

Campus Planning Meets Kyoto Compliance:

Can Higher Education Wrestle Godzilla to the Ground?

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**“As Senate debates
greenhouse gas caps,
Lewis & Clark College
is first to achieve Kyoto
Protocol compliance.”**



Laura Matson '05 and Brian Erickson '06



Presentation Outline:

- L&C College Profile
- Background
- Campus Carbon Footprint Study
- Example Study for Lewis & Clark College
- GHG Study of Lewis & Clark College Master Plan
- GHG Reduction Study
- Lessons Learned & Next Steps



Lewis & Clark College

- Residential Liberal Arts College in Portland, Oregon
- Liberal Arts, Law & Graduate Teacher Education
- Total enrollment about 3,200
- 700 employees
- 60 Buildings, ~1.2M SF, 137 acres



Facilities Profile

- 
- Law School: 132,000 SF.
 - Graduate School: 30,000 SF.
 - Undergraduate Residential: 375,000 SF.
 - General Academic: 382,000 SF.
 - Support: 320,000 SF.
 - New or Renovated since 1993: 400,000 SF.

Background

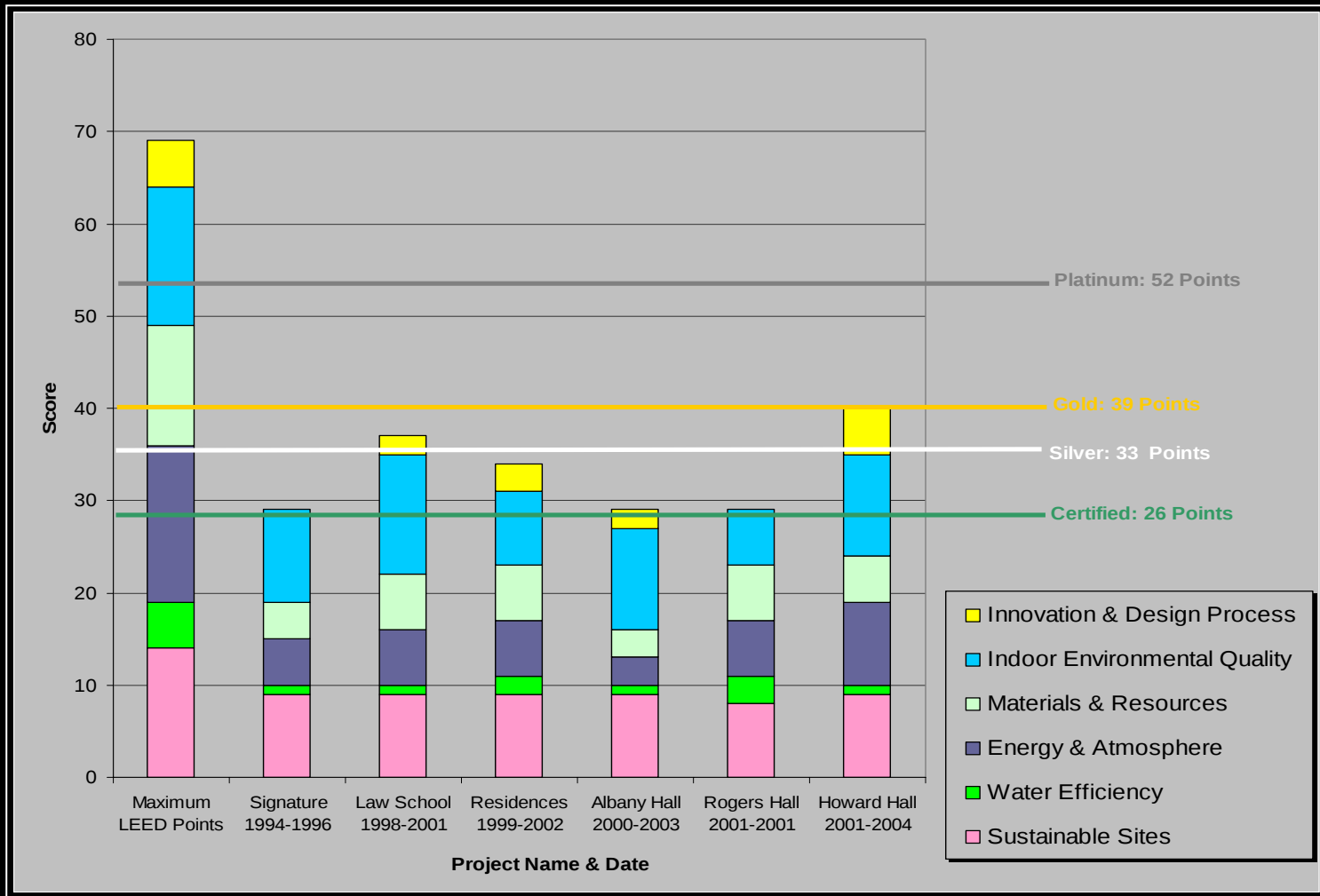
- A “Green” Master Plan
- History of successful green building development
- Student body interested and active in sustainable development
- Green House Gas Inventory
- Kyoto Compliance Study



Current Green Building Strategy

- **Implement sustainable development strategies without increasing baseline construction costs.**
- **Justify sustainable development costs using life cycle cost/benefit analysis.**
- **New construction only (USGBC is developing a standard for existing buildings).**
- **10 year energy conservation paybacks are “no-brainers”.**
- **Evaluate green strategies against other project priorities.**
- **Use LEED Guidelines; strive for “Silver” rating.**

LEED Equivalent Project Scores, 1994 - 2004



Campus Carbon Footprints

Why do a Greenhouse Gas Emission Inventory?

