Carbon Neutral Assessment Project

University of Florida
Office of Sustainability
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Dear Reader:

The 2001 mandate from the University of Florida Faculty Senate and President to the Sustainability Task Force (STF) was to design a plan by which UF would become "a global leader in sustainability." Accordingly, the STF developed a set of visionary recommendations that were subsequently ratified by the Faculty Senate and affirmed by then UF President Charles Young.

Among the 45 pioneering recommendations set forth by the STF was the sweeping directive to "map all UF-related greenhouse gas (GHG) emissions and develop a strategy for carbon neutrality with an ambitious, yet realistic timeline."

This report details the results of a study commissioned by the UF Office of Sustainability for the STF in response to the challenge to become carbon neutral. The study was performed by the International Carbon Bank and Exchange, Inc. and staff from Greening UF. Advanced work by the Rocky Mountain Institute (RMI) performed under contract with Dr. David Orr at Oberlin College provided a basis by which assumptions were made and analyzed and data compared.

While it is important to not under estimate the difficulty facing UF—or any organization—undertaking this seemingly daunting task, it is heartening to note that the UF study's findings compare favorably with those made by RMI: that UF can achieve carbon-neutrality in 20-30 years and show a revenue-positive result in the process.

The study also included developing an online relational database that has been loaded with ten years of energy-use data for every facility on the University of Florida campus. The program allows users to determine the GHG emissions from each facility—and project the cost savings from various mitigative measures capitalized over time.

Hopefully, this study can help inform the emerging conversation related to the University of Florida's efficient use of available fiscal and environmental resources while combating the growing threat to global security posed by climate change.

Once again, the University of Florida is poised to grasp a global leadership position in a significantly important issue of our time. Perhaps this study is a first step towards that position.

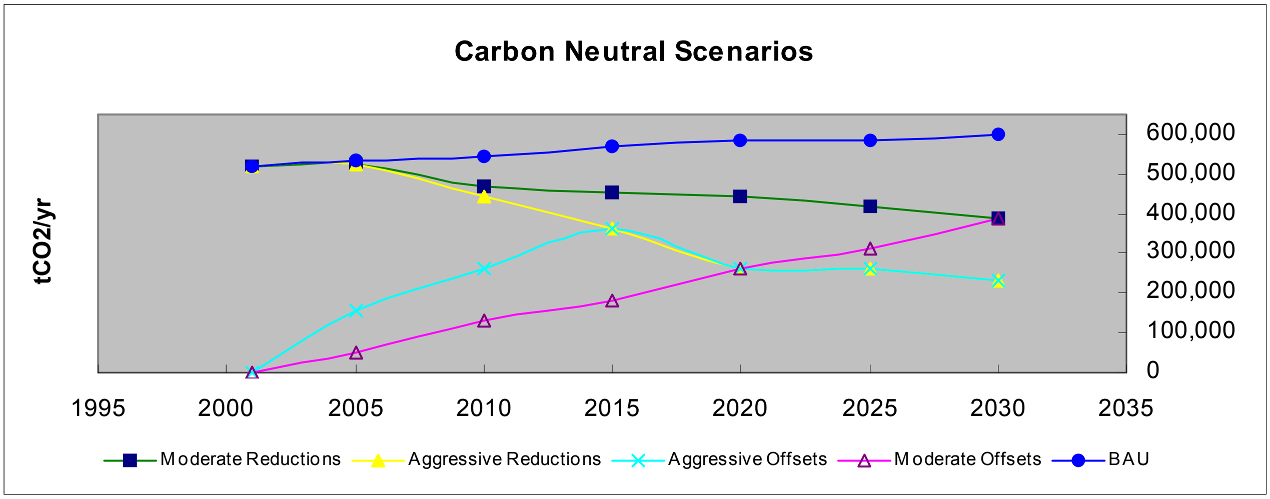
Sincerely,

Dave Newport
Staff to the Sustainability Task Force

Executive Summary

How to determine a date by which UF can cost effectively become carbon neutral.

This report introduces a study of options by which the University of Florida can reduce its Greenhouse Gas (GHG) emissions to the point where it has no net impact on climate change. Our findings show that significant on-campus reductions can be achieved cost effectively through appropriately scheduled infrastructure renovation, equipment upgrade and advancing a new energy management approach. Enhancing carbon sinks on UF lands, initiating local projects and purchasing emissions reductions on the market can be used to offset any remaining emissions.



A combination of reduction strategies and offsets results in UF becoming carbon neutral as early as 2020 under an "aggressive" scenario or by 2030 under a "moderate" scenario.

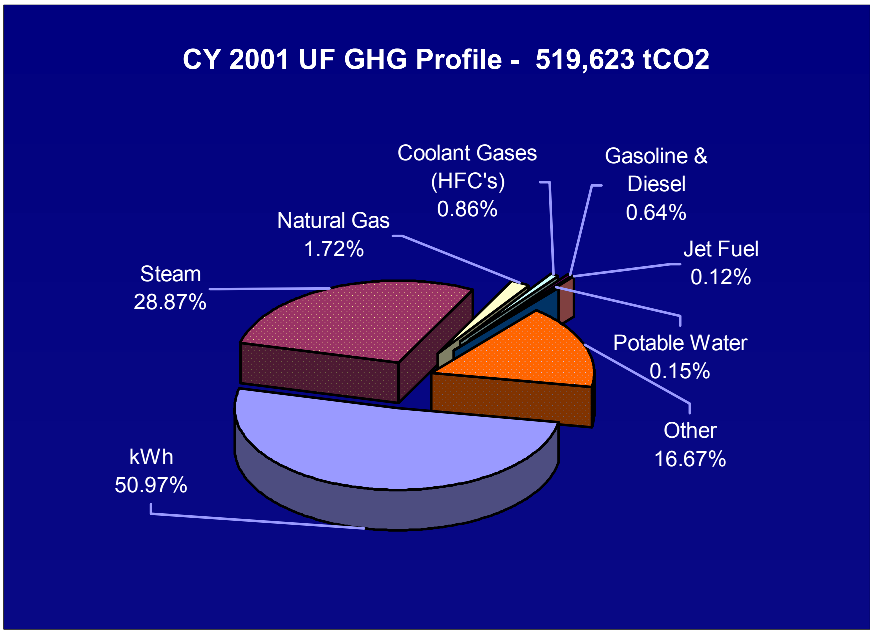
This report looked at GHG activities on the main UF campus only and analyzed emissions associated with building energy consumption and from the UF vehicle fleet. These two items likely represent 80% of GHG emissions incurred by routine campus operations.

As the majority of the GHG emissions associated with campus operations come from energy consumption, a CO_2-neutral situation can be achieved by reducing electrical demand of buildings, greening the energy supply and by sequestering and offsetting remaining emissions. To reduce emission from the vehicle fleet, available options suggest a progressive change to hybrid and other alternatively powered vehicles, and a re-absorption of any remaining emissions in alternate reduction activities.

The study discovered that existing campus energy initiatives routinely save money and that simply enhancing these programs can account for over half of possible reductions. The report also found that typically two dollars or more are saved for every dollar invested in energy programs and that up to a 40% reduction in energy demand can be realized while positively improving the operational budget.

The study concludes that achieving carbon neutrality is possible at no net cost, and, if desired, attainable within two decades. The study found that most of the risk lies in the execution of the plan, and as such, the report identifies a dedicated mission with an independent budget as key ingredients for success.

Campus GHG Profile



Function	tCO_2
kWh	264,868
Steam	150,000
LNG	8,943
Coolant Gases	4,489
Gasoline & Diesel	3,351
Jet Fuel	601
Potable Water	767
Other	86,604
Total	**519,623**

Items shaded in blue are considered direct emissions. Un-shaded items are considered indirect since UF doesn't own the emissions source. Indirect emissions, however, are the largest part of the GHG Profile.

Precise information was available for emission rates associated with kWh use, natural gas, potable water, gasoline, diesel and jet-fuel consumption. Greenhouse gas emissions estimates were created for the use of steam and chiller coolant gases (CFC's & HFC's).

A miscellaneous category named "other" serves as a placeholder for emissions not included in this initial inventory such as those from paint and fertilizer use, lab and medical applications, emissions associated with various forms of waste disposal, construction and vendor activity on the campus.

As for emissions reductions, the study made no attempt to account for the bio-sequestration potential of UF owned lands, which may prove to hold pleasant surprises. A future GHG inventory should address greenhouse impacts from UF's waste recovery practices, commutes to and from campus by students, faculty and employees, and air transport to conferences and UF business, study abroad programs, athletic events and so on, as is becoming the norm in academic GHG reporting.

Though the greenhouse emissions identified in this study are the ones typically recognized under international GHG accounting principles, further evaluation is needed to determine the actual numbers in the Main UF Campus as well as across the entire organization for all greenhouse sources and sinks.

Boundary – Main Campus	Emissions in tCO2	Emissions in tCO2	Water in Gal	Water in tonne
Students	per student/yr	per ft2/yr	per student/yr	per student/yr
40,000	13	0.0291	26,272	99
Salaried Employees	per employee/yr	per day	per day	per day
10,000	52	1,424	2,879,088	10,899
Budget (CY 2001)	per budget $/yr	per hour	per hour	per hour
1,857,000,000	0.000280	59	119,962	454
Humans served	per human/yr	per human/day	per human/day	per human/day
50,000	10.39	0.028	58	0.22
UF Credit Hour	per credit hour		per credit hour	per credit hour
1,222,673	0.42		859	3.25

Campus Electricity

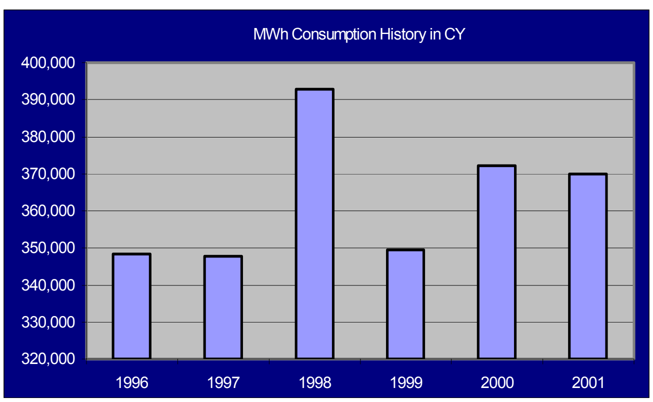
Consumption of electricity on the UF Campus was measured using all available meter data and includes parking garages, chiller plants, pump houses, sports facilities and student housing.

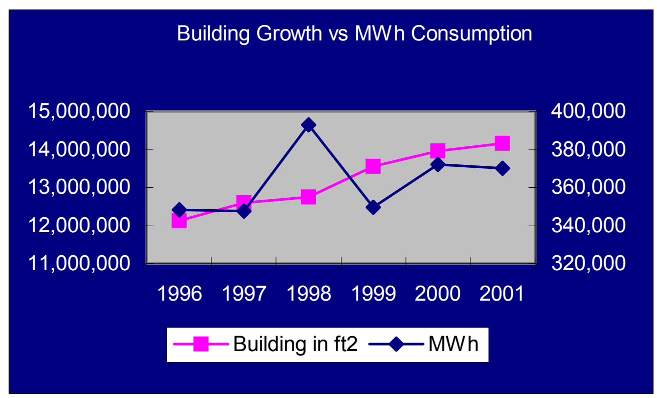
From 1996 to 2001, absolute kWh consumption increased by 6.2%. Over that period, however, consumption relative to square footage decreased every year, eventually reducing by 3.5%. This indicates a successful effort in energy management policies, especially considering Campus square footage grew by 14% in those six years.

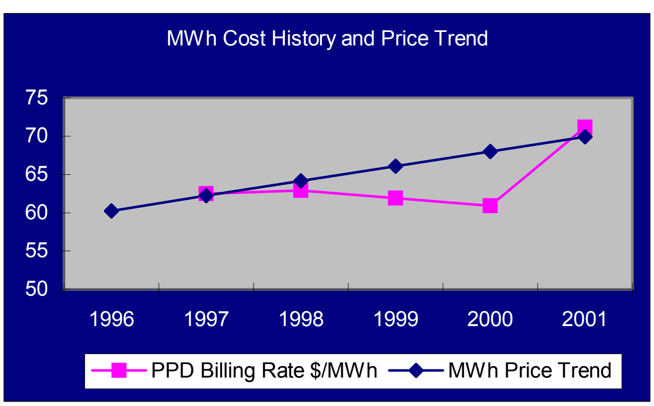
Based on this data, two conclusions can be drawn. First, kWh consumption is increasing as the campus expands. Second, demand side management (DSM) policies are lowering relative demand, but can't keep up with campus growth.

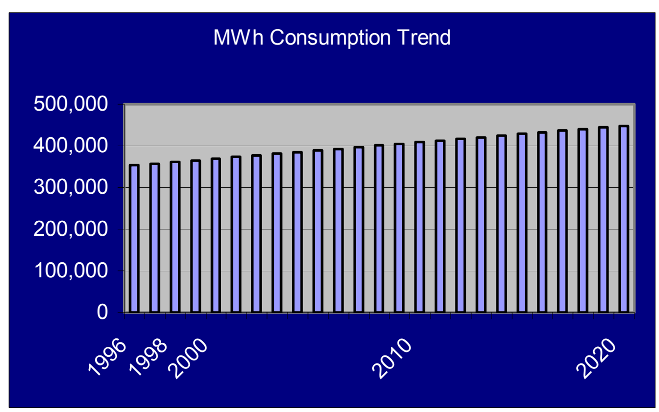
The Third Draft of the University of Florida Comprehensive Master Plan indicates that an additional 16% gross square footage (GSF) is anticipated on the main UF Campus over the next 10 years. Under a 'business as usual' scenario, this would likely lead to a notable increase in MWh consumption.

For the most part, cost and emission rates associated with electrical consumption over the next two decades are influenced by circumstances on the generation side (no control), the trend towards electronization of the work environment (some control), and the energy management approach the University chooses (most control).







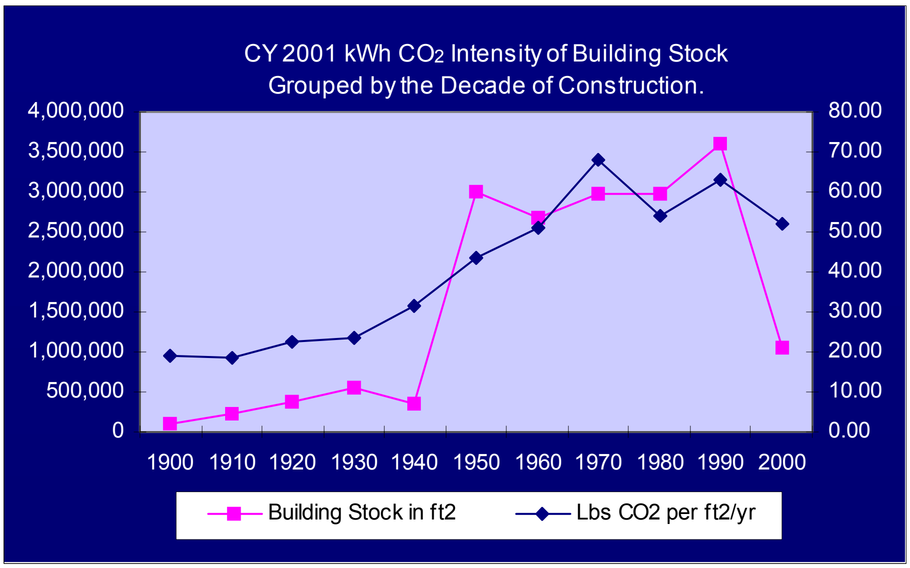


Campus Buildings

The kWh analysis focused on the 398 buildings equipped with electrical meters. Another 553 campus buildings have no electrical meters or are connected to buildings with meters.

Buildings with meters accounted for 14,169,525 of the 17,858,737 square foot (79%) of campus building space. Metered space includes attics, closets, hallways, indoor and outdoor staircases etc., with about 82% of square footage listed as interior, conditioned space.

The study found that the 50 largest buildings on campus accounted for 40% of the square footage and 42% of the CO_2 produced in CY 2001. On the other end of the spectrum, the 50 smallest buildings accounted for 0.2% of square footage and 0.6% of CO_2 production.



Notable is that in CY 2001 the CO_2 intensity of building stock from 1900 ~1950's averages 26.38 Lbs CO_2/ft2, while the CO_2 intensity of buildings 1960 ~ 2000 averages 57.59 Lbs CO_2/ft2.

Building stock from the 1970's has the highest CO_2 intensity at 68.20 Lbs CO_2/ft2/yr.

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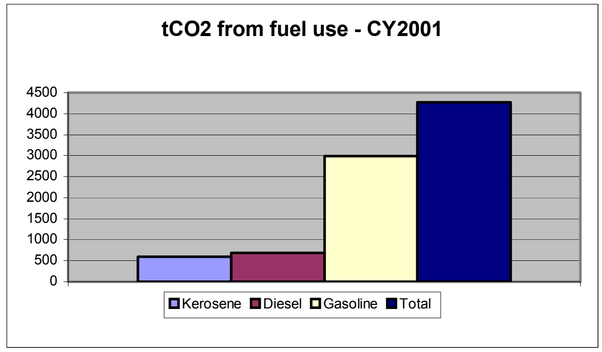
Building Name	Area in ft2	MWh in 2001	tCO2 in 2001	Lbs CO2/ft2	Building Year
WM A. SHANDS TEACHING HOSPITAL	526,310	12,730	9,112	38.18	1956
DENTAL SCIENCE	503,640	7,786	5,573	24.40	1975
STETSON MEDICAL SCIENCES	379,040	5,239	3,750	21.82	1956
COMMUNICORE	300,690	5,545	3,970	29.11	1975
STEPHEN C. OCONNELL CENTER	295,990	4,326	3,096	23.07	1980
J. WAYNE REITZ UNION	283,030	8,876	6,354	49.50	1967
ACADEMIC RESEARCH BUILDING	240,660	8,084	5,787	53.02	1989
PHYSICS BUILDING	232,730	5,406	3,870	36.66	1998
BRAIN INSTITUTE	206,789	7,425	5,315	56.67	1998
RALPH D. TURLINGTON HALL	180,610	663	475	5.79	1977
FLORIDA GYMNASIUM	162,560	1,568	1,122	15.22	1949
ANNIE D. BROWARD HALL	159,100	2,467	1,766	24.48	1954
JOSEPH WEIL HALL	151,100	2,119	1,517	22.13	1950
RAE O. WEIMER HALL	145,155	2,683	1,921	29.17	1980
ENGINEERING	140,190	2,883	2,064	32.46	1997
VET MED ACADEMIC WING	139,450	4,432	3,172	50.16	1996
BEN HILL GRIFFIN STADIUM	136,340	1,864	1,335	21.58	1930
SPESSARD L. HOLLAND LAW CENTR	132,620	1,629	1,166	19.39	1968
SHANDS MEDICAL PLAZA A	126,200	2,154	1,542	26.95	1991
VET MED TEACHING HOSPITAL	123,170	10,634	7,612	136.27	1977
Total	**4,565,374**	**98,513**	**70,519**	**35.80**	**1973**
Relative to Campus Total	25.56%	26.62%	26.62%	+6%	+3yr
Campus Total	17,858,737	369,951	264,868	33.73	1970

Profile of the "20 largest buildings" excludes parking garages.

Campus Vehicles

Annual fuel data from the UF Vehicle Fleet was provided by Physical Plant Motor Pool and reflects consumption data generated by the TRAK fueling system and other methods. The UF fleet includes 2,133 buses, trucks, tractors, excavators, mowers, airboats, service vehicles, vans, SUV's, and passenger vehicles that are owned, leased or rented by UF, most of which are attached to the main campus. Fuel purchased while on the road is not reflected in this data set.

