Local Efforts to Monitor and Mitigate Greenhouse Gas Emissions: A Case Study from the University Park Campus of Penn State University

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ABSTRACT

Increasingly, universities are developing greenhouse gas emission inventories for university-related activities. Microcosms of larger-scale entities, universities offer a unique opportunity to examine emissions in a largely autonomous setting. This paper explores the greenhouse gas inventory conducted for the University Park campus of Penn State University, including a discussion of the calculator developed specifically for the inventory. The inventory spans from 1990-1999 and includes projected emissions for 2000-2012. Following the completion of the inventory, dialogs of mitigation planning emerged in a concerted effort between University stakeholders and researchers to reduce the University's greenhouse gas emissions. We conclude with recommended future actions for Penn State's ongoing effort to curtail greenhouse gas emissions as part of a larger commitment to environmental stewardship.

INTRODUCTION

International and national efforts to reduce greenhouse gas (GHG) emissions have fallen short of expectations in both the reductions realized and participation commitments from contributing emitters. The *Kyoto Protocol* put forth targets and timelines for thirty-eight countries of the industrialized north to reduce their emissions (Victor, 2001). The Protocol called for the United States to reduce emissions to seven percent below 1990 levels by 2012. While the United States did sign the Protocol, it was not ratified. The absence of the United States' twenty-four percent of global emissions from the Protocol reduction creates a setback in the global effort to mitigate greenhouse gas emissions.

The literature cites many shortcomings of the Protocol itself as potential causes for its less than successful reception among the global community and recognizes that a more localized approach is necessary (Betsill and Bulkeley 2004; Fleming and Webber 2004; Betsill 2001, 2001; Kates et al. 1998; Kates and Torrie 1998; Collier and Lofstedt 1997). This paper illustrates how the issue of scale plays an instrumental role in emission reductions. We examine GHG emissions at the local scale as opposed to the national or global scale. Exploring emissions from a local perspective offers several benefits:

- *Emissions occur at a local scale* (Wilbanks and Kates 1999).
  For monitoring and inventorying purposes, the local scale is the scale at which data is readily available. It requires little aggregation and offers place-specific information.
- *Every place is unique.*
  Emission mitigation opportunities for any locality differ based on a variety of factors. While larger scale emissions reduction strategies offer blanket approaches to controlling emissions, a localized effort affords flexibility and consideration of place-based characteristics. Social, economic, and environmental factors combine to create unique circumstances for different areas.
- *Local efforts facilitate stakeholder involvement.*
  Just as emission sources operate at local scales in specific places and sectors, so too do the stakeholders who can provide data and perspective on emissions. The Penn State case study relied extensively on close relationships with University stakeholders who supplied activity

data, expertise, and other insights into the circumstances surrounding the University's emissions.

Universities in particular are excellent laboratories of local places. They operate under similar bureaucratic structures to cities and can contribute substantial emissions. Many large university campuses like University Park are virtually self-sufficient entities, generating their own power, managing wastewater, and providing a living and working environment for thousands of people. University Park, founded as a land grant institution in 1855, is situated in central Pennsylvania (Figure 1). The core campus is home to over 200 major buildings totaling 15.5 million square feet of space, more than 2000 classrooms, two steam plants, a nuclear reactor facility, a football stadium and a wastewater treatment plant. With a student population at just under 45,000 along with almost 14,000 faculty and full time staff members, University Park truly is the size of a modest city. In addition to the aforementioned benefits of examining GHG emissions at a local scale, universities – particularly large research institutions such as Penn State – are laboratories for scientific advancements and provide a unique opportunity for collaboration and innovation in GHG mitigation.

This paper outlines the methodologies employed and results found from conducting both an emission inventory and the beginnings of a mitigation plan for the University Park campus of Penn State University. It discusses the process by which an emission calculator, inventory, and projection were developed as well as suggesting shortcomings of data availability and reliability. The discussion of mitigation planning highlights the complexity of University Park's emissions and consequently emission reduction potential. Finally, further action and research for greenhouse gas emissions monitoring and mitigation is offered.

