jurisdiction make repowering of coal plants outside the city limits, as a result of City actions, low. Rather, any such repowering needs to be part of a broader regional or national set of efforts. The repowering of coal plants located within Illinois is more feasible if the State can develop the right set of incentives for the owners of these plants.

Crawford & Fisk: Coal-Fired Electricity Generation in Chicago:

The Fisk and Crawford plants, the two coal-fired plants located in the city of Chicago are owned by Midwest Generation. In 2000, GHG emissions were 1.7 MMTCO2e from Fisk and 2.9 MMTCO2e from Crawford.[9] These two plants are also a source of other criteria pollutant emissions. These facilities are the two largest single sources of particulate-forming air pollution in Chicago, but were grandfathered into New Source Review rules exempting pre-regulation plants from pollution control requirements.

Repowering the two coal fired power plants physically located in Chicago—Fisk and Crawford—could reduce emissions in absolute numbers by 1.92 MMT CO2e. However, the model used in this analysis uses a consumption based methodology which takes into account all the plants that make up the regional electricity supply so Chicago's benefits are scaled to be proportionate to its regional share of electricity consumption (7.26%).Therefore Chicago's carbon reduction benefit from repowering Fisk and Crawford is only 0.14 MT CO2e.

Total emissions in 2000 from the plants are 4.53 MMT CO2e, and Chicago's proportionate share would be 0.33 MMT CO2e. However unlike the repowering scenario where the repowered plants would replace the generation in the regional power pool with new, cleaner generation, if Fisk and Crawford were to shut down completely it is unclear how the kilowatt hours they supply to the grid would be replaced. Fisk and Crawford also provide voltage support that help to maintain grid reliability to the intense concentration of electrical demand in the Chicago Loop. If they were shut down, alternative methods of providing that reliability service would need to be developed.

As part of an agreement with the state of Illinois, Midwest Generation has already agreed to a comprehensive long-range plan to cut emissions at each of the company's six plants in Illinois. As part of its implementation plan, the company plans to shut down the three smallest generating units in its fleet – two units at the Will County Station in Romeoville and one at its Waukegan Station—between the end of 2007 and the end of 2010.

The company also has committed that Fisk will either have additional pollution controls or be shut down by the end of 2015. The same agreement to shut down or install additional controls applies to the plant in Waukegan by the end of 2014 and to Crawford by the end of 2018.[10]

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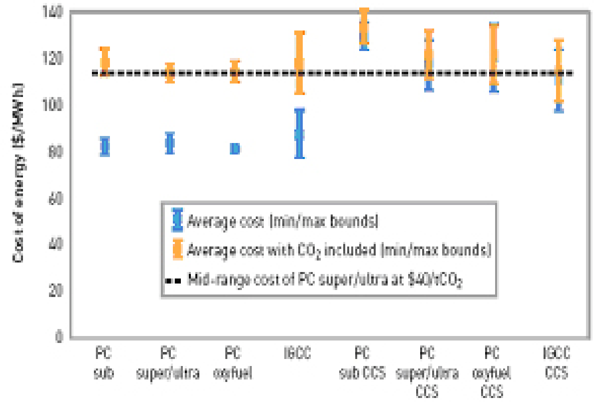
Mitigation Strategy #16
Sequester Carbon in New Plants

Strategy Summary	Scale	Value
CO2e Savings Against BAU	+++	2.17 MMT CO2e
Scale of deployment	+++	All new coal plants
Timing	+	Technology not mature
Regional Impact	+++	6.5 MMT CO2e
Financial Savings in relation to Cost	+	Likely to increase costs
Additional Benefits in relation to Burdens	++	Could be an opportunity to use Illinois' large coal reserves
Feasibility assessment	+	Large technological and financial barriers

Figure 1 Comparison of coal-fired generation



Source: <www.environmentaldefense.org/documents/6455_Midwest%20Power.pdf>, pg 13.

Overview

This mitigation strategy focuses on incorporating carbon sequestration capacity into all new coal power plants so that CO2e from power generation can be significantly reduced.

Coal plants are currently the largest emitters of CO2 in the electricity sector and, if new coal plants are built using current technologies, high emissions will continue over the life of those plants. Emerging carbon sequestration technology injects CO2 from a power plant into underground geological formations. Carbon sequestration is similar in concept to natural gas storage and presents a model for coal-powered electricity generation that could potentially have very low emissions. While coal plants with sequestration will never reach the zero direct GHG emissions of renewables and nuclear power, they have the potential to provide the lowest emitting use of fossil fuels. Illinois has significant coal reserves that hold more potential energy than the oil reserves of Saudi Arabia and Kuwait combined.[1] Using this coal for energy production could support U.S. energy independence.

As energy demand grows over time, new power plants will be built to serve that demand and to replace older plants that retire. While peak demand is likely to continue to be met with natural gas fired peaker plants, the options for baseload generation are renewables (addressed in other mitigation strategies), coal and nuclear. Because of the long life—30 to 50 years[2]—of baseload plants, making the right decisions about power plant construction will have significant impact on CO2e emissions for decades to come.

Sequestration of carbon from coal-fired power plants is very much a developing technology in its early research stages; it is not yet a commercially available technology. Important considerations as sequestration is being researched and tested include: cost, the amount of additional energy required for sequestration and the geological feasibility of sequestration. However, the high greenhouse gas (GHG) reduction potential of sequestration makes it a strategy worthy of further investigation.

Quantitative Results

GHG Reduction Potential: 2.17 MMT CO2e

Electricity consumption in Chicago is expected to increase by 4,780 gigawatt-hours by 2020 under a business as usual (BAU) scenario. If all new electricity was produced using the best proposed carbon sequestration technology—Integrated Gasification Combined Cycle (IGCC) with sequestration—2.17 MMT CO2e could be reduced.[3]

Figure 2 compares IGCC with sequestration to other technology options. Since the region has a large base of nuclear, i.e., zero-emitting plants, adding new fossil fuel power generation that does not use the latest technology with sequestration will result in additional emissions.

Figure 2: Electricity Production Technology Options

Technology Option	Emissions Rate (Metric Tons CO2e per MWh)	CO2e Emissions for 4.78 TWh Generation (MMT)	CO2e compared to 2020 BAU forecast (MMT)
2000 Emissions Rate (BAU scenario)	0. 60876	2.91	-
Pulverized Coal	0. 80000	3.83	0.92
Pulverized Coal with sequestration	0. 52000	2.49	(0.42)
IGCC	0. 86000	4.11	1.20
IGCC w/sequestration	0. 15600	0.75	(2.17)

Scale

4,780 gigawatt-hours of incremental new load by 2020 is roughly the equivalent of the generation of the two coal plants in Chicago. One of those plants is roughly the size of typical plants in the region, while the other is smaller. Thus it is assumed one to two new plants will be built by 2020 in order to serve Chicago's load growth.[4]

Timeline

At this time it is not clear whether carbon sequestration will have advanced enough by 2020 to be a technology that can be implemented at scale. However, the long lifespan of electricity generation facilities means that technology decisions made at the development phase continue to have impacts decades later.

IGCC is a new technology for using coal, with only four operational plants in the world. IGCC still requires more operational and construction experience to become a fully available technology. Despite the early stages of IGCC, many new plants have already been proposed.[5]

Currently, sequestering carbon from coal is only in use in one plant, and it is a plant that produces synthetic methane, not electricity.[6] Research into the feasibility and practicability of storing carbon underground is ongoing. The Midwest appears to have geology amenable to this technology.[7] One potential response to the developing nature of this technology is to develop power facilities that are designed to be compatible with sequestration when the technology matures, but this solution does not reduce GHGs in the near term.

Per-unit Reduction Potential

The potential is to reduce emissions from the current baseline of 0.60876 tons CO2e per MWh to 0.1560 tons CO2 per MWh.

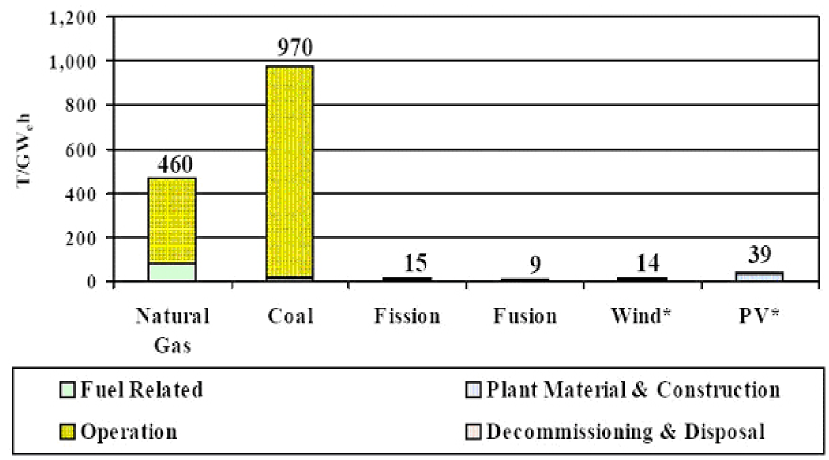
Activity Savings

Sequestering carbon will not change the amount of electricity consumed in Chicago. It will potentially increase total generation at power plants, as additional electricity will be needed to operate the sequestration equipment.[8]

Lifecycle GHG Impacts

Lifecycle GHG impacts are significantly higher from traditional coal and gas-fired electricity generation than from coal plants with sequestration. Figure 3 shows the emissions associated with several different types of electricity generation in tons CO2e per gigawatt-hour of electricity generated. The emissions from operation are much higher than from the plant materials, construction or decommissioning of each plant type.[9] Emissions from the fuel of a coal plant with sequestration are potentially 50 to 90% lower than the fuel from a conventional plant.

Figure 3: Emissions Comparisons (tons CO2e per Gigawatt-hour)



Regional GHG Reduction Potential

The regional GHG reduction potential is approximately 6.5 MMT CO2e. Because this strategy is implemented on the supply side, emissions reduction potential is proportionate to the total electricity consumption, which is three times greater in the region as compared to Chicago.

Municipal operation GHG Reduction Potential

If municipal operation electricity use were to grow at the same rate as the city as a whole, the GHG reduction potential for municipal operations would be 0.11 MMT CO2e in 2020.

Economic Profile

Adding sequestration to a coal plant increases the net price of electricity between $10 and $50 per megawatt-hour,[10] or 1 to 5 cents per kilowatt-hour—the typical unit of measurement for consumers. At the high end this represents close to doubling the current price of purchase electricity. If a carbon tax of $40 per ton were implemented, it could offset that price increase.[11] (For more on the carbon tax, see Mitigation Strategy #5.)

Qualitative Results

Program elements

Building new coal plants with sequestration will require a variety of approaches tailored to the specific regulatory framework in each Midwestern state, the motivations and drivers for each plant owner, and the regulations of the Independent System Operator for the plant's control area. Financing will be at the heart of any program element, as resources are needed for significant construction projects. Program elements will have to address the complex regulatory approval processes, which are likely to be quite lengthy for a new technology with significant costs. While the adoption of new sequestration technology is sure to produce buzz and excitement, opposition in the regulatory process could come from rate payer advocates who do not want the additional cost of plants to be absorbed in charges to customers and from skeptics of the technology.

Benefits and Burdens

Emissions from coal-fired power plants are one of the most significant sources of air pollution. Any new coal plant with sequestration is likely to have significantly lower emissions of other pollutants, like mercury, than older coal plants. Reducing air pollution has ancillary health benefits.[12] However, the environmental impacts resulting from coal extraction, transport and processing remain present in a plant equipped for sequestration.

Becoming a leader in sequestration could have economic development and job creation benefits for Illinois. An increase in the price of electricity due to the additional costs associated with sequestration would have negative impacts on households and businesses, especially low-income households which spend a larger proportion of their income on energy than the average household.

Implementation Mechanisms

The City could encourage the ongoing research and development of carbon sequestration technologies through advocacy at the state and federal levels. This could include both policy initiatives and the pursuit of research and development funds for Chicago area research institutions and universities. It is unlikely that new coal plants with sequestration will be built within the city limits so the City's promotion of this technology will be indirect.

The City could be an active participant in state, federal, and Independent System Operator proceedings that could have an impact on decisions made by plant operators to choose whether or not to invest in new coal fired power plants that sequester carbon. Where possible, the City could be involved in any plans for new procurement models for ComEd and for alternative electric suppliers by encouraging them to purchase electricity from plants that sequester carbon from coal rather than from coal plants that do not sequester carbon.

Current Initiatives and Models

No models have been identified for actual implementation. A number of initiatives are working on the various aspects of research and development of carbon sequestration. In this region, the Midwest Regional Carbon Sequestration Partnership is currently studying the technical aspects of sequestration, including the geology of the region. There are plans to conduct small scale research and pilot studies.[13]

Feasibility

Financial

The cost of building coal plants with sequestration will be enormous. Absent a carbon tax or similar mechanism that makes more conventional fossil fuel generation less economical, coal plants with sequestration are not likely to be financed at scale.

Technical

Whether or not sequestration at scale is feasible is largely unknown. Only ongoing research, development and more test operations can address this issue.

Political

The political challenges for sequestration largely result from the cost of the technology and the uncertain cost of carbon in the near and long-term. Implementing a carbon tax would make carbon more expensive and new low carbon technologies, such as sequestration, more desirable. The City of Chicago could support the creation of a carbon tax that will support low carbon practices and technologies.

The City of Chicago cannot require power plants outside of the city limits to use new and unproven technologies, and it is not likely that any new coal plants will ever be built within the city limits due to the lack of large spaces needed. But, the City of Chicago can work with utilities and generators in the Chicago region to encourage the adoption of carbon sequestration technology.

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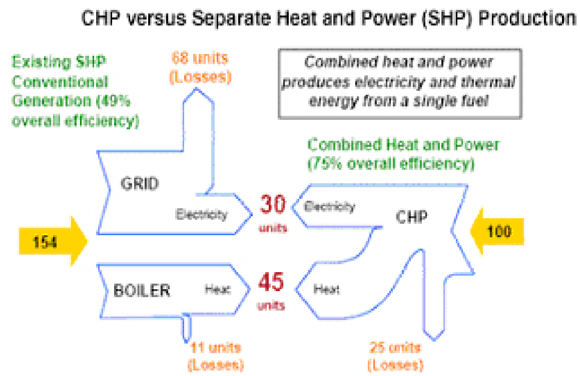
Mitigation Strategy #17
Distributed Generation and Combined Heat & Power Projects

Strategy Summary	Rating	Value
CO2e Savings Against BAU	++	1.12 MMT CO2e
Scale of Deployment	+++	2.45 GWHs of DG and CHP
Timing	++	Depends on rate of new buildings
Regional Impact	+++	3.3 MMT CO2e
Financial Savings in Relation to Cost	+	Variable and highly dependent on specific systems
Additional Benefits in Relation to Burdens	++	
Feasibility Assessment	++	Technically and politically feasible; Financially challenging

Figure 1 Combined Heat and Power



Source: <http://www.epa.gov/CHP/what_is_chp.htm>

Overview

Chicago can reduce its reliance on central station power plants and increase the use of clean, efficient power generated onsite at local facilities by creating rules and incentives that promote increased use of distributed generation (DG) and combined heat and power (CHP) projects. This mitigation strategy focuses on the use of DG and CHP to reduce CO2e from electricity generation.

Over the past one hundred-plus years, the traditional model of creating electric energy and supplying it to end-use customers has been to produce electricity at large central station power plants and then move it over electric wires to customers. The efficiency of large power plants was greater than that of small generators, and the structure of the electric industry set up a framework that favored this type of electric system. In the Midwest, it has led to reliance on nuclear power and coal-fired power plants as the primary sources of electric generation.

With small scale generation technologies improving and fuel options growing, the possibilities for cleaner, cheaper and more reliable on-site generation that does not suffer the losses in the transmission system inherent with central station power has created new interest in both DG and CHP. While onsite renewable energy sources are sometimes considered a form of DG, they are not included in this strategy because their intermittent availability (requiring either sun or wind) does not provide the amount of power needed for these applications.

A Note about Emergency Generators

There is a category of on-site generation that is used for emergency back-up functions; typically in locations that cannot afford (financially or functionally) to lose power. These locations include hospitals, police stations, grocery stores, and buildings with elevators. Emergency generators are typically run on diesel fuel and are designed to run for only short periods of time. Because they use a dirty fuel and do not deliver significant amounts of kilowatt-hours, emergency generation is not a model that is relevant to this strategy.

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

Quantitative Results

GHG Reduction Potential: 1.12 MMT CO2e by 2020

By adopting goals set by the City in its 2001 Energy Plan,[1] there is a potential to reduce emissions by 0.685 MMT CO2e from cleaner electric generation and 0.430 MMT C02e from reduced natural gas use for creating heat.

Scale

According to a market potential study by the Energy Resources Center (ERC) at the University of Illinois at Chicago, there is a potential for between 2,400 and 7,500 megawatts (MW) of capacity for CHP projects statewide, compared to a current installed capacity of less than 200 MW at 58 facilities.[2] Chicago consumes approximately 17 percent of the state's electric use[3] so it could be assumed that between 408 and 1,275 MW—or 17% percent of the potential capacity for CHP projects statewide—exist in Chicago. If these units operate 6,000 hours per year (68% capacity factor), then the potential is between 2.45 and 7.65 gigawatt-hours (GWHs) of DG and CHP. Chicago currently has approximately 110 MW of CHP installed although it currently does not operate at that high of a capacity factor, for several reasons including current high natural gas prices.[4] Goals for DG and CHP set by the City of Chicago in 2001 (see program description below) were for 22 percent of new load to be met by DG and a similar amount for CHP. At current rates of

Distributed Generation

Renewable energy systems applicable to commercial and industrial sites in Chicago include photo-voltaic (PV) and wind power systems. There are limited opportunities for wind power in Chicago especially in the downtown commercial district. Even for sites that are appropriate for wind turbines which are more commonly found outside Chicago in the six-county region, commercial buildings encounter insurance liabilities related to mounting large wind turbines on their buildings. While PV systems can be sized to fit a residential load, this is more challenging to do on a commercial scale. Solar energy systems deliver the best return on investment when used on buildings that have strong electrical or hot water use during daylight hours. PV and solar hot water systems can be integrated with existing electrical or hot water heating systems to provide a portion of the energy needs of commercial buildings. Currently in Chicago, installing PV systems as a retrofit to existing commercial buildings is not cost-competitive as compared to the cost of purchasing electricity.[14] "Building integrated PV" are newer, custom applications that can be designed as exterior wall treatments, upscale entryway treatments, fencing, and roof structures. PV is cost-competitive with other premium building materials such as polished stone, tiles, or stainless steel providing a beautiful, glass-like finish while doubling as an electric generation source. PV solutions are most cost-effective when integrated into the early design phase of new construction or extensive refurbishing projects.[15]

There are currently 28 commercial buildings with PV installations in Chicago. An example of a typical PV application is the Mexican Fine Arts Museum. This 68,000 square foot building located in Chicago's Pilsen neighborhood, has 429 PV tiles on the roof which generate an annual output of 61,800 kWh or approximately eight percent of the annual consumption.[16]

load growth, approximately 2.267 gigawatt-hours of DG and CHP could be built by 2020. This is a slightly lower number than the ERC statewide estimates, due to differing types of potential applications in the city and the state.

Timeline

The opportunities for DG and CHP lie largely in new construction. Therefore, the timeline for adoption will depend on the rate of development of new commercial, industrial and institutional (including City of Chicago) buildings. For example, an economic slowdown may decrease new construction and likewise slow down new DG and CHP opportunities.

Per-unit GHG Reduction Potential

Each DG installation must be tailored to the individual application, so there is no typical size. DG systems range from 25 MW to as small as a few kilowatts (KW). Depending on the technology used, emissions could be either higher or lower than the current regional average. The following chart provides some examples of relative emissions for each MW of various DG technologies, providing the comparable emissions from a traditional coal plant for reference. For CHP, there are additional savings of approximately 66 therms for every megawatt-hour (MWH) of power produced. This savings comes from avoided heat production in conventional boilers.

Figure 2: Generation Technology[5]

Generation Technology	GHG Emissions MT C02/MW/ year*	Change from Average Baseline Rate MT CO2/MW/Year
Typical Coal Plant	5,756	2,104
Distributed Generation Microturbine	4,344	691
Distributed Generation Diesel	3,897	245
2000 Baseline Avg Rate	**3,653**	0
Large Distributed Generation Gas Turbine	3,486	-166
Distributed Generation Simple Cycle Gas Turbine	3,141	-512
Distributed Generation Solid Oxide Fuel Cell	2,585	-1,067
Large Distributed Generation Gas Combined Cycle Turbine	2,112	-1,541
* assumes 6,000 hours of operation		

While fuel cells have a very attractive potential emissions reduction, at this point in time they remain a technology with limited applications and a very high installation cost.

Activity Savings

Employing this strategy can result in replacement of 2.264 GWH of electricity and 81 million therms of natural gas.

Lifecycle GHG Impacts

The largest input into distributed generation is the fuel. The impact of emissions from burning natural gas in onsite generation has been calculated here and savings are in reference to the emissions from fuel consumed by central station power plants in the region. Other potential impacts are the manufacturing of the generators which should not be significant compared to the throughput of fuel; and the impact of reducing line losses which is not part of the emissions model used for this analysis, but could reduce emissions by approximately seven percent.[6]

Regional GHG Reduction Potential

If the region adopted the same goals for DG and CHP as the City of Chicago, there is the potential to replace 6.8 GWH of electricity and 3.3 MMT CO2e in the region in 2020. There may be additional opportunities for CHP in greenfield areas where basic services such as healthcare facilities—good candidates for CHP—have not yet been developed.

Municipal GHG Reduction Potential

Many new City buildings could benefit from DG and CHP. A study prepared by the Energy Resources Center at the University of Illinois at Chicago for the City of Chicago Department of Environment found that 33% of facilities they evaluated for CHP installed systems.[7] If the City builds 40 new buildings per year this is a potential of 13 new CHP systems per year.[8] The numbers could be higher or lower depending upon the types of facilities constructed, making an exact estimate of GHG emissions reductions difficult.

Economic Profile

Financial Costs

The least expensive technology is large gas combined cycle turbines, which cost approximately $600/KW to install. The most expensive technology is fuel cells, which could run $5,000/KW to install. There are a range of more conventional but less efficient smaller gas generators with costs from $1,000 to $1,800 KW.[9] In addition, customers must pay a substantial one-time cost for an interconnection study to satisfy utility requirements. These studies are reported to range from $3,000 to $250,000 depending on the size and complexity of the system.[10]

Financial Savings

The financial savings from DG are highly dependent on several factors: 1) the future cost of natural gas as a fuel source relative to the cost of coal and uranium—the fuels for central power stations; 2) rate structures, e.g., these systems could be required to pay large standby fees;[11] and 3) potential application for peak load shaving. Peak load power is typically the most expensive to buy from the market, so use of DG to avoid purchasing it could provide savings for customers on rates that pass through market-based prices.

Qualitative Results

Program Elements

In the 2001 Energy Plan, the City of Chicago set an ambitious goal of meeting 22 percent of new energy demand with distributed generation by 2010, and a slightly higher level for CHP. For this mitigation strategy, the growth rates assumed in that goal have been projected out to 2020. The assumption underlying this model is that the use of these technologies would be used in an increasingly aggressive fashion in new buildings, rather than in the more difficult challenge of retrofitting existing buildings. CHP is best suited for applications including healthcare, retail food stores, and educational facilities.

Consumption of electricity in Chicago is forecast to rise by 4,800 gigawatt-hours (GWHs) between 2000 and 2020. Meeting 22 percent of this increase with DG would result in approximately 1,000 GWHs of generation supplied by DG rather then central station power and 1,200 GWHs supplied by CHP.

Benefits and Burdens

The main benefits of DG and CHP will be more efficient generation of power. If low emissions generation technologies are used, emissions will be lower than that of the regional emissions profile. Additional benefits will come from reducing line losses and capturing waste heat for other uses. As newly planned facilities are identified that could benefit from the use of either DG or CHP in their design, the potential for Chicago could be significant

There are several challenges to this mitigation strategy, which include: 1) meeting interconnection standards that make installation difficult; 2) changing how architects and engineers think about building design; and 3) selecting the most effective technology to meet economic, technical, and CO2e reduction goals. The technology used is critical for determining CO2e savings potential.[12] For any given specific project, what may make economic or technical sense for the use of DG or CHP may be a type of generator with emissions higher than that of the Chicago baseline and, therefore, would not result in emission reductions. The use of systems that capture heat for a CHP application rather than just a DG application is one potential way to mitigate this challenge.

Finally, DG and CHP are not emissions-free technologies. The combustion of natural gas to generate power creates criteria air pollutant emissions that must be addressed. This is especially true in Chicago, a densely populated city where air quality is a concern. All efforts must be made to mitigate any criteria pollutant emissions impacts.

Current Initiatives and Models

The State of Illinois Small Business $mart Energy Program administered by the Department of Commerce and Economic Opportunity, and the Smart Energy Design Assistance Center at the University of Illinois Urbana-Champaign, help businesses with the upfront costs of energy efficiency projects such as DG or CHP. The Midwest CHP Application Center, the Midwest CHP Initiative, and the Midwest Cogeneration Association also provide resources and technical support for DG and CHP. The Environmental Law and Policy Center is currently leading efforts to create good interconnection standards, in which the City could participate.[13]

For a database of CHP installation by state, consult <www.eea-inc.com/chpdata/index.html>, maintained by Energy and Environmental Analysis Inc. Another valuable resource is the U.S. EPA Combined Heat and Power Partnership. Their website includes a listing of award-winning CHP installations with project descriptions, which can provide an overview of the types of potential applications of CHP. See: <www.epa.gov/CHP/index.htm>.

Implementation Mechanisms

The City can achieve set DG and CHP goals by enacting an ordinance that requires all new building projects over a certain size to conduct a feasibility study for the use of DG or CHP. The results of the feasibility study would be used in the building permitting process to determine if DG or CHP should be required for the building. The City could need to develop guidelines for assessing those feasibility studies and the technical resources to assist developers in preparing them. The City could also provide targeted incentives to assist with the upfront additional incremental costs.

Feasibility

Financial

DG and CHP face a number of significant financial hurdles including installation costs, which could involve regulatory fees and equipment costs, as well as the cost of natural gas. This mitigation strategy will be more feasible for developers and building owners if new buildings can incorporate these costs into their financing and operations budgets.

Technical

Technology for DG and CHP systems exist today and are in use in facilities all around the world.

Political

The less clearly feasible aspects of DG and CHP are changing the mindset of architects, building engineers, and developers to seriously consider how to incorporate DG or CHP into new building in an economical manner. With the City's support, as evidenced in their Energy Plan, political capital can be invested in working with architects, building engineers, and developers to actively pursue DG and CHP in new buildings. Aldermen should be made aware of the GHG reduction potential afforded by DG and CHP, and encouraged to think about these systems when reviewing development plans in their respective wards.

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Mitigation Strategy #18
Household Renewable Energy Generation

Strategy Summary	Rating	Value
CO2e Savings Against BAU	+	0.28 MMTCO2e
Scale of Deployment	+++	55,000 homes (5% housing stock)
Timing	+++	Beginning with 2,000 homes in 2008
Regional Impact	+	0.84 MMTCO2e
Financial Savings in Relation to Cost	++	Ranges depending on systems
Additional Benefits in Relation to Burdens	+++	Controlled Household Energy Costs, Job creation
Feasibility Assessment	+++	Proven models

Overview

By increasing the use of household-scale renewable power in the form of distributed generation, Chicago can increase the use of clean, efficient power generated locally while reducing its reliance on central station power plants. Renewable energy generation on the household level can reduce 0.28 MMT CO2e.

Distributed generation (DG) at the household level is on-site generation of electricity which allows families to decrease or eliminate the amount of electricity purchased from the electricity grid. DG systems include photovoltaic (PV) panels or wind turbines that can be installed on roofs or in yards, and gas-fired micro-turbines that could be located in basements. Households in Chicago will probably want to interconnect their home DG systems to the city-wide electric grid in order to sell excess power, as well as purchase power when their home systems do not provide sufficient capacity.

Electric energy creation and supply in Illinois are based almost exclusively at large central station power plants that predominantly use coal or nuclear power. Natural gas, the primary source of space and water heating in Illinois, is also obtained via a delivery system from a central supply provided by a utility. Centralized power stations, at their inception more than one hundred years ago, provided the most efficient method for the creation and distribution of electricity. In recent years, as more fuel options and improved technologies have come to market, generation of renewable energy on a household level has become a viable option. And beyond viable, DG by households is attractive for many reasons that include environmental impact (e.g., greenhouse gas (GHG) reduction potential), ability to address supply problems (e.g., power quality and availability), and energy security (e.g., eliminate potential for centralized electricity failure). Proven DG technologies are available to provide energy, but the adoption rate continues to be low; high initial investment costs are one of the major barriers.

Quantitative Results

GHG Reduction Potential: 0.28 MMT CO2e in 2020

It is possible to reduce 0.28 MMT CO2e by 2020 by deploying household-scale DG.

Scale Assumed

This mitigation strategy assumes that 55,000 housing units will install renewable generation equivalent to 100 percent electricity replacement on each house. It is also assumed that 55,000 housing units will install solar domestic hot water, reducing natural gas consumption by 25% per participating household. Fifty-five thousand housing units represent five percent of the Chicago housing stock.[1] Figure 1 shows the GHG reduction potential with different percentages of housing stock utilizing renewable generation.

Figure 1: Scale and GHG Reduction Potential of Household-based Renewable Generation

% of Housing Stock	Total Number of Units	Total GHG Reduction (MMTCO2e)
50%	550,000	2.80
35%	385,000	1.96
20%	220,000	1.12
10%	110,000	0.56
5%	55,000	0.28

Timeline

The strategy to install renewable generation in 55,000 housing units by 2020 assumes that renewable generation is installed on 2,000 units beginning in 2008, increasing by 10% annually. It is estimated that there are currently fewer than 100 units powered by distributed renewable generation in Chicago.

Per-unit GHG Reduction Potential

The GHG reduction potential is 5.07 metric tons per housing unit per year assuming that both solar domestic hot water (1.88 metric tons) and renewable electricity generation (3.19 metric tons) are installed in one housing unit.

Activity Savings

Employing this mitigation strategy can result in savings of 287 gigawatt-hours of electricity and 19.5 million therms of natural gas annually.

Lifecycle GHG Impacts

Research conducted to estimate the lifecycle GHG impacts of building integrated renewable technologies shows that the emission rate is lowest for wind (15 tons/GWH) and then photovoltaic (39 tons/GWH) with a much higher emission rate with electricity produced from natural gas turbine technologies (464 tons/GWH).[2] An analysis of solar domestic hot water systems compared to conventional systems revealed a net lifecycle emission savings after 2.5 to five years.[3]

Regional GHG Reduction Potential

Assuming that this strategy is deployed at the same rate throughout the region as in the city of Chicago, there is a reduction potential of 0.84 MMT CO2e.

Municipal GHG Reduction Potential

The municipal reduction potential—assuming that all 25,000 new housing units owned by the Chicago Housing Authority had renewable installations—is 0.13 MMT CO2e.

Economic Profile

The costs of renewable power generation at the household level depend on the system technology, utility interconnection costs, labor and installation costs, associated costs for building permits, maintenance costs, costs for replacement and repair, and the salvage costs (or value).[4] The costs of installing renewable electricity systems vary greatly—$15,000 to $50,000. Solar hot water systems are much less expensive at $1,500-$3,000, with a payback period of four to 14 years.[5]

Initial capital costs are high and payback periods for renewable energy without subsidies can be relatively long. However, building-integrated photovoltaic (PV) systems at the time of new building construction are found to be more cost-effective than retrofitted systems.[6] The economics of building-integrated PV systems configured to provide peak shaving were evaluated in 10 utility areas in the U.S. The benefit-cost ratios ranged from 1.03 to 1.47 and the payback periods ranged from one to four years. This shows that there is a near-term market for PV systems configured to provide peak shaving and emergency power functions in the new buildings sector.[7]

While there is strong interest in PV technology from homeowners, both in new construction and as add-on retrofits, the capital costs remain a major deterrent. Some financial assistance to defray the costs is available. The State of Illinois offers rebates for alternative energy system installation, providing up to 30 percent of the installation cost.[8] The demand for these funds consistently exceeds available financing, which has resulted in only a small number of installations. Federal funding in the form of a 30 percent tax rebate, or up to $2,000, was offered in 2006 and 2007; however, this allowance has not been re-authorized.[9] While PV systems provide "free electricity," this avoided cost is very small compared to the cost of a PV system, which is approximately $6/watt, at a minimum.[10]

Qualitative Results

Program Elements

DG is defined as the use of small-scale power generation technologies that are located at the site of the load being served. Technologies that could be utilized in Chicago include PV solar systems and wind turbines, which produce electricity. These technologies are described below. Although solar thermal technology does not produce power, it is discussed in this section due to its capacity to replace fuel sources that produce GHGs.

1) **Photovoltaic (PV):** Electricity-producing photovoltaic cells are a reliable, time-tested technology. Systems installed more than 20 years ago are still in operation today. Research is ongoing for improving the efficiency of solar cells. In 2000, ComEd offered a "utility-tie" option to customers who had solar or wind systems, which greatly enhances the usefulness of DG. Interconnection allows the generator to use power from the electrical grid when necessary, and provide power back to the electrical grid when they are producing in excess of their demand.

2) **Wind:** Wind turbines in urban settings are also used to produce electricity. The traditional horizontal axis windmill design, powered by a trio of blades, is often prohibited by City codes, although not in Chicago where an extensive buffer setback is required to avert hazards associated with blade loss. An alternative windmill design, the Savonius rotor, is a viable urban option. These vertical axis rotors can operate using lower speed winds originating from any direction.[11]

3) **Micro-turbines:** Micro-turbines are high-speed, gas fired turbines that generate electricity in the range of 25-500 KW, as compared to an average home which has a three to five KW load.[12] Although micro-turbines do not utilize renewable fuels, this technology could play and important role in facilitating distributed generation at a household and/or neighborhood level. While micro-turbines are being used in commercial settings, residential applications are very limited. Micro-

turbines, as part of micro-grids, are seen as more viable. However, this concept is still in the design phase, and there are no operational examples. Micro-turbines are not free of direct GHG emissions, as PV or wind are, and are not included in the GHG analysis of this strategy. Additionally, there is evidence that micro-turbines have ongoing maintenance issues.[13]

4) **Fuel Cells:** A fuel cell is an electrochemical energy conversion device. A fuel cell converts the chemicals hydrogen and oxygen into water, and in the process, it produces electricity. Fuel cells are easier to size for residential applications. Despite their high profile reputation, fuel cells have remained a nascent technology for the past decade and few residential applications exist. The Electric Power Research Institute (EPRI) has been working on demonstration projects for residential applications; commercial applications currently exist.[14] There are high initial capital costs for both residential and commercial fuel cells.

5) **Solar Thermal Power:** Solar thermal systems use panels similar in appearance to PV panels, but provide heat instead of electricity. The most common application in the Chicago area is solar water heating, where these systems supplement, but do not replace, residential hot water heating systems. Solar thermal systems can also provide space heating.

Benefits and Burdens

Renewable energy sources create strong benefits because they do not directly generate criteria air pollution emissions (as defined in the Clean Air Act) and therefore do not have the associated health and habitat impacts of traditional energy sources. This is especially important in a dense urban area where air quality is a concern.

Chicago already has substantial resources in place necessary to further DG. The city has a large contingent of building professionals who are familiar with, and are even enthusiastic about, green architecture, including those in the Chicago chapter of the U.S. Green Buildings Council. Skilled trades people are also in place. For example, the International Brotherhood of Electrical Workers has provided training in PV technology for several years and has a pool of qualified system installers. The City attempted to establish PV manufacturing in Chicago by inviting Spire Solar, a supplier of PV technology, to establish a factory in Chicago. This endeavor resulted in the successful installment of PV technology on 28 municipal buildings, museums, and schools. Unfortunately, efforts to jumpstart PV installations for residences were not successful and Spire Solar closed down their manufacturing operations after a few years, although they still maintain a sales office in the city. Increasing the quantity of household-based DG could result in job creation in this area as more people would need to be trained to install and maintain systems.

