A Greenhouse Gas Inventory as a Measure of Sustainability for an Urban Public Research University

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Greenhouse gas (GHG) inventories are becoming a common measure of environmental impact and sustainability for institutions. The University of Illinois in Chicago (UIC) prepared a GHG inventory for fiscal years 2004–2008. UIC conducted a commuter survey to obtain data regarding the commuting habits of its faculty, staff, and students. In fiscal year 2008, UIC's carbon footprint was not significantly higher than the 2004 emissions (275,000 vs. 273,000 metric tons of carbon dioxide equivalents, respectively). For 2008, the largest source of emissions was buildings (83%), followed by commuting (16%) and waste (1%). When compared to 85 other doctorate-granting universities, UIC's gross emissions per square foot (21.4%) are lower than average. The variation in the emissions over the five years studied is largely influenced by the amount of electricity purchased and the mix of sources of that electricity (i.e., nuclear vs. coal). Conducting a baseline GHG inventory can serve as a measure of progress toward more sustainable practices within an institution and as a tool for developing goals, strategies and policies to reduce emissions.

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The first prominent "sustainability" programs at colleges and universities focused on recycling of wastes such as paper, glass, and plastics. Recently attention to sustainability started encompassing the overall and perhaps greater impact that higher education plays in preparing future generations to address the impacts of human life on the planet. Campus greening projects, from materials consumed (e.g., food, water, paper), energy to waste management practices, and emissions reductions, are expanding at an exponential rate. These projects include waste reduction programs such as food composting, trayless dining in cafeterias to reduce waste and water consumption, and reuse of waste vegetable oil as fuel to power campus vehicles. Energy projects run the gamut from energy conservation competitions to energy efficiency projects to renewable-energy installations such as wind and solar. Colleges and university facilities are constructed to meet green building standards, and the administrators are developing green purchasing policies. Programs that promote public transit, carpooling, and bicycling are found on many campuses. Water conservation through installation of low-flow and no-flow restroom fixtures, gray-water systems, and capturing rainwater for irrigation purposes is becoming common. Many practices serve multiple purposes, such as green roofs that conserve energy and capture rainwater (Simpson, 2008).

These initiatives are frequently driven by students and faculty. They are often integrated into the teaching and research activities of the campuses, using them as "living labs" where students and faculty can study and test real-life solutions to environmental problems on the campus itself. Upper administration is beginning to understand the economic value of conserving resources and the marketing value of the green campus—for attracting students and for retaining faculty. University staff frequently participate in sustainability committees and are often responsible for the implementation of the operational programs (Rappaport and Creighton, 2007).

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Nationally, organizations such as the Association for the Advancement of Sustainability in Higher Education (AASHE) and Second Nature are mobilizing sustainability programs by providing resources and challenging colleges and universities to become more sustainable (Bardaglio and Putman, 2009). In 2006, Michael M. Crow (President, Arizona State University) and other university presidents joined forces and developed the American College & University Presidents' Climate Commitment (ACUPCC). In 2007, Crow stated that "more than ever, universities must take leadership roles to address the grand challenges of the 21st century, and climate change is paramount among these" (ACUPCC, 2007, p. 3). This pledge challenges all universities to develop a comprehensive plan to achieve climate neutrality as soon as possible, initiate two or more tangible actions to reduce greenhouse gases (GHGs) while developing a more comprehensive plan, and make their comprehensive plan and progress reports publicly available.

The basis for a climate action plan is a GHG inventory. The generally accepted methodology for conducting an inventory is based on the Greenhouse Gas Protocol developed by World Business Council for Sustainable Development and the World Resource Institute (WBCSD/WRI, 2001). In general, tools are either sector-specific tools (e.g., aluminum, cement) or cross-sector tools for application to many different sectors (e.g., stationary combustion, mobile combustion). Since this is the most widely recognized standard for conducting a GHG emissions, the ACUPCC participants must use a reporting tool that is compliant with the Greenhouse Gas Protocol (Simpson, 2009).

The nonprofit organization Clean Air–Cool Planet developed a Campus Carbon Calculator version 6.2 based on the protocol, which is endorsed by the ACUPCC. Numerous northeastern universities collaborated to develop the Campus Carbon Calculator, and it has been used at more than 200 campuses in North America. It uses an electronic MS Excel workbook that calculates estimated GHG emissions from the data collected (Hough et al., 2008). Although calculator is very user friendly and catered to all campuses, some campuses designed their own tool based directly on the WRI protocol (Mace, 2008). For example, Tufts University developed a methodology and spreadsheet for performing the calculations (Tufts Climate Initiative, 2002). Although not explicitly stated, the methodology appears to comply with the WRI protocol. The California Climate Action Registry (2009), a voluntary GHG registry, developed its Climate Action Registry Reporting Online Tool (CARROT) based on the WRI protocol. The Climate Registry, based on the California Climate Action Registry, is open to all institutions in North America and uses the online Climate Registry Information System as a reporting and verification tool (Climate Registry, 2008). The Chicago Climate Exchange (2007), a voluntary cap-and-trade program, also uses the WRI protocol to calculate emissions. Other proprietary tools have been developed by consulting firms to provide that service to customers such as Virginia Commonwealth University and the City College of New York (ACUPCC, 2009).

Several universities, including Middlebury College (Middlebury, Vermont), the University of Colorado at Boulder, and Oberlin College (Oberlin, Ohio), adopted climate action strategies early and prior to the ACUPCC initiative and conducted GHG inventories. In a study conducted by the National Wildlife Federation (NWF), a case-study basis was used to compare seven campus climate action strategies. Of the seven campuses, four used the Campus Carbon Calculator. Brown University used its own tool based on the WBCSD/WRI protocols along with the United States (US) Environmental Protection Agency's (EPA's) eGRID (Emissions & Generation Resource Integrated Database) for emissions from electricity production. The two California schools used the California Climate Action Registry tool. Emissions varied from 30,000 metric tons of carbon dioxide equivalents (CO_2e) for Middlebury College (2,400 undergraduates) to 260,000 metric tons CO_2e for Yale University (11,300 students total) (Eagan et al., 2008).