- Establish & prioritize emissions reductions strategies
- Establish a baseline from which to measure progress
- Compare emissions with other campuses
- Educational benefits



How to do a Greenhouse Gas Inventory:

- **Key Concepts:**
 - Emissions Coefficients
 - Global Warming Potential
 - Boundary
- **Primary emissions sources and sinks:**
 - Energy
 - Transportation
 - Waste
 - Miscellaneous



Energy Emissions Sources:

- **Natural Gas (including pipeline leakage), Distillate Fuel, Residual Fuel, Propane/LPG, Electricity**

Emissions Coefficients	CO ₂	N ₂ O	CH ₄
Natural Gas (lbs./MBTU)	117.08	0.000233	0.000287
Distillate Fuel (lbs./gal.)	22.384	0.00019	0.000226
Residual Fuel (lbs./gal.)	26.033	0.00019	0.000226
Propane (lbs./gal)	12.669	0.0	0.00024

Electrical Energy Emissions Sources:

- Natural Gas, Coal, Hydropower, Nuclear, Renewable (wind, solar, etc.), Net Purchasing

Emissions Coefficients (lbs. CO ₂ /kWh)	1990	Latest Year
Natural Gas	1.253	1.173
Coal	2.148	2.177
Hydro	0	0
Nuclear	0	0
Renewables	0	0
Net Purchasing	Variable by region	Variable by region

Transportation Emissions Sources:

■ Gasoline Consumption, Commuting, Air Travel

Emissions Coefficients (lbs. CO ₂ /kWh)	1990	Latest Year
Lbs. CO ₂ / mile (Auto)	1.06	1.01
Lbs. CO ₂ / mile (Light Truck/SUV)	1.767	1.405
Lbs. CO ₂ / mile (Weighted Average)	1.26	1.15
Lbs. CO ₂ / Gal. motor gasoline	19.62	19.56
Lbs. CO ₂ / Passenger Mile Bus	0.3642	0.389
Lbs. CO ₂ / Pass. Mile Dom. Air)	0.7707	0.6333
Lbs. CO ₂ / Pass. Mile Int'l Air)	0.7103	0.6443

Waste Emissions Sources & Sinks:

- Solid Waste Decomposition, Solid Waste Combustion, Waste Water, Compost

Emissions Coefficients

0.06435 lbs CH₄ / lbs decomposing solid waste, adjusting
for captured CH₄

0.0001 lbs N₂O / lbs combusted solid waste

0.4 lbs CO₂ / lbs combusted solid waste

- 0.286 kWh / lbs combusted solid waste

0.0006 lbs N₂O / person-day

0.066 lbs CH₄ / person-day, adjusted for captured CH₄

Miscellaneous Emissions Sources & Sinks:

- Fertilizer application, Limestone & dolomite application, Domestic animals, Compost

Emissions Coefficients
0.031 lbs N ₂ O / lbs N applied as synthetic fertilizer
0.028 lbs N ₂ O / lbs N applied as organic fertilizer
0.44 lbs CO ₂ / lbs limestone
0.477 lbs CO ₂ / lbs dolomite
- 0.103 lbs CO ₂ / lbs composted yard waste

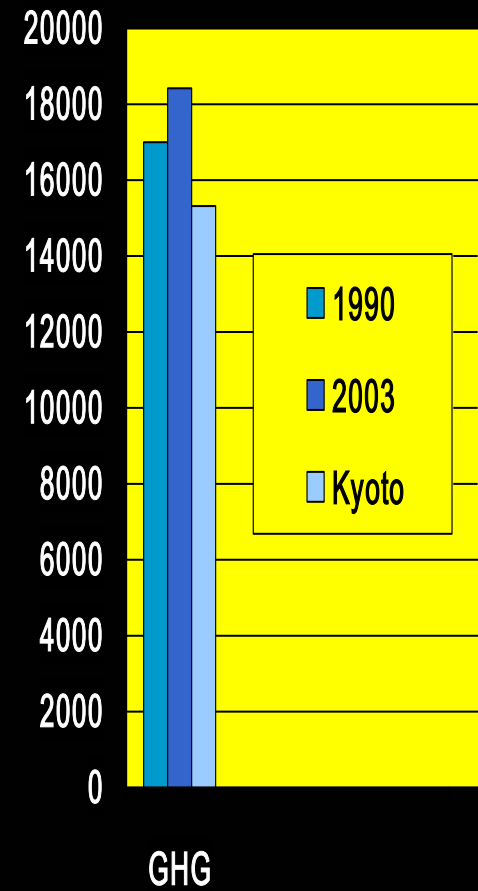
Excluded Sources & Sinks:

- Some sources or sinks could not be evaluated:
 - Refrigerants
 - Land Use
 - Construction / Subcontracting
 - Product Lifecycle Emissions
 - Recycling

