Carbon Reduction Strategies for the City of Cambridge, UK

Capstone Project Results from the 2006 Cambridge Summer Program in International Energy Policy and Environmental Assessment

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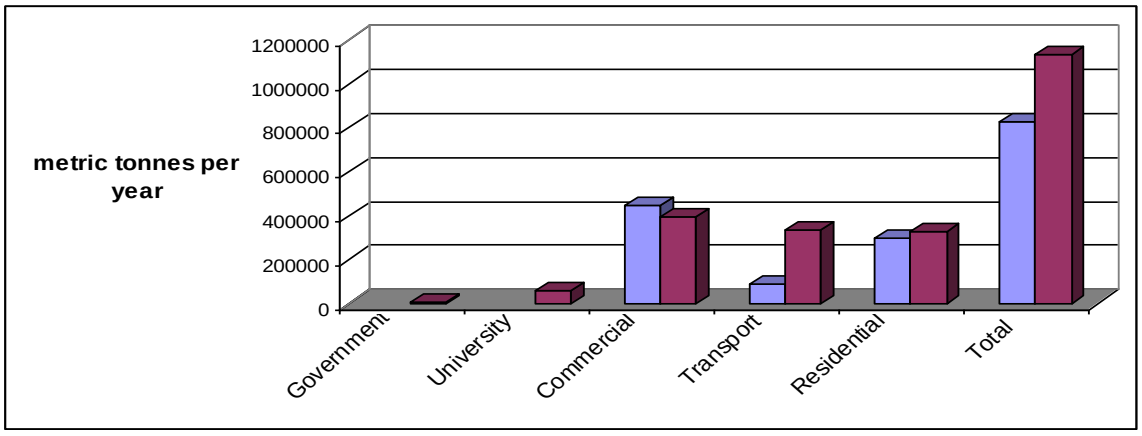
1. Introduction

The following report contains the results of the team-based projects performed by the students of the 2006 Summer Programme in International Energy Policy and Environmental Assessment in 2006. The projects were developed in collaboration with the Sustainability Team of the City Council of Cambridge, UK, based on plans for the City Council to move forward on a series of strategies to reduce carbon dioxide emissions in the city. The goal was to assess strategies across a range of sectors in the city, consistent with the break-down of the carbon footprint for the city.

The projects were selected through consideration of the seven primary ways in which the city council is moving forward on climate change:

- Signing the Nottingham Declaration on Climate Change
- Identifing and implementing energy management initiatives for 25% reduction in the near term, and more later
- Producing a home energy strategy to improve energy performance by 5% per year
- Introducing a sustainable purchasing initiative and waste minimization programme
- Reducing transport emissions by reviewing staff travel plan
- Promoting renewable energy technologies through a Sustainable Design and Construction Supplementary Planning Document
- Increasing climate change awareness and action amongst staff

The projects drew on previous carbon footprints developed by the 2005 Summer Programme team and the UK Department of Environment, Food and Rural Affairs (DEFRA), shown in figure below with Summer Programme figures in purple and DEFRA figures in blue. The primary difference lies in Transport, where DEFRA did not include emissions from vehicles whose trips passed through but did not originate in Cambridge.



The team would especially like to acknowledge the assistance of partners from:

- Cambridge City Council Environment Centre
- East of England Regional Assembly
- East of England Development Agency
- Cambridgeshire County Council
- Cambridge Carbon Footprint
- The Carbon Trust
- The Energy Savings Trust
- The University of Cambridge
- Cambridge Architectural Research, LTD
- Cambridge Energy Forum
- Department of Environment, Food and Rural Affairs

