The University of Connecticut Climate Action Plan:

Guiding the Path toward Carbon Neutrality

Storrs Campus
August 2009

Section 2:
Greenhouse Gas Inventory

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Executive Summary

This inventory represents the University's first comprehensive attempt to document our greenhouse gas emissions in relation to campus sustainability efforts. While it is not without limitations, it is a reliable tool to guide future action. Emission values noted throughout this document are meant to provide a baseline for comparison between emission sources, but are assumed to be estimates. The following pages provide a detailed estimate of the University's 2007 greenhouse gas emissions, as compiled by student interns in the UConn Office of Environmental Policy using Version 6.1 of the Clean Air Cool Planet (CACP) Campus Carbon Calculator.

The UConn greenhouse gas inventory is conducted according to the calendar year, and addresses activities at the main campus in Storrs, Connecticut (including the nearby Depot Campus and several parcels in Mansfield, Connecticut). All scope 1 and 2 emissions are well-documented and form the basis for the University's carbon neutrality commitment. Scope 3 emissions are included to the extent that data was available.

2007 Inventory Results

The University scope 1 and 2 emissions during the 2007 calendar year totaled approximately 179,000 $MTeCO_2$. The vast bulk of the University's emissions come from energy-related activities, specifically the on-campus generation and use of electricity and steam production (*i.e.,* operation of the university cogeneration facility) and the use of purchased electricity. Additional scope 1 emissions sources documented include on-campus stationary sources (*e.g.,* boilers, chillers and generators), the campus fleet, refrigerants, animal husbandry, and fertilizer applications. Scope 3 emission sources (*e.g.,* solid waste disposal, wastewater treatment, commuter emissions, off-campus travel) are also discussed, but analysis was limited by data availability and emissions values are, therefore, likely underestimated. Figures 2.1 and 2.2 provide an overview of the 2007 inventory. Detailed values are provided in Table 2.1.

Future Inventories

As the inventory process becomes more institutionalized, the quality and accuracy of the campus greenhouse gas inventory are likely to improve. However, as emissions sources are better 'captured' through data collection and analysis improvements, an apparent increase in campus emissions is likely to be observed, even in the absence of true increases in emissions. Caution should therefore be exerted when comparing data and inventories.

Goals for future campus greenhouse gas inventorying efforts include increasing awareness and understanding of the process, maximizing efficiency and continuity of the data collection, and improving the inventory to identify data gaps, provide greater reporting flexibility, and better capture overall campus emissions and credits (*i.e.,* carbon sequestration opportunities). In order to achieve these improvements, it is recommended that the University form a campus greenhouse gas inventory meta-data workgroup and continue to allocate funding for a student intern dedicated to compiling the inventory. The workgroup and intern will be responsible for working with relevant departments to establish an understanding of data requirements and develop associated annual reporting protocols. Finally, it is recommended that the University establish a web-based automated data reporting process and seek periodic third party verification.

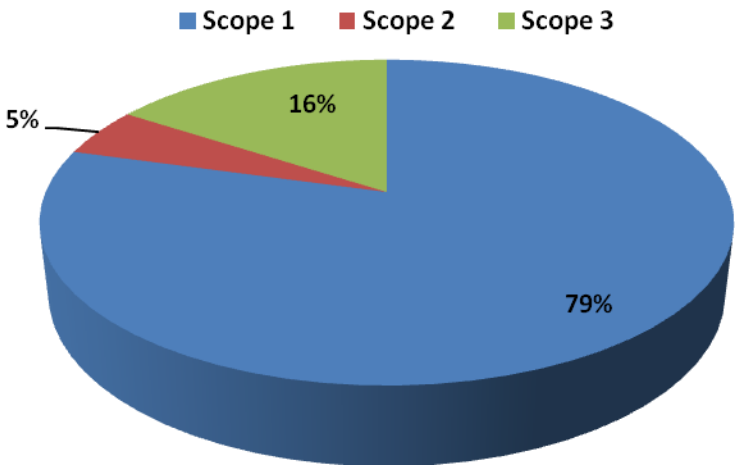


Figure 2.1. 2007 Greenhouse gas emissions by scope.

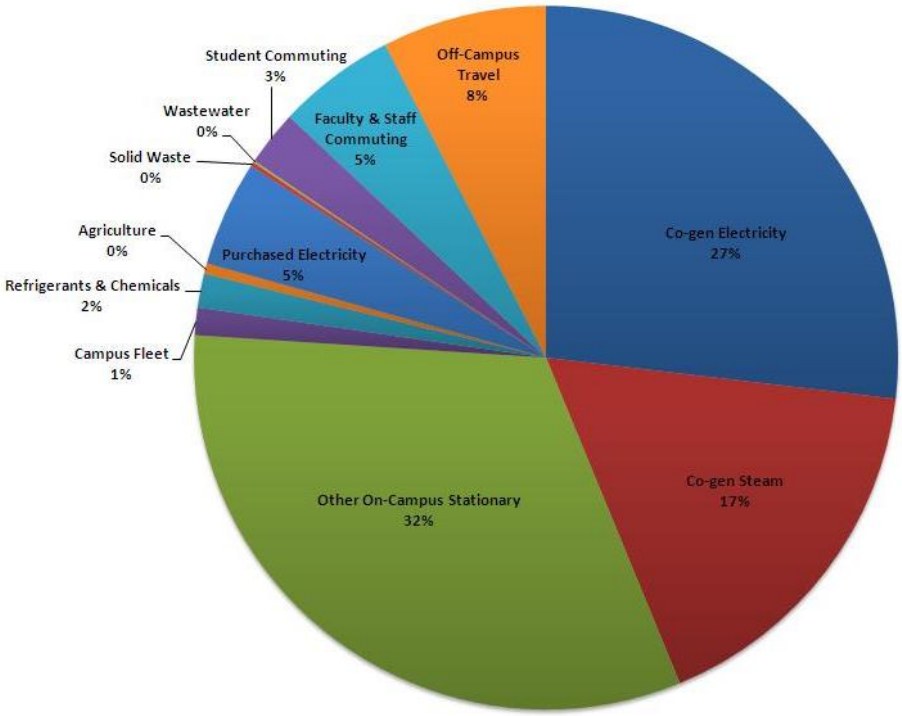


Figure 2.2. 2007 Greenhouse gas inventory by source of emissions.

Table 2.1. 2007 UConn Storrs Greenhouse Gas Inventory							
Emission Source:		Energy Consumption (MMBtu)	CO_2 (kg)	CH_4 (kg)	N_2O (kg)	eCO_2 (Metric Tons)	%Total Emissions (eCO_2)[1]
Scope 1	Co-gen Electricity	1,077,043.2	56,947,522.6	5,715.6	117.1	57,113.6	27.4
	Co-gen Steam	678,671.5	35,884,038.3	3,601.6	73.8	35,988.7	17.2
	Other On-Campus Stationary	1,232,864.5	68,291,157.1	7,379.2	217.6	68,525.3	32.9
	Campus Fleet	37,010.5	2,619,527.6	347.4	127.4	2,665.2	1.3
	Refrigerants & Chemicals	0.0	0.0	0.0	0.0	3,317.3	1.6
	Agriculture	0.0	0.0	37,944.5	528.1	1,029.0	0.5
Scope 2	Purchased Electricity	174,933.5	10,272,158.1	196.7	135.6	10,316.8	4.9
	Scope 2 T&D Losses	17,301.1	1,015,927.7	19.4	13.4	1,020.3	--
Scope 3	Solid Waste	0.0	-271,040.0	30,115.6	0.0	421.6	0.2
	Wastewater	0.0	0.0	0.0	614.4	181.9	0.1
	Student Commuting	160,852.4	11,279,052.7	2,256.1	776.6	5,408.4	2.6
	Faculty & Staff Commuting	75,249.7	5,276,549.9	1,055.5	363.3	11,560.8	5.5
	Off-Campus Travel	81,588.6	16,014,591.4	157.8	181.2	16,071.9	7.7
Totals	Scope 1	3,025,589.7	163,742,245.6	54,988.3	1,064.0	168,639.2	80.8
	Scope 2	192,234.6	11,288,085.8	216.1	149.0	10,316.8	4.9
	Scope 3	317,690.7	32,299,154.0	33,585.0	1,935.5	33,644.6	16.1
	Scope 1+2	3,217,824.3	175,030,331.4	55,204.4	1,213.0	178,956.0	85.7
	Scope 1+2+3	3,535,515.0	207,329,485.4	88,789.4	3,148.5	212,600.6	100.0

Table 2.2. 2007 Summary Data Normalized by Demographic Data		
Operating Budget	g e CO_2 / $	276.8
Research Budget	kg e CO_2 / $	3.8
Energy Budget	kg e CO_2 / $	7.2
Students	MT e CO_2 / Person	10.9
Community Members	MT e CO_2 / Person	9.1
Building Space	kg e CO_2 / ft2	19.9
Research Building Space	kg e CO_2 / ft2	294.8
Heating Degree Days	MT e CO_2 / HDD	37.0
Cooling Degree Days	MT e CO_2 / CDD	316.8

[1] Values do not total to 100 due to rounding.

Inventory Boundaries

Temporal Boundaries

The UConn Storrs greenhouse gas inventory is conducted on an annual basis. Reporting for fiscal information (*e.g.,* operating and energy budget) is reported on the financial year (July 1- June 30), while reporting for activities related to GHG emissions is on the calendar year.

The 2007 campus inventory is the first inventory to be completed extensively according to the ACUPCC recommendations. Data for previous years has been collected and recorded wherever possible. In particular, a strong effort has been made to establish an estimate of 1990 greenhouse gas levels. However, caution should be exerted when comparing inventories conducted prior to 2007 as the availability of data varied widely. Historical data and any associated limitations are included, as available, throughout this plan.