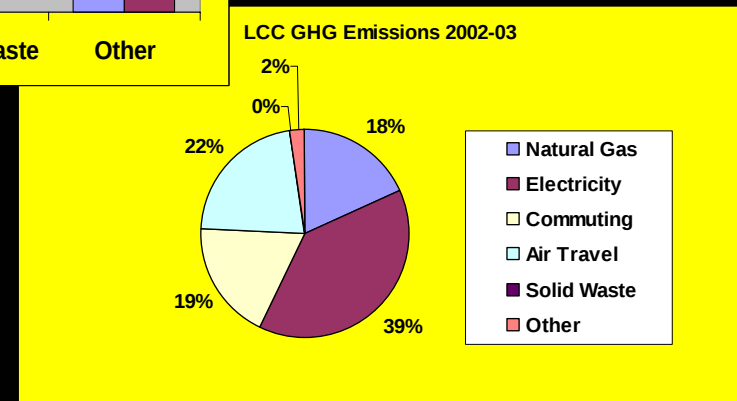
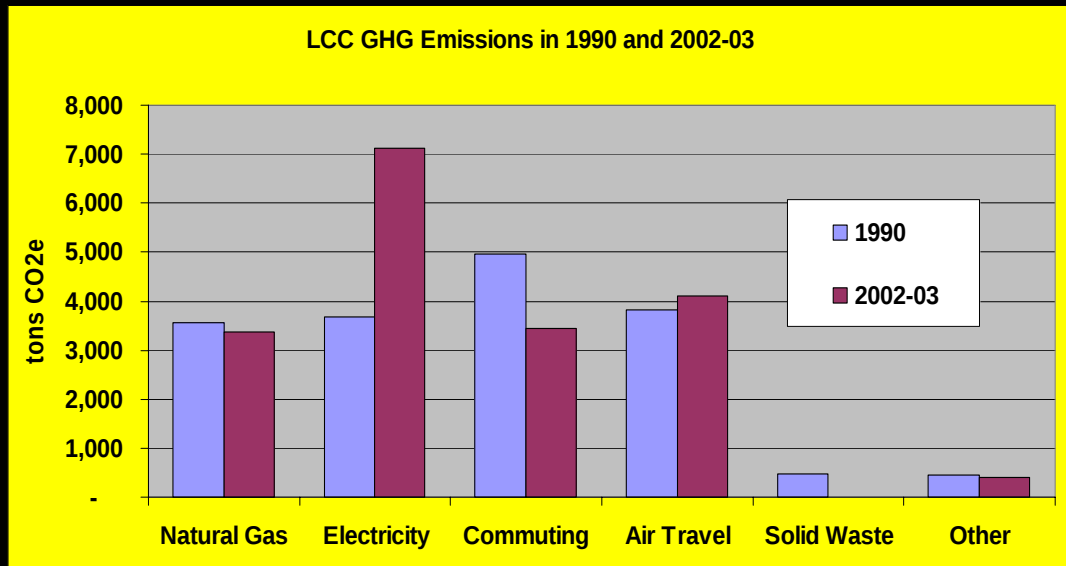


GHG Study for Lewis & Clark College

- In 1990, Lewis & Clark College released ~17,000 tons of CO₂e.
- In 2002 – 03 the College emitted ~18,400 tons CO₂e.
- Lewis & Clark must reduce its emissions level to ~15,300 tons CO₂e by 2012 to achieve the Kyoto target of 7% below 1990 levels.
- This reduction is ~3,100 tons CO₂e, or 17%, below current levels.



Greenhouse Gas Contributions by Source, 1990 - 2002:



GHG Master Plan Analysis

Building to Kyoto Compliance?

- Will replacing old inefficient buildings with new green buildings as foreseen in the Lewis & Clark Master Plan be sufficient to meet the Kyoto targets?
- To answer this question, we analyzed 3 potential building plans under 3 tracks of variables for a total of 9 different scenarios.



3 different building programs:

- There are three ranges of building development that reflect different assumptions about available funds and timing.

	Added sq. ft.	Demolished sq. ft.	Retrofitted sq. ft.	Total sq. ft.	Campus Residents
2002-03	0	0	0	982,005	887
Baseline	181,632	39,460	0	1,124,177	1060
Mid-Range	251,379	39,460	55,000	1,193,924	1260
Unlimited Money	1,206,024	426,361	55,000	1,761,668	1600

3 variable development tracks:

- Reflect different assumptions about facilities, enrollment, energy consumption and emissions coefficients for air and automobile travel.

	2002-03	Low	Middle	High
Total Enrollment	3076	3000	3,250	3,500
Electricity Consumption	14,608,548	14,608,548	16,798,548	18,258,548
Domestic air travel (mi.)	2,760,000	3,460,000	3,560,000	3,660,000
Emissions coefficient for domestic air travel	0.6333	0.4	0.5	0.6
Emissions coefficient for international air travel	0.6443	0.5	0.55	0.6
Emissions coefficient for automobile travel	0.99	0.94	0.96	0.98

Additional assumptions:

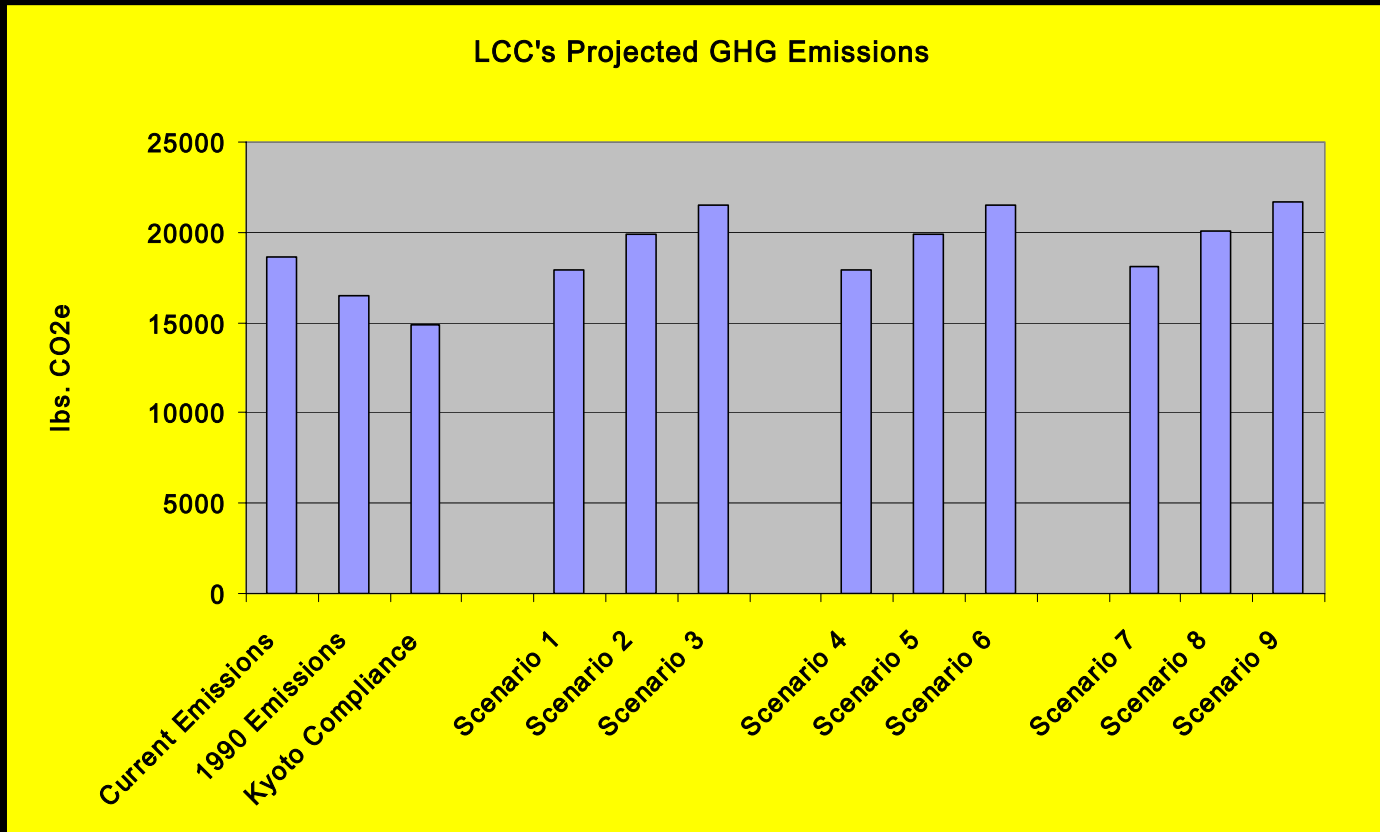
■ At Lewis & Clark:

- Each additional campus resident consumes and additional 1200 kWh per year.
- Demolished buildings consume 70,000 BTU of natural gas per SF and 14 kWh per SF per year.
- New buildings consume 15,000 BTU of natural gas per SF and 8 kWh of electricity per SF per year.
- Retrofitted buildings consume 30,000 BTU of natural gas per square foot and 10 kWh per SF per year.
- All variables not otherwise mentioned remain unchanged over the decade.

Surprise!!!!!!!!!!



From a GHG perspective, it doesn't matter which building plan Lewis & Clark College undertakes!



Creating a GHG Reduction Strategy

- Step 1: Inventory
- Step 2: Evaluate
- Step 3: Set Reduction Targets
- Step 4: Identify Possible Reductions Options.
- Step 5: Evaluate options & identify “most likely to succeed”.
- Step 6: Fit reduction options to master plan.
- Step 7: Run the numbers.



1 & 2, Inventory and Evaluate: Categorize Sources

At Lewis & Clark College	2002/03 GHG Emissions (%)
Electric	39
Natural Gas	18
Commuting	19
Air Miles	22
Other	2



1 & 2, Inventory & Evaluate: At Lewis & Clark Electrical Sources are 39% of all GHG's!!!

	% Use within Category	% Total GHG Emissions
Building Lights	35%	13.65%
Equipment Loads	20%	7.80%
Cooling	10%	3.90%
Domestic Water Heating	10%	3.90%
Office & Classroom plug loads	10%	3.90%
Space Heating	10%	3.90%
Campus & Grounds	5%	1.95%

1 & 2 Inventory & Evaluate:

At L&C Natural Gas Sources are 18% of all GHG's

	% Use within Category	% Total GHG Emissions
Domestic Water Heating	70%	12.60%
Space Heating	27%	4.86%
Other (Cooking, Labs)	3%	0.54%
Cooling	0%	0.00%



1 & 2 Inventory & Evaluate:

At L&C, Commuting is 19% of all GHG's.