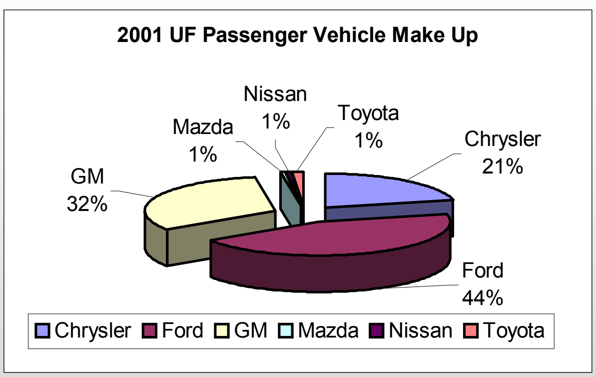


The two primary fuels provided by the Motor Pool are gasoline and diesel. Fuel and mileage of a particular vehicle are recorded when the user inserts a special key to activate the pump. In addition, the Aviation Department of the University Athletic Association estimated 62,138 gallons of A-1 Jet Fuel (Kerosene), based on 300.4 logged flight hours in CY 2001.

Historical data was spotty, so we opted to use a small, but highly detailed 4-month record set that TRAK gathered since November 1, 2001. A sample reading showed that 73% of the vehicle fleet drove less than 10 miles a day and performed at -42% of their EPA rated City MPG. This is likely due to the short driving distances and low campus speed limit.

The vehicle fleet represents less than 1% of UF's GHG emissions profile, on the other hand, the fleet produces the majority of emissions directly experienced by the campus community. On average, fleet activities introduce 16,251 Lbs of CO2, CH4, NOx, SOx, PM-10 and other compounds into the UF airshed every day, mostly between 7AM and 5PM.

Most of campus vehicle emissions occur while vehicles are at low speed. Hybrid vehicles typically rely on regenerative braking and battery functions to move around at low speeds and can reduce CO2 output by half, and NOx, particulate matter (PM) and others by 75%.



Make & Model	Specifications	Emission Standard	MPG: City
HONDA CIVIC GX	1.7L 4, auto CVT	SULEV	30
TOYOTA RAV4 EV	Electric	ZEV	37
TOYOTA PRIUS	1.5L 4, auto CVT	SULEV	52
HONDA CIVIC HX	1.7L 4, manual	ULEV	36
TOYOTA ECHO	1.5L 4, manual	LEV	34
NISSAN SENTRA CA	1.8L 4, auto	SULEV	27
HONDA CIVIC	1.7L 4, manual	ULEV	33
MITSUBISHI MIRAGE	1.5L 4, manual	LEV	32

Sample of low emissions passenger vehicles available in U.S. market

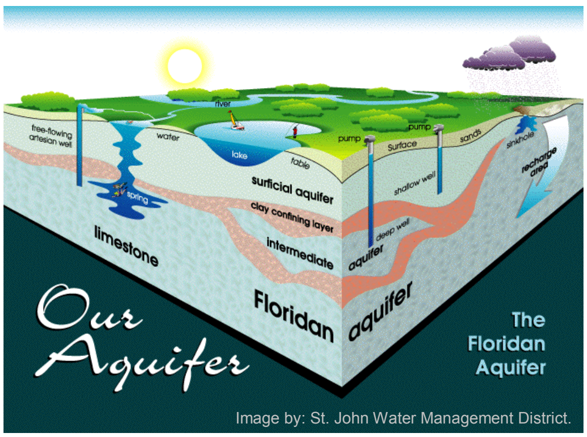
Year	Engine size (L)	Pistons	Mile/day	Gallon/day	MPG/day	kgCO2/day	lbsCO2/day
1992	**4.63**	**6.83**	**10.34**	**1.15**	**9.02**	**10.03**	**22.11**

Above data represents CY 2001 activity profile based on a sample reading (5%) of passenger vehicles in the UF Fleet.

Campus Water

The University of Florida campus consumes 120,000 gallon of drinking quality water per hour, all year around. Most of this water is provided by Gainesville Regional Utilities (GRU), who tap it directly from the Floridan Aquifer using any of 14 local wells. Because the aquifer holds some of purest water in the country it requires only minimal treatment and the process of extraction, filtering and distribution results in only a small amount of greenhouse gases to UF's GHG budget.

The total amount of water needed to service one student is an impressive 219,000 Lbs/yr. The campus itself consumes a whopping 2.8 million gallons of fresh water a day, only a small amount of which is actually consumed as drinking water. Acquiring this water is so easy that to go use up over a billion gallons, only 770 tCO2 is incurred on UF's GHG bottom line.



Yet with water as one of the critical issues of the future for Florida and the planet, it seems logical to take the opportunity and explore ways to become more water efficient. One idea is to create ways to conserve water and to harvest, store and make use of rainwater falling on the campus area.

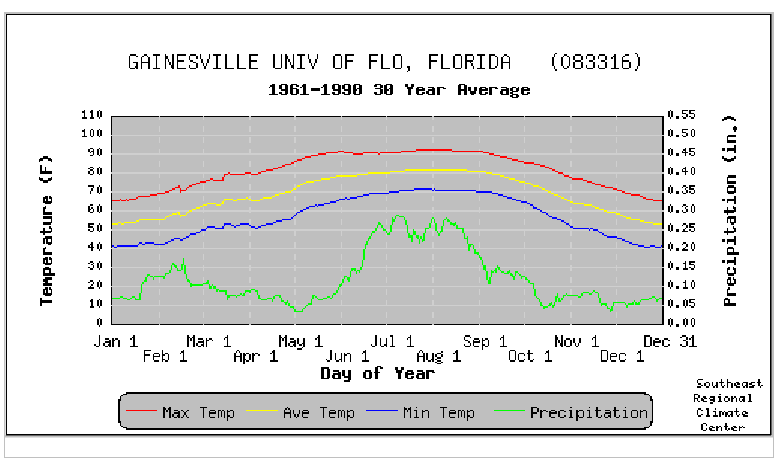
On average, the campus receives three times more rainwater per year than it purchases from GRU. Yet, with the exception of Rinker Hall, there are no comprehensive rainwater recovery systems in place on the UF campus. Rainwater can easily be caught using roofs and other surfaces and led to hidden rainwater filtering systems. The rainwater could then be used in toilets, irrigation, cooling and other mass applications. As is, UF takes from the underground aquifer a third of what it receives from the heavens each year.

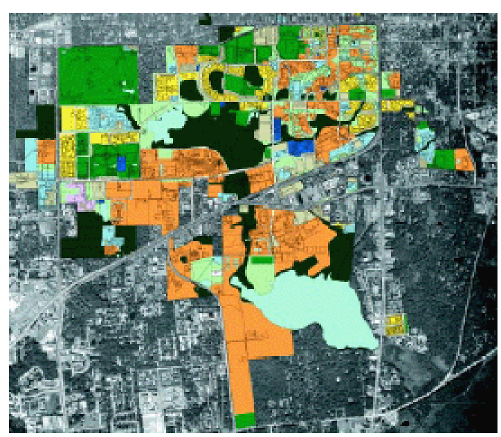
Potable Water CY 2001

total gallon	tCO2 total from water use	total cost water
1,050,867,018	766.95	$ 914,254

Rain Water CY 2001

area UF Main Campus, in acres	ft2 per acre	average annual rainfall, in foot
1,966	43,560	4.29
total rainwater, in gallons		% bought vs 'received'
2,750,957,294		38.20%





Reduction Technologies

Reduction Technologies - Lighting

Lighting accounts for 20% to 25% of all electricity consumed in the United States. Meanwhile, in a typical commercial lighting installation, 50% or more of the lumens are wasted by obsolete equipment, inadequate maintenance or inefficient use.

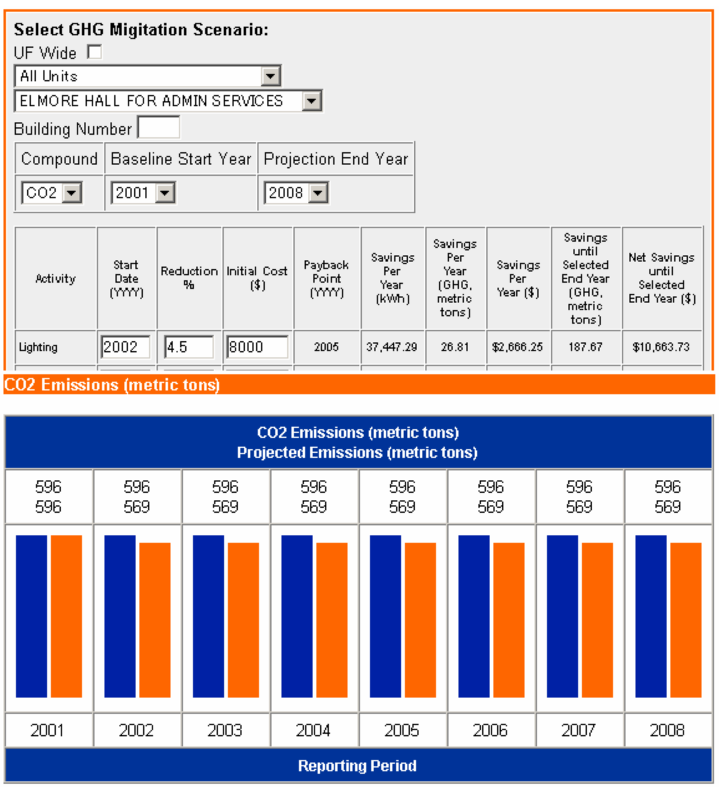
For the purpose of this discussion, we characterize the UF Campus as a commercial establishment because of the many similarities in building and occupancy make-up. The good news is that technologies developed during the past 10 years can help cut lighting costs 30% to 60% while enhancing lighting quality and reducing environmental impacts.

Using lighting as a way to reduce costs and lower GHG's is immediately attractively because upgrades can be performed incrementally with comparatively small budgets, the payback time is short, and the procedure can be performed quickly with little intrusion to day-to-day Campus operations.

Saving lighting energy requires either reducing electricity consumed by the light source or reducing the length of time the light source is on. This can be accomplished by:

- Lowering wattage, which involves replacing lamps or entire fixtures.
- Reducing the light source's on-time, which means improving lighting controls and educating users to turn off unneeded lights.
- Using daylighting, which reduces energy consumption by replacing electric lights with natural light.
- Performing simple maintenance, which preserves illumination and light quality and allows lower illumination levels.

UF PPD is continually upgrading lights as budgets permit and indicates it could do more. A recent example is the re-lamping of Elmore Hall, finished on October 30, 2001. A total of 267 new light fixtures, mostly T8's with improved electronic ballasts, were introduced in the lobby, hallways, conference and mailrooms. The upgrade has an expected payback period of 3.28 year and reduces yearly operational costs by $2,666 and lowers annual GHG's by 27 tCO_2. When this new lighting technology is in place for seven years, the project ROI is 2.3.



Activity	Start Date (YYYY)	Reduction %	Initial Cost ($)	Payback Point (YYYY)	Savings Per Year (kWh)	Savings Per Year (GHG, metric tons)	Savings Per Year ($)	Savings until Selected End Year (GHG, metric tons)	Net Savings until Selected End Year ($)
Lighting	2002	4.5	8000	2005	37,447.29	26.81	$2,666.25	187.67	$10,663.73

Snapshot of the relational database as used to calculate an energy, cost and greenhouse reduction scenario for Elmore Hall.

On the UF Campus, there are still plenty of light fixtures that can be upgraded to T8 and other new versions. Even more exciting is the digitally controlled, next-generation technology called T5. T5 is smaller, brighter, more efficient, and steadily becoming affordable. The upgrade scenario from T8 to T5 can be planned ahead of time with a trigger event located at a specific product price level. This makes the upgrade costs, and resulting operational and GHG savings highly predictable.

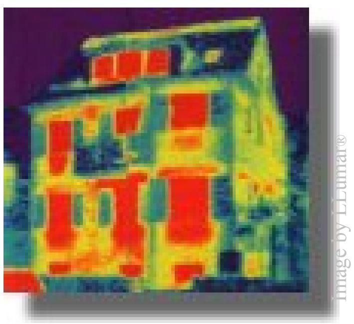
Reduction Technologies – Windows

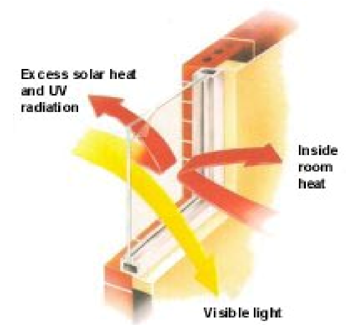
In 1990, unwanted heat loss and gain through windows cost the United States almost $20 billion, roughly one-fourth of all the energy used for space heating and cooling. Notwithstanding, windows play an important role in the built environment as they bring light, warmth, and beauty into buildings and give a feeling of life, openness and space to internal areas. Fortunately for us, the technology surrounding glazing has improved dramatically in the last decade and many cost effective solutions have come to the fore.

The primary options available to controlling window energy flow are:

Caulking and Weatherstripping - Caulks are airtight compounds, like silicone and latex, that fill cracks and holes. It is important to apply the caulk during dry, but warm weather.
Replacing Window Frames - The type and quality of the window frame affect a window's air infiltration and heat loss characteristics, e.g., windows with compression seals permit about half the air leakage as sliding windows with sliding seals.
Change the Type of Glazing Material - Now several types of special glazing are available that can help control heat loss and condensation.

- **Low-emissivity (low-e) glass** has a special surface coating to reduce heat transfer back through the window. These coatings reflect from 40% to 70% of the heat that is normally transmitted through clear glass.
- **Heat-absorbing glass** contains special tints that allow it to absorb as much as 45% of the incoming solar energy, reducing heat gain.
- **Reflective glass** has been coated with a reflective film and is useful in controlling solar heat gain during the summer. It also reduces the passage of light all year long, and, like heat-absorbing glass, it reduces solar transmittance.





Window upgrades are part of the tasks that PPD performs when the budget allows for it. Recently, Tropical Solar Film, a local glass tinting shop, was hired to re-cover the 280 windows on the east and west side of the Engineering Sciences (Aerospace) building with LLUMAR® R-20 Silver. This unique sun-film is able reject 79% of external UV and solar energy, while allowing 85% of the light to pass through.

The Aerospace building is a long, narrow structure with a north-south axis and particularly vulnerable to radiated heat, light and glare. The film upgrade for the whole building cost $11,200, and covered 4081 ft2 of window space. In CY 2001, the cooling cost of building 725 was $35,085.

No payback figures were available from the installer, but if the upgrade reduces the need for chilled water (the cooling agent) by 15%, the payback time is just over 2 years. This also reduces operational cost by $5,262/yr, and saves the environment approximately 38 tCO2 annually. The life expectancy of the film is 15+ years, providing this investment with a potential ROI of 7.1. According to PPD and the professionals at Tropical Solar, many opportunities for window upgrades exist on the Campus today.

Non-glazing options, such as awnings, shutters and screens can be applied on the inside and outside of windows to reduce heat loss in the winter and heat gain in the summer. In many cases, these window treatments are more cost-effective than window replacements and should be considered first.

Reduction Technologies – Plug Load

Electricity use by office equipment is growing faster than any other end-use in commercial buildings. Both the number and variety of electrical products have increased and equipment such as computers, printers, copiers, phones, chargers etc., draw energy not only when they are in use, but also when the power is ostensibly off. This is also true in the learning environment where these tools represent an increasing share of the electricity and resulting GHG pie.

Category	Devices
Office Equipment	Copier Computer peripherals Battery charger Answering machine Cordless phone Cellular phone charger
Kitchen	Microwave oven Coffee machines
Security & Protection	Smoke detector Security alarm system Doorbell Baby monitor (student housing)
Audio & Video	Audio system Boombox, Walkman® etc. TV, VCR, DVD, Mixing Boards

At the same time, substantial progress in recent years has improved the energy efficiency of equipment. This study found numerous examples and reports indicating that if you install the latest energy-efficient electrical products in older buildings, you can reduce your energy costs by 40 percent.

Efficient equipment also produces less heat, which leads to lower cooling costs. One study performed by UBS, Switzerland, lead to the phase out of all CRT-screens by LCD-screens in their offices nationwide when it was calculated that savings achieved by reducing the impact on the summer thermal load could well pay for the new equipment. Targeting equipment to lower energy use is also an attractive option because of the multiple benefits involved. First, the user gets new equipment and probably better features. Second, the procurement of desired equipment can be managed by adjusting existing purchasing policies. Third, operational and GHG savings can be forecasted very accurately for most electrical items since their precise consumption rates are typically included in product information.

From the administration's point of view, this provides a great deal of control. For example, a new refrigerator with automatic defrost and a top-mounted freezer typically uses less than 650 kWh's per year, whereas the same model sold in 1973 used nearly 2000 kWh per year. If UF decided to change out all of its fridges, it could calculate to the dollar how much to subsidize each department to encourage the event to take place, while still realizing operational savings.

Thus, UF could drive these events to take place according to explicit formulas that satisfy given financial objectives, such as duration of payback, ROI, IRR, subsidy amount and so on. It could search out specific items for change-out and leave others for later. For instance, in 2001, PPD conducted a test using Vending Misers, which uses electronics to que vending machines into service only when users are present, as opposed to being on-full alert 24 hours a day. According to the sample test, applying the Vending Miser to all vending machines on campus would result in $62,784 in electric saving and 718 tCO2 reductions per year. PPD has installed 26 Misers and is awaiting funding to "Miser" 400 more machines. The Vending Miser retails for about $225 and comes with a 10-year warranty.

If the University secures a 3-year loan at 5% to purchase Vending Misers, the monthly principal and interest payments per Miser would be approximately $6.74. However, the monthly savings in kWh's for each Miser equipped machine is about $12.28, resulting in a net gain for the University of $5.53/month for the first 36 months, and a total of $1,230 over the 10-year life of the Miser.

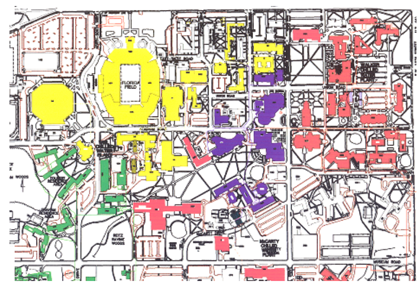
Reduction Technologies – Cooling

At UF, chiller plants consume 24.8% of the yearly kWh budget to generate chilled water. An additional 14% cooling capacity is extracted from waste steam supplied by the cogen plant, while thousands of individual window AC units serve on campus dorms and smaller buildings.

Because cooling is the largest single draw of energy, likely comprising in excess of 30% of the energy budget at UF, cooling systems are among the first to consider when reviewing energy upgrades.

	weighted Plant age	industry kW/ton for that age	Actual UF kW/ton	relative to industry average
McCarty Plant	1996	0.61	0.79	+22.8%
SE Plant	1997	0.60	0.81	+26.0%
SW Plant	1990	0.65	0.7	+6.9%
West Plant	1994	0.62	0.95	+34.5%
Walker Hall Plant	1984	0.70	0.79	+11.0%
Weil Hall Plant	1983	0.71	0.72	+1.2%
Holland Law Plant	1984	0.70	0.78	+9.7%
	weighted Fleet Age	industry kW/ton for 2000	UF weighted kW/ton	UF relative to 2000 average
	1990	0.55	0.77	+28.91%

Chillers are rated by the volume of water they can chill in an hour, expressed in kilotons. A 1,200-ton unit is common on the UF campus, which altogether has 42 units working in tandem to maintain a total of 38,328 ton cooling potential. The 42 units pool into 10 loops, each loop serving anywhere from 2 to 18 buildings. The result is that each set of client buildings receives cooled water generated at varying efficiency levels as seen above.



It would be interesting to look at the flow of coolant energy in more detail at the next opportunity. The energy consumption rates of chillers plants are extensively logged and are available down to the hour. This data provides highly accurate forecasting capabilities when considering investments in upgrades.

Figure 3: Operating cost comparison.