Organizational Boundaries

The University of Connecticut Greenhouse Gas (GHG) inventory has been executed under the premise of operational and financial control: the University is responsible for those activities over which it has operational control (*i.e.,* university operations), as well as those activities over which it exercises financial control (*e.g.,* purchased travel, purchased electricity, purchased fuel, etc.).

The physical boundaries include the University's holdings in the town of Mansfield, furthermore designated as 'the campus' at Storrs (Figure 2.3). In addition, the inventory includes emissions associated with the following properties located in Mansfield, CT: the Mansfield Depot Campus, the UConn Plant Science Research Farm, all rental properties owned by the University, and all areas designated as "UConn Forest," including forest and farm properties in adjacent towns.

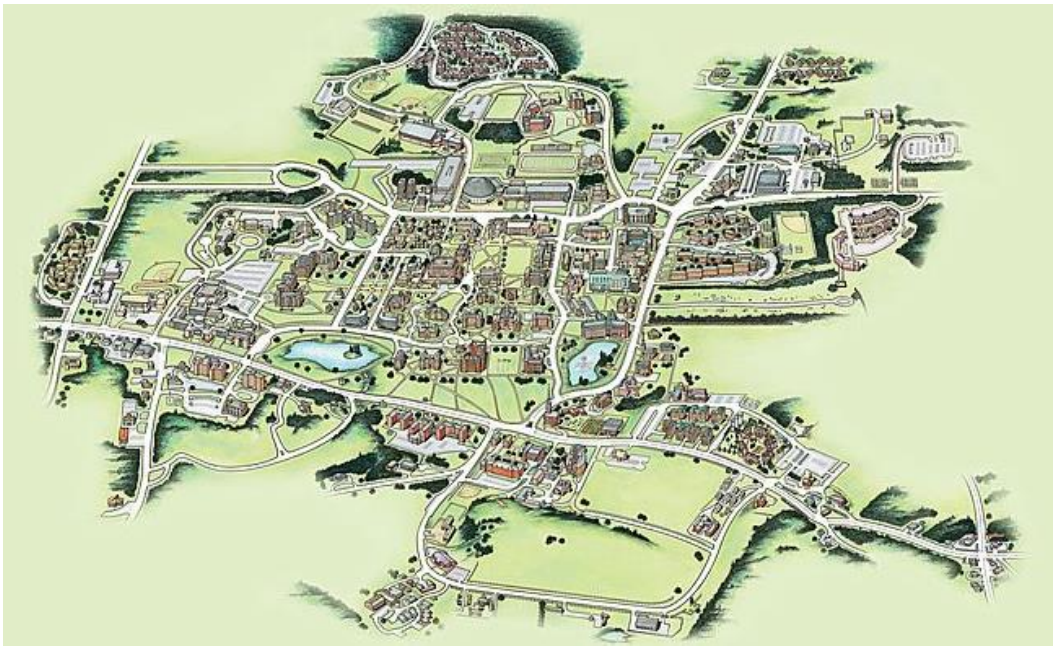


Figure 2.3. The UConn Storrs campus. Not shown: the Mansfield Depot Campus, the UConn Plant Science Research Farm, and off-campus UConn forest and agricultural parcels.

The ACUPCC was signed by President Hogan in March 2008, specifically on behalf of the UConn Storrs (*e.g.* main) campus. Therefore, the inventory does not include the University's regional campuses located elsewhere throughout the state (*e.g.,* Avery Point, Greater Hartford, Stamford, Torrington, and Waterbury campuses, the UConn Health Center, or the UConn Law School).

Operational Boundaries

The University's baseline for planning carbon neutrality includes all 2007 scope 1 and 2 emissions. The University is committed to tracking and reporting scope 1, 2, and 3 data, where realistically feasible (*i.e.,* to the extent that data is available).

Scope 1 emissions are *direct emissions* from sources that are owned or controlled by the University. Scope 1 emissions, therefore, include those emissions resulting from the following sources:

- Energy (*i.e.,* thermal and electric) generated on campus
- Operation of the university vehicle fleet (*e.g.,* combustion of fossil fuels)
- Fugitive emissions associated with the use and storage of refrigerants and chemicals
- Fertilizer applications (*e.g.,* nitrous oxide)
- Campus agricultural herds (*e.g.*, methane)

Scope 2 emissions are *indirect emissions* from sources that are neither university-owned nor operated, but *whose products are directly linked to on-campus energy consumption*. Since UConn does not purchase steam or chilled water from off-campus sources, the University's scope 2 emissions are limited to those emissions resultant from electricity purchased from an outside supplier. Although produced off-site, the university exerts a certain degree of control over these emissions through the selection and purchase (and therefore financing) of power suppliers who offer an electrical mix with greater proportions of renewable energy (*e.g.,* hydroelectric, wind, or nuclear).

Scope 3 emissions are *all other indirect emissions* that are attributed to the University that are neither University owned nor operated but are either directly financed or otherwise linked to the University. In most cases, the University has more limited control over these emissions (as compared to scope 1 and 2 emissions). The University of Connecticut accounts for the scope 3 emissions associated with the following activities:

- Solid waste disposal
- Wastewater treatment
- Regular student, faculty and staff commuting (*i.e.,* daily commuting to and from campus).
- Study abroad travel
- University reimbursed travel (*i.e.,* directly financed outsourced travel) including athletics

Data associated with certain scope 3 emission sources is not readily available. Notably, the present University reimbursement data system provides 'lump sum' reimbursements, preventing the compilers of the University's inventory from being able to distinguish between directly financed off-campus travel (*e.g.,* rental cars, train tickets, air fare) and other travel expenses (*e.g.,* hotel reservations, food purchases, conference fees). Similarly, detailed commuter data could not be obtained. Crude estimates of annual commuter miles were developed using campus population data.

Due to the complexity and limitations of data associated with scope 3 emissions the University does not include these emissions when establishing its baseline for neutrality. Nevertheless, the University will continue to seek to identify opportunities to minimize scope 3 emissions where feasible. Emphasis will

also be placed on working with the existing university departments and associated data reporting structures to facilitate and improve future inventory data collection efforts.

The University does not presently purchase greenhouse gas offsets and does not intend to do so in the near the future. Those activities which result in carbon sequestration (*e.g.,* forestry and composting) are, however, included in the inventory.

Table 2.3. Inventory Data Sources

	Data Requested	Reporting Agency
Institutional Data	Operating & Research Budgets	Office of Institutional Research
	Energy Budget	Energy Utility Services Manager (Facilities Operations)
	Population Data (e.g., employees, students)	Office of Institutional Research
	Campus Infrastructure (e.g., building space, research space)	University Master Planner (Architectural & Engineering Services)
Scope 1 Emissions	Cogeneration Facility (e.g., fuel use, electric & steam output, and efficiency)	Energy Utility Services Manager (Facilities Operations)
	On Campus Stationary Sources (e.g., generators, boilers, small chillers)	Office of Environmental Policy
	Campus Fleet (e.g. gasoline & diesel fuel use)	Motor Pool
	Biodiesel Fuel Use	UConn Biofuels Consortium
	Refrigerants & Chemicals	Office of Environmental Policy
	Fertilizer Applications	Farm Services Research & Education Facilities Manager (Plant Science Department); Athletics Department; Facilities Operations; Private Contractor
	Animal Husbandry (e.g. animal head counts)	Farm Services Manager
Scope 2 Emissions	Purchased Electricity	Energy Utility Services Manager (Facilities Operations)
Scope 3 Emissions	Commuter Data (e.g., parking pass data)	Parking Services
	Directly Outsourced Travel (e.g., travel reimbursements)	Travel Services; Private Travel Agencies
	Study Abroad Travel (e.g., destinations, participant counts)	Office of Study Abroad
	Solid Waste (e.g., incinerated & landfilled waste tonnages)	Private Trash Hauler (Willimantic Waste)
	Waste Water Volume	Wastewater Treatment Facility Manager (Facilities Operations); Office of Environmental Policy
Offsets	Composting Volumes	Farm Services; Office of Environmental Policy
	Forest Management	Forest Manager (Cooperative Extension System)

Institutional Data

Institutional data (*e.g.*, institutional budget, population and physical size) are collected annually in association with the campus greenhouse gas (GHG) inventory. These data are not used directly to calculate emissions, but, rather, are used to develop rough metrics of efficiency and energy use per capita and per square foot, allowing for comparison of GHG emissions statistics across institutions. Caution should be exerted when making comparisons, however because energy use is highly dependent upon building application (*e.g.,* scientific research *versus* storage space).

Table 2.4 summarizes the University's institutional data. Although 2007 is used for the baseline inventory, data for previous years is provided to illustrate data trends. In general, budget figures (*e.g.,* operating, research, and energy) are reported for a fiscal year (i.e., July 1-June 31). Population data is reported according to the academic year, with counts generally conducted within the first weeks of the fall semester (i.e., September).

Table 2.4. Institutional Data[2]

	Budget (in millions of $U.S.)[3]			Population					Physical Size (Building space, million ft^2)	
Year:	Operating	Research	Energy	Full-Time Students	Part-Time Students	Summer Students	Faculty	Staff	Total	Research
1990	406.6	45.0	12.5	14,550	3,317	8,319	1,253	4,379	5.7	1.6
2000	414.7	103.7	14.0	16,638	2,298	3,640	876	2,550	7.0	1.9
2005	736.7	64.4	23.4	17,496	2,198	8,291	985	2,733	9.2	2.5
2006	752.9	54.2	30.0	18,109	2,321	8,270	1,091	2,732	9.4	2.5
2007	766.8	56.3	29.3	18,531	1,855	6,699	1,113	2,771	10.7	0.7

Faculty and staff population counts generally include both full-time and part-time (at least 50%) employees. Special payroll employees (individuals paid for an occasional temporary service – days or weeks of service) are typically excluded.