	% Use within Category	% Total GHG Emissions
SOV	82%	15.58%
Carpool	13%	2.47%
Bus	5%	0.95%

At L&C Air Travel is 22% of all GHG's

	% Use within Category	% Total GHG Emissions
Domestic	51%	11.22%
International	49%	10.78%

4 Identify:

Policy & Planning Reduction Options:

- Extend energy payback from 10 years to ?? Years.
- Convert from CRTs to Flat Screens.
- No Air Conditioning in all future buildings.
- Improve transit incentives.
- Impose Air Travel restrictions.
- Construct more “walk to school housing”.
- Improve building utilization and/or multi-functional uses to minimize future construction.
- Install information systems that education end users about energy consumption.
- Change green design standards from LEED to ??????
- Plant more trees.

4 Identify:

Energy Generation Reduction Options:

- Install Photovoltaic.
- Install domestic solar water heating.
- Switch to ground source heat pumps.
- Construct co-generation systems.
- Fuel Cells.
- Construct and LC nuclear fusion plant.
- Change fuel mix (hydro, renewable, nuclear, fossil, etc.)

4 Identify:

Energy Minimization Reduction Options:

- Reduce or eliminate heat islands.
- Recycle water (irrigation, toilet flushing).
- Convert space heating from electric to gas.
- Convert domestic water heating from electric to gas.
- Building envelop enhancements (insulation, low e glass, reflective roof surfaces, etc)
- Improve Equipment efficiencies (“eco elevator”, motor efficiencies)
- Reduce plug loads, maximize day lighting, etc
- Don’t build more buildings!

5 Pick “Most Likely to Succeed”



- Matrix – downloaded, reloaded and uploaded.
- Rank and rate reduction options.
- Matrix analysis based on use profile.

5 Identify “Most Likely to Succeed”: The GHG Reduction Options Matrix

	GHG %	Policy and Program Strategies	Energy Generation Strategies	Energy Minimization Strategies
Electric	39	✓	✓	✓
Natural Gas	18	✓	✓	✓
Commuting	19	✓	✓	✓
Air Miles	22	❖		
Other	2			

Go to [Options Matrix](#)

6 Develop Strategies:

- Select reduction options that have best potential to succeed.
- Combine to form comprehensive strategies that have high potential.



6 Lewis & Clark's Test Strategies:

- Strategy 1: Building more “walk to school” housing.
- Strategy 2: Improve energy efficiency:
 - Of existing structures by 25% and
 - Raise new structures from LEED Gold to LEED Platinum with 20% improvement in energy profile.
- Strategy 3: Add on-site energy production:
 - Photovoltaics
 - Solar H2O
 - Ground Source Heat Pumps
 - Co-Generation
- Strategy 4: Right Sizing



6 Strategy Example 1:

Provide more student housing

- Improve energy efficiency of “keeper” housing stock.
- Demolish “energy hog” housing.
- Expand housing w/ “climate neutral”, “walk to school”, housing at higher densities.
- Results:
 - 2,479,582 reduction in kWh Electric
 - 13,649 reduction in MBTU Gas
 - 700 fewer commuters
- **For a total reduction of 2,838 Tons of CO₂e**

See: <http://www.bedzed.org.uk> for an example of carbon neutral residential development.