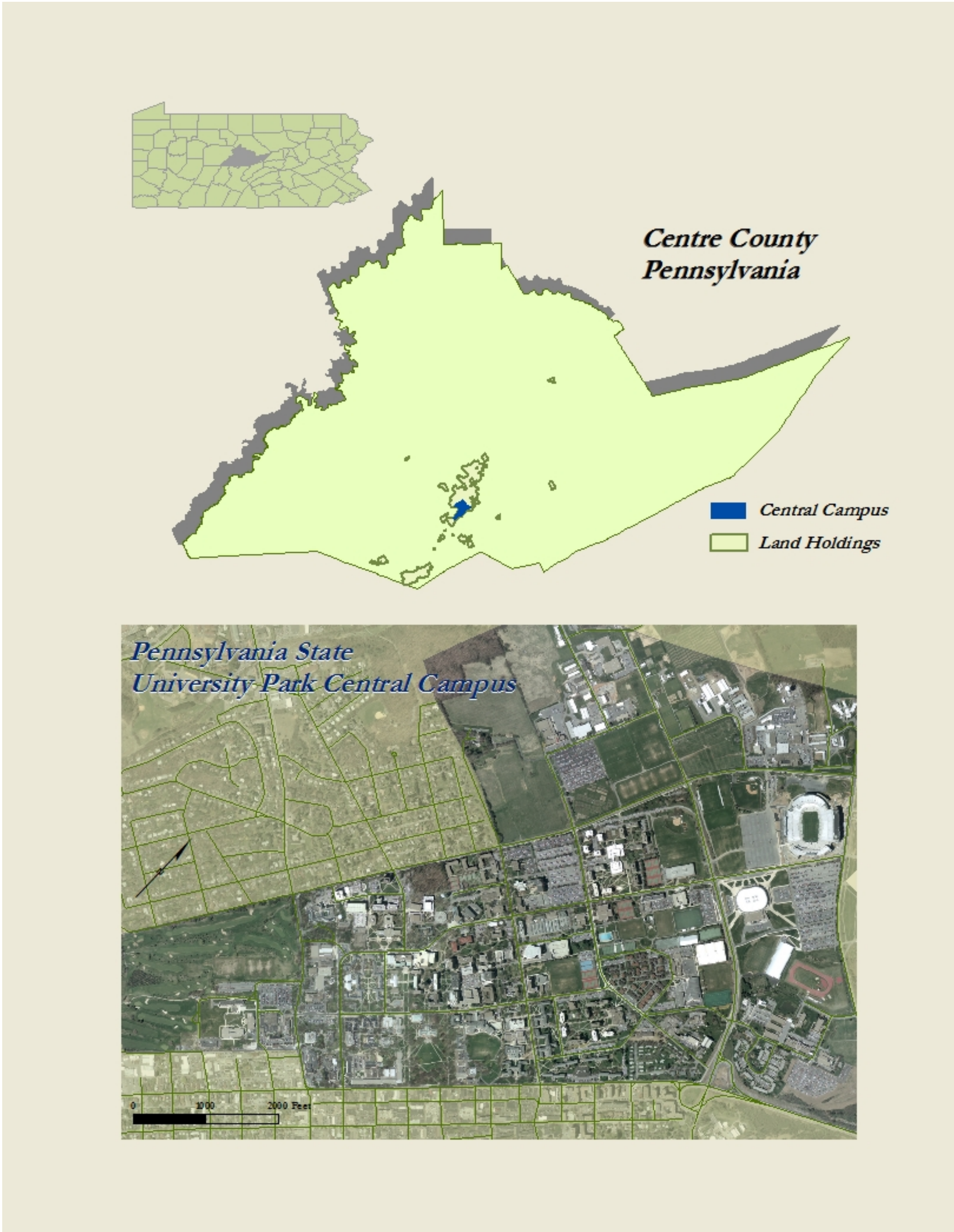

Figure 1: University Park Campus

EMISSION INVENTORY METHODOLOGY

We sought to develop a university-based inventory that exemplified these three criteria:

- Presents a detailed profile of University Park's emissions while maintaining a generalizable quality for comparison with other university institutions
- Includes all emissions from the University
- Facilitates easy annual maintenance of the inventory

The University Park GHG Inventory borrows from several emission inventory methodologies. The Intergovernmental Panel on Climate Change's (IPCC) Revised 1996 Guidelines for National Greenhouse Gas Inventories and the Greenhouse Gas Emissions Inventory for Pennsylvania Phase I

Report provided several specific calculations for the inventory. Volume VIII of the Emissions Inventory Improvement Program (EIIP) served as the primary resource for emissions calculations. Because EIIP methods are designed for state-level inventories, there were instances when the methods proposed by EIIP were too sophisticated for the university scale. In this situation, we referenced Clean Air-Cool Planet's (CA-CP) Emissions Inventory Toolkit.

An Excel-based GHG emissions calculator specific to University Park (UP GHG Emission Calculator) was developed that streamlined methodologies provided by the above sources, allowed for emission factors specific to University Park (e.g., local coal carbon-contents), and ensured consistency for all years in the time series. While emissions are similar by source, intricacies within sources can vary substantially depending on local circumstances. Available emission estimation tools did not allow the user to adjust emission factors according to the specifics of their institution, which limits emission inventory accuracy. To improve upon this limitation, the University Park GHG Emission Calculator stripped all emission estimation methods down to the basic formula of activity data multiplied by an emission factor equals emissions. The University Park GHG Emission Calculator allows users to enter activity data and either accept coefficients developed for the University Park inventory or adjust them to represent their own emissions accurately.

Consistent with common GHG inventory practices and IPCC guidelines, we divided the data for University Park into sectors. The six sectors for University Park emissions are Energy, Transportation, Land Management, Animal Management, Synthetic Chemicals, and Waste. These sectors are broken down further to sources within the sector (Figure 2). In deciding how broadly or narrowly to scope the inventory, we chose to include all direct emissions generated on campus as well as the indirect emissions associated with purchased electricity. While it would be impossible to account for all upstream emissions, we felt that the electricity generated at the power plant was in response to University demand, and therefore a necessary component of the inventory.

The acquisition of activity data involved numerous meetings and other correspondences with university personnel across the campus. In some cases, data was not readily available, and necessitated searching and compiling from various locations.

Figure 2: Profile of University Park's Greenhouse Gas Emissions by Sector and Source

Methods by Sector*

The **Energy Sector** includes emissions from campus stationary sources (e.g., boilers, generators, and heaters), steam plants, and purchased electricity. These sources produce carbon dioxide (CO_2), methane (CH_4), and nitrous oxide (N_2O) emissions. EIIP methods were used to calculate the CO_2 emissions resulting from the combustion of fossil fuels to supply these energy demands. For CH_4 and N_2O, however, the EIIP methods were overly complex; therefore, simplified CA-CP methods were employed. For purchased electricity emissions, the UP GHG Emission Calculator considers distribution losses and production efficiencies to convert the University's electricity consumption to energy consumed, and emissions produced, by fuel type at the power plant. Purchased electricity and stationary source activity data were obtained by month from the University's Environmental Compliance Specialist. Where data were limited or questionable, proxy data from accurate months were used.

The **Transportation Sector** includes emissions from University fleet vehicles and commuter travel to and from campus (which is further broken down into driving commuters and Centre Area Transit Authority bus riders). Transportation emissions were calculated using fuel consumption and vehicle miles traveled (VMT) data. To calculate emissions from University fleet vehicles, we used fuel consumption data for each campus pumping station as well as data from Fleet Operations for gasoline purchases made during business travel. For years when data were unavailable, an average of the previous and following year was invoked.