Student population counts generally include full-time, part-time, degree-seeking, and non-degree-seeking students taking credit courses. The counts generally do not include non-credit registrations. The figures shown in Table 2.4 are actual matriculation numbers. Fall 2007 student enrollment expressed in full time enrollment (FTE), was:

- Undergraduate degree and non-degree seeking students = 15,892
- Graduate degree and non-degree seeking students = 2,414
- Pharmacy and professional students = 296
- Total Fall 2007 Storrs Campus student population = 18,602

FTE is calculated using the total registered credits divided by 15 for undergraduate students and by 12 for graduate and professional students.

According to the University's Architectural & Engineering Services Office, the UConn Storrs campus had 10,677,000 square feet of building space (including the Depot Campus), with 720,197 square feet, or

[2] Sources: UConn Office of Institutional Research, UConn Architectural & Engineering Services.
[3] Budgets are normalized by 2005 $USD values.

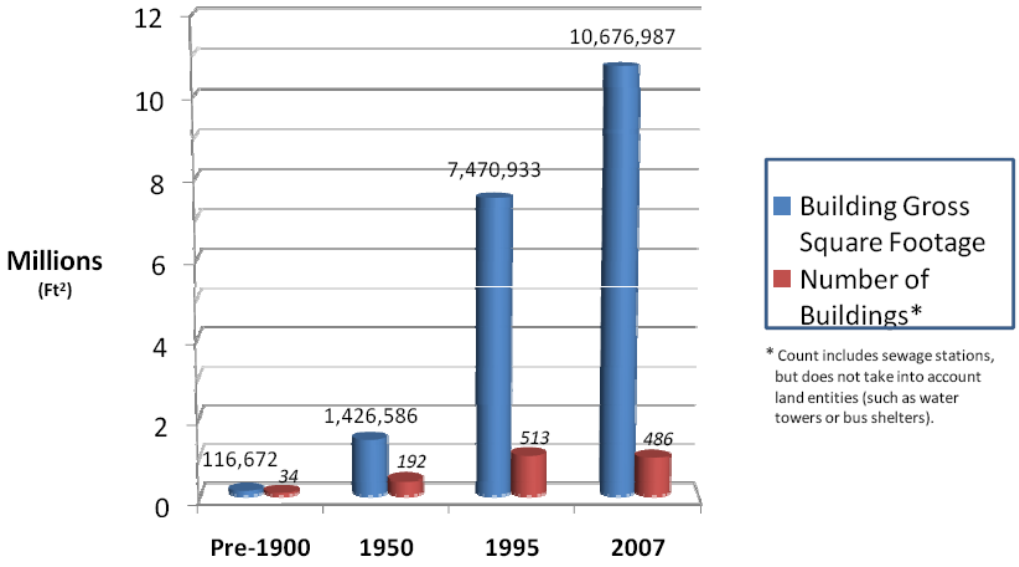
6.7%, used for active research (excluding teaching laboratories) in 2007.[4] Notably, over 3.4 million square feet, approximately 32% of all building space in 2007, was associated with student living facilities. UConn houses approximately 76% of all full-time undergraduate students in University-owned, on–campus housing, which has significant implications for the University's energy and water demand.

Projected Campus Growth

The UConn Storrs Campus has experienced tremendous growth over the past decade (Table 2.5). Since 1995, building square footage (*i.e.,* gross area) throughout the UConn system (*i.e.,* including regional campuses) has increased by 43% despite a 5% reduction in building numbers. As of 2007, the University operated 525 buildings throughout the state, totaling 12.4 million gross square footage (GSF). Of the statewide UConn GSF, the 486 buildings located on the UConn Storrs campus comprised 86% of this total GSF, or 10.6 million square feet of total building space (Figure 2.4). (There was no change in campus area during 2008.)

Table 2.5. UConn Storrs Campus: Physical Size

Year:	Total Building Space (ft^2)	Total Research Building Space (ft^2)
1990	5,719,046	1,575,864
2000	7,082,871	1,906,811
2005	9,208,655	2,465,356
2006	9,374,400	2,465,356
2007	10,676,987	720,197*



[4] Caution should be exerted when comparing research space for years prior to 2007. Prior to 2007, research space was calculated to include faculty offices, teaching space, and other passive space associated with research activities. As of 2007, the University uses AutoCAD drawings to calculate the space inventory. Only space categorized as "Research Laboratory," as defined by the Postsecondary Education Facilities Inventory and Classification Manual (FICM) codes 250 and 255, is presently considered 'research space.

Figure 2.4.[5] Campus Building Trends Pre-1900 to 2007.

Limited additional building growth is expected over the next 5-10 years in order to provide quality space to meet the needs of the university research and teaching faculty. Student enrollment rates are expected to remain stable over the next several years.

Building Growth

Short-term growth projections for the campus are based upon the UConn 21st Century and UConn 2000 plans. In 1995, the Connecticut legislature passed a groundbreaking program of reconstruction and new building at the University called *UConn 2000*. This 10-year program to rebuild, renew and enhance the statewide campuses of the University remains unprecedented among public higher education in the United States. The transformation has been so remarkable that in 2002 the Legislature voted to extend the rebuilding program with an additional investment under the title *21st Century UConn*. UConn 21st Century is scheduled to fund several new construction projects, including new academic buildings and residence halls at the Storrs campus.

Previous projections based upon UConn 21st Century plans estimated a 3% increase in overall gross building area (365,351 ft^2) by 2015 (compared to 2007 data). Due to scheduled demolitions, building *numbers*, however, are expected to decline by 3% during this same time frame. This growth is primarily associated with anticipated increases in student support services, university operations, and academic building spaces (Table 2.6). Recent changes in the state budget, however, are expected to postpone several projects, resulting in lower annual growth rates than initially predicted (*i.e.,* 1-2%) and causing growth to occur over a slightly longer period of time (*i.e.,* 2009-2020).

Student Enrollment

The University does not anticipate changes in enrollment between 2009 and 2025. Enrollment projections are tied to birth rates, which have decreased in Connecticut over the past several years. This decrease in birth rates is expected to lead to lowering or stabilization of college and university enrollments throughout New England, for the foreseeable future.[6] Conversely, recent declines in the state and national economy have the potential to increase enrollment rates, as students who otherwise would have attended out-of-state colleges and universities will instead remain in-state. However, the economic downturn has limited the university's ability to provide the space and faculty to accommodate a growing student population. Therefore, the University is not in a position to increase enrollment rates to accommodate these students.

[5] Source: February 14, 2008 UConn Architectural & Engineering Services (A&ES) presentation to the UConn Capital Project Planning Advisory Committee (CPPAC).
[6] This does not account for changes in immigration or international student populations.

Table 2.6. Projected Storrs Campus Growth[7]										
	Number of Buildings	Gross Building Area (ft2)	Academics	Academic Support	Student Living	Student Support Services	University Operations	Financial Operations	Athletics	(Other)
Pre-1995	513	7,470,933	2,505,796	630,783	2,451,475	233,057	956,568	26,478	456,582	210,195
2007 (Existing)	486	10,676,987	3,394,150	705,168	3,401,553	446,613	1,887,258	26,478	668,877	146,891
Difference (<'95-'07)	-27	3,206,054	888,354	74,385	950,079	213,556	930,690	0	212,294	-63,304
Percent	-5%	43%	35%	12%	39%	92%	97%	0%	46%	-30%
2015 (Projected)[8]	472	11,042,338	3,496,816	693,543	3,401,553	674,681	2,070,534	26,478	668,877	9,857
Difference ('07-'15)	-14	365,351	102,666	-11,625	0	228,068	183,276	0	0	-137,034
Percent	-3%	3%	3%	-2%	0%	51%	10%	0%	0%	-93%
Pre-1995	513	7,470,933	2,505,796	630,783	2,451,475	233,057	956,568	26,478	456,582	210,195
2015 (Projected)	472	11,042,338	3,496,816	693,543	3,401,553	674,681	2,070,534	26,478	668,877	9,857
Difference (<'95-'15)	-41	3,571,405	991,020	62,760	950,079	441,624	1,113,966	0	212,294	-200,338
Percent	-8%	48%	40%	10%	39%	189%	116%	0%	46%	-95%

[7] Source: February 14, 2008 UConn Architectural & Engineering Services (A&ES) presentation to the UConn Capital Project Planning Advisory Committee (CPPAC).
[8] Projected growth does not include facilities identified by the School of Fine Arts Master Plan, athletic facilities funded through department budget, and the proposed Student Services recreation center.

Scope 1 Emissions

Scope 1 emissions are *direct emissions* from sources that are owned and/or controlled by the University. Scope 1 emissions, therefore, include those emissions resulting from the following sources:

- Energy (*i.e.,* thermal and electric) generated on campus
- Operation of the university vehicle fleet (*e.g.,* combustion of fossil fuels)
- Fugitive emissions associated with the use and storage of refrigerants and chemicals
- Fertilizer applications (*e.g.,* nitrous oxide)
- Campus agricultural herds (*e.g.*, methane)

Table 2.7 provides an overview of the University's scope 1 emissions and the corresponding source. The sections to follow provide more detailed information about each emission source.

Table 2.7. Scope 1 Emissions Summary

Emission Source	$MTeCO_2$	%Scope 1	% Total[9]
Cogeneration Facility (Electric & Steam)	93,102.3	55.2	44.6
Other On-Campus Stationary	68,525.3	40.6	32.9
Campus Fleet	2,665.2	1.6	1.3
Refrigerants & Chemicals	3,317.3	2.0	1.6
Agricultural Sources (Fertilizers & Animal Husbandry)	1,029.0	0.6	0.5
Total Scope 1 Emissions:	**168,639.4**	**-**	**80.8**

Cogeneration Facility

The University of Connecticut's state-of-the-art Cogeneration Facility began operation on March 15, 2006. The facility has an electrical production capacity of 24.9 Megawatts, a steam production capacity of 600 KP per hour, and a chilled water production capacity of 10,300 tons. Electrical demand averages ~18 MW per day. (The University's energy dashboard provides real-time data online at http://www.fo.UConn.edu/cogen.html.) **Total 2007 cogeneration facility GHG emissions were estimated to be 93,102 $MTeCO_2$, approximately 45% of the University's overall emissions.** Direct reductions in cogeneration facility GHG emissions will be realized through increases in facility operational efficiency. Additional indirect reductions will be realized in response to decreases in campus energy demand associated due to changes in individual behavior, building design improvements, and building and utility system renovations. (*Refer to Section 3 of this report for more details*.)