2. Home Energy Efficiency in Existing Private Residential Homes in Cambridge

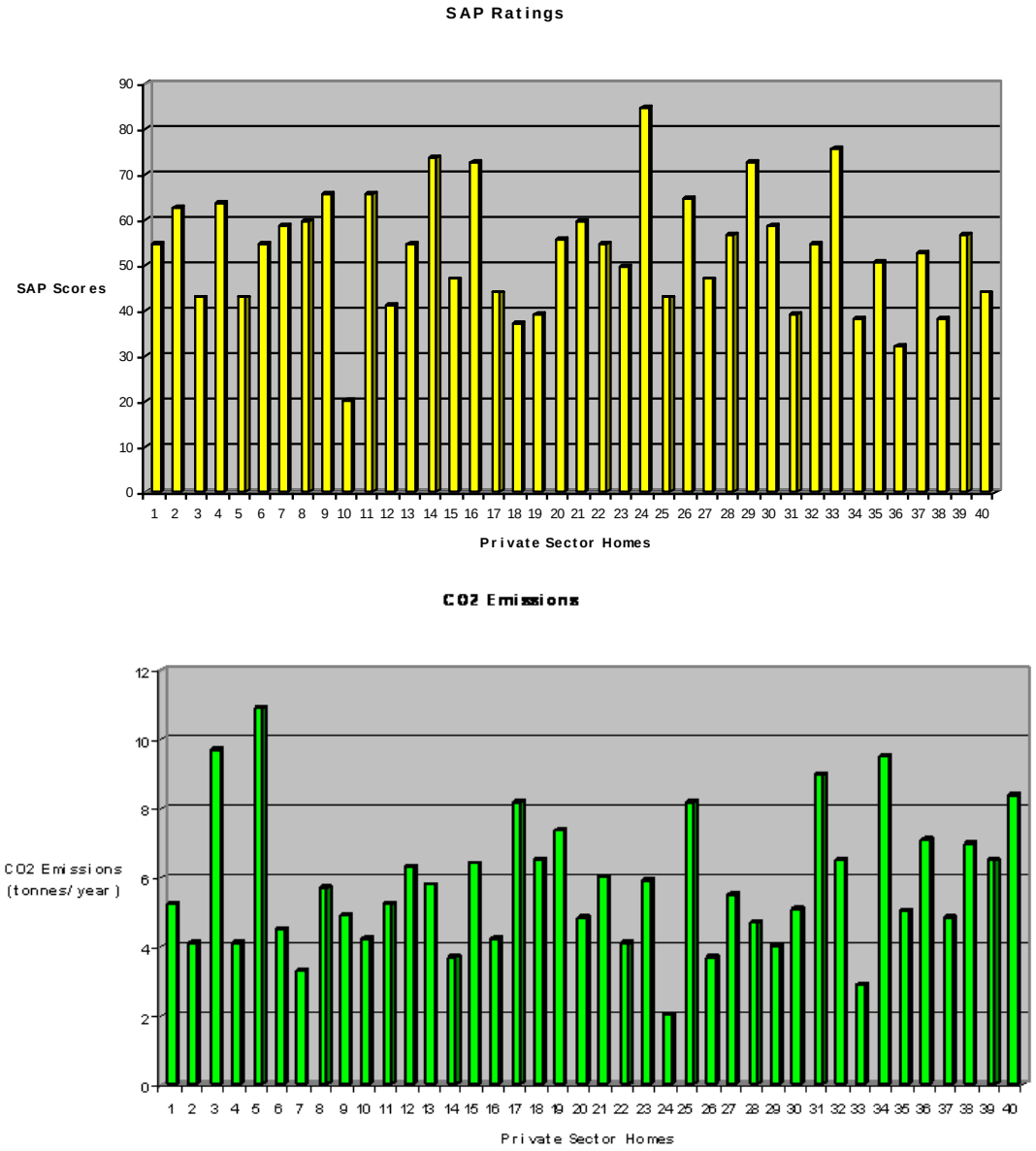
The Energy Saving Trust of England has a wide variety of helpful hints on reducing energy use in homes. Causes of energy loss are shown in the figure.