If UF were to have a completely modern chiller fleet a decade from now, operating at 30% higher efficiency than today, it would take about another 10 years to achieve the payback point. This is among the longest returns of any of the energy investments identified. However, most cooling equipment is industrial strength and good for 20 years and more, suggesting a simplified payback of at least 2.0.

Complementary reduction avenues include integrating GeoExchange to cool UF buildings, using landscaping to change building energy profiles and automating air handlers to make more efficient use of chilled water and heat energy.

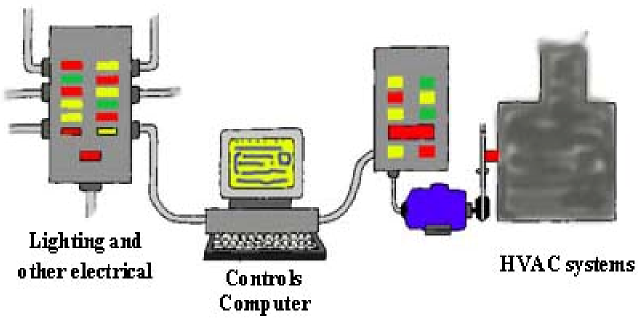
Chiller Efficiency Progress (kW/ton)

"Chillers in 1978 used 50% more energy than in 1998"

	1978	1980	1990	1991	1993	1995	1997	1998
Average	0.80	0.72	0.65	0.64	0.63	0.61	0.60	0.59
Best	0.72	0.68	0.62	0.60	0.55	0.52	0.49	0.48<

Reduction Technologies – Controls

The ultimate objective of any serious energy conservation program is a central, computer automated, electronic control system. An integrated system of remote sensors and management devices permits the optimal use of energy across all areas while providing the best environment for building occupants.

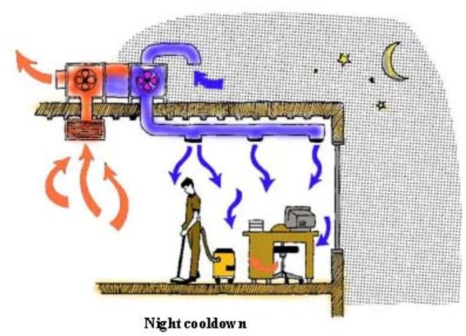


Tremendous advances in computer technology over the last decade have lead to increased sophistication and falling costs of Direct Digital Control (DDC) systems for buildings. DDC systems are now affordable for almost any size building and allow much finer control and energy savings than traditional controls. In addition, DDC can also integrate fire and security and connect systems to existing computer networks. The following are some of the common applications for DDC.

Optimized start/stop of air handling units - This is simply a more sophisticated use of the on/off controls of the air-handling units in a building. Instead of a complete cut off, the thermostat is setback at night and on weekends in a fashion that mimics the temperature curve outside. This allows for a computer program to match the thermal momentum of the building mass and the volume of air already conditioned inside to maintain temperatures within the comfort zone for the balance of the day.

Demand limiting - The demand limiting philosophy is to turn off equipment as electrical use approaches demand peaks. The software simply follows a prioritized list of items to be turned off until the energy use curve levels and the peak load passes. Clever operators will make use of the building mass to provide thermal momentum during these periods, extracting or rejecting heat energy, to always maintain a comfortable environment.

Peak load shifting - Some systems accomplish demand limiting by shifting the building load to off peak hours and storing energy until it is needed later. There are several thermal masses that can be manipulated this way: the building mass, the volume of fluid in the chilled water loop, the volume of cooled air within the building and the humidity of the cooled air in the building. An hour or two before the peak load is expected, based on a dynamic profile generated during previous days, the building and its systems float below the set point, storing energy that is released for the next few hours until the peak is passed.



Load leveling - Whereas the use of energy at a facility cannot be avoided, the timing is often flexible. Instead of operating the laundry in the middle of the afternoon, when the HVAC (heating, ventilation, and air conditioning) is approaching its peak, the laundry can be done earlier in the day. DDC type controls coupled with a thorough understanding of daily routines can greatly enhance a facilities' ability to smooth out the demand curve and lower utility fees.

-- Nearly all the text in the Controls section was borrowed from Energy Savings Now, Siemens Building Technologies, while the images in Controls belong to the Santa Monica Green Building Program --

Two stage controls - There are many applications for two-level controls. One example is a room served by two air handlers, both directly controlled by a single thermostat, which often leads to intense cycling and excessive energy use. Instead, the more sophisticated two-level controller activates one unit, then both, as the load demands. Another example is controlling the motor speed of an air handler. Dual stage controls are a good compromise for system retrofits where the Variable Frequency Drive (VFD) is too costly.

Automated processes save time, money and energy consumption - A DDC system provides many benefits, including lower energy costs, finer temperature control, flexibility, lower maintenance costs and real-time graphical displays of the facility systems. DDC also provides better use by allowing facility managers and others to easily change standard set points and schedules, including daylight savings time, three day holidays etc., through user friendly Windows based interfaces. For instance, for a special basketball game weekend, when the building would otherwise be closed, the coach enters the date, time and the areas (e.g., the gym and locker rooms) requiring the HVAC system to be operational. The rest of the building remains shut down, the DDC system only supplies energy where needed, which lowers energy cost and extends the lifetime of the equipment.

Designed with minimal moving parts, a DDC system also experiences far fewer mechanical failures and requires less maintenance than a traditional system. Service calls are reduced as well, as the automatic climate adjustments eliminate frequent calls to adjust uncomfortable air settings. Finally, a DDC system generates reports that measure and record energy consumption, service call activity and the maintenance schedule.

Examples of savings from controls and other upgrades - The study found many detailed examples of cost savings achieved through upgrades and automation in public, commercial and military facilities. Operational savings after upgrades typically ranged from 30% to 70%. One such example takes place on Kodiak Island, Alaska, where the Coast Guard is saving more than $220,000 a year in energy costs by completing $1.1 million of work in a pilot program for energy-saving projects. The improvements there have a pay back period of just over five years, and since the lifetime expectancy of the upgrades spans almost two decades, the project ROI is an impressive 4.0.

Another example takes place in San Diego, California, where the City Council upgraded a 1981 office building and lowered operational costs by 60% compared to an identical building right next door to it. The indoor air quality was improved by quadrupling the flow of outdoor air to 20 cubic feet per minute (cfm), compared to 5 cfm when the building was originally built. Energy-efficiency measures began by replacing the entire HVAC with high-efficiency systems, equipped with computerized energy management controls. High-efficiency window films reduced heat gain, fluorescent lamps and fixtures were installed with daylight sensors and occupancy sensors.

Green Strategies used at Ridgehaven
San Diego, California

Minimize solar heat gain
Use of light-colored exterior walls and roofs
Minimize non-solar cooling loads
Reduce internal heat gains by improving lighting and appliance efficiency
Cooling systems
Use accurate simulation tools to design cooling system
Use efficient cooling towers
Use water-cooled mechanical cooling equipment
Commission the HVAC system
Light sources
Use high-efficacy T8 fluorescent lamps
Controls and zoning
Use direct digital control (DDC) systems
Use variable-volume air distribution systems
Computers and office equipment
Use an occupancy sensor to turn off computer peripherals when the office is unoccupied

David A. Gottfried, who worked on the project, points out that "since the project qualified for San Diego Gas & Electric financing, all high performance, state-of-the-shelf measures were financed by the utility," the return on the energy-saving measures was infinite. Gottfried notes that even if the City itself had paid for these measures, the internal rate of return would have been over 30 percent. The energy consumption of the Ridgehaven building dropped to 7 ~ 8 kWh/ft2 from 21 ~ 22 kWh/ft2 before the upgrades. In CY 2001, energy consumption at the University of Florida averaged 20.7 kWh/ft2.

Controls on the UF Campus

A limited amount of direct controls exist in a handful of buildings on the Campus through the use of the Johnson Controls' Metasys® System. This has lead to the advantages mentioned above, including cost savings and a positive experience on the part of the occupants as well as the building engineers. Many types of Energy Management Systems (EMS) exist in the marketplace, with simple EMS systems starting at $4,000 installed, and more sophisticated wireless units available for around $10,000 per copy.

With nearly 40% the Campus kilowatt consumption incurred in just 50 buildings, it is easy to see that equipping those buildings with EMS systems would greatly enhance the Universities' ability to develop a feel for and better control its energy functions. Just like a patient in an operating room benefits from immediate attention to an increased heart rate or belabored breathing, so will the building infrastructure and university budget profit from access to modern day diagnostics.

Operating the Campus is like an orchestra playing music; each energy consumption point participates in creating the score. From an energy perspective, PPD, Operations Engineering, HVAC, Building Services, Facilities, Athletics and Forestry all play a role in how energy flows and is consumed within the campus system. It makes sense, therefore, that these actors receive the mandate and supportive funding necessary to lead the transformation of UF's energy management structure into the 21st century.

Today, a man tours the Campus with a notebook and pencil to collect building utility data. The result is 12 sets of numbers to express usage during academic and earth cycles for around 8760 hours of building operation. Tomorrow, a student will be able to pull up the exact energy consumed by his own building during the first 11 minutes of class. From an energy management perspective, it is the difference between navigating the ocean with a sextant or a global positioning unit (GPS).

For a reasonable amount of money, relying on existing human resources and off-the-shelf technology, it is quite feasible for the University to attain real-time control over the energy flows in 80% of the Campus load in under 3 years. Of the many options available, this is the most strategic first step towards improving our understanding of and ability to reduce costs and greenhouse gases in the University system.

Set Back Temperature	65	62	60	57	55	50	45
Per Cent Savings	4.0%	8.0%	10.7%	14.6%	17.3%	23.9%	30.7%

Percent winter savings from Set Back for a typical building in Philadelphia assumes 70 degrees F as the original base temperature.

Aerial Photo - 1949

Aerial Photo – 1990

Produced by the U.S.D.A. Natural Resources Conservation Service (Soil Conservation Service), these prints were used to create soil survey reports.

At first blush, it appears that UF has more carbon sequestered on Campus today than 40 years ago.

Reduction Options

Reduction Options - Green Buildings

Buildings use the majority of energy and represent the greatest source of greenhouse gas (GHG) emissions on the UF Campus. Buildings also offer the largest opportunity to reduce GHG's and lower monthly operating expenditures.

New approaches in design and construction routinely result in buildings that reduce operating costs by 50% or more without requiring a significant increase in design or material costs. One such example is Rinker Hall, which uses a fraction of the energy and water consumed by conventional buildings, lowering operating costs by around 60%.

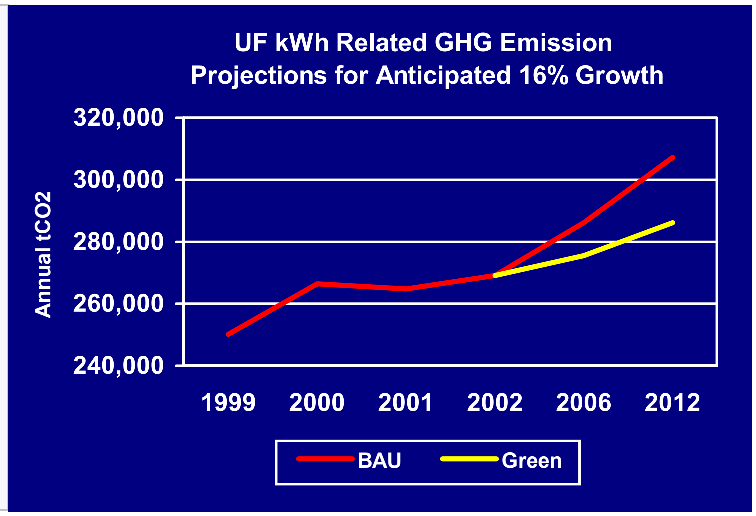
Given the availability of alternative construction options, adopting high standards for new buildings and evaluating the existing building stock for "green upgrades" represents an effective strategy for lowering GHG's while capturing operational savings in the UF campus setting.

UF is planning to grow by 16% over the next 10 years… What are the potential annual dollar and GHG savings if all new buildings are Green and operate at 50%?

Annual — **\$1,743,000 + 21,000 tCO_2**

Over 50 years — **\$87,150,000 + 1,050,000 tCO_2**

(Based on emissions from electric consumption only, using constant 2001 emission rates and pricing. Green buildings also reduce the use of steam, water, coolant gases, light fixtures, maintenance etc., and total savings would likely be higher)



From experience we know that choosing a green building design increases overall project outlay, in the case of Rinker Hall, by about ~ 10%. Compared to operational savings, however, this cost increase is offset in the first few decades by savings in electrical, steam, cooling and water.

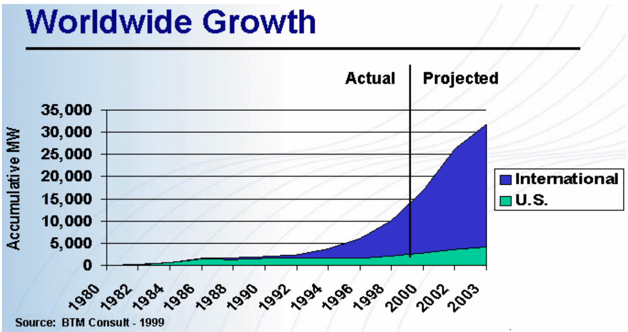
What is LEED?

The LEED (Leadership in Energy and Environmental Design) Green Building Rating System is a voluntary, consensus-based national standard for developing high-performance, sustainable buildings. Developed by members representing all segments of the building industry, LEED standards are currently available for new construction, upgrading existing buildings and commercial interior space.

LEED emphasizes strategies that promote integrated, whole building design practices that include sustainable site development, water savings, energy efficiency, materials selection and indoor environmental quality, among others. The overall benefit of LEED or "Green Buildings" to the occupant is a healthier, more pleasant work environment, resulting in elevated productivity and lowered operational costs. Any savings in GHG's are incidental, but highly measurable.

Reduction Options - Renewable Energy

If all the energy the University of Florida consumes came from renewable sources, the Campus GHG profile would shrink by 80%. Renewable energy therefore emerges as the ideal long-term solution for the campus' energy needs.

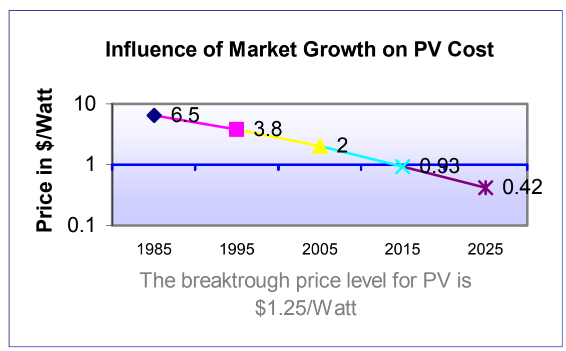


Renewable energy is also enjoying unprecedented popularity. Both Wind and Photovoltaic have experienced 6 years of back-to-back 20% growth. Renewables are the fastest growing segments in the energy industry for the last decade, primarily because they make electricity possible in remote locations.

While these novel power sources steadily gained market share, advances in computer design technologies, improvements in the manufacturing process of silicone, high-strength low-weight materials, gear technologies and software control systems have helped make renewables better and more reliable.

The sun and the earth

At the rate the Renewable Energy (RE) industry is growing, it is just a matter of time until these clean technologies become cost competitive enough for the University of Florida to consider implementing in large scale. The study found that Photovoltaics (PV) could be financially attractive as early as a decade from now. This is important, because roof space built today needs to be compatible with the energy panels of tomorrow. To ensure this, PV friendly design parameters need to be introduced as a component of current building planning process.



The ideal renewable technologies for Florida are Photovoltaic, Solar Thermal, and Geothermal. Over time, these technologies can be integrated into the UF campus setting and supply "home grown" power by perhaps as much as 20%. To better understand the potential of renewables at UF, consider the following; each year, the energy in the sunlight striking the State of Florida is about 10 times the amount of all energy consumed by the United States each year. The question is not whether there is enough sun; the question is what it takes for us to adapt our infrastructure to take advantage of this energy opportunity.

Solar Thermal (ST) technology can convert 30 ~ 50 percent of the received sunlight and use it to heat up air and water. Many off-the-shelf ST products exists that can be used to heat air and water cheaply and reduce the need of, for example, Natural Gas (LNG), which represents 1.72% of UF's GHG budget, and $1.7 million/yr in capital outlay. NG is used to heat water in dorms, fraternities/sororities, cafeterias, office buildings, laundry facilities etc., and can be replaced or reduced with ST applications with minimal investment risk. Solar Thermal has traditionally had the fastest payback of any commercially available RE technology, typically breaking even in 5 ~ 7 years. ST potential on the UF campus therefore merits a thorough review.

Photovoltaic (PV) systems can convert 6 to 15 percent of the solar energy received directly into electricity. With PV, the sun can be used to reduce the need for greenhouse gas causing fuels whenever it shines. One idea is use the solar panels as covers on UF parking lots to provide shade to the vehicles while generating electricity. To offset the cost, these energy petals could be sponsored by donors or by selling the green attributes to students and UF alumni.

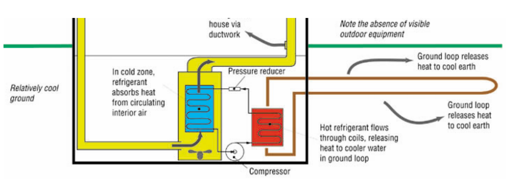
The world's largest parking lot solar system is located in Sacramento, California.

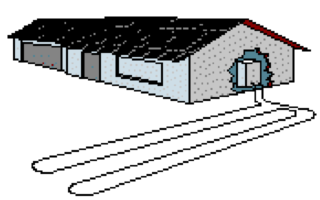
Building #	Building Name	Footprint (ft2)	
0209	PARKING GARAGE 2 (SHANDS WEST)	92,620	
0364	PARKING GARAGE 3 (SHANDS WEST)	78,941	
0173	HEALTH CTR GARAGE 9	44,103	
0358	PARKING GARAGE 4 (MUSEUM RD)	59,706	
1166	CULTURAL COMPLEX GARAGE	46,136	
0148	PARKING GARAGE 7 (SOC)	50,806	Sample PV panel
0207	PARKING GARAGE 1 (SHANDS EAST)	24,875	Shell SP150-P
0442	PARKING GARAGE 8 (NORMAN HALL)	46,106	

ft2 to m2 conversion		Total square footage	m2
0.0929		443,293	41,182
PV system cost per W ($)	watts per module	m2 per module	Cost per m2
12	150	1.32	$1,363.64
Cost to create PV roofs for above parking facilities (using 2001 prices)		Coverage %	W per m2
$22,462,865		40.00%	113.64
Cost to create PV roofs minus revenue from kWh		Project lifetime in years	total power in W
$17,051,561		40	1,871,905
Price per tCO2 lifetime $/tCO2 FPC		Lifetime output in MWh	Lifetime tCO2 FPC
242		98,387	70,347
Price per tCO2 lifetime $/tCO2 GRU		Yearly output in MWh	Lifetime tCO2 GRU
183		3,075	93,173
Lifetime revenue from MWh ($)		Revenue per kWh	Life time net cost in $/kWh
$5,411,304		$0.055	$0.1733

Geo Thermal (GT) or ground-source heat pumps, capitalize on the fact that temperatures 4 to 6 feet underground remain almost constant throughout the year. In Florida's case, ground temperatures are around 72°F year round. Because GT systems interact with this essentially 'free' thermal mass, GT systems are typically 10 ~ 30% more efficient than conventional heat pumps. In Geothermal systems, a transfer fluid, usually water, flows through a loop of underground plastic piping to carry energy back and forth to the building. In the summer, heat is extracted from the building by the fluid and is shed to the ground. In the winter, the fluid picks up heat stored in the relatively warm ground after which the heat pump boosts the temperature and delivers it to the building.