As shown in Table 2.8, the primary fuel for the cogeneration facility is natural gas, recognized as one of the cleanest burning fossil fuels available. (The facility does not use residual oil (#5-6), liquid propane gas, coal, incinerated waste, wood chips, wood pellets, grass pellets, or biomass.) For the purposes of the University's inventory, the cogeneration facility is defined as the newest installation of equipment in the Central Utility Plant (CUP), and is limited to the combustion turbines 1-3, steam turbine and

[9] Total emissions include scope 1, 2, and 3 emissions.

associated duct burners. Fuel use in MMBtu of natural gas and #2 diesel is associated with the duct burners and turbines only. (All other CUP equipment is classified as 'other on-campus stationary' sources.)

Through the cogeneration process, the facility both produces electric energy and recovers useful thermal energy (e.g. steam). This steam is used for both heating and cooling throughout the campus and to generate additional electricity (steam generator). Since this process also reduces congestion and electrical distribution loss on the transmission grid, it is twice as energy efficient as purchasing power. In fact, **a study conducted in 2006 illustrated that UConn's cogeneration facility avoids an estimated 30,000 tons of carbon dioxide emissions annually as compared with other fossil fuel powered suppliers on the regional grid.**

Table 2.8. On-Campus Cogeneration Plant Emissions Summary

	Inputs		Output		Efficiency	
	Distillate Oil (#1-4)	Natural Gas	Electric	Steam	Electric	Steam
Year	(Gallons)	(MMBtu)	(kWh)	(MMBtu)	(%)	(%)
2006	43,272	1,329,000	94,858,906	265,657	27.00%	27.00%
2007	76,672	1,745,134	112,391,903	241,651	27.00%	27.00%

Beyond its positive environmental attributes, cogeneration also offers economic benefits. The University anticipates saving nearly $180 million in avoided energy costs over the forty-year design life of the plant. Furthermore, Connecticut's renewable portfolio standards (RPS) law (State of Connecticut Public Act No. 07-242) creates a powerful incentive for development and commercialization of renewable energy sources and includes cogeneration as a Class III renewable resource.

Efficiency ratings are estimated on an annual basis and are derived from RPS compliance reports generated by University Facilities and Office of Environmental Policy staff. The CACP Campus Carbon calculator is unable to account for steam energy associated with the campus chiller (*i.e.,* summer cooling), resulting in an underestimate of the overall facility efficiency. An approximate 54% efficiency was used as a low-end estimate for emissions calculations based upon data from 2008. (Since the CA-CP calculator arbitrarily separates total efficiency into two categories, electric and steam, 27% efficiency was estimated for each to sum to a total efficiency of 54%.) Facility operations have been improved since this time, however, and current efficiency levels are believed to approach 70%. Further efficiency gains may also be possible through improving operation performance. It is therefore recommended that future inventory efforts seek to refine these efficiency calculations.

Other On-Campus Stationary Sources

The University's remaining on-campus stationary fuel use occurs primarily in association with campus emergency generators, individual boilers, chillers, and individual hot water heaters. Emergency generators supplied by various fuel types (e.g. propane, natural gas, oil) are located both at the central plant and throughout campus. Several large industrial boilers (natural gas and oil fired) and chillers (natural gas fired) located at the central utility plant contribute steam and chilled water to the central distribution system. In addition, various fossil fuel fired small chiller systems, heating systems, and HVAC systems, separate from the central distribution system, are located throughout campus. Table 2.9 provides a summary of 'other on-campus stationary sources' consumption by fuel type for 1990-2007.

Table 2.9. Other On-Campus Stationary Sources Fuel Use Summary			
	Fuel Inputs		
	Distillate Oil (#1-4)	Natural Gas	LPG (Propane)
Year:	(Gallons)	(MMBtu)	(Gallons)
1990	3,000,006	412,001	No data
2000	843,273	864,960	30,777
2005	690,709	935,645	16,890
2006	690,709	935,645	16,890
2007	1,198,647	1,066,838	7,115

Total 2007 GHG emissions from on-campus stationary sources (excluding the cogeneration facility as defined above) were estimated to be 68,525 MTeCO_2, approximately 33% of overall campus emissions.

On-Campus Vehicle Fleet

The University of Connecticut owns a large fleet of vehicles including, but not limited to, those vehicles owned and operated by Transportation Services (*e.g.,* buses and shuttles), Facilities Management (*i.e.,* heavy-duty trucks and other maintenance vehicles), Farm Services (*i.e.,* tractors and other large agricultural equipment), University Mail Services (*i.e.,* small motorized carts and box trucks), Dining Services (*i.e.,* box trucks), and the various academic departments (*i.e.,* cars, SUVs, and light-duty trucks). The majority of campus vehicles operate using either gasoline or diesel fuel. In addition, approximately 2-5% of the campus bus system's annual fuel requirement is supplemented with biodiesel. The University does not currently own any natural gas, ethanol or hydrogen vehicles. University vehicles travelling on or near campus refuel at one of the campus fueling stations (*i.e.,* the motor pool or the Farm Services pump); annual vehicle emissions are therefore calculated directly from fuel use recorded at these stations (Table 2.10). (Emissions associated with vehicles travelling and fueling up off-campus are considered scope 3 emissions as discussed later in this document.) **An estimated 2,665 MT eCO_2 of greenhouse gases were emitted in association with the operation of the campus fleet in 2007, approximately 1.3% of total campus emissions.**

Table 2.10. On-Campus Vehicle Fleet Fuel Inputs			
Year	Vehicle Fuel Inputs (Gallons)		
	Gasoline	Diesel	B100
2005	123,708	104,667	0
2006	151,595	135,036	723
2007	158,602	124,025	1,600

Hybrid-Electric & Electric Vehicles

The UConn Office of Environmental Policy maintains annual preferred vehicle purchasing lists, which highlight recommended choices for each vehicle class based upon EPA fuel economy estimates and

emission standards. These lists are used by University Purchasing agents to encourage university buyers to purchase the most fuel efficient vehicles possible. Hybrid-electric vehicles are typically among the top vehicles recommended. The decision (and the cost) to purchase fuel efficient vehicles, including hybrid-electric vehicles, however, ultimately remains with the university buyer. Consequently, less than 1% of the University's current 600-vehicle fleet is comprised of hybrid-electric or electric vehicles. In 2007, the State of Connecticut passed legislation mandating that beginning January 1, 2008, "any car or light duty truck purchased by the state shall have an efficiency rating that is in the top third of all vehicles in such purchased vehicle's class and fifty per cent of such cars and light duty trucks shall be an alternative fueled, hybrid electric or plug-in electric vehicle" (PA 07-242, Section 122). As a state agency, the University's fleet is included in the determination of the state fleet mix. Therefore, it is expected that the proportion of hybrid-electric and plug-in electric vehicles on campus will increase significantly over the next several years.

Campus Bus & Shuttle Systems

The University currently provides transportation between the main Storrs campus, the Depot Campus, and nearby University owned housing sites via the UConn campus bus system. University shuttles also run on request to the airport, train station and ferry. In addition, the UConn Police Department runs a free service that provides students with a safe ride home during limited evening hours throughout the week. Greenhouse gas emissions associated with each of these services (*i.e.,* vehicle fuel use) is included in the on-campus fleet emissions.

Biodiesel Production & Use

Biogenic emissions, those emissions resulting from combustion of a non-fossil fuel source such as pure biodiesel, are considered part of the "closed loop" carbon cycle. Therefore, for inventorying simplicity, the Clean Air-Cool Planet Campus Carbon Calculator (V6) assumes that B100 biodiesel has no net impact on greenhouse gas emissions. Combustion of biodiesel that is mixed with petro-diesel is assumed to emit a proportional amount of greenhouse gas emissions. For example, a B20 blend would be assumed to release 80% of the emissions associated with the use of 'regular' diesel, whereas a B5 blend would be assumed to release 95%, and so on.

In the summer of 2004, students and faculty in the University's Chemical Engineering Department produced biodiesel from the University's waste cooking oil for the first-time. Shortly thereafter, in 2005, the UConn Biofuels Consortium was established and began production of biodiesel on a consistent basis. In 2007, the Consortium produced B100 biodiesel at a rate of 50 gallons per week for the duration of the school year (approximately 32 weeks), producing approximately 1600 gallons of B100. (Pure biodiesel was then blended into the campus diesel stock, resulting in a final overall campus blend approaching B1.) Presently, the University (*i.e.,* the UConn Biofuels Consortium) has the capability to replace up to ~5% of the petro-diesel fuel consumption of university vehicles, using waste vegetable oil from dining services as the feedstock. Biodiesel is delivered regularly to the university motor pool. Plans are underway to expand the University's production capabilities to replace 100% of the campus petro-diesel fuel requirements.

Bicycling & Walking

Bicycling and walking are not directly represented in the University's greenhouse gas inventory, yet remain important modes of transportation on campus. Improved pedestrian access and safety, specifically the establishment of a pedestrian-only campus core, is central the University's Master Plan. Similarly, numerous efforts, including the development of a campus bicycle plan and a plan to develop a campus bicycle loaner program, are focused on increasing the proportion of individuals who opt to bike

around campus. Increasing bicycling and walking rates is assumed to indirectly decrease emissions associated with the campus fleet through reductions in total vehicle miles travelled.