One of the major benefits of distributed PV generation is that the systems provide the most power precisely when additional demand is needed—on hot summer days when air conditioner usage spikes peak electrical demand. ComEd's interconnection policy enables customers to contribute their excess loads back to the grid. The interconnection program also benefits PV system owners, allowing them to avoid the purchase of expensive storage batteries for supplying power in non-daylight hours.

Current interconnection policies could be improved to encourage greater participation in this strategy. Today, small-scale interconnected generators can only be reimbursed up to the amount of the power that they consume—no profit is possible, regardless of how much power is supplied back to the grid. ComEd also retains the rights to the "green tags" associated with this electricity. Green tags, also called renewable energy certificates, are the property rights to the environmental benefits, including GHG reductions, from generating electricity from renewable energy sources. These certificates can be sold and traded, and the owner can legally claim to have purchased renewable energy. This issue would need to be addressed to ensure increased household DG is a true GHG mitigation strategy for Chicago.

Existing PV systems are vulnerable to disruption due to construction that blocks previously available sunlight. To forestall this situation, some municipalities have ordinances that prohibit blocking radiation from existing solar installations.[15]

The potential for wind power to displace traditional power load generation in Chicago has not been fully explored. Wind levels in Chicago are relatively low, and for safety reasons, siting of traditional bladed windmills in crowded urban environments is difficult. Vertical windmill designs are an option that avoids these problems. There are limited available data on power production from vertical windmills, and the grants and rebates that are available from the State of Illinois are not approved for vertical axis windmills at this time.

Current Initiatives and Models

There are numerous examples of DG throughout the City. Several homes in Chicago generate sufficient electricity to supply their personal loads, as well as provide excess power back to the grid. PV systems can be seen in new construction in demonstration projects, such as the Green Homes and Green Bungalows. While it is possible to install PV as a retrofit on existing structures, integrating PV into new construction during the design phase is more economical and provides the best opportunities to maximize the potential generation capabilities. The City's Green Permit program, which includes reduced cost, expedited permits, supports including distributed generation in construction projects.

Vertical windmills have been installed in several locations in Chicago, including the Near North Side Single Residency Occupancy (SRO) owned by Mercy Housing. These projects can provide production data for the evaluation of cost-effectiveness, which may then facilitate wider use of the technology.

Implementation Mechanisms

Chicago's current building and zoning codes could be updated to support the installation of DG systems. In particular, Chicago could enact an ordinance that prohibits blocking sunlight from buildings with existing solar installations, and adjust zoning codes to support this practice.

The City of Chicago could continue to support and expand training classes on renewable generation. Classes at the City's "Green Tech U," at the Center for Green Technology, provide education and tips on renewable generation. The Illinois Solar Energy Association provides one-day "Solar 101" workshops for a $100 fee. Another venue that allows interested parties to see "solar at work" is the annual Solar Homes Tour, an opportunity for the public to visit open houses and speak with owners and residents. Financial and publicity support would help increase the impact of this event.

One model for financing PV installations involves building owners leasing roof space to companies that install the system. Building Owners or "leasees" receive free electricity, while the hardware and other assets, including the green tags, are the property of the leasing company. Citizenre has been marketing this type of program in Chicago, but to date, no systems have been installed.[16]

Feasibility

Financial

Renewable generation may be financially feasible for moderate and upper income households. To implement a program at scale, however, there has to be a larger outreach and significant financial resources to fund initial capital costs of equipment in the form of grants or loans will be needed.

The significant capital outlay required for installing PV systems will continue to be a deterrent to many consumers. In particular, lower income property owners will be unable to invest in these systems, even with financial support available. But at present, a persuasive argument can be made for those with discretionary income to invest in clean, renewable energy. Distributed energy offers real solutions to energy and electric problems.

Technical

It is technically feasible to implement this mitigation strategy. There are numerous examples of installed projects. Renewable energy systems are an attractive technology by virtue of their high visibility and green "cachet," which help make political arguments for greater support of renewable generation at a household level.

Political

In order for household level renewable distributed power generation to be feasible, it is necessary to ensure ease of interconnection with the electric grid. This will require state legislation or a negotiated solution with ComEd. Additionally, the City Council could pass an ordinance protecting access to sunlight to assure ongoing high performance of solar systems.

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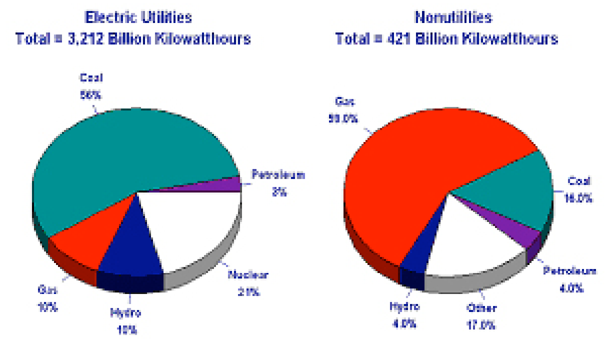
Mitigation Strategy #19
Establish Efficiency Standards for Electricity Generation

Strategy Summary	Rating	Value
CO2e Savings Against BAU	++	1.04 MMTCO2e
Scale of deployment	+++	246 existing plants and all new plants
Timing	++	By 2020
Regional Impact	+++	3.54 MMTCO2e
Financial Savings in relation to Cost		Unknown
Additional Benefits in relation to Burdens	++	Allows existing plants to continue providing jobs
Feasibility assessment	+	Requires Regional or National Solution

Figure 1 Electric Power Industry Generation by Source



Notes: "Other" energy sources include geothermal, wind, biomass, solar thermal, and photovoltaic. See text for a list of biomass sources. For utilities, "other" energy sources contribute less than 1 percent. For nonutilities, there are no nuclear units.
Source: Energy Information Administration, *Electric Power Annual 1998 Volume II*, Table 1, pages 12-13.

Overview

More efficient fossil fuel generation can contribute significantly to greenhouse gas (GHG) emission reduction goals. While strategies to replace fossil fuel generation with renewable generation are viable, it is important to consider technologies that can improve the efficiency of existing and newly built fossil fuel generation. Fossil fuels are the energy source supply for about 70 percent of the nation's generation requirements as shown in Figure 1.[1] Coal, petroleum, and gas are currently the dominant fossil fuels used by the industry.

The Energy Policy Act of 2005 (EPAct) encourages energy conservation and efficiency, improved electric reliability, and use of alternative sources of energy. EPAct added five new federal standards to the Public Utility Regulatory Policy Act of 1978 (PURPA)—one of which, Section 1251(a)—set a standard for Fossil Fuel Generation Efficiency. Specifically, the standard states, "each electric utility shall develop and implement a 10-year plan to increase the efficiency of its fossil fuel generation."[2] These policies are intended to encourage optimal efficiency of electricity generation by promoting upgrades of existing plants and efficiency for new plants. Plant upgrades include replacement of equipment, modification of facilities or implementing changes to Operating and Maintenance (O&M) practices. New plants could be built with the most efficient available technology. The policies mentioned provide no specific requirements or efficiency goals, and no efficiency standards have yet to be implemented in the United States. Owners of electric generation maintain that standards are not necessary because the electricity markets promote improved efficiency by creating competition among generators.[3]

Quantitative Results

GHG Reduction Potential: 1.04 MMT CO2e in 2020

The calculation for the GHG reduction potential assumes that standards are adopted for improving the efficiency of existing fossil fuel electricity generation by 5%, and new fossil fuel generation by 13%. This calculation assumes that all of the savings result from a reduced plant heat rate in BTUs per kWh. It is based on the Energy Information Administration, which assumes the efficiency of new plants could be improved by 3-13%.[4]

The emission reduction resulting from the improved efficiency of existing electricity generation plants is 0.65 MMT CO2e. The emission reduction resulting from the improved efficiency of new fossil fuel plants is 0.39 MMT CO2e. The total emissions reductions resulting from the improved efficiency of existing electricity generation and the improved efficiency of new fossil fuel plants is 1.04 MMT CO2e.

Scale

The scale assumed for this mitigation strategy is all existing fossil fuel electricity generation plants in the North American Electric Reliability Corporation (NERC) region that supplies Chicago. The region includes 79 coal, 87 natural gas, and 70 oil-fired plants.[5] It is assumed that, on average, these 246 plants can improve efficiency by 5% by 2020. It is also assumed that all new generating capacity (4,859 GWH) will be 13% more efficient.

Timeline

To serve load increases by 2020, Chicago will require building between one to two new, typical-sized coal plants. This strategy assumes that these new plants will be built to the highest efficiency standards. It also assumes that all 246 existing plants will be upgraded by 2020. Building a new coal plant requires many years of planning even before construction begins, and changing existing plants also will require years of planning, so efforts to increase efficiency must start soon to meet this goal by 2020.

Per-unit GHG Reduction Potential

There is a potential to reduce an average of 3.85 metric tons CO2e per GWh of generation annually.

Activity Savings

Employing this strategy can result in savings of 99.5 million MMBTUs in fossil fuels.

Lifecycle GHG Impacts

The lifecycle costs of electricity generation are substantial. The literature shows that energy efficiency improvements on the demand-side typically show a net benefit when considering life cycle GHG emissions.[6] Supply-side options, including improved efficiency of generation, are generally found to involve some net costs.[7]

Regional GHG Reduction Potential

The regional emission reduction potential is 3.54 MMT CO2e; 2.01 MMT CO2e from improved efficiency of existing electricity generation plants and 1.53 MMT CO2e from improved efficiency of new fossil fuel plants.

Municipal GHG Reduction Potential

The municipal emissions reduction potential is 0.05 MMT CO2e; 0.032 MMT CO2e from improved efficiency of existing electricity generation plants and 0.0178 MMT CO2e from the improved efficiency of new fossil fuel plants.

Economic Profile

The costs associated with upgrading plants are substantial. Financial savings are derived from the reduction of the consumption of fossil fuel and related costs. The cost of power from a plant is a combination of the fuel cost, operational costs, and the capital costs of construction. In an upgraded plant, the fuel costs should be lowered proportionately to the efficiency upgrade, but these cost savings will be offset by the increase in recovery of the capital costs required to make the plant more efficient. Exact calculations of these trade-offs are not available. This type of data is proprietary and only available publicly when it has been filed as part of a rate case. This will only occur in states that have not been deregulated and therefore have plants that fall under traditional rate making proceedings. Merchant power plants such as those in Illinois do not have to file any data of this type.

Qualitative Results

Program Elements

While most jurisdictions have yet to address the provision of EPAct, which encourages efficiency standards for fossil fuel generation, the following are excerpts from two utilities plans that describe their ongoing efforts to improve efficiency. While both plans suggest that efficiencies will be improved through market forces, and that a mandated efficiency standard is not needed, they illustrate the means by which utilities would improve efficiency standards.

1) **Improve the operating efficiency.** Operating efficiency is improved by lowering the Equivalent Forced Outage Rate (EFOR), or the amount of down time that the plant requires for operation and maintenance.[8] EFOR can be improved by changes in plant operation as well as upgrades to equipment.

2) **Improve the plant heat rate.** The plant heat rate is measured in BTUs of energy required to produce a MWh of electricity. Higher efficiency equipment—accomplished by installing new equipment or upgrading existing equipment—results in improved combustion, or lower losses.[9] Improved combustion translates into less fossil fuel to generate the same amount of electricity.

Benefits and Burdens

As fossil fuel electricity generation plants are made more efficient, there are overall reductions in criteria pollutants.[10] Additionally, many of these plants serve as the major employer in small, rural communities and upgrading and continuing to operate these plants maintains an important positive impact on the local economy.

Although efficiency standards will reduce the rate of fossil fuel consumption, this strategy does assume a continued reliance on fossil fuels for electricity generation. Burning fossil fuel has a continuing negative impact on the public health of the nation. Emissions from these plants provide an on-going threat to the environment and to human health.[11]

Current Initiatives and Models

While most jurisdictions have yet to address the provision of EPAct for encouraging efficiency standards for fossil fuel generation, the following are excerpts from two utilities' plans:

1) "[Tennessee Valley Authority] has ongoing efforts to improve the reliability and efficiency of its fossil fleet. Since FY 2000, the equivalent forced outage rate (EFOR) has improved from 10% to approximately 6%, and plans are to be in the top quartile of performance in the coming years. Additionally, efforts to improve plant heat rate (a measure of consumed fuel per unit of electricity)

are ongoing at several facilities and will be standardized across the fossil fleet to improve efficiency. "[12] (Tennessee Valley Authority)

2) "The 'supply of low-cost, competitive electric power' is one of the four basic principles of CPS Energy's Strategic Energy Plan. Potential upgrades to equipment or facilities are identified by CPS Energy plant management and by power plant or engineering personnel. If an upgrade initially appears to be viable, a more rigorous project justification process is performed to evaluate the feasibility and cost effectiveness of a proposed upgrade in detail. Such a cost/benefit analysis addresses all projected O&M costs associated with the modifications being considered. Cost savings associated with efficiency improvement projects are estimated utilizing analytical models that account for projected generation needs, fuel costs, O&M costs, ERCOT market, and other pertinent variables. Projects are typically supported using 3 to 7 year paybacks based on Net Present Value computations. " [13](CPS Energy, Texas.)

Implementation Mechanisms

There are at least three mechanisms for implementing standards for fossil fuel generation:

1) **Voluntary compliance.** Individual plants and/or electricity generation companies may choose to implement standards without regulatory or legislative mandates.

2) **Market level standards.** The regional organization that manages the electricity market assures the reliability of the power supply and manages the transmission systems, and could negotiate a standard for all electricity generation that is sold into its market. PJM manages all power provided to Chicago electricity consumers.

3) **Nationally enforced requirement.** The Federal Energy Regulatory Commission (FERC) regulates and oversees energy industries in the economic, environmental, and safety interests of the American public. FERC could establish and enforce efficiency standards for fossil fuel generation across the United States.

Either a regional or national implementation strategy is most likely to succeed, because it would require all plants to improve to a specified efficiency level over their baseline operations. This is not a strategy that can be implemented locally, although Chicago can support policies at the regional and national levels.

Feasibility

Financial

Cost is a big consideration in upgrading plants. And, as noted in Technical Feasibility, technology choices which impact emission rates are largely based on what costs the least.

Technical

From the plant owner's point of view, the technology choices for new plants or upgrading generating capacity are made to minimize initial capital costs while meeting local and Federal emissions constraints. The technology choice for adding new capacity is based on the least expensive option available.[14]

There is a balancing act between reducing emissions and increasing energy efficiency. Emission controls consume energy and therefore increase the energy consumed per kWh generated. Therefore, it may be more reasonable to promote environmental performance standards and emissions limits as opposed to efficiency standards, allowing for the most appropriate engineering solution for each plant.

Political

Currently there are no efficiency standards for fossil fuel electricity generation in place. Utilities and Electricity Market Organizations oppose enforced standards because they believe the market will naturally result in the most efficient generation. They argue that the deregulated electricity market currently selects the most energy efficient and least expensive generation to be used first.[15] Overcoming this opposition will be a necessary first step towards creating mandated efficiency standards for electric generation.

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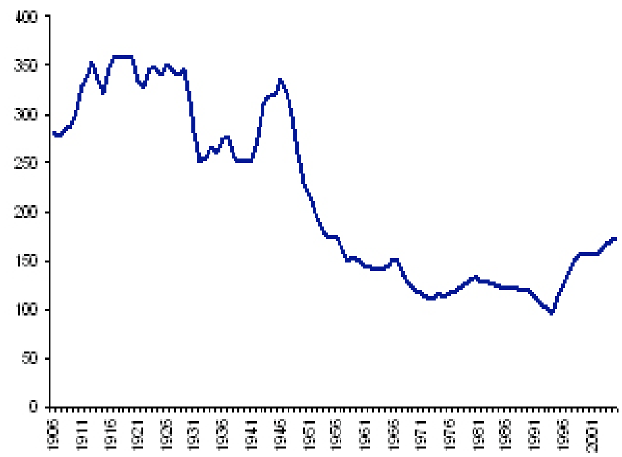
Mitigation Strategy #20
Increase Transit Service

Strategy Summary	Rating	Value
CO2e Savings Against BAU	++	0.83 MMT CO2e
Scale of deployment	+++	Increase transit ridership 30%
Timing	++	Short term for increasing access, frequency, and bus routes; long term for expanded track miles
Regional Impact	+++	1.28 MMT CO2e
Financial Savings in relation to Cost	+	Significant public investment; some innovative funding mechanisms
Additional Benefits in relation to Burdens	+++	Improved air quality, reduced household costs
Feasibility assessment	++	Significant public funding and political support required

Figure 1 Chicago Transit Riders per Capita, 1906-2005



Overview

A comprehensive and accessible transit system is the linchpin to a wide network of strategies to reduce carbon emissions in the transportation sector. The key to reducing reliance on carbon-intensive vehicle travel is to provide a wide choice of transportation modes—walking, biking, car-sharing, car pooling, and transit. The potential success of other transportation sector mitigation strategies, such as parking cash-out programs and congestion pricing, are also reliant on the availability of convenient public transit.

Some agreement exists that it may be possible to reduce annual vehicle miles traveled (VMT) by one-quarter to one percent, by increasing access to public transit and implementing more regional smart growth practices.[1] While transit consumes energy on a passenger mile basis, it consumes far less than the corresponding number of passenger vehicles.[2] In the places where transit is an option, a significant proportion of the population uses it, especially for work commutes. According to the 2000 Census, over a quarter of Chicagoans take transit to work.[3] According to the same census figures, over 70% of Chicago households own one or no vehicles[4], implying that the potential transit market may be quite large.

In order to provide the comprehensive transit service required to create a system of transportation choices that reduce carbon emissions, the City and CTA could set a goal of increasing transit ridership by 30% over

2000 levels by 2020, increasing annual ridersip by 147 million trips. This would likely require increasing routes and frequency (days and hours of service), as well as a wholesale review of market incentives for various modal decisions, and consideration of priority use of public space by public vehicles.

The Chicago Transit Authority (CTA) is the nation's second largest transit system[5], with an average weekday ridership of 1.6 million rides.[6] Approximately one-third of these rides are by train and two-thirds are by bus.[7] However, this system has been strained by ongoing budget challenges. A firm commitment, both in political will and dollars, is required to ensure that transit operates as a cornerstone mitigation strategy to reduce transportation-related emissions. Beyond a commitment to maintaining the system, Chicago's transit system can increase service and ridership by increasing bus routes, track miles, accessibility, and frequency to attract more riders.

After many years of decline in the 1980's, CTA's ridership began rebounding in 1998. The RTA reported to the Illinois General Assembly in 2004 that "From 1994 to 1998 CTA ridership dropped by 24 million."[8] By January 2007, CTA reported that since 1997, annual CTA ridership grew by nearly 55 million, achieving ridership increases in eight of the previous nine years.[9] The initial rebound was attributed to an influx of university students introduced to the CTA through the U-pass program, as well as innovations in fare cards.[10]

Only 18% of trips are work-related, while the remainder are for personal, family, social, school, and faith-related trips.[11] Different types of transit—train, bus, express bus, streetcar and paratransit—are appropriate for different lengths and types of trips. Transit use is also correlated with frequency of service and hours of operation. The recent rise in CTA ridership parallels other travel innovations, such as the ability to bring bicycles on buses.

Latent demand for increased transit has been documented, both nationally and in Chicago. In a survey conducted for the Federal Highway Administration, over 65 percent of respondents thought their communities would be improved by "expanding existing public transportation" and "offering new public transportation service"—above building new highway capacity.[12] In this region, public engagement preceding the adoption of the 2030 Regional Transportation Plan Update found that 80% of participant groups wanted roadways retrofitted to better serve transit, bikes and pedestrians, finding little demand for new highways. "More and better integrated public transit" was the highest priority among pre-existing regional "themes," with 83.3% of participant groups endorsing that theme.[13]

Quantitative Results

GHG Reduction Potential: 0.83 MMT CO2e

Figure 2 shows the potential GHG savings if the transit system in Chicago increased its ridership by 5% to 60% as compared to the business as usual (BAU) trajectory. An attainable goal, and one that gives substantial savings, would be to increase ridership 30% over 2000 levels by 2020. This increase, as opposed to a decrease in ridership which is forecast in the BAU, would save 0.83 MMT CO2e in 2020. The BAU scenario for this section assumes that ridership will decrease at the same rate that took place from 1974-1994 (a decline of 31.0%), due to a leveling off and beginning of decline in ridership in 2006-7. The transit ridership increase assumes a corresponding reduction of single vehicle occupancy use.

Figure 2 Chicago Transit: Potential Service Increases and Related Emissions

Chicago	Bus	EL	METRA	TOTAL
If we increase transit ridership by	Reduced emissions from ridership increase metric tons (MT) CO2e			MMTCO2e
5%	274,434	173,087	39,918	0.49
10%	312,508	197,101	45,456	0.56
15%	350,582	221,114	50,995	0.62
20%	388,655	245,127	56,533	0.69
25%	426,729	269,140	62,071	0.76
30%	**464,802**	**293,154**	**67,609**	**0.83**
35%	502,876	317,167	73,147	0.89
40%	540,950	341,180	78,685	0.96
45%	579,023	365,193	84,223	1.03
50%	617,097	389,207	89,761	1.10
55%	655,170	413,220	95,299	1.16
60%	693,244	437,233	100,837	1.23

Scale Assumed

This saving is a result of examining the population growth in Chicago, and assumes equal level ridership increases on CTA bus, CTA rail, and Metra.

Timeline

The 30% ridership increase assumes a 1.5% annual increase in ridership from 2000-2020. The BAU assumes a corresponding decrease of 1.5 percent annually.

Per-unit Reduction Potential

For every 5% increase in ridership, there is a 0.07 MMT CO2e savings in GHG emissions.

Activity Savings

Vehicle travel will decrease, and although there will be an increased demand on the transit infrastructure, the balance is a significant net reduction in GHGs.

Life cycle GHG Impacts

Increased ridership will reduce the need for maintenance to support auto use, but increase the need for maintenance to support transit.

Regional GHG Reduction Potential

The overall 30% increase in ridership in the six-county region, not including Chicago, could result in an annual GHG savings of 0.45 MMT CO2 above the BAU forecast. With Chicago included in the calculation, the savings would be 1.28 MMT CO2e. Figure 3 demonstrates the CO2e savings potential in the region, with and without Chicago, from increasing transit ridership.

Figure 3 Reduced emissions from ridership increase metric tons CO2e Savings

Region Without Chicago	Bus	EL	METRA	SUBURBAN TOTAL	REGIONAL TOTAL
If we increase transit ridership by	Reduced emissions from ridership increase metric tons (MT) CO2e			MMTCO2e	MMTCO2e
5%	24,927	37,841	204,053	0.27	0.75
10%	28,385	43,091	232,362	0.30	0.86
15%	31,843	48,341	260,671	0.34	0.96
20%	35,301	53,591	288,980	0.38	1.07
25%	38,759	58,841	317,289	0.41	1.17
30%	**42,217**	**64,091**	**345,599**	**0.45**	**1.28**
35%	45,676	69,341	373,908	0.49	1.38
40%	49,134	74,591	402,217	0.53	1.49
45%	52,592	79,841	430,526	0.56	1.59
50%	56,050	85,090	458,835	0.60	1.70
55%	59,508	90,340	487,145	0.64	1.80
60%	62,967	95,590	515,454	0.67	1.91

Municipal GHG Reduction Potential

As transit expands both service and service areas, GHG emissions from transit system vehicles will also grow, although there is not a direct 1:1 relationship between GHG emissions and ridership. Despite upgrades needed and anticipated increased emissions from transit, emissions are lower per passenger mile as more passengers are added. The reduction of GHG emissions from transit service comes from reduced private auto use. CTA will not be able to account for these reductions. However, it is clear that this increase of transit emissions will be offset by overall GHG reductions.

Economic Profile

Financial Costs

Three large-scale route extensions within city limits have received consideration by transit authorities in recent years: the Red Line extension to 130th St., the Circle Line, and the Mid-City Transitway. As of 1997, the proposed Red Line expansion was expected to cost $282 million and the Mid-City Transitway to cost $1 billion.[14] The Circle Line was proposed in a later plan, without a financial estimate. According to press reports, the plan is estimated at $1 billion.[15]

Express bus service has proven to be a popular service enhancement, expanding from one line in the 1990s to 10 lines in 2007[16]. The changeover to express bus service costs approximately $1 million per route.[17]

Minimal costs are associated with dedicated bus and bike lanes, which speed service, allow adherence to transit schedules without bus bunching, and give transit the advantage over congested private vehicle travel. This would require only modest planning, signage and re-striping expenses.

Priority signal technology for buses would reduce idling at lights and increase transit attractiveness by reducing travel time. The RTA has committed $13 million in Congestion Mitigation and Air Quality (CMAQ) funds to regional transit signal priority.[18] The amount required to implement priority signalization in the city is unknown.

Financial savings

The New Starts rail projects—Red Line Extension, Mid-City Transitway and Circle Line—will draw much of their capital funds from federal and state resources. Neither the bus system nor the rail system has an adequate resource base for operating costs. The income-producing recommendations (see Implementation Mechanisms) will provide resources for the operating budget of the CTA. Where transit increases, households also can benefit from a decrease in the proportion of their budgets committed to transportation.

Qualitative Results

Program Elements
Increasing transit use involves increased service (route miles, hours of operation, and frequency), increased connectivity and market-based pricing for competitor modes.

1) **Increased service includes new rail and bus lines**, or extension of existing lines; new options on existing routes like express bus, bus rapid transit and dedicated bus and bike lanes; longer hours of service; increased frequency of service; and new stations or stops.

2) **Increased connectivity** includes: service coordination between transit providers; service coordination with taxi and car-sharing companies; better signage and information about how to make connections; fare card coordination; and station transfer points where feasible.

3) **Market based pricing** includes innovations that have not yet been implemented in Chicago, although initial discussions have taken place. Examples include: investigate where parking policies incentivize private vehicle travel over transit; congestion pricing of transit; congestion tax on private vehicles in the downtown area; and a parking tax to generate income for transit and reduce the perceived incentive for "free" travel by vehicle owners.

Additional market innovations to increase access include a deeded transit pass with the purchase of certain residences in transit-rich communities, and a "mobility card"—one smart card that would work for transit, taxis, car-sharing, bike-sharing, parking lots, and Amtrak.[19]

Benefits and Burdens
Benefits of increased transit, and associated decreased VMT, include improved air quality, reduction in road construction and maintenance costs, reduced congestion, improved access to jobs, access for young, old and people with mobility limitations, fewer vehicle-related fatalities and serious injuries, and increased routine physical activity, i.e., walking to stations or bus stops.

Studies have shown transit leads to job creation, increased business sales located near transit, increased tax revenue for state and local governments and reduced infrastructure costs related to roads and stormwater management.[20] According to former U.S. Secretary of Transportation, Norman Mineta, transit returns $6 to a region for every $1 invested.[21]

There are savings for household as well. Research reported by the American Public Transportation Association found that households with two workers, one car, and access to transit within ¾ of a mile, saved $6,251 a year—more that the average family spends each year on food.[22]

A fundamental benefit of transit is the intrinsic synergistic support it provides to other transportation mitigation strategies in contributing to their success. Biking, car sharing, and parking programs cash-out programs are some of the many strategies that increase their success when convenient public transit is available as a transportation choice.

Burdens include the need for the three transit agencies in the region—CTA, Pace, and Metra—to plan for service coordination. History has shown this could be a protracted and politically-charged process. Some financing recommendations, such as transit congestion pricing or a downtown congestion tax, will affect personal budgets. The City may assume the burden of a significant public education campaign to convey the necessity and benefits of transit as a primary mode for Chicagoans and visitors.

Implementation Mechanisms

The City of Chicago can make transit a cornerstone of its transportation climate strategy by making a public commitment to transit, working to secure funding, and applying market driven strategies to equalize incentives between transit and private vehicle use. Revenue producing strategies, as described below, can help to stabilize operating funding for the transit system. Since significant transit funding comes from state and federal budgets, Chicago's elected representatives could advance this strategy by uniting behind the most advantageous expansion programs to compete for state funding and federal New Start money.

Potential income-producing transit incentives

There is great potential to create new or expanded revenue streams for the transit system. The City could promote the equivalent of a U-Pass for its employees, public school employees and major businesses. A potential model is the city of Boulder's (CO) EcoPass, where employers purchase bulk transit passes at a discount. The costs are primarily for marketing the pass, and the revenue from bulk pass purchases would provide a net increase to the CTA system.

Congestion pricing by time of day is an alternative that could also be explored, particularly on the rail lines which 1) tend to be more crowded than buses at rush hour and 2) tend to carry more affluent customers who would not be as severely impacted by the increase. Once the planning studies were concluded, implementation could provide a net increase to the system.

To equalize the market incentives that lead people to believe a car trip is cheaper than a transit trip, the City could adjust the price of vehicle stickers, residential parking permits and visitor permits to reflect the true market cost to resurface and maintain street parking areas, provide adequate drainage, and provide traffic control. This expanded revenue can be directed to support transit. There is little cost to making the change functional, although a large-scale public education campaign would be required to build political will for such a change.

Chicago has begun to investigate market based parking policies, including the new Transportation Enhancement Districts (TEDS) which build on research by Donald Shoup.[23] The use of market based policies could be expanded as quickly as possible, since they have been shown to generate significant amounts of revenue and simultaneously return benefits to those seeking parking, as well as easing bus navigation by reducing cruising for parking.

The City could consider a special property tax on parking spaces in public and private lots to equalize the field between transit and private vehicle trips and provide revenue for the CTA. The actual costs of parking are extensively researched in Donald Shoup's *The High Cost of Free Parking*, including a chapter entitled "The Ideal Source of Local Public Revenue."

Current Initiatives and Models

The City's "Take 5" pledge asks citizens to replace one car trip a month with a transit trip; which would account for an additional 18,500,000 transit trips per year, or about half the number of trips proposed.

There are currently several transit expansion plans under consideration. The Mid-City Transitway is a proposed 21-mile circumferential corridor extending from the Jefferson Park station on the CTA Blue Line south to Midway Airport then southeast to the 87th Street station on the CTA Red Line.[24] (An alternative plan to develop a limited access truck route for this right-of-way is also under consideration.)

The proposed Red Line extension would extend CTA rail service south of 95th street to 130th Street. CTA has recently narrowed down the proposed extensions to three possible routes for consideration.[25] While $14 million has been budgeted for 2007 to perform Alternative Analysis for New Start Projects, the 2007-2011 Capital Program does not identify future funding for projects for the given assets.[26]

The proposed Circle Line would link all of CTA's rail lines and all of Metra's lines in a study area bounded by 39th Street on the south, Fullerton Parkway on the north, Western Avenue on the west and Lake Michigan on the east, creating improved connections and shorter travel times for transit customers throughout the six-county region, thereby reducing traffic congestion.[27]

Funding any one of these proposed expansions is a challenge. The "Moving Beyond Congestion" campaign is currently working on getting increased funding as part of the state budget process. The campaign goal is to move toward a regional transit authority that has sufficient capital and operating funds to maintain, enhance, and expand transit options. Specific proposals under this campaign include more frequent, better and coordinated transit service, and a universal fare card.[28]

There is great potential to direct increased revenues from other climate strategies to funding transit. This includes revenue from a proposed carbon tax, increased parking, and city sticker and congestion fees. There is precedence for this practice. In Quebec, a projected $200 million dollars a year anticipated from a new carbon tax is largely directed to fund public transportation.[29]

Other cities have implemented innovative strategies to increase ridership. Transit agencies in San Jose, Dallas, Denver and Salt Lake offer transit passes to employers who in turn provide the passes to their employees in lieu of parking.[30] Some stadiums (and theaters and other cultural institutions) can offer transit passes with tickets, especially in those cases where free or discounted parking is offered. The University of Washington offers such a program in conjunction with Seattle Metro.[31]

The city of Pasadena, California has implemented market based parking pricing, which reduces the number of cars cruising for free parking.[32] Studies in New Haven, Connecticut and London, England have shown that cruising disproportionately affects buses, congesting the right-hand lane.

Feasibility

Financial

Investment in transit is a major capital investment requiring federal, state, and local cooperation. The financial feasibility of this strategy is somewhat dependent upon the commitment to leverage and devote revenues from other climate mitigation strategies such as a carbon tax, parking revenues, and congestion pricing to finance the transit system.

Technical

The Chicago region is utilizing Intelligent Transportation System infrastructure in its transit systems. Innovations like the Bus Tracker system piloted on the #20 Madison route, provide web-based real-time location and arrival time information. When expanded to the entire system, these new technologies will enhance transit service. The technology for parking pricing management has not yet been applied in Chicago, although the pilot programs in three Chicago communities may benefit from that technology.

Political

Inter-regional cooperation has increased with the coordination of land use and transportation planning in one agency at CMAP, and with the maturation of the Metropolitan Mayors' Caucus. Competition for limited New Start funding can still be expected to intensify.

Innovations such as employee transit passes combined with market based parking pricing offer a "carrot and stick" approach that the City can implement with minimal regional, state or federal partnerships.

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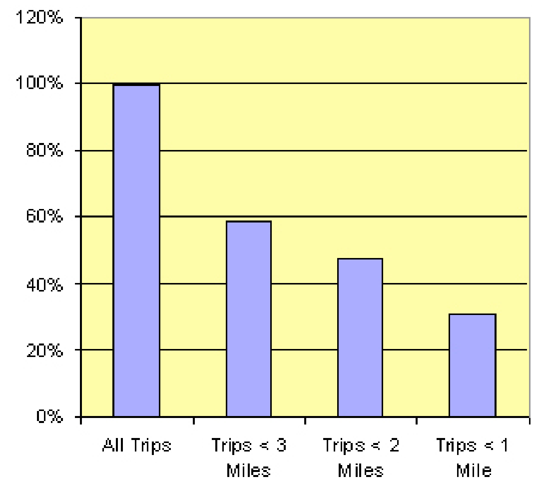
Mitigation Strategy #21
Increase Walking and Bicycling Mode Share

Strategy Summary	Scale	Value
CO2e Savings Against BAU	+	0.01 MMT CO2e
Scale of deployment	+++	1 million trips--double today's rate.
Timing	+++	Beginning 2008
Regional Impact	+	Importance of regional bicycle and pedestrian facility interconnection.
Financial Savings in relation to Cost	++	Investment needed, household savings
Additional Benefits in relation to Burdens	+++	Health and financial benefits
Feasibility assessment	+++	Bicycle plan already exists. Pedestrian plan in process

Figure 1 Percent of all trips by Length, Chicago, 1988-1991



Source: Soles and Spokes, http://www.cmap.il.gov

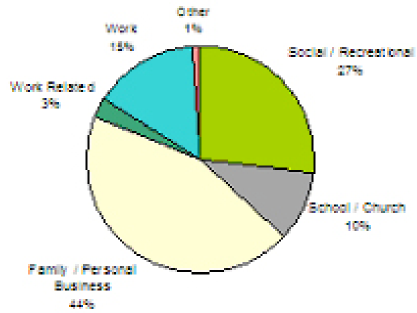
Overview

Walking and biking trips reduce greenhouse gas (GHG) emissions by decreasing the number of trips taken in motor vehicles. The graph above shows that for City of Chicago almost one third of all trips are one mile or less, and nearly half are shorter than two miles. These short trips provide a distinct opportunity to increase bicycle and pedestrian mode share, an opportunity that has not been sufficiently exploited. While it might not seem that these short trips equate to large GHG emissions reductions, it is important to remember that a short pedestrian or cycle trip often replaces a longer automobile trip, e.g. a pedestrian might choose a local store for shopping over driving to a major shopping center.

This mitigation strategy recommends doubling the current number of total walking and biking trips in Chicago by 2020. The recommendation is to target those trip lengths with the most potential; biking trips less than 5 miles, and walking trips less than 1 mile.

The U.S. Census' 2000 "Journey to Work" data shows that 73,512 people (5,956 bikers, 67,556 walkers) aged 16 or above walk or ride their bicycles to and from work in Chicago[2]. These numbers represent slightly more than six percent of the total 1,192,139 work trips that take place in the City. However, the NHTS[3] estimates that less than 15 percent of total walking and biking trips are journey to work (Figure 2), which means that the total number of pedestrian and cycling trips for all purposes is close to half a million. We recommend enacting measures to double the pedestrian-bicycling mode share to one million trips.