Colleges and universities emit about 2%–3% of the GHGs in North America (ACUPCC, 2008a). In the US, emissions from buildings comprise 48% of energy consumption and carbon emissions (Architecture 2030, 2009). Colleges and universities, particularly those with hospitals and large research enterprises, contain highly energy-intensive buildings and therefore are a major source of carbon emissions. A comprehensive GHG inventory can provide a first-degree quantitative measure of an institution's progress toward sustainability. This report presents a case study of what that inventory looks like for an urban public research university: the University of Illinois at Chicago (UIC).

Over the past two years, a stagnant sustainability movement on the UIC campus reemerged with the formation of the UIC Campus Sustainability Task Force in April 2007. Per the task force recommendation, former Chancellor Sylvia Manning signed the ACUPCC on September 14, 2007, making UIC one of the inaugural signatories. Additionally, in December 2007, the task force recommended to the chancellor to establish an Office of Sustainability staffed by a full-time sustainability professional and form a chancellor's committee to continue to address issues of sustainability on campus. Over the next few months, both the Office and the Chancellor's Committee on Sustainability and Energy were established. In February 2008, Interim Chancellor Eric Gislason signed on to the Illinois Sustainable University Compact, which committed UIC to a number of sustainability initiatives such as reducing energy consumption, purchasing alternate fuel vehicles, and increasing recycling rates by the end of 2010. Finally, on Earth Day 2009, UIC's current chancellor, Dr. Paula Allen-Meares, signed the international Talloires Declaration. This is a pledge to implement a 10-point action plan to incorporate sustainability and environmental literacy into UIC's teaching, research, operations, and outreach. These commitments and the task force's recommendations form the sustainability plan for the campus and drive the initiatives and activities of the Office of Sustainability.

The ability to measure and track environmental or sustainable performance is necessary in any environmental or sustainability program to demonstrate progress toward goals. As signatories to the ACUPCC, UIC committed to performing a GHG inventory for the campus and developing its Climate Action Plan with goals and deadlines for emissions reductions. Therefore, as a first-degree measure of UIC's progress toward becoming a more sustainable campus, we conducted a GHG inventory that includes emissions from campus operations, purchased electricity, and commuting to campus.

Methods

Institution

UIC is a major public research university located in near the center of the third largest city in the US. As the largest university in the Chicago area, UIC has 25,000 students and annual research expenditures exceeding $307 million. It has more than 110 buildings on over 240 acres, including 13 colleges and a medical center (Figure 1). Historically known as a commuter campus, construction of three new residence halls on the new South Campus nearly doubled

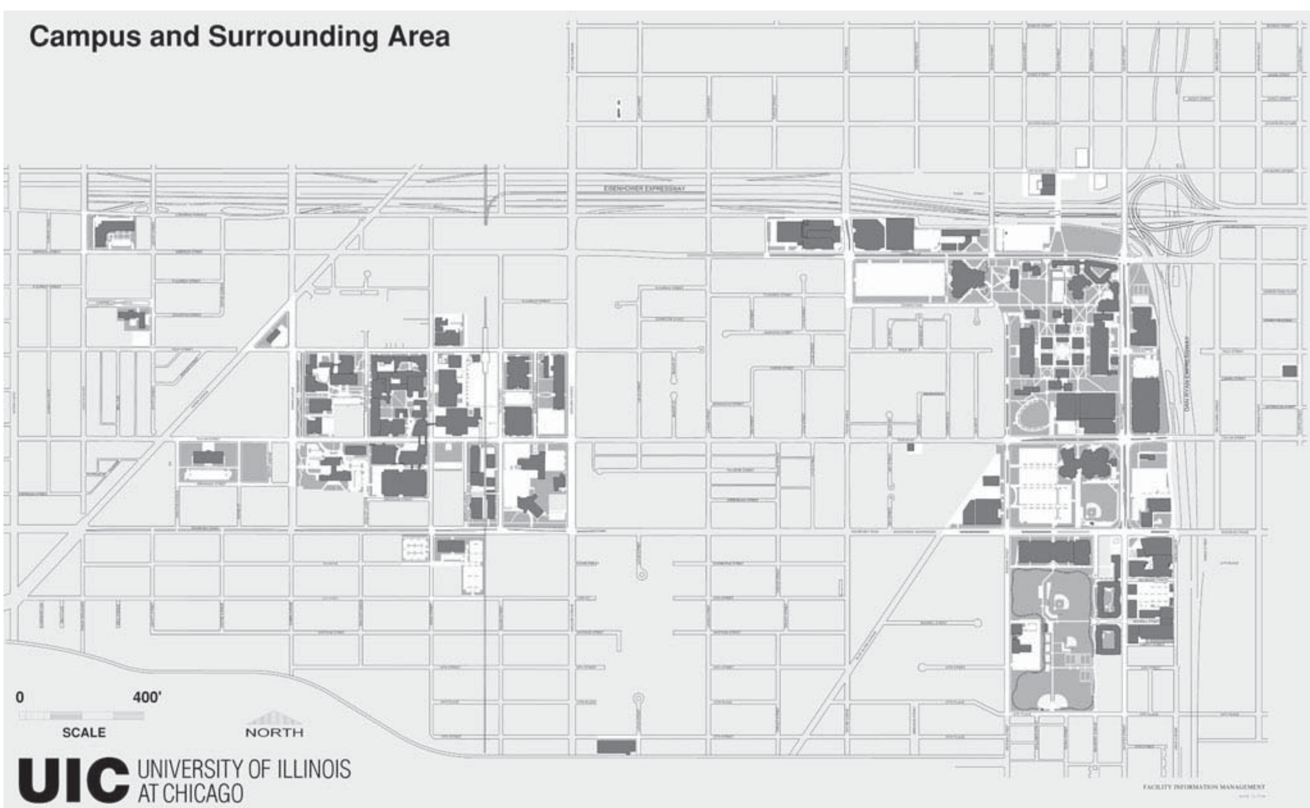

Figure 1. Map of the University of Illinois at Chicago campus.