Refrigerants & Chemicals

Refrigerants

2007 emissions due to campus refrigerants were estimated based upon purchase records (Table 2.11). (These records account for University purchases only; refrigerants purchased and used by on-campus vendors for large equipment are not included in these figures.) For emissions calculations purposes, it is assumed that all refrigerants purchased in a given year are used completely. The resulting calculated emissions are therefore a conservative estimate of what was actually used to replace the amounts in air conditioners, refrigerators, freezers, etc.

Table 2.11. 2007 Refrigerant Purchases[10]

Description	Total (lbs.)
134A	390
404A (HP62)	360
409A	30
Freon 22	3120
MP39 (R401A)	120
MP66 (R401B)	120

Certain purchased refrigerants were reported as conglomerate refrigerants and required additional conversion to allow for input into the CA-CP calculator (Table 2.12). Manufacturer's MSDS sheets were used to obtain the constituent percentages.

Table 2.12. Refrigerant Conversion

Refrigerant Trade Designation (ASHRAE)	Total Weight (lbs)	Constituent	% Total	Constituent Weight (lb)
R401.A	120	HCFC-22	53	63.6
		HCFC-124	34	40.8
		HFC-152a	13	15.6
R401.B	120	HCFC-22	61	73.2
		HCFC-124	28	33.6
		HFC-152a	11	13.2
409A	30	HCFC-22	60	18.0
		HCFC-124	25	7.5
		HCFC-142b	15	4.5

Table 2.13 summarizes the 2007 refrigerant data and emissions. **Based upon the inventory, total emissions due to campus refrigerant and chemical use in 2007 were approximately 3,317.3 MTeCO_2, approximately 2% of total campus emissions.** Greenhouse gas inventories conducted for the campus prior to 2007 did not include refrigerant data.

[10] Source: UConn Office of Environmental Policy

Table 2.13. 2007 Greenhouse Gas Emissions Associated with Refrigerants					
Chemical	**Input (Pounds)**	**Global Warming Potential[11]**	**$MTeCO_2$/lb[12]**	**Emissions ($MTeCO_2$)**	**%Total Refrigerant Emissions**
HCFC-22	3,274.8	1,700	0.771	2525.22	76.12
HFC-404a	360	3,260	1.489	532.34	16.05
HFC-134a	390	1,300	0.590	229.97	6.93
HCFC-124	81.9	620	0.281	23.03	0.69
HCFC-142b	4.5	2,400	1.089	4.90	0.15
HFC-152a	28.8	140	0.064	1.83	0.06
			TOTAL = 3,317.3 $MTeCO_2$		**100%**

Green Cleaning

'Green Cleaning' is a widely accepted standard that uses procedures and products to make the health of building occupants, janitors, and the environment a primary concern. Some of the more potent cleaners contain volatile organic compounds, phenol compounds, or petroleum solvents. Few of these potent cleaners are biodegradable. In comparison, green cleaning products are characterized by environmentally 'friendlier' attributes, including biodegradability, low toxicity, low volatile organic compound (VOC) content, reduced packaging, and low life cycle energy use. Replacing more dangerous chemicals with green cleaners can therefore help improve water and indoor air quality.

Connecticut accepted the green cleaning standard on April 17, 2006, when Governor Jodi Rell issued an executive order which declares that all state facilities and workplaces shall "procure and use, whenever practicable, cleaning and/or sanitizing products having properties that minimize potential impacts to human health and the environment, consistent with maintaining clean and sanitary State facilities." A year and a half after this executive order, the Connecticut Legislature passed Public Act 07-100, which mandates that cleaning products used in State buildings must meet environmental standards set by a state-approved environmental certification program (*e.g.,* Green Seal™).

Agricultural Emissions: Fertilizer Applications & Animal Husbandry

Initially founded as the Storrs Agricultural School in 1881, the University of Connecticut continues to honor its agricultural legacy through an active Farm Services department and through the teaching and research of the College of Agriculture and Natural Resources and the Cooperative Extension System. The primary emissions associated with agricultural operations on campus include methane (*i.e.,* from domesticated animals) and nitrous oxide (*i.e.,* from fertilizer applications, animal production and waste, and certain crops). Energy and fuel use associated with crop and herd management, building operations, transporting food or feed to and from campus, and the disposal of associated wastes also contribute greenhouse gas emissions. These emissions, however, are captured within the campus vehicle fleet emissions, cogeneration facility, other stationary sources, and purchased electricity categories. The 'agricultural category,' therefore specifically addresses emissions associated with campus fertilizer applications and animal husbandry (Table 2.14).

[11] Source: USEPA 2007.
[12] MTeCO2/lb = (1lb)x(Global Warming Potential)x(kg/lb)x(MT/1000 kg).

Table 2.14. Campus Agricultural Emissions[13]										
	Fertilizer Application				Animal Husbandry					
	Synthetic		Organic		Dairy Cows	Beef Cows	Swine	Sheep	Horses	Poultry
Year	Pounds	%N	Pounds	%N	#	#	#	#	#	#
1990	ND[14]	ND	ND	ND	180	137	25	150	85	3,211
2005	16,070	23	ND	ND	177	146	6	118	84	2,608
2006	16,070	23	8,000	45	207	130	ND	130	80	2,450
2007	28,000	32	18,000	45	201	60	81	80	82	6,090

A significant amount of fertilizer is used for non-agricultural purposes (*i.e.,* athletic field maintenance and landscaping). Quantities of synthetic fertilizer in Table 2.14 are lump sums of all campus fertilizer use, regardless of application type, according to fertilizer nitrogen contents. Total synthetic fertilizer use in 2007 was 28,000 lbs (32% nitrogen), while 18,000 pounds of organic fertilizer (45% nitrogen, all urea) was applied. Actual synthetic fertilizer use in 2007 included 2,500 pounds of 15-15-15, 300 pounds of 46-0-0 (urea), and 200 pounds of 33.5-0-0 (ammonium nitrate).

The University uses soil testing both annually and seasonally to determine the fertility needs of the campus cropping area. All appropriate integrated pest management (IPM) methods are also implemented. The University also has on-going research related to low maintenance turf grass using organic (*i.e.,* compost) and non-organic fertilizer methods; these small plot research treatments are not part of the above totals.

The University has an active animal husbandry program which includes dairy and beef cows, swine, sheep, horses and poultry. Animal husbandry efforts are primarily research and education oriented, however, associated food products are produced and used on campus (*e.g.,* milk, cheese, ice cream, eggs). Animal wastes are currently stored on campus and spread throughout the year on campus agricultural fields. Plans are underway to construct a campus animal waste compost facility.

In 2007, combined campus fertilizer applications and animal husbandry efforts produced an estimated 1,029 MT eCO_2, less than one percent of the University's overall greenhouse gas emissions.

Scope 2 Emissions:

Scope 2 emissions are *indirect emissions* from sources that are neither university-owned nor operated, but *whose products are directly linked to on-campus energy consumption*. Since UConn does not purchase steam or chilled water from off-campus sources, the University's scope 2 emissions are limited to those emissions resultant from electricity purchased from an outside supplier.

Table 2.15 provides an overview of the University's scope 2 emissions and the corresponding source.

[13] Source: UConn Farm Services Department.
[14] ND =No data.

Table 2.15. Scope 2 Emissions Summary			
Emission Source	**MTeCO$_2$**	**%Scope 2**	**% Total[15]**
Purchased Electricity	10,316.8	100	4.9
Purchased Steam	0	0	0
Purchased Chilled Water	0	0	0
Total Scope 2 Emissions:	**10,316.8**	**100**	**4.9**

Purchased Electricity

The University purchases less than 5% of its electrical need due to infrastructure limitations and to supplement electrical needs during periods when the cogeneration facility is offline. In 2007, the University purchased 24,916 MWh from Connecticut Light & Power (CL&P) (Table 2.16). **According to the campus greenhouse gas inventory, an estimated 10,317 MTeCO$_2$ was released in association with the generation of this electricity, approximately 4.9% of total campus greenhouse gas emissions in 2007.**

Table 2.16. Purchased Electricity	
Year	**MWh**
1990	70,000
2000	110,621
2005	141,195
2006	70,591
2007	24,916

Emissions from purchased electricity are calculated using subregional emission factors (NPCC New England, Table 2.17) derived from the US EPA Office of Atmospheric Programs' Emissions & Generation Resource Integrated Database (eGRID; USEPA 2000). eGRID integrates available data for regional electricity generating with EPA emissions data and EIA generation data to produce average subregional emission factors. The emissions factors shown in Table 2.17 are an average from 1998-2000.

Table 2.17. NPCC New England (NEWE) Emission Factors[16]				
Carbon Dioxide (kg CO$_2$/kWh)	**Methane (kg CH$_4$/kWh)**	**Nitrous Oxide (kg N$_2$O/kWh)**	**Carbon Dioxide Equivalents (MTeCO$_2$/kWh)**	**Transmission & Distribution Loss Factor (%)**
0.412	0.00000789	0.00000544	0.000414	9.0%

[15] Total emissions include scope 1, 2, and 3 emissions.
[16] Source: US EPA Office of Atmospheric Programs (2000) as cited in Clean Air-Cool Planet Campus Carbon Calculator V6.

The NEWE emission factor was used to calculate the greenhouse gas emissions associated with purchased electricity in 2007 because actual data regarding the University's regional grid mix was not available. There are limitations, however, to using a constant electric emission factor, notably that the positive environmental impacts of switching to cleaner fuel sources will not be represented in calculations. As a state agency, the University has committed to increasing the proportion of renewable energy it purchases. As of 2009, the University purchases 15% green renewable power above the renewable portfolio standards (RPS) requirements. In order to capture the positive impact of this and any future such changes, it is recommended that a custom grid mix be used to calculate future purchased electricity emissions.