Figure 2. U.S. Household Trips by Purpose



Data from the National Household Transportation Survey[1]

Quantitative Results

GHG Reduction Potential: 0.012 MMTCO2e

Doubling the number of total bicycle and pedestrian trips in Chicago would result in 104, 960 fewer VMT per day. Assuming the same diversion rates as used to estimate Congestion Mitigation and Air Quality bicycle and pedestrian projects this strategy would encourage residents of Chicago to trade auto trips for walking and biking trips. The following table shows how much reduction in driving would result from this mode shift. When this goal is achieved there will be more than one hundred thousand miles of auto use reduced a day relative to business as usual, resulting in an annual greenhouse gas reduction of 0.012 MMTCO2e.

Figure 3

	City of Chicago			Six-County Region - not Chicago		
	Bicycle	Walk	Total	Bicycle	Walk	Total
Journey to work trips[2]	5956	67556	73512	6049	52,263	58,312
Total Trips	39707	450373	490080	40327	348,420	388,747
Total Diverted Trips[4]	14997	159117	174114	15231	123,097	138,328
Total Diverted VMT	35,279	69,682	104,961	33,924	141,364	175,287
MTCO2e/Day	10.35	20.450	30.804	9.956	41.487	51.443
MTCO2e/Year	3,779	7,464	11,243.313	3,633.888	15,143	18,777
MMTCO2e/Year	0.004	0.007	0.011	0.004	0.015	0.019
Population increase from 2000 to 2020[5]	1.037	1.037	1.037	1.072	1.072	1.072
2020 reduction	0.004	0.008	0.012	0.004	0.016	0.020

Scale Assumed

490,080 is the total number of new bike-pedestrian trips desired by 2020—a 100% increase from 2000.

Deployment Timeline Assumed

Beginning in 2000, this strategy assumes 25,000 new bike-pedestrian trips per year.

Per-unit Reduction Potential

For every additional 10,000 bicycle and pedestrian trips, 2.9 MT CO2e is reduced.

Activity Savings

Replacing motor vehicle travel with bike-pedestrian travel would result in reduction of total vehicle miles traveled of 104,960 miles per day—the same as the lifecycle of an automobile.

Life-cycle GHG Impact

Increased walking and biking does require some infrastructure changes, and biking requires a bicycle. However, the incremental demand over auto infrastructure construction and maintenance will not have a large impact (more likely, the impact will reduce greenhouse gases).

Regional GHG Reduction Potential

In the six-county region, shifting car travel to walking biking for 280,247 vehicle miles traveled per day will reduce greenhouse gases by 0.032 MMTCO2e per year.

Municipal GHG Reduction Potential

The City of Chicago can reduce CO2e by encouraging its employees to bike and walk to work.

Economic Profile

Financial Cost

The financial costs of this strategy include implementing the recommendations of the Bike 2015 Plan and the forthcoming Pedestrian Plan. Both of these plans include specific changes that the City can make to encourage biking and walking in Chicago (see Program Elements below). Costs vary greatly depending on the specific recommendation. New sidewalks, for example, cost approximately $15/linear foot for curbing and $11/square foot for walkways.[6] A crosswalk can cost as little as $100 for a regular striped crosswalk to $3,000 for a patterned concrete crosswalk. The popular traffic calming strategy of curb extensions costs from $2,000 to $20,000 per corner, depending on design and site conditions. Bike lanes cost approximately $5,000 to $50,000 to install per mile, depending on the condition of the pavement, the need to adjust signalization, and other factors. So-called "soft programming," or non-engineering strategies, also vary dramatically in cost of implementation. A Safe Routes to School encouragement or education program could be implemented at a school for as little as $5,000-15,000, while larger bicycle and pedestrian events, safe driving campaigns or personalized mode-shift marketing can cost upwards of $50,000 to $550,000 annually. Basic adult bicycles can be purchased for as low as $100-$300, and even less if purchased used.

Financial Savings

While many of the financial costs of this strategy are concentrated on upfront capital expenditures, the savings are distributed among the residents and businesses in the city. Increased walking and biking coupled with access to transit reduces households' dependence on personal vehicles, which lowers operation costs and frequently reduces car ownership. CNT's research has shown that owning fewer cars saves households money on transportation expenditures. Households that own two or more vehicles spend 19 percent of their total income, on average, on transportation expenditures, while households that own one or less vehicles and have access to transit spend as little as 10 percent of their total income on transportation expenditures.[7] Additionally, increasing the mode share of walking and bicycling can help reduce vehicle congestion on Chicago's roads, saving residents and businesses valuable time.

Qualitative Results

Program Elements

Doubling the number of walking and biking trips in Chicago is a multifaceted challenge. The Bike 2015 Plan effectively approaches its goal to increase bicycle mode share with several diverse programs including improved infrastructure, educational programs, financial incentives to bike, and increased enforcement. This plan has already resulted in an increase in bike-to-work levels.[8] Chicago can continue to implement and expand the depth of the Bike 2015 Plan. Completing and implementing a Pedestrian Plan with similarly ambitious, but achievable, mode shift goals and comprehensive strategies can also be pursued. Additionally, the speedy and comprehensive implementation of the City's new Complete Streets Policy[9] will help improve the built environment for walking and biking.

One of the major factors influencing travel mode choice—especially walking and biking—is location of travel destinations. Places that people want to go to must be within convenient walking or biking distance to choose non-motorized modes of travel. Therefore, one of the most important policies in support of increased cycling and walking is compact land use. Additionally, transit has a symbiotic relationship with walking and biking, enabling walkers and bikers to link trips to travel greater distances. Other policies with positive effects on bike-pedestrian mode share include parking reforms, incentives for carpooling, and increased car sharing. Each of these policies can reveal the incremental costs and benefits of mode choice, resulting in increased walking and biking for shorter trips. Studies conducted on car sharing; for example, show that users walk and bike greater distances than before they joined a car sharing service.[10] All of these policies provide an essential framework for bicycle and pedestrian mode. However, since they affect pedestrian and bicycle mode share indirectly, and are also addressed in other mitigation strategies, this strategy focuses on specific changes that can help improve the environment for pedestrians and bicyclists to increase non-motorized travel mode share.

Benefits and Burdens

Walking offers great health benefits as the most accessible form of exercise, and is considered to be one of the key strategies to confronting the looming obesity epidemic.[11] According to Lilah Besser and Andrew Dannenberg, in an article for American Journal of Preventive Medicine, "Americans who use transit spend a median of 19 minutes daily walking to and from transit; 29 percent achieve more than 30 minutes of physical activity a day solely by walking to and from transit."[12] Additionally, a walkable, bikeable city relieves its residents of the financial burden of owning and operating a car (see Financial Savings section below). Other benefits include increased public safety through more "eyes on the street," and the economic benefits to local business through increased foot traffic.

Implementation Mechanisms

There are numerous strategies required to increase bicycle and pedestrian mode share, many of which are included in the Bike 2015 Plan and will figure largely in the forthcoming Pedestrian Plan. As is modeled in the Bike 2015 Plan, it is important that the implementation mechanisms pursue the mode-shift goal from multiple vantages. As a GHG mitigation strategy, this plan could be fully implemented and even expanded.

1) **Implement City of Chicago Bike 2015 Plan.** The overall goal of the Bike 2015 Plan is to increase the bicycle mode share to five percent of all trips less than five miles. Focusing on implementation of the following goals and performance measures, as stated in the Plan, will help achieve the increase in bicycle trips:

    a. **Bikeway Network** – Establish a 500-mile bikeway network that serves all Chicago residents and neighborhoods by 2015.

b. **Bicycle-friendly Streets** – Make all Chicago's streets safe and convenient for bicycling. Bicyclists' needs could be considered in every Chicago roadway project by 2010.
c. **Bike Parking** – Provide convenient and secure short-term and long-term bike parking throughout Chicago. Install 5,000 total bike racks and 1,000 long-term bike parking spaces by 2015.
d. **Transit** – Provide convenient connections between bicycling and public transit. Increase the number of bike-transit trips by 10 percent per year.
e. **Education** – Educate bicyclists, motorists, and the general public about bicycle safety and the benefits of bicycling. Educate 250,000 people per year about bicycle safety and the benefits of bicycling.
f. **Marketing and Health Promotion** – Increase bicycle use through targeted marketing and health promotion. Encourage 150,000 people per year to make additional bicycle trips because of targeted marketing and health promotion.
g. **Law Enforcement and Crash Analysis** – Increase bicyclist safety through effective law enforcement and detailed crash analysis. Reduce the number of serious and severe bicycle crashes by 50 percent by 2015.
h. **Bicycle Messengers** – Expand the use of bicycle messengers; improve their workplace safety and public image. Increase the number of bicycle deliveries in Chicago by 25 percent by 2015.

2) **Create and Implement City of Chicago Pedestrian Plan.** Chicago's forthcoming Pedestrian Plan will develop a set of policies to address, improve, and enhance pedestrian safety and activity throughout the city. It will develop a set of actions that will identify how, what, who, and when to implement pedestrian improvements. The plan is being developed with the guidance of the Mayor's Pedestrian Advisory Council (MPAC). Many of the goals and strategies of the Pedestrian Plan are likely to overlap in significant measure with the Bike 2015 Plan. Arguably the most crucial strategy for the purposes of climate change mitigation is a clear goal to increase pedestrian mode-share by an ambitious but achievable percentage by 2020. This overall goal would be pursued, like the Bike 2015 Plan, through an array of sub-goals and strategies, including but not limited to:

a. **Increase enforcement and education of pedestrian laws**, such as the pedestrian right-of-way at crosswalks.
b. **Improve year-round maintenance** of pedestrian infrastructure, including snow removal.
c. Due to the symbiotic relationship between walking and transit, work to systematically **improve transit access and egress** at all train stations and bus stops.
d. **Improve driver behavior** through traffic calming (crossing islands, bump-outs, etc), and social marketing campaigns, especially around schools, transit, senior centers and other areas with a high concentration of pedestrian activity and/or pedestrian potential.
e. **Market and promote the health and financial benefits** of increased walking. Launch walking promotions similar to the City's Bike Month.
f. **Develop and implement School Travel Plans** for every Chicago school. Leverage participation in Illinois Department of Transportation's (IDOT) Safe Routes to School Program and build off of the success of the Bicycle Ambassador and Walking School bus programs.
g. In addition to focusing on high pedestrian crash locations, the Pedestrian Plan could **target its strategies and goals to areas and populations with the most potential for increased walking.** Areas around transit and areas with elderly populations and children often have high unmet potential for non-motorized transportation. Portland, Oregon has developed a Pedestrian Potential and Deficiency index for determining areas with the highest pedestrian potential.[14]
h. **Implement a widespread individualized mode shift marketing program**, providing households with the personalized attention they need to shift their travel habits.
i. Finally, **collect better pedestrian data** to determine effective strategies for increasing pedestrian mode share.

Current Initiatives and Models

There are several successful programs and pilot projects that the City of Chicago can build off of to help increase bicycle and pedestrian mode share. These programs include:

- The City of Chicago has increased the focus on bicycling with bike facilities—parking and showers—at Millennium Park. All new City facilities could include bike parking, lockers, showers and other facilities that make biking to work and other destinations possible.
- The Chicago Department of Transportation (CDOT) pedestrian program is responsible for both the Bicycle Ambassador program, which teaches bicycling skills, and the Walking School Bus Programs.[15] A walking school bus is a group of children walking to school with one or more adults. It can be as informal as two families taking turns walking their children to school to a structured route with meeting points, a timetable and a regularly rotated schedule of trained volunteers.
- The Chicagoland Bicycle Federation's individualized mode shift marketing program—Go Healthy!—encourages residents to include active travel in their lives.[16] The program works by identifying people within a target population who aspire to change their travel behavior. The program's goal is then to shift two trips a week per person in any one household to biking, walking, transit, or some combination of the three. It adapts and builds on the successful TravelSmart program from Australia and Portland, Oregon.[17]
- The successful five-month "Bike Chicago" program from the Mayor's Office of Special Events could be replicated in a "Walk Chicago" encouragement program. This type of program would foster a culture of walking similar to the pronounced bike culture that has been created in Chicago.

The TravelSmart program identifies individuals who want to change the way they travel and provides them with the information, incentives, encouragement and tools they need to shift from driving to transit, bicycling, walking, car sharing or carpooling. Participants are identified by targeted outreach to those geographies with the greatest mode shift potential. In Portland, the program resulted in nine percent less car travel in the targeted geography with a corresponding eight percent increase in walking, cycling, and public transit.[18] These figures represent a 12 percent reduction in Vehicle Miles Traveled (VMT). Changes in travel behavior were shown to sustain one year after the initial marketing efforts. Furthermore, the data indicated that these results did not affect participants' overall mobility in terms of their activities outside the home, travel time and number of trips per day. The results support the use of individualized marketing as an effective strategy to increase environmentally friendly modes of travel and reduce car travel.

Paris, France recently launched a bicycle rental program that aims to put over 20,000 bicycles at 1,400 stations throughout the city. The bicycles, which are paid for by the user by the half hour are intended for short trips. The effort is managed by a private venture owned, in-part, by the advertising and street furniture company JCDecaux.[19] The program is a larger-scale version of free community bicycle programs that have been attempted to mixed success in many cities.[20]

Feasibility

Financial

There will be financial costs to making Chicago more bikeable and walkable (see Economic Profile). The actual figure will depend on specific plans, which, if funded by the federal government through the Surface Transportation Program, will include a level of community participation.

Technical

The tools needed to increase walking and biking to replace motorized travel exist. This strategy is technically very feasible.

Political

This strategy is very feasible as there is already a Bike Plan for the City of Chicago. The Bike Plan could be expanded to include 2020 goals, as well as be used as a model to develop a pedestrian plan. There are a number of bike and pedestrian partnerships that exist in the City of Chicago including Chicago Bicycle Federation and the Mayor's Pedestrian Advisory Council.

While there is great support in the City for increased bicycle access and pedestrian travel, there can be political tensions between bicycle and driving proponents. Some efforts for traffic calming have met with resistance from motorists and local establishments who fear limits on driving speeds and/or parking limitations.

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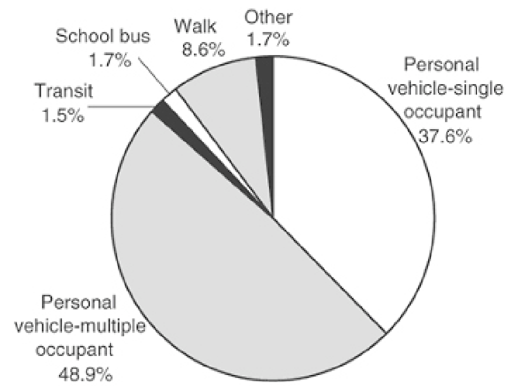
Mitigation Strategy #22
Increase the Use of Car Sharing, Carpooling and Vanpooling

Strategy Summary	Scale	Value
CO2e Savings Against BAU	+	0.300-0.511 MMT CO2e
Scale of deployment	++	10-20%increase each year
Timing	+++	2008-2020
Regional Impact	+	0.307-0.518 MMT CO2e
Financial Savings in relation to Cost	++	High upfront costs, but funding potential and household savings
Additional Benefits in relation to Burdens	+++	Air quality, mobility, community development and livability
Feasibility assessment	++	High costs but existing programs to draw from

Figure 1 Proportion of Trips by Mode



Source: 2001 National Household Travel Survey, daily trip file, US Department of Transportation

Overview

Car sharing and carpooling and vanpooling are two alternatives to daily and weekly travel in a single-occupancy vehicle that can reduce greenhouse gas (GHG) emissions. The CO2e savings potential ranges from 0.300 to 0.511 MMT CO2e depending on how aggressive the policy implementation is for each program.

Car sharing is a membership program that offers an alternative to car ownership by providing members access to a fleet of vehicles that can be reserved and paid for on an hourly basis. Insurance, maintenance and gas costs are covered under an hourly and per mileage rate. Car sharing does not necessarily preclude car ownership, but makes traveling without having to own a car more feasible and attractive, particularly when a diversity of vehicles are offered that can be used for a range of activities—transporting large items or going to a doctor's appointment for example. The pricing structure of car sharing is designed to support short-term trips and is not a tool for daily commutes to work. Car sharing is a CO2 reduction strategy because it supports less frequent driving, and allows car-sharing participants to make greater use of public transportation, biking, and walking. Also, CO2e is reduced to the extent that car-sharing fleets are more fuel and emissions efficient than average private cars.

Carpooling and vanpooling are based on the idea that, while it is difficult to reduce the number of trips or vehicle miles traveled (VMT) needed to commute to work, it is quite feasible to double up on the vehicle occupancy, or in the case of vanpooling to increase the occupancy up to 12 people. Carpooling is the practice of increasing vehicle occupancy per trip and is usually organized around journey to work trips. Carpooling tends to be informally organized through friends, coworkers, or online carpooling websites. Similarly, vanpooling serves as a transportation alternative whereby employers, transit agencies, or Transportation

Management Associations organize groups of 6 or more individuals to use an independently owned van for their daily work commute. Typically, all members pay on monthly basis for the service with the exception of the volunteer driver, whose monthly fee is waived for their services.

Promoting car sharing and carpooling not only increases mobility options for residents but also works to reduce the total vehicle miles traveled for Chicago residents. The strategies are complementary, as car sharing is suited for most trips other than journey to work, so a car sharing participant would benefit from being able to carpool or vanpool to work. Car sharing, carpooling, and vanpooling are feasible mitigation strategies, as both entail the expansion of preexisting programs, with little focus on start-up efforts. However, the challenge still lies in expanding the scope of these programs to the degree that they will have a significant impact on the City's CO2e emission reduction goal.

Quantitative Results

GHG Reduction Potential: 0.300-0.511 MMT CO2e by 2020

Of the GHG reduction potential, 0.164-0.375 MMT CO2e is from expanding car sharing programs and 0.136 MMT CO2e is from increasing carpooling and vanpooling options.

Scale Assumed

There are presently two car sharing companies in Chicago.[1] To reach the low-level projected savings of 0.164 MMT of CO2, overall service would have to increase by 10% more than the BAU, to 5,369 vehicles.[2] To reach the more aggressive savings potential of 0.375 MMT CO2, the level of service, including the number of cars and members, would have to increase by 20% more than the BAU. Figure 2 shows different scenarios for increasing service and reducing CO2e.

This mitigation strategy calls for going beyond the Business as Usual (BAU) projection by increasing the number of car sharing vehicles 10-20% more per year. The BAU scenario assumes car sharing in Chicago continues to grow at historical rates of 60 additional cars per year.[3] The BAU scenario saves nearly 0.046 MMT CO2 annually by 2020 compared to no car sharing program.

Figure 2 Potential CO2e Savings from Car Sharing

Increase in Service	Number of Cars Required in 2020	Difference from BAU	MMT CO2 Savings in 2020
BAU (add 30 cars per year per company)	1,180.00	0.00	0.000
5%	2,684.90	1,504.90	0.059
10%	5,369.80	4,189.80	0.164
15%	8,054.70	6,874.70	0.269
20%	10,739.61	9,559.61	0.375
30%	16,109.41	14,929.41	0.585
40%	21,479.21	20,299.21	0.796

The GHG reduction potential of car sharing is calculated based on the long-term study of City CarShare in San Francisco carried out by Robert Cervero et al, which found that the average car share member consumes just 0.03 gallons of gasoline per day for all trips in all modes, while the average nonmember consumes 0.31 gallons, or ten times more. The resultant emissions savings of a car share member is 0.897 metric tons CO2 per year.[4] At the time of the study, City CarShare had 3,800 active members and 87 vehicles, for an average of 43.7 active members per vehicle.[5]

The carpool and vanpool portion of this strategy assumes a 10% increase in the number of people who choose to carpool and vanpool to work rather than drive alone, resulting in 0.136 MMT CO2e savings in 2020. Figures 3 and 4 show CO2e savings scenarios from carpools and vanpools respectively.

Figure 3 Potential CO2e Savings from Carpools

	Percent of Commuters Carpooling	Number of People Carpooling	(Average) Number of Carpools	CO2e Savings in MMT	CO2e Savings from BAU
2000	22.42%	168765	75,679	0.265	
2020 - Business as Usual	22.42%	182,919	82,027	0.288	
5% Increase in Commuters Carpooling and Vanpools	27.42%	224,666	100,747	0.353	0.066
10% Increase in Commuters Carpooling and Vanpools	32.42%	266,412	119,467	0.419	0.131
15% Increase in Commuters Carpooling and Vanpools	37.42%	308,158	138,188	0.484	0.197
20% Increase in Commuters Carpooling and Vanpools	42.42%	349,904	156,908	0.550	0.262
Sources: US Census Bureau, 2000 Decennial Census with 2020 Projections calculations from Northeastern Illinois Planning Commission (NIPC). Calculations assume the average carpool in Chicago is 2.23 people and the average commute is 30 miles round trip, 250 works days per calendar year and 0.38kg CO2e/VMT (solo travel at 23 mpg). BAU assumes the same 22% of workers who commute to work by vehicle continue to carpool (and that 25% of total projected population are workers 16 years or older).					

Figure 4 Potential CO2e Savings from Vanpools

	Number of People in Vanpool	(Average) Number of Vanpools	CO2e Savings in MMT	CO2e Savings from BAU (in MMT)
2000	3,957	440	0.010	
2020 - Business as Usual	4289	477	0.011	
5% Increase in Commuters Carpooling and Vanpools	5268	585	0.013	0.002
10% % Increase in Commuters Carpooling and Vanpools	6247	694	0.016	0.005
15% % Increase in Commuters Carpooling and Vanpools	7225	803	0.018	0.007
20% % Increase in Commuters Carpooling and Vanpools	8204	912	0.021	0.010
Sources: Calculations assume the average vanpool is 9 people and that 2.3% of workers who carpool and vanpool that use vanpools in 2020 – these commuters are not included in the totals for Figure 3 Potential CO2e Savings from Carpools since they would then be counted twice.				

Timeline

In order to reach the GHG reduction potential from this mitigation strategy, both car share cars and car share members must increase 10% by 2020.

Per-unit Reduction Potential

Every car sharing car saves an average of 39.19 metric tons of CO2e annually.[6] Each two-person carpool saves 2.85 metric tons CO2e per year.[7] Each 9-person vanpool saves 22.8 metric tons CO2e per year.[8]

Activity Savings

Car sharing has the potential to save 20-46 million gallons of gasoline in 2020. Carpooling and vanpooling can potentially save 16 million and 265,600 gallons of gasoline respectively.

Regional GHG Reduction Potential

The regional GHG reduction potential from this mitigation strategy is 0.307-0.518 MMT CO2e by 2020.

While car sharing is not as suitable for less dense suburban communities, there is potential to expand around Metra stations and denser suburban communities like Elgin and Joliet. There are 156 suburban Metra stations; placing a car sharing vehicle at each station would result in an additional savings of 0.006MMT CO2e per year at average usage rates.[9]

There are 36 major employment centers in the six-county suburbs, constituting 585,350 jobs. If each employment center operated 5 vanpools of 9 people, there is the potential to reduce an additional 0.004MMT CO2e.[10]

Life cycle GHG Impacts

Any reduction in gasoline use will have additional lifecycle GHG benefits, as the US EPA estimates that the lifecycle CO2 emissions of gasoline are 24-31% higher than the tailpipe emissions. In addition, a reduction in vehicle demand would reduce the GHG impacts of vehicle materials and manufacturing.

Municipal GHG Reduction Potential

Based on the average savings for a car share car, if City of Chicago were to replace its 25 leased hybrid sedans plus an additional 5 cars from its municipal fleet every year beginning in 2008 until 2020, there is the potential to save 0.0035 MMT CO2e.[11] However, this savings assumes that drivers using the city fleet have the same usage patterns as the average driver. Much of the savings resulting from car share use derive from reduced vehicle travel, if a transition of the city fleet to car share cars did not alter vehicle travel patterns, and vehicle efficiency were similar, there would be no savings to the city from this strategy.

Approximately 40,000 people are employed by the City of Chicago government.[12] Many of these people drive to work. If City departments organized carpools or vanpools, particularly for workers who live in areas of Chicago where transit access is limited, City government could set an example for other large employers.

Economic Profile

Financial Costs

Growth of car sharing involves considerable investment on the part of the car sharing operator; however, over time car sharing user fees can support increased growth in fleets. If car sharing is to be a strategy widely available throughout the city, investment will be necessary to grow car sharing, particularly in less dense communities.

There is no cost on the part of the municipality, although the City could choose to provide parking spaces for car sharing vehicles.

Financial Savings

Car sharing provides cost savings over owning and operating a private vehicle. In Chicago, the average car sharing member could save as much as $4,000-$6,000 per year in transportation costs.[13]

Municipalities can realize savings by transitioning their fleets to car sharing. The City of Philadelphia has confirmed a cost savings of $5,385,000 over the next 5 years, by removing 75 cars from its fleet and replacing them with 3 Philly CarShare vehicles.[14]

Carpooling and vanpooling, which distribute vehicle costs across passengers, also reduce transportation expenditures per person. Reduced traffic that may result from increased carpooling and vanpooling could lead to savings from lower congestion and road repair.

Qualitative Results

Program Elements

This mitigation strategy calls for increasing the use of car sharing in Chicago by increasing the number of cars to 5,369 vehicles and the number of members to 204,022 by 2020. Further, this strategy calls for increasing participation in carpools and vanpools by 97,961 people and 1,153 people respectively. The City of Chicago could foster this growth through parking allocations, membership expansion from its own employees and marketing assistance.

Benefits and Burdens

Numerous studies have shown the benefits of car sharing in both car ownership patterns and travel behavior. According to the I-GO car sharing program, every car sharing vehicle in their fleet replaces 17 privately owned vehicles. Vehicle replacement numbers vary from 5 to 20 depending on the car sharing company—how many cars they operate, where they are located in relation to members, how dense an area is and how accessible to alternative modes of transportation, and members' behavior in terms of selling cars and/or delaying the purchase of new cars. Car sharing also alters member behavior. Members drive less; they chain trips together when driving and use other modes of transportation, especially public transportation, more often. These behavior changes result in reduced vehicle miles traveled (VMT) and travel distances—as people are more likely to use services closer in proximity, which in turn benefits the community.

The direct benefits of reduced vehicle travel, whether through car sharing, carpooling or vanpooling include reduced gasoline usage, road congestion, criteria air pollution and parking needs—both for residents and businesses. Users can also see individual cost savings from lowering gasoline use, car maintenance and possibly automobile purchases.

The burdens of car sharing are carried by the car sharing companies themselves. The major expenses incurred are the purchase price of cars or the cost of maintaining leases for the fleet, and the price of parking downtown and in certain neighborhoods. Carpool or vanpool organizers must handle similar issues, such as coordinating passenger logistics, auto maintenance, and managing shared expenses.

Implementation Mechanisms

Although the number of cars in a fleet and the number of members in a car sharing organization are not directly in the realm of City government, Chicago can still implement a number of policies that help achieve the goals:

1) **Incorporate car sharing vehicles into city fleet.** A number of cities nationwide are gradually transitioning their City fleets to car sharing. Fleet partnership arrangements allow designated vehicles to be reserved for City business during the working day and then are open to all members during the evenings and weekends. These partnerships have so far resulted in cost savings for the municipality and membership and usage growth for the operator.[15]

   While fleet partnerships are advantageous to cities with older, less fuel efficient fleets, Chicago is actively working to green their City fleet with advanced fuel technology and low-emission, hybrid vehicles. For this reason, a partnership between the Department of Fleet Management and Chicago's car sharing companies could primarily take the form of parking provisions and encouraging membership among employees while transitioning a portion of the City's current fleet to car sharing vehicles.

Currently, the City of Chicago's fleet contains a number of low-emission vehicles, as listed in Figure 5. As Howard Henneman, Commissioner of the Department of Fleet Management, recently presented, part of the Green City Fleet Action Agenda is to increase the size of the alternative fuel and hybrid fleet by 10% annually. There are two elements to the Action Agenda that have the potential to incorporate car sharing. First, of the City's 83 hybrid sedans, 25 are leased by the City and not currently owned. Potentially, the City could replace leased vehicles with low-emission car sharing vehicles. Second, instead of purchasing new hybrid vehicles each year, the City could commit to adding access to car sharing vehicles on a yearly basis. Clearly, car sharing could not compensate for the 10% annual increase as car-sharing vehicles do not include the heavy construction machinery, emergency vehicles, and alternative fuel vehicles that constitute the majority of the fleet.

Figure 5 City of Chicago's Green Fleet

Type of Vehicle	Number of Cars in Fleet
Ethanol (E-85) light duty vehicle	192
Compressed Natural Gas (CNG) powered vehicles, including 2 newly repowered CNG refuse trucks, equipped with Cummins Westport #CG-275 engines	78
Hybrid Sedans	58 (33 City owned and 25 leased)
Hybrid SUV's	99

A partnership between the Department of Fleet Management and Chicago's car sharing companies could also include access to parking spaces downtown and throughout the City, and membership subsidies for City employees. The City of Chicago owns and maintains parking lots and garages downtown and at various city buildings throughout the City, i.e. libraries, fire stations, police stations, etc. They could offer free or subsidized parking or even in some cases the ability to rent parking spaces in these parking facilities to car sharing companies. Furthermore, the City could offer incentives for City employees to sign up for car sharing.

2) **Incorporate development incentives for car sharing into the zoning code.** Currently, developers of multi-family residential and condominium buildings can work with car sharing companies on an ad-hoc basis and negotiate parking requirements when car sharing is incorporated into the development project. However, the City of Chicago could codify these incentives into their zoning regulations. Linking access to car sharing to planning and zoning decisions (1) provides the foundation for longer-term growth and (2) allows for the longer-term impacts of car sharing to be captured through a reduced level of parking or roadway infrastructure.

3) **Work with car sharing companies to provide on- and off-street parking.** This is another implementation mechanism to increase the number of parking spaces available to car sharing vehicles and to increase program visibility. Marked parking zones for car-sharing, free metered on-street parking, and discounts in municipal lots are typical examples of parking support. Currently, several Aldermen have created on street parking for car sharing. These kinds of agreements could be made into an official, community-wide process, similar to models in Seattle and Philadelphia.

4) **Team up with transit agencies to market car sharing.** While some transit agencies provide free or reduced parking rates for car share vehicles, the Regional Transit Authority and specifically the

CTA could work to promote car sharing through other channels. Typically, marketing is mainly provided on transit agency websites and through advertisements and brochures on buses and trains and in stations. Transit riders are usually the core market for car sharing operators and marketing the two services together can be beneficial to both operations.

5) **Include privately-owned vehicles in car sharing.** A mechanism to incorporate private vehicles in car sharing programs could expand available fleets. This model has already been implemented in Germany's CashCar organization.[17] According to this model, when an individual is not using his or her personal car, it can be incorporated into the car sharing fleet, with a portion of revenues going to the private owner.

6) **Expand carpooling websites and databases.** This could be acheived by incorporating a carpooling service into existing car sharing organizations. Carpooling software could easily be bundled into a car sharing service.

7) **City of Chicago could organize and run employee vanpools.** The City could also offer incentives to other major employers who organize and run employee vanpools.

Current Initiatives and Models

Car sharing in Chicago, and car sharing programs in other cities, have been shown to alter the driving patterns of users, increase transportation savings, reduce car ownership levels, and produce GHG reductions. These programs, if expanded as proposed in this strategy, would significantly reduce CO2e in Chicago.

There are examples of extensive car sharing programs across the nation and throughout Europe that can serve as examples for how to expand car sharing in Chicago. Many of these programs are implementing some of the mechanisms listed in the previous section.

As noted earlier, the City of Philadelphia joined Philly CarShare—reducing its fleets by more than 330 municipal vehicles, saving the taxpayers $2 million annually.[18] The City of Berkeley adopted a similar fleet reduction policy in 2005, and has so far eliminated 15 vehicles from its fleet, replacing them with low-emissions car shares.[19] The Philadelphia Parking Authority (PPA) provides free off-street parking for Philly CarShare in about half a dozen different facilities, mainly in residential areas.[20] Other cities that provide on-street parking, as well or instead of off street parking, are Portland, Seattle and Vancouver, BC.

For carpooling, a recent is example is GoLoco—a part carpooling, part social networking website provides access to real-time carpooling information, while adding a fun social element that may make carpooling more attractive to some. Illinois Lt. Governor Pat Quinn hosts a carpooling site[21] that similarly works to connect people to car sharing opportunities in Illinois.

A more formal example of facilitating carpooling involves employers creating disincentives for parking, which often results in increased carpooling. In 1990, Cornell University in Ithaca, NY determined that their 9,000 faculty and staff were a burden on the University's parking system. The University decided to raise parking fees to create a disincentive to driving to campus alone. This change resulted in 600 fewer cars being driven to campus each day and an average vehicle occupancy of 2.2 people per car. Each individual in a registered carpool received up to two books of 10 one-day parking permits per year. Cornell estimated that in 15 years, they were able to reduce commuter miles by 10 million VMT/year.[22]

There are also existing carpooling and vanpooling operations in the region—one started by the Lake-Cook Transportation Management Association (TMA) and now run by PACE which successfully organizes shuttles and vanpools—that can be expanded upon.[23] PACE also runs a Vanpool Incentive Program (VIP), which is an example of how a transit agency can promote various modes of transportation. Among their programs are the traditional types of vanpools: 1) rider pays a monthly fee and employer shuttles, 2) employer pays for service and Metra feeder, and 3) riders pay to have vanpool between the Metra station and office.[24]

Feasibility

Financial

Given the current growth rate of car sharing in Chicago, and the growing awareness and popularity of car sharing in the United States, the goal of 10% annual increase in service is certainly within reach. However, the biggest obstacle to the 2020 goal of 5,369 vehicles will remain the acquisition of new vehicles. To achieve this goal, Chicago could explore the use of available federal funds in fleet acquisition (e.g., Congestion Mitigation and Air Quality grants or Job Access Reverse Commute funds which would help operators locate in low income neighborhoods). Support for research into new methods of growth, such as the possibility of including private cars in car sharing fleets would also be useful in fully realizing the potential of this mitigation strategy.

Technical

The technology to expand car sharing and carpooling and vanpooling exists, and is currently operational.

Political

For the level of car sharing service to increase by 10% annually—the less aggressive and more feasible of the two scenarios described—car sharing would need explicit support from both the City government, the Regional Transit Authority and the Chicago Transit Authority, particularly in the form of parking provisions and marketing assistance.

Expansion of carpooling and vanpooling is entirely feasible. There is very little cost associated with both carpooling and vanpooling. The major obstacle is attitude of commuters who may prefer to be in control of their schedule and route with a private vehicle. Attitudes may be changing given the rising gasoline costs and traffic congestion in the Chicago region.

References

1 Two companies were used based on existing programs in Chicago—I-GO car sharing and Zip Car. Both are established and have plans to expand in the Chicago area. I-GO is a non-profit affiliate of CNT.

2 This scale has been achieved by Mobility Car sharing in Switzerland.

3 Both I-GO and Zipcar have grown in fleet size and membership since inception. During its five year existence, the median increase in fleet size for I-GO is 40 cars per year. Given the unlikelihood of maintaining an exponential rate of growth, a more conservative 30 cars per year is being used here for the BAU model.

4 CO_2e savings were not calculated, because N_2O and CH_4 emissions from mobile combustion are highly dependent on vehicle type. CO_2e savings could be 2% -5% higher than CO_2 alone.

5 Robert Cervero, Aaron Golub, and Brendan Nee, Institute of Urban and Regional Development, University of California at Berkeley, "San Francisco City CarShare: Longer-Term Travel-Demand and Car Ownership Impacts," Department of Transportation and Parking, City of San Francisco, http://www-iurd.ced.berkeley.edu/pub/WP-2006-07.pdf.

6 Robert Cervero, Aaron Golub, and Brendan Nee, Institute of Urban and Regional Development, University of California at Berkeley, "San Francisco City CarShare: Longer-Term Travel-Demand and Car Ownership Impacts," Department of Transportation and Parking, City of San Francisco, http://www-iurd.ced.berkeley.edu/pub/WP-2006-07.pdf.