Table 1. Sources of data

Type of data	Unit
Electricity, steam, fuel, cogeneration plants	Utilities Operations
Solid waste and compost	Facilities Management
Refrigeration	Facilities Management
Transportation (university fleet)	Facilities Management
Numbers of students, faculty, staff, zip codes of residences	Data Resources and Institutional Analysis (DRIA)
Parking permits and transit benefits	Parking
Student residences	Campus Housing
Building square feet	Office of Facility Information Management

the number of students living on campus (to 3,800) since 2004 (UIC News Bureau, 2009).

Institutional Data

We collected data for this study from numerous sources on campus (Table 1). Data Resources and Institutional Analysis (DRIA) provided data for the size of the campus population. Campus Housing provided the number of students living on campus. We counted emissions only from faculty and staff that work on the Chicago campus because we calculated the GHG emissions only for the Chicago facility. However, DRIA provided numbers for total student enrollment; therefore our calculations include numbers of students from the main Chicago campus, as well as the Peoria and the Rockford sites. Facility Information Management provided space data (Table 2).

Boundaries and Scope

The Kyoto protocol proposes accounting for GHG emissions from a baseline year of 1990 (Europa, 2008). However, UIC had reliable utility and transportation data beginning only in 2003. Since UIC operates on a fiscal year (FY) calendar that starts on July 1, we conducted GHG inventories for the period of July 1, 2003, to June 30, 2008, designated as 2004–2008.

When conducting an inventory, it is necessary to determine which sources the GHG emissions are attributed to as a way to prevent counting emissions or credits twice. The World Business Council for Sustainable Development and the World Resource Institute (2001) defined a set of accounting standards that classify the scope of the emissions based on the source. These standards provide concepts and systems that guarantee transparency, accuracy, and standardization for carbon management. These protocols are used by the majority of reporting institutions worldwide. These are the scopes:

- *Scope 1* includes GHG emissions from direct sources owned or controlled by the institution—*production* of electricity, heat or steam, transportation or materials, products, waste, and fugitive emissions.
- *Scope 2* includes GHG emissions from *purchases* of electricity, heat, or steam.
- *Scope 3* includes other indirect sources of GHG emissions that may result from the activities of the institution but occur from sources owned or controlled by another entity, such as: business travel, outsourced activities and contracts, emissions from waste generated by the institution when the GHG emissions occur at a facility controlled by another company (e.g., methane emissions from landfill waste), and the commuting habits of community members.

Our goal was to calculate emissions from all three scopes.

Next, we determined the institutional boundaries by using a consolidation methodology that reflects whether the institution has a partial ownership share or working interest,

Table 2. Population and space data used for the greenhouse gas inventory

Fiscal year	Full-time students (*N*)	Part-time students (*N*)	Faculty (*N*)	Staff (*N*)	Total building space (square feet)	Total research building space (square feet)
2004	20,155	5,073	2,350	8,495	14,063,190	759,246
2005	19,630	4,777	2,379	8,500	14,431,675	901,948
2006	19,622	4,731	2,417	8,714	14,501,696	929,092
2007	19,480	4,720	2,453	8,973	14,888,520	925,486
2008	20,125	5,000	2,574	8,941	14,692,023	976,526

holds an operating license, or leases, or that otherwise represents joint ventures or partnerships of some kind. These methodologies include the equity share, operation control, and financial control approach. We chose an operational control approach which we based on UIC's authority to control operations through policy implementation. Our boundary included those buildings that comprise the east, west, and south sides of the Chicago campus. These are serviced by the campus physical plant operations and the University of Illinois Utilities Operations. It did not include off-campus sites within the Chicago region or the Peoria and Rockford campuses. A map of the site is provided as Figure 1.

Utilities Operations runs two power plants that cogenerate heat and electricity on campus. However, based on several economic and operational factors, it also purchases electricity from the grid. Therefore, this GHG inventory calculated all of Scope 1 and Scope 2 emissions. In addition, we obtained data to calculate some of the Scope 3 emissions, specifically for commuting of faculty, students, and staff and for solid waste. Other emissions that fall into Scope 3, such as from agricultural operations and refrigerants, were excluded because there are no agricultural operations on campus and the main refrigerant used on campus is chilled water. We also excluded air travel emissions since obtaining reliable data during the time of this project was not possible.

Scope 1 Emissions

For Scope 1 emissions we calculated GHG emissions from the production of electricity, high temperature hot water or steam, and transportation at UIC. We describe the sources of GHG emissions that are located on the campus.

The primary source of GHG emissions in the two power plants, located on either side of campus, is natural gas that is combusted to provide electricity, heating, and cooling to the campus. The plants can run on fuel oil, but it has rarely been economical to do so. The power plants use a process of cogeneration that increases the efficiency of energy generation by recovering the excess heat from the electricity-generating equipment to preheat water used to heat the campus. The two plants use a variety of equipment that enables flexibility in operations. The east plant can generate a total of 20.2 megawatts of electricity. Cogeneration can produce up to 200 million Btu (MMBtu)/h of high-temperature hot water. The plant also produces chilled water for cooling the east-side buildings. The west plant can generate up to 37.2 megawatts of electricity and 360,000 lb/h steam with three turbines that recover heat through three exhaust-gas heat-recovery steam generators with supplemental duct burners. There are also three reciprocating engine generators that run on natural gas to produce electricity without heat recovery. Utilities Operations provided gas and fuel oil consumption data. These data are internally validated since they are also used in reporting to the Illinois EPA (IEPA) for permit reporting under the Clean Air Act.