To estimate commuter emissions, the Traffic Assigner Model (Neff 2005), which utilizes census data to estimate emissions, was used. The Traffic Assigner utilizes census data to calculate commuter populations in a locality and the distance they travel to and from work. The Traffic Assigner uses transportation analysis zones (TAZ) and a road network in ArcGIS spatial software to allocate commuter origin-destination data. While the Transportation Department data was not reliable for annual commuter totals, we were able to use it to analyze University commuter zip codes of origin. About 91 percent of the commuters reside within the same county as University Park – Centre County, PA, while remaining commuters reside in neighboring counties. Calculations were completed assuming two trips a day for 214 working days a year.

Emissions were also estimated for University Park's commuter bus system – the Centre Area Transportation Authority (CATA). For early years in the time series, the CATA bus fleet ran on diesel, but in 1996, they began converting the fleet to Compressed Natural Gas. Therefore as of 1997, the inventory reflects the conversion of the entire fleet (though in reality this process took several years to complete). We obtained data on the number of bus miles traveled. According to census data, 68 percent of Centre County commuters commuted to work on the bus. The University Park GHG Emissions Calculator determines CO_2, CH_4, and N_2O emissions for all of this activity data.

The **Waste Sector** considers CO_2 (from flared CH_4), CH_4, and N_2O emissions resulting from treatment of wastewater, landfilling of solid waste, waste incineration and composting waste. The UP wastewater treatment plant handles waste from both the campus and the State College Borough. Following treatment, the sludge dries and is eventually shipped to the Laurel Highland landfill. Treated effluent is sprayed across more than 500 acres of farmland north of campus. Following EIIP suggestions, emissions were calculated by determining the biochemical oxygen demand (BOD) of the wastewater flow. While applicable at the state level, this methodology diminished in accuracy at the university scale. Instead, we obtained wastewater flow data and divided campus wastewater flow by total wastewater flow. For calculating sewage sludge sent to landfills, we implemented EIIP methods. Based on correspondences with the wastewater supervisor, we assumed that the treatment plant captures all the necessary CH_4 to heat the sludge digesters. The plant flares surplus CH_4, resulting in CO_2 emissions. CA-CP emissions calculations were utilized for landfill solid waste emissions. Solid waste totals and sewage sludge totals were summed together and attributed to the year in which transport to the landfill occurred. A small portion of UP waste is incinerated on campus. CA-CP methods were utilized for these emissions. The University began a composting program in 1997, diverting 1500 tons of waste from landfills annually. Food waste from the dining halls and other food service facilities on campus is composted. We employed EIIP methods to calculate emissions from the composting activities. Because composting keeps waste out of the landfill, CH_4 emissions avoided are considered a negative emission in the calculator. To account for the breakdown of material, EIIP methods for measuring N_2O emissions associated with organic fertilizers were used.

The **Synthetic Chemical Sector** includes sources such as synthetic fertilizers for landscaping and agricultural uses and refrigerants utilized on campus. Lime is also used as a fertilizer, and though a natural chemical, was treated as a synthetic chemical for simplicity's sake in the inventory. Fertilizer records were obtained from the three storage facilities on campus. With a few exceptions, the data was complete. For years when data was not available, the previous and following years were averaged together. While emissions methodologies continue to be refined, this inventory considers direct N_2O emissions resulting from nitrification/denitrification processes and indirect emissions from nitrogen volitization and leaching/runoff. University Park consumes refrigerants through Housing and Food Services dining facilities and dormitories, air conditioning units in cars and campus buildings, and campus water chillers. Data on refrigerant collection practices for University equipment was nonexistent. While there may be some collection and recycling of refrigerants from equipment taken out of use, this inventory assumes that all refrigerants consumed on campus will eventually be released back into the atmosphere. To calculate emissions, tons of refrigerants consumed were multiplied by global warming potential (GWP) for each specific refrigerant and converted this to metric tonnes. The IPCC provided GWP values for most of the refrigerants consumed at University Park. Where it did not, we used a GWP value of 2200, based on the average of other campus refrigerants. The refrigerant consumption data was only available for 1995 – 2003. An average of these years was utilized for 1990 – 1994.

The **Animal Management Sector** considers CH_4 and N_2O emissions resulting from enteric fermentation and manure management on Penn State' agricultural lands. Manure applied to agricultural fields as organic fertilizer is distinguished from the application of synthetic fertilizer to agricultural fields covered in the Synthetic Chemicals Sector. Though the EIIP methods categorize livestock into an extensive range of classifications, this inventory utilizes a simplified classification system. These classifications are: two dairy cattle classes (cows and heifers), five beef cattle classes (feed steers, bulls, cows, heifers, calves), four poultry classes (layers, breeders, broilers, turkeys), and four other classes (horses, swine, sheep, and other). EIIP methods for calculating methane produced through enteric fermentation involve determining the pounds of methane generated annually by animal type and size and converting this value to $MTCO_2E$.

The **Land Management Sector** includes University forest acquisition and loss. While this component of the inventory is a crude estimate at best, it is at least present and can be refined in the future if data becomes more available. The University owns over 7,000 acres of forested land. This land is harvested actively; however, no accurate harvest records were available. An analysis of land use change of University-holdings determined there was no appreciable difference along forest boundaries. Because the University owned this land prior to the completion of the inventory, the sequestration it provides is not included as a sink.

EMISSION INVENTORY RESULTS

From 1990-99, University Park's GHG emissions increased from 336,273 $MTCO_2E$ to 408,332 $MTCO_2E$, an increase of 21.4 percent (Figure 3). Emissions increased each year in the decade, with the largest jump occurring from 1995 to 1996. Emissions per student increased from 8.7 $MTCO_2E$ in 1990 to 10.0 $MTCO_2E$ in 1999. Although total emissions increased substantially, emissions increases were not observed in four of the six sectors (Table 1). CO_2 was the most emitted GHG, largely due to energy emissions, whereas waste and animal management dominated CH_4 and N_2O emissions. All HCFC and HFC emissions resulted from synthetic chemical use. Approximately 90 percent of campus emissions come from the Energy Sector, with the Transportation Sector coming in second at almost 9 percent. The remaining four sectors – Land Management, Animal Management, Waste, and Synthetic Fertilizers together represent only approximately 1 percent of total emissions.