7 This is calculated as - (30 mile round trip commute)*(250 days of work in a year)* (0.38kg CO2/VMT – assumes solo travel at 23 miles per gallon)/1,000

8 Assumes same journey to work as for carpool (noted in the sentence directly preceding the sentence on vanpool) by a 9

person vanpool.

9 This is calculated as – (156 Metra Stations)*(39.19 CO2 per car sharing vehicle)/1,000,000

10 This is calculated as - (5 vanpools)*(36 major suburban employment centers)*(9 people per vanpool)*(30 mile round trip commute)*(250 days of work in a year)* (0.38kg CO2/VMT – assumes solo travel at 23 miles per gallon)/1,000

11 This is calculated as – (25 leased hybrid sedans)+(5 cars removed from municipal fleet per year)*13(years)*(39.19 metric tons CO2)

12 Kathryn Peterson, "Chicago's Largest Employers," Crain's Chicago Business, August 1, 2005.

13 ZipCar estimates the monthly cost of car ownership in Chicago is $839/month and that a heavy ZipCar user spends about $311/month on car sharing. The yearly difference is $6,336. Source: ZipCar, www.zipcar.com\/chicago/is-it/compare-own.

14 Philly Car Share, www.phillycarshare.org/24/news/press-room.

15 Tom Bates, "Commentary: Berkeley is Once Again a Progressive Leaser," The Berkeley Daily Planet, July 12, 2005.

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21 Illinois Lt. Governor Pat Quinn's Carpooling Website, http://www.standingupforillinois.org/carpool/index.html.

22 U.S. Environmental Protection Agency, Office of Air and Radiation. Carpool Incentive Programs: Implementing Commuter Benefits as One of the Nation's Best Workplaces for Commuters. November 2005, http://www.bwc.gov/pdf/carpool.pdf.

23 Rachel Harshman and Mary DeBacker, Metropolitan Planning Council. Transportation Solutions for Employers and Employees: Transportation Management Association of Lake-Cook. February 2001, http://www.metroplanning.org/resource.asp?objectID=450.

24 Pace, "Vanpool Programs: Metra Feeders," http://www.pacebus.com/sub/vanpool/metra_feeders.asp.

Mitigation Strategy #23
Develop Intercity High Speed Rail Network

Strategy Summary	Rating	Value
CO2e Savings Against BAU	+	.006 MMT CO2e
Scale of Deployment	++	13.6 million riders expected annually (from region)
Timing	+	10-year build-out
Regional Impact	+	0.01 MMT CO2e
Financial Savings in Relation to Cost	++	1.8 benefit to cost ratio
Additional Benefits in Relation to Burdens	+++	HSR provides many opportunities
Feasibility Assessment	++	Expensive but technically and politically feasible

Figure 1 Figure 1 Proposed Midwest Regional High Speed Rail Network[1]

Overview

High speed rail can serve to make intercity passenger travel more efficient—reducing high-emitting passenger vehicle and air trips less than 500 miles in length. High speed rail is a piece of an interconnected transportation system that provides choice, brings economic benefit and stands to reduce CO2e. Introducing high speed rail that will serve Chicago and its residents is at the center of this mitigation strategy.

High speed rail has multiple definitions. It has been defined such that it must meet speed requirements ranging from 110-150 MPH. The Federal Rail Administration defines high speed rail as anything faster than driving that is time competitive with air or automobile travel at distances of 100 to 500 miles. A combination of those two types of high speed rail within the framework of an interconnected network that includes feeder routes to high volume corridors may be practical for the Midwestern United States. The Midwest High Speed Rail Association notes that these feeders are comparable to arterial roads, whereas the high volume corridors could be equated to interstates. Both scales of infrastructure and routes are necessary to form a regional high speed rail network.[2]

Figure 2 Emission factors for various modes of intercity travel[3]

Mode	Emissions Per 1000 Vehicle Miles (Tonnes CO2)	Passengers Per Vehicle	Emissions Per 1000 Passenger Mile (Tonnes CO2e)
Bus	2.21	35	0.06
Conventional Rail	30.37	322	0.09
High Speed Rail (IC-3)	11.39	97	0.12
Automobile	0.39	1.6	0.24
Airplane	21.79	77	0.28

Intercity travel in the U.S. is currently accomplished primarily using automobiles, airplanes, and buses. Amtrak and commuter rail serve only one percent of all intercity trips. Automobile trips dominate the intercity market accounting for 90 percent of all trips, followed by air with seven percent and bus with only two percent. The idea of intercity rail travel, in particular high speed intercity rail, is gaining in popularity in the U.S. and there are now 11 federally designated high speed rail corridors. Chicago serves as the hub for one of those corridors.[4]

This strategy will highlight the plan developed by The Midwest Regional Rail Initiative (MWRRI). The MWRRI is a coalition of federal and state agencies that formed in 1996 to identify rail connections, ways to use existing rail, and places to improve intermodal connections to enhance overall system access in the Midwest region.[5] The MWRRI advanced from a series of service concepts to a well-defined regional transportation plan, which is referred to as the Midwest Regional Rail System (MWRRS). The MWRRS is a hub-and-spoke rail network in which Chicago serves as the hub. The MWRRS plan outlines high speed rail service to more than 100 cities, uses 3,000 miles of existing rail track, and crosses seven state lines providing service to 80 percent of the region's 65 million residents (see Figure 1).[6] This interconnected high speed rail network is estimated to generate ridership of 13.6 million annually by 2025.[7]

Quantitative Results

GHG Reduction Potential: .006 MMT CO2e

It should be noted that the MWRRS calls for a 10-year phasing program and the greenhouse gas (GHG) emissions are obtained from another report that lists projections for 2025. However, if the system were to be built today following the 10-year phasing schedule, the emissions savings listed would be valid for the base year of 2020.

Given the nature of an intercity high speed rail network, it is necessary to look at the reduction potential for the entire Midwest region, then extrapolate the benefits to Chicago by scaling reduction potential by the relative population (~3 Million/[~65 Million*0.8, since only 80% of the Midwest will be served]). Chicago's reduction potential, using the aforementioned calculation, is approximately six percent of the total service area's reduction potential. While there are other plans to enhance intercity travel in the Midwest, this report focuses on just the implementation of the MWRRS.

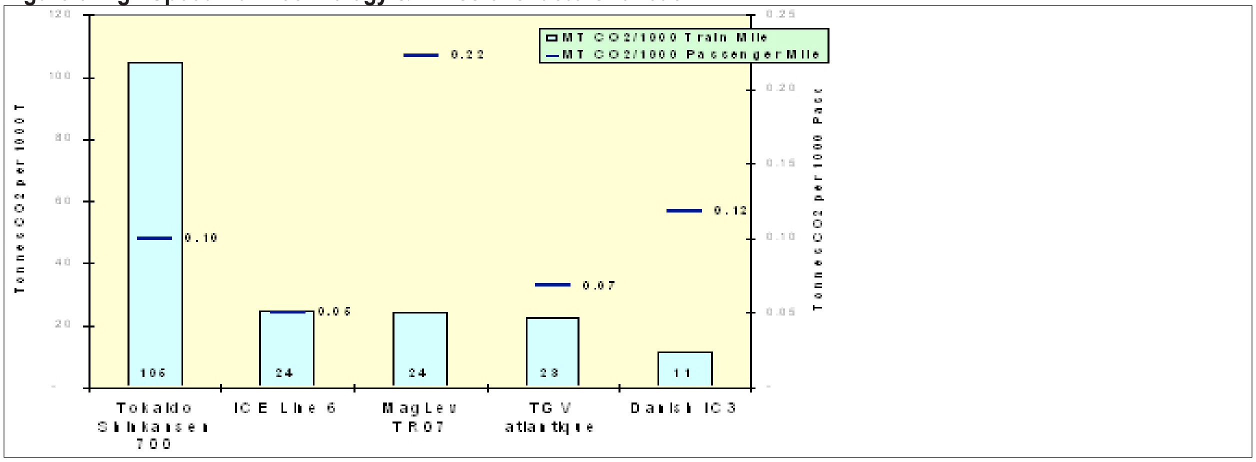
High Speed Rail and Air Travel Emissions

High speed rail in the Midwest, if built, is projected to divert 2.5 million passengers annually from air to train travel. The GHG reduction potential of this is significant at 0.123 MMTCO2e per year. As Chicago is the hub of the proposed Midwest Regional Rail System, a large portion of these diverted passengers likely would have otherwise used the O'Hare or Midway airports.

Domestic travel at Chicago's two airports accounted for 7.6 MMTCO2e emissions in 2000 (based on fuel sales). These emissions are considered separately from Chicago's baseline in this report, but mitigation strategies for air travel must be developed. High speed rail's potential to reduce airport emissions could be increased though efforts to enable intermodal travel, such as a long flight linked to a shorter train trip, with connectivity, seamless ticketing and baggage transfer.

GHG reduction potential varies by rail technologies. For comparative purposes, the potential GHG emissions for five trainset technologies are shown in Figure 3.

Figure 3 High Speed Rail Technology & Emissions factors for each[8]



The MWRRS plan outlines trainsets that would reach a maximum speed of 110 mph, which is roughly the equivalent to the IC-3 Danish that has a maximum speed of 99 mph. The Danish IC-3 train is a good model for the trains to be implemented on the MWRRS.

Based on projections for the year 2025, and using these for a quicker build-out year of 2020, Figure 4 shows diverted trips from other intercity travel modes, and, using projected trip lengths,[9] demonstrates how high speed rail will reduce GHG emissions in the Midwest.

Figure 4 GHG saving by diverted mode for the entire Midwest region – Excluding conventional rail, which High Speed Rail will replace.

	Airplane	Automobile	Bus	Total	Total (Excluding Air)
Number of Diverted Passengers Annually	2,490,432	7,222,253	2,863,997	12,576,682	10,086,250
Vehicle Trips Displaced	28,466	4,513,908	81,828	4,624,202	4,595,736
Trip Length	300	130	161	188	160
Diverted Passenger Miles	747,129,600	938,892,890	461,103,517	2,147,126,007	1,399,996,407
Metric Tons CO2e Diverted	211,434	226,246	29,102	466,782	255,348
Metric Tons CO2e from High Speed Rail (Danish IC-3)	87,693	110,201	54,121	252,014	164,322
Net Annual GHG Savings (Metric Tons CO2e)	123,741	116,045	(25,019)	214,767	91,026

Figure 5 shows how this can be apportioned to Chicago. The figure also includes a calculation for a different scenario that relates to this reduction strategy developed by Environmental Law and Policy Center for the State of Illinois' climate change plan. In this scenario, an alternative to the current network of intercity train options for the state of Illinois, called "Illinois Five-Year Passenger Train Capital Plan", was developed. This plan includes a high speed corridor to St. Louis, and focuses largely on expanding conventional rail routes to other Illinois cities, and increased capacity on those routes. For the Illinois Five-Year Passenger Train Capital Plan the predicted reductions from the population of just Illinois vs. Chicago have been scaled.

Figure 5

	Region	Population Served	Regional Reduction	Chicago Population	Chicago's Reduction (Metric Tons)	Chicago's Portion of Reduction (MMT)
Midwest High Speed Rail Not counting Air Travel	Midwest	46,876,841	90,474	2,896,016	5,589	0.006
Midwest High Speed Rail including Air Travel	Midwest	46,876,841	188,911	2,896,016	11,671	0.012
Illinois Five-Year Passenger Train Capital Plan (high speed and conventional)	Illinois	12,419,293	136,321	2,896,016	31,788	0.032

The Illinois Five-Year Passenger Train Capital Plan estimates CO2e reductions based on travel throughout the state of Illinois. The MWRRS estimates regional Midwest high speed rail travel passing through Chicago, and therefore provides a more appropriate estimate for Chicago's emissions reductions from high speed rail.

For the Midwest region, there is a projected annual reduction of 0.09 MMT CO2e. Based on Chicago's portion of the Midwest population the reduction is .006 MMT CO2e. However, since the emissions for air travel have not been included, the table shows that air travel diversion will enhance this number significantly, to 0.19 MMT CO2e for the Midwest, with Chicago's share of the reduction being 0.012 MMT CO2e.

Scale Assumed

There are nearly three million residents in Chicago that would have ready access to a high speed rail network as it would serve key markets such as:

- Chicago-Detroit-Michigan
- Chicago-Cleveland
- Chicago-Cincinnati
- Chicago-Carbondale
- Chicago-St. Louis
- Chicago-Quincy-Omaha
- Chicago-Twin Cities

The MWRRS plan outlines high speed rail service to more than 100 cities, uses 3,000 miles of existing rail track, and crosses seven state lines providing service to 80 percent of the region's 65 million residents.[10] This interconnected high speed rail network is estimated to generate ridership of 13.6 million annually.[11]

Deployment Timeline Assumed

The MWRRS assumes a ten-year phasing from the time it is started. The service will be added to the regional system based on market demand. Those corridors with the highest potential ridership will be developed first. Key markets slated for early development include Chicago-Detroit, Chicago-St. Louis, and Chicago-Twin Cities. The branch lines that are expected to generate less revenue will be developed once the initial routes are self-sustaining. A high level of coordination is required for this multi-state initiative. For example, during the initial phases of implementation, Illinois, Michigan, Minnesota, Missouri, and Wisconsin will perform construction-related activities while Indiana, Iowa, Nebraska, and Ohio will be involved in design and other preconstruction activities.[12]

Per-unit Reduction Potential
Every 100,000 passenger miles traveled by high speed rail saves 12 metric tons of CO2e over that same trip in a car at average occupancy rates. Every 100,000 passenger miles traveled by High Speed Rail saves 16 metric tons of CO2e over that same trip in an airplane.[13]

Activity Savings
Gasoline is saved from trips diverted from cars. However, there is a trade-off since the high speed rail uses diesel fuel. For all projected auto trips diverted to high speed rail, there would be a reduction of 29 million gallons of gasoline with a corresponding increase of 11 million gallons of diesel fuel.

Lifecycle GHG Impacts
The lifecycle GHG emissions of new, higher efficient trainsets are assumed to be similar to the current fleet of diesel trains currently in operation. The construction of the rail system, stations and track will have a one-time impact, but the maintenance of these systems will be similar to conventional rail. The fuel savings from passenger mode shifts would have additional lifecycle benefits, as the lifecycle emissions profile of gasoline in passenger cars is 24-31 percent higher than tailpipe emissions.[14] The full lifecycle cost of train versus auto has not been examined in detail.

Regional GHG Reduction Potential
The region's population of eight million people represents 12% of the Midwest population. Using the same logic as developed in the GHG Reduction Potential section, the regional GHG reduction's potential is 0.01 MMT CO2e not including air, and .026 MMT CO2e when including the proportional air trips diverted to high speed rail.

Municipal GHG Reduction Potential
The City of Chicago's employees could take advantage of a high speed rail network with connections to Springfield. It currently takes three hours and 20 minutes to travel from Chicago to Springfield. Under the MWRRS, this time would be reduced to two hours and 29 minutes, a savings of 51 minutes per trip. The time savings would make this trip more convenient and efficient for City employees that must travel to the state capital for business. Specific GHG reduction potential has not been calculated.

Economic Profile

Financial Costs
The MWRRS total costs are estimated at $7.7 billion (2002 dollars). The new fleet of high efficient trainsets will cost approximately $1.1 billion and the necessary infrastructure improvements are estimated to cost $6.6 billion. The $6.6 billion public investment is estimated to spark an additional $2.6 billion in public and private sector investments for improving and building amenities at or near stations.[15]

Figure 6 shows three key markets as examples of cost and travel time from Chicago to Milwaukee, Detroit and Champaign. This figure illustrates why MWRRS would be a cost competitive intercity travel option. The roundtrip fares are considerably less than driving or flying to the same destinations. For example, travel from Chicago to Milwaukee costs approximately $36 on rail, $82 to drive, and $527 to fly. The time it would take to travel to these destinations is also competitive.

Figure 6 Example MWRRS Roundtrip Fares in Relation to Estimated Auto and Airline Costs and Travel Time

	Cost Non-Business MWRRS	Cost Business MWRRS	MWRRS Travel Time (hours)	MWRRS Time Savings from Current Rail Technology (hours)	Driving Costs	Auto Drive time (hours)	Air Costs	Air Travel Time (hours)
Chicago to Milwaukee	$36	$48	1: 04	0:25	$82	1:42	$527	0:40
Chicago to Detroit	$90	$120	3:46	1:52	$252	4:27	$192	1:12
Chicago to Champaign	$56	$76	1:50	0:20	$123	2:20	$482	3:38

Financial Savings

Assuming the system is built within the 10-year phasing and that the financial forecasts are met, the MWRRS will generate $23.1 billion in user benefits over 40 years and have a benefit-to-cost ratio of 1.8. The MWRRS is also expected to spark considerable investment at or near the rail stations, referred to as joint development potential. The total of joint development potential is estimated at $4.9 billion, of which Chicago could receive anywhere from $1.15 to $1.73 billion.[16]

Qualitative Results

Program Elements

This strategy focuses on the MWRRS, which would offer a viable transportation option in corridors that currently experience high levels of congestion. The success of the MWRRS depends on broad-based support for a regional high speed rail network. Support could be developed by enhancing intercity bus service, which could include increasing the level of service for cities already served, or creating new service where none currently exists. As the MWRRS is developed, the increased bus service could provide feeder service to the rail corridors. The feeder service is important to increase the level of access people have to the high speed rail corridors.

Another project that would support the success of the MWRRS involves increasing the reliability and frequency of existing train service to meet demand and provide a viable transportation option. Doing so involves Amtrak adding new trains to meet demand and updating the technology used in those trains. Higher efficiency trains offer much more comfortable seating, are fully American Disability Act (ADA) compliant and provide quiet areas and a range of lounge cars.[17]

Tracks should be added for both freight and passenger train operation. Safety devices that allow trains to move faster should be included. And, to cut down on train congestion and delays, rail flyovers should be built at key rail junctions. The Transportation Freight Report series highlights a number of grade crossing and flyover improvements proposed under the CREATE plan (see Improve Freight Efficiency Mitigation Strategy #27). Trainsets and rail upgrades are important for moving the MWRRS forward.

Benefits and Burdens

The MWRRS would provide a competitive travel option and alternative, especially for smaller cities currently underserved by air service. The MWRRS "A Transportation Network for the 21st Century" cites other advantages, such as being attractive to both business and leisure travelers, providing an opportunity to expand the workforce across cities, developing intercity connectivity, and serving as an alternative for those who cannot drive or chose not to own a vehicle.[18]

An economic analysis created for the MWRRS found that building out the system as prescribed would generate a benefit-to-cost ratio of $1.8 billion. This same economic analysis concluded that the MWRRS would generate the highest economic benefit from rail investment anywhere in the U.S., with the exception of Amtrak's Northeast Corridor. In addition to the $1.8 billion benefit-to-cost ratio, the MWRRS has an overall economic benefit projected at $23.1 billion with an estimated 57,450 new jobs created.[19]

The initial outlay of funds and time to build out the high speed rail system in this region are two of the burdens. Another burden is making rail travel more mainstream and relevant to potential users. Moreover, high speed rail is not pollutant free. While trains in general offer net GHG benefits, the health impacts associated with diesel criteria pollutants need to be examined more closely to fully understand their implications. Finally, any expansion in rail corridors must carefully manage wildlife habitat impacts, safety, noise pollution, and traffic congestion at crossings.

Implementation Mechanisms

The MWRRS has a 10-year phasing schedule.[20] Incremental steps, to begin immediately, include: increase high quality bus service, develop partnerships with private railroad companies and improve grade crossings. Each of these would improve the current quality of intercity travel service and build broad support for a regional rail network. The sooner the high speed rail network is started, the quicker the GHG emissions savings will be realized. The research of GHG emissions for the MWRRS relates to 2025. However, if the system is developed by 2020, it is likely those benefits will be realized by that timeframe. Moreover, the City of Chicago cannot do it alone, although it is to serve as the hub of this network. There needs to be bipartisan political support, and widespread governmental agency and general public support from the other cities served by the system.

Current Initiatives and Models

There are several intercity trains that operate in the U.S. that serve as examples for a high speed rail network. The Amtrak Acela Express is a high speed train that travels along the east coast connecting Washington, D.C. to Boston. It stops in 15 cities along the way and reaches speeds up to 150 mph. The Acela Express offers a viable alternative to travel along the east coast, particularly for business travelers who enjoy amenities such as reserved first class and business seating, electrical outlets at every seat, and conference tables.

Similarly, the Amtrak-operated Hiawatha intercity rail service from Chicago to Milwaukee could serve as a starting point for an expanded Midwest intercity rail system. Fourteen trains—seven daily roundtrips, six on Sunday—run between the two cities, boasting the best on-time service of any intercity route in the nation.

The Hiawatha, which costs $42 roundtrip, has increasing ridership. Ridership in May of 2005 was up 18 percent—from 36,871 to 43,598—numbers that reflected the sixth straight month of record ridership.[21] In 2006, more people boarded the Hiawatha than ever before, with an estimated 588,036 passengers boarding at one of the five stations, an increase of 8.2% from the previous year. The increase marks the 26th straight month of record breaking ridership. Wisconsin Department of Transportation Secretary Frank Busalacchi said,

> *"the ridership increases are reflective of the investments we've made in the train sets and infrastructure all along the line," and, "as a result of the increased ridership, we anticipate the need to add an additional car on each of the Hiawatha Service runs later this year to eliminate the times when there's standing room only."*[22]

The Milwaukee to Madison Hiawatha extension has support from the Amtrak Board Chairman David Laney. Laney believes the extension could be completed in two years if the federal government were to invest 80 percent of the $318 million total project costs.[23] This 80:20 ratio is in line with how other highway and public transit projects are funded.

Feasibility

Financial

It will be an uphill battle to implement the whole MWRRS plan given the current transportation funding crisis, despite its widespread support and that "Amtrak has tested, refined and confirmed" that the MWRRS is feasible.[24] However, if key markets could first be served with high quality efficient rail, than the demand for that same type of rail in other markets will increase and help to create the necessary support for a project of this scale. Additional support will be needed from the public, to encourage their elected officials to secure the necessary funding. There are also innovative funding partnerships that could be further explored.

Technical

High speed rail is a considerable component of intercity travel in Europe. There are many existing trainsets in operation. While technology is always evolving, the GHG reduction potential projected in this report is based on existing technology.

Political

The MWRRS has support from Amtrak, the Federal Rail Administration, and the following state DOTs: Illinois Department of Transportation, Indiana Department of Transportation, Iowa Department of Transportation, Michigan Department of Transportation, Minnesota Department of Transportation, Missouri Department of Transportation, Nebraska Department of Transportation, Wisconsin Department of Transportation, and the Ohio Department of Roads and Ohio Rail Development.[25]

Partnerships among the major railroads for the MWRRS must be created. Much of the current intercity rail operates on Class One freight lines owned and operated by private railroads. The railroads currently have only a limited financial incentive to share their rail lines with intercity passenger trains. Moreover, current policies offer the railroads no incentives to make infrastructure upgrades that result in faster, more reliable passenger trains. A new partnership could include incentives to make it profitable to operate passenger trains.[26]

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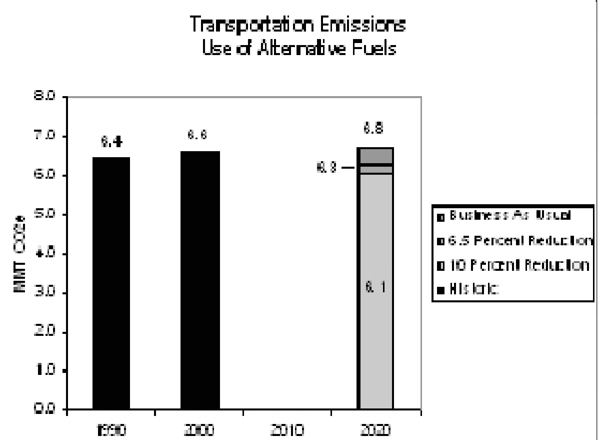
Mitigation Strategy #24
Increase Supply and Use of Alternative Fuels

Strategy Summary	Rating	Value
CO2e Savings Against BAU	++	0.675 MMTCO2e
Scale of Deployment	+++	6.5% in 2020
Timing	Later	2% by 2010
Regional Impact	++	2.5 MMTCO2e
Financial Savings in Relation to Cost	+	higher cost per unit energy
Additional Benefits in Relation to Burdens	+	energy independence
Feasibility Assessment	+++	broad support

Figure 1 Transportation CO2e



Overview

The mitigation strategy discussed here proposes reducing CO2e per unit of energy—in this case, gallon of fuel—by at least 6.5 percent by 2020 through the use of alternative fuels with a corresponding reduction in the use of gasoline. A more aggressive, but still feasible, goal would be to reduce emissions of CO2e per unit of energy through the use of alternative fuels by 10 percent by 2020.

Replacing a portion of gasoline with cleaner, alternative fuels can generate moderate savings in Chicago's greenhouse gas (GHG) emissions. There are more than 19 pounds of carbon dioxide emitted per gallon of gasoline combusted.[1] Most alternative fuels produce less CO2e per gallon, largely because the CO2 emitted from biofuels during combustion is treated as biogenic carbon and accounted for in agricultural, forestry, and other land use emissions profiles. These biofuel emissions are considered in the lifecycle GHG impacts discussion in this strategy.

Current technology permits the use of ethanol, primarily from corn, biodiesel, and compressed natural gas-powered vehicles. In the near future, the possibility of even lower lifecycle GHG forms of ethanol, such as cellulosic ethanol,[2] and greater use of hydrogen and plug-in electric cars could have an even greater potential for emission reductions. Advanced technologies and alternative fuels are being researched by national laboratories and universities and it is expected that they will become more financially and technically feasible in the near future. Figure 2 provides a summary of various alternative fuels and their properties.

Figure 2 Alternative Fuel Properties

	BioDiesel	Compressed Natural Gas (CNG)	Ethanol (E85)	Liquefied Natural Gas (LNG)	Liquefied Petroleum Gas (LPG)	Methanol (M85)
Chemical Structure	Methyl esters of C16-C18 fatty acids	CH4	CH3CH2OH	CH4	C3H8	CH3OH
Primary Components	Vegetable oil, animal fats, or recycled restaurant grease	Methane	Denatured ethanol and gasoline	Methane that is cooled cryogenically	Propane	Methanol and gasoline
Main Fuel Source	Soybean oil	Underground reserves	Corn, grains, or agricultural waste	Underground reserves	A by-product of petroleum refining or natural gas processing	Natural gas, coal, or woody biomass
Energy Content per Gallon	117,000 to 120,000 Btu	33,000 to 38,000 Btu @3000 psi	80,460 Btu	73,500 Btu	84,000 Btu	65,350 Btu
Energy Ratio Compared to Gasoline	1.1 to 1 or 90%	3.94 to 1 or 25% @3000 psi	1.42 to 1 or 70%	1.55 to 1 or 66%	1.36 to 1 or 74%	1.75 to 1 or 57%
Liquid or Gas	Liquid	Gas	Liquid	Liquid	Liquid	Liquid

Source: Table produced by the Department of Energy, Alternative Fuels Data Center and copied from their website[3]

Quantitative Results

GHG Reduction Potential: 0.675 MMTCO2e in 2020

Switching to a greater share of alternative fuels has the potential to save approximately 675,000 metric tons of CO2e annually by 2020. A less aggressive policy would save nearly 440,000 metric tons of CO2e annually by 2020. The results are highlighted in Figure 3.

Figure 3 CO2e Savings Potential

	VMT (in Billions)	Gallons Consumed (in Millions)	kg of CO2 per gallon	CO2 Savings over BAU
1990	11.5	713.5	9.0	-
2000	12.2	741.5	8.9	-
2020 BAU	13.8	766.4	8.8	-
2020 Less Aggressive (6.5%)	13.8	766.4	8.2	438,783
2020 More Aggressive (10%)	13.8	766.4	7.9	675,051

Scale

This strategy assumes that there is a small increase in alternative fuels starting in 2008 growing to at least 6.5 (or as high as 10) percent in 2020 with a corresponding reduction of gasoline consumption. This increase will initially be in ethanol, biodiesel, and compressed natural gas. As other alternative fuels are brought to the market, these too may be used to decrease gasoline use.

In the more aggressive scenario, a 10 percent increase in the use of alternative fuels in 2020 translates into a 10 percent reduction in CO2e generated per unit of energy in 2020. The CO2e savings per gallon of gas assumes that low GHG fuels are used and applied to all VMT in the Chicago area.

Timeline

In order to achieve the savings for the two scenarios described in this report, the scale of 6.5 or 10 percent of alternative fuel use must be achieved by 2020. The savings would be gradual over time and can start immediately, albeit at much lower levels. The longer it takes for the initial deployment and build-out of alternative fuel capacity, the shorter the period of time remaining to ramp up to the levels described for 2020. Therefore, rapid deployment is encouraged. In order to reach the goal in 2020, a good course of action would be to decrease two percent in CO2e generated per gallon of fuel, at a minimum by 2010. People and businesses within the city of Chicago are constantly making decisions regarding filling up their tanks, purchasing vehicles, and upgrading gas stations. These decision points can be leveraged immediately to encourage increased use of and access to alternative fuels.

Per-unit GHG Reduction Potential

Under the Business As Usual (BAU) scenario, every 2,042 vehicle miles traveled (VMT) equals approximately one metric ton of CO2e. Under our less aggressive scenario, this would increase to 2,184 VMT to one metric ton of CO2e created and almost 2,269 VMT in the more aggressive scenario.

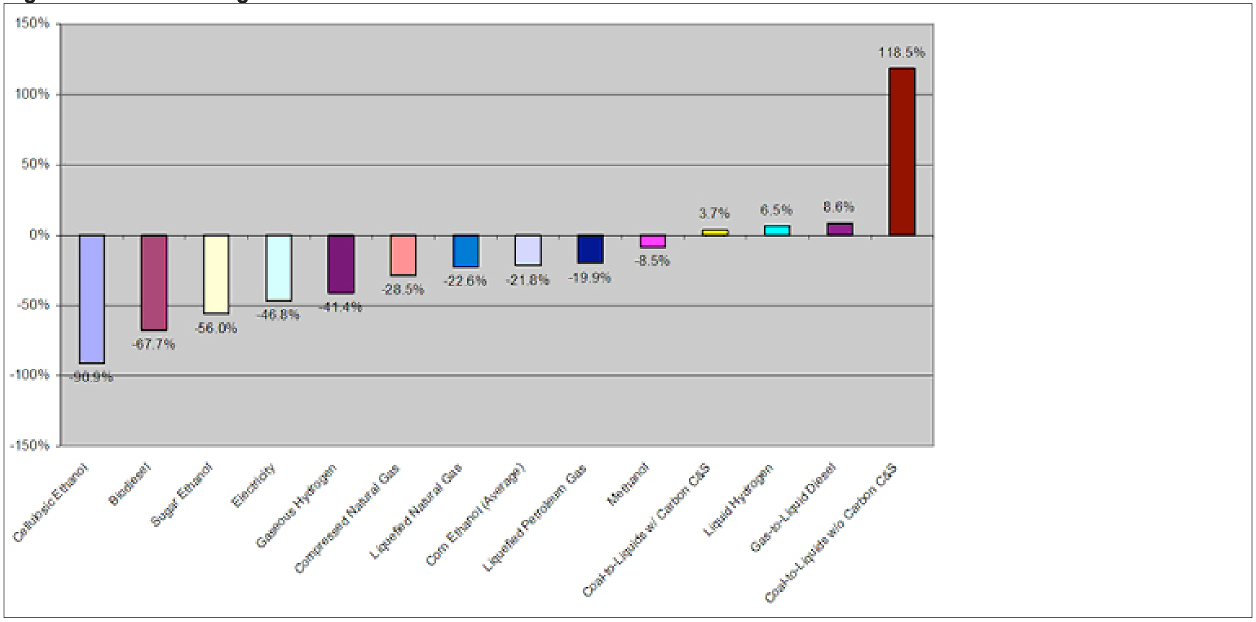
Activity Savings

Assuming that the alternative fuels would emit no tailpipe emissions and achieve the same fuel efficiency as gasoline, approximately 50 million gallons of gasoline (6.5 percent of the total) would need to be substituted with alternative fuels by 2020 to achieve the less aggressive goal. Seventy-six million gallons (10 percent of the total) of alternative fuels would need to be substituted to achieve the more aggressive goal. In these scenarios, 50 million and 76 million gallons of gasoline, respectively, could be saved in 2020.

Lifecycle GHG Impacts

Figure 4 shows the impact of different alternative fuels in terms of their full lifecycle. The full lifecycle includes emissions from all part of the process of making the fuels, including fossil extraction, feedstock growth and distribution, producing and transporting fuels. Studies vary as to how much CO2e results from alternative fuels, particularly when considering the full lifecycle, or “wells-to-wheels,” of fuels. The U.S. Environmental Protection Agency released a study in April 2007 that demonstrates the GHG savings potential from different fuels when compared with gasoline consumption. The study’s findings are illustrated in Figure 4, which shows savings as a negative number and additional GHG emissions, above and beyond those produced from gasoline, as positive numbers. The U.S. EPA’s results vary from other studies, and the science of this is evolving, but Figure 4 provides a reasonable representation of fuel lifecycle GHG impacts.

Figure 4 Percent Change in GHG Emissions



Source: Graph copied from EPA420-F-07-035, April 2007[4]

Regional GHG Reduction Potential

The regional savings are approximately 2.5 MMT CO2e in 2020 under the less aggressive scenario and 3.9 MMT CO2e in 2020 under the more aggressive scenario. These savings are possible when gasoline reductions are applied to the regional VMT at the same rate as the Chicago strategy. Four hundred sixty gallons of gasoline will be saved in 2020 if this strategy is adopted across the region. The strategies needed to increase the use of alternative fuels have to be scaled for the region, not just for Chicago. The buying power of the entire region could be leveraged to bring a greater supply of alternative fuels at lower prices than if this was merely a policy aimed at the city of Chicago. The State of Illinois is currently reviewing fuel standards that would require a certain quantity of low GHG fuels to replace gasoline. The resulting plan will be applied across the State, thereby including Chicago and the region.

Municipal GHG Reduction Potential

The City of Chicago's fleet was responsible for 107,000 tons of CO2e in 2005 using approximately 11 million gallons of fuel. Following the same reduction patterns in CO2 generated per unit of fuel, the City could reduce up to 10,700 tons of CO2 or 10 percent of their total emissions in 2020 even if fuel use was kept constant.

Economic Profile

Gas station owners will incur investment costs to increase the availability of alternative fuels. However, there are federal government programs that provide tax credits and other incentives to gas stations for the purpose of including more alternative fuel pumps.[5] Alternative fuels, in the face of rising gas prices, can be less expensive per gallon. But, as Figure 5 shows, consumers may end up spending more money on alternative fuels as one may need more gallons of some alternative fuels, when compared to gasoline, to travel the same distance. National, state, and local policies are supportive of increased use of alternative fuels. An expanding market is likely to lower prices of alternative fuels to a level that is competitive with, or below that, of gasoline. Moreover, as gas prices continue to rise with unstable international oil markets and amid growing concern about the carbon content of fuels, alternative fuels become more attractive and have been receiving increased attention. There are potential savings for the City of Chicago which already has fueling centers and can easily incorporate alternative fuels into its fleet.

Figure 5 Fuel Prices

March 2007 Nationwide Prices on Energy-Equivalent Basis

	Nationwide Average Price For Fuel In Gasoline Gallon Equivalents	Nationwide Average Price For Fuel In Gasoline Diesel Equivalents	Nationwide Average Price For Fuel In Dollars per Million Btu
Gasoline	$2.30	-	$19.96
Diesel	-	$2.63	$20.40
CNG	$1.94	$2.17	$16.82
Ethanol (E85)	$2.96	$3.31	$25.68
Propane	$3.62	$4.04	$31.35
Biodiesel (B20)	$2.31	$2.58	$20.05
Biodiesel (B2-B5)	$2.34	$2.61	$20.26
Biodiesel (B99-B100)	$3.26	$3.64	$28.30

Source: U.S. Department of Energy[6]

Qualitative Results

Program Elements

Increasing the supply and use of alternative fuels in Chicago are the key components of this mitigation strategy. As a general rule, an increase of alternative fuels with a corresponding decrease in the use of gasoline will reduce CO2 emissions. By merely changing the type of fuel vehicles use, a reduction in CO2 emissions can be achieved.