Image by Trane®

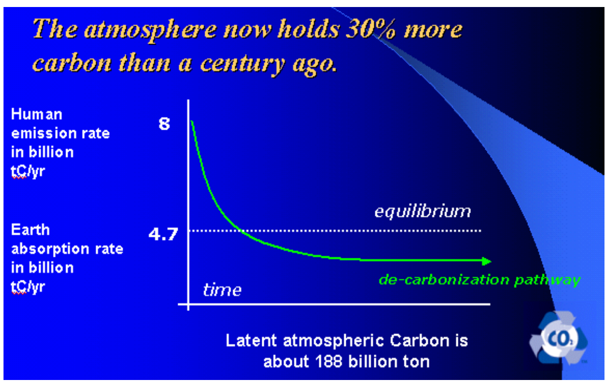




Reduction Options - Sequestration

Carbon sequestration could offer a local solution to UF's emissions profile that has the benefit of low price, beauty and bio-diversity while providing a form of economic stimulus to the community. Capturing CO2 using bio-systems is also the cheapest way to cause emission reductions to happen, cheaper then installing PV, for example. Since the University of Florida owns and is surrounded by land, the study suggests inventorying existing carbon sinks and to explore the modalities of sequestration programs here and abroad. Sequestration could be a keystone in UF's carbon neutrality program.

In addition to the practical advantages UF has in engaging and managing sequestration programs, it is important to understand that sequestration is globally considered to be integral to the long-term solution to climate change. Sequestration is currently a hot topic in industry and government research activity. Sequestration programs designed to help UF become carbon neutral may well be leveraged to attract additional research and outside funding opportunities.



Of all available measures, only sequestration can erase our global warming "debt", as carbon is actually removed from the atmosphere. This means that even after society shifts to a low carbon infrastructure (stop the fever from running up), large-scale sequestration programs are necessary to harvest CO2 back out of atmosphere (lower the fever). To illustrate the scale of this challenge, 7% of the land surface on planet earth would need to be rededicated from scratch with large, Douglas-type fir trees to remove man's excess carbon.

To balance out one year of UF GHG emissions, you would need to raise a 1,700-acre Longleaf pine forest. In relation, if 5% of Alachua County were reforested with Longleaf pine, UF could be neutralized for 20 years. Though a single project may be easier to manage, there are advantages to creating a portfolio of domestic and international activities encompassing a variety of sequestration pathways such as soil, forestry, wetlands, tidal marshes and energy crops. The study proposes inviting relevant UF departments to suggest their ideal dual-purpose sequestration programs where the primary beneficiaries are the advancement of research funding and UF's GHG bottom line.

Sequestration potential using Longleaf pine, a common species in North Florida, rotation age about 30 years.

Annual tCO2 to be offset	tCO2 to tC	value in tC	sequestration potential of Pinus palustris in tC/ha	
519,623	0.2727273	141,715		200
Annual hectares needed	acre to hectare	annual acres needed	assumed cost per tCO2	rotation age (yr)
708.58	2.47105	1,750	$5	30
cost to UF and total value to farmer		annual value	value per acre	value per acre/year
$2,598,115		$86,604	$1,484	$49.46

Sequestration potential using UF campus soils, designed and sponsored as a coastal defense project

area UF Main Campus	square foot per acre	average annual soil addition in inch and foot	
1,966acres	43,560	0.25	0.02
ft3 of new soil/yr	cubic yard/yr	weight in tonne	% carbon (by weight) in new soil
1,784,152	66,085	44,964	2
Annual carbon weight (t)	tC equivalent in tCO2		program life in years
899	3,297		100
tCO2 over program life	height gain (ft) UF Campus over program life		cost
329,736	2.08		????

Reduction Options - Emission Trading

Emission trading is an instrument that enables UF to purchase reductions achieved elsewhere and apply those reductions to its own bottom line. The trading of greenhouse gases is a fast growing, internationally available practice which in turn subsidizes and encourages the use renewable energy, energy efficiency, sequestration and other emission reduction activities.

Depending on the eventual approach the University chooses to address its GHG profile, emission trading could be used to offset part or all of its emissions. In turn, emissions trading could be used to generate revenue for UF by selling off reductions achieved by internal efficiency actions and campus RE activities. In the latter scenario, UF achieved reductions are removed from the UF GHG profile and transferred elsewhere, thereby increasing the GHG bottom line. However, the reductions have still taken place, UF is still benefiting from a lowered monthly energy outlay while the revenue from sales can be used to co-fund additional reduction activities.

Emission trading usually involves a buyer, a seller, a verification/certification agent, and a broker. The University, through the Office of Sustainability, has evaluated two rfp's for emissions reductions, one offered by the utility BC Hydro in Vancouver, Canada, and another by the City of Seattle in Washington state. Both rfp's have the same general constraints in terms of size and delivery schedule, with BC Hydro offering \$5/tCO2 and Seattle offering \$4/tCO2. The Seattle rfp requires action by January 31, 2003 the BC Hydro rfp is ongoing.

Emission trading has also been introduced recently in the U.S. congress as a way of lowering emissions on a national level, suggesting that perhaps UF may be faced with trading issues regardless of its own action timetable. Emission trading is also a key component of the Kyoto Protocol (KP), an international treaty aimed at lowering the emissions of greenhouse gases. The treaty goes into effect in 2008 and requires GHG reductions of over 20% by most industrialized nations. To meet these targets, trading is already taking place, which in turn is driving up the price of reductions. Depending on whether UF becomes a seller or buyer of reductions, the market price will influence the fiscal construct of any GHG reduction planning.

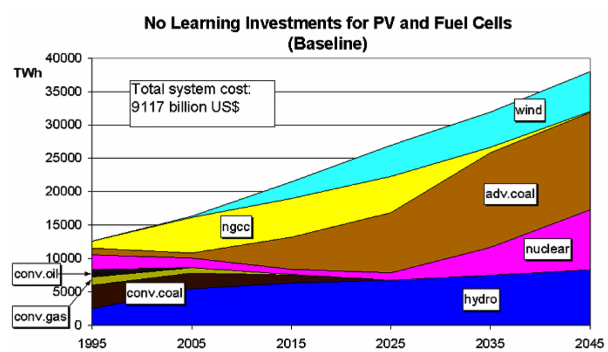
This table portrays the potential value of UF GHG reductions over the next two decades.

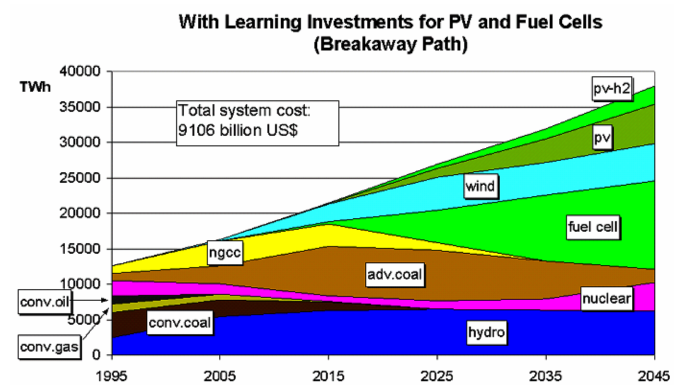
tCO2/yr	Total tCO2 generated by 2020	$/tCO2	$/tCO2	$/tCO2	$/tCO2
519,623	9,353,206	5	10	15	20
Reduction period		**Offset Value**			
2002-2005	0.25	$ 11,691,508			
2005-2010	0.25		$ 23,383,015		
2010-2015	0.25			$ 35,074,523	
2015-2020	0.25				$ 46,766,031
					$ 116,915,076

Total electric outlay by 2020 in $

$ 521,233,636

Based on emissions from electric, steam, water, coolant gas and fuel consumption, assuming continued 2001 emission rates and pricing. Value attributed to emissions reductions are based on available models, reflecting the demand over time as participating Kyoto countries try to reduce their GHG emissions. The Kyoto commitment periods run in 5-year blocks, the first of which is from 2008 to 2012. The underlying objective of KP is to reduce global GHG emissions by 60% or more, in 4 to 5 separate commitment stages.





Experience Curves for Energy Technology Policy. ISBN: 92-64-17650-0, International Energy Agency

The character of the future global grid is primarily influenced by the locking-out or locking-in of cost-efficient, CO_2-mitigation technologies.

Reduction Estimates

Reduction Estimates - Overview

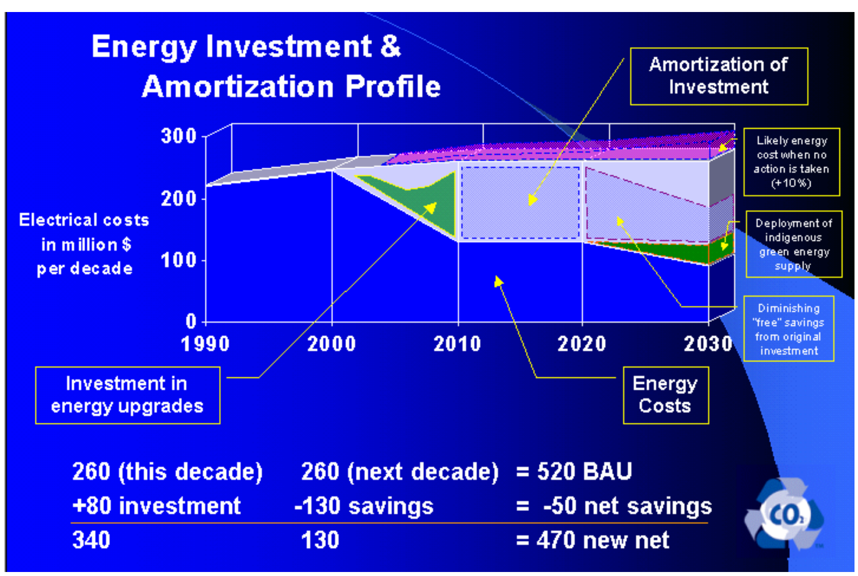
From a practical point of view, UF could achieve carbon neutrality simply by investing in a large-scale afforestation or reforestation project somewhere in the Americas and forego any reduction activities in-house. On the other hand, in-house reductions, which require a focused effort to accomplish and carry with them the challenge of up-front capitalization, insure long term cost savings and permanent reductions in the emissions budget.

The gross cost to achieve carbon neutrality is consequently heavily influenced by the proportion of reductions achieved inside the UF Campus system. In the short term, Campus reductions are costly, but in the long term they pay for themselves and can be used to raise funds and co-finance further reduction projects. The trick may lie in designing an infrastructure investment menu in which only alternatives that pay back at least twice their worth appear. The control functions of time and relative risk could then be used to shape the decision matrix to select low cost & quick return projects first and higher cost & slower return projects later.

For the purposes of this reduction estimate, the following basic reference was utilized. Between 2000 and 2020, UF is expected to pay a minimum of $521 million for electricity, primarily to operate campus buildings. On this 20-year scale, each percentage point is worth a bit over $5 million. If UF can manage to reduce one percent of electrical consumption for two million dollars, than she is three million dollars ahead. Since investments make the improvements possible, the sooner the execution, the quicker and longer benefits can be reaped.

Using the bi-decadal scale, if an $80 million dollar investment in UF infrastructure can achieve $130 million in electrical savings, it should be considered because the money dynamics are there and valuable environmental savings such as greenhouse gases are essentially incurred for free. This research found that an appropriately executed investment of $40 to $80 million dollars in lighting, heating, cooling, glazing, diagnostics, sensors, control software, plug-load change-out and real time management capabilities can achieve a substantial reduction in energy consumption, varying between 30% to 50%, in the main UF Campus setting.

"We wanted to know if all the improvements took place this decade, what would next decade look like?"



Reduction Estimates

Because of UF's considerable size and the highly distributed nature of greenhouse emission events, any attempt to transform the UF Campus to a sustainable, low-carbon operation can only be achieved by involving the many departments and personnel that participate in its daily operations.

One of the first things to consider is the shape and nature of the framework in which these various participants can contribute to the transformation process. The framework would be the body in which objectives are articulated, resources are allocated and results are recorded. The framework would likely remain active through the transformation process, though participants may drop in and out as their objectives are achieved. Though the functionality would remain the same, the framework may scale somewhat depending on whether UF pursues a moderate or an aggressive approach to carbon neutrality. The framework would need to be anchored by a core of people with long term attachment to UF, good access to decision makers and excellent cross campus coordination skills.

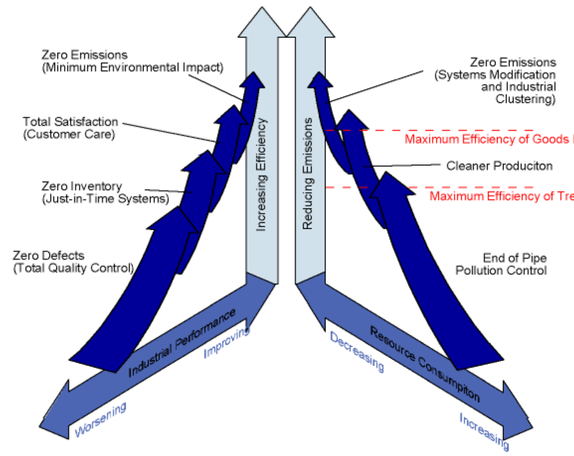
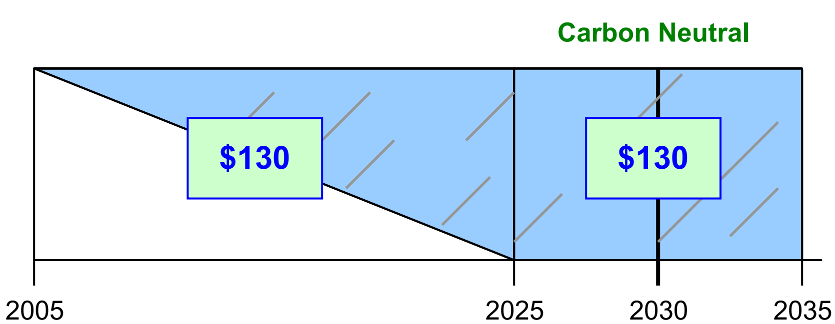


Image by NIRE, Japan

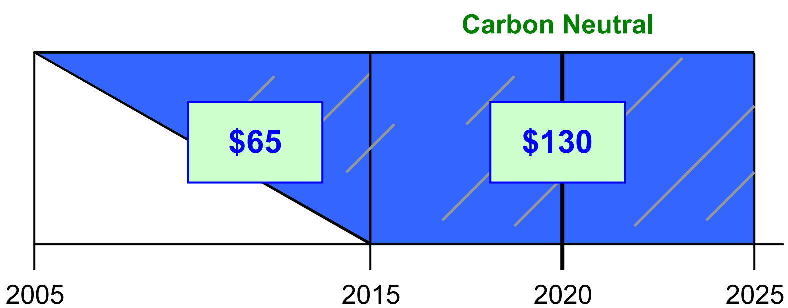
Business As Usual (BAU) for the purpose of this report refers to facilities management on the scale and tempo that currently has UF ranked as one of the better-maintained campuses in the nation. The range of services provided by UF staff span from plumbing to landscaping, automotive repair to architectural work and dozens of activities in between. It is not uncommon for PPD to fulfill over 4,000 work requests a month to service the ten million square feet and two thousand acres that 50,000 students, faculty and staff make use of on a daily basis. Managing this facility is an awesome thing; it is the mojo that keeps the campus humming. Nonetheless, at the rate of expansion anticipated, BAU would likely result in increased energy consumption and resulting greenhouse gas emissions in the order of 8% ~ 12% by 2020.

Moderate Approach (MA) this report reflects an investment strategy that lowers the annual financial commitment in return for achieving carbon neutrality later rather than sooner. The basic characteristic of this approach is to table low-cost, quick return projects first, wait for those projects to reach their payback point, and then use any further savings to finance higher cost & slower return projects. In the moderate approach, carbon neutrality is reached around 2030. The advantage of MA is a larger return on investment, simply because the energy saving measures have more time to accrue costs savings before the carbon neutrality point is reached. In MA, offsets are higher priced, as they are acquired later when global competition for them is expected to have driven prices up.



Savings	2005 - 2025 =	130
Savings	2025 - 2035 =	130
Investments	2005 - 2025 =	- 80
Investments	2025 - 2035 =	- 40
Offsets	2025 - 2035 =	- 62
Net	2005 - 2035 =	78
ROI energy investment	2.166	(30yrs)
ROI carbon neutral	1.428	(30yrs)

Aggressive Approach (AA) this study has the same investment characteristics as the moderate approach, except that the entire upgrade schedule is executed in one decade (front-loaded). Cost savings from energy upgrade measures made at the onset of the schedule have therefore less time to accrue, which leads to a lower overall return by the time carbon neutrality is reached. On the other hand, offsets are cheaper because they are purchased before competition really intensifies, compensating somewhat for the lower energy ROI. In the aggressive approach, carbon neutrality is reached by 2020. It should be noted that in both MA and AA the investments are of the same dollar amount and target the same upgrades and infrastructural improvements. In addition, after the primary objectives have been reached, both models assume continued elevated funding for energy related projects above and beyond BAU to keep the University at the highest efficiency levels possible.



Savings	2005 - 2015 =	65
Savings	2015 - 2025 =	130
Investments	2005 - 2015 =	- 80
Investments	2015 - 2025 =	- 40
Offsets	2015 - 2025 =	- 37
Net	2005 - 2025 =	38
ROI energy investment	1.625 (20yrs)	
ROI carbon neutral	1.242 (20yrs)	

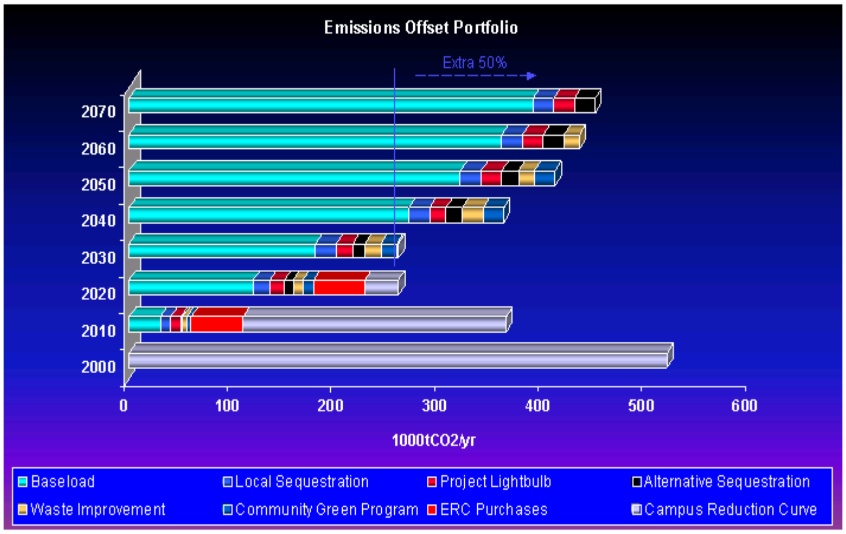
Detailed Estimate, Aggressive Reductions

For the purpose of the "aggressive model", the study mimicked the complete retrofit of cooling and lighting components in the UF Campus, a subsidy to phase out pre-1994 electrical and other non Energy Star® equipment, the installation of sensors and bi-directional controls on buildings making up 80% of the electrical load, a healthy budget to change the thermal characteristic of buildings through glazing improvements, insulation and so on, rounded out by a modest green energy component.