Scope 3 Emissions:

Scope 3 emissions are *all other indirect emissions* that are attributed to the University that are neither University owned nor operated but are either directly financed or otherwise linked to the University. In most cases, the University has limited control over these emissions (as compared to scope 1 and 2 emissions). The University of Connecticut tracks, to the extent that data is available, scope 3 emissions associated with the following activities:

- Solid waste disposal
- Wastewater treatment
- Regular student, faculty and staff commuting (*i.e.,* daily commuting to and from campus).
- Study abroad travel
- University reimbursed travel (*i.e.,* directly financed outsourced travel) including athletics

Due to the complexity and limitations of data associated with scope 3 emissions the University does not include these emissions when establishing its baseline for neutrality. Table 2.18 provides an overview of the University's scope 3 emissions and the corresponding source.

Table 2.18. Scope 3 Emissions Summary

Emission Source	$MTeCO_2$	%Scope 3	% Total[17]
Solid Waste Disposal	421.6	1.3	0.2
Wastewater Treatment	181.9	0.5	0.1
Student, Faculty & Staff Commuting	16,969.2	50.4	8.1
Study Abroad Travel	5,543.7	16.5	2.7
Directly Financed Off-Campus Travel	10,528.2	31.3	5.0
Total Scope 3 Emissions:	**33,644.6**	**--**	**16.1**

The sections to follow provide more detailed information about each emission source.

[17] Total emissions include scope 1, 2, and 3 emissions.

Solid Waste Disposal

Solid waste numbers were obtained from the contracted university waste hauler, Willimantic Waste. Data were reported as annual tonnages of municipal solid waste (MSW) and bulky waste, as shown in Table 2.19. According to Willimantic Waste, bulky waste is processed for recyclables; it was therefore assumed, based upon estimates provided by Willimantic Waste that 40% of the bulky waste collected annually is recycled. Municipal solid waste is not processed. It was further assumed based upon the data provided that approximately 50 percent of the net waste (excluding recycled bulky waste) is sent to mass burn incineration facilities and the remaining 50 percent is sent to landfills with methane (CH_4) recovery and flaring. Actual disposal sites may vary. Final disposal is handled by a subcontractor of the University's waste hauler; therefore, ultimate disposal sites may change, unbeknownst to the University, depending on economic or other factors.

It is estimated that -0.03 MTCE CO_2 (-110 kg CO_2) is generated per short ton of solid waste disposed through mass burn incineration. The factor includes emissions from the combustion of the waste, excluding biogenic sources. Energy recovery is assumed when using the CACP Campus Carbon Calculator; emissions factors are therefore negative because energy generation from solid waste incineration is assumed to result in fewer emissions than standard utility generation.[18]

Waste disposed at landfills with CH_4 recovery and flaring resulted in an estimated 0.07 MTCE CH_4 (12.22 kg CH_4) per ton of waste disposed. The factor incorporates emissions associated with transporting the waste to the landfill and CH_4 from biogenic sources, excluding the combustion of biogenic CH_4.[19]

Table 2.19. Solid Waste Disposal Data

	Waste (Tons)			Incinerated Waste (Mass Burn)			Landfilled Waste (CH4 Recovery & Flaring)			Total Net Waste	
		Bulky Waste									
Year	MSW	Total	Net	Tons	$kgCO_2$	$MTeCO_2$	Tons	$kgCH_4$	$MTeCO_2$	Tons	$MTeCO_2$
2006	4,247	1,017	610	2,429	-267,190	-267	2,429	29,688	683	4,857	416
2007	4,077	1,420	852	2,464	- 271,040	-271	2,464	30,116	693	4,928	422

Using the USEPA/CACP calculator emissions factors it was calculated that approximately 421.6 $MTeCO_2$ of greenhouse gas emissions were generated in 2007 in association with the University's solid waste disposal. Data from 2006 is shown for comparison. In 2007, solid waste tonnages increased by 1.5% over the previous year's tonnage, resulting in a parallel increase in solid waste greenhouse gas emissions. 2007 greenhouse gas emissions due to solid waste disposal, however, remain **less than 1% of total estimated annual GHG emissions for the campus.**

Wastewater Treatment

The University of Connecticut (Storrs Campus) serves as its own water supplier and source of wastewater treatment. **Approximately 376.9 million gallons of wastewater were aerobically processed by the central treatment system in 2007, generating an estimated 181.9 $MTeCO_2$ or 0.1% of the total campus emissions.** The wastewater treatment emissions factors used to generate this estimate are shown in Table 2.20.

Table 2.20. Wastewater Treatment Emission Factors

[18] Source: USEPA 2006 (as cited in the CACP Campus Carbon Calculator).
[19] Source: USEPA 2006 (as cited in the CACP Campus Carbon Calculator).

kg BOD / gallon wastewater	% accidental anaerobic degradation	% BOD removed by Primary Treatment	kg CH_4 / kg BOD	kg CH_4 / gallon wastewater	kg N_2O / gallon wastewater
0.0007	0.0%	0.0%	0.18	0	1.63E-06

The University supplies water to the core campus from two well fields with a total registered diversion of 3.152 MGD. Storage consists of 5.4M gallons of untreated water in an underground reservoir and ~1.9M gallons of treated water in standpipes. All storage will be treated at the new chemical treatment facility at the Willimantic Well Field in 2009-2010. Most of the campus is served by gravity flow from these standpipes, although some flow is pumped to a booster pump station to serve higher elevations.

Wastewater is managed using the 2007 Water and Wastewater Master Plan and the 2006 Campus Wide Drainage Master Plan. The campus wastewater system includes the wastewater pollution control facility (WPCF), collection system pump stations, and collection system piping. The current service area for the wastewater collection system includes the campus and non-university properties immediately surrounding the campuses. (In addition, there are a few small septic systems which are not accounted for in the inventory.) The WPCF treatment capacity is 3.0 MGPD (on average) and 7.0 MGPD (peak flow). The wastewater collection system is served by a number of pump stations, including 22 stations that serve the main campus (including Depot Campus). A gravity pipeline conveys the treated wastewater to the Willimantic River.

The University is presently designing a reclaimed water utility that will provide additional treatment, storage, and distribution of WPCF effluent for reuse as central utility plant feed water, irrigation water, and for other applications.

Student, Faculty, & Staff Commuting

The commuting habits of University faculty, staff, and students are not well understood. Estimates of the associated greenhouse gas emissions are generated based upon assumptions for each population (*i.e.,* faculty and staff, students). Due to data limitations, the inventory assumes that all commuting is conducted using personal vehicles; no students, faculty or staff, commute by bus, light rail, or passenger rail.

The University of Connecticut allows on-campus students with 56 or more credits to obtain a parking pass. Commuter students and graduate students are able to obtain a parking pass regardless of standing. Over 10,000 student parking passes were issued in the fall of 2007 (Table 2.21), 6,613 of which were issued to students living off-campus and graduate students (the majority of whom live off-campus). Therefore, it was estimated that approximately 35.5%[20] of students commuted regularly to campus (*i.e.,* 4 round-trips per week during the 30-week school year). A crude analysis of common off-campus housing patterns resulted in an average trip distance estimate of 16 miles per round-trip. Approximately 4% of those students commuting to campus were believed to carpool.

Table 2.21. Student Parking Permits Issued: 2007 & 2008

Parking Pass Type	Eligibility	Fall 2007	Fall 2008
Resident Student	On-campus students	3659	3687
Commuter Student	Students living off-campus	5103	4875

[20] Based upon comparison to total student enrollment for the Fall 2007 semester in full time equivalents (18,602 FTE).

Grad Asst[21]	Graduate students with an assistantship*	1510	1528

Similar assumptions were used to estimate faculty and staff annual commuting mileage and the associated emissions. It is estimated that 92% of all Storrs campus faculty and staff in 2007 commuted to campus via personal vehicle. 3% of these individuals were believed to have carpooled. On average round-trip distance travelled is estimated to have been 29 miles (based upon analysis of faculty and staff addresses). Trips are assumed to have occurred 5.5 times per week for the duration of the calendar year. (Two weeks of vacation were assumed for staff and four for faculty.)

The Clean Air-Cool Planet calculator assumes that all vehicles are gasoline-powered and have the same average fuel efficiency for the given inventory year (regardless of vehicle make, model or year). In 2007, personal vehicles therefore were assumed to have an average fuel efficiency of 22.10 miles per gallon. Final estimates for total annual commuter mileage and fuel use (Table 2.22), were therefore calculated as follows:

Total Distance = [(#Individuals * % Drive Alone) + (#Individuals * % Carpool)/2] * (Trips Per Week) * (Commuting Weeks Per Year) x (Miles Per Trip)

Fuel Consumption = Total Distance / Fuel Efficiency

Table 2.22. 2007 Commuter Mileage and Fuel Use

Student Commuters				Faculty & Staff Commuters			
Students (# FTE)	Commuters (%)	Total Distance (Miles)	Gasoline (Gallons)	Faculty & Staff (#)	Commuters (%)	Total Distance (Miles)	Gasoline (Gallons)
18,602	35.5	13,244,900	599,317	3884	92	23,720,205	1,073,312

Based upon the commuter fuel use estimates shown in Table 2.22, **approximately 16,969.2 MTeCO_2, or 8.1% of the University's total greenhouse gas emissions, were generated in association with student, faculty and staff commuting to campus during the 2007 calendar year.**

Off-Campus Travel

Each year faculty, staff, and students travel off-campus for University purposes (*i.e*. athletics, conferences, volunteer programs, study abroad, and research). Travel modes covered within the 'off-campus travel' category include bus, train, rental car, and air travel conducted on behalf of the University.

Given these data limitations, the current estimate of off-campus travel-related greenhouse gas emissions is assumed to be low. Future efforts will focus on rectifying these and other off-campus travel issues in order to better track the greenhouse gas emissions associated with off-campus travel.