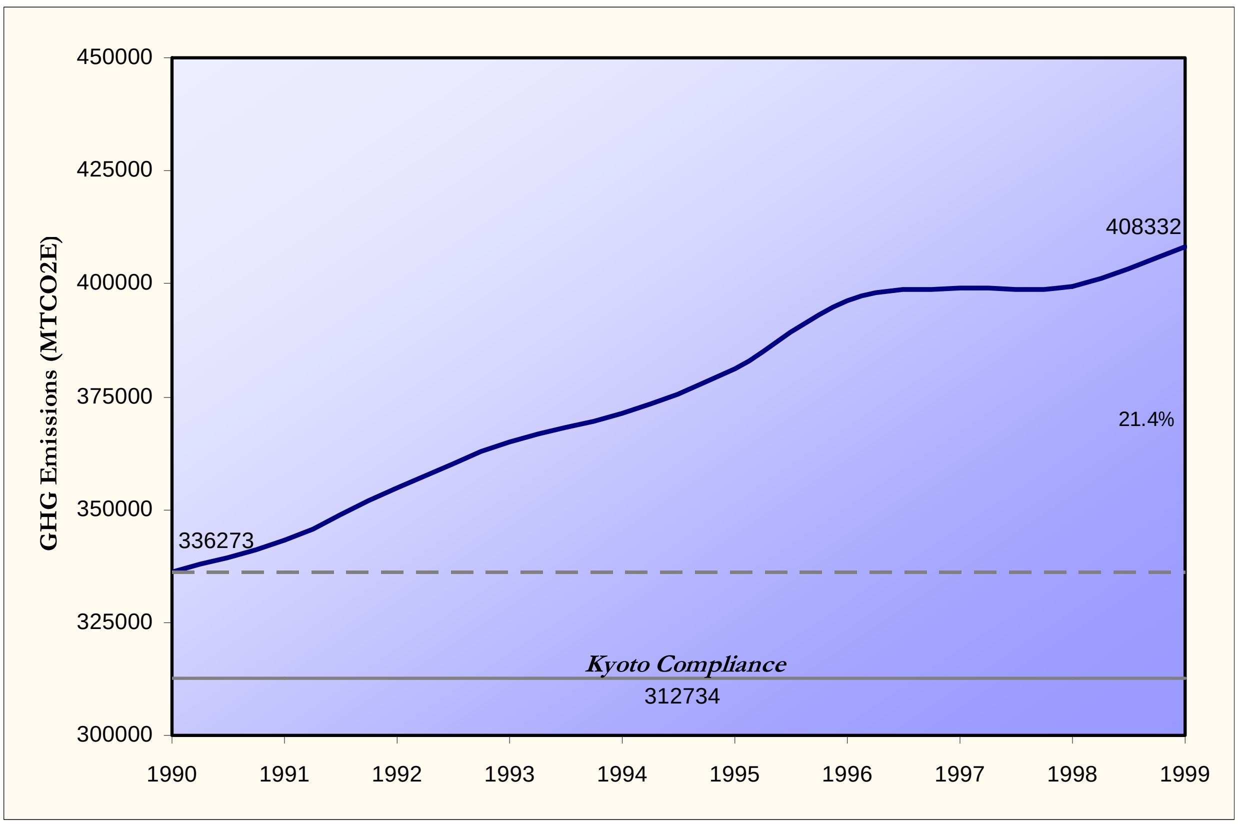

Figure 3: University Park's Greenhouse Gas Emissions Trendline 1990-1999

	Energy	Transpor-tation	Waste	Synthetic Chemicals	Animal Management	Land Management	Total
1990	297753	29641	2243	4977	2717	-1058	336667
1991	304553	30006	2123	4910	2717	-1058	343651
1992	315842	30372	2106	4904	2717	-1058	355288
1993	325649	30737	2137	4944	2717	-1058	365537
1994	331332	31103	2236	4918	2717	-1058	371664
1995	344372	31405	2086	1469	2717	-1058	381420
1996	356716	31918	1973	3829	2717	-1058	396515
1997	360955	31859	1778	2913	2717	-1058	399603
1998	358924	31584	1904	5283	2717	-1058	399736
1999	367639	32495	2039	4500	2717	-1058	408572
Change	**23.5%**	**9.6%**	**-9.1%**	**-9.6%**	**0.0%**	**0.0%**	**21.4%**

Table 1: University Park's total GHG emissions and percent change by sector 1990-99 ($MTCO_2E$)

Energy Sector emissions grew from 297,753 to 367,639 $MTCO_2E$ between 1990 and 1999. Purchased electricity escalated by 44 percent during the decade. Of GHG emissions generated by purchased electricity, 83 percent came from coal combustion, followed by natural gas (16 percent) and fuel oil #5 (1 percent). Purchased electricity relies heavily on fossil fuel use, thus leading to mainly CO_2 emissions. Steam plant emissions fluctuated throughout the decade, but experienced a five percent overall increase. On average, 95 percent of the steam plant's emissions come from coal combustion, which provides 91 percent of the energy generated and results primarily in the release of CO_2. Natural gas burning produced the remaining five percent of emissions, while producing nine percent of the energy generated. In 1999, the steam plants produced 163,731 $MTCO_2E$ of CO_2, 31 $MTCO_2E$ of CH_4, and 189 $MTCO_2E$ of N_2O. Stationary sources only produce two percent of UP's energy emissions; however, this amount still exceeds emissions from the Waste or Animal Management sectors. Stationary source emissions varied from 1990-99, achieving an overall increase of 29 percent.