There are three main barriers that may negate some of the CO2e reduction potential:

1) ethanol and some other biofuels tend to get lower gas mileage due to lower energy content than current petroleum fuels;
2) some alternative fuels currently cost more than gasoline and most are not available for mass consumption at this time;
3) according to the U.S. EPA, not all alternative fuels emit less GHGs during their full lifecycle than gasoline.

These latter include Coal to Liquids (both with and without carbon sequestration), Liquid Hydrogen, and Gas-to-Liquid Diesel (see Figure 4). Additionally, much research has been done on the lifecycle emissions of corn ethanol, which is a prevalent alternative fuel, particularly in the Midwest. Ethanol from corn may result in higher GHG than gasoline.[7] As time passes advances in technology may open up more solutions. Economies of scale should also start to lower prices and make alternative fuels more comparable, in terms of cost, to current fuels.

Benefits and Burdens

Increasing the use of alternative fuels reduces our reliance on fossil fuels, and, therefore, oil imports. Policies that support alternative fuel development, distribution, and use ensure greater energy independence. Other benefits include the potential to increase jobs in the United States directly tied to all aspects of alternative fuel production and use. Alternative fuels, with low tailpipe emissions, can also serve to reduce criterion pollutants which are direct causes/irritants of asthma.

As noted under Program Elements, burdens of increasing the use of alternative fuels include determining the best fuels to use that reduce lifecycle GHG emissions.

Current Initiatives and Models

San Francisco has adopted an ambitious goal for all diesel vehicles in its public agencies to use at least a 20 percent biodiesel (B20) blend by the end of 2007.[8] The City created the Biodiesel Access Taskforce for support and advice on their biodiesel projects.[9] Since Mayor Newsom issued this executive directive in June 2006, San Francisco has made significant progress toward achieving its goal and announced in April 2007 that 39 percent of the City's fleet had already converted to the biodiesel blend, ahead of its scheduled goal of a 25 percent by that date.[10] Additionally, all of Norcal Recycling/Waste Management's 400 garbage collection vehicles have converted to the use of biodiesel, which will cut the fleet's GHG emissions by 5,400 tons per year, or a 21 percent decrease from using only diesel.[11]

The City of Chicago's participation in the Chicago Area Clean Cities (CACC) and the Metropolitan Mayors Caucus are both geared towards promoting the increased use of alternative fuels.[12] The City has committed to increasing the number of alternative fueling stations that are available to support the municipal fleet with compressed natural gas, E85 (85% ethanol, 15% gasoline), propane, and biodiesel. Chicago's current efforts can be expanded more quickly for greater impact.

Implementation Mechanisms

While the long term success of alternative fuels will largely depend on circumstances out of the control of a city government, there a number of options the City can consider in fostering such opportunities. The City can play a role in the rate of deployment for alternative fuel options. Here are some action items that could be considered to help achieve the goals laid out:

1) Require the City fleet to use alternative fuels which would help set a local market to both add a supply of alternative fuels for the region, and help add enough volume for economies of scale to work to reduce costs.

2) Reduce or waive local sales taxes for alternative fuels while their price remains higher than gasoline. This would remove some price disparity as a barrier to deployment.

3) Set benchmarks for annual alternative fuel purchases. If these are not met, the City, with the help of the State, could begin to require fuel stations to sell alternative fuels. This would allow the market to work its course and would only require intervention if it was unable to meet realistic targets that would ensure a reduction in emissions by 2020.

Feasibility

This is one climate change mitigation strategy that has support across the political spectrum. There are two major contributing factors: 1) the environmental concerns from continuing use of gasoline under BAU; and 2) reduction of our use of gasoline contributes to our reduced reliance on foreign oil. While those two factors may not always coincide, they could be leveraged as much as possible in advancing this mitigation strategy. The targets listed are entirely achievable and may even be surpassed if the price of gasoline continues to spiral upward.

The CACC received grants from the federal Congestion Mitigation and Air Quality Improvement Program (CMAQ) for funding new alternative fueling stations. There are other federal financial programs that support increased use of alternative fuels, including through the Renewable Fuel Standard Program run by the U.S. EPA.

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Mitigation Strategy #25
Increase Fleet Efficiency

Strategy Summary	Scale	Value
CO2e Savings Against BAU	+	0.209 MMTCO2e
Scale of Deployment	+++	100% of fleets by 2020
Timing	+++	Beginning in 2008
Regional Impact	+	Proportional to fleet size and use
Financial Savings in Relation to Cost	++	Varies by fleet and technology
Additional Benefits in Relation to Burdens	++	Benefits from reduced petroleum use
Feasibility Assessment	++	Capital costs but existing technology and programs

Overview

There are many vehicle fleets operating in the city of Chicago: commercial, personal, City-owned and operated, Chicago Transit Authority, and car sharing. These fleets account for a large portion of vehicle miles traveled (VMT) within the City and corresponding greenhouse gas (GHG) emissions. The City has total control over its own fleet of vehicles—the size, composition, and fuels used—and limited control over a number of others such as CTA buses, taxis, and school buses. This section will explore strategies that require greater fuel efficiency or the use of alternative fuels to reduce emissions from the fleets that the City controls and/or plays some role in operations, including taxis, school buses, CTA buses, and garbage trucks. Figure 2 shows a savings potential of at least 209,000 metric tons of CO2e annually by addressing each of these fleets.

Figure 1 GHG Reduction Potential by Fleet

Fleet	Number of Vehicles	Technology Change	CO2e Savings Potential MMTCO2e
Taxis	6,300	hybrid vehicles	0.129
School Buses	2,600	B20	0.0098
CTA Buses	1,878	diesel hybrids	0.07
Garbage Trucks	Unknown	B20	Unknown
Total	10,778	-	0.209

Quantitative Results

GHG Reduction Potential: 0.209 MMTCO2e in 2020

By switching 100 percent of the taxi fleet to hybrid electric vehicles with better fuel efficiency, there is the potential to save 129,000 tons CO2e annually.[1,2] This savings assumes that the current fleet—comprised of 6,300 Crown Victorias, or their equivalent, which average 14 miles per gallon (MPG) and are driven an average of 60,000 miles per year—are replaced with Ford Escape Hybrids, or their equivalent, which average 34 MPG.[3] Each taxi would save more than 20 tons CO2e per year, approximately one ton for every 3,000 miles they drive. Approximately 15.9 million gallons of gasoline would be saved annually.

Hybrid Electric Vehicle
A hybrid electric vehicle is a one which combines a conventional propulsion system with an on-board rechargeable energy storage system to achieve better fuel economy than a conventional vehicle, without being hampered by range from a charging unit like an electric vehicle

Assuming each of the 2,600 school buses in the City averages 13,000 mile per year while operating at seven miles per gallon of diesel fuel, replacing current fuel with B20 gasoline could reduce emissions by up to 9,800 metric tons CO2e annually.[4,5]

CTA Buses traveled 66.2 million miles in 2000 while getting 3.1 miles per gallon, using diesel fuel.[6] Switching to diesel hybrids would save 30 percent of the gallons of gas consumed and nearly 70,000 tons CO2e annually.

The savings from switching fuels in garbage trucks is difficult to calculate as there are a number of private haulers and private transfer points to which they deliver. (However, savings relating to franchising private garbage haulers are covered in *Strategy #31: Zero Waste).*

Scale

The savings outlined above assume the following scales: all 6,300 taxis to hybrids by the end of the phase-in plan; the entire fleet of school buses to switch to B20 and all CTA buses in the fleet to switch to a hybrid-diesel format.

Timeline

The hybridization of the taxi fleet would need to start immediately to reach a 100 percent penetration rate by 2020. Hybrid vehicles with a fuel economy of 34 MPG are currently available so it is possible for the fleet to start adding hybrid cars immediately. The taxi fleet turns over vehicles every three to five years.[7] This strategy assumes a six-year phase-in of hybrid taxis and full deployment before 2020 and a steady phase-in of B20 capable school buses and hybrid-diesel CTA buses that begins in 2008 with full deployment by 2020.

B20 Biodiesel
Biodiesel refers to a diesel-equivalent, processed fuel derived from biological sources, such as vegetable oils, which can be used in unmodified diesel engine vehicles. Biodiesel is biodegradable and non-toxic, and typically produces about 68% less net carbon dioxide emissions than petroleum-based diesel in its full lifecycle. A B20 blend uses 20 percent biodiesel along with 80 percent of traditional diesel fuel. B20 reduces non-biogenic carbon dioxide emissions by 20% and lifecycle emissions by 15%. (Source:EPA420-F-07-035, April 2007)

Per-unit GHG Reduction Potential

Each hybrid taxi would reduce more than 20 tons of CO2e per year, or approximately one ton for every 3,000 miles they drive. Switching each school bus from diesel to B20 fuel would save approximately three tons of CO2e per bus annually. If averaged for the entire fleet of 1,878 buses, 37 tons of CO2e would be saved per CTA bus. Another way of calculating savings would be one ton CO2e saved for every 950 miles traveled.

Diesel-run garbage trucks have fuel economies as low as three MPG.[8] This means that the average garbage truck, which travels 25,000 miles per year, burns approximately 8,900 gallons of diesel fuel and emits 904 metric tons of CO2e.[9] Garbage trucks that run on biodiesel (B20) can cut carbon dioxide emissions by 20 percent, or 18 metric tons CO2e, compared to trucks using only diesel.[10]

Activity Savings

Pilot programs of the Ford Escape Hybrid in San Francisco[11] show that it saves approximately 1,666 gallons of gas over the course of 100,000 miles compared to a conventional cab. In contrast to a current standard such as the Ford Crown Victoria, which gets about 14 city MPG, the Ford Escape Hybrid receives 34 city MPG.[12] Approximately 15.9 million gallons of gasoline would be saved annually by switching to an all hybrid taxi fleet. Switching all school buses to B20 fuel will save 720,000 gallons of diesel annually. Nearly 6.5 million gallons of diesel fuel would be saved annually on CTA buses.

Lifecycle GHG Impacts

The CO2 emitted by biodiesel upon combustion is treated as biogenic carbon and therefore not included in the emissions profile of this strategy. However, the manufacture and transport of biodiesel has associated emissions that should be accounted for in a lifecycle assessment. The use of biodiesel fuel reduces overall lifecycle emissions by 68 percent over petroleum based fuels.[13] The U.S. EPA estimates that the lifecycle CO2 emissions of gasoline are 24-31% higher than the tailpipe emissions and diesel lifecycle emissions are 15-25% higher.[14]

Regional GHG Reduction Potential

There are no official statistics for the number of taxis in the entire region. Assuming the regional fleet is comparable to the Chicago fleet and that there is a hybridization of the fleet as suggested in this strategy, there is the potential to reduce one ton CO2e savings for every three miles driven.

There are also no official statistics for the number of school buses in the entire region. But, if the average school bus in the region fit the parameters laid out for the City, the savings could be calculated on a per-unit basis of three tons CO2e reduced per school bus operated annually.

If Pace buses operated under the same general guidelines as CTA buses, there would be comparable savings from adopting hybrid-diesel buses for its 680 fixed-route buses.[15]

Municipal GHG Reduction Potential

None of the fleets discussed here are directly operated by the City of Chicago or incorporated in its municipal operations GHG baseline. Taxis are independently operated, Chicago Public Schools contracts the operation of its 2,600 school buses to vendors,[16] and the CTA is an independent entity. However, the City has the opportunity to influence the operations of these fleets, as discussed further below.

Economic Profile

Costs

The City currently has a list of approved makes and model year vehicles that are approved for taxi use. The list of approved vehicles could be amended to allow only hybrid vehicles such as the Ford Escape Hybrid (over time) as part of this strategy. A new Ford Escape Hybrid, which is being used in this strategy for illustrative purposes, costs approximately $26,000.[17] This is slightly more than a new Ford Crown Victoria (used for illustrative purposes in this strategy as the typical current taxi) which costs approximately $25,000 and is more expensive than some other cab options.[18] As in New York City and other cities, cab companies are required to purchase their own vehicles.[19]

There have been concerns regarding the durability of hybrid vehicle engines. Prior to pilot programs in San Francisco and New York, there were concerns about whether the Hybrid taxis could endure the long shifts on San Francisco hills or in New York congestion, along with skepticism that their engines would last until the 100,000 mile warranty.[20] However, test programs in both cities have had cabs hit 100,000 miles without reporting any major problems in terms of wear and tear.[21]

Almost all school buses and garbage trucks, including older models, can switch to the B20 grade of biodiesel without expensive retrofitting. Depending on the year of manufacture, most models require no modification to the engine. Biodiesel has also shown to decrease wear and tear on bus engines.[22,33] Moreover, the national average price for B20 is currently competitive with diesel.[24] The centralized fueling of fleets makes the distribution of alternative fuels like B20 much less capital intensive than a citywide alternative fuel program. A hybrid bus currently costs between $200,000 and $250,000 more than the standard diesel buses that the CTA typically uses.[25]

Savings

Fuel savings can amount to approximately $6,000 per year per taxi, with variation due to mileage and the cost of fuel.[26] Pilot programs have shown that cab drivers in Ford Escape Hybrids save $30 per 150- to 300-mile shift as compared to the same distance with the traditional, full-sized sedan cabs.[27] As fuel prices continue to rise, these financial benefits will only increase. The CTA could save approximately $56,000 per year on fuel, using the Energy Information Administration (EIA) average price for diesel gas in May 2007, by switching to hybrid buses.[28] Hybrid buses cost 15% less to operate than diesels due to fuel savings[29] and decreased maintenance fees.[30]

For school buses, B20 is a better lubricant and keeps fuel lines cleaner than diesel, resulting in less expense for vehicle maintenance.[31] As B20 becomes more prevalent, it is likely that its cost will drop and become more comparable to the cost of diesel. The same is applicable to garbage trucks, as this strategy proposes a switch from diesel to biodiesel.

Qualitative Results

Program Elements

Chicago's bus, taxi and garbage truck fleets provide important public services. For example, taxis often supplement public transportation, walking and/or biking—serving as an important mobility option for short trips. While it is unlikely that the number of taxis and buses driven or their respective VMT will be reduced given the nature of the service they provide, it is possible to save CO2e in fleets through increasing fuel efficiency and reducing petroleum use. Taxis make good use of electric hybrid technology since fuel is saved in stop-and-go urban traffic. For this reason, it makes sense to transition the entire fleet of taxis to use electric hybrids by 2020.

Garbage trucks and buses are also ideal platforms for hybrid technology, since they frequently stop and idle to load, however a switch to biodiesel has the advantage of low upfront capital costs. Therefore, this strategy proposes the adoption of B20 biodiesel for school buses and garbage trucks and the use of hybrid buses by the CTA, where, among other things, the large number of miles driven per year may make the transition more cost effective. There are other fleets operating within Chicago that this strategy does not directly address, but the technologies discussed here would be applicable to other fleets as well.

Benefits and Burdens

Increasing the efficiency of fleets will have the additional environmental benefit of reducing criteria air pollutant emissions that contribute to smog and harm public health. Reduced petroleum use has lifecycle environmental benefits to land, water, and air from all phases of manufacturing from extraction and refining through distribution and retail sales. Reducing petroleum use also reduces dependence on foreign sources of oil.

Emissions from diesel buses and garbage trucks have serious public health consequences, since they contain large quantities of gases, fine particulates, and more than three dozen toxic contaminants. Switching to biodiesel has significant health benefits for students since it decreases exposure to pollutants linked to asthma, heart disease, cancer, and other health problems.[32] Some studies have shown that biodiesel use may result in slightly elevated emissions of nitrogen oxides, but the research is not conclusive.[33] Heavy-duty natural gas vehicles continue to be cleaner for criteria pollutants, except carbon monoxide, than low-sulfur diesel equipped with the most advanced after-market treatments.[34]

The sustainability of biodiesel at a large scale warrants further research and is an area of great interest as the market for alternative fuels grows. One additional benefit for the use of biodiesel in Chicago might be the ability to support agriculture in Illinois. But, the growth of biodiesel crops faces all of the same environmental sustainability concerns as the current agricultural system in terms of issues such as water quality, wetland protection and pesticide risks.[35]

Current Initiatives and Models

Chicago has already started addressing fleet efficiency, and these current initiatives can be built upon to create a climate change mitigation strategy.

- As of June 2007, the City of Chicago requires any taxicab medallion holder who owns or controls at least 50 taxicab medallions to have at least one hybrid vehicle as a taxi.[36]
- Chicago Public Schools (CPS) has already started to take steps to reduce emissions from its school bus fleets. School officials estimate that roughly a quarter of the Chicago system's 2,600 buses[37] are already fueled by biodiesel or ethanol, or have some form of a pollution control device.[38] In November 2006, CPS announced that 27 of its buses owned by Falcon Transportation would begin using a new ethanol-blend fuel developed by Delaware-based O2 Diesel Corp. in an attempt to further reduce school bus emissions.[39] The Illinois EPA sponsors its own Clean School Bus Program, which qualifies districts that use B20 blend for more than half of the school year for a rebate of up to 80 percent of the incremental costs.[40]
- In December 2006, CTA placed the first of 20 diesel-electric hybrid buses into service as part of a one-year pilot program to test the models in Chicago's extreme weather conditions.[41] With the addition of more than 464 new buses since 2000, CTA has already reduced its bus fleets' total annual emissions by 22 percent, or 564 tons CO2e, since 1997.[42]
- In 2004, the City of Chicago Department of Fleet Management received a $200,000 grant from the U.S. EPA as part of the Region's Great Cities Partnership Program to retrofit 100 City garbage trucks with oxidation catalysts.[43] While oxidation catalysts minimize greenhouse gas emissions to a certain degree, additional measures need to be taken to reduce emissions from Chicago's garbage truck fleet.

New York and California have many current initiatives for fleet efficiency that can serve as models for programs in Chicago:

- New York has set the goal to transition their taxi fleet to 100 percent hybrids by 2012, which will incorporate an annual increase of roughly 25 percent until 2012. There are as many as 288 hybrid taxis currently in use in New York.[44]
- In New York State, funds provided by Governor George Pataki's Clean Air/Clean Water Bond Act, NYSERDA (New York State Energy Research and Development Authority), have enabled some 2,500 school buses from 84 school districts to be retrofitted with emission control technology, and have supported purchase of new natural gas buses which use 100% alternative-fuels.[45]
- NYC Transit currently has the largest hybrid-electric bus fleet in North America. By the end of 2007,

their hybrid fleet will exceed 550 buses.[46]

- The combination of mandates and economic incentives to offset capital costs has provided an effective impetus for garbage truck fleet owners in California to switch to alternative fuels. In 1991, the South Coast Air Quality Management District in California mandated that operators of municipal fleets that contain more than 15 heavy-duty vehicles buy natural gas-powered vehicles. California also provides heavy-duty private fleets with public funds to support the purchase of alternative fuel vehicles. As a result, today nearly 85 percent of the nation's natural gas garbage trucks—only one percent of the total national garbage truck fleet—operate in California.[47]
- This year San Francisco assisted private garbage collection contractors to transition from diesel to clean alternatives. The largest waste collection company, NorCal, replaced its diesel garbage transfer truck fleet to either liquefied natural gas or biodiesel B20.[48] The fleet of 400 garbage trucks travel as much as 600 miles per day, which means switching to alternative fuels results in GHG emissions savings of 5,400 tons per year, a 21 percent decrease from when the trucks were using only diesel. The City has obtained grant funding to cover the incremental cost between the diesel and liquefied gas trucks.[49]

Implementation Mechanisms

The City of Chicago Department of Consumer Affairs regulates taxis, which are considered public vehicles, through a process that requires the issuance of medallions.[50] A requirement for hybrid taxis can be built into this existing process.[51] Chicago could implement a measure, much like the San Francisco Taxi Commission, that would require taxi companies to buy only alternative-fuel, hybrid or high mileage vehicles when replacing retired cabs.[52] The rate of fleet turnover averages three to five years, so this measure would greatly decrease total implementation time.[53] Given the environmental and financial benefits of this strategy, and the fact that taxis are particularly suited for hybrid use, there is no reason why this strategy could not be fully implemented by 2014.

The City of Chicago and CPS can continue to build on their past and current efforts to pursue alternative fuels incentive grants for school buses. Possibilities at the federal level include the U.S. EPA's Clean School Bus USA program,[54] funds from the Congestion Mitigation Air Quality (CMAQ) program, energy and investment tax credits for manufacturing and purchasing alternate fuel school buses and funding mandates to meet safety, environmental and security standards. There are also independent clean air subsidy programs like the City Home Program,[55] which help subsidize use of alternative fuels in school bus fleets. Since school buses operate independently under contracts with Chicago Public Schools, switching fuels is largely a procurement issue. Goals could be set to incrementally increase the total number of school buses using alternative fuels.

Assuming the CTA's pilot diesel-electric hybrid buses prove durable in extreme Chicago weather,[56] the number of these hybrid buses in the fleet could be increased. One effective method to phase in diesel-electric hybrid buses in the CTA fleet is to purchase them at the rate of fleet replacement. In 2004, San Francisco voters passed Proposition I, which mandates that Muni replace diesel buses purchased before 1991 with green-powered vehicles.[57] In recent months, the City has been putting about five hybrid buses into service each week until it reaches its goal of 86 new vehicles.[58]

Chicago could increase the number of garbage trucks running on alternative fuels, such as B20. Natural gas trucks also present a cleaner alternative to diesel trucks, which many fleet operators, particularly in California, have purchased in recent years.[59] Even though there are dozens of private waste hauling companies licensed to operate in Chicago, the City can work with the private industry to encourage switching to alternative fuels, since the City does have some broad oversight and regulatory powers over them. The City could leverage its powers in order to create the most fuel efficient garbage collection system that is possible. These powers could expand to route management and fuel efficiency among other items in hopes of minimizing GHG emissions from garbage collection.

Feasibility

Financial

The financial feasibility of this strategy varies by fleet, technology, and use rates. The largest barriers are the upfront capital costs for biodiesel fueling stations and hybrid vehicles. However, it is feasible to significantly increase the number of hybrid buses in the fleet with sufficient capital funds. Between 1996 and 2005, New York City purchased 450 Compressed Natural Gas buses and 325 hybrid buses.[60] The Energy Policy Act of 2005 provides several tax credits to help offset the capital costs of purchasing hybrid or natural gas trucks.[61] Once these upfront costs are overcome, there are operating savings to be found in fleet efficiency.

Technical

This strategy discusses technologies that are currently available in the marketplace. However, the CTA is still observing the performance of the first 20 hybrid buses to make certain that they can withstand extreme Chicago weather conditions.[62]

Political

Alternative fuels and hybrid vehicles are increasingly popular as environmental, fuel cost, and fuel security issues have gained importance. This makes a fleet efficiency strategy much more politically feasible than it might have been in the past. However, the City will have to work in partnership with the independent fleet operators to make this strategy work. Both San Francisco and New York City, who starting July 1, 2007, will fuel its fleet of 4,500 garbage trucks with a biodiesel blend (B5), were able to encourage private garbage hauling companies to make the switch.[63]

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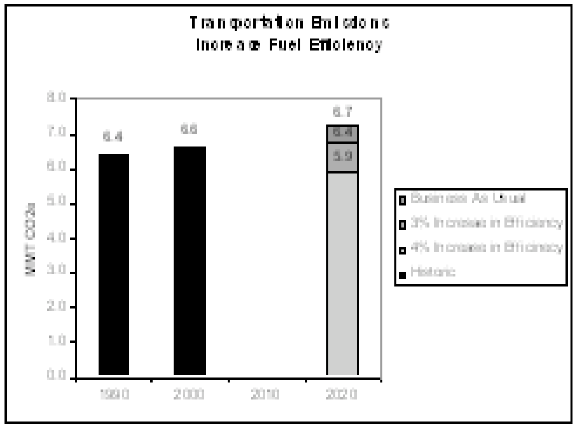
Mitigation Strategy #26
Enable More Efficient Use of Fuels

Strategy Summary	Scale	Value
CO2e Savings Against BAU	++	0.512-0.858 MMTCO2e in 2020
Scale of Deployment	+++	all new vehicles
Timing	+++	starting 2010
Regional Impact	++	3.1- 5.1 MMT CO2e in 2020
Financial Savings in Relation to Cost	++	Cost per car $230 - $5-7,000
Additional Benefits in Relation to Burdens	++	public health and energy security
Feasibility assessment	++	success in other countries

Figure 1 Increased Fuel Efficiency



Overview

Increasing gas mileage in vehicles can lead to dramatic improvements in greenhouse gas (GHG) emissions. Fuel economy standards currently are, as they have been since its creation in 1975, set through the Corporate Average Fuel Economy (CAFE), administered by the National Highway Traffic Safety Administration (NHSTA). Until 1997, recent CAFE standards required new passenger vehicles to average 27.5 miles per gallon (MPG) of fuel, and new light trucks 22 MPG for an overall average of 24.7 MPG.[1] With the passage of the Energy Independence and Security Act of 2007, fuel economy standards are required to be raised to an average to an average of 35 mpg by 2020—the first time the CAFE average has been raised since the 1970's. The bill calls for increasing CAFE standards every year, starting in 2011, and raising it to a "maximum feasible rate" between 2021 and 2030. The City of Chicago could be at the forefront of the efforts to advocate for rapid implementation of the new CAFE standards.

The business as usual (BAU) forecast assumes a 1.9 percent annual increase in fuel economy for new vehicles, factoring in on road performance and the penetration rate of new vehicles with higher fuel economy into the overall, on road fleet. This strategy calls for a higher annual rate of increase—three or four percent—beginning in 2010.

In Figure 2, two scenarios are outlined: one less aggressive calling for a three percent annual increase and another more aggressive approach calling for a four percent annual increase.[2] A three percent increase is also feasible, and takes into account resistance to a higher increase. The two scenarios demonstrate a range of what is possible. The new fuel economy rates for the entire fleet of vehicles are shown in Figure 2—adjusted for fleet penetration and actual on road performance.

Figure 2 Fuel Economy- Miles per Gallon

	2000	2020
BAU	16.5	18.0
Low Scenario (3% Increase)	-	19.5
High Scenario (4% Increase)	-	20.7
Source: Source: EPA; fleet penetration research conducted by David Greene – analyzed and provided by Center for Clean Air Policy		

Quantitative Results

GHG Reduction Potential: 0.512-0.858 MMTCO2e in 2020

By increasing fuel efficiency by four percent annually beginning in 2010, Chicago could save 858,000 metric tons of CO2e in 2020. A less aggressive goal of three percent annual improvements would yield savings of 512,000 metric tons of CO2e.

Scale Assumed

The savings potential assumes an increase in fuel economy for all new vehicles—passenger, light duty trucks, and heavy duty trucks. The penetration rate is estimated to be 50 percent by 2020.

Per-unit Reduction Potential

Fuel efficiency increases 8.5 percent in the less aggressive scenario and 15.1 percent in the more aggressive scenario from 2010 to 2020 over business as usual (BAU) assumptions.

Activity Savings

Nearly 360 million gallons of fuel are saved annually under the less aggressive goal and more than 600 million gallons are saved under the more aggressive goal in 2020 alone.

Deployment Timeline Assumed

This strategy would start in 2010 with a three or four percent annual increase in fuel economy thereafter.

Lifecycle GHG Impacts

The savings of fuel will have broad impact—in Chicago and beyond. Higher fuel economy results in less fuel used, which lowers the amount of oil that needs to be drilled, refined, and shipped. The U.S. EPA estimates that the lifecycle CO2 emissions of gasoline are 24-31 percent higher than the tailpipe emissions and diesel lifecycle emissions are 15-25 percent higher.[3] The lifecycle GHG impacts of the vehicle technologies needed to improve fuel economy are less well known, but a shift to smaller or lighter vehicles could have GHG benefits at the vehicle manufacturing level.

Regional GHG Reduction Potential

The six-county region around Chicago would save approximately 5.1 MMT CO2e in 2020 under the more aggressive target and approximately 3.1 MMT CO2e in 2020 under the less aggressive target.

Municipal operation GHG Reduction Potential

In 2000, the City of Chicago's fleet used approximately 6.7 million gallons of fuel. Considering the same quantity of fuel used and applying the projected 2020 fuel economy standards, the reduction potential is 870,000 gallons of gasoline (13.1 percent) and 7,600 metric tons CO2e (12.7 percent) in 2020.

Economic Profile

Financial costs

The costs of implementing an increase in CAFE standards are debatable. The Congressional Budget Office (CBO) estimated in 2004 that a rise in CAFE standards of 3.8 MPG—enough to reduce the amount of gasoline used by 10 percent—would cost $3.6 billion per year nationally, or approximately $230 per new vehicle.[4]

The auto manufacturers paint a different picture. General Motors estimates the cost of raising CAFE standards from 25 to 35 MPG by 2020 at $5-7 thousand per vehicle in current dollars.[5] Officials from General Motors also claim that every new car made by 2020 would need to be a hybrid or diesel-powered to meet the new standard.[6]

Financial Savings

Chicago recently hit a record high of $4.25 per gallon of gasoline.[7] Assuming a constant price of $4.00 per gallon of fuel, Chicago consumers would save $400 million annually with increased fuel economy standards. These savings would only increase as the price of gasoline increases.

Qualitative Results

Program Elements

The City of Chicago can encourage a rapid implementation of the new CAFE standards and other increased fuel economy measures through leadership efforts and anti-idling programs.

Leadership

The City of Chicago could be at the forefront of the push to implement CAFE standards rapidly on an annual basis. The City's leadership could take the form of lobbying the federal government, as well as encouraging the State of Illinois to become active in lobbying the federal government. In a recent case before the Supreme Court, states led by Massachusetts sued the U.S. EPA to make them regulate GHGs.[8] In a five-to-four decision, the Supreme Court found that the U.S. EPA was not fulfilling its duty in refusing to regulate vehicle standards—a ruling that is likely to precipitate the U.S. EPA's involvement in increasing fuel economy standards. State and local governments, particularly a large city like Chicago, have the capacity to impact federal policy. The City of Chicago can also strive to set an example for governments, businesses, and individuals in the region by pledging to purchase vehicles for its fleet with the highest fuel efficiency possible.

Anti-idling

The City could develop an anti-idling policy, especially for diesel trucks, which use up to 1,500 gallons of fuel per year while idling.[9] This could largely mirror the Vehicle Idling Management Policy that currently governs the City's fleet of vehicles. This ordinance limits idling to no more than five minutes per hour while not in traffic and does not apply to emergency vehicles. An anti-idling policy would discourage inefficient fuel consumption.

Benefits and Burdens

There is very little downside for Chicago in increasing the fuel economy of vehicles. If the estimates from the CBO are accurate, the increased costs of new vehicles should not bring an undue burden upon the public. With the fierce competition among auto manufacturers, increased costs would need to be kept to a minimum rather than risk decreasing market share. If the costs associated with increasing CAFE standards are closer to General Motors' estimates, consumers would pay higher prices for vehicles.

Fuel savings could keep hundreds of millions of dollars in the city, rather than being directed to pay for fuel imported into the city. There are also important ancillary benefits to increased fuel efficiency. These include reduced smog, improved breathing conditions for those with respiratory ailments, and a reduced dependence on foreign oil.

Implementation Mechanisms

The City of Chicago could encourage increased fuel economy in a number of ways; four specific implementation mechanisms are described below. While CAFE standards are implemented at the national level, the Supreme Court's recent decision signifies a local role in pressing for increased standards.

1) **User fees for vehicle ownership.** User fees could be applied to vehicle purchases to incentivize the purchase of more fuel efficient vehicles. For example, the difference in the City residential vehicle sticker is only $15 between regular passenger vehicles and large passenger vehicles (including SUVs) which is not nearly enough of a deterrent to purchase a smaller, more efficient vehicle.[10] User fees would need to increase dramatically if long-term behavior and purchasing patterns are to be altered. With investments in new vehicles costing anywhere from $20-40,000, user fees would need to be significant for any local long-term changes to fuel efficiency.
2) **Feebate.** Like a user fee for vehicle ownership, a feebate system, "a tax on vehicle purchases or a rebate given to buyers of new vehicles based on fuel economy,"[11] could be implemented in the city on vehicles purchased within the City limits. The tax and rebate are intended to offset each other, with the tax providing the money for the incentive to purchase more efficient vehicles. The Center for Clean Air Policy identifies the CO2e savings potential from a feebate introduced on a state level, or for 100,000 cars, as 1,321 metric tons. A feebate system that encourages even a .01 increase in MPG can significantly reduce CO2e. Like the user fee described above, a feebate would also have to be priced to encourage behavior change—on the order of $1800 for a 20 mpg shift in fuel efficiency.[12]
3) **Increased gas taxes.** Chicago currently has a gas tax rate of five cents per gallon. This is on top of six cents per gallon for Cook County taxes and 21.6 cents per gallon for Illinois (22.6 cents per gallon for diesel).[13] A recent report by the CBO cites a 10 year old study by the U.S. Department of Energy that states a 15 cent hike in the gas tax would reduce VMT by 3.8 percent.[14] Given today's gas prices, it is likely that a higher level of additional taxes would be necessary to achieve the same result. With record high gas prices, it is challenging for a local government to consider substantial increases in gas taxes.
4) **Expand Vehicle Idling Management Policy.** The City currently has a Vehicle Idling Management Policy which limits idling for City vehicles to no more than five minutes per hour while not in traffic.[15] (This policy does not apply to emergency vehicles.) This policy could be expanded by ordinance to apply to private vehicles, including trucks and buses to reduce wasted fuel.

Current Initiatives and Models

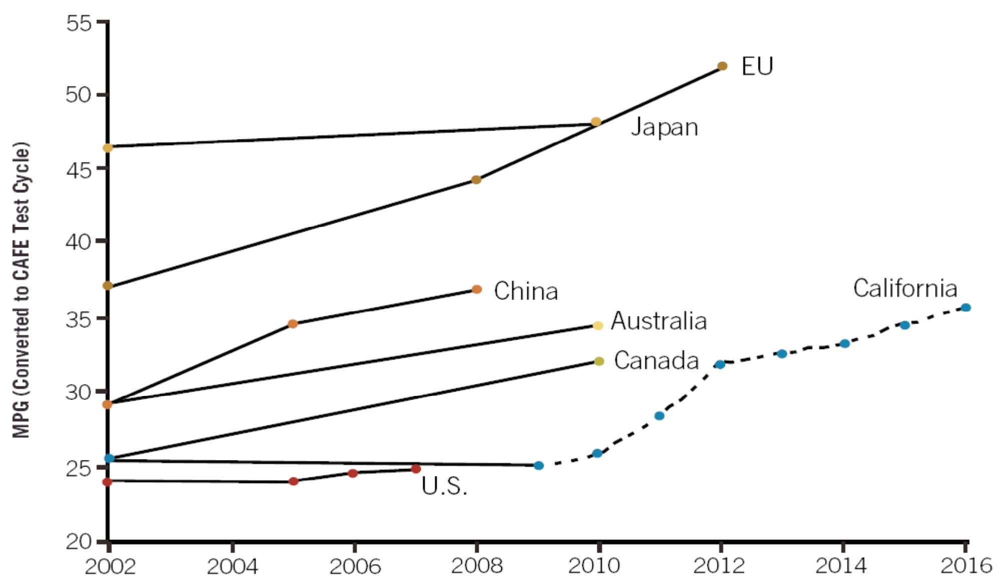
California

In July 2002, California passed AB 1493, which required the California Air Regulations Board to develop and adopt measures that achieve the most feasible and cost-effective reduction of GHG emissions from passenger cars and light trucks sold in California.[16] After a series of public workshops and hearings, standards were adopted that would apply to 2009 and later model years and would require approximately 30 percent reductions in GHG emissions by 2016.[17] California was the first state to pass such standards and has been followed by eleven other states.[18] This bill has been delayed due to pending lawsuits and Congress is currently debating whether or not to grant a waiver to California so it can implement the law in time to apply it to the 2009 model year of vehicles.[19]

Feasibility

The goals proposed are viable from both a business and technological point of view. European and Asian countries have standards that are currently much higher than even the proposed standard would be in the United States by 2020. Figure 3 shows the fuel economy standards for various countries in the world. The United States continues to lag behind the rest of the world. Since auto manufacturers produce vehicles for countries around the globe there is little reason to think that the differences between regulations need to be as vast as is currently the case. Chicago alone will be unable to do much to implement any real change at the national level. However, the recent Supreme Court case Commonwealth of Massachusetts et al. v. Environmental Protection Agency et al left the door open for individual states to raise standards when the federal government is unwilling to do so.