	MWh/yr	MWh 2002-2020	$/MWh	Value tCO2 2010-2020	Value kWh 2010-2020		
	369,951	6,659,118	72	$ 26,468,600	$ 266,364,720		
Function		**Remaining Load**	**Relative Reduction**	**Value of tCO2 @ $10/t**	**Value of kWh Savings ($)**	**Combined Value ($)**	**Cost**
Behavior	5%		30%	1,323,430	13,318,236	14,641,666	$ 4,500,000
AC	15%	14.8%					
AC Reduction	10%		40%	2,593,923	26,103,743	28,697,665	$ 13,563,200
Lighting	8%	8.0%					
Lighting Reduction	12%		60%	3,176,232	31,963,766	35,139,998	$ 7,617,119
Equipment	10%	10.0%					
Equipment Reduction	10%		30%	2,646,860	26,636,472	29,283,332	$ 11,098,530
Remaining Load	14%	14.0%					
Other LEED & controls	10%		30%	2,646,860	26,636,472	29,283,332	$ 39,000,000
Bio Fuel	5%	5.0%	5%	1,323,430	-2,774,633	-1,451,203	$ 2,774,633
PV, ST	1%	1.0%	1%	264,686	2,663,647	2,928,333	$ 4,000,000
Total	**100%**	**52.8%**		**$ 13,975,421**	**$ 124,547,704**	**$ 138,523,124**	**$ 82,553,481**

In the above example, energy saving measures implemented in the 2000-2010 timeframe results in over $40M in savings the decade after implementation. The value of the GHG reductions, expressed here as tCO2, can be counted as currency under evolving GHG asset recognition standards. The reductions can also be sold to a third party, in which case the value transfers off the UF balance sheet.

What to do with emissions you can't avoid? – Whether she chooses a moderate or intensive reduction approach, UF will be faced with continued emissions in the near to intermediate term and needs to prepare to offset those emissions. One of the more attractive strategies is to create a long-term base load reduction project, accompanied by a subset of smaller, short-term projects to provide for flexibility. The baseload project sees mainly to lower the cost of achieving carbon neutrality and indirectly support smaller, higher cost projects.



The baseload project is purposely arranged to grow beyond UF's own reduction needs so it can be leveraged later this century to fund projects after UF itself has reached carbon neutrality. At this time, carbon will have become but another financial instrument in UF's daily business practices.

In this scenario, UF's offsets intersect with the declining emissions rate around the 2020-2030 time frame. The baseload is supersized by 50% relative to current needs, as shown in blue. This would allow UF to include off-Campus assets, neutralize old emissions, or commoditize the reductions.

Carbon Neutral Investment Menu, assemble your own portfolio

All items in the menu help reduce greenhouse gases, but the chart only rates options according to savings from a cost perspective. Therefore, enhancing UF's role in Public transport, though very valuable from a GHG perspective, is listed as having zero payback. Cost is expressed as a combination of the gross amount and the time it takes for the payback point to be reached. For example, Green buildings are listed as high cost because it takes a decade or so for the investment to start paying off even though the green upgrade is typically only 10% or 20% of total building cost. Similarly, Green fleet is listed as medium cost, because though hybrid vehicles cost a few thousand dollars more then the BAU alternative, the vehicles easily recoup the difference in fuel savings in under 5 years. Risk mostly expresses the challenges of execution. Lights, for example, are listed as low risk because they are low tech and usage is constant. Controls, Chillers and Forestry are thought of as medium risk because they require planning, engineering and dedicated maintenance programs to be successful.

Item	Investment Profile	Point of return	Item life cycle (yrs)	Item Price
Lights	Low cost / low risk / short payback	2 ~ 3 yrs	10	$10,000
Solar film	Low cost / low risk / short payback	2 ~ 3 yrs	20	$10,000
Sensors	Low cost / low risk / short payback	1 ~ 2 yrs	20	$5,000
Controls	Low cost / medium risk / short payback	1 ~ 2 yrs	20	$10,000
Plug load	Low cost / medium risk / medium payback	3 ~ 5 yrs	5 ~ 30	$200
AC units	Medium cost / low risk / medium payback	3 ~ 5 yrs	20 ~ 30	$500
Air handlers	Medium cost / low risk / medium payback	3 ~ 5 yrs	20 ~ 30	$5,000
Chillers	High cost / medium risk / long payback	7 ~ 10 yrs	20 ~ 30	$500,000
Green buildings	High cost / low risk / long payback	10 ~ 30 yrs	50 ~ 100	$750,000
Bio-diesel	Low cost / low risk / zero payback	N/A	N/A	$9,000/yr
Green fleet	Medium cost / low risk / medium payback	3 ~ 5 yrs	8 ~ 15	$2,000
Public transport	Medium cost / medium risk / zero payback	N/A	N/A	$1,500,000/yr
Project light bulb	Medium cost / low risk / medium payback	3 ~ 5 yrs	5 ~ 7	$90,000/yr
Local forestry	Medium cost / medium risk / zero payback	N/A	25 ~ 35	$5,000,000
Overseas forestry	High cost / medium risk / long payback	N/A	45 ~ 99	$10,000,000

Carbon Neutral Assessment Project

University of Florida
Office of Sustainability
November 2003

Acknowledgements/References

Acknowledgements/References

This report was made possible by the contribution of countless hours, phone calls, emails, data sets, anecdotes and on-site visits provided by the incredibly patient and forthcoming UF staff.

Below is a short list of the many people who contributed knowledge, help and guidance necessary in assessing the various business processes of the UF Campus system. There were many more contributors, to whom I apologize for not including.

Sustainability Task Force, for commissioning this ambitious study.
Office of Sustainability, for support and encouragement.
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"For UF, cost effective carbon neutrality lies at the intercept of on-campus energy optimization, off campus project development, carbon sequestration and long term operational savings."

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Method of Analysis

Method of Analysis

A variety of resources were used to derive emission and reduction values in the course of this project. All values were compared against the 1996 *IPCC Guidelines for National Greenhouse Gas Inventories* and checked for accuracy and relevance. The general boundary of the initial inventory was established during a meeting with the Sustainability Task Force, representatives of Administrative Affairs and the investigators. The confluence of data availability and ease of project execution directed focus of the initial inventory to the main Campus using available data only. Later, a regional transportation and public transport emissions impact component was added as an observational, non-itemized article to the inventory.

Facilities Planning and Construction provided spatial and occupancy data for the 17million square feet of Campus building space, Physical Plant Division provided monthly meter readings and pricing for 6 product values reflecting the last six years consumption for all tracked buildings. This was blended in a relational database with the emissions rate, enabling the user to view consumption, cost, energy and greenhouse impact at any point in the organizational hierarchy and select to view these impacts laterally for a particular building, or department or college wide. The application was fitted to provide the user the ability to create a baseline for a particular impact group and model financial and environmental benefits using a menu driven investment table. Some of these features were used to establish reductions scenarios discussed in the report. Members of the Physical Plant, Heat Plant 2, were instrumental in creating the detailed HVAC data set, while Motor Pool provided the vehicle consumption records on a granular level. The Flight Director of the Athletic department calculated the Jet Fuel use and Regional Transport System (RTS) supplied the highly detailed bus-rider information. Only for electricity was the data coordinated to start in January 1996, for all other emissions events calendar year 2001 data was utilized. None of the provided data sets were checked against a second source, but were visually and algorithmically examined for consistency and completeness. A qualitative description of emissions totals as listed in the report is mentioned underneath; with the confidence level of the emissions results expressed at 3 levels, low, medium and high.

Electricity - *high* - emission rates associated with kWh consumption were borrowed from the U.S. Environmental Agency's (EPA) Emissions & Generation Resource Database, eGRID, and reflect the emissions generated in the power control area (PCA) that the University is located in. The database lags a few years in production, but has up to date values for 1996 ~ 2000. For CY 2001, year 2000 emission rates were applied. No discounting was factored in to account for distribution losses, which nominally stand at about 10% for the State of Florida. It is recommended for a future study to collaborate with the University's energy provider, Progress Energy, to ascertain system and distribution losses to and from Campus, as well as within the campus proper.

Water - *high* - emission rates associated with water consumption were provided by Gainesville Regional Utilities (GRU) and reflect the energy use associated with water extraction, treatment and pumping from the Murphree Water Treatment Plant to the UF Campus. Emission rates for GRU's Power Control Area (PCA), as used in the production of drinking water, were borrowed from eGRID.

CFC's & HFC's - *low* - emission values for Chlorofluorocarbons and Hydrofluorocarbons used in HVAC cooling applications at the Universities central chiller facilities were sourced from The Air Conditioning & Refrigeration Technology Institute's Refrigerant Database. Actual consumption and loss figures were largely un-attainable, as no central data collection point for these activities exists at UF at this time. Using popular references, an annual loss quotient of 3% was introduced, reflecting broadly recent gas recovery techniques in the industry.

It is recommended that for a future study coolant gas usage data is carefully tracked as some of the gases used at UF have a global warming potential in the 5000 range and can maintain their molecular shape and heat trapping characteristics for over half a century or more.

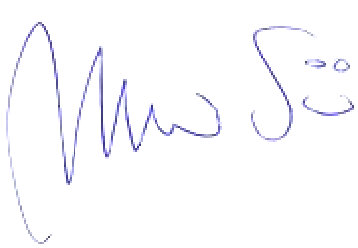
Steam - *medium* - emission values for steam use were un-attainable and an approximation was derived using the electric allocation factor, sourced form eGRID, for the University of Florida Co-generation plant, currently owned and operated by Progress Energy. The gas fired cogen plant is located on campus and produces electricity and several qualities of steam. The emission values for the steam components vary according to the energy expended to produce the primary, secondary and tertiary products, which alternatively can be electricity or steam. It is recommended that in a future study the University work together with Progress to determine on a monthly basis the energy and relative emissions associated with UF steam consumption.

Liquid Fuels - *high* - emission values for Natural Gas, Diesel, Gasoline and Jet Fuel were sourced from Argonne National Laboratories' Greenhouse Gases, Regulated Emissions, and Energy Use in Transportation Model, commonly known as GREET**.** The values applied reflect the consumption of the fuels themselves, not the energies expended during recovery, processing and transportation of the fuels.

Emissions Reduction Technologies - *high* – reduction values derived from energy efficiency measures such as digital controls, solar shading and compact fluorescent lights, renewable energy applications, low emission vehicle technologies and carbon sequestration were compiled using a mix of on Campus examples, case study's gathered by the U.S. Department of Energy (DoE), various State energy programs, research publications and manufacturers specifications. It is recommended, however, that each engineering or upgrade project be carefully evaluated as the figures used in this report are broader stroke and may not apply in any particular case. The study further recommends that UF engage itself over time to evaluate possible carbon sequestration options within its own holdings as well as through its academic and business network as the greatest amount of reductions for the lowest price can be accomplished that way, and as such sequestration can hold great sway in the total cost of any potential carbon neutrality plan that may come under consideration.

For ICBE:
Mark van Soestbergen

April 23, 2004
Gainesville, Florida, U.S.A



Assumptions

Assumptions used in creating the 2001 UF Greenhouse Gas (GHG) Profile.

UF Campus

acres	1,966
employees	10,000
students	40,000
building ft2	14,169,525

Fuel

gasoline (gal)	342,417
diesel (gal)	65,927
jet fuel (gal)	62,138

Other energy

kWh	369,951,000
steam (lbs)	873,635,000
water (gal)	1,050,867,018
natural gas (Therm)	1,662,542

Carbon intensity of energy

gCO2/kWh	715	
gCO2/Kgal	730	
gCO2/Klbs steam	715,000	(est.)
gCO2/MCF natural gas	55,623	
gCO2/gallon gasoline	8,750	

Emissions per sq. foot per year

kgCO2/ft2/yr	18.69
lbsCO2/ft2/yr	41.20
kWh/ft2/yr	26.11

Cost per unit of energy

$/kWh	0.07120
$/MWh	71.20
$/Mcf natural gas	10.59
$/Kgal	0.87

Greenhouse Gases (GHG's)		profiled
carbon dioxide	CO2	√
methane	CH4	-
nitrous oxide	N2O	-
hydrofluorocarbons	HFC's	√
perfluorocarbons	PFC's	-
sulfur hexafluoride	SF6	-

Source types profiled
all campus facilties, physical plant(s), transportation

Emissions types included in profile
direct & indirect

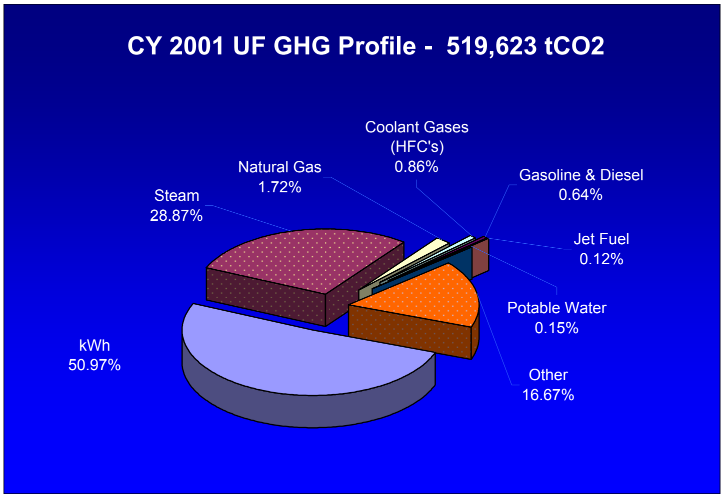
Measurement protocols applied on a best-fit basis
IPCC, EPA, Argonne, WBCSD, ICBE

Internal UF auditing
to be determined

Third party verification
provided by Purvis & Gray, Gainesville, Florida

Submitted to the Sustainabilty Task Force on 092303

The Greenhouse Gas Profile for the main UF Campus.

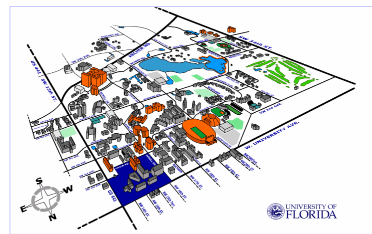


Function	tCO2	Cost in USD
kWh	264,868	$ 26,340,495
Steam	150,000 (est.)	$ 3,337,286
Natural Gas	8,943 (est.)	$ 1,702,675
Coolant Gases (HFC's)	4,489 (est.)	
Gasoline & Diesel	3,351	$ 500,413
Jet Fuel	601	$ 167,151
Potable Water	767	$ 914,254
Other	86,604 (est.)	
Total tCO2 CY 2001	519,623	$ 32,962,274

GHG and cost rate per hour and day

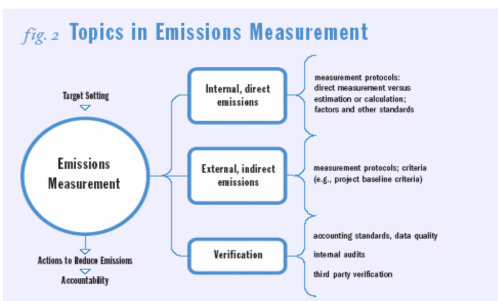
per hour	59	$ 3,763
per day	1,424	$ 90,308

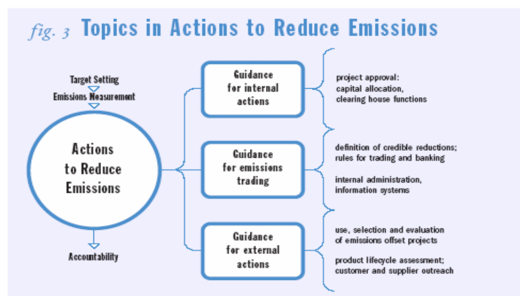
Take a Virtual Tour of the UF Campus



Learn about accounting protocols
Standards for carbon accounting are evolving

Considerations in play when counting greenhouse emissions.





Images by Environmental Defense

Partnership for Climate Action (PCA)

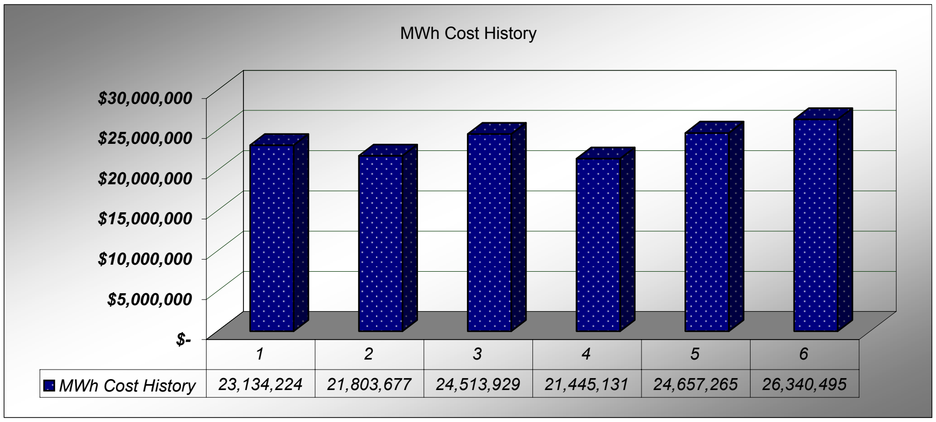
The UF GHG profile as compared to the number of students, annual budget and other parameters.

			% Comparison
tCO2 CY 2001		519,623	10.392% Gainesville
lbs CO2 per student/day	78	61,980,000	0.838% Florida
kg CO2 per student/day	36	6,746,000,000	0.008% U.S.
		23,000,000,000	0.002% Global

UF general characteristics		CO2 in tonne		CO2 in tonne		Water in Gal		Water in tonne	
Students	40,000	per student/yr	13	per ft2/yr	0.02	per student/yr	26,272	per student/yr	99
Salaried employees	10,000	per employee/yr	52	per day	1,424	per day	2,879,088	per day	10,899
Budget (CY 2001)	1,857,000,000	per budget $, in lbs	0.62	per hour	59	per hour	119,962	per hour	454
Humans in the educational process	50,000	per human/yr	10.39	per human/day	0.028	per human/day	58	per human/day	0.22
UF credit hour	1,222,673	per credit hour	0.42			per credit hour	859	per credit hour	3.25

Chart reflecting main Campus electrical consumption and cost figures.

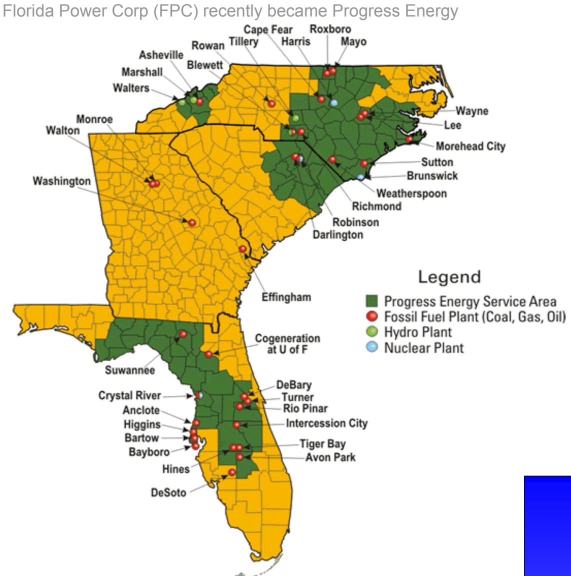
CY Year	MWh	Total Cost	Price	% change in price baseline = 1996
1996	348,269	23,134,224	0.0625	
1997	347,727	21,803,677	0.0629	1.01
1998	392,801	24,513,929	0.0619	0.99
1999	349,447	21,445,131	0.0609	0.97
2000	372,148	24,657,265	0.0712	1.14
2001	369,951	26,340,495	0.0712	1.14



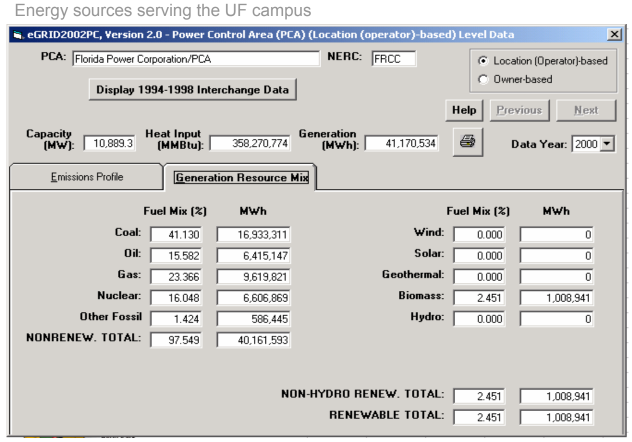
Learn about Physical Plant Services
Learn more about UF's energy provider

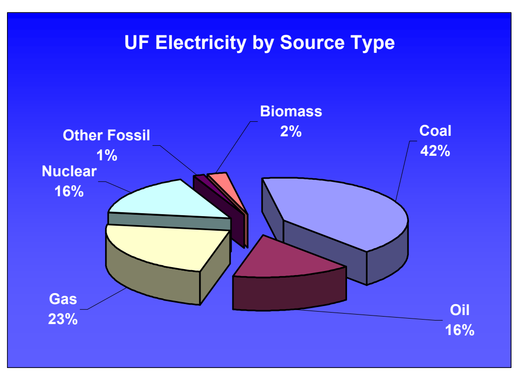
The University of Florida's energy is generated by a mix of fossil, nuclear and renewable technologies.