Some direct gas use is metered at the building level. This gas is typically used in laboratories and kitchens. A limited number of buildings have their own boiler systems. Utilities Operations provided the gas consumption data.

The only other Scope 1 emissions we accounted for are from the university fleet (direct transportation), which consists of trucks, buses, grounds vehicles, departmental cars and vans, rental cars, etc. A number of the buses used for shuttling students and staff around campus run on compressed natural gas (CNG). Other vehicles use gas, diesel, and biodiesel. In 2008, the transportation department began to buy hybrid vehicles, as well. A fueling station is located at the Transportation Facility on campus. The newer biofuel vehicles can use E85 (85% denatured fuel ethanol), but a fueling station is not available on campus, so E85 is not reported. Most of the data used for the calculations accounted for the gasoline dispensed from the pumps at the Transportation Facility. However, the meter on the natural gas pump began to malfunction sometime in 2005, so we based some of the earlier data on CNG purchased. The data do not include fuel purchased off campus, which we assumed to be minimal.

Scope 2 Emissions

For Scope 2 emissions, we calculated GHG emissions from purchases of electricity, heat, or steam. UIC purchases electricity from Commonwealth Edison (ComEd). Utilities Operations provided the number of kilowatt-hours purchased from ComEd for the campus. No heat or steam is purchased.

Scope 1 and 2 Calculations

We used the Campus Carbon Calculator version 6.2 prepared by Clean Air–Cool Planet to perform the calculations for the expanded inventory. Campus Carbon Calculator includes the six GHGs defined by the Kyoto Protocol (carbon dioxide, methane, nitrous oxide, sulfur hexafluoride, hydrofluorocarbons, and perfluorocarbons) (Hough et al., 2008). Each gas, based on its atmospheric chemistry, captures different amounts of reflected heat, thus contributing differently to the greenhouse effect, which is known as its global warming potential (GWP). Carbon dioxide, the least capture efficient of these gases, acts as the reference gas with a global warming potential of 1 (WBCSD/WRI, 2001).

The Campus Carbon Calculator calculates emissions using this formula:

$$A \times F_g = E_g \quad (1)$$

Where A is the quantification of an activity in units that can be combined with emission factor of GHG g (F_g) to obtain the resulting emissions for that gas (E_g). Examples of activity units include MMBtu of natural gas, gallons of heating oil, kilowatt-hours of electricity, and miles traveled. Total GHG emissions can be expressed as the sum of the emissions for each gas multiplied by its GWP. GHG emissions are reported here in metric tons of carbon dioxide equivalents (metric tons CO_2e).

$$\mathrm{GHG} = \Sigma_g E_g \times \mathrm{GWP}_g \quad (2)$$

The Campus Carbon Calculator includes the following major emissions sources: on-campus energy production; purchased electricity; natural gas service to buildings for laboratories and cooking; transportation (including air travel and commuting); waste; paper; agriculture; and refrigerants.

The Campus Carbon Calculator estimates E_g from the quantity of fuel burned using national and regional average emissions factors, such as those provided by the US Department of Energy's Energy Information Administration (2009).

Chicago is part of the electricity grid subregion designated as Reliability First Corporation West (RFCW), which includes northeastern Illinois, Indiana, southwestern Pennsylvania, and portions of Wisconsin and Michigan. ComEd provides electricity from a mixture of sources, which is quite different from the rest of that region, in that it is highly dependent on nuclear energy (as much as 88% in FY 2006). To provide the most accurate emissions for the campus, we used the custom mixture function of the Campus Carbon Calculator. This allowed us to define the specific custom mixture of power sources (e.g. nuclear, coal, natural gas, wind) instead of using a regional average (Illinois Commerce Commission, 2009).

Scope 3 Emissions

For Scope 3 emissions, we calculated emissions for solid waste and for commuting of faculty, students, and staff.

UIC handles municipal solid-waste collection internally, using its own fleet and drivers except for the hospital, which outsources the service. We collected data on waste disposal from Facilities Management. These records are based on the tonnage charges for the waste. Environmental Services in the hospital provided information on their waste disposal.

We developed an online survey to estimate the emissions from commuting to campus for work or study. The Office of Sustainability conducted this survey in the fall of 2008 by using an online tool called Survey Monkey. We used UIC's mass e-mail system to solicit responses and administered the survey over a period of approximately six weeks. The questionnaire asked faculty, staff, and students which mode or combination of modes they use to commute to campus (up to three), the distance traveled by that mode, and the frequency of their commute. We considered four transit modes: driving (including carpooling), bus, light-rail, and commuter rail.

We used the commuter survey to determine the total passenger miles traveled by UIC commuters for each transit mode. For a known population, we analyzed the survey data to determine the percent of the population that used each transit mode. Then, based on a known number of trips and the average trip distances, we determined the passenger miles for each transit mode.

Emission factors were generated by the Campus Carbon Calculator. These factors were based on government documents and software from the US Department of Transportation, the U.S. Environmental Protection Agency, and the US Department of Energy (Hough et al., 2008). We calculated emissions for three GHGs: carbon dioxide (CO_2), methane (CH_4), and nitrous oxide (N_2O) and determined emissions using Equations 1 and 2 for each of the four transit modes under consideration.

The Campus Carbon Calculator accounted for emission factors only from fuel combustion during transportation in the type of vehicle under consideration. The calculations did not include any upstream impacts from mining, extraction, and processing of fuel. Vehicle emission factors in the Campus Carbon Calculator were derived using an average fuel economy of 22.1 miles per gallon (9.4 km/liter) and a commuter vehicle mix of 62% cars. Bus emission factors were derived from a normalized fuel efficiency of 39.7 miles per gallon per passenger (16.9 km/liter-passenger). The calculator attributed the local commuter rail (Metra) a fuel economy of 132.3 passenger miles per gallon of diesel (56.2 passenger-liter/km). Light-rail (the El) emission factors were calculated from a factor of 2.9 passenger miles per kWh (4.6 passenger-km/kWh).