Study Abroad

The University of Connecticut has an active Study Abroad program and each year students travel to locations throughout the world to earn credits towards their UConn degree. Actual travel data related to these trips, however, is limited. Under the present system, students make their travel arrangements independently of the University. Study abroad related travel was therefore calculated based upon non-stop flight distances from Hartford, Connecticut to the final destination. Using this method, 2007 study

[21] Graduate assistant passes are issued to graduate students living both on and off campus.

abroad enrollment is estimated to have resulted in over 7 million air miles and over 14,000 train miles. This estimate does not include any travel required to get to the public transit stations or travel conducted while abroad and is assumed to be an underestimate of actual mileage.

Directly Financed Off-Campus Travel

A significant effort was made to determine directly financed off-campus travel mileage for 2007 (*i.e.,* air travel, car rentals, etc.). However, in-house data was determined to be of limited utility for inventorying purposes. In certain cases, off-campus travel is paid for directly from a department budget (*i.e.* Athletics). Typically, however, an individual pays their travel expenses out-of-pocket and applies for reimbursement through the University Travel Services Department. Records of personal reimbursements are not itemized, however, but rather recorded as a lump sum reimbursement for all travel expenses (*e.g.,* hotel reservation, food expenses, conference registration fees). Therefore, this information cannot be used to estimate greenhouse gas emissions associated with off-campus travel. Consequently, the final 2007 off-campus travel estimate was constructed by averaging data from previous years. Excluding study abroad related travel, it is estimated that the University faculty, staff and students travelled over 13.5 million air miles in 2007.

Combined off-campus travel (*i.e.,* study abroad and directly financed) is estimated to have produced *at least* 16,071.9 MTeCO_2 or approximately 7.7% of the University's total greenhouse gas emissions for 2007. Actual emissions were assumed to be higher than this value.

Offsets & Sequestration Activities

It is generally acknowledged that most large research-oriented institutions will be unable to achieve carbon neutrality without the purchase of offsets. However, UConn does not presently purchase carbon offsets to supplement its greenhouse gas reduction activities. Furthermore, given the current fiscal situation, **the University does not plan to pursue the purchase of large-scale offsets in the near future.** Rather, it is the position of the University that the limited funds presently available are better directed towards achieving direct reductions in demand and increases in efficiency. Small offset certificates are, however, purchased on occasion through individual University departments. (For example, offset certificates have been purchased in the past in association with the university's annual EcoMadness residence hall contest.) These small certificates are not included in the University's greenhouse gas inventorying efforts.

The University can also seek to 'mitigate' emissions through on-campus carbon sequestration activities. Forest preservation and composting are the primary sequestration activities discussed in this action plan, though additional activities are possible (*e.g.,* crop management to increase soil carbon) and should be pursued where appropriate. Current sequestration activities are limited in scope but are expected to increase in response to the strategies proposed through this plan.

Forest Management

According to recent GIS calculations, the University presently owns 2,273 acres of coniferous forest, deciduous forest, and forested wetlands[22]. Approximately 2,130 acres of this land is officially designated as "UConn Forest," including several large forest tracts (*e.g.,* the Fenton Tract, Moss Tract/Research

[22] This figure was reached by merging Town of Mansfield parcel data and University parcel data. All UConn-owned polygons in the resultant file were then used to clip out the corresponding areas from the latest Center for Land Use Education and Research (CLEAR) 30m land cover data. The combined acreage of coniferous forest, deciduous forest and forested wetlands was then calculated.

Forest, Moss Sanctuary, North Eagleville Tract, and Spring Hill Tract). A map of the current university forest holdings is shown in Figure 2.5. These parcels are managed by the University's Department of Natural Resources and the Environment and have been used for educational, research, and recreational purposes, along with (to a lesser extent) forest products (timber, maple syrup, honey, fuelwood). An individual forest management plan exists for each forest tract, though many of these plans are over a decade old and need updating. Primary management goals have traditionally centered around three objectives:

1. Sustain the health and biodiversity of the forest.
2. Demonstrate forest management practices appropriate for private forest landowners, land trusts, and municipal forests.
3. Create an outdoor classroom where students and Cooperative Extension clientele can develop skills and gain practical experience in natural resource conservation.

Previous University calculations estimated that, under current management plans, the University's forest holdings sequester an estimated 3,840 $MTeCO_2$ annually[23]. This plan recommends that the parcel management plans be updated to include a fourth management goal: maximize carbon sequestration. More intensive, proactive management of these lands could provide for additional carbon sequestration, as well as offer a variety of research, educational, environmental, and economic opportunities currently not explored. Additional details regarding this opportunity are discussed in Section 3.

[23] This figure has not been verified.

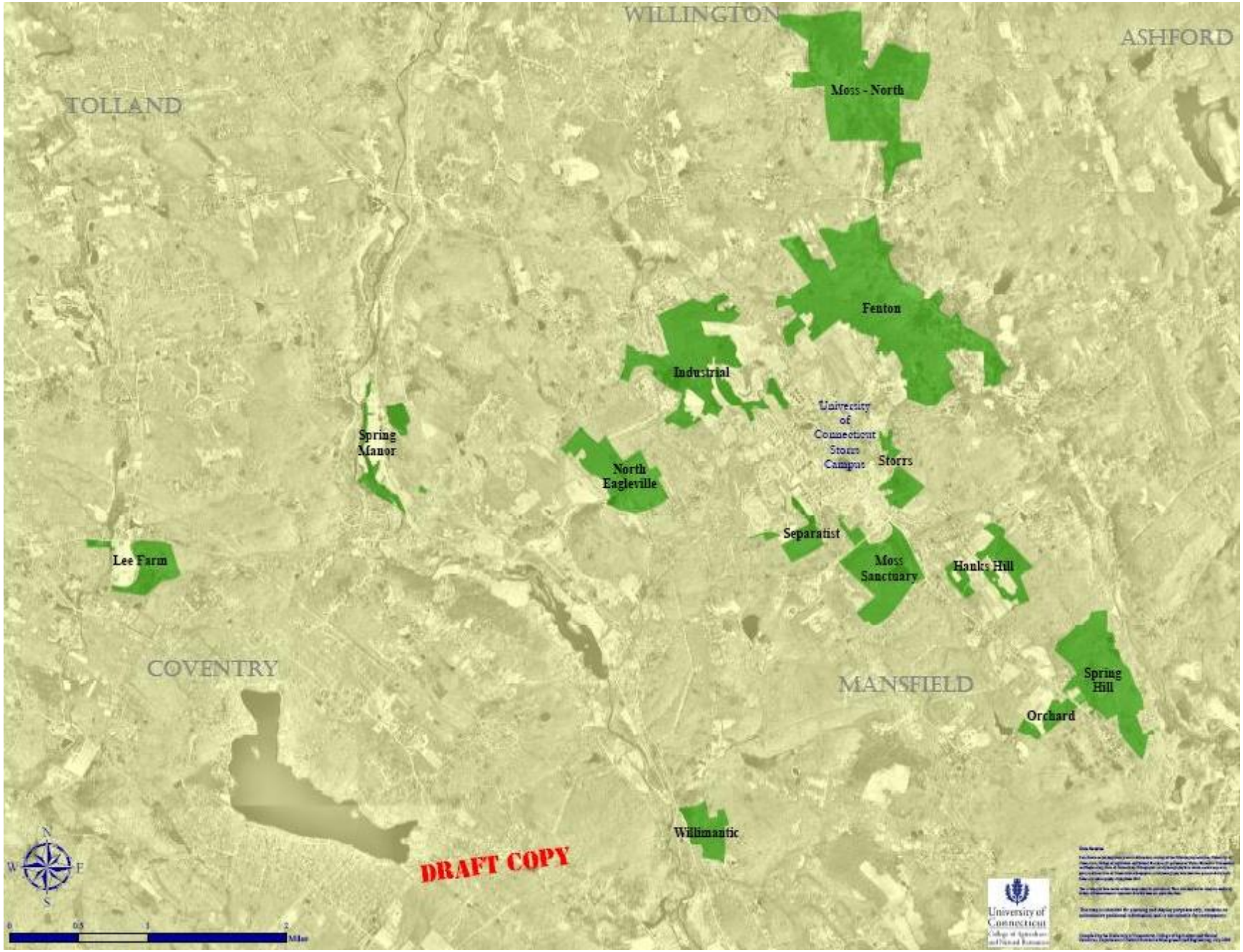


Figure 2.5. University of Connecticut Forest Tracts.

Composting

Several small-scale composting efforts occur on campus. These efforts are grassroots, voluntary efforts that were spearheaded and managed by a relatively small group of individuals. Since composting is not yet common on campus, all current practices are recognized and included in the inventory to provide support and encouragement for their continuation. These small steps have led the way to the exploration of larger-scale campus composting, and therefore remain significant, regardless of size.

Total 2007 composting volumes were estimated to be 8.28 tons[24]. The Clean Air-Cool Planet Campus Carbon Calculator estimates that -0.385 $MTeCO_2$ is sequestered for every short ton of wet compost produced. Therefore, **the University's composting activities in 2007 sequestered an estimated 3.19 $MTeCO_2$.**

Floriculture Greenhouse

In 2003, University staff at the Floriculture Greenhouses recognized an opportunity to divert organic waste from the campus waste stream and begin performing basic composting. All compostable materials are separated out of the greenhouse waste stream, stored in composting bins, and eventually redistributed around campus. It is estimated that approximately 20 yards of compost (~5.4 tons) is generated annually in this manner.

Plant Science Farm

For several years, the University's Plant Science Research and Education Farm has maintained two small compost piles: one for brush and the other for compostable organic matter (e.g., turfgrass clippings, soilless media from pots). Each pile is an approximately 360 cubic feet in volume, producing an estimated 2.9 tons combined of compost per year.