The home, including space heating and cooling, is where citizens can have the largest influence on carbon dioxide emissions. Up to 25% of heat can be lost through the roof, 35% through the walls, 15% through the floors, 15% through the doors, and 10% through the windows (1). This project focused on understanding how existing homes in Cambridge perform with respect to the energy envelope that affects energy use for heating and cooling.

A random data sampling of private residences (both privately-owned and Council-owned, excluding flats because these are not considered private residences) in Cambridge was examined to assess their energy efficiency, using the Energy Saving Trust's survey tool. This survey included, but was not limited to several variables such as property type, year built, number of rooms and floors, double-glazing of windows, main heating system, insulation type, wall type, draught-proofing, and secondary heating. The surveys were conducted for various age groups, genders, and races. Mr. Sam Griggs, the Home Energy Officer, provided a computer program ArcAsset to convert survey results to a standard measure of home energy use: the Standard Assessment Procedure (SAP) score.

Using the United Kingdom's 3 year average fuel prices, the SAP scores are based on energy expenditures for space and water heating under standard occupancy (2 people per dwelling). The SAP scale is from 1 to 120 (2). The most efficient homes have a high SAP rating while homes lower in efficiency receive lower scores. The average SAP rating for the private residential sector in Cambridge was found to be 48; for comparison, the average for Council housing was 62. The overall average across

privately-owned residences and Council-owned residences was 53, with a range from 20 to 85.