We calculated travel frequency for faculty, staff, and students from the transportation survey responses regarding the number of days per week and weeks per year that an individual commutes to campus. We determined percentages of the UIC campus population who used each transit mode by calculating the weighted average of the trip distances for multiple types of transit modes. That number was then divided by the total number of responses within that population group to estimate the percentage of commuters that would use that mode. For example, if the average trip distance was 8.5 miles (13.6 km) for 207 students using light-rail for the first leg of their trip, 8.6 miles (13.8 km) for 230 students using light-rail for the second leg of their trip, and 3.6 miles (5.8 km) for 62 students using light-rail for the third leg of their trip, the overall average trip distance was

$$\text{average trip distance} = [(207)(8.5) + (230)(8.6) + (62)(3.6)]/(207 + 230 + 62) = 7.9 \text{ miles}$$

Although the survey was conducted in the fall of 2008, we assumed that the data were similar in fall 2007.

To calculate the emissions for 2004–2007, we examined historic trends in parking permit and transit benefit use. We received these data from Campus Parking. UIC provides a pretax transit benefit to its full-time employees. This benefit allows them to withhold a set sum from their paycheck to be used for the purchase of transit services on the public transit systems available in the Chicago region, effectively reducing their costs by their marginal tax rate. Parking permits are issued on an annual or semester basis for a fee. These were considered an indicator of the number of people who drive to campus. We received zip-code data for faculty, staff, and student residences from DRIA. We used these data to estimate the average distance traveled by students and employees by calculating a weighted average of distance traveled between the residence zip code and the campus zip code.

Data provided by Campus Parking for 2001–2009 showed a 33% overall decrease in permit holders (Figure 2). This decrease is particularly evident for students (57%). Residents showed a 25% reduction in parking use. The other categories remained fairly constant, given the change in population. During 2004–2008, the overall population of students increased 8.7% (Table 1). Nonacademic employee parking permits on the east side decreased by 38%, whereas the permit numbers increased slightly on the west side from 2001 to 2009. The number of academic participants (faculty and staff) in the transit benefit program increased 233% from 2002 to 2009, whereas the number of nonacademic staff participants increased by 26% (Figure 3). Although there was a large increase in transit benefit use over this period, this is not reflected in the reduction in parking permits. Many of these people were probably using public transit prior to the start of the program.

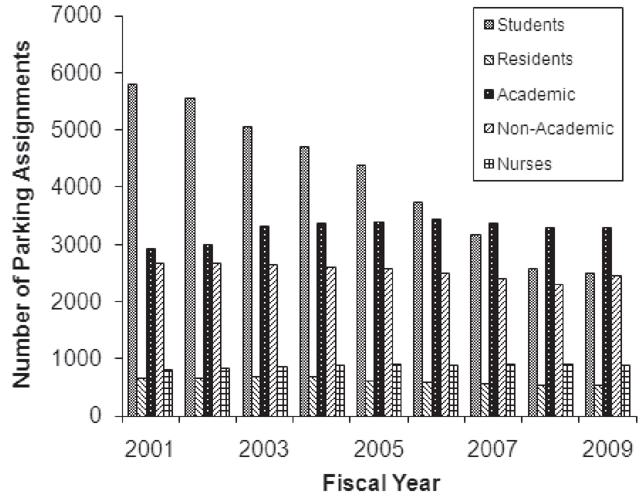

Figure 2. Parking assignments by user type.

Using the zip-code data, we calculated the average distance traveled by staff and students to be 15 miles, and the faculty traveled 13 miles.

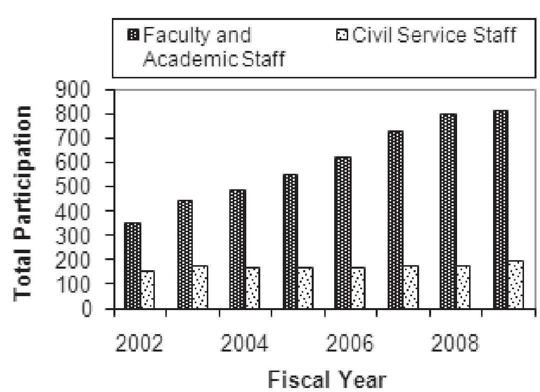

Figure 3. Transit benefit participation by employee class.

Table 3. Summary of percent of the population using a transit mode to commute to the University of Illinois at Chicago (UIC) campus

UIC role	Population	% Driving	% Carpool	% Light-rail	% Commuter rail	% Bus
Students	22,625	32	5	44	24	47
Staff	8,941	53	10	24	31	26
Faculty	2,574	43	7	25	26	28

We adjusted the percentage changes in parking permits issued for population changes and then averaged them over the period of the study. We used these percentages to adjust the proportion of those commuting by car versus transit. For students, this was done by increasing the rate of driving alone by 3% each year going backward and decreasing the rate of bus, light-rail, and commuter rail by 1% each per year. For faculty and staff, the rate of driving alone was increased by 1% each year going back to FY 2004, and bus and light-rail was decreased by 1% each per year. Commuter rail was held steady.

Results

Survey Results

Among the total campus community sent a mass e-mail invitation, 2,785 UIC campus community members responded to the survey. Table 3 indicates the percentages of each population that used each mode of transit. For example, 53% of UIC staff drove to UIC. Of that group, 10% carpooled. Similarly, 47% of UIC students used the bus to reach UIC. The percentages summed for each row do not add up to 100% because commuters were allowed to use up to three different modes of transportation for one trip to UIC. Survey responses indicated that, on average, two people rode together in those vehicles that carpooled.