EcoGarden Club & Dining Services

Beginning in the fall of 2008, the student led UConn EcoGarden Club, developed a cooperative composting program with the University's dining halls. Food waste is delivered daily from Whitney and Towers (Gelfenbein Commons) dining halls to the garden by Dining Services staff. Total volume varies but averages approximately 60 pounds per day when the dining halls are in operation. EcoGarden members maintain the compost bins and use the finished product in the on-campus produce gardens. The annual composting volume from this program will be estimated during the fall of 2009.

Proposed Agricultural Waste Composting Facility

The University has completed plans to develop a large-scale composting facility on the Depot Campus. This new facility will convert the University's animal waste into high-grade compost. The proposed UConn compost facility will be a 10,000 square foot hoop barn structure constructed on a concrete pad. In addition, the site will contain a 10,000 square foot paved pad for finished compost. The facility is expected to accommodate approximately 15-25 truckloads of dry manure, liquid manure, and leaves throughout the year. Additional details regarding this proposal are discussed in Section 3.

Conclusion

[24] Estimates assume that approximately 40% of the original material collected is converted to usable compost.

The University remains committed to reducing its carbon footprint and maximizing environmental sustainability. As a signatory of the American College and University Presidents Climate Commitment, UConn has embarked on the long, arduous task of neutralizing our greenhouse gas emissions. According to the inventory presented in this section, the University scope 1 and 2 emissions during the 2007 calendar year totaled approximately 178,956 $MTeCO_2$. This inventory represents the University's first comprehensive attempt to document our greenhouse gas emissions in relation to campus sustainability efforts. **This inventory is not without limitations, however, and should be interpreted as a tool to guide future action rather than a technical compliance report. Emission values noted throughout this document are meant to provide a baseline for comparison between emission sources, but are assumed to be estimates with inherent error.**

Understanding Increases in Emissions

Given the University's plan for continued physical expansion over the next decade (*i.e.,* UConn 2000 and UConn 21st Century), emissions are likely to continue to increase if reduction strategies are not implemented. When measuring progress over time, it is important to understand true increases in emissions and those that are a result of data collection and inventory process improvements. As the inventory process becomes more institutionalized, the quality and accuracy of the campus greenhouse gas inventory are likely to increase. However, as emissions sources are better 'captured' through data collection and analysis improvements, an apparent increase in campus emissions is likely to be observed, even in the absence of true increases in emissions. Therefore, caution should be exerted when comparing data and inventories.

Obtaining complete inventory data for the years prior to 2007 has proven difficult. Data from years prior to 2007 have been included as available throughout this inventory. Previous greenhouse gas emissions inventories have been conducted by the university; however, these inventories were not conducted with the same rigor as the 2007 inventory, likely resulting in an underestimate of campus emissions. Specific causes for apparent emissions increases in the 2007 inventory include:

- The 2007 inventory is the first to include the Depot Campus, resulting in an increase in total building space, research space, and, subsequently, emissions.
- The university cogeneration facility came online in mid-2006, resulting in a redistribution of energy-related emissions. While the benefits of the facility are generally recognized (*e.g.,* increased efficiency, cost savings, educational opportunities) the University purchases power from a regional grid that contains a significant proportion of renewable energy sources (*e.g.,* nuclear, hydroelectric). Therefore, converting to a predominantly natural-gas fired source, while cleaner than other available fossil-fuel sources, resulted in a significant increase in campus emissions.
- Data previously unavailable has since been obtained and included in the 2007 inventory. Specifically, refrigerants and study abroad travel data were not included prior to 2007. Several data sources, including campus fertilizer use, were also better tracked and reported than in previous years.

Efforts are underway to complete the University's 2008 and 2009 inventories for comparison to the 2007 baseline. Implementation of the CAP will begin during fall 2009, however, there will likely be a lag period before the impact of emissions reductions strategies is observed in the greenhouse gas inventory. Furthermore, as University departments become more accustomed to annual inventory data requests, it is anticipated that data quality and availability will increase, further improving the accuracy of the inventories. This may however, result in additional apparent increases in campus emissions. Given these factors (*i.e.,* improved data and lag periods associated with implementing reduction

strategies), the University should not expect immediate (*i.e.,* within 5-years) reductions in the campus inventory.

Limitations of the Current Inventory

The process of inventorying campus emissions has increased campus awareness of the University's commitment to carbon neutrality and has served as a valuable tool to help individuals and departments better understand the environmental impact of regular campus operation. Furthermore, the inventory has the potential to assist university efforts to reroute protocol and reporting regulations in order to achieve increased efficiency, sustainability and social responsibility.

UConn chose to use the Clean Air-Cool Planet Campus Carbon Calculator (*i.e.,* CACP calculator) to inventory 2007 emissions for inclusion in the Climate Action Plan. Previous, less-detailed inventories have also been conducted using earlier versions of the CACP calculator. The Clean Air Cool Planet (CACP) Campus Carbon Calculator is an excellent resource for a variety of reasons, including:

- It is easily accessible and can be obtained free of cost;
- CACP provides excellent access to support staff;
- Minimal training and expertise is required to conduct an inventory;
- The inventory relies upon in-house data sources; and
- Many colleges and universities, including the majority of ACUPCC signatories, use the calculator, allowing for easy comparisons between institutions.

The CACP calculator's simplicity makes it an attractive choice for campuses new to the inventorying process. However, the calculator's simplicity also creates several limitations. Notably, as a land grant institution with a strong tradition in the agricultural and natural resource sciences, the calculator undervalues the impact of land management strategies, instead focusing on campus infrastructure and fleet. Consequently, reliance on the calculator to measure emission reduction progress, 'favors' the selection of solutions that fit within the bounds of the inventory. For example, the only strategy that will produce a measurable reduction in 'agricultural' emissions, as defined by the CACP calculator, is a reduction in herd *size*. However research has demonstrated that herd *management* can also have carbon footprint implications.[25]

Using the CACP calculator output as the basis of CAP development also encourages the formation of a plan that outlines a series of projects with measurable emissions, rather than a plan that is able to inspire changes in institutional policy and pedagogy. **The UConn climate action plan attempts to balance project-based solutions with those strategies that address core operational or management principles. The latter, however, are believed to form the true core of the University's CAP - institutional change.** Consequently, limited emphasis has been placed on attempting to model and project future emissions scenarios until either the CACP calculator further evolves or a more appropriate tool can be identified.

Recommendations for Future Improvement

The current inventory process lacks streamlined reporting as well as a sense of personal responsibility for recording, maintaining and internally reporting the data required to estimate campus greenhouse

[25] e.*g.,* Boadi *et al.* 2004; Lovett *et al.* 2006; Weiske *et al.* 2006.

gas emissions. Furthermore, the present system is restricted by the calculator upon which it is based and likely does not capture the complete carbon footprint of the University. Goals for future campus greenhouse gas inventorying efforts include:

1. **Increase awareness and understanding** of the University's greenhouse gas inventory efforts;
2. **Maximize efficiency and continuity** of the data collection and inventory compilation process;
3. **Refine the campus greenhouse gas inventory** to identify data gaps and analysis errors, provide greater reporting flexibility, and better capture overall campus emissions and sinks.

In order to achieve the above goals and to improve the campus inventorying process overall, the following actions are recommended:

I. Immediate Actions (within 1 year):

- **Form a campus greenhouse gas inventory meta-data workgroup**. The workgroup will ensure that future inventories can be conducted and repeated with greater ease and will provide a forum to address inventory data gaps, issues, and opportunities for improvement. The Environmental Policy Advisory Council (EPAC) should select workgroup members based upon familiarity with and access to the required data. Workgroup members will be expected to assist with annual data collection and serve as a liaison to their respective department leadership. It is recommended that the workgroup meet, at a minimum, once per year.
- **Continue to allocate funding for a student intern to compile the inventory**. The 2007 inventory was compiled by a lead student intern working with the assistance of other interns and the Climate Action Plan Project Manager in the Office of Environmental Policy. Student interns provide a low-cost strategy for ensuring the completion of the campus inventory. In turn, students gain valuable hands-on experience interacting with various departments throughout the university, collecting and analyzing data, and problem solving solutions to inventory issues. The student intern(s) will serve as staff support to the meta-data workgroup, and be responsible for compiling associated progress reports to the EPAC.

II. Short-term Actions (within 2-3 years):

- **Work with relevant departments to establish a memorandum of agreement (MOA) regarding annual data submission requirements and reporting protocol**. The interns compiling the 2007 inventory were fortunate to be able to identify campus 'champions' in many of the relevant departments, and therefore collect the necessary data for the inventory. However, certain departments do not maintain their data in a format that is amenable to use in the inventory (*i.e.,* travel data). Without this data it will be difficult to estimate the associated emissions and to measure the impact of implementing reduction strategies. The meta-data workgroup and the student intern(s) should therefore:
    - Communicate data needs and purpose to the leadership of each department involved in the inventory process;
    - Work with department leadership and staff to develop a mutually agreeable annual reporting protocol;
    - Establish a channel of communication (*e.g.,* department representative on the meta-data workgroup) to discuss data collection and reporting issues as well as suggestions for improvement; and
    - Develop an MOA with relevant departments outlining annual data submission requirements and reporting protocol.

III. Long-term Action (within 5-7 years):

- **Establish a web-based automated data reporting process**. The current inventory process is labor intensive and dependent upon the voluntary cooperation of departments. Furthermore, the ability to tailor the calculator to the UConn Storrs campus is limited. Therefore, to increase the accuracy and utility of the inventory results and to encourage increased participation from across the University, the metadata workgroup should work with campus IT staff to develop a web-based, UConn-specific software service to inventory campus greenhouse gas emissions. This service should allow departments to access a department-customized, user-friendly interface to input required data on an on-going basis and edit data as needed. The software should then automatically route the reported data to the official campus inventory. Additional inventory sources and sinks should be added, as appropriate, to the inventory.

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