6 Strategy Example 2: Improve energy use profiles

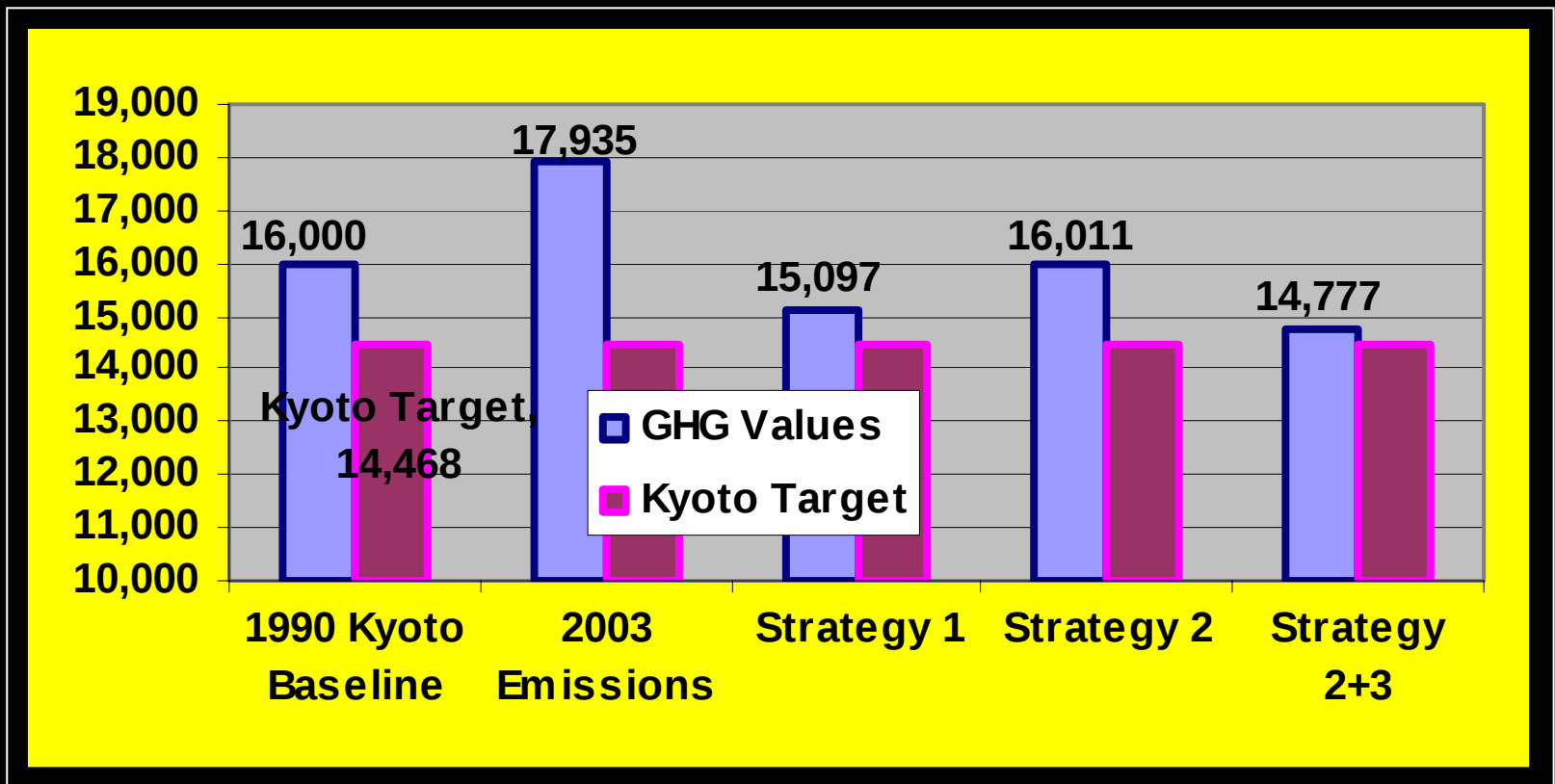
- Implement energy minimization strategies.
- Improve energy profiles of existing buildings by 25%.
- Demolish “energy hog” buildings.
- Construct new buildings to be 20% more energy efficient than baseline LEED Gold building.
- Results:
 - 2,492,239 reduction in kWh Electric
 - 10,547 reduction in MBTU Gas
- **For a total reduction of 1,924 Tons of CO₂e**

6 Strategy Example 3: Construct On-Site Energy Generation

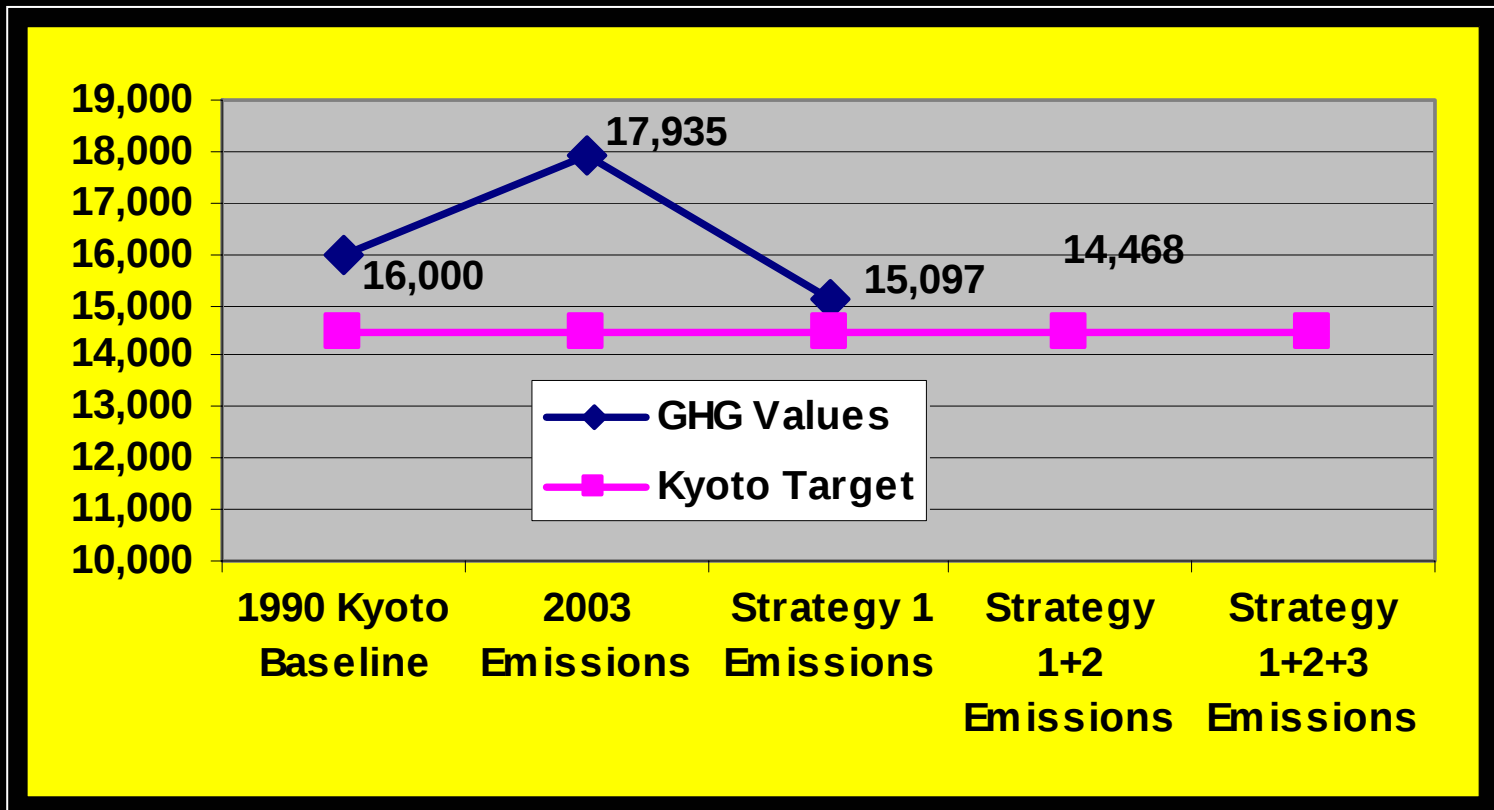
- **In addition to everything in Strategy 2,**
- Assume that 50% of base energy demand for new construction is met by one or more of the following:
 - Photovoltaics
 - Solar H2O
 - Ground Source Heat Pumps
 - Co-Generation
- **Results:**
 - 4,655,639 reduction in kWh Electric
 - 14,635 reduction in MBTU Gas
- **For a total reduction of 3,158 Tons of CO₂e**