The **Transportation Sector** accounts for just under 9 percent of the total campus emissions. This sector experienced nearly a 10 percent increase over the decade, beginning at 29,641 $MTCO_2E$ and finishing at 32,495 $MTCO_2E$ in 1999. Commuting accounts for the vast majority (84 percent) of the sector's emissions. The remaining emissions come from Office of Physical Plant (OPP) vehicles, Fleet vehicles, and Golf Course vehicles at 8, 7.5, and 0.5 percent, respectively. The sector experienced a 10 percent increase over the decade. For commuter emissions, drivers account for more emissions than those commuters riding the bus. While many less commuters are traveling in from outside Centre County, they comprise about 38 percent of the commuter driver emissions. Driver emissions increased by 13 percent over the decade while bus commuter emissions decreased by 10 percent. This decrease is due to the conversion of the CATA fleet to CNG.

Waste Sector emissions decreased by nine percent from 1990-99, largely due to an increase in recycling and the development of a composting program. These processes, and the practice of capturing CH_4 at both the campus wastewater-treatment plant and landfills, place the Waste sector as the second lowest campus emitter. Emissions from the Campus Wastewater Treatment Plant increased over the decade, from 48 $MTCO_2E$ to 58 $MTCO_2E$. Unlike most campus emissions sources, nearly all wastewater emissions are N_2O. Remaining emissions are CO_2 from flared CH_4. While wastewater plants typically generate substantial CH_4 emissions, the University captures CH_4 to heat sludge digesters, thereby significantly reducing waste emissions. Solid waste disposal practices generate more CH_4 than any other UP source, accounting for over 50 percent of campus CH_4 emissions. Solid waste emissions began the decade at 2,194 $MTCO_2E$ and finished the decade at 2,331 $MTCO_2E$. Emissions in 1999 were the decade's highest, with the lowest (1,925 $MTCO_2E$) occurring in 1996. The following year, the campus began incinerating waste at the Animal Diagnostics Lab (ADL) incinerator, generating an annual average of 58 $MTCO_2E$. In the same year, the campus began a composting program, which composts 1,500 tons of waste each year, saving 411 $MTCO_2E$.

Synthetic Chemical Sector emissions vary considerably between years, reaching a maximum value of 5,283 $MTCO_2E$ in 1998 and a minimum value of 1,469 $MTCO_2E$ in 1995. Overall, emissions decreased by nearly 10 percent from 1990-99, but the change might be more related to interannual variation than to a decreasing emissions trend. On average, refrigerant emissions account for 92 percent of the sector's emissions. Remaining University Park synthetic chemical emissions are largely N_2O from synthetic fertilizer application.

The **Animal Management Sector** is University Park's largest source of N_2O emissions, and second largest source of CH_4 emissions, but only the fourth largest source for overall emissions. Enteric fermentation and CH_4 produced through manure management resulted in 1,860 $MTCO_2E$ each year, which more than doubled annual emissions of N_2O (858 $MTCO_2E$) produced through nitrification/denitrification processes. Dairy cattle generated the most annual emissions (1,666 $MTCO_2E$), followed by beef cattle (657 $MTCO_2E$), other livestock (e.g., swine, sheep, horses) (366 $MTCO_2E$), and poultry (28.6 $MTCO_2E$).

The **Land Management Sector** is University Park's only sector that results in overall negative emissions. On average, forest land acquisitions offset 1,058 $MTCO_2E$, or 0.3 percent, of campus emissions each year.

PROJECTED EMISSIONS

The *Kyoto Protocol* called for the United States to reach its GHG emissions reduction target by 2008-12. The goal of projecting University Park's GHG emissions is to establish a 2000-12 estimated trend line, which will present future emissions within the *Kyoto Protocol* timeframe. Projected emissions provide a business-as-usual future emissions scenario, indicating the degree to which University Park must lower emissions to achieve Kyoto Compliance.

The same six sectors are considered for the projected emissions. Because the Energy Sector overwhelmingly dominates campus emissions, it is the focus of the projection. For Energy Sector emissions, patterns established in past energy use (1990-99) are considered under University Park's future planning strategies and in relation to national projections. Non-energy sectors are considered individually, noting parameters used to project their emissions. The calculator used to determine inventory emissions was modified into a projection calculator. For the Energy Sector as well as several others, observed data was utilized for 2000, 2001, and 2002.

The dramatic increase in **Energy Sector** emissions is not surprising given the rapid increase in both electronic devices and new campus buildings. By 1992, all of the campus residence halls were furnished with microwaves, refrigerators, and cable television hookups. (GDC, 2001) Computers continue to be more commonplace and many buildings across campus were outfitted with air conditioning. New buildings on campus not only increase electricity demand, but also the steam demand. Increases in electricity use and building construction will continue to place additional demands (and create increased emissions) in the coming decade. Planning efforts have begun to incorporate a consciousness of environmental stewardship. This growing trend will play an important role in determining future emissions. The projected emissions account for building growth by calculating the electricity and steam demands projected by the University Park Master Plan for each building and incorporating it into the projection based on its anticipated year of completion.

For the **Transportation Sector** projections, GHG emissions were projected from campus vehicles by averaging annual fuel increases for observed years, despite incomplete records. While commuter miles traveled (CMT) increased over the 1990s, the rate at which it did so fell. Applying the slowed rate of increase to University Park CMT projections assumes that University Park commuters will change at a rate equivalent to Centre County's population change. The correlation between the number of University Park commuters and Centre County population was strong during the 1990s (Pearson's correlation coefficient of 0.96), which justifies this assumption. University Park CATA bus-rider CMT are herein assumed to increase at an equivalent rate to driving CMT. Because it was available, observed miles traveled from 2000-03 were used. Additionally, new campus bus loops beginning in 2002 were incorporated, and all emissions from these routes are attributed to University Park because they do not leave campus grounds.

To project **Waste Sector** data, the change in observed-year values were averaged and applied to projected years.