Figure 3 Fuel Economy and GHG Emission Standards from Around the World



Notes: (1) dotted lines denote proposed standards (2) MPG = miles per gallon (3) CAFE is Corporate Average Fuel Economy

* The chart is re-produced from a report entitled "Climate Change: Technological Solutions" by the Pew Center on Global Climate Change

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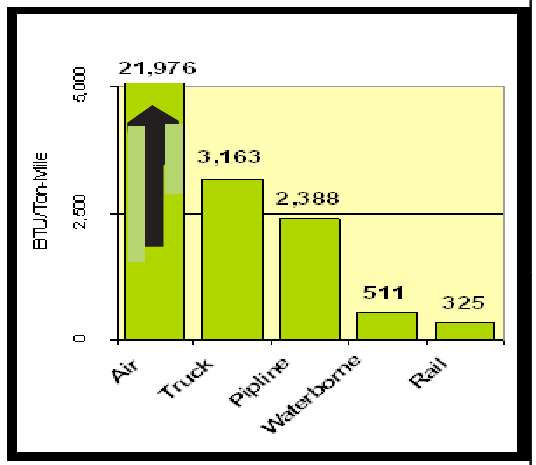
Mitigation Strategy #27
Implement Efficient Freight Movement

Strategy Summary	Symbol	Value
CO2e Savings Against BAU	++	1.61 MMT CO2e
Scale of deployment	+++	There are many factors of freight to address—from efficiency to modes to routes
Timing	Fast	CREATE begins in 2009
Regional Impact	+++	7.327 MMT CO2e
Financial Savings in relation to Cost	+++	$595 million in improved efficiences
Additional Benefits in relation to Burdens	+++	Job creation, improved flow of freight and passenger traffic
Feasibility assessment	+++	Widespread support

Figure 1 Energy Intensity of freight movement



Source: Greenhouse Gas Emissions from Freight Trucks, International Emissions Inventory Conference, May 16, 2007, John Davies U.S. EPA Office of Transportation and Air Quality, Christiano Facanha ICFI Consulting

Overview

Freight movement contributes to greenhouse gas emissions—emissions that will continue to grow along with the projected increases in freight for this region. Greenhouse gas (GHG) emissions reductions in the City of Chicago and the region from freight could be realized by implementing one or more of the following suggestions: 1) moving as much freight by rail and waterborne modes as possible; 2) allowing for swift movement of goods—avoiding as much congestion as possible—where mode shift cannot be accomplished; 3) implementing land use and planning practices that allow the region to lower its GHG impact from freight—encouraging development around this historically valuable regional asset; and 4) making rail more efficient.

The freight industry is a major economic force for Chicago and the region. On rail alone, $350 million worth of goods move to, from or through the region annually.[1] There are over 20 railroads that directly employ 37,000 workers with an annual payroll of $1.7 billion operating in the region. The economic force is even greater when considering trucking and related jobs in manufacturing, warehousing, shipping, and firms that cluster near rail access points. Trucks carry $572 million worth of goods, to, from or through the region every year. The Chicago region has 2,800 miles of rail line. There are 78 terminals along these rail lines and they are used by 1,200 trains per day (500 freight and 700 passengers). The freight industry is expected to increase from 37,500 railcars moving through Chicago per day in 2004 to 64,000 railcars moving through Chicago per day in 2030.[2] Assuming linear growth, there will be approximately 53,800 railcars in 2020.

Given anticipated growth and the corresponding economic pressures for the region, it is necessary to take a proactive position in addressing the antiquated rail infrastructure to accommodate the projected growth.

This will ensure that the current rail traffic remains on rail and continues to be an economic force in the region. In addition to economic benefits of improving the rail infrastructure, there is potential to reduce greenhouse gas emissions from this sector by making the system more efficient.
Strategies to lower GHGs from the freight sector are to move freight by the lowest impact mode available or to reduce the need to move freight. The following strategies will help lower GHGs:

1) Move as much freight as possible by rail, a lower impact mode than trucks;
2) Move more freight by barges and other waterborne modes, and develop the Port of Chicago to be a more effective asset;
3) Reduce the miles of trucks at freight transfer stations by optimizing routes, relieving congestion, or removing the truck from the transfer altogether;
4) Create a better environment for manufacturers to establish themselves in Chicago, thus removing some of the demand for freight movement into the region;
5) Use land use planning to optimize truck-rail connections in communities with freight facilities;
6) Move as little freight as possible via air; and
7) Relieve the congestion on the region's rail system and, in particular, implement the Chicago Region Environmental and Transportation Efficiency Program (CREATE)[3] as quickly as possible.

The growth of globalization and containerized freight has changed the nature of freight movement in the Chicago region. In 1997, the number of container lifts in the Chicago region was more than twice that of any other port in North America.[4] In 2004, if the region was considered a port, it would be the fourth largest in the world after Hong Kong, Singapore, and Shanghai.[5] This focus on containers and transfer stations provides an opportunity for GHG reduction since much of the transfers are completed by truck and many of those transfers are done within the City of Chicago.

Quantitative Results

GHG Savings Potential: 1.61 MMT CO2e by 2020

The nature of freight movement intrinsically makes the strategy national, or at least regional, in scope. Evaluating just the City of Chicago's contribution is impossible for the all of strategies listed above. A calculation, explained below, was used to determine Chicago's share of national potential GHG reductions from freight. Savings assume the following changes: transferring truck to rail, transferring truck to waterborne modes, train-train transfers rather than train-truck transfers, better usage of freight facilities, and implementation the CREATE program.

The freight-related GHG reduction potential for Chicago was determined by estimating the national GHG reduction potential and scaling it to Chicago using the ratio of Chicago's estimated population in 2020 to the national estimate. This scaling will underestimate the amount of GHG reductions in Chicago, but does reflect that the goods are moved to an eventual destination to fulfill consumer needs. Simply, the derived fraction represents the citizens of Chicago's part in GHG emissions from the national freight movement. In 2020, the U.S. Census projects the U.S. population to be 335,805,000. CMAP's 2020 population projection is 3,139,270[6]--Chicago representing 0.93% of the U.S. population. Figure 2 shows how much freight was moved in 2002 and estimates the freight movement in 2020, with GHG emissions.

Figure 2 Surface Freight Transportation in the United States

Mode	Tons of Freight 2002[7]	MMTCO2e 2002[8]	Tons of Freight 2020[9]	Estimated MMTCO2e 2020[10]
Truck	11,712	359	18,130	556
Rail	1,979	40	2,894	59
Water	1,668	47	1,487	42

Truck to Rail

From Figure 1, it is clear that for every ton-mile of freight moved from truck to rail, the emissions will be reduced to 325/3163 or 10.3%. Therefore, in 2020, if 25% of the freight moved by truck could be moved by train, the savings would be 124.7 MMT CO2e or 1.16 MMT CO2e for Chicago using the prorated population fraction. For every percent of ton-miles of freight moved from truck to rail, there will be a national savings of 5.0 MMT CO2e; Chicago's fraction is 0.047 MMT CO2e.

Truck to Waterborne Mode

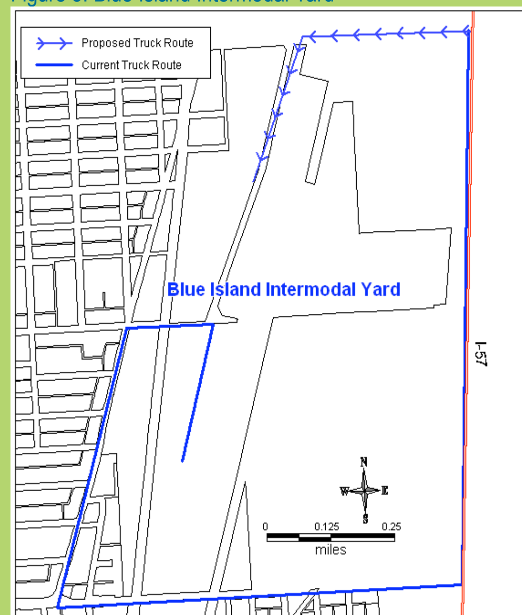
Similarly, if 10% of truck freight was moved to barge or other waterborne modes, the national savings would be 46.6 MMT CO2e and Chicago's portion would be 0.43 MMT CO2e. For every percent of freight moved by waterborne mode rather than by truck, there would be national GHG savings of 4.7 MMT CO2e and Chicago-specific savings of 0.043 MMT CO2e.

Train-Train Transfers

With all the intermodal transfers that happen in the City of Chicago, there could be some benefit from moving as many transfers from train-train rather than from train-truck, or transferring a series of train cars via a direct recoupling of those cars. The emission savings from this, while it may be substantial, has not been calculated in this analysis.

In Blue Island, trucks had to make a circuitous route to the transfer station at the rail yard. A plan was developed to reroute the truck traffic to a 1.4 mile shorter route (see map below). By rerouting trucks a daily GHG savings of 187.8 lbs of CO2 or and annual reduction of 31 MTCO2e were shown to be achievable.

Figure 3: Blue Island Intermodal Yard



Better Usage of Freight Facilities

In many of Chicago communities there are neglected and underutilized freight facilities. By utilizing smart growth planning principles, these underutilized assets and the communities they are located in can be used to reduce GHGs. Truck routes near the intermodal transfer yards can be optimized and land uses can be changed to reduce truck VMT. See the side bar for an example of such an effort. Similar to the example in the side bar, Chicago's 12 intermodal yards could pose an opportunity for GHG reductions. In Blue Island, by just rerouting trucks, an annual savings of 31 million tons CO2e could be achieved. If Chicago finds similar opportunities, the savings would scale up to an annual GHG reduction of 372 million tons CO2e or 0.0004 MMT CO2e.

CREATE Program

The CREATE Program estimates that the railroads' diesel consumption will be reduced by 7 million gallons in 2007 with fuel savings expected to increase to 18 million gallons in 2042.[11] Assuming linear growth, there would be a savings of 11 million gallons in 2020. Given that this amount of fuel is expected to be saved in the Chicago region[12] it is estimated that Chicago would save one-third of this amount based population trends, which would amount to a savings of 21,600 million tons CO2 or 0.022 MMT CO2e.

Air Freight

Under this strategy, air freight would be only the mode of last resort. Given Chicago's dominance in this area, savings could be achieved, but this benefit was not calculated for this study.
The sum of all of above reductions is 1.612 MMT CO2e for the City of Chicago.

Scale Assumed
Freight movement is a national and international issue. The scope of mitigation opportunities is at the national level, and Chicago, being at the center of freight movement, will influence the future of the movement of goods.

Timeline
The sooner more freight is moved on rail, rather than trucks, the better. To enable this transition, CREATE needs to be supported. The CREATE Program has a six year construction phase and there is currently funding to begin the construction process for 32 of the 78 projects by 2009. This will enable more freight to be moved on rail and allow for enhanced freight rail movement in the country.

Per-unit Reduction Potential
For every percent of ton-miles of freight moved from truck to rail, there will be a national savings of 5.0 MMT CO2e; Chicago's proportion is 0.047 MMT CO2e. For every percent of freight moved by waterborne mode rather than by truck, there will be a national savings of 4.7 MMT CO2e. Chicago's proportion is 0.043 MMT CO2e.

Activity Savings
Changing as much freight movement in this country from truck to rail will provide the largest GHG reduction. Controlling congestion on the Chicago regional rail network will reduce shipping delays and avoid idling trains and backups at congested grade crossings. Therefore, the direct reductions come from reducing the amount of diesel fuel used in moving every ton-mile of freight.

Life cycle GHG Impacts
The benefits of the CREATE Program reach local, regional, and national levels. Locally and regionally, there will be specific improvements made to ease congestion in Chicago—improving the efficiency of freight, trucking, personal auto use, and commuter and Amtrak passenger travel. These improved efficiencies will allow the freight industry to expand to meet projected demand. This growth will yield an increase in GHGs. However, if the improvements outlined in the CREATE Program and others are not addressed, the freight rail lines would no longer be competitive. The efficiencies built into the rail infrastructure will allow more fluid travel from coast to coast as it passes through the Chicago region—contributing to the efficiency of the national freight system.

Regional GHG Reduction Potential
Since all of these reductions are regional or national in scope, the Chicago benefits can be scaled up using the population of the region. In 2020, Chicago will have 22% of the region's households. The regional savings will be 7.327 MMT CO2e.

Municipal GHG Reduction Potential
Specific CO2 calculations for the City of Chicago have not been performed. The benefits of the CREATE Program—quantified in terms of the region—have a local impact, as seen through the Central corridor 23 mile freight rail route, which will remove trains from a seven mile stretch along Lake Michigan and 1.1 miles from the newly developed residential and commercial areas just south of the Loop.[13]

Economic Profile
The CREATE Program provides major reinvestment to railways with $1.5 billion allocated for addressing congestion problems along five rail corridors; 25 at-grade crossings and six rail flyover crossings.

Financial Costs

The CREATE Program will take six years to complete and cost an estimated $1.5 billion. The participating railroads will pool their resources together to contribute $232 million toward the $1.5 billion.[14]

Financial Savings

The CREATE Program estimates that the Chicago region will generate $595 million for improved efficiencies for rail passengers and motorists. The CREATE Program also estimates air quality improvements valued at $1.1 billion and construction related benefits valued at $2.2 billion.[15]

Qualitative Results

Program Elements

The City of Chicago could work with partners to implement efficient freight strategy that can:

1) Encourage freight rail and waterborne freight;
2) Provide support for lowering truck transfers at intermodal yards;
3) Promote local manufacturing;
4) Incorporate smart growth planning principles to optimize truck-rail connections;
5) Move as little freight as possible via air;
6) Adopt Cargo Oriented Development;[16]
7) Improve inefficient truck routes;[17]
8) Reduce dependence on non-local goods;[18]
9) Plan to increase more production of goods locally where there are available workforces, and develop infrastructure of multi-modes of transportation, and underutilized or vacant industrial land; and
10) Support all these by supporting the Chicago Region Environmental and Transportation Efficiency Program (CREATE).[19]

The following outlines the planned activities of the CREATE Program[20]:

1) Grade separation for six rail-to-rail crossings to eliminate delays primarily between freight and passenger trains[21].
2) Improve grade separations at 25 highway rail crossings to reduce auto congestion, improve safety and decrease energy consumption and air pollution.
3) Improve connections, crossovers, rail tracks, signage and other improvements to improve train movement across the 5 target corridors.

Benefits and Burdens

There are both benefits and burdens to many of the program elements:

- The benefits of proposed grade separations for rail-to-rail crossings in the CREATE Program include decreased rail congestion, particularly between freight and passenger service.
- Each of the 25 grade separation improvement projects in the CREATE Program has listed specific improvements it aims to meet. Generally, the projects are designed to improve safety, reduce travel time, reduce congestion, improve air quality and decrease energy consumption.
- The CREATE Program's five rail corridor projects are designed to improve the flow of both freight and passenger traffic
- There are many benefits to shopping locally and producing goods in the U.S. experienced by everyone from the local farmer to the manufacturing plant that serves as an employment base. The burdens of these actions include large scale policy reforms and buy-in from the private sector that will not likely support such initiatives given the potential added costs.

- The benefits of Cargo Oriented Development include neighborhood revitalization and job creation in areas with high unemployment rates.

Implementation Mechanisms

The CREATE Program has a detailed schedule of projects along with their estimated costs and benefits. The COD program is well underway in Blue Island and Harvey and there are plans to open the program to other south suburban Cook County communities that have a need and hold opportunities for industrial infill development. These programs can be springboards for other program elements.

The City of Chicago, working with other municipalities, could develop a Freight GHG Reduction Plan designed to benefit the region. As a leader in freight movement, Chicago could also take a national role in promoting best GHG reduction practices while improving freight movement. Chicago can play some role in each of the implementation mechanisms that are also detailed in the explanation of calculations in the GHG Reduction Potential section.

Current Initiatives and Models

The CREATE Program is unique as it is the first time that state and local governments have partnered with the rail industry at such a large scale to address problems with congestion. Chicago is the only place in the U.S. where six of the seven major railroads meet, and all six are partners in the CREATE Program. Public partners include the State of Illinois, City of Chicago, and Metra. The six major railroads that pass through Chicago are BNSF Railway, Canadian Pacific Railway, CN, CSX Transportation, Norfolk Southern Corporation, and Union Pacific Railroad.[22]

Other initiatives are also taking place at a local level to address infill opportunities in the Chicago region. Cook County south suburbs hold great opportunity given the rich transportation infrastructure and vacant, or often times underutilized, parcels. In many cases, the areas adjacent to these vacant or underutilized industrial parcels also have access to Metra rail to couple the redevelopment effort with higher density, mixed-use walkable neighborhoods. When these opportunities exists side-by-side, the effort is commonly referred to as Cargo Oriented Development (COD) and Transit Oriented Development (TOD). Currently, there are strong COD/TOD efforts underway in Blue Island and Harvey with efforts being planned for additional communities.

There are a number of initiatives to encourage people to shop locally. For example, local farmers markets provide opportunities for people to buy fresh produce while at the same time limit the distance of travel needed to purchase those goods. These local initiatives also provide economic life to the farming community.

Feasibility

Financial

The partnership with the six largest railroads in the U.S. provides the necessary financial backing to move the CREATE project forward. There is currently funding to get 32 of the 78 CREATE projects underway by 2009. Beyond the CREATE program, there are freight efficiency funding programs at the federal level run by the U.S. DOE and U.S. EPA.

Technical

The capacity of the railroad system has to be improved to handle current and projected traffic, as well as the freight that is transitioned from truck to rail. Existing efficiency technologies could be utilized to increase efficiency and safety.

Political

The CREATE Program has widespread support and is endorsed by many federal, state, and local elected officials. In addition to this support, the Northwest Municipal Conference, the Illinois Chamber of Commerce, the Chicagoland Chamber of Commerce and Southland Chamber of Commerce, and nearly 40 key trade and business organizations all endorse the CREATE Program.[23]

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6 This uses CMAP’s 2030 population projection and scales it back to 2020 assuming linear growth.

7 How We Estimated The CFS Out-of-Scope Sectors, presentation slide 20, www.fhwa.dot.gov/download/hep/freightplanning/talkignfreight02_15_06ft.ppt

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10 This quantity is extrapolated from the other three, and assumes that moving a ton of goods will emit the same amount of GHGs in 2020 than it did in 2002.

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

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

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16 There is a need to identify industrial infill opportunities where sufficient land can be assembled on underutilized parcels for freight intermodal development. These opportunities, referred to as Cargo Oriented Development (COD), take advantage of existing transportation infrastructure and reduce the highway truck traffic for last mile deliveries.

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Mitigation Strategy #28
Enact Automobile User Fees

Strategy Summary	Rating	Value
CO2e Savings Against BAU	+	0.021-0.381 MMT CO2e
Scale of Deployment	+++	All VMT and 25% of parking meters
Timing	++	Begins in 2008; approx 5 years to scale up
Regional Impact	+	78,000-2.2 MMT CO2e
Financial Savings in Relation to Cost	+++	Costs are low relative to savings
Additional Benefits in Relation to Burdens	+++	Increase quality of life; may adversely impact low-income households
Feasibility Assessment	+++	Proven Models

Overview

Congestion pricing and an enhanced parking pricing system are two types of automobile user fees that will reduce personal motorized vehicle demand, resulting in CO2e savings. These two strategies are detailed in this mitigation strategy report with the description of congestion pricing preceding parking pricing under each sub-heading that follows.

Congestion pricing is a user fee to motorists for using public roadways, with the dual goals of reducing congestion and raising revenue. Congestion pricing throughout this report refers more specifically to cordon pricing—charging a fee to enter or drive within a congested area.[1] This approach has been implemented in London, Singapore, and Stockholm and was recently considered for New York City.

An enhanced parking pricing system corrects for the low cost of curbside parking. It raises the cost of parking enough so that parking districts are nearly full—but not completely—so that people will be able to depend on finding a space in commercial and retails districts without spending an inordinate amount of time driving around, consuming fuel and contributing more to CO2e emissions. Enhanced parking pricing functions in a similar manner as congestion pricing in that the costs are raised to encourage shifts to other modes of travel, while improving access to those willing and able to pay an extra amount for that benefit.

A national study of downtown parking found that the average price of curb parking is only 20 percent of what it costs to park in a garage.[2] Under-priced curb parking gives drivers a strong incentive to cruise for a parking space, which accounts for as much as 30 percent of traffic in central business districts.[3] Cruising increases congestion, wastes fuel and pollutes the air. Most importantly, it increases greenhouse gas (GHG) emissions as a result of the additional Vehicle Miles Traveled (VMT).[4] If parking meters are priced to match demand at the 85 percent occupancy rate, drivers can always find one or two open curb spaces per block upon immediate arrival.

Quantitative Results

GHG Reduction Potential: 0.021-0.381 MMT CO2e in 2020

The actual savings from congestion pricing will vary greatly from city to city based on tolls charged, incoming traffic, and the elasticity of the demand. The Pew Center for Climate Change cites studies that show congestion pricing can reduce vehicle miles traveled (VMT) anywhere from 0.2 percent to 5.7 percent. Applying these findings to Chicago, GHG reductions for city traffic would be between 13,000 and 373,000 metric tons annually in 2020.[5]

Following a methodology and test case laid out by Donald Shoup in his book "The High Cost of Free Parking,"[6] the potential annual GHG savings in Chicago from an enhanced parking system is approximately 8,300 metric tons CO2e. This assumes that parking pricing would be "enhanced" at 25 percent of the City's 28,000 parking meters (based on parking spaces in 2000).[7]

Caveats for the enhanced parking pricing savings range:

- The variables in Shoup's test case were not specific to Chicago. More in-depth testing would be needed to calculate the true savings for Chicago, which may be higher or lower than what's estimated here.
- The projected savings are estimated in terms of reduced cruising time when looking for parking, and do not take into account the potential savings from reduced driving trips to these locations. As parking rates increase, more people are likely to take alternative means of transportation to these areas leading to additional GHG savings.

Scale Assumed

Savings from congestion pricing assume that all Chicago-based VMT are reduced between 0.2 and 5.7 percent annually, or 28 to 78.6 million VMT, from the "business as usual" (BAU) forecast after a congestion fee is introduced. Savings from an enhanced parking pricing system assumes that approximately 7,000 parking meters,[8] or 25% percent of Chicago's parking meters, are priced to ensure about 85% percent occupancy with reduced "cruising."

Per-unit Reduction Potential

Based on Chicago's anticipated vehicle fleet in 2020,[9] every 1 million VMT reduced from congestion pricing will result in a savings of 474 metric tons of CO2e. The average "enhanced priced" parking meter would save 1.2 tons of CO2e annually in 2020.

Activity Savings

Using BAU fuel economy in 2020, between 1.5 million and 44 million gallons of fuel could be saved annually from congestion pricing. And approximately 1 million gallons of fuel could be saved annually from reduced cruising for parking spaces.

Deployment Timeline Assumed

It is assumed that the congestion pricing system has been firmly established by 2020. A steady increase in the number of parking meters that are enhanced begins in 2008 with full deployment—25 percent of all metered spaces—in place in advance of 2020. Enhancement of the parking pricing system could be phased in over a five-year period.

Regional GHG Reduction Potential

A congestion pricing system for downtown Chicago will also have a great impact on the region as a whole, as many people from the suburbs and surrounding areas commute to downtown. Applying Chicago VMT reduction potential to the region's VMT reduces mileage between 165 million to 4.7 billion and GHG reduction between 78,000 and 2.2 MMT CO2e. Anywhere from nine to 262 million gallons of gasoline would be saved as well based on projected fuel economy in 2020.

Savings from enhanced parking pricing could also apply to the region, though the variables applied—number of affected parking spaces, average cruising distance and parking turnover rates—vary greatly by neighborhood and locality. Regional savings from this automobile user fee is highly speculative at this time.

Municipal GHG Reduction Potential

There is little to no potential to reduce GHG from municipal operations with the two proposed auto user fees. Chicago, like London, would likely exempt all emergency vehicles and transit buses from the congestion tax.[10] Some City-owned and operated vehicles serving downtown areas may incur congestion pricing. The travel patterns of City vehicles were not ascertained as part of this research and savings are not calculated here.

An enhanced parking pricing system will likely have no effect on municipal operations. The City itself maintains parking spaces for the vehicles it owns so there is no "cruising" for spaces to eliminate. No significant savings in GHGs can be expected.

Economic Profile

Financial Costs

London and New York City's efforts provide examples of financial costs for implementing and operating a congestion pricing system:

- London's system cost approximately 200 million pounds ($400 million) to set up and has an annual operating cost of 115 million pounds ($230 million).[11] Currently, vehicles pay 8 pounds ($16) per day when entering the congestion zone.[12]
- New York City requested $536.9 million in federal funds to implement a congestion pricing system. In the end, this project was not approved by the New York state legislature. Of the funds proposed, $107 million would have been spent on equipment—EZ-Pass transponder readers and license plate cameras; $207 million for 367 new buses to accommodate displaced commuters who would have traveled less often, if at all, by personal vehicle; $52 million for infrastructure improvements such as bus layover stations; $37 million to install a traffic light system giving priority to buses; and $72 million for a processing center to oversee the program.[13] It was proposed that passenger cars would pay $8 and trucks $21 per day to enter the congestion zone.[14]

For an enhanced parking pricing system, new parking meters or parking kiosks may be needed. New parking meters cost $175 each. 7,000 new meters would cost $1.2 million.[15] Parking kiosks may cost more initially but can replace an entire block of parking meters. There would also be costs associated with studying the pricing point to achieve an 85 percent vacancy rate in different areas.

Market forces can set the price of meter parking so that occupancy rates remain around 85 percent, and roughly 15 percent of spaces—one out of every seven—are vacant at all times. Market prices may vary by location and time of day to balance the fluctuating demand for parking with a fixed supply of spaces.

Financial Savings

Financial savings related to congestion pricing include fuel savings as people reduce their VMT. Savings are also derived from recovering time and productivity that had otherwise been lost to congestion. There could be a significant amount of revenue earned through the congestion tolls that can be used for various transportation improvements. London had a net gain of 122 million pounds ($244 million) in its last fiscal year.[16] New York City's plan estimated gross annual revenues of $380 million.[17]

Financial savings related to parking pricing come from reduced use of fuel to cruise while looking for a parking space. Additionally, the increased parking revenue could be used for neighborhood development and encouragement of other modes of transportation, including walking and biking to the area.

Qualitative Results

Program Elements

The overarching goal of the congestion pricing will need to be determined. The two major goals of congestion pricing are to remove congestion and add revenue. The goal of the system would be a major factor in determining the boundaries for such a toll, the scale of pricing, and the hours of operation.

- If the primary goal of the system is to reduce congestion, the pricing would be prohibitive to prevent a certain percentage of traffic from entering the zone. Since downtown travel is considered rather inelastic in most cases, a high enough toll would have to be levied in order to provide a barrier for some downtown travel.
- If the primary goal of the system is to raise revenue, a toll would be implemented that would allow the generation of revenue while presenting a minimal barrier to traffic in terms of additional costs.

The three major components of a downtown congestion pricing system are:

1) boundaries of the toll zone;
2) amount of the toll; and
3) whether or not dynamic or time-based controls are used to raise tolls during peak periods of traffic.

Incentives for adopting more environmental vehicles and fuels could also be incorporated into a congestion pricing system. For example, London allows vehicles that use alternative fuels or fuel cells to be exempted from the congestion pricing system. These vehicles must be approved for use in order to gain the exemption.[18]

Benefits and Burdens

The major benefits of the first form of congestion pricing, focused on reducing congestion, include: improved quality of life by reducing congestion, lowered travel times, reduced air pollution (particularly criteria pollutants), and more foot traffic which could benefit businesses.

A burden may fall on low income workers who may not be able to afford the toll and need to drive through the central city to places of work which may be difficult to access by public transportation. There are opportunities for exemptions from the congestion fees as London has made available for disabled drivers.[19] Similar exemptions can be considered for low income workers.

In addition to the transportation and environmental benefits derived from an enhanced parking system, cities that have adjusted their meter rates (see Current Initiatives and Models) report returning all the increased meter revenues to the metered districts.[20] This provision ensures support for increasing meter prices from merchants, residents, and property owners. The performance-based prices can yield ample revenue to pay for sidewalk cleaning and repair, street lighting, graffiti removal, tree planting, and security patrols. These public improvements in turn attract more customers to the metered districts.[21]

One burden from increased metered parking fees is the increased cost of parking, which again could disproportionately impact lower income households. With prices adjusted to maintain 85 percent occupancy, there are nearly as many people parking than prior to the increase. If higher prices force a higher vacancy rate, the parking price could be lowered.

Current Initiatives and Models

There are a number of automobile user fee initiatives and models to consider. Below, congestion pricing initiatives and models are discussed first, followed by enhanced parking pricing system examples.

Congestion Pricing

Stockholm held a congestion pricing trial during the first half of 2006, after which voters passed a referendum to maintain the charge. Polling showed that at the outset, only 31 percent of residents supported the congestion pricing, which grew to 67 percent support after the trial was completed. Traffic declined by 15 percent.[22]

Singapore has employed congestion pricing since 1975. For many years there were merely low-tech daily charges in order to enter the central business district.[23] Currently, the system uses a dynamic charging system that varies depending upon location and time of day.[24]

New York City proposed an $8 fee for cars and $21 fee for trucks to enter Manhattan south of 86th Street. If it had been implemented, the cashless system would have used EZ Pass and a camera license plate recognition technology to enforce the tolls.

London started congestion pricing in its central business district in 2003. The original price was five pounds and is now eight. It is collected from 8:00 AM to 6:00 PM on Monday through Friday.[25] The toll is tracked through the use of cameras that successfully identify 90 percent of all license plates that enter the congestion zone.[26] There are a number of notable logistics and results from the London effort that could inform Chicago-based congestion pricing:

- According to a published report from Transport for London, congestion levels in the zone are 26 percent lower on average than in 2002 before the scheme was introduced.[27] The national environmental transport body, Transport 2000, claims that during charging hours, 65,000 fewer car movements per day are made into or through the zone.[28]
- By law, all of the money raised by the congestion fee must be put back into the transportation system. Most of the 84 million pounds raised per year has been reinvested in bus service.[29] Bus service has been increased by 29,000 passengers and 560 extra runs each weekday.[30]
- Transport for London has reported that carbon emissions in the zone have been reduced by 16 percent.[31]
- There have been mixed effects reported on businesses. Fighting for Private Business conducted a survey of 500 small to medium-sized firms in London in November 2006 and found that 58 percent had seen profits drop since the congestion charge was introduced.[32] Meanwhile, a third had thought of relocating, and two thirds reported a drop in footfall of clients and customers. According to the Commission for Integrated Transport, larger businesses are doing better. They point out that potential benefits flowing from improved transport speeds and reliability should reduce the cost of operating in Central London.[33] Transport for London has reported no identifiable

effect on business turnover within the zone compared to the rest of London.[34]

Enhanced Parking Pricing System

In Chicago, the 53rd Street business district on the South Side and Milwaukee Avenue in Logan Square are considering raising meter rates from 25 cents an hour to one dollar an hour to match parking demand. The City would continue to receive the revenue from the old rate, and split the 75-cent increase with the neighborhood transportation districts. The neighborhoods can then use the money to help pay for sidewalk improvements, beautification, cleaning, and security.[35]

The Old Pasadena district in Southern California receives $1.2 million a year in net parking revenue from its parking meters, which it uses for public improvements in the area. In 1993, officials persuaded merchants in the district to install parking meters as long as the revenues paid for improvements in the dilapidated shopping area.[36] A 2001 study found that the average curb-space occupancy rate was 83 percent, which means that customers can always find a parking space.[37] The shopping district has experienced a revival, evolving from a Skid Row to one of the region's premiere shopping areas today.[38]

Bus ridership in Portland's Lloyd District shopping area has tripled in the last 10 years, due in part to 75 cent per hour charge at previously free parking spots.[39] The switch to performance-based meter prices has encouraged store and office employees to commute by public transportation.

San Francisco is experimenting with a system that can track parking space usage and availability and adjust the price based on demand.[40]

Implementation Mechanisms

Congestion pricing could be implemented by setting up a series of electronic tolling booths using the I-PASS system without providing any barriers to traffic. Additionally, a series of cameras could identify cars that did not have the electronic transponders and those occupants would pay through the internet or at terminals set up throughout the city.

Congestion pricing could also be implemented in the form of increased parking taxes in the central business district. Increasing the parking tax by the same amount as a congestion fee for moving traffic could result in reduced congestion and corresponding CO2e with less overhead, as a parking tax is already in place and could be implemented with a much lower startup cost.

Two models—pricing by street and rolling rates—to implement an enhanced parking system are described below. These could be investigated by the City of Chicago for their applicability.

1) **Pricing by Street** - Redwood City, California has strategically changed meter prices in its main shopping district to provide incentives for drivers to park a few blocks away from the main shopping street and walk. The meters on the main shopping street cost 75 cents per hour, side streets are 50 cents per hour, and lots and garages are 25-50 cents per hour. Redwood City also eliminated parking time limits and dedicated all surplus revenue to improving the business district. New parking meter technology allows officials to monitor vacancy rates and adjust the hourly price of downtown spaces to control occupancy over time. The City's 40 parking meters have WiFi connectivity so that customers have real-time credit card authorization.[41]
2) **Rolling Rates -** San Francisco has installed parking meter kiosks that take credit cards in addition to quarters. They eliminated the flat parking rate of two dollars per hour and implemented a four-hour rolling rate that starts at three dollars an hour and rises to five dollars an hour for a total of $15 for four hours.[42]

Feasibility

Financial

There would be significant costs to implement a congestion pricing system with the promise of significant revenues. If London's experience is replicable, Chicago can expect to recoup the cost of investment within a few years of implementation.

There are some startup costs for an enhanced parking pricing system, but also with the promise of increased revenue. Costs are relatively low compared to the expected return—neighborhood investment, and reduced VMT and CO2e emissions.

Technical

Both congestion pricing and enhanced parking pricing systems are feasible. As noted in Current Initiatives and Models, there are many existing programs in place using existing technology.

Political

Many of the congestion pricing systems instituted started out as unpopular policies.[43] However, all of the current projects are moving forward, with the exception of New York, and none would be considered failures by the general populace. The feasibility in Chicago is still to be determined. Many details would need to be worked out before any system could even be evaluated. London, for example, had a much more extensive transit system in operation when congestion pricing was introduced, which provides viable alternatives to paying the congestion fee. Enhancing public transit service would be a critical component of successful congestion pricing in Chicago. Other details such as the exact pricing, congestion zone, exemptions, hours of operation, and how the revenue is distributed will determine whether a project of this scope is feasible in Chicago.

Acceptance of the changed meter pricing mechanisms is more politically feasible than congestion pricing, as its more localized and increased revenues can be dedicated to improving the metered area. In the long-term, investment in technology like San Francisco's Streetline Network sensor meters would provide valuable information about parking demand patterns and better inform pricing mechanisms. Outreach to the business community to demonstrate the success of these technologies in other cities could go a long way in alleviating any fears about increasing the parking in their districts.

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

Strategy Summary	Rating	Value
CO2e Savings Against BAU	+	0.0291 MMTCO2e
Scale of deployment	++	60,000 Chicago employees
Timing	+++	Can be implemented now
Regional Impact	+	0.0615 MMTCO2e
Financial Savings in relation to Cost	++	Little additional costs to employers, benefits to employees
Additional Benefits in relation to Burdens	+++	Very little down side, employee satisfaction and benefits associated with reduced petroleum use
Feasibility assessment	++	Reasonable cost, technically feasible, some political barriers

Overview
This mitigation opportunity is enacting programs that normalize the costs of transportation based on greenhouse gas emissions. The three programs detailed in this section are parking cash-out options, raising the city parking sticker based on fuel efficiency, and pre-tax transit passes.