Inventory Results

The results of the GHG inventory are summarized in Table 4 and Figure 4. The campus emitted 275,000 metric tons CO_2e in 2008, which is an increase of less than 1% over the 2004 emissions of 273,000 metric tons CO_2e. However, in 2006 there was a 21% reduction in emissions as compared to 2004 and then a similar increase by 2008. Emissions from cogeneration (i.e., power plants) have decreased over

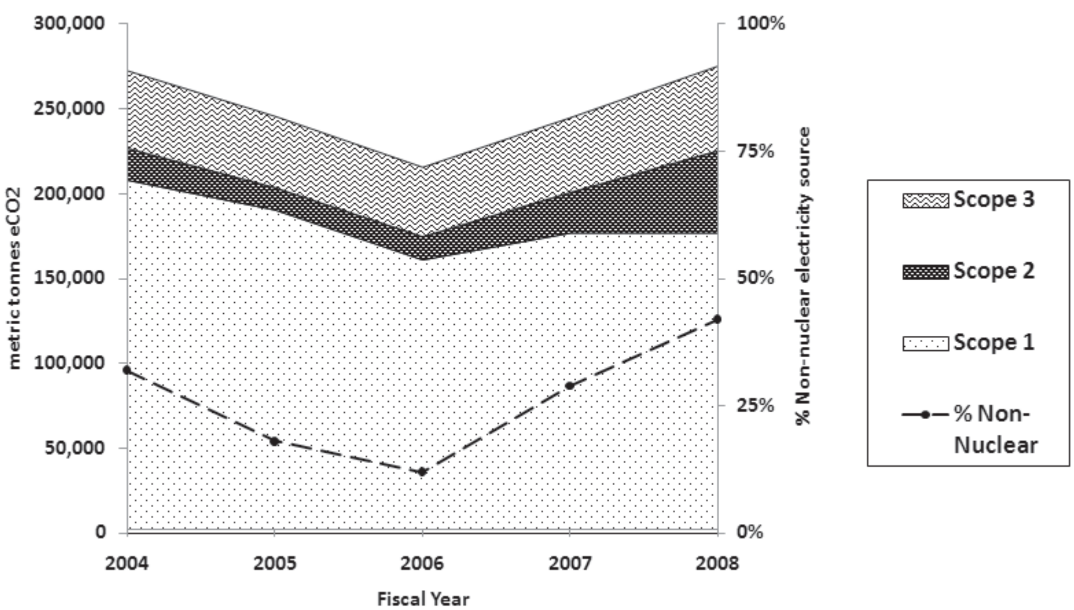

Figure 4. University of Illinois at Chicago greenhouse gas emissions by scope and the nonnuclear portion of purchased-electricity mix. CO_2e, carbon dioxide equivalents.

Table 4. Summary of University of Illinois at Chicago's greenhouse gas emissions for fiscal years (FYs) 2004–2008

	1,000 Metric tons of carbon dioxide equivalents				
	FY 2004	FY 2005	FY 2006	FY 2007	FY 2008
Scope 1					
Power plants (cogeneration)	203	186	157	173	173
Other on-campus stationary sources	4	4	3	3	3
Campus fleet	2	2	2	2	1
Scope 2					
Purchased electricity	18	13	13	24	48
Scope 3					
Faculty/staff commuting	19	19	19	21	22
Student commuting	23	20	19	19	21
Solid waste	2	2	2	2	2
Scope 2 T&D losses	2	1	1	2	5
Totals					
Scope 1	209	191	162	177	178
Scope 2	18	13	13	24	48
Scope 3	46	42	41	44	50
All scopes	273	246	216	245	275

T&D, transmission and distribution.

time from 203,000 in 2004 to 173,000 metric tons CO_2e in 2008, while emissions from purchased electricity have increased from 13,000 in 2005 to 48,000 in 2008.

The GHG emissions dipped significantly in 2006 (Figure 4). The dashed line in Figure 4 represents the non-nuclear portion of the electricity, which dipped to nearly 10% in 2006 and then began to rise again. The sources of emissions for 2008 are shown in Figure 5. Buildings were

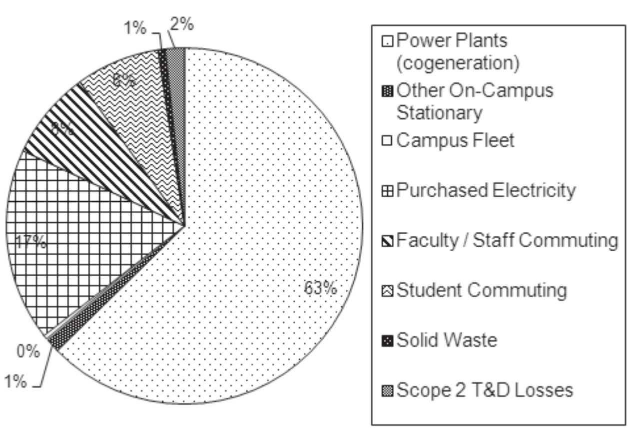

Figure 5. Sources of greenhouse gas emissions for fiscal year 2008 for University of Illinois at Chicago campus. T&D, transmission and distribution.

the largest source of emissions (83%). Scope 1 emissions from the power plants, other on-site stationary sources and purchased electricity make up 82% of building emissions. Less than 2% of additional building emissions are Scope 3 transmission and distribution (T&D) losses, which are due to losses of energy while the electricity moves from the source to the customer. The additional emissions are made up by commuting (16%) and waste (1%).

The overall energy consumption (in MMBtu) by the campus decreased slightly from 2004 to 2007 but then increased in 2008 (Figure 6).