For the **Synthetic Chemical Sector**, it was difficult to project future consumption for refrigerants because refrigerant use did not correlate to campus growth or population increase. Therefore, the values from 1999 were applied to all projected years as a safe baseline assumption of refrigerant use over the projected time period. After discussions with University personnel, it was decided that fertilizer use would not change substantially and therefore a zero percent change was applied to these values for agricultural fields and golf courses. On average, Pollock Shop increased fertilizer consumption by 4.5 percent for each year in the 1990s, which was applied to projected years. West Campus Shop decreased fertilizer use by 1.2 percent annually in the late 1990s. This decrease was applied for projected years as well.

The **Animal and Land Management Sectors'** projections are based on one year of livestock population data and one value for land acquisition. Livestock populations will fluctuate in future years, but fixed agricultural facilities should prevent appreciable variation from the sample year. Sample year livestock populations were applied to projected years. Though University Park will pursue future land acquisitions, it is impossible to predict acquired amounts. Therefore, the same value of 2.5 acres/yr used in the previous decade was applied to projected years.

University Park's projected GHG emissions increase 56 percent over 1990 levels by 2012 (Figure 4). GHG emissions begin the projection period at nearly 420,000 $MTCO_2E$ (2000) and finish at over 525,000 $MTCO_2E$ (2012). The increase is overwhelmingly due to campus' growing energy needs. Despite higher GHG emission levels, the rate of increase slows from 21.4 percent (1990-99) to 18.2 percent (2000-09), largely due to environmental stewardship.

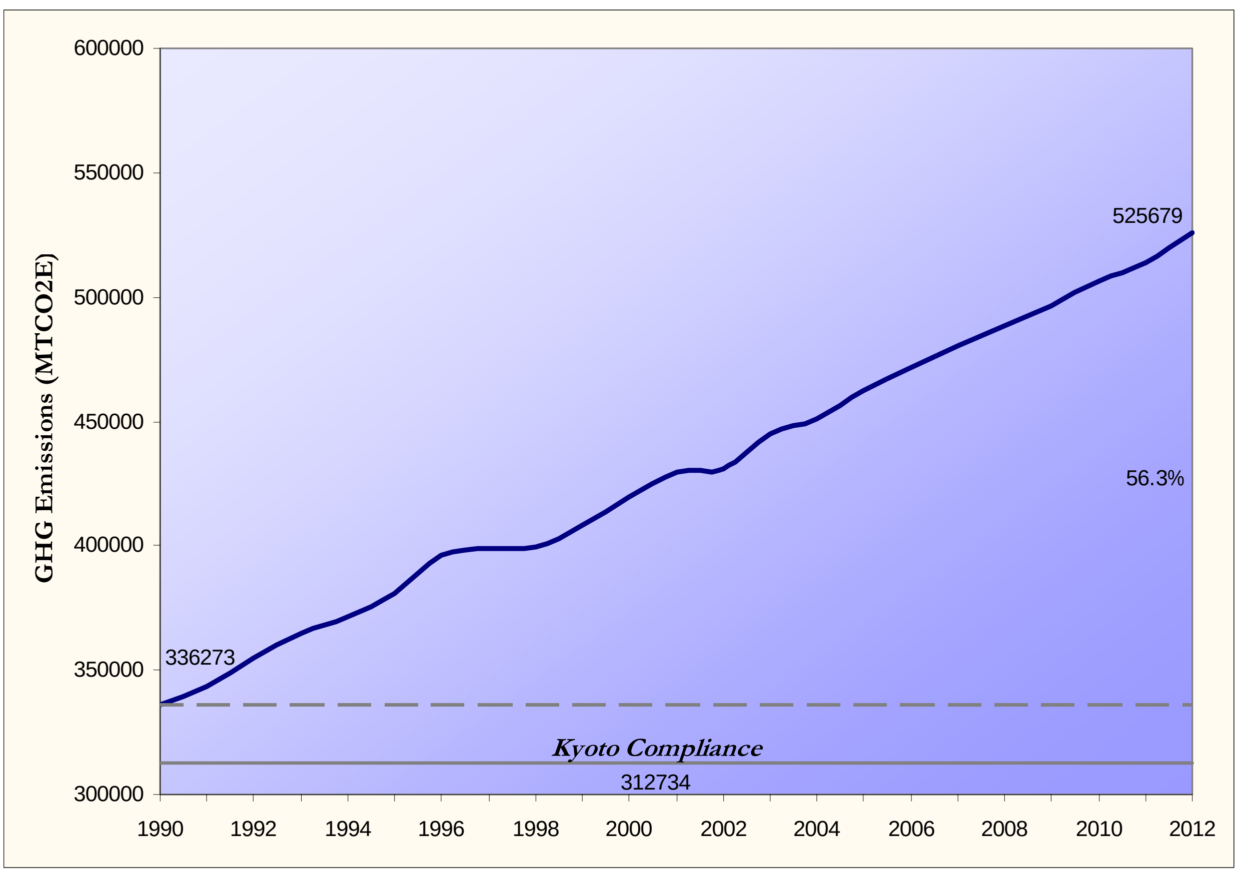

Figure 4: University Park's observed (1990-99) and projected (2000-12) GHG emissions

MITIGATION PLANNING METHODOLOGY

After the completion of the inventory, we continued to work with University stakeholders to develop mitigation strategies for University Park. Mitigation discussions occurred in several phases, including two rounds of focus group meetings. University stakeholders who had been part of the inventory process were invited to participate in the mitigation planning meetings. From this initial list, the group expanded and eventually incorporated many other individuals who offered invaluable insight into the problems associated with reducing University Park's GHG emissions. For a profile of participants, see Figure 5.

To conduct the investigation at University Park, we relied extensively on the input of local stakeholders from the University to incorporate the specific economic, environmental, and social characteristics of the campus into a compendium of mitigation recommendations. The assumption used here is that collaboration with stakeholders will result in a more feasible and realistic agenda for invoking change than if external agents imposed mandates on the University. Working with the people who know the intricacies of the steam plants or transportation patterns of campus, for example, will foster the development of mitigation strategies best tailored to University Park.