The current transportation system benefits automobiles over other means of travel. In Chicago, gas is still relatively affordable, roads are mostly free with inexpensive toll roads, and free parking is supplied by many employers. These costs, or lack thereof, when combined with the ease of getting into a car and traveling on your own schedule make automobiles the preferred method of travel for the majority of people as shown by the average Chicago household owning 1.08 cars in 2000.[1]

Quantitative Results

GHG Reduction Potential 0.0291 MMTCO2e
According to national parking cost expert Donald Shoup, offering six million commuters nationally with parking cash-out will reduce commuter travel by 3.9 billion VMT, save 156 million gallons of gasoline, and reduce 2.2 MMT CO2e per year.[2] Assigning Chicago's savings based on their share of national population would yield approximately 20,600 metric tons of CO2 in savings.

As of October 2003, the CTA and RTA have 1,800 enrolled businesses and 40,000 participating employees in the pre-tax transit program. If this program was expanded by 25 percent of that total, there is the potential to reduce 8,480 metric tons of CO2e.

There is not potential for great reductions in greenhouse gases by increasing city vehicle stickers by any amount that would be politically feasible. An increased fee could be part of an overall plan aimed at improving efficient use of vehicles (see *Mitigation Strategy #26*) but by itself would not achieve any measurable improvement.

Scale Assumed

The scale assumed in the parking cash-out scenario is that 56,000 Chicago employees would participate in the system. The pre-tax transit program scenario assumes that an additional 4,000 employees ride the CTA to work instead of driving due to the cost savings of the program.

Timeline

This program can be implemented in the very near future as a parking cash-out system could benefit a great number of Chicago employers. The pre-tax transit program is growing rapidly and this timeline assumes that 4,000 extra riders are added by 2020.

Per-unit Reduction Potential

Using Donald Shoup's scenario, a parking cash-out system would save 0.37 metric tons of CO2 for every employee that was offered such a plan. The savings in this example include employees that were offered the plan and not only those who participated in the cash-out. Each employee taking advantage of the pre-tax transit program reduces 0.8 metric tons of CO2 annually.

Activity Savings

Chicago's share of fuel savings for a parking cash-out system would be approximately 1.5 million gallons. If 4,000 additional employees used the CTA due to the pre-tax transit program 380,000 gallons of gasoline would be saved annually in 2020.

Regional GHG Reduction Potential

The Chicago region has the potential to save 61,500 metric tons of CO2e and 4.4 million gallons of gasoline if a parking cash-out system was implemented regionally. The data on employees using the pre-tax program does not include their location so the regional reduction is the same as the local reduction for Chicago in this scenario.

Municipal GHG Reduction Potential

There are no municipal savings possible under a parking cash-out, system pre-tax transit system, or increased vehicle stickers. The savings are for individual drivers and do not apply to the city fleet in any way.

Economic Profile

Financial costs

A parking cash-out should not increase any costs to employers. It should be used to either offset leased parking spaces or to save money on building more parking for employees. Employers may have to pay increased taxes on money given to employees but they can reduce the amount of their cash-out to prevent that from happening. For example an employer may save $145 by giving up a lease on a parking spot and offer $130 to the employee as incentive to not use that spot. The employer would be responsible for

approximately $11 in payroll taxes but still comes out ahead. There are many examples of different plans that can save costs for both employers and employees that follow this model.
A pre-tax transit system does not have any additional costs to the employer, employee, or transit agency. The only parties that lose revenue are those that collect money off of income taxes. In this case that would be the U.S. Government and State of Illinois. The tax lost to these entities can vary due to the different tax brackets associated with each employee and the amount deducted and used for transit.

An increased city vehicle sticker would add extra costs to owners of high-emission vehicles to provide an incentive for them to purchase a more fuel efficient vehicle in the future.

Financial Savings

A parking cash-out system should result in savings for the employees who participate in the program while employers should break even as described above. The actual savings for employees depends on the price of parking their employer is paying. The savings for employees could be used to pay for a transit pass, that would be tax-free (up to $110 per month), or to supplement their paycheck, which would have taxes deducted from it.

A pre-tax transit program saves employers and employees money by deducting transit costs from their paychecks before taxes are calculated. If an employee purchases a monthly CTA pass for an entire year ($900 per year), the annual savings on transit costs can be as high as $348, or less for people in lower tax brackets. Employers can also benefit as they do not have to pay their share of an employee taxes on the pre-tax income dedicated to transit.

Along with increasing city vehicle stickers for large passenger vehicles there could also be a discount for hybrids cars or those using alternative fuels causing little greenhouse gas emissions. This would provide an extra incentive for the use of technologies and fuels that produced low amounts of greenhouse gases.

Qualitative Results

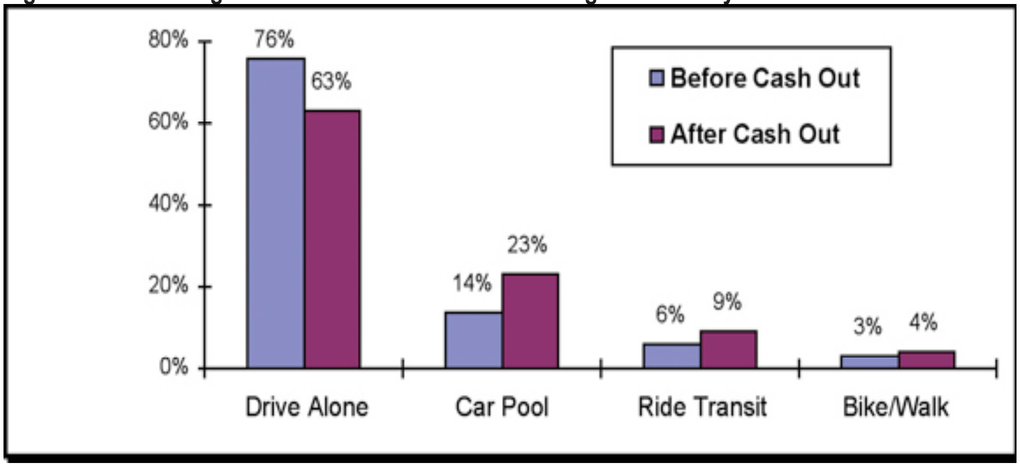
Program elements

Mandated Parking Cash-outs

This program would provide a cash equivalent to employees who do not use free parking provided by their employer. Since parking costs employers money, and employees who use public transportation, walk, or bike do not use these parking spaces, they are compensated at a reduced rate of the parking space benefit. The "cash-out" saves employers money while providing a cash incentive to employees for taking alternative forms of transportation to work, thereby reducing personal vehicle travel and related VMT and CO2e. The employees who "cash-out" benefit from extra income, offsetting transportation costs (e.g., transit pass, bike maintenance). Employers benefit by reducing costs associated with providing parking spaces to employees. For example, on an $80 space, the employer could pay $70 for the cash out. The employee could benefits by using $50 of that amount (tax free) for a transit pass, while pocketing the remaining $20 (taxed) each month as extra money.

Figure 2 shows the results from a 1997 survey of eight California firms that instituted a parking cash-out option. Vehicle trips declined by 17 percent after cash-outs were implemented in various urban and suburban locations.[3]

Figure 2: Commuting Patterns Before and After a Parking Cash-Out System



Increased City Vehicle Sticker

Under this program, the City could modify its current vehicle sticker program to create a tiered system based on the fuel efficiency of vehicles—less fuel efficient vehicles costing more than more efficient vehicles. There is already a vehicle sticker system in place that could be leveraged for a fuel efficiency component. By making the cost of City stickers parallel with fuel mileage, the City could discourage larger, gas guzzling vehicles. This could encourage a behavior change over time and slowly increase the fuel efficiency of the fleet of cars traveling in the City.

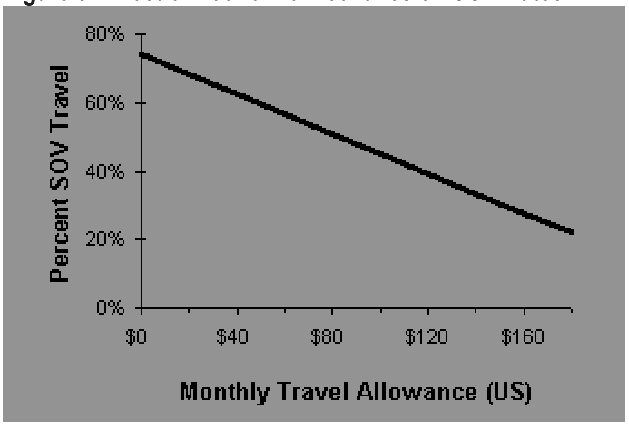
Pre-tax Transit Passes

The City could encourage more employers to offer pre-tax transit passes, available through the RTA/CTA Benefit Program, to their employees. There is some correlation to pre-tax transit passes and an increased use of transit, with a corresponding reduction of VMT and emissions. Pre-tax transit, which is a commuter benefit, can contribute to a 5-25% VMT reduction on a site basis, i.e., at a particular place of employment where commuter benefits are offered.[4] Commuter benefits, as tracked through Best Workplaces for Commuters, a voluntary program run by the U.S. EPA and U.S. Department of Transportation, led to 3.4 MMTCO2 savings from 2001-2005 from program participants.[5]

The RTA/CTA Transit Benefit Program is based on a federal tax law designed to encourage the use of public transit. As part of the Transportation Equity Act for the 21st Century (TEA-21), employees can use up to $110 per month ($1320/year) of pre-tax income to pay for transit.[6] Employers have the option of subsidizing employees' transit costs at a level of their choice.

If an employee purchases a monthly CTA pass for an entire year ($900 per year), the annual savings on transit costs can be as high as $348, or less for people in lower tax brackets. The greater the travel allowance, the less likely people are to travel in Single Occupancy Vehicles (SOV), as shown in Figure 3.

Figure 3: Effect of Economic Incentives on SOV Rates



Source: Scott Rutherford, Shauna Badgett, John Ishimaru and Stephanie MacLachlan (1995), "Transportation Demand Management: Case Studies of Medium-Sized Employers," Transportation Research Record 1459, TRB (www.trb.org), pp. 7-16.

Benefits and Burdens

Parking cash-outs and pre-tax transit passes serve as recruiting and retention tools for companies. The programs outlined are likely to result in less congestion, lower travel times and higher quality of life.

A program to link the cost of City stickers with the fuel economy of a vehicle may disproportionately affect low-income households, who typically own and operate older cars that are not as fuel efficient as newer models.

Implementation Mechanisms

Parking Cash-outs

The City could work with private employers to promote parking cash-out programs—demonstrating the potential benefits, providing marketing materials, and recognizing the companies for providing comprehensive commuter benefit packages. Additionally, the City and county governments could offer parking cash-out to their respective employees.

Pre-tax Transit Passes

The current RTA/CTA Transit Benefit Program should be expanded by marketing it to more businesses. This program is already in place and many employers and employees are unaware of it. Awareness would lead more people to take advantage of the program and increase their transit ridership, while decreasing personal vehicle usage. It should also be marketed to businesses as a cost savings, since they save on the employer share of taxes on the pre-tax income devoted to transit program.

Increased City Vehicle Sticker

The pricing mechanism of the current City sticker program would need to be altered to include higher charges for low fuel economy vehicles.

Current Initiatives and Models

Parking Cash-out Programs

- Calvert Group, Bethesda, Maryland: Calvert began subsidizing all commuters. Drivers received $75/month while transit riders received the full cost of their commute. Bicyclists also received a one-time $350 reimbursement and walkers received $75. Turnover was decreased from 25 to 12 percent with the program serving as a major draw in recruitment.[7]

- C2M Hill, Bellevue, Washington: Upon moving into new offices, C2M Hill began offering free parking to employees who drove or $40 per month to those who did not use a parking space. The firm's drive alone rate fell from 89 to 54 percent, eliminating concerns over the scarcity of parking.[8]

Pre-tax Transit Passes

Transit agencies in Dallas, Denver, Salt Lake, San Jose, and Boulder sell employers "Eco Passes." These passes are sold to employers at a discount in larger quantities. The transit agency receives the revenue from companies, albeit at a discounted price, and employers receive a discount and are able to offer a great benefit to their employees.

For example, the Santa Clara Valley Transportation Authority (SCVTA) charges between $5 and $80 a year per employee for Eco Passes—1 to 19 percent of the price of its conventional pass, depending on the employer's location and number of employees. The passes allow unlimited free rides on any SCVTA bus or rail line, seven days a week.

Increased City Vehicle Sticker

Richmond upon Thames, a borough in southwest London, began an experiment charging up to 450 pounds (roughly $900) per year for the least fuel efficient cars while the cleanest cars parked for free.[9] Since the start of the project, it has expanded to approximately one-third of all boroughs in London.[10] Other policies have varied between raising prices for high fuel users to free parking for cleaner cars. Specific results on long-term behavior change are currently unavailable.

Feasibility

Financial

The programs proposed cost relatively little to expand or amend, and would result in some savings to employers and employees alike, besides generating savings related to reducing congestion.

Technical

There are systems in places for parking cash-outs, pre-tax transit passes, and vehicle City stickers. The programs outlined in this mitigation opportunity are completely feasible.

Political

Politically, the least palatable program suggestion would likely be increasing City vehicle stickers. Different levels of vehicle stickers for different levels of fuel economy would add some administrative tasks and system requirements that may be cumbersome.

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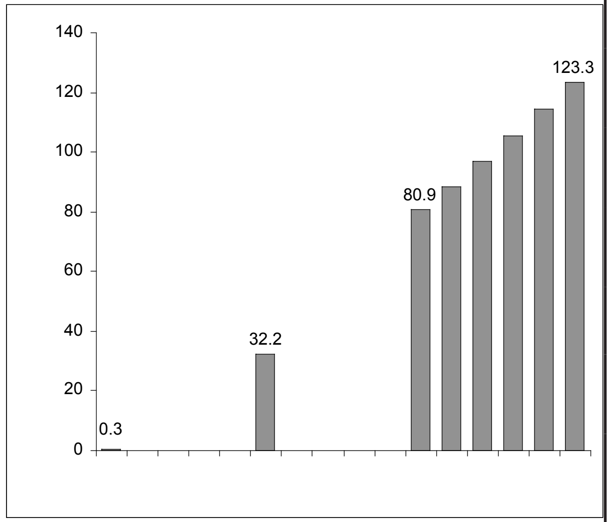
Mitigation Strategy #30
Use of Alternative Refrigerants

Strategy Summary	Rating	Value
CO2e Savings Against BAU	+++	1.159 MMTCO2e
Scale of deployment	+++	50% reduction by 2020
Timing	+++	Reductions begin in 2010
Regional Impact	+++	3.466 MMT Co2e
Financial Savings in relation to Cost	Unknown	Unknown
Additional Benefits in relation to Burdens	+	The major benefit is GHG reduction.
Feasibility assessment	+	Technical development of alternatives are very much in process

Figure 1 Growth of Ozone Depleting Substitutes in the United States, 1990-2005



Source: Environmental Protection Agency. "2007 Draft U.S. Greenhouse Gas Inventory Report" February 2007, p 4-47

Overview

This strategy proposes the use of alternative refrigerants to replace greenhouse gas producing HydroFluoroCarbons (HFCs), used primarily in air conditioners, refrigerators and freezers.

In 1987, the Montreal Protocol was designed to end the use of chemicals that damaged the ozone layer. Enforcement began two years later and has since been adopted by all but five nations in the world (Andorra, Iraq, San Marino, Timor-Leste, and Vatican City).[1] As part of the Montreal Protocol, countries began to phase out hydrochlorofluorocarbons (HCFCs) with ninety percent removal planned for 2015 and their complete elimination set for 2030.[2] These HCFCs, which are primarily used in refrigeration, were causing holes in the ozone layer and needed to be removed from use to stop causing any further damage.

The most popular replacement for HCFC (Freon was one of the most common HCFCs used) became HFC-134a,developed by DuPont. HFC-134a met the standards set by the Montreal Protocol by producing no harmful

Global Warming Potentials (GWPs)

HydroFluoroCarbons (HFCs) have a proportionately larger impact on global warming than more common greenhouse gases, such as carbon dioxide. One ton of HFC-134a has the same global warming impact over 100 years as 1,300 tons of CO2. This ratio is called the Global Warming Potential (GWP) of a GHG. Throughout this report where GHG emissions are labeled in carbon dioxide equivalents (CO2e) each GHG has been multiplied by its GWP to represent its relative impact on global climate change. GWPs have changed over time as the scientific understanding of GHGs has improved. This report uses the GWPs from the Third Assessment Report of the United Nations Intergovernmental Panel on Climate Change.

ozone gases. However, HFC-134a has a global warming potential (GWP) of 1,300—meaning that one ton of HFC-134a is the equivalent to 1,300 tons of CO2 in terms of climate change impact.[3] Since the Montreal Protocol was designed only to reduce ozone depleting gases, it placed no restrictions on HFCs. These HFCs do not produce greenhouse gases during normal use but they can be released through leakage or when service is incorrectly performed on the refrigeration or air-conditioning system.

The end-use sectors contributing the most towards emissions of HFCs as ozone depleting substitutes are refrigeration and air-conditioning (87 percent of the national total), aerosols (9 percent of the national total), and solvents (1 percent of the national total). Within refrigeration and air-conditioning, motor vehicle air-conditioning by itself makes up approximately 43 percent of HFC emissions.[4]

Quantitative Results

GHG Reduction Potential: 1.159 MMT CO2e in 2020

A reduction of 50 percent of the business as usual forecast in ozone depleting substitutes in Chicago would result in savings of 1.159 MMT CO2e—greenhouse gases (GHG)—in 2020.

Scale Assumed

The GHG reduction potential represents savings from across the board in all HFCs, although the largest single HFC gas is HFC-134a which represents over half of all the CO2e created by HFC gases. Savings would be phased in as older air conditioners and refrigeration units were replaced with newer systems. This would be similar to the phase-out of the HCFCs that have taken place since the Montreal Protocol.

Timeline

An ambitious timeline would start to place limitations on HFCs in 2010 with a complete ban on new uses by 2020.

Per-unit GHG Reduction Potential

There are no specific metrics for measuring HFC reduction since no releases, which are the direct cause of CO2e from these products, are caused by normal use. However, since HFC-134a has a GWP of 1,300, a release of just 1 kilogram of HFC-134a would have the same impact as driving a standard passenger car 4,500 miles in 2020.

Activity Savings

The goal is not necessarily to reduce the amount of refrigerants that would be used, but rather the reduction of refrigerants with significant GWP.

Life cycle GHG Impacts

These refrigerants, HFCs, have large life cycle GHG impacts as they require large investments of energy for the development of facilities and manufacturing. This is in addition to the large amount of toxic waste produced in the manufacturing process, which must be disposed of in some way. Reducing, and eventually replacing HFCs, will have wide-scale GHG savings potential.

Regional GHG Reduction Potential

A reduction of 50 percent of the business as usual forecast in ozone substituting products would result in savings of 3.466 MMT CO2e in 2020 in the Chicago region.

Municipal GHG Reduction Potential

There will be GHGs reduced in municipal operations from reducing, and then phasing out HFCs. Specific savings cannot be calculated as there is no per-unit reduction potential to assign individual users a share of HFC use and savings.

Economic Profile

Costs

Costs are largely speculative at this time. Even in the European Union, where HFCs are scheduled to be replaced beginning in 2011, HFC replacement refrigerants have not been determined. There are anticipated costs for the chemicals themselves and a system redesign for producing the alternative refrigerants. DuPont and Honeywell are looking to minimize these costs by designing an automobile cooling replacement that can use the existing tools, space and systems as those used for HFC134a.[5] And, as mentioned earlier, automobile cooling systems are one of the largest users of ozone depleting substitutes.

Savings

There will likely be no financial savings as the market moves away from HFCs. A replacement will likely be introduced that will cost around the same, if not slightly more than its predecessor. Any cost associated with producing alternatives may be passed on to the consumer in the price of appliances and automobiles.

Qualitative Results

Program Elements

HFCs are powerful GHGs and must be phased out of use. The City of Chicago could use its power with state and national leaders to begin a phase-out of these chemicals. This could follow the model of the Montreal Protocol which worked successfully in the past to remove the chemicals which caused destruction to the ozone layer.

While no clear successor has been chosen for HFC-134a, there are at least two potential alternatives being developed. The first is a CO_2 based system with a GWP of 1 which tends to work better in cooler climates in its current state. Honeywell and DuPont are also working on a direct replacement of HFC-134a called DP-1 that would have no ozone depleting material and a GWP of only 40.[6]

Benefits and Burdens

Assuming a suitable replacement is found, the benefit would be greatly reduced production of greenhouse gases. This should not alter the types of refrigeration that currently serve the market. The average consumer will be unaware of the transformation, just as when HCFCs were phased out in favor of HFCs.

There is a potential burden on manufacturers to overhaul systems not compatible with the manufacturing of a new refrigerant. This could add significant costs to phasing out HFCs. There is also a potential burden on low-income consumers who cannot afford to replace cars and appliances with newer models that use alternative refrigerants with low, or no, GWP. There could be efforts to consciously pair appliance trade-in programs with this mitigation strategy so that replacement refrigerators and air conditioners made available to low-income households at reduced rates or no charge will reduce energy use and HFCs.

Current Initiatives and Models

The European Union recently passed the MAC directive which targets the reduction of fluorinated greenhouse gases, including HFCs, perfluorocarbons (PFCs), and sulphur hexafluoride (SF_6)—all potent greenhouse gases. The MAC directive will phase out HFC-134a for all new models of cars beginning in

2011 and for all vehicles beginning in 2017. [7] Acceptable leakage rates were also set for automobile air conditioning systems.

The California Air Resources Board (ARB) has restricted the purchase of "do-it-yourself" automobile refrigerants.[8] This action was taken under the California Global Warming Solutions Act of 2006. Only licensed professionals may purchase HFC-134a when performing maintenance on automobiles. When amateur mechanics use these types of refills, they often unknowingly leak chemicals into the air or leave leftovers in the can which leak out over the course of time. Due to the large GWP of HFC-134a, even a small leak can have large impacts on global warming. The ARB estimates this Act will save California 1-2 MMT CO2e by 2020.[9]

Implementation Mechanisms

The City of Chicago could join cities, states, and countries worldwide in a movement to ban HFCs. Phasing out HFCs would be most effective if done on an international level. While California has banned the individual sale of HFC-134a, it has also been investigating the ban of HFCs altogether, much like the action taken by the European Union. A state-by-state approach will take too much time to reduce significant amount of HFCs, which continue to be used in vehicle, household, and commercial cooling systems. The Montreal Protocol worked to end the proliferation of ozone depleting gases and could be reconfigured to end greenhouse gas causing HFCs as well. Under an international agreement, in the vein of the Kyoto Protocol, HFCs could be phased out simultaneously, and efforts combined to identify and implement the use of safer alternatives.

Feasibility

Financial

Manufacturers will pass along research and production costs to the consumer, however, the cost is not expected to change to a large degree, which makes these replacements feasible from a financial perspective. These burdens can be greatly reduced if replacements can be found that would not require systems to be redesigned.

Technical

No suitable alternative has been agreed to in the European Union even though their phase-out begins in just four years. Honeywell, DuPont, and other major chemical players are currently researching alternatives.

Political

Due to the GWP of HFCs and their tremendous growth over the past 15 years, it is essential that something is done to curb their use. Although this sector of greenhouse gas emissions has not received much national attention, they are growing at such a rapid rate that alternatives must be proposed in the near future.

The City of Chicago could issue a ban against the use of HFCs, but this is complicated by the availability of alternatives and the City's capacity to leverage a deal for alternatives specific to this area when refrigerators, air conditioners, and automobiles are produced worldwide. This mitigation strategy necessitates partnerships with manufacturers and different levels of government.

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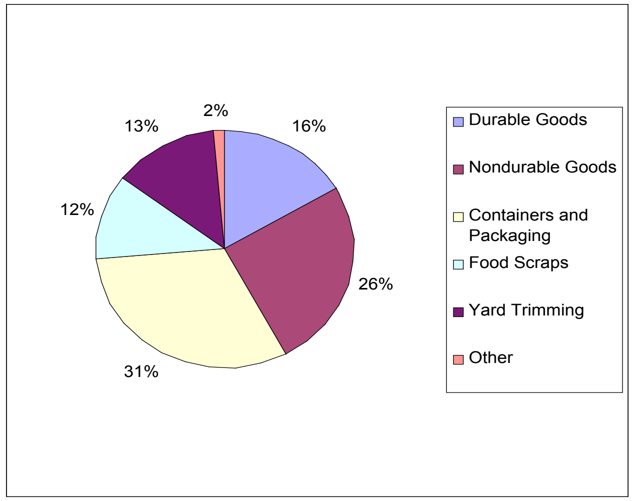
Mitigation Strategy #31
Zero Waste Policy

Strategy Summary	Rating	Value
CO2e Savings Against BAU	++	0.919 MMT CO2e
Scale of deployment	+++	All waste
Timing	+++	Begins in 2008
Regional Impact	++	1.993 MMT CO2e
Financial Savings in relation to Cost	++	Savings may balance costs
Additional Benefits in relation to Burdens	++	Potential land and water benefits
Feasibility assessment	++	Existing technologies, but requires systematic change

Figure 1: Products Generated in the Municipal Solid Waste Stream, United States, 2005



Source: Environmental Protection Agency. "Municipal Waste in the United States: 2005 Facts and Figures" October 2006. p 84

Overview

In a perfect 'zero waste' system, each unit of energy and material would be somehow reused.[1] Consider this picture: no landfills are needed because consumers recycle all packaging material and compost food scraps, industrial byproducts are reused, and all energy is clean—leaving no toxic substances behind.

The picture seems utopian in nature. The City of Chicago and other cities are beginning to set goals to eliminate municipal solid waste—taking steps towards the utopian picture.

Quantitative Results

GHG Reduction Potential- 0.919MMT CO2e

The greenhouse gas (GHG) reduction potential represents the elimination of all waste emissions associated with methane production in landfills forecasted for Chicago for 2020. The reduction potential does not include any all the GHG saved from reduced vehicle trips that could result from eliminating municipal garbage truck trips to and from landfills, nor does it include any additional transportation needs due to an increase in recycling levels.

However, there are opportunities resulting from restructuring the way garbage and recycling will be collected. There is potential for CO2e reduction that includes franchising the private collection of waste from large residential and commercial sources. Currently, the owners of these buildings contract private haulers to collect this waste, and there is no coherent collection plan. This proposed innovation follows the lead in other cities to franchise this collection to a single hauler for each neighborhood. This would eliminate redundancies in the waste collection process and is estimated to remove 2,000 heavy duty diesel trucks from the streets each day[2], resulting in an additional 0.110 MMT CO2e reduced. Thus the total reduction directly from eliminating waste and reducing collection efforts will be 0.919 MMT CO2e.

If 90% of all methane producing waste is eliminated by 2020, the reduction will be 0.728 for the waste reduction, and 0.110 for franchising the private collection for a total reduction of 0.838.

The scale assumed would require the City to recycle, reuse or reduce all waste generated within city borders. Chicago generated 5.6 million tons of municipal solid waste in 2005, 44 percent of which was diverted through recycling.[3]

If Chicago's waste is not eliminated, but is still sent to landfills, the City could eliminate waste emissions by capturing all methane emissions and using that methane to generate energy, offsetting other fossil fuel energy sources.

Timeline

It is assumed that the zero waste policy could be incrementally introduced starting in 2008, with full implementation by 2020.

Per-unit GHG Reduction Potential

The GHG reduction potential of this strategy correlates with the amount of waste sent to landfills. In 2005, Chicago's emissions associated with solid waste were 0.4 metric tons of CO2e per ton of solid waste sent to landfills (net of recycling). A ten percent reduction in waste sent to landfills in 2020 would result in .0809 MMT CO2e, or 10% of the total reduction potential identified.

Activity Savings

The main activity savings associated with this strategy is a decrease in waste generation. This strategy could also result in transportation fuel savings due to reduced waste transport, though there will likely be an escalation of travel related to recycling to consider in any activity savings calculation. These transport savings are not calculated as part of the GHG reduction potential of this strategy.

Life Cycle GHG Impacts

Zero municipal waste would reduce direct emissions of methane, and indirectly those produced from the consumption of gasoline or other fuel used in garbage trucks that transport waste. Increased recycling and reuse of materials would lower the emissions associated with the entire life cycle of a product, including resource extraction and material manufacturing. However, expanding recycling efforts exponentially would increase energy associated with recycling.

According to an analysis by The Boston Consulting Group, using the U.S. EPA's "WARM" model, the greenhouse gas savings can total 6.2 million metric tons when factoring in the full lifecycle savings of a zero waste policy. The large majority of these savings (5.6 MMT CO2e) come from the reduced emissions associated with recycling as compared to using new materials.

Regional GHG Reduction Potential

The Chicago region has the potential to reduce 1.993 MMT CO2e by diverting all trash from landfills in 2020.

Municipal GHG Reduction Potential

There is modest GHG reduction potential from Chicago's municipal operations. The city government's zero waste would represent a small fraction of the total savings.

Economic Profile

Costs

Costs can vary greatly in any recycling program due to frequency of pickups and how many pickups are made by each crew per day. The Chicago Recycling Coalition created an estimate of how much curbside recycling would cost for the entire City. Their low estimate, which included biweekly pickups of 800 totes per day, was $14 million. Their high estimate, which included weekly service picking up 400 totes per day, was priced at $58 million per year. A midrange estimate of $28 million included either weekly pickups of 400 totes per day or biweekly pickups of 800 totes per day.[4] It is important to note that these figures only cover roughly 660,000 households in Chicago that are serviced by the City of Chicago Department of Streets and Sanitation. The remaining 340,000 households in multifamily housing of four or more units are serviced by private contractors, and an additional cost would be incurred from these residents.

Savings

In addition to aforementioned costs, recycling also has savings potential for the City operations. Chicago currently pays $36 for every ton it sends to a landfill. The City could save money by recycling more and sending less to a landfill—potential savings ranging from $6.4 to $8.6 million annually based on estimates from the Chicago Recycling Coalition.[5] The Coalition also estimates the City could sell its recycled material for $40 per ton generating an additional $7.2 to $9.6 million per year.[6] When looking at costs and savings together, recycling could be a breakeven proposition or even generate a slight profit based on these calculations. Only the most inefficient system, using weekly pickups of only 400 totes per week per crew, would result in substantial financial losses.

Qualitative Results

Program Elements

There are three potential steps towards a zero waste system:

1) **Zero Waste Emissions**- Solid waste generates methane while it degrades in a landfill. Methane has 100 year global warming potential (GWP) of 23, meaning that it is 23 times more powerful than carbon dioxide in terms of causing global warming.[7] Zero waste emissions can be achieved by capturing methane as it emerges from the landfill and turning that methane into energy. Even if a waste system receives garbage, zero emissions can still result by using a waste-to-energy system to offset other fossil fuel uses.
2) **Zero Landfill Waste**- By recycling or reusing all discarded materials from residents and commercial businesses, all waste could be diverted from landfills. Expanded recycling systems and composting make this an ambitious but attainable goal, and one that seems most popular among municipalities. Composting can generate methane as waste decomposes, but according to the U.S. EPA, a well managed composting system oxidizes methane so that only biogenic CO2 is emitted.[8]

Waste to Energy System

According to the U.S. EPA, waste-to-energy plants work very much like coal-fired power plants. The difference is the fuel. Waste-to-energy plants use garbage—not coal—to fire an industrial boiler. In 100 pounds of typical garbage, more than 80 pounds can be burned as fuel to generate electricity at a power plant. Those fuels include paper, plastics and yard waste. A ton of garbage generates about 525 kilowatt-hours (kWh) of electricity—enough energy to heat a typical office building for one day.

3) **True Zero Waste**- True Zero Waste means that no waste would be generated from any manufacturing processes or energy production. True Zero Waste would require changes to many manufacturing processes to ensure that all excess items are used in other processes and are not discarded.[9]

Methane Flaring
Flaring of methane is a method of reducing the GHG emissions of a landfill by turning methane into CO2, water vapor, heat and light. CO2 has a GWP of 1, so flaring results in a net decrease in GHG emissions, but is not emissions free. However to the extent that the methane flared is associated biogenic sources, such as paper waste, the carbon dioxide emitted started its lifecycle in the atmosphere, was captured by photosynthesis, and has no net impact on global warming upon release. Flaring is a less optimal use of landfill methane than waste-to-energy.

Benefits and Burdens

A zero waste system has many economic and environmental benefits. Taxpayers currently pay for transporting waste to landfills and the management of landfills—essentially paying for items twice—first, in the original purchase and then later, in the disposal of the waste associated with the item. This is economically inefficient—an efficiency that can be corrected through zero waste programs. Zero waste reduces methane and the large transportation emissions associated with hauling trash from the city to various landfills throughout the region. Reducing landfill waste also has the potential to reduce other environmental hazards associated with some landfills, such as toxic releases and impacts on water quality.

The burdens of this strategy mainly relate to behavior change. Systems would have to be changed at manufacturing companies, and trainings held for employees, to show how byproducts of processes should be used for non-waste activities. Consumer waste can be significantly reduced by cutting down on packaging materials, which represents a change for both consumers and manufacturers. By multiplying the number of public recycling bins and instituting a more stringent residential recycling program, the City of Chicago can make recycling more mainstream and widespread.

Current Initiatives and Models

Even though San Francisco currently has the nation's highest recycling rate of 68 percent, it is pursuing a much larger goal.[10] San Francisco aims to divert 75 percent of waste from landfills by 2010 and have zero waste by 2020.[11] As part of their recycling process, three bins are given to each household:

- A blue cart for paper, glass, plastics, and metal recyclables,
- A green cart for food and yard waste to be composted, and
- A black cart for landfill trash.[12]

Incentives are provided for producing less waste. Residents save $5 off their $22 collection rate by using a smaller black bin for landfill trash. Merchants get discounts for recycling and Norcal, the city's trash hauler, earns bonuses for sending less trash to landfills.[13]

Wal-Mart has an internal policy to achieve zero waste for all of its Wal-Mart and Sam's Club stores by 2025.[14] Wal-Mart has met with suppliers to reduce packaging, which make up 31 percent of municipal waste according to the U.S. EPA.[15] Suppliers get a scorecard based on nine factors of their packaging including CO2 emissions, product-to-package ratio and use of recycled content.[16] Wal-Mart wants these companies to reduce packaging by 5 percent, which will save $11 billion in reduced production, transportation and waste removal costs.

Wal-Mart has also begun recycling within its stores. It crushes waste in a sandwich bale which is then hauled off to recycling companies who sort the waste into recyclable parts. Instead of paying to have their trash removed, Wal-Mart is paid for its recyclable material. Considering the size of Wal-Mart's reach as the nation's largest retailer, even a small effort can lead to large gains in the move towards zero waste.

Implementation Mechanisms

The first stage of the zero waste program could be either flaring all excess methane or, ideally turning the waste into energy. To move towards a 100 percent diversion of materials from landfills, the City would most likely have to establish a large-scale recycling program. The City has started a pilot program for blue bin recycling that will expand in 2008.[17] This pilot program could be expanded to the entire City and eventually include bins for compost materials as well. If recycling needs a jumpstart, the system could move towards "pay as you throw" where people are charged more for larger garbage bins that go to landfills. Deposit fees for all glass or plastic bottles could also be explored, especially if participation in the recycling program is lacking. The City might also consider building in a zero waste to its contracts to encourage its vendors to also pursue zero emission policies, thereby encouraging local businesses to amend their practices to reduce GHG.

Feasibility

Financial

Increasing recycling in the City could have a substantial cost, but savings potential, could outweigh costs. Based on experiences elsewhere, recycling can be instituted citywide without generating substantial costs.