Discussion

We calculated the annual GHG emissions for UIC to be between 216,000 and 275,000 metric tons of CO_2e during FYs 2004–2008. These numbers do not reflect several programs UIC implemented prior to 2004 that most likely reduced GHG emissions. These programs include introduction of cogeneration and transition to natural gas from diesel oil for boilers around the turn of the 20th century, a universal transit pass (U-PASS) program for students (fall 2001), and a pretax transit benefit program for faculty and staff (2002). The use of cogeneration in the power plants probably reduced the campus' carbon emissions signifi-

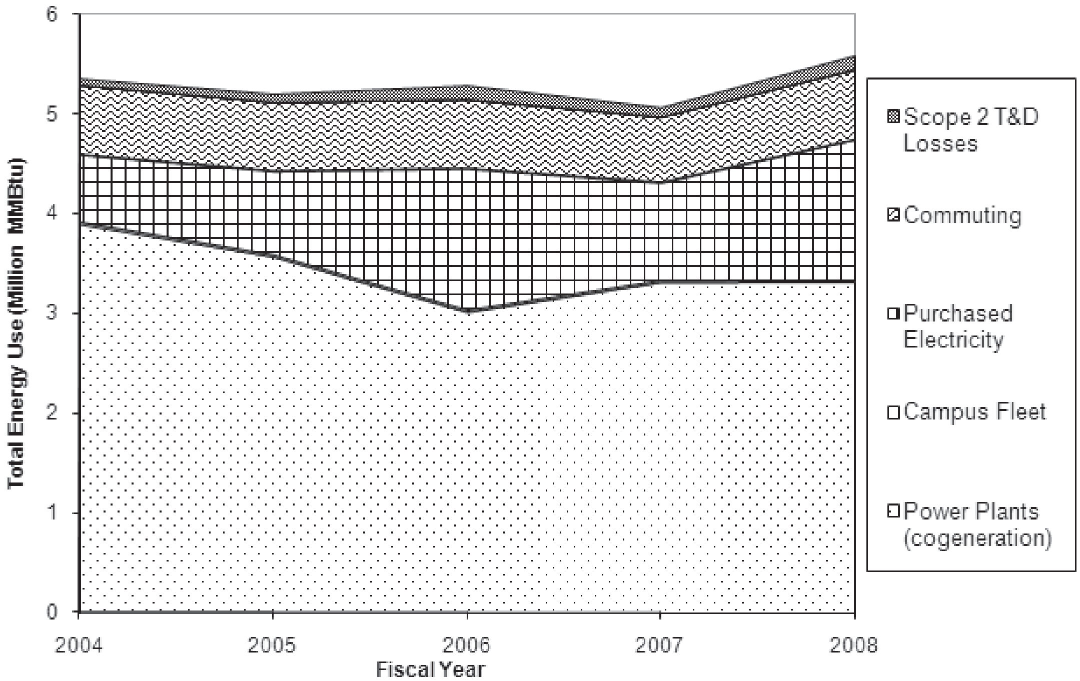

Figure 6. Energy consumption by source for fiscal years 2004–2008. T&D, transmission and distribution.

cantly by its increased efficiency. However, the quantitative effects of these programs could not be documented fully because the historic energy consumption data that were available from 1995 were found to be inconsistent with the data available from Utilities Operations from 2003 on. Also, no fuel consumption data were available for the campus fleet prior to 2003. Therefore, we recommend that an emissions baseline for the campus be set as 2004.

The overall emissions trend for the five years shows an increase of less than 1%; however, in 2006 there was a 21% reduction in emissions as compared to 2004 and then a similar increase to 2008. In the middle years, low carbon sources (e.g., nuclear power) provided higher amounts of electricity than in other years (Figure 4), and a larger amount of energy (i.e., electricity) was purchased in 2006 than in any other year (Figure 6). The second largest source of electricity from ComEd, after nuclear, is coal, which is a significant source of GHG emissions. This phenomenon is supported by the total energy consumption profile (Figure 6), which remains fairly level until it increases slightly in 2008. These two factors account for the large dip in emissions in 2006. The variation in ComEd's electricity emissions is due to a factor that currently is not under UIC's control. One way to control emissions would be to have a power-purchase agreement that defines the sources of electricity that UIC purchases. To be most effective, the agreement should contain a large renewable component. The data also show there has been a transition to less direct emissions for generated electricity and more indirect emissions from purchased electricity.

Although, a commuter survey was first conducted in 2008, data provided by Campus Parking for the years 2001–2009 showed a 33% overall decrease in permit holders (Figure 2). The distances traveled by each population group from the zip-code data aligned with the data collected in the survey. This decrease is particularly evident for students (57%) and aligned with the implementation of the U-Pass program in 2001 on campus. This demonstrates the effectiveness of having a "free" transit pass on the use of transit versus driving a car. Medical residents also showed a 25% reduction in parking use, although they do not have access to the U-PASS. This may reflect overall increases in transit use in Chicago as a whole (Chicago Transit Authority, 2008). It is hard to measure the effect of the transit benefit program on transit use since early increases in enrollment were due to the introduction of the program. This may be a good metric for monitoring transit use in the later years.

We intend to include air travel emissions in future GHG inventories, as UIC is improving the reporting system for travel that will make the data more easily retrievable. In-

Table 5. Average greenhouse gas emissions metrics for doctorate-granting universities ($n = 85$)

	Average emissions per 1,000 square feet (metric tons CO_2e)	% Average gross per 1,000 square feet	Average emissions per FTE (metric tons CO_2e)	% Average gross per 1,000 square feet
Scope 1	6.1	28	2.7	31
Scope 2	10.1	47	4.2	48
Scope 3	5.2	24	1.9	22
Gross emissions	21.4	100	8.8	100

CO_2e, carbon dioxide equivalents; FTE, full-time equivalent enrollment.

cluding air travel emissions will likely increase the total GHG emissions for UIC by about 1%–13%; this estimate is based on a comparison of UIC with 10 similar universities (urban, research, or Big Ten) that reported air travel emissions to the ACUPCC. Although air travel emissions can be reduced through more teleconferencing and the promotion of the use of trains for travel within shorter distances, there is currently no foreseeable carbon neutral alternative to jet fuel. This means that to reach climate neutrality, an air travel offset program would be required.