The focus groups were with open-ended questions. The first round of focus groups was designed to get people thinking about the issue. Participants were given long lists of possible mitigation activities and were asked to go through this list and discuss which alternatives might be feasible in the University Park setting. The goal was to find mitigation options that offered substantial reductions without substantial costs of implementation. Options not only had to be financially reasonable for the University, but they could not disrupt the overall operation of the University. This session got participants thinking about the problems of greenhouse gas emissions at University Park and forced them to analyze what sort of actions the University needs to take to reduce these emissions. The researcher's role in this meeting was to facilitate discussion and keep the group on task; we did not interject our own suggestions for mitigation options. The purpose of the meetings was to find out what the University stakeholders saw as the most attractive options and to harbor an open discussion environment in which participants led the conversations.

The second round of focus groups, held six weeks after the first meetings allowed us to reconnect with the stakeholder groups and present some more information on the mitigation alternatives discusses at the first meetings. Before the second round of focus groups in November, we investigated the potential of the mitigation options identified in the first round. This background work provided additional information on mitigation options that was presented to participants at the second meeting. Instead of discussing mitigation alternatives from the long list as they had the first time, this time we gave participants several handouts she created based on their opinions and concerns at the first round. The groups used these materials as a basis for our discussions.

The findings of the first round of focus groups fueled the discussions of the second round, which was a refined iteration of the earlier round that narrowed in on specific mitigation options and suggested additional avenues of mitigation for further exploration. Altogether, the focus groups demonstrated a clear and necessary reliance on the knowledge of participants to inform a mitigation action plan.

After the focus groups, the audio recordings of the meetings were transcribed. We were able to refer back to these transcripts as she investigated concerns raised by stakeholders. We also utilized notes taken during the meetings.

Although the focus group sessions provided a comprehensive picture of the current energy reduction projects and potential greenhouse gas mitigation strategies at Penn State, the primary researcher still wanted to familiarize herself more thoroughly with individual campus projects in order to improve her understanding of available mitigation options. To do so, she met with more than half of the focus group stakeholders individually to talk specifically about their involvement in projects underway on campus. She also toured some of the facilities (including the recycling facilities, both steam plants, and the composting site) at University Park to comprehend processes described during the focus group sessions. These meetings and tours were an opportunity to gain a better understanding of how participants' jobs fit within the larger structure of both general operations and environmental stewardship on campus.

September 17, 2004 9-11 am
Environmental Compliance Engineer
Environmental Compliance Specialist
Manager Engineering Services
Manager Fleet Operations
Manager Utility Services
Superintendent of Steam Services
Utility Systems Engineer

September 17, 2004 1-3 pm
Commissioning Engineer
Energy Program Engineer
Facilities Administrative Officer
Supervisor of Central Support Services
Supervisor of Grounds Maintenance

November 8, 2004 9-11 am
Director of Environmental Health and Safety
Energy Program Engineer
Environmental Compliance Engineer
Facilities Administrative Officer
Manager Engineering Services
Manager Fleet Operations
Superintendent of Steam Services
Supervisor of Grounds Maintenance
Wastewater Services Supervisor

November 8, 2004 1-3 pm
Commissioning Engineer
Environmental Compliance Specialist
Manager Utility Services
Manager of Forest Resources
Superintendent of Golf Courses
Supervisor of Central Support Services
Utility Systems Engineer

Figure 5: Focus Group Participant Profile by Job Title

MITIGATION PLANNING RESULTS AND DISCUSSION

The overwhelming result of the first round of focus group meetings is that Penn State is already doing a lot to reduce GHG emissions. Participants spent much of the time during the first round of meetings talking about current or past projects – both triumphs and disappointments. In terms of energy-related emissions, the University actively pursues efficiency upgrades because more efficient equipment saves money on energy costs. Whether it is replacing incandescent light bulbs with compact fluorescent ones, or recommissioning a building's heating and ventilation system, the university is already taking action. The University participates in a Guaranteed Energy Savings Program (GESP) in which upgrades made to a building to improve efficiency are guaranteed to pay for themselves in cost avoidance. The Continuous Commissioning Program (CCP) targets energy recovery from heating, ventilation and air conditioning systems. It also improves indoor air quality.

Transportation emissions have also been targeted. In recent years, parking on the interior of campus has decreased substantially. Instead, faculty, staff, and students must park at the periphery of campus and take a free bus ride to their building (on a CATA CNG bus). Not only does this change decrease emissions from people driving all over campus, it eliminates traffic congestion as well. University stakeholders were very interested in developing additional programs to encourage university faculty, staff, and students to use public transportation, ride bicycles, or walk to work.

Despite the fact that the remaining four sectors (Land Management, Animal Management, Waste, and Synthetic Chemicals) account for a very small proportion of University Park's emissions (about 1 percent), participants spent a considerable amount of time in meetings discussing activities that reduce emissions and promote environmental stewardship. This commitment demonstrates an encouraging awareness among university stakeholders to approach these problems holistically and make improvements, even if small, where possible.

Participants were eager to talk about the success of the recycling program. They looked to this program as a model of implementing an environmentally responsible practice with tangible, substantial results. The success of this program is an example of the potential of Penn State to invoke substantial improvements to the quality of the local environment while educating members of the community and university. Participants were particularly interested in the behavioral changes credited to the recycling program. Through education and outreach activities, the recycling program has successfully altered people's habits. One of the main tenets of this success has been the attention to convenience. Recycling receptacles are located with or very near regular trash cans to encourage students to recycle without inconveniencing them. This general theme is applicable to all attempts at behavioral changes – change is gradual and must be convenient relative to current practices.

After hearing during the first round of focus groups about all the innovative projects under way at Penn State, we were forced to rethink our strategy for mitigation planning. This unforeseen twist caused us to look beyond technological fixes to the problem to the more daunting behavioral influences. While participants were able to talk at great length about improvements in energy efficiency, the GHG emissions inventory for University Park shows a growing campus with growing emissions. Despite all the hard work the university was already doing, it just was not enough. Emissions were not even stabilized, much less decreasing. The University was already taking command of the technical aspects of the problem, but had done little to promote these activities or encourage conservation practices among students, faculty, and staff.