Technical

Technically, there may be some issues with altering manufacturing processes or the packaging of consumer products or utilizing byproducts more efficiently to reduce waste. The technology currently exists to eliminate GHG at a minimum. The City currently flares approximately 75 percent of all methane emissions, and the technology exists to flare all emissions. In addition, waste-to-energy technology is readily available. There are also existing recycling programs that, once piloted and evaluated, could be expanded city-wide.

Political

While a true zero waste system may appear to be an unattainable goal because of its scope, it is feasible to first achieve zero waste emissions, and then to divert all municipal solid waste from landfills by 2020. However, time is of the essence and a zero waste policy would need to be enacted in the very near future. Cities like San Francisco and Seattle have had official zero waste policies for a number of years, providing examples of effective municipal plans.

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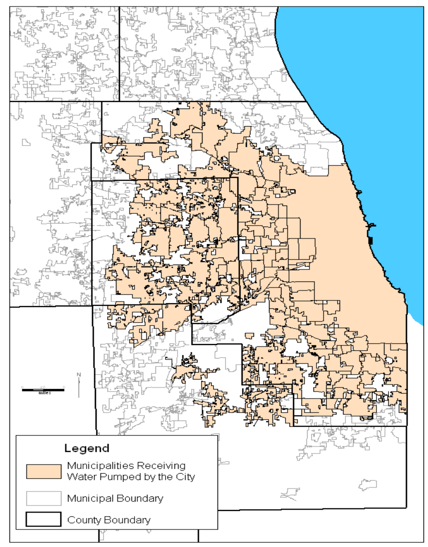
Mitigation Strategy #32
Reduce Water Supply Use and Manage Water and Sewer Effluents

Strategy Summary	Rating	Value
CO2e Savings Against BAU	+++	0.135 MMTCO2e
Scale of deployment	+++	All Chicago and suburbs sharing City's water supply
Timing	+++	Some efforts have already started; 2008
Regional Impact	++	Not all programs applicable
Financial Savings in relation to Cost	++	Financial savings are proportional to CO2e savings
Additional Benefits in relation to Burdens	++	Benefits outweigh burden of cost
Feasibility assessment	+++	Expensive but there has been growing support for conservation and improved water resource management efforts

Figure 1 Communities served by Chicago water department



Overview

The water sector includes all emissions related to water use in the City of Chicago and the communities that it supplies with water. There are a number of programs that can reduce water supply use and increase efficiency of stormwater management, which will result in CO2e savings. This report focuses on 1) reducing leakage in the water distribution system, 2) enhancing industrial efficiency, 3) supporting residential water conservation, 4) reducing turf grass lawns, and 5) employing green infrastructure measures strategically to reduce CO2e.

In 2006, the City of Chicago purified more than one billion gallons of water per day for use by the residents of Chicago and 124 neighboring suburbs.[1] Emissions related to water are generated from pumping water, filtration and treatment, distribution, heating for home use, and actual use, i.e., running water from facets. Increased efficiency and corresponding reductions can be addressed in each of the following areas (information provided by WaterSense, a U.S. EPA website):

- The City of Chicago Department of Water Management used 190,266 MWh of electricity in 2005[2] therefore the one billion gallons pumped per comes to 0.52 MWh/Million Gallons of water to pump and treat the water;
- The national average from the U.S. EPA is:
    - » surface water supply consumes 1,500 kWh per million gallons of water delivered, including

  pumping raw water, filtration and treatment, and
  - distribution[3] and waste water treatment consumes 1,800 kWh per million gallons of water treated[4],
  - scaling the national average for waste water treatment by the same as the ration of the national average to the Chicago average for pumping and treating water, gives 0.625 MWh/Million Gallons;
- Heating water electrically consumes 353 therms/million gallons of water heated and 70% of water used in homes is heated water.[5]

The City of Chicago provides water at the temperature of Lake Michigan, modified as the water flows through treatment and pipes. The Metropolitan Water Reclamation District of Greater Chicago (MWRD) is responsible for treating all of the wastewater generated by the City and its water customers. Thus, there are three major sources of greenhouse gas emissions from the Chicago water supply system. The generation of electricity in Chicago emits 0.61 metric tons of CO2e per MWh.[6] The electricity use and emissions from these sources can be estimated as follows:

- Chicago purifies one billion gallons per day[7] supplied x 365 days/year x 521 kWh per million gallons, or 190,266 mWh per year.
- The MWRD estimates that it treats one billion gallons per day. (However, this is not all of the same water that is supplied by the City. Nearly all of the water leaking from the City's water supply pipes is not treated by the MWRD. On the other hand, the MWRD treats nearly all of the stormwater that enters the sewer system.) The treatment of water consumes one billion gallons per day x 365 days per year x 625 kWh per million gallons, or 228,319 MWh per year.
- Once water enters a home or business, a major fraction of it gets heated for use. If it is assumed that the 70% factor sited by U.S. EPA above also applies to industrial and commercial uses, the electrical energy needed to heat the water would be the 126 mWh per million gallons calculated above.

Quantitative

GHG Reduction Potential: 0.135 MMTCO2e

Reductions of about 0.135 MMTCO2e can be anticipated from an aggressive water conservation program.

Scale Assumed

The scale includes the whole City plus the suburbs served by the water supply system.

Activity Savings

The following activities could be achieved by

• Reducing leakage in the water distribution system	0.003 MMTCO2e/yr
• Industrial efficiency water conservation	0.003 MMTCO2e/yr
• Residential water conservation by metering	0.014 MMTCO2e/yr
• Reductions in turf grass lawns that are watered	0.017 MMTCO2e/yr
• Reductions due to green infrastructure	0.098 MMTCO2e/yr

The total reductions by these measures would be 0.135 MMTCO2e per year.

Deployment Timeline Assumed

It is assumed that deployment of conservation programs and reduction of water supply will happen incrementally between 2008 and 2020.

Lifecycle GHG Impacts
The impacts of life cycle (i.e. equipment replacement and maintenance) would be negligibly different from current operations.

Regional GHG Reduction Potential
The regional savings for water conservation in the home and businesses would be roughly proportional to those shown here. However, the impacts of Chicago water pipe replacement and green infrastructure would not apply at significant amounts to other municipalities.

Municipal GHG Reduction Potential
The City of Chicago controls the water pipe replacements and will be a major influence on the other factors proposed to reduce emissions.

Economic Profile

Financial Costs
The replacement of water mains is not driven by energy reduction. It is required in order to maintain acceptable levels of service, however if the resources were made available to double these efforts the reduced leak rate would reduce emissions. The costs that are attributable to GHG reduction are not significant. The cost of installing water meters for 350,000 residences is a major burden, estimated at some $350 million. The costs of replacing lawn with native vegetation and implementing green infrastructure, over the long term, have been estimated to be equivalent to annual expenditures for typical landscaping by the private sector.

Financial Savings
Savings will be proportional to the savings for energy shown here.

Qualitative

Program Elements

Water Conservation: Industrial Efficiency
In Chicago, all industrial water users have water meters and pay for their water based on how much they use. Therefore, these users recognize the value of water. The City of Chicago helps businesses save money on water by developing conservation plans. Water conservation recently was incorporated into the City of Chicago Department of Environment's Industrial Energy Efficiency Program. The program provides large industrial energy users with an energy-and-process audit and interest-free loans to implement the audit's recommendations. So far these audits have identified almost 130 million gallons per year in water savings for 12 Chicago businesses.[8]

If an additional 12 comparable businesses were audited, and implemented conservation during each of the next 13 years, the reduction in water use would be 13 x 130 million or about 1,690 million gallons per year. At 3,300 kWh per million gallons for supply and treatment, the energy savings would reduce the emissions by 0.003 MMTCO2e per year.

Water Conservation: Residential Water Conservation
The City of Chicago Department of Water Management is developing a plan to meter all 350,000 residential households in single family homes that are currently not metered.[9] The challenges facing this effort are

enormous—a similar program in New York City took 10 years to complete.[10] The cost may be in the range of $400 million—over $1,000 per installation. The benefits of the program are speculative and will require a campaign to convince people that they are worth the price; a 20% reduction in water use in the newly metered homes is estimated.

If the 350,000 households contain 2.7 people each and use 100 gallons per person per day, the current water usage would be 94.5 million gallons per day. Savings of 20% would be 18.9 million gallons per day or 6,900 million gallons per year. Savings for supply and treatment of this water and the savings of energy used for heating 6,900 million gallons per year would reduce the GHG emissions by 0.014 MMTCO2e per year.

Water Conservation: Reductions in Turf Grass Lawns

One of the major water uses is watering turf grass lawns. Lawn care accounts for approximately 32 percent of outdoor water use.[11] But this does not address how much total water use there is, or the range of use depending on population density. A study in a Chicago-area conservation community found that water use rose by 60% in the summer due to lawn watering.[12]

Recent work has been done to characterize land uses in the urban area, which includes the amount of lawn.[13] In a city neighborhood, lawn covers roughly 64% of the land. Chicago has an area of 234 square miles, or 149,760 acres, so that lawns in Chicago total about 95,800 acres. A common recommendation for watering lawns is 1 inch per week during the growing season, unless significant rain has occurred or is forecast.[14] If it is assumed that, at most, this would be 20 weeks per year, the total water recommended for Chicago is 160,000 acre-feet. This represents 373 million gallons per day during the growing season, or 37% of the total water pumped by the City during that season. While this seems to be a very high amount, it is not inconceivable. When spread over the entire year, it represents 14% of the total pumpage.

If half of the turf grass is replaced with native vegetation that requires watering only for newly planted areas, there would be a savings of 7% of the energy used for water supply, with a corresponding reduction of 0.017 MMTCO2e.

Stormwater Management: Reductions due to Green Infrastructure

All of the water that falls on Chicago and nearby suburbs that have combined sewer systems, other than what soaks into the ground or re-enters the atmosphere, is directed into the combined sewers where it is mixed with sanitary sewage and must be treated before being discharged to the river system. During storms exceeding a half inch of rainfall, which happens in the area approximately 25 times per year, the combined sewage is diverted to the tunnel and reservoir plan where it must be pumped back up to the surface—some 250 feet or approximately three times the energy per gallon needed for the water supply. Thus, the pumping of this water requires approximately 3 x 521 or 1,563 kWh per million gallons for pumpage and 626 kWh for treatment, or a total of 2,186 kWh per million gallons to return it to the waterways.

Green infrastructure is the use of natural systems such as native vegetation and landscape features that result in infiltration of stormwater before it enters the sewer systems. It has been estimated that a long-term campaign to establish green infrastructure throughout the public and private lands in the Chicago region would result in fewer discharges to the tunnel and reservoir plan. Currently, when a neighborhood in the combined sewer area receives more than roughly 0.5 inches of precipitation in a day, the large sewers are filled and excess water is dropped into the tunnels. It is projected that when a neighborhood contains a sufficient amount of green infrastructure, the precipitation level that will result in use of the tunnels will increase to approximately 1.5 inches. It is estimated that the discharge into the tunnels would be reduced from 25 times per year to 3 times per year. The total precipitation that would need to be pumped from the tunnels and treated would be reduced by approximately 11 inches over the combined sewer area of 378 square miles. This reduction would total 74,000 million gallons per year of water that would no longer have to be pumped and treated. The reduction in emissions from this energy conservation would be 0.097

MMTCO2e.

Benefits and Burdens

The benefits of the programs outlined and related reductions, in additions to climate change impacts, are reduced energy costs to the local government and consumers.

A major burden is cost, which would also by incurred by the local government and consumers. There are costs for conservation measures as well as to educate the public about their role in making the changes.

Current Initiatives and Models

Water Conservation: Reducing leakage in the water distribution system

According to the City of Chicago's Water Agenda 2003:

> *"Chicago's Department of Water Management is implementing a five-year, $620 million capital improvement program that includes replacing approximately 50 miles of old leaking water mains every year. Additionally, the Department is helping other units of local governments examine their distribution systems for leaks. The improvements in Chicago alone will save an estimated 120 million gallons of water each day."*[15]

This program plans to replace 250 miles of the 4,200 total miles (6%) by 2008, yielding a 12% reduction in water use from 2003.[16] According to the plan, repairs and reductions in water use—6% and 12% every five years respectively—will occur at the same rate after 2008 through 2020, resulting in 600 miles of replaced pipe water use, reduced by an amount equivalent to 28.8% of the water currently supplied. If the program proceeds according to plan, this savings is considered as part of business as usual and a mitigation strategy. However if this could be doubled, then the benefits could be captured as a GHG mitigation strategy.

Assuming water use to be a billion gallons per day, a 28.8% savings is 288 million gallons per day, or 105,120 million gallons per year. If this effort was doubled in the, the emission reduction would be 0.003 MMTCO2e per year.

Implementation Mechanisms

The City of Chicago's policy of replacing 50 miles of water main per year is an excellent mechanism. The City's program of working with specific companies to foster water conservation is also a good model. Providing meters to all non-metered households is onerous, but necessary.

The use of green infrastructure, including replacement of turf grass by native vegetation, requires a vast array of mechanisms for implementation. They include research on the effectiveness of best management practices (BMPs), demonstration projects that can be replicated, technical assistance, access to native plants throughout the area, education, and tracking of results.

Feasibility

Financial

There are existing programs that are being financed. One of the biggest barriers to expand existing efforts for greater impact is expense of some conservation measures.

Technical

Technically, the reduction of water used and conservation efforts described are very feasible.

Political

The real test of feasibility will be the ability of local leaders to continue and expand the programs, even as they meet resistance due to the need for public investment.

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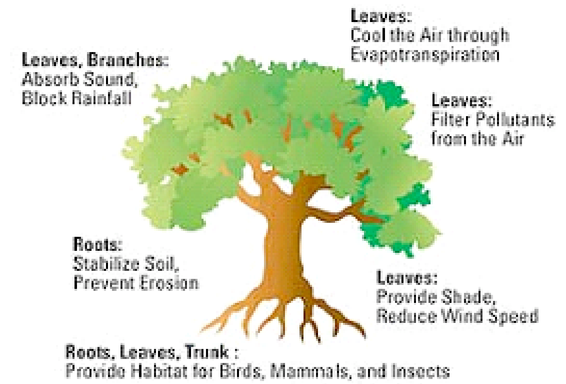
Mitigation Strategy #33

Reduce Emissions Through Tree Planting & Green Roofs

Strategy Summary	Rating	Value
CO2e Savings Against BAU	+	0.10-0.17 MMT CO2e
Scale of deployment	+++	Plant one million new trees by 2020 and add 500 green roofs per year
Timing	+++	Start in 2008
Regional Impact	+	Full data unavailable
Financial Savings in relation to Cost	+++	Low costs, energy savings
Additional Benefits in relation to Burdens	+++	Many documented environmental and social benefits to greening
Feasibility assessment	++	Large in scale, but politically and culturally popular

Figure 1 Benefits of Trees



Source: U.S. EPA, http://www.epa.gov/heatisland/strategies/vegetation.html

Overview

This mitigation strategy is to increase Chicago's urban forest through tree planting and to expand the number of green roofs in Chicago. This strategy proposes planting one million new trees by both the public and private sectors, with a subsequent increase in the city's tree canopy to 17%. The City could also increase green roof coverage to 7 million square feet by 2020 on a total of 6,000 buildings across Chicago.

Planting additional trees and rooftop gardens in the city can lower the City's greenhouse gas emissions. By shading and cooling buildings, trees reduce heating and cooling energy usage. By reducing wind speeds and transpiring water, trees lower air temperature and indirectly reduce energy needs. Also, trees absorb atmospheric carbon dioxide. As trees grow, they take carbon dioxide out of the air and transform it into roots, leaves, bark, flowers, and wood. Through photosynthesis, they store or sequester the carbon.[1] Protecting, preserving, and improving the life of existing trees is extremely important as older, mature trees have a higher potential for sequestration, especially in the near term.

Green roofs, "roofs planted with vegetation,"[2] can moderate building heat gain and loss that will decrease energy load for both heating and cooling. Solar gain and radiation can significantly impact building heating and cooling efficiency. During the day, the sun's energy is absorbed through walls and roofs heating the interior. At night, heat escapes through the building envelope by radiation and conduction.

Green roofs absorb the sun's heat energy before it is transferred and absorbed into the building and results in more temperate surface that reduces air conditioning demand. In cold climates, the superior insulating qualities of green roofs help reduce heat loss as well. Green roofs improve the efficiency of the roofing system and reduce energy demand in three ways: shading, evaportranspiration and improved insulation values (r value).[3]

Soils, natural grasslands and wetlands present important opportunities for sequestration, but have not been included in this strategy because sequestration rates were not available. This is an area for further research.

Quantitative Results

GHG Reduction Potential: 0.10-0.17 MMT CO2e

Shade, lower summer air temperatures, and a reduction in wind speed associated with increasing tree cover by 5% percent can lower total heating and cooling energy use by 2.5 to 5% annually.[4] With an estimated canopy cover increase of approximately three percent, savings can be expected to range between 1.5 - 3%. Taking into consideration the mature height of trees, the tree planting strategy is only effective for low-rise 3 story or lower buildings. Assuming 85% of the 1,061,928 occupied housing units[5] are low rise buildings, and with annual household heating and cooling energy use estimated at 6.1 MMTCO2e, a reduction of 1.5 to 3% translates to a savings potential of 73,620 to 147,240 metric tons CO2e annually.

Based on a 2005 tree canopy of 14%[6] providing an annual net sequestration of 22,406 metric tons CO2e per year, increasing the canopy to 17% will increase the annual net sequestration to 26,762 metric tons CO2e per year, an increase of 4,356 metric tons CO2e per year.

Studies conclude that green roofs can substantially reduce the heat flux from a building, but the thermal performance savings varies widely. Thermal savings can be determined by various approaches: field experimentation, numerical studies and combinations of lab and field experiments with numerical models. However, design engineers do not have a standard procedure or calculation tool to calculate energy savings from green roofs.[7] Studies show a range of 20%-30% savings on heating and cooling demand.[8] One such field test of an extensive roof at the National Research Council in Ottowa showed a 75% kWh reduction compared to a reference roof. If the lower estimate of 20% savings is used, then the CO2e savings would be 20,578 metric tons CO2.

Additional energy savings can be realized with downsized HVAC units, but precise figures are difficult to accurately quantify. For new construction or major renovations where new HVAC equipment is needed, green roofs will allow for smaller units to be installed. Downsizing HVAC equipment alone has significant energy cost savings and efficiency gains. Yet, quantifying the energy savings from downsizing is difficult because each building must be modeled and appropriate alternatives analyzed individually.

Scale Assumed

This strategy proposes planting one million new trees by both the public and private sectors, with a subsequent increase in the city's tree canopy to 17%.

The City of Chicago is currently home to over 200 green roofs totaling more than 2.5 million square feet, significantly more than any other city in the U.S.[9] To increase the quantity of green roofs to nearly 7 million square feet by 2020 on a total of 6,000 buildings across the city. The City would have to implement green roofs on 500 buildings a year to 2020. Ninety-four percent of the buildings selected can be from the residential sector, and the remainder from the commercial sector. The 6,000 buildings represent ~2.4% of the buildings appropriate for a green roof.

Timeline

As the number of trees which need to be planted is very significant, and benefits increase over time with the trees growth, the tree plantings needs to begin immediately. In order to reach the goal of one million new trees, a combined average of 83,333 trees need to be planted annually, by the public and private sectors, for the next 12 years.

The City of Chicago has $100,000 for incentive grants for 20 green roofs in 2007 and anticipates the same levels of funding for 2008.[10] In order to get 6,000 green roofs by 2020, the city must increase the number of buildings to 5,000 per year. This is a significant ramp up to their recent initiatives.

Per-unit Reduction Potential

To achieve stable long-term reductions, a population of trees must remain stable as a whole. Therefore, it is useful to look at the collective of trees as an entity—the urban forest. This requires a diverse mix of species and ages so that the overall tree canopy cover remains intact, even as individual trees die and are replaced. Although sequestration rates will level off once an urban tree planting project reaches maturity, the reduced emissions due to energy savings will continue to accrue annually.[11]

Activity Savings

Energy saved from tree planting is estimated to range between 1.5% to 3% of annual heating and cooling costs. The estimated savings would be between 12,880,201 to 25,760,402 therms and 8,338,874 to 16,677,749 kWh.

Energy savings for residential and commercial buildings with roof gardens is estimated at 20%. Residential energy savings is estimated at 1,088,618 kWh and 1,681,857 therms. For commercial buildings, savings are estimated at 10,985,485 kWh and 798,895 therms.

Life cycle GHG Impacts

There is a current debate regarding whether the sequestration effect is temporary or more lasting. The startling conclusion that tree planting increases global warming by absorbing more heat, especially in temperate latitudes, is based on modeling of the reflectance—albedo—of forest canopies that are darker than snow, grass, or crops and, therefore, absorb more heat. The models rely on various assumptions, such as widescale afforestation, or broad plantings of trees on grass and croplands. While more precise measurements may be warranted, the necessary conclusion that the earth would be cooler if the forests were cut down defies common sense and is neither realistic nor ecologically desirable. In cities, the climate effects of incremental darkening from increased tree canopy cover are even less relevant. Asphalt, concrete, and roof surfaces account for 50 to 70 percent of urban areas, with the remaining area covered by trees, grass, and bare soil. The difference in the albedos from the different urban surfaces is small. Vegetation canopies have albedos of 0.15 to 0.30, the albedo of asphalt is 0.10, that of concrete and buildings is 0.10 to 0.35, and the overall albedo in low-density residential areas is 0.20.[12] In cities, increasing urban tree canopy cover does not appreciably alter surface reflectance or increase heat trapping. Also, dead trees can be converted to wood products or used as bioenergy, further delaying, reducing, or avoiding greenhouse gas emissions.[13]

Regional GHG Reduction Potential

Increasing the canopy to 40% in Cook and DuPage counties, as recommended by the American Forests for a metropolitan region, will increase the annual net sequestration to 296,029 million tons CO2e, an increase of 155,415 million tons CO2e per year. Current canopy average for Cook and DuPage counties is estimated at 19%.[14] An assessment of the current canopy cover in Kane, Lake, McHenry, and Will counties would need to be made to determine benefits of additional tree plantings in these counties.

Municipal GHG Reduction Potential

The City itself can receive direct monetary savings from this program. Tree plantings strategically placed to shade City-owned buildings can reduce energy costs in these buildings 2.5 to 5%. The City could consider green roofs on large, new construction projects with a large building footprint to maximize municipal savings in energy costs. New construction better allows for initial appropriate structural engineering needed to support a green roof. However, since the Public Building Commission has not recently built new construction to the scale that is needed to reach the 6,000 building goal by 2020, municipal buildings will be only a small portion of the total number of green roofs annually. However, the City can capitalize on its image of being the recognized leader in green roofs in the U.S. by selectively creating showcase projects. Chicago's City Hall is perhaps the most widely cited and recognized green roof in the U.S., and its roof garden enhances the City's image as the leader in green roof policy in the U.S.

Economic Profile

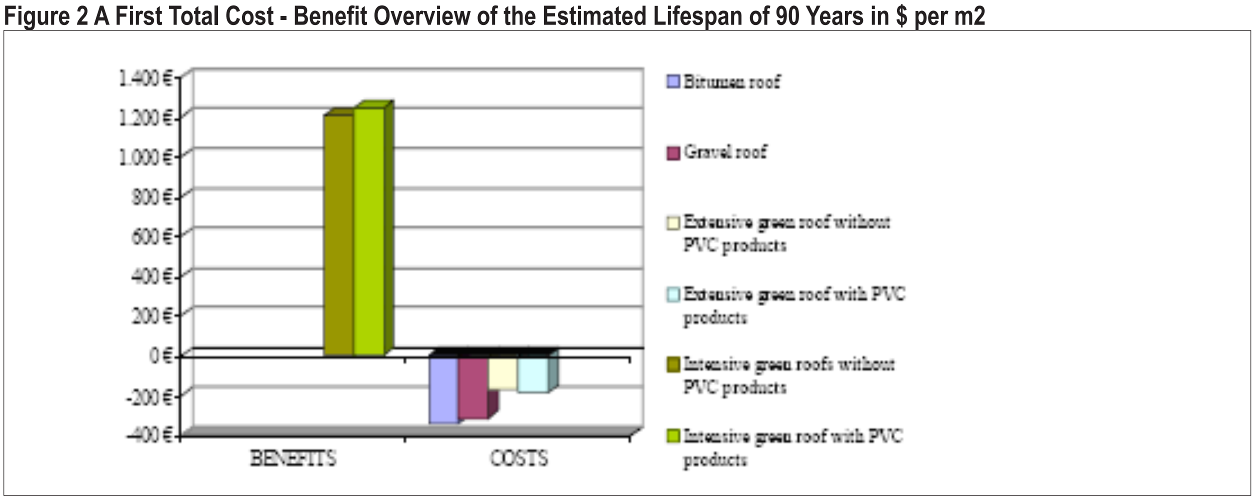
Tree plantings produce a net benefit. The 30 year net present value of investment in tree planting and care is $402 per tree. Projected benefit-cost ratios are largest for trees planted in residential yards and public housing sites (3.5), and least for parks (2.1) and highways (2.3). Expenditures for planting alone account for over 80 percent of projected costs, while the largest benefits are attributable to scenic, social, economic values, and energy savings.[15]

The costs for an installed extensive roof typically costs between $10 and $24 per square foot.[16] The costs for green roofs in the U.S. are comparable to those in Germany[17], which is often cited as an international leader in green roofs. Green roofs cost approximately twice the amount of a conventional roof.

The financial savings from green roofs is best realized in reduced heating and cooling costs. However, increased roof lifespan is also a factor. U.S. data suggest that green roofs will last 2-3 times as long as a conventional roof. [18] Research on the life cycle savings of green roofs in Germany show that green roofs last 30 years or longer than traditional roofs which require major repair or replacement after 15 years. Some older green roofs in Berlin demonstrate a life span of 90 years, making the lifecycle costs of a green roof significantly lower than conventional ones.[19]

Stormwater runoff savings are also significant in municipalities that charge annual fees for stormwater that accumulates on impervious surfaces, such as many cities in Germany. This is not currently applicable in Chicago, but could be in the future. Figure 2 is a graph showing the life cycle costs and benefits of green roofs in Germany.[20]

Figure 2 A First Total Cost - Benefit Overview of the Estimated Lifespan of 90 Years in $ per m2



Qualitative Results

Program Elements

The City can implement a tree planting strategy directly through street tree and park tree plantings, and indirectly by providing incentives that promote tree planting to property owners. To maximize the impact of tree planting, the City could consider the following:

1) Focus street tree planting near and roof gardens on multi-unit residential buildings so as to increase the number of households benefiting from energy savings and to increase aggregate savings.

2) Focus street tree planting efforts and roof gardens in areas that currently have minimal canopy coverage in order to reduce the heat island effect in these areas.

3) Focus on adequate maintenance and care of the existing urban forest. Poor soil conditions and lack of maintenance can cause tree death. The use of structured soils can be used to extend the life of the tree and facilitate stormwater drainage.

4) A public education program that: 1) provides information about energy savings and the proper placement of trees and roof gardens to maximize these savings. For example, planting large trees close to the west wall of buildings, dense planting on the north, and avoidance of planting on the east and south are recommended to maximize energy savings potential;[21] and 2) informs about the additional social and environmental benefits of healthy and productive urban forests and roof gardens.

5) Develop a yard tree planting program that would stress strategic tree planting to reduce building energy use that could be sponsored by Exelon.

6) Develop a mechanism that would provide property owners monetary incentives for strategic planting of trees on their property or installations of roof gardens.

Benefits and Burdens

In addition to reduced energy needs and carbon sequestration, a tree planting initiative will provide significant additional environmental benefits. Trees reduce stormwater runoff and provide habitat for wildlife. Trees remove many pollutants from the atmosphere, including nitrogen dioxide (NO2), sulfur dioxide (SO2), ozone (O3), carbon monoxide (CO), and particulate matter of ten microns or less (PM10). The Chicago Urban Forest Climate Project (CUFCP) completed a three-year study of the effects of urban vegetation in Cook and DuPage Counties in 1994 with the following pollution removal results, estimated to have a $1 million value:

- 15 metric tons of CO
- 84 tons of SO2
- 89 tons of NO2
- 191 tons of O3
- 212 tons of PM10

Within the Cook and DuPage counties an estimated 6,145 tons of air pollutants were removed, providing air cleansing valued at $9.2 million dollars.

Trees also provide social benefits. Trees introduce nature into the urban form, adding color and texture that contrast with the built environment. The shade of trees in open green spaces provides places for people to meet and socialize. Urban trees and wildlife help people maintain their connection with nature.

The USDA provides the following documented benefits, among many others, attributable to trees in an urban setting[23]:

- Improve healing — (Ulrich, 1984)
- Improve mood — (Hull, 1992)
- Reduce road rage — (Cackowski, 1999)
- Improve worker productivity — (Kaplan, 1993a, 1993b)
- Improve real estate values — (Dwyer, McPherson, Schroeder, & Rowntree, 1992)
- Attract shoppers — (Wolf, 1997, 1998, 1999, 2003a, 2003b)

Roof gardens also provide additional environmental benefits. If widely adopted, rooftop gardens could reduce the urban heat island, which would decrease smog episodes, problems associated with heat stress and lower energy consumption. They could also help to improve storm water management if sufficiently implemented in an urban area. Part of the rain is stored in the growing medium temporarily, and will be taken up by the plants and returned to the atmosphere through evapotranspiration. Rooftop gardens delay run-off into the sewage system, thus helping to reduce the frequency of combined sewage overflow events, which is a significant problem for many major cities in North America. The gardens can serve as living environments that provide habitats for birds and other small animals. The plants and the growing medium can also filter out airborne pollutants washed off in the rain, thus improving the quality of the run-off.

Non environmental benefits include increased membrane durability, additional green space in urban areas, and increased property values.[24] Food production is another benefit. The Fairmount Waterfront Hotel in Vancouver used its green roof to grow herbs, flowers, and vegetables, saving its kitchen an estimated $30,000 a year in food costs. Green roofs offer quality of life benefits not applicable to traditional roofs, like offering additional amenity and recreational space and aesthetic appeal. The aesthetic appeal has numerous community and economic benefits including lower vacancy rates, community marketability and increased property values, but more research is needed to quantify the economic value of these quality of life benefits in the U.S.

Implementation Mechanisms

The City could consider public and private implementation strategies. Public mechanisms can include partnering with Exelon, and or a non profit organization, to develop a public education campaign & yard planting program. To increase annual street tree plantings the City can devote more financial resources, or partner with Exelon for funding. In order to induce private investment, the City can enact legally binding instruments such as ordinances, contracts and easements which would require tree planting or roof gardens at time of sale of property, and maintenance of existing tree canopy and roof gardens.

The City of Chicago could also create connections between their green roof programs and other City sustainability initiatives, such as the Department of Planning and Development's Eat Local Live Healthy Plan[25] that sets a framework for a sustainable food system in Chicago. The City could meet its goal of increasing food production in urban settings and encourage children to develop an interest in gardening skills by creating a roof garden that incorporates food production, like the Fairmount Waterfront Hotel in Vancouver who used its green roof to grow herbs, flowers, and vegetables, saving its kitchen an estimated $30,000 a year in food costs.[26]

Current Initiatives and Models

The City has adopted an open space impact fee ordinance that requires new residential development to contribute a proportionate amount of open space or recreational facilities, or to pay fees that ensure community residents of continued access to greenspace. In June 2001, Chicago amended its energy code to include requirements for reflective or green roofs.[28] Chicago has enacted legislation to require landscaping around parking lots.

The City of Chicago is known as a leader in incenting green roofs in the U.S. The City of Chicago is currently home to over 200 green roofs totaling more than 2.5 million square feet, significantly more than any other city in the U.S.[29] The City's green roof/green building policy encourages and in some cases requires green roofs through the City of Chicago Department of Planning and Development's Building Green/Green Roof Matrix.[30] The matrix provides guidelines for residential, commercial, and industrial developments that do receive public assistance, or for developments that do not receive public assistance but are planned developments (PDs), or are subject to the Lakefront Protection Ordinance.

The Department of Planning and Development also initiated in 2006 a one year pilot Green Roof Improvement Fund program that provides technical and financial incentives for the installation of Green Roofs on commercial buildings in the Central Loop Area Tax Increment Financing (TIF) district that are in compliance with the Central Loop redevelopment plan.[31]

Finally, the City's Department of Environment has offered the Green Roof Grants Program since 2005 for residential and small commercial buildings. As mentioned above, Department of Environment has $100,000 for incentive grants for 20 green roofs in 2007 and anticipates the same levels of funding for 2008.[32] In order to get 6,000 green roofs by 2020, the city must increase the number of buildings to 500 per year. This is a significant ramp up to their recent initiatives.

The State of Illinois is pursuing tree planting in efforts to curb global warming. The Illinois Task Force on Global Climate Change recommends tree planting, along with energy efficiency strategies, as the centerpiece of Illinois' Climate Change Policy, seeing tree planting and management as low-cost, "no regrets" options that provide benefits beyond emission reductions. The State's Afforestation Initiative Policy, recommended in Illinois' State Action Plan in response to the findings by the Illinois Task Force on Global Climate Change, promotes expanding the rural and urban tree planting programs and providing cost sharing that increases forest management assistance to private forest landowners. From 2000 to 2002, the programs estimated reduction in GHGs is 20,000 million tons CO2e per year.[33]

In Los Angeles, California, in 1980 TreePeople saw an opportunity when the City of Los Angeles drafted an Air Quality Management Plan calling for the planting of one million trees to help comply with the air quality standards set by the 1970 Clean Air Act. The city estimated the undertaking would cost $200 million and take 20 years. TreePeople declared it could galvanize the public to do the job in three years—in time for the 1984 Summer Olympics in Los Angeles—at no cost to the city. In 1981, TreePeople recruited an advertising agency which worked pro bono to promote the campaign. To increase public education and raise awareness, A Planters' Guide to the Urban Forest was published. After three years, four days before the lighting of the Olympic flame, the campaign reached its goal and planted the millionth tree.[34]

Other cities, including Santa Monica, Sacramento, and New York, are implementing tree planting programs. The New York City Department of Parks and Recreation estimates that it planted approximately 139,000 street trees between 1995 and 2006. Based on this calculation, street trees planted between 1995 and 2006 resulted in the annual combined sequestration and avoidance of 24,000 million tons CO2e by 2006.

Power companies, recognizing a need to be seen as environmental stewards, are initiating tree and vegetation planting programs. As program sponsors they can also claim carbon offsets. Exelon has undertaken a number of environmental initiatives related to trees. Exelon has been an advocate of tree planting and other environmental issues, as briefly described in the following activities and associations:

- TreeVitalize[35] is an aggressive four-year, $8 million partnership to plant more than 20,000 shade trees and restore 1,000 acres of forested riparian buffers in southeastern Pennsylvania. In addition to planting, TreeVitalize is focusing on improving tree care with municipalities.
- Prairie Grass Restoration of more than 110 acres in Illinois since 1994 has helped to sequester CO2, restore wildlife habitat, prevent runoff and improve water quality. Exelon has taken on prairie grass restoration projects in DuPage and Will Counties.
- Capturing CO2 emissions through tree plantings through its participation in the PowerTree Carbon Company, LLC,[36] an initiative formed in 2003 by 25 U.S. power generators as part of a voluntary industry response to climate change. As of December 31, 2004, PowerTree Carbon Company had planted in excess of 2,000 acres of seedlings, using native tree species. Managing trees along rights of way, includes tree trimming, removal and herbicide application and other methods following the standards of American National Standards Institute, the Occupational Safety and Health Administration (OSHA) and the International Society of Arboriculture, to protect overhead electric lines and promote safety.

Feasibility

Financial

Tree planting is a low cost alternative, making implementation of this strategy quite feasible. No investment of time or funds is needed to develop any new technology.

Technical

There are no technical barriers to immediate implementation of planting trees and roof gardens. In order to maximize results, public education and outreach regarding proper tree and plant selection, and tree placement, need to be focused on and implemented.

Political

To date, the City has demonstrated a commitment to increasing the urban forest. Successful implementation of planting 1.1 million new trees requires a long-term commitment, and the City would need to adopt a more aggressive strategy in order to reach desired planting levels.

Exelon has demonstrated through existing initiatives that it is a ready partner.

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