Florida Power Corp (FPC) recently became Progress Energy



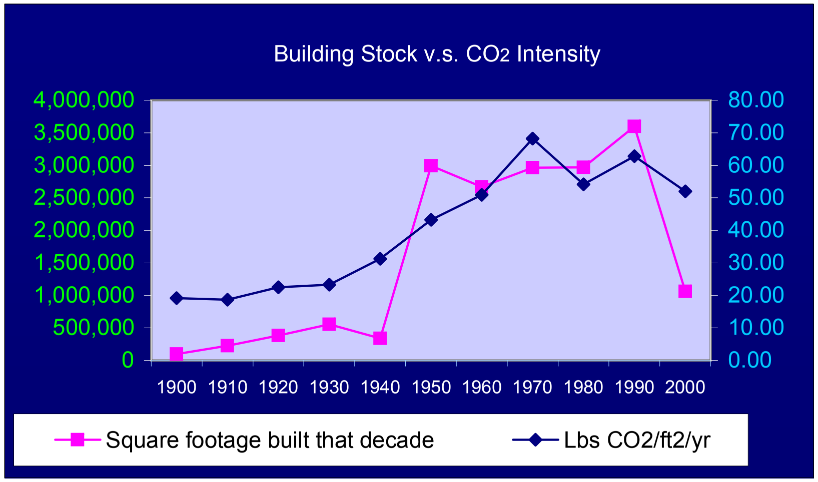
Energy sources serving the UF campus





Coal	41.13%
Oil	15.58%
Gas	23.37%
Nuclear	16.05%
Other Fossil	1.42%
Biomass	2.45%
	100.00%

Chart describing CY 2001 kWh related CO2 emissions rate of the UF building stock, square footage grouped by the decade of its construction.



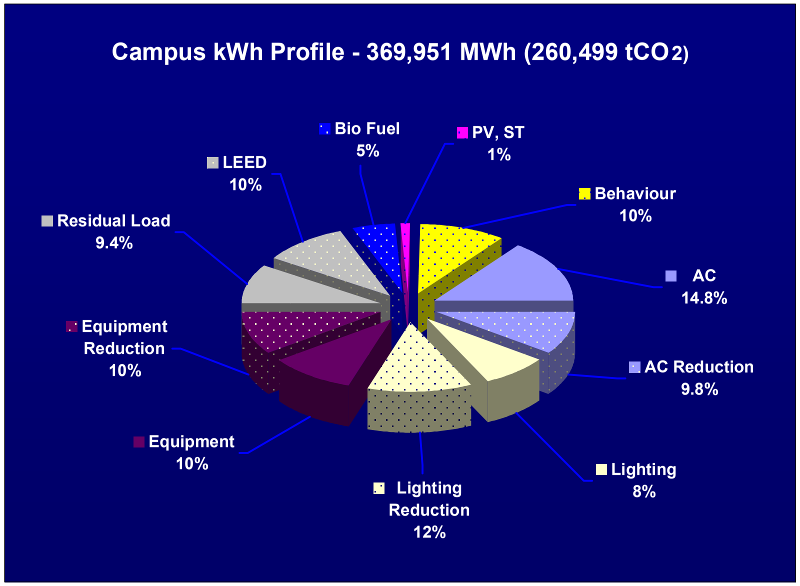
Decade	Buildings	ft2	% of ft2	CO2/ft2
1880	2	6,720	0.04	
1900	4	97,640	0.55	19.21
1910	9	225,034	1.26	18.69
1920	12	383,276	2.15	22.52
1930	16	557,177	3.12	23.30
1940	27	340,321	1.91	31.30
1950	148	2,991,517	16.75	43.28
1960	182	2,669,090	14.95	50.89
1970	174	2,965,498	16.61	68.20
1980	152	2,966,148	16.61	54.11
1990	197	3,596,950	20.14	62.81
2000	28	1,059,366	5.93	51.95
totals	951	17,858,737	100	53.07
				weighted

Average 1900-1950
26.38

Average 1960-2000
57.59

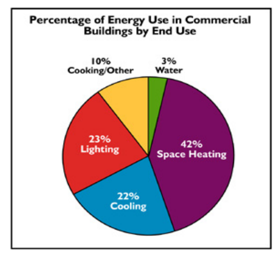
Learn more about UF buildings
Locate buildings on the UF Campus

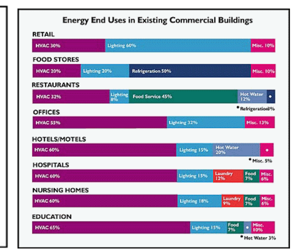
Chart modeling some of the electrical end-use assumptions and reduction areas identified in creating UF Carbon Neutral Scenarios.



Function	%	Remainder
AC	14.8	14.8
AC Reduction	9.8	
Lighting	8	8
Lighting Reduction	12	
Equipment	10	10
Equipment Reduction	10	
Residual Load	9.4	9.4
LEED	10	
Bio Fuel	5	5
PV, ST	1	1
Behaviour	10	
Total	**100**	**48.2**
Total Reductions	51.8	
Total Conversions	6	
Total % CO2 Affected	57.8	

[Learn about load reduction in office equipment]
[Review eeBuilding tools]
[Electricity and the UF Master Plan]
[Energy Conservation & the UF Campus]





Images by DOE

Tables extrapolating consumption, emissions and cost data for natural gas use on the main Campus area.e

Extrapolated Natural Gas Consumption Data 1999 / 2000

	July	August	September	October	November	December	January	February	March	April	May	June	Extrapolated Annu
Natural Gas	110,288.00	103,023.00	92,851.00	110,148.00	121,630.00	136,689.00	179,760.00	184,777.00	204,567.00	141,719.00	0.00	0.00	1,662,542
Electricity	38,040,920.00	27,623,734.00	35,308,441.00	28,274,615.00	23,321,362.00	26,307,189.00	24,699,097.00	24,800,551.00	21,759,868.00	31,482,442.00	0.00	0.00	337,941,863
Water	46,491.60	50,056.60	53,665.10	62,672.40	55,565.20	48,797.30	45,349.40	40,588.00	45,845.60	49,506.90	0.00	0.00	598,246
Chilled Water	10,406.99	10,585.70	10,032.79	7,659.43	5,128.38	5,420.76	4,886.70	4,344.53	5,002.72	7,038.50	0.00	0.00	84,608
Steam	82,779.44	65,000.14	73,469.47	64,897.55	60,614.39	68,656.98	101,540.70	76,437.57	63,276.85	71,356.04	0.00	0.00	873,635

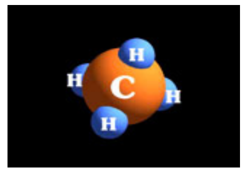
Therms	1,662,542
SCF	160,781,388
ratio SCF/Therm	96.71
tCO2	8,943
Mcf Value	$1,702,675

GHG rate	Heating Value	Density	C ratio	C ratio	CO2 ratio	CO2 ratio
Mcf to tCO2	Btu/SCF	grams/SCF	% by weight	grams/SCF	grams/SCF	grams/Mcf
17.98	1031	20.5	74.0	15.17	55.62	55,623

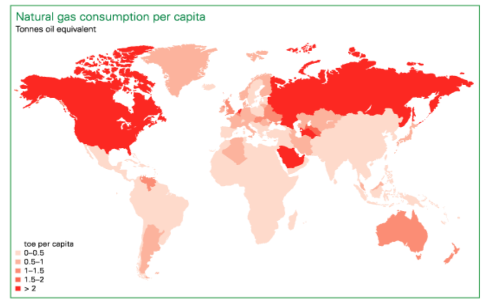
Useful reference:
http://www.iea.org/Textbase/stats/gasresult.asp
http://earthtrends.wri.org/text/CLI/variables/483.htm

Reference Data (highlight to view)

SCF	4583000
Therms	47390
BTU	4739000000
Heating Value	1034.04
tCO2	264.16
Value $/MCF	$10.59
Total value	$48,534



Natural Gas Molecule



Natural Gas Market Overview

Tables showing CY2001 UF Campus fresh water consumption, rainwater precipitation and related emissions figures.

Potable Water CY 2001				
total Kgal	kWh factor per Kgal	GHG factor per kWh (g)	GHG per Kgal (g)	tCO2 total from water use 2001
1,050,867	0.77	947.84	729.83	766.96
total gallon				
1,050,867,018			cost per Kgal	total cost water
			$ 0.87	$ 914,254

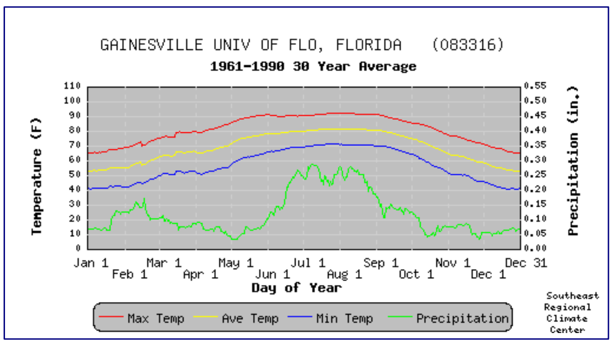
Rain Water CY 2001				
Area UF Main Campus		square foot per acre	avarage annual rainfall in inch and in foot	
	1,966 acres	43,560	51.53	4.29
ft3 water UF campus yearly		gallon per ft3	campus rainwater in gallons	total Kgal
367,749,474		7.48	2,750,957,294	2,750,957
% bought vs 'received' water		**% rain water vs 'bought' water**		
38.20%		**261.78%**		

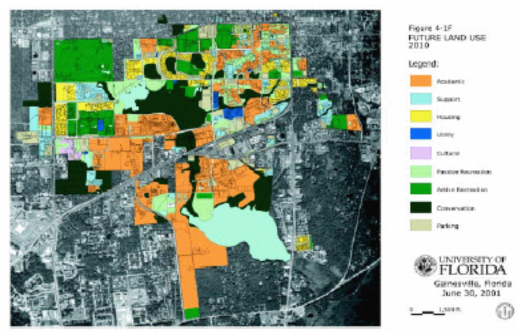
http://www.phys.ufl.edu/cgi-bin/weather.cgi/
Learn about local drinking water

About saving rainwater
Learn about sustainable rainwater management

Rainwater as drinking water
Rainwater harvesting tips

Florida functions like a giant Britta filter and naturally offers us some of the finest water on earth.





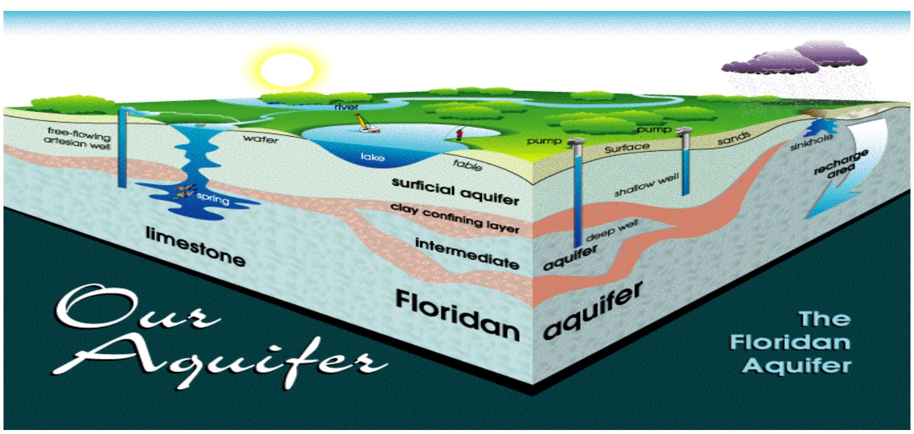


Image by: St. John's Water Management District.

Tables showing GHG emissions from vehicle fleet and jet air activities.

2001 Calendar Year Usage Averages

Gas (gal/wk)	Diesel (gal/wk)
6,100	1,500

2000-2001 Fiscal Year Total Usage
(July 1 2000 - June 30 2001)

	Gas (gal)	Diesel (gal)	
	342,417	65,927	
	$/gal	$/gal	
	$1.24	$1.15	Fuel Cost
	$ 424,597	$ 75,816	$ 500,413

Fleet FY 2000 tCO2 gasoline	Fleet FY 2000 tCO2 diesel	Fleet FY 2000 tCO2 fuel
2,996	681	3,677

2000-2001 Calendar Year Total Usage
(Jan 1 2000 - Dec. 31 2000)

Jet Fuel (gal)	
62,138	
$/gal	
$2.69	Fuel Cost
$ 167,151	$ 167,151

Air CY 2001 tCO2 kerosene	Fleet & Air 2000/2001 tCO2 fuel
601	4,278

[Learn about Fuel Cycles]

Tables present approximations for UF rider impact on Regional Transit Service's (RTS) direct and indirect GHG emissions.

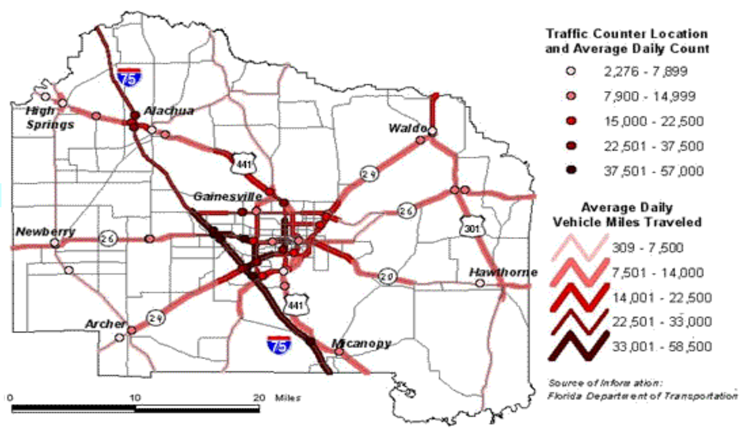
FY 2002 RTS Energy / Emissions Profile

Diesel (gal)	tCO2 fuel	
700,716	7,242	
RTS ridership	RTS vehicle miles	RTS intensity
7,185,018	2,332,684	3.08
Student ridership	Student tCO2 share	Student funding/yr
75%	5,432	$ 3,600,000
UF ridership	UF trip count	Per student mile
5,388,764	2,694,382	$ 0.17
miles per one-way trip	Miles avoided	Cost per tCO2
4	21,555,054	$ 373
MPG avoided miles	Gallons avoided	Likely tCO2 avoided (net)
10	2,155,505	9,656
Gross tCO2 avoided	Certainty factor	Likely tCO2 avoided (gross)
18,860	80%	15,088

Tool estimating UF employee and student share of community-wide transportation related GHG emissions.

1998 Mobile Source Emission Estimates and VMT/Day Categorized by Roadway, Alachua County, FL

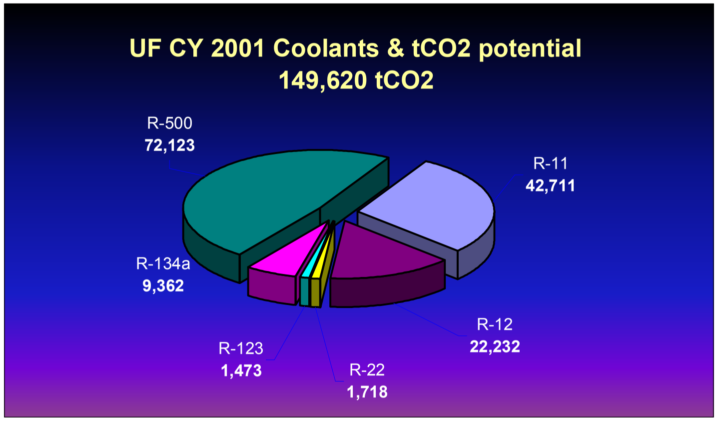
4,949,444 VMT
30% UF share
15 MPG
98,989 Gallon/day
866 tCO2
300 Days
259,839 total tCO2



Roadway Type	VMT/Day	√ Included / X not
Interstate	1,493,315	x
Principal Arterial	2,256,530	√
Minor Arterial	1,066,989	√
Urban Major Collector	637,995	√
Rural Minor Collector	72,085	√
Locals	915,845	√
Totals	**6,442,759**	**4,949,444**

http://environment.alachua-county.org/Pollution_Prevention/air/emission/mobile.htm

Chart portaying the warming potential of refrigerants used and stored in chiller equipment on the main UF Campus.



coolant in lbs	type	GWP	atmospheric lifetime
20,470	R-11	4600	45
4,624	R-12	10600	100
1,994	R-22	1900	0.034
27,060	R-123	120	1.4
12,900	R-134a	1600	13.6
20,204	R-500	7870	0.605

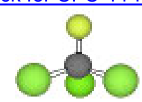
total weight in lbs	weighted GWP	weighted lifetime
87,252	3,781	18

coolant weight in tonne	% yearly coolant loss
40	3.00%

Refrigerant Data: The Air Conditioning & Refrigeration Technology Institute's Refrigerant Database
http://www.arti-21cr.org/db/

Learn about Fluorocarbons
Why use Fluorocarbons?
CFC's & HCFC's in depth

Click for CFC-11 Model



Click for CFC-12 Model

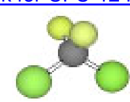
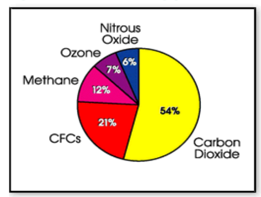


Figure 2: Global warming gases.



Although CFC's make up only 0.0000001 percent of the volume of the atmosphere, they contribute 21 percent of global warming.

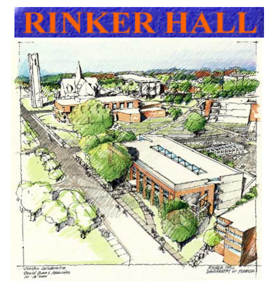
http://www.trane.com/commercial/issues/environmental/cfc/cfc1.asp

Chiller Plant - Machine #	Chiller Mfg.	Capacity, Tons	Refrig. Quantity - Lbs	Refrigerant	Atmospheric Life Years	GWP 100 Yr
McCarty Plant - # 1	Trane	1200	2100	R-123	1.4	120
McCarty Plant - # 2	Trane	1200	2100	R-123	1.4	120
McCarty Plant - # 3	Trane	1200	2100	R-123	1.4	120
McCarty Plant - # 4	Trane	1200	2100	R-123	1.4	120
McCarty Plant - # 5	Trane	1200	2100	R-123	1.4	120
McCarty Plant - # 6	Trane	1200	2100	R-123	1.4	120
Walker Hall Plant - # 1	York	750	1200	R-11	45	4600
Walker Hall Plant - # 2	York	750	1200	R-11	45	4600
Walker Hall Plant - # 3	Carrier	1050	3950	R-12	100	10600
Walker Hall Plant - # 4	Trane	1000	2500	R-11	45	4600

Green building worksheet comparing Rinker Hall with the Campus average to establish a financial and carbon ROI.