7 Run the Numbers

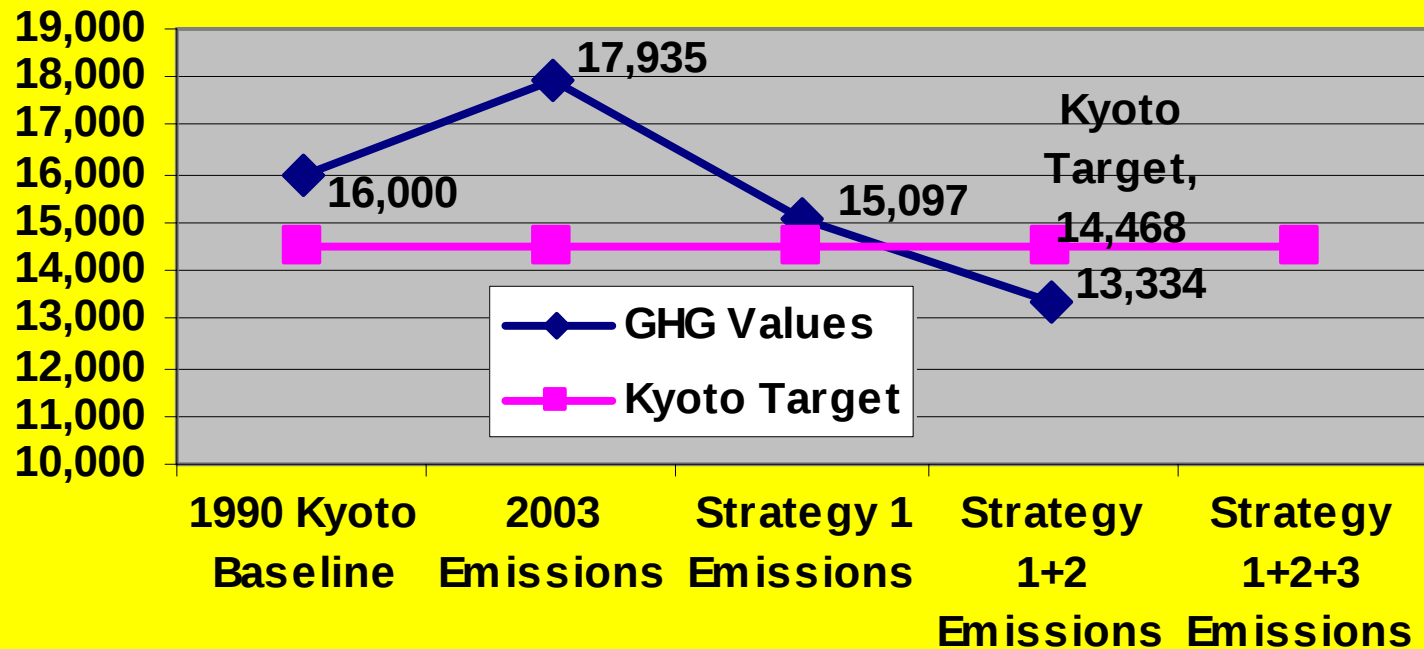
Individual strategies yield good but insufficient results