Since these GHG emissions are based on estimates using fuel consumption data, except for those from waste, rather than direct measurements of emissions, exact emissions figures are uncertain. Due to the complexity of landfill operations, uncertainty in the emissions from landfills may be as great at 10%–30% in the US. Overall, uncertainty in a well-developed GHG inventory is estimated to range from 5% to 20% (Rypdal and Winiwarter, 2001). In terms of UIC's inventory, the area of greatest uncertainty is commuting emissions. The data were extrapolated from a survey of a limited number of community members (8%) and were not administered by a statistically significant procedure. When the GHG emissions calculated from the commuter survey are compared to the GHG emissions calculated in the first study on GHG emissions (Klein-Banai, 2007), the results in our current study were found to be 12%–13% lower. This would reduce the overall emissions by approximately 2%. The data for Scope 1 and 2 emissions is accurate to a much higher level since the calculations use direct consumption data.

The signatories to the ACUPCC must report their emissions on a publicly accessible Web site. When compared to the total ACUPCC database for 85 doctorate-granting universities (Table 5), UIC's gross emissions per square foot (18.4) are lower than average (21.4%). These comparative data illustrate that UIC's emissions fall within the range of other universities and validate the results. However, generally these data are not audited or verified, so there could be errors or omissions in reporting. Although all institutions reporting to the ACUPCC must use the WBCSD/WRI protocol and most use the Campus Carbon Calculator, the specific data-collection methodologies for calculating emissions may vary, especially for Scope 3 emissions. Therefore, care is needed when comparing emissions among institutions.

Numerous other factors contribute to differences in emissions among institutions. Climate (e.g., the number of heating and cooling degree days) will affect the energy consumption within buildings. The functions of the buildings on campus and their relative proportion, such as the presence of a hospital or large laboratory buildings, can increase energy consumption considerably. A commuter campus, especially one with little access to public transit, can have high emissions from commuting.

Conclusion and Implications

Our study revealed that although UIC is primarily a commuter campus, its commuting emissions make up only 16% of the total university emissions. The Center for Neighborhood Technology (2008) calculated that commuting emissions make up 20% of Chicago's total emissions. This is probably because of UIC's proximity to all modes of public transit—bus, elevated train, commuter rail, and bicycle routes. Also, the campus provides an intercampus shuttle between the east and west sides of campus, a semester express shuttle for students living in the south campus residences, and a commuter shuttle to the commuter rail stations, reducing the need for cars on campus. In spite of this, additional outreach programs and incentives to reduce emissions from commuting to campus should be developed.

This study illustrates that GHG inventories do not account for all environmental emissions. For instance, much of UIC's electricity is purchased from nuclear power plants, which have no carbon emissions, thereby lowering our footprint, but do produce nuclear waste. This suggests that there is a need to go beyond just GHG analyses when evaluating sustainability and include all forms of energy and their consequences. Further, the greatest variability in UIC's emissions over time was due to the mix of purchased electricity and not to any action undertaken by the university itself. Under the current electricity-purchasing arrangement, there is no control by UIC of the source of electricity being sold to the university and therefore no control over the emissions from that generation. The cost of gas versus purchased electricity has been driving the campus away from producing its own electricity, yet this leads to less control of the source.

GHG inventories do not account for hazardous waste disposal in the waste component. UIC's inventory does not consider other air pollutants such as sulfates, nitrates, nitrous oxides, or particulate matter. There is no accounting for water consumption or wastewater emissions. Finally, the scope of the inventory does not include upstream emissions from the manufacture or transport of energy or materials.

UIC is using its GHG inventory to develop strategies and goals for its Climate Action Plan and to inform policy making. In its first Climate Action Plan, using the 2004 baseline, UIC set a target of 40% emissions reduction by 2030 and greater than 80% emission reduction by 2050. The largest reductions should come from efforts to reduce emissions from buildings. Since the electricity and steam or high-temperature hot water and chilled water are supplied through a central system, the accuracy and reliability of energy consumption at the building level is poor. The first step in UIC's plan is to meter the largest and most energy-consuming buildings on campus through state-of-the-art electronic meters for electricity, chilled water, high-temperature hot water, and steam. This will create a baseline for energy efficiency and conservation projects such as energy performance contracting, heating, ventilation, and air-conditioning system upgrades and automation, and shadow billing to make colleges and administrative units more aware of and accountable for their energy use. Prospective renovation projects will be evaluated for their energy savings. UIC will continue to replace light fixtures with more efficient compact fluorescent, T-8 fluorescent ballasts and lights, and with light-emitting diodes (LEDs). By the end of FY 2010, over 40,000 bulbs will have been replaced. UIC will continue to use reflective and green roofs to save energy. All new buildings and renovations costing more than $5 million will meet or exceed the Leadership in Energy and Environmental Design (LEED) Silver standard, and all projects of less than $5 million will do so to the extent possible.

The second major strategy in the Climate Action Plan is to use renewable energy sources such as the geothermal heating and cooling system recently installed for three small classroom buildings and to use the 51-kW solar photovoltaic system on the roof of one of the classroom buildings. Further renewable energy may be purchased through power-purchase agreements and by seeking a biogas or other renewable energy source for UIC's gas-fired power plants (UIC Office of Sustainability, 2009).

Despite its limited scope, a GHG inventory can be used as one metric of environmental impact or sustainability. It is an accounting tool that may be used to compare similar institutions and can be used within an institution to track progress toward a certain goal. A GHG inventory can be used to establish a baseline for policy and as a planning tool for goal setting that can be framed within larger local, regional, state, national, and international goals. The results show the huge impact the university's built environment has on the emissions. Thus strategies to make the campus more sustainable by reducing emissions should primarily target the buildings to reduce their energy demand, as well as the source of energy.

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