Building Number	Building Name	Total Area (sq. ft)	Total Usage (kWh)	Total Usage (MWh)	CO2 Produced (metric tons)	CO2 per Area (lbs/sq. ft.)	Construction Date	Building Age from 2001 (yrs)
272	M.E. RINKER HALL	46,530					2002	1
	Annual results using UF average		1,214,898	1,215	868.65	41.20		
	Annual results using Green Coefficient		607,449	607	434.33	20.60		

Green Coefficient in % 50	Lifetime tCO2 86,865 / Lifetime tCO2 43,433	Lifetime Cost $ 8,650,076 / Lifetime Cost $ 4,325,038
Project Total Cost $ 7,000,000	Project Lifetime in yr 100	Lifetime $/tCO2 (gross) $ 16
Green Building Charge $ 700,000	Lifetime ROI 6.18	Lifetime $/tCO2 (net) $ (83)
Green Cost Increase 10%	Lifetime Savings per ft2 (kWh) $ 92.95	
Project Coverage ft2 46,530	Lifetime Operational Savings (kWh) $ 4,325,038	
Additional cost per ft2 $ 15.04	Lifetime Savings in tCO2 43,433	
Savings/yr $ 43,250	Project kWh ROI in years 16.2	



Learn about LEED buildings
Learn about GeoExchange

Worksheet to profile cost and benefit of lighting systems upgrades on the UF campus, using Elmore Hall 0465 as the example.

Building Number	Building Name	Total Area (sq. ft)	Total Usage (kWh)	Total Usage (MWh)	CO2 Produced (metric tons)	CO2 per Area (lbs/sq. ft.)	Construction Date	Building Age from 2001 (yrs)
0465	ELMORE HALL	18,230	832,162	832.16	595.69	72.05	1991	10

ft2 to m2 conversion	square footage	area in m2
0.0929	18,230	1,694
Cost per installed light	**Number of lights**	**Total cost**
$ 30.00	267	$8,010
Cost to install lights minus kWh savings		**Expected savings**
$ (15,690)		4.00%
Yearly savings in $	**Yearly savings MWh**	**Yearly tCO2 savings (FPC)**
$ 2,370	33.29	24
Lifetime savings in $	**Lifetime savings MWh**	**Lifetime tCO2 savings (FPC)**
$ 23,700	332.86	238
Price per tCO2 lifetime	**Project ROI**	**Price of kWh**
$ (66)	3.0	0.0712

Light Type = T-8 by:
Advanced Energy Solutions, Haines City, FL.

Cost per m2	Cost per ft2
$ 4.73	$ 0.44

Project Lifetime in years
10

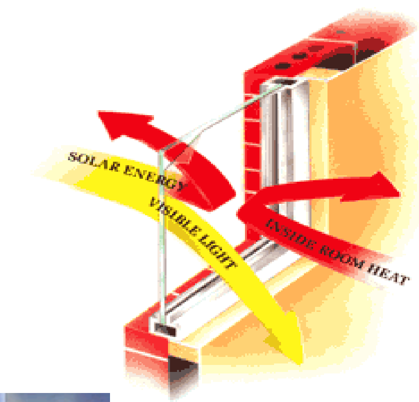
CO2 intensity difference FPC & GRU (%)
0.24

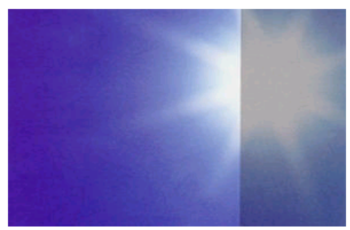
Elmore Hall for Administrative Services
Learn about energy efficient lighting

Worksheet demonstrating Solar Film application results in the Engineering Sciences Building 0725, CY 2001.

Building Number	Building Name	Total Area (sq. ft)	Total Usage (kWh)	Total Usage (MWh)	CO2 Produced (metric tons)	CO2 per Area (lbs/sq. ft.)	Construction Date	Building Age from 2001 (yrs)
0725	ENGINEERING SCIENCES	40,930	540,080	540.08	386.61	20.83	1967	34

Project Cost	Project Lifetime	Lifetime $/tCO2
$11,200	20	$ 12.20
Project Coverage ft2	Lifetime ROI	Lifetime $/tCO2 (net)
4081	8.16	$ (87.38)
Cooling Reduction after Film	Cooling Bill CY 2001	
12%	$38,085	
Savings/yr	Lifetime Saving in kWh	
$ 4,570	1,283,764	
Project ROI in yr	Lifetime Operational Savings	
2.5	$ 91,404	
Lifetime savings per ft2	Lifetime Savings in tCO2	
$ 22.40	918	
Cost per ft2 of window		
$ 2.74		

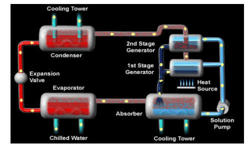




Learn about energy efficient windows

Worksheet tracking Campus chiller plant make up costs and relative efficiencies. UF operates 42 chillers pooling into 10 cold water loops.

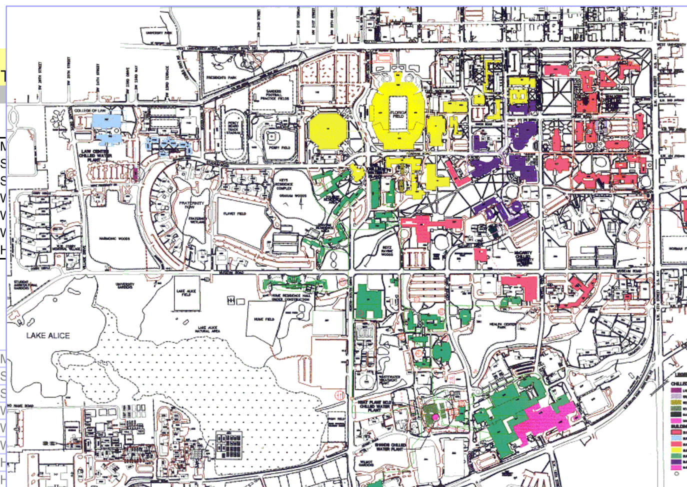
	weighted Plant age	industry kW/ton at that age	actual kW/ton	relative to industry average
McCarty Plant	1996	0.61	0.79	22.8%
SE Plant	1997	0.60	0.81	26.0%
SW Plant	1990	0.65	0.7	6.9%
West Plant	1994	0.62	0.95	34.5%
Walker Hall Plant	1984	0.70	0.79	11.0%
Weil Hall Plant	1983	0.71	0.72	1.2%
Holland Law Plant	1984	0.70	0.78	9.7%
	weighted kW/ton	weighted Fleet Age	industry kW/ton 2000	UF relative to 2000 average
	0.77	1990	0.55	28.91%



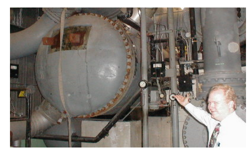
Learn about cooling principles
More cooling basics

CenTraVac™ Renewed Chiller
Brochure: E/CTV-S-68

FY00/01	Cost per KTH	KTH cost - wtr. & sewage	KTH made	weighted KTH cost	kWh required	kW/ton	weighted age of plant
McCarty Plant	53.07	49.36	19,797		15,633,011	0.79	1996.0
SE Plant	54.52	50.70	8,394		6,809,777	0.81	1997.0
SW Plant	46.9	43.62	5,395		3,764,740	0.70	1990.9
West Plant	63.64	59.19	2,505		2,372,427	0.95	1994.0
Walker Hall Plant	52.88	49.18	10,960		8,623,846	0.79	1984.0
Weil Hall Plant	48.31	44.93	14,708		10,573,031	0.72	1982.8
Heat Plant II	66.03	?	?		?	?	?
Holland Law Plant	52.11	48.46	2,862		2,218,953	0.78	1984.0
Sid Martin Bldg.	?	?	?		?		
BioTech (1040) - East	?	?	?		?		
					Total value ($)	weighted kW/ton	weighted age all
				48.36	3,124,737	0.77	1990.0



relative to industry average
3.9%
0.9%
-2.1%
-5.1%
-8.1%
-11.1%
-14.2%
UF relative to 2000 average
28.91%



Learn about cooling principles
More cooling basics

...quired	kW/ton	weighted age of plant
,997	0.05	1975.7
,082	0.05	0.0
,622	0.05	0.0
,619	0.05	0.0
,071	0.05	0.0
,978	0.05	0.0
?	?	?
,215	0.05	0.0
?		

Sid Martin Bldg. ? ? ?

Worksheet examining the savings and potential environmental revenues associated with chiller upgrades under various circumstances.

Steam in KLBS FY00/01	#2	#3	% of Plant Total	#2 & #3 Steam Cost	Total Plant Steam in KLBS	Steam Cost Total	#2 & #3 tCO2	Total Plant tCO2
July 2000	14,029.95	7,503.35	0.56	$77,304.55	38,450.75	$138,038.19	1,724.77	3,079.81
August	9,201.69	4,624.42	0.59	$49,635.73	23,388.24	$83,963.78	1,107.44	1,873.34
September	14,687.31	7,284.55	0.59	$78,878.98	37,234.53	$133,671.96	1,759.89	2,982.40
October	9,978.04	3,209.80	0.71	$47,344.35	18,616.81	$66,834.35	1,056.31	1,491.16
November	8,344.56	2,782.93	0.60	$39,947.69	18,612.57	$66,819.13	891.29	1,490.82
December	4,079.99	2,738.01	0.35	$24,476.62	19,614.32	$70,415.41	546.11	1,571.06
January 2001	1,193.68	2,441.90	1.00	$13,051.73	3,635.58	$13,051.73	291.20	291.20
February	0	4,265.86	0.30	$15,314.44	14,274.80	$51,246.53	341.69	1,143.38
March	0	5,184.45	0.24	$18,612.18	21,647.99	$77,716.28	415.26	1,733.95
April	0.21	2,870.15	0.20	$10,304.59	14,062.76	$50,485.31	229.91	1,126.39
May	40.98	2,855.69	0.19	$10,399.05	15,239.12	$54,708.44	232.02	1,220.62
June 2001	7,249.27	4,116.72	0.45	$40,803.90	25,196.13	$90,454.11	910.39	2,018.15
	68,805.68	**49,877.83**	**0.48**	**$426,073.80**	**249,973.60**	**$897,405.22**	**9,506.26**	**20,022.29**
Total KLBS Chiller # 2 & # 3					118,683.51			

Below Combines Operational Savings and CO2 Revenue @ $5 per tCO2 for the Replacement of Steam Chiler #2 & #3 at Heat Plant #2

New Chillers in KLBS	#2 - KBLS	#3 - KLBS	Yearly KLBS Savings	Yearly KLBS Savings in $	Operational Savings in 10 years	Yearly tCO2 reductions	10 Year tCO2 reductions	10yr Revenue at $5/tCO2
20% improvement	55,044.54	39,902.26	23,736.70	$85,214.76	$852,147.60	1,901.25	19,012.53	$95,062.64
30% improvement	48,163.98	34,914.48	35,605.05	$127,822.14	$1,278,221.40	2,851.88	28,518.79	$142,593.96
40% improvement	41,283.41	29,926.70	47,473.40	$170,429.52	$1,704,295.20	3,802.51	38,025.06	$190,125.29

New Chillers Savings & Revenue	10 Years	15 Years	20 Years	Cost per Unit in USD		Emission Rates per Unit in kg
20% improvement	$947,210.24	$1,420,815.37	$1,894,420.49	0.0625	kWh	0.715
30% improvement	$1,420,815.37	$2,131,223.05	$2,841,630.73	3.59	KLBS	80.10
40% improvement	$1,894,420.49	$2,841,630.73	$3,788,840.98			

Below Combines Operational Savings and CO2 Revenue $5 per tCO2 for the Replacement of all Electric Chillers on Campus - 31 Units

Electric Chiller Total FY 00/01	Total kWh	Total kWh Costs	Total tCO2	Cost of kWh/tCO2
	69,820,259.36	$4,363,766.21	49,921.49	$87.41

Complete Electric Chiller Upgrade	10 Years	15 Years	20 Years	Yearly tCO2 reductions	10 Year tCO2 reductions	15 Year CO2 Reductions
20% improvement	$9,226,747.27	$13,840,120.91	$18,453,494.55	9,984.30	99,842.97	149,764.46
30% improvement	$13,840,120.91	$20,760,181.37	$27,680,241.82	14,976.45	149,764.46	224,646.68
40% improvement	$18,453,494.55	$27,680,241.82	$36,906,989.10	19,968.59	199,685.94	299,528.91

Below Shows Operational Savings and CO2 Revenue at $5 per tCO2 for the Upgrade of Entire Campus Chiller Fleet - 34 units

Electric Chiller Total FY 00/01	Total kWh	Total kWh Costs	Total tCO2	Cost of kWh/tCO2	KTH delivered
	69,820,259.36	$4,363,766.21	49,921.49	$87.41	98,046

Steam Chillers Total FY 00/01	Total KLBS	Total KLBS Cost	Total tCO2	Cost KLBS/tCO2	tCO2 per KTH
	249,973.60	$897,405.22	20,022.29	$44.82	1.40

Total Steam and Electric FY 00/01		$5,261,171.43	69,943.77

ALL Campus Chiller Upgrade	10 Years	15 Years	20 Years	Yearly tCO2 reductions	10 Year tCO2 reductions	15 Year tCO2 Reductions	20 Year tCO2 Reductions
20% improvement	$10,722,566	$16,832,671	$22,443,561	13,989	139,888	209,831	279,775
30% improvement	$16,832,671	$25,249,006	$33,665,342	20,983	209,831	314,747	419,663
40% improvement	$22,443,561	$33,665,342	$44,887,122	27,978	419,663	419,663	559,550

Upgrade without revenue from tCO2	10 Years	15 Years	20 Years	yearly kWh savings	Equipment cost/tCO2	Equipment cost/tCO2	Equipment cost/tCO2
20% improvement	$10,522,343	$15,783,514	$21,044,686	$1,052,234	$22	-$10.58	-$26.74
30% improvement	$15,783,514	$23,675,271	$31,567,029	$1,578,351	-$11	-$32.13	-$42.90
40% improvement	$21,044,686	$31,567,029	$42,089,371	$2,104,469	-$18	-$42.90	-$50.98

		Installed Tons	Cost
AC Cost per Ton	$ 200	38,752	$ 7,750,400
Installation Cost per Ton	$ 150	38,752	$ 5,812,800
Total			$ 13,563,200

ROI at 10 years for fleet-wide industry best upgrade
1.36
Investment cost to achieve $1 in savings at year 10, best case scenario.
$ 0.73

Worksheet for Project Lightbulb - incoming Freshmen receive 2 energy efficient lightbulbs each.

Project cost: $90,000/yr **Project return: 8,907tCO2/yr** **Audience = 18% of the Campus Community (per annum)**

	2003	2004	2005	2006	2007	2008	2009	2010	Cumulative this decade	
# of Freshman	9,000	9,000	9,000	9,000	9,000	9,000	9,000	9,000	72,000	
# of bulbs per Freshman	2	2	2	2	2	2	2	2		
cost per bulb	$5.0	$5.0	$4.5	$4.5	$4.0	$4.0	$3.5	$3.5	$4.25	average
attrition rate	5.0%	5.0%	5.0%	5.0%	5.0%	5.0%	5.0%	5.0%		
bulb rating	20	20	20	20	16	16	16	16		
replacing	75	75	75	75	75	75	75	75		
hours in use	10,000	10,000	10,000	10,000	10,000	10,000	10,000	10,000		
watt consumption	400,000	400,000	400,000	400,000	320,000	320,000	320,000	320,000		
watt savings	1,100,000	1,100,000	1,100,000	1,100,000	1,180,000	1,180,000	1,180,000	1,180,000	9,120,000	kWh
gCO2/kWh GRU	947	947	947	947	947	947	947	947		
tCO2 savings per bulb	0.52085	0.52085	0.52085	0.52085	0.55873	0.55873	0.55873	0.55873		
tCO2 savings per program year	8,907	8,907	8,907	8,907	9,554	9,554	9,554	9,554	**73,843**	tCO2
Cost per program year	$90,000	$90,000	$81,000	$81,000	$72,000	$72,000	$63,000	$63,000	$ 612,000	cost
Cost per tCO2	$10	$10	$9	$9	$8	$8	$7	$7	$ 8.33	average
tCO2 savings per Freshman	0.99	0.99	0.99	0.99	1.06	1.06	1.06	1.06		
Assumed cost of kWh	0.072									

Energy saved by students yearly in cash: **$ 677,160** — $ 5,417,280 savings

Net cash benefit to participant community — **$ 4,805,280** program net

Worksheet to model cost and benefit of Photovoltaic (PV) applications on campus parking facilities.

	Building Number	Building Name	Total Area (sq. ft)	Footprint	Total Usage (kWh)	Total Usage (MWh)
√	0209	PARKING GARAGE 2 (SHANDS WEST)	303,600	92,620	549,360	549.36
√	0364	PARKING GARAGE 3 (SHANDS WEST)	300,000	78,941	635,280	635.28
	0208	PARKING GARAGE - EAST	248,000		640,380	640.38
√	0173	HEALTH CTR GARAGE 9	239,000	44,103	773,695	773.70
√	0358	PARKING GARAGE 4 (MUSEUM RD)	183,990	59,706	384,304	384.30
√	1166	CULTURAL COMPLEX GARAGE	178,000	46,136	398,400	398.40
√	0148	PARKING GARAGE 7 (SOC)	167,650	50,806	415,119	415.12
√	0207	PARKING GARAGE 1 (SHANDS EAST)	134,850	24,875	71,698	71.70
√	0442	PARKING GARAGE 8 (NORMAN HALL)	120,100	46,106	315,228	315.23

PV system cost per W ($)	ft2 to m2 conversion	Available footprint in m2	PV eligible footprint in ft2	Coverage %
12	0.0929	41,182	443,293	40.00%

Cost per module	Watts per module	m2 of module	Cost per m2	Watts per m2
$ 1,800	150	1.32	$ 1,364	113.64

Learn how PV works

Cost to create PV roofs for above parking facilities	Total Power (w)	kVa (kW)	MW
$ 22,462,865	1,871,905	1,871.91	1.871905

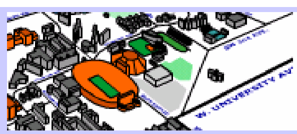
Cost to create PV roofs minus revenue from kWh	Example PV panel Shell SP150-P	Project lifetime in years
$ 16,067,688		40

The world's largest parking lot solar system is located in Sacramento, California.

Annual MWh	as % of UF annual MWh	Yearly tCO2 (FPC)	Yearly tCO2 (GRU)
3,075	0.83%	2,198	2,912

Lifetime MWh	as % of annual MWh	Lifetime tCO2 (FPC)	Lifetime tCO2 (GRU)
98,387	26.65%	70,347	93,173

$/tCO2 lifetime FPC
$228
$/tCO2 lifetime GRU
$172



The O'Connell Center parking garage can be covered with PV for under $2.5 million.

About 20% of the urban lanscape is devoted to parking lots.

Comment:

Lifetime Revenue from MWh production	Revenue from kWh	kWh cost over project lifetime
$ 6,395,178	0.065	$ 0.1633

Worksheet to model viability of low-wind applications on the UF campus.