Behavioral changes present a much murkier set of problems than do technological changes. The university can replace every incandescent light bulb on campus with a highly efficient compact fluorescent one, but how do we make people *turn them off* when they leave a room? Not only are these problems harder to solve, it is also harder to quantify emissions reductions attributable to education and outreach activities targeting the issue. Below are the set of suggestions we offered to the University in light of their current state of energy efficiency activities and other projects on campus targeting environmental stewardship.

Tracking and crediting emissions reductions – If the University continues to monitor emissions as completed in this inventory, they can collect data from all sectors, determine areas of reduced emissions, and target areas needing increased mitigation activities. This continued monitoring provides several benefits to the University. A comprehensive inventory forces emissions-producing entities on campus to keep detailed records and hold sectors accountable for their emissions. In turn, this activity also facilitates the crediting of emissions reductions to the proper sources. Data completeness varied considerably across different campus offices when the inventory was conducted. Improved data maintenance in all areas of campus will ease the upkeep of the GHG emissions inventory and could save the University time and money in operational costs.

Collaboration with academic departments – One example of a successful collaboration between academic departments and operational facilities is evident in the Green Destiny Council's project to reduce the overall ecological footprint of Mueller Building. Members of the biology department (housed in Mueller Building) worked together to improve the building's environmental quality and impact (GDC, 2001). Many other departments across campus could replicate this project –

particularly those with an environmental focus (i.e., Environmental Engineering, Geography, Geology, and Environmental Pollution Control). A University such as Penn State houses a great wealth of gifted research scientists study a whole host of environmental issues. Facilities management and academic research collaboration could develop into innovative solutions to reducing GHG emissions on campus and facilitate environmentally responsible practices within academic units.

Increased interaction among campus initiatives - Although the University has many initiatives running concurrently across campus, there appears to be little interaction among these activities. By establishing an integrated approach, people working on separate projects at University Park could have a broader knowledge base to tap and could prevent duplication of ideas, thus making individual projects stronger and more influential. It is important for all stakeholders to be "on the same page" when it comes to mitigation actions across campus. This integration would benefit from a centralized repository to collect and disseminate information campus wide. Whether integration is accomplished via a website, newsletter, email list, or other means, the information must reach individuals involved in relevant initiatives across the University Park community.

Advertising current initiatives – With so many projects and programs on campus to improve local environmental quality, the University should be proud of its accomplishments and eager to spread the good news on and off campus. Surprisingly, little of the University's work on environmental stewardship is known outside the circles in which it happens. The student population is largely unaware of the University's efforts to curb environmental degradation, leading to potential misconceptions by students that the University is not conserving resources or promoting sustainability. Penn State needs to take public pride in the accomplishments of past and current programs, as well as to encourage the wider University Park community to take part in future initiatives.

Student outreach – In conjunction with increased publicizing of current programs, Penn State should involve both individual students and student groups in projects to create a more sustainable Penn State. Involving students in the process encourages environmental stewardship that will outlast their tenure on campus, will put projects in the public eye more effectively, and will illustrate to the University Park community that Penn State is committed to creating a more environmentally responsible campus.

CONCLUSIONS: MOVING FORWARD

Penn State University continues to work toward innovative solutions to reducing GHG emissions. As part of this ongoing effort, the University still maintains this inventory annually to track the growth of emissions in all sectors. In light of this project, the University has taken a heightened interest in encouraging behavioral changes among its faculty, staff, and students. The completion of the emissions inventory allowed university officials to understand where University Park's emissions are coming from so that they more accurately target reduction strategies. Incomplete data was a problem in some areas, and necessitated the use of averages for some activity data values. This incompleteness highlights the importance of having a multiple year inventory as opposed to conducting an inventory for one baseline year. University Park's emissions rose 21.4 percent – attributable to the construction of many new buildings on campus and a 44 percent increase in purchased electricity as electronic devices in residence halls and offices became more commonplace. If the University wishes to reduce emissions substantially, the energy sector must be the primary focus – with about 90 percent of total GHG emissions attributable to this sector.

This study also evaluated the suitability of various mitigation strategies for the University Park campus of Penn State in a stakeholder-driven process. Through two rounds of focus groups, university stakeholders (including engineers, project managers, supervisors, and directors of university operations) discussed the feasibility of potential mitigation strategies and how their future implementation would work within the routine activity and budget constraints of the University. Stakeholders also utilized this time to bring to light some of the environmentally responsible practices already ongoing at Penn State, which facilitated discussions on why, despite these steps to reduce consumption and improve efficiency, the University's emissions continue to rise. The University has already implemented many projects to make campus buildings energy efficient. From a large-scale Guaranteed Energy Savings Program to a

Continuous Commissioning Program, University Park stakeholders are already working hard to run at peak efficiency - not just for the environmental benefits, but also for the economic savings. This begs the question: ***What else can they do?***

In the focus groups and during individual interviews, several problems with the University's current projects became clear. The first is that few among the general campus population know anything about them. Although the University is taking major strides to become more environmentally responsible, students, faculty, and staff outside OPP are largely unaware of these efforts. Another problem is that because the University is such a large institution, with many academic units; effort and knowledge are duplicated unnecessarily and unknowingly. Lastly, although the University has made many technical changes needed to reduce greenhouse gas emissions, it has done little to change the way the University population uses its resources. Invoking behavioral changes among the transient university population is difficult, but the continued escalation of emissions despite technical improvements suggests that behavioral change is a necessary component of emissions reductions. As the University moves forward with efforts to reduce GHG emissions, they look to incorporating behavioral changes within the campus community to help them achieve their goals.

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* If you would like detailed information on the equations and coefficients utilized in this inventory, please contact Brandi Nagle at brandinagle@psu.edu.