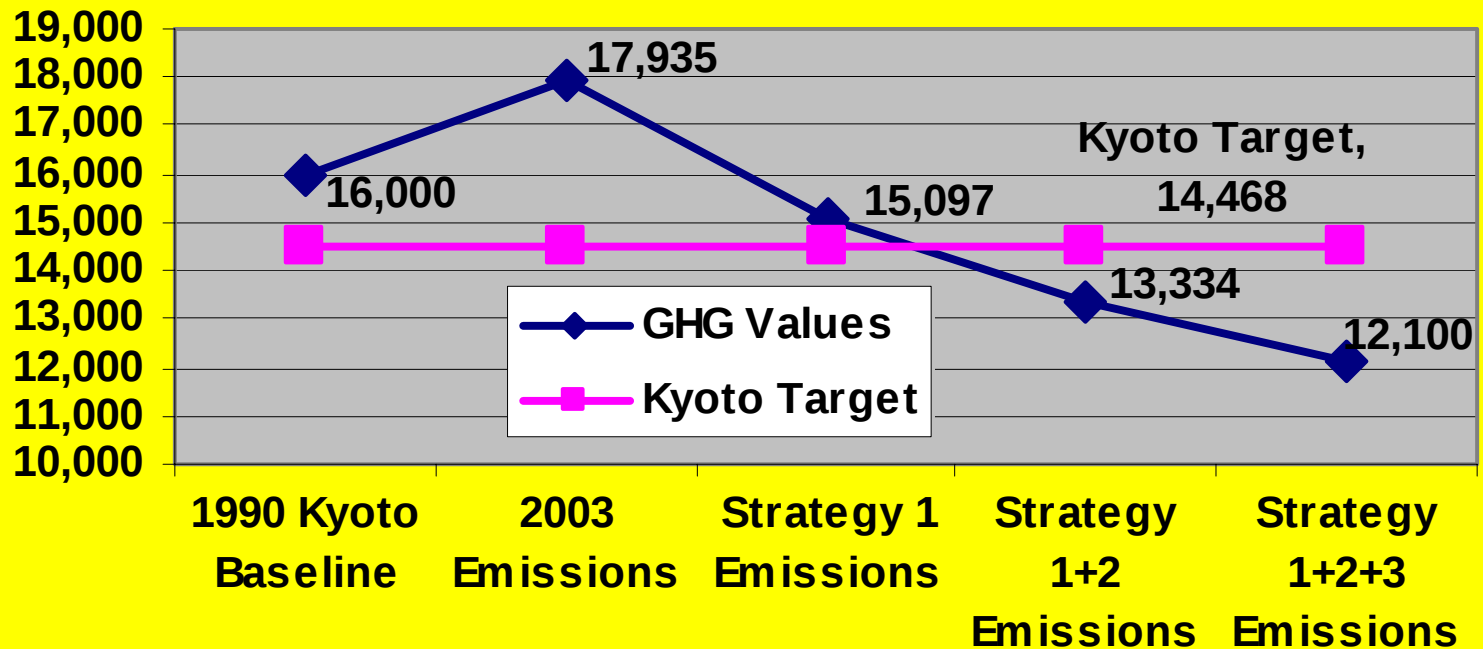
7 Run the Numbers: Cumulative Results with Strategy 1+2:



7 Run the Numbers: Cumulative Results with Strategy 1+2:



7 Run the Numbers: Cumulative Results with Strategy 1+2 +3:



6 Strategy Example 4:

Use existing space more efficiently

- Improve classroom utilization from 30% to 60%.
- Convert old classrooms to other functions.
- Build less new classroom space.
- Do a better job of “lean and mean” space allocation.
- Extend hours of operation for buildings.
- In other words “Right – size the Campus”!

Lessons Learned:

- Good baseline data is critical.
- Good information about building energy uses (existing and proposed).
- It will likely require multiple energy conservation and production strategies to make the target.
- It may help to connect Kyoto reduction strategies to Campus culture and long range development objectives.
- LEED Platinum may be a minimum standard.
- Remember to pick the low hanging fruit first!

Next Steps:

- Further evaluation of on-site generation potential.
 - Verify area and sub-surface geology for ground source heat pumps.
 - Evaluate cost/benefits of different solar options.
 - Evaluate potential to retrofit existing buildings even though slated for long term demolition.
- Set up a project by project evaluation strategy
 - Link on-site generation technologies to building types.
 - Link energy efficiency targets to building types.
- Set up a GHG accounting strategy
 - Track GHG reductions.
 - Modify targets to be consistent with achievements.
- Go for the low hanging fruit!
 - “Right size” the campus.
 - Improve facilities utilization factors.
- Look at how our energy use per capita compares to others.

Credits & References

- Guidelines for College-Level Greenhouse Gas Emissions Inventories, Version 1, August 2002, Julian Dautremont-Smith
- Planning for Higher Education: Sustainability: Taking the Long View, Vol. 31, #3, Mar. 2003
- Building to Kyoto-Compliance?, Julian Dautremont-Smith December 18, 2002
- Lewis & Clark College Master Plan, May 1998.
- Robert Gulick, CPE, Carson, Bekooy Gulick and Associates, Portland, Oregon, rwgulick@cbg-engrs.com
- All photos from Lewis & Clark College archives unless otherwise noted.
- Godzilla photos from Barry's Temple of Godzilla, <http://www.stomptokyo.com/godzillatemple/index2.htm>
- Genzyme photos from <http://www.behnisch.com>, Behnisch, Behnisch and Partner, Architects, Germany
- For more information: <http://www.lclark.edu/dept/planning/>