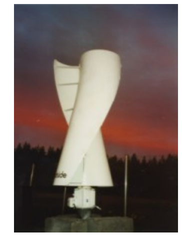
UF windspeed (m/s)	Cost of unit	Unit output (yearly, kWh)	Yearly MWh	Lifetime unit	Emission Rate (FPC)
3	$16,000	172	0.172	40	0.715
Number of units	**Cost installed**	**Output 40 years (kWh)**	**40 year output in MWh**		**Emission Rate (GRU)**
30	$576,000	206,400	206.4		0.947
Yearly tCO2 (FPC)	**as % of tCO2 from electricity**	**Lifetime tCO2**	**as % of yearly electrical tCO2**		
3.69	0.00001393	147.58	0.000557		
Yearly tCO2 (GRU)	**as % of tCO2 from electricity**	**Lifetime tCO2**	**as % of total yearly tCO2**		
4.89	0.00001845	195.46	0.000376		

[Learn how wind works](#)

Price per tCO2 lifetime $/tCO2 (FPC)
$3,903

Price per tCO2 lifetime $/tCO2 (GRU)
$2,947

Cost of wind relative to PV	PV price per tCO2 lifetime (FPC)
1709%	$ 228
	PV price per tCO2 lifetime (GRU)
	$ 172



Example Wind Model
Windside WS-4C

Revenue from MWh	Price per green kWh	Lifetime kWh cost
$ 11,352	$ 0.055	$ 2.79

Model:	Average wind speed	3 m/s	5 m/s	7,5 m/s	10 m/s	
WS-0,15	=	8	25	60	129	kWh/year
WS-0,30C	=	17	60	120	258	kWh/year
WS-2	=	86	301	800	1720	kWh/year
WS-4	=	172	602	1700	3440	kWh/year
WS-30	=	1290	4532	12000	25800	kWh/year
WS-75	=	3225	11283	32000	64500	kWh/year

http://www.windside.com/
http://www.windpower.org/core.htm
http://www.ropatec.com/
http://www.solwind.co.nz/vertical.htm

Example Wind Model
Windside WS-0.3
http://www.phys.ufl.edu/~weather/pages/

Gainesville historical (last 18 years) wind data in miles per hour wind speed

jan	feb	mar	apr	may	jun	jul	aug	sep	oct	nov	dec	average
7	7.5	7.9	7.3	6.9	6.1	5.7	5.4	5.8	6.4	6.2	6	6.5

Windspeed measurements from 10 random days in fall of 2002 at the Physics building, UF Campus

http://www.phys.ufl.edu/~weather/text/

	070202	071002	072002	073002	081002	082002	083002	091002	1010002	102002	miles/hour
12a	0	3	2	1	6	0	3	3	4	1	2.3
1p	2	3	3	0	3	0	1	3	3	2	2
2p	3	0	3	0	5	0	2	4	3	0	2
3p	1	0	4	3	3	0	3	6	3	0	2.3

Worksheet modeling fuel consumption and carbon emissions for traditional and hybrid vehicles.

Vehicle type and yearly CO2 emissions.

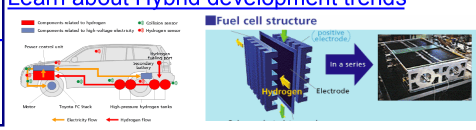
		Ford Escort	Chevy Malibu	Honda Civic	Toyota Prius
Miles driven yearly	7500	2.24	3.05	1.11	1.37
	10000	2.98	4.07	1.47	1.83
	12500	3.65	4.98	1.81	2.29
	15000	4.47	6.09	2.22	2.74
	20000	5.96	8.14	2.94	3.66
average tCO2/yr		**3.86**	**5.266**	**1.91**	**2.378**
CO2 emissions over 5 year use		19.3	26.3	9.55	11.95
CO2 emissions over 7 year use		27.02	36.82	13.37	16.64
CO2 emissions over 9 year use		34.74	47.34	17.19	21.4
average tCO2/vehicle life		**27.02**	**36.82**	**13.37**	**16.66**
averaged CO2 emissions over vehicle life			**31.92**	**15.02**	
conventional v.s. hybrid CO2 difference			**16.9**		
vehicles needed for -10,000 tCO2			**592**		
extra cost per copy	$4,000	$2,368,000	**196**	vehicles/yr for a 3 year phase-in	
cost plus volume discount	$2,000	$1,184,000	**148**	vehicles/yr for a 4 year phase-in	
fuel saving over lifetime	$1,311,000	-$127,000	**118**	vehicles/yr for a 5 year phase-in	

Note:
at $1.15/gallon, -10,000 tCO2 also saves $1,311,000 in fuel costs

Learn about Toyota Prius

Learn about Honda Civic

Learn about the $2,000
Clean Fuel Vehicle Tax Deduction
See Flash demo on Integrated Motor Assist (Japanese)
Learn about Hybrid development trends



Clean Cities Resources on Clean Vehicles

Worksheet modeling the introduction of biodiesel into the UF fleet and local transportation system.

Project Biodiesel UF:

2003-2004 Fiscal Year Total Usage

Diesel (gal)	Bio-Diesel (gal)	Fuel Cost Difference	Cost Per Gallon	Cost Per tCO2
65,927	65,927			
$/gal	$/gal			
$1.15	$1.25			
$ 75,816	$ 82,409	$ 6,593	$ 0.10	$ 34.22

Fleet FY 2003	Fleet FY 2000	Fleet FY 2000
tCO2 diesel	tCO2 biodiesel	tCO2 difference
681	489	193

Project Biodiesel RTS:

200?-200? Fiscal Year Total Usage

Diesel (gal)	Bio-Diesel (gal)	Fuel Cost Difference	Cost Per Gallon	Cost Per tCO2
750,000	750,000			
$/gal	$/gal			
$1.15	$1.25			
$ 862,500	$ 937,500	$ 75,000	$ 0.10	$ 34.22

RTS 200?	RTS 200?	RTS 200?
tCO2 diesel	tCO2 biodiesel	tCO2 difference
7,752	5,560	2,192

FY 2002 RTS Rider and energy/emissions profile without biodiesel

Diesel (gal)	tCO2 fuel	
700,716	7,242	
RTS ridership	RTS vehicle miles	RTS boarding intensity
7,185,018	2,332,684	3.08
Student ridership	Student tCO2 share	Student funding/yr
75%	5,432	$ 3,600,000
UF ridership	UF trips	Cost per boarded mile
5,388,764	2,694,382	$ 0.17
miles per one-way trip	Miles avoided	Cost per tCO2
4	21,555,054	$ 372.81
MPG avoided miles	Gallons avoided	Likely tCO2 avoided (net)
10	2,155,505	9,656
Gross tCO2 avoided	Certainty Factor	Likely tCO2 avoided (gross)
18,860	80%	15,088

Commercial biodiesel
Learn about biodiesel
Biodiesel multimedia
Biodiesel indepth

Below are some of the assumptions used in formatting fuel related GHG data

Conventional Gasoline

GHG rate	Heating Value	Density	C ratio	C ratio	CO2 ratio	CO2 ratio	S ratio
Gallon to tCO2	Btu/gallon	grams/gallon	% by weight	grams/gallon	grams/gallon	grams /liter	ppm by weight
114.29	115,000	2,791	85.5	2,386	8,750	2,311	200

Conventional Diesel

GHG rate	Heating Value	Density	C ratio	C ratio	CO2 ratio	CO2 ratio	S ratio
Gallon to tCO2	Btu/gallon	grams/gallon	% by weight	grams/gallon	grams/gallon	grams /liter	ppm by weight
96.75	128,500	3,240	87.0	2,819	10,336	2,730	250

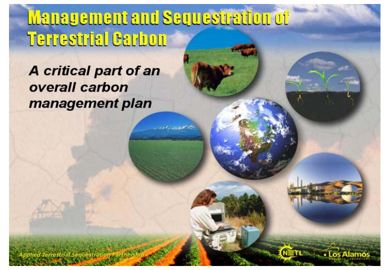
Bio Diesel

GHG rate	Heating Value	Density	C ratio	C ratio	CO2 ratio	CO2 ratio	S ratio
Gallon to tCO2	Btu/gallon	grams/gallon	% by weight	grams/gallon	grams/gallon	grams /liter	ppm by weight
134.90	128,000	2,592	78.0	2,022	7,413	1,958	??

Worksheet used to evaluate popular and geographically compatible carbon sequestration methods available for North Florida.

Sequestration potential using Longleaf pine, a common species in North Florida, rotation age about 30 years

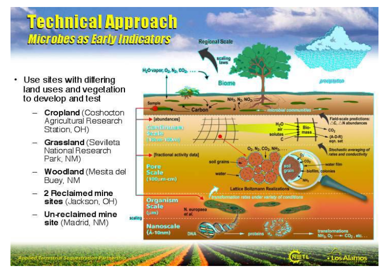
annual tCO2 to be offset	tCO2 to tC	value in tC	sequestration potential of Pinus palustris tC/ha	
100,000	0.272727273	27,273	200	
annual hectares needed	acre to hectare	annual acres needed	assumed cost per tCO2	rotation age (yr)
136.36	2.47105	336.96	$5	30
cost to UF and total value to farmer		annual value	value per acre	value per acre/year
$500,000		$16,667	$1,484	$49.46



Los Alamos National Laboratory

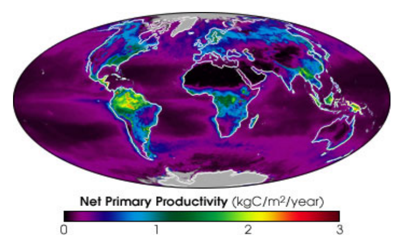
Soil sequestration potential using the UF campus, deployed as a research project

area UF Main Campus	square foot per acre	avarage annual soil addition in inch and foot	
1,966 acres	43,560	0.25	0.02
ft3 of new soil yearly	cubic feet to cubic yard	cubic yard/yr	lbs per cubic yard
1,784,152	0.03704	66,085	1,500
annual soil weight (lbs)	lbs to tonne	weight in tonne	% carbon (by weight) in new soil
99,127,502	2,204.60	44,964	2
annual carbon weight (t)	tC equivalent in tCO2	as % of annual tCO2	program life in years
899	3,297	0.0063	100
tCO2 over program life	height gain (ft) UF Campus over program life		cost
329,736	2.08		????

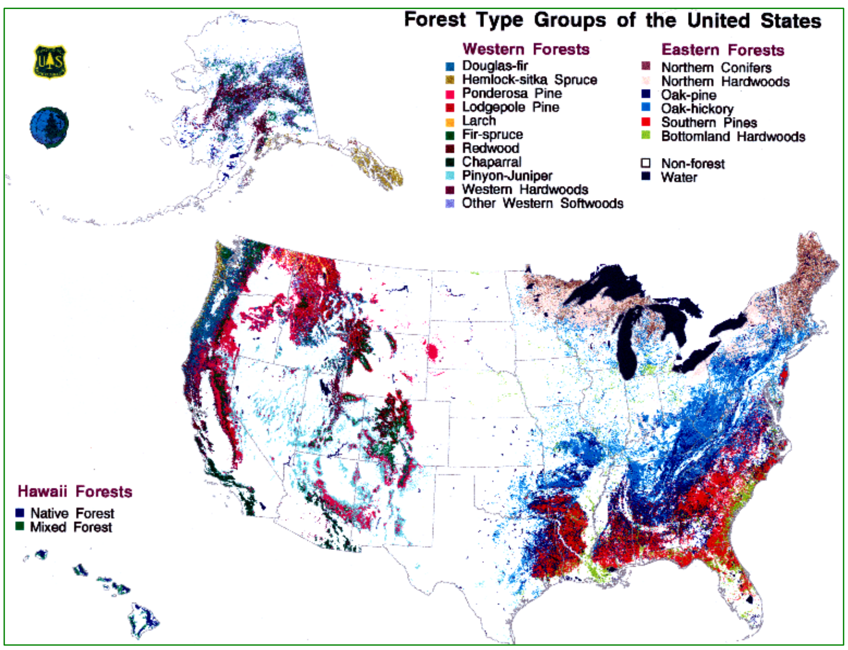


Learn about GeoSequestration
About Carbon Sequestration R&D
Learn about Natural Carbon Sequestration

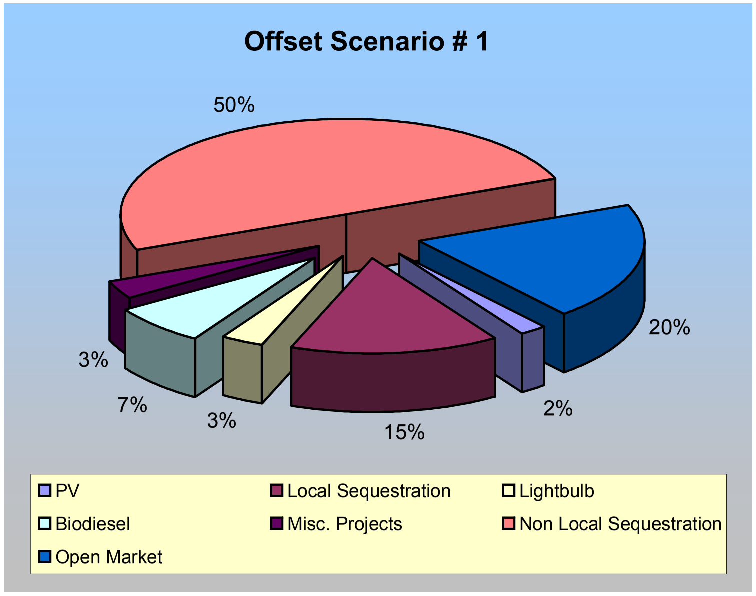
View tree absorbing CO2
Movie by NASA



Learn about carbon cycles on planet earth

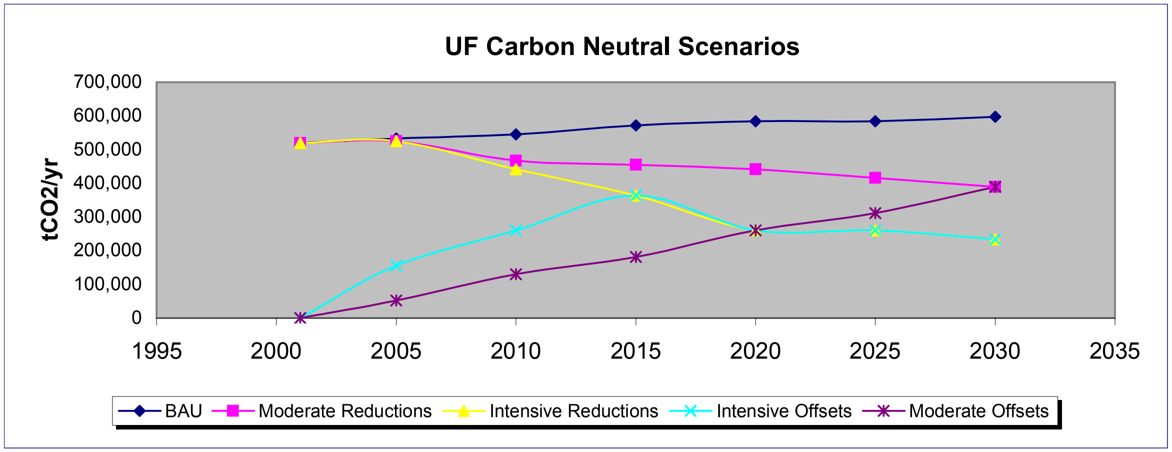


A worksheet used to assemble and visualize a basic portfolio of offsets.



	$/tCO2	% CO2	Annual tCO2	Annual Cost	% Cost
PV	200	2%	6,000	$ 1,200,000	40%
Local Sequestration	5	15%	45,000	$ 225,000	8%
Lightbulb	8	3%	9,000	$ 72,000	2%
Biodiesel	35	7%	21,000	$ 189,000	6%
Misc. Projects	9	3%	9,000	$ 81,000	3%
Non Local Sequestration	2	50%	150,000	$ 300,000	10%
Open Market	15	20%	60,000	$ 900,000	30%
weighted average	11.71				
Grand Total			300,000	$ 2,967,000	100%
Target size CO2 offset portfolio		300,000			

Graphical tool to chart the trajectory and numerics of reductions and offsets.



	2001	2005	2010	2015	2020	2025	2030
BAU		2.5%	5.0%	10.0%	12.5%	12.5%	15.0%
Moderate Reductions		1.2%	-10.0%	-12.5%	-15.0%	-20.0%	-25.0%
Intensive Reductions		1.0%	-15.0%	-30.0%	-50.0%	-50.0%	-55.0%
Intensive Offsets		30.0%	50.0%	70.0%	50.0%	50.0%	45.0%
Moderate Offsets		10.0%	25.0%	35.0%	50.0%	60.0%	75.0%

tCO2/yr

BAU	519,623	532,614	545,604	571,585	584,576	584,576	597,566
Moderate Reductions	519,623	525,599	467,661	454,670	441,680	415,698	389,717
Intensive Reductions	519,623	524,897	441,680	363,736	259,812	259,812	233,830
Intensive Offsets	0	155,887	259,812	363,736	259,812	259,812	233,830
Moderate Offsets	0	51,962	129,906	181,868	259,812	311,774	389,717

our mission: "to make UF a global leader in sustainability"

-President Charles E. Young

UF Carbon Neutral Report 2003

Assumptions
Report
Slideshow

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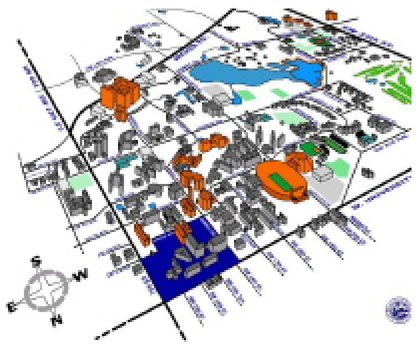

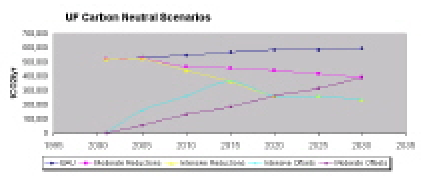

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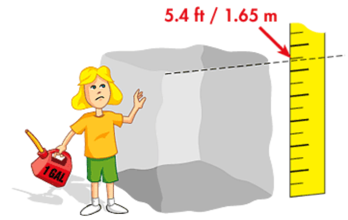
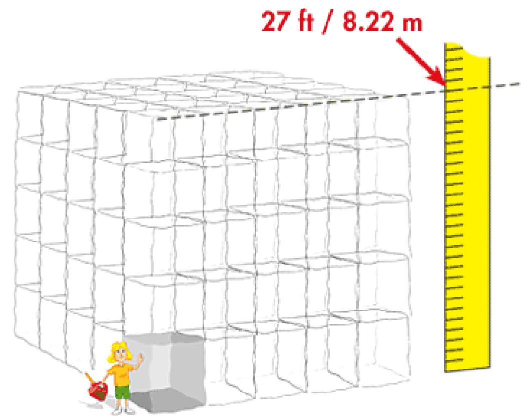
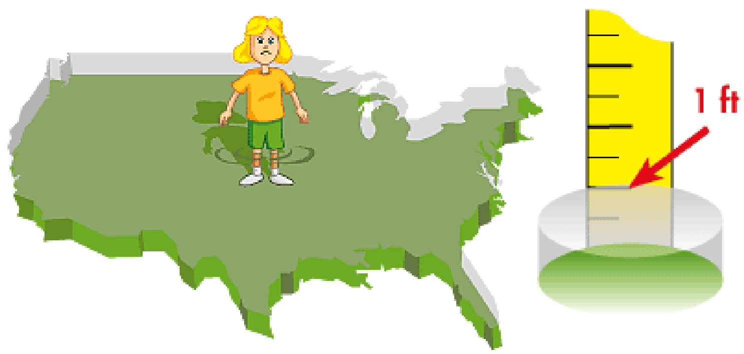
Dave Newport, Office of Sustainability
314 Rinker Hall, P.O. Box 115703
University of Florida, Gainesville, FL 32611-5703



1 gallon of regular gasoline turns into 172 cubic feet / 4.87 cubic meters of pure CO_2.



One ton of CO_2 easily fills up a 19,000 cubic feet / 556 cubic meters container.



Every year, the United States produces enough CO_2 to cover its entire land surface, including Alaska and Hawaii, with 1 foot of CO_2.

Timeline

November 2001
Sustainability task force commissions carbon neutral assessment project

March 2002
Campus spatial data integrated with building energy consumption records and emissions factors

July 2002
UF's gaseous emissions profile established online, research and modeling starts

May 2003
First draught and index report reviewed, addition of local and regional transportation data

November 2003
Final draught assessment project & audio visual presentation reviewed, begin post production

April 2004
First printing of Carbon Neutral Assessment Project