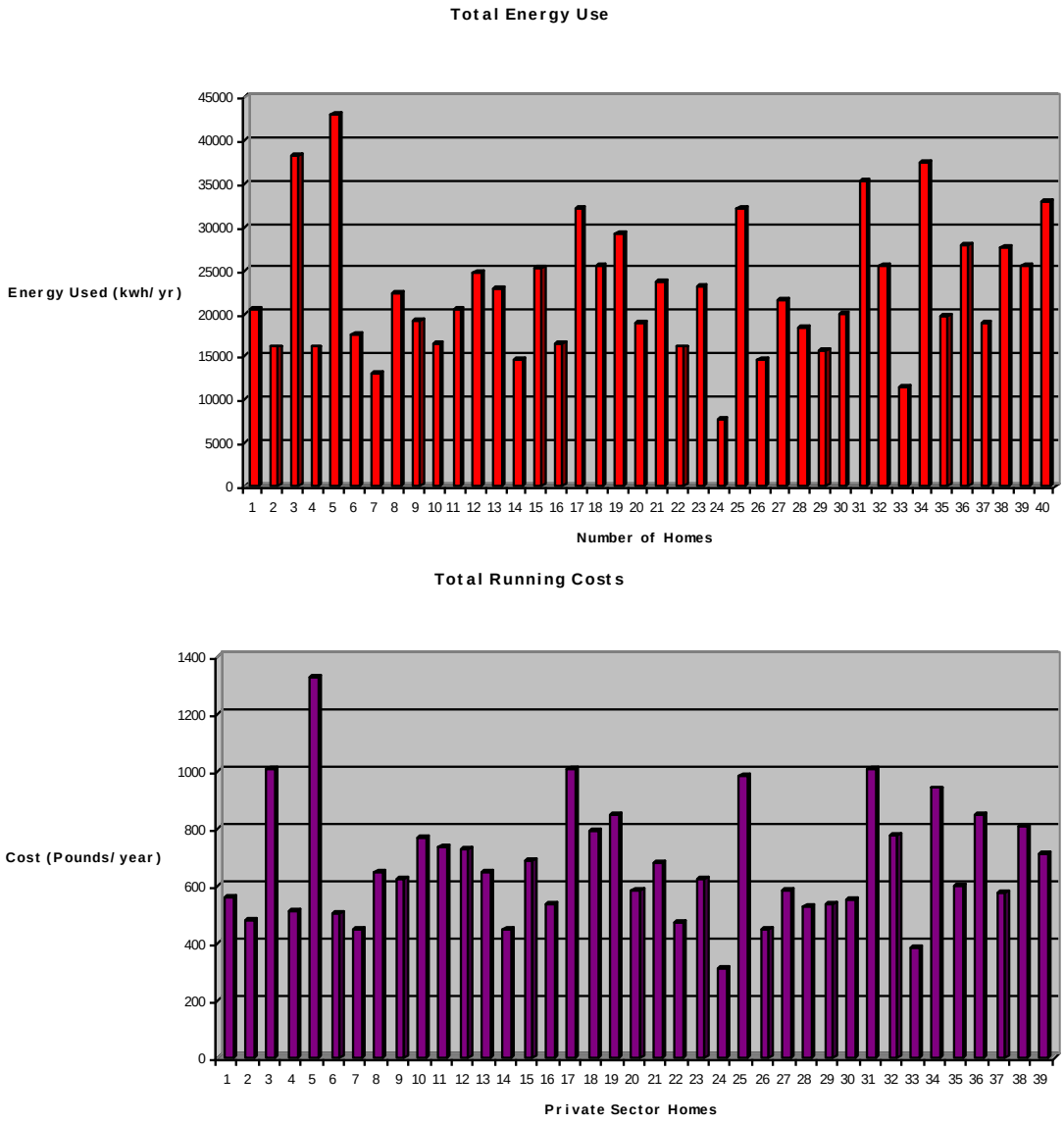


SAP ratings (top figure) and carbon dioxide emissions (bottom figure) calculated for the 40 residences in the survey conducted for this study.

The SAP results also yielded estimates of carbon dioxide emissions per household, which averaged approximately 6 tonnes per year in the survey sample, with a range of 2 to 11 tonnes per year. In analyzing the data from the surveys, it was found that the higher carbon dioxide emissions are from homes that are older and have little or no insulation and energy efficient appliances and lighting (3). These homes also generally have two fuel sources (3).

Total energy use in homes was calculated from the carbon dioxide emissions using the following formula:

Energy use (kW-hrs/year) = carbon dioxide emissions (tonnes/year) / (0.80*0.00019 + 0.20*0.00051).



Energy use (top figure) and energy costs (bottom figure) for the homes in this study.

The denominator in this calculation is the release factor, or carbon dioxide emissions rate per kW-hr, using the national average of 80% of home heating energy from natural gas (with a release factor of 0.00019 tonnes per kW-hr) and 20% from electricity (with a release factor of 0.00051 tonnes per kW-hr). The resulting average energy use for existing private residences in Cambridge is 23,000 kW-hrs (averaged over privately-owned and Council-owned).

The average running cost per household is approximately £678 per year, with a range of £310 per year to £1300 per year (again, averaged over privately-owned and Council-owned). This figure could be reduced by nearly a third (£200 per year) through installations of insulation, double-glazing and draught-proofing (4).

The measures of efficiency above are primarily influenced by the following factors: age of home, amount of insulation, primary heating fuel and secondary heating fuel. In Cambridge, there are many homes that date back to pre-1918 construction; the Council-owned private residences tend to be constructed slightly more recently, which may account for their higher SAP ratings. The older homes are less energy efficient than the newly constructed homes. Homes equipped with insulation, be it solid wall, loft, or any other type, are more efficient than homes with less insulation. Having more than two fuel sources also decreases the efficiency of homes (probably because such homes tend to have older heating systems).

The most cost efficient way to improve household efficiency is to make enhancements in insulation, draught proofing and double glazing (5). Un-insulated cavity walls can add up to 25% onto the heating bill (4). However, insulating the wall cavity can save households £220-£270 a year (4). Loft insulation is the most cost effective energy saving measure and is the easiest to install (4). This measure can save over 30% of heating costs (4). Another way to improve efficiency is to double glaze windows, which can cut heating bills by £60-£70 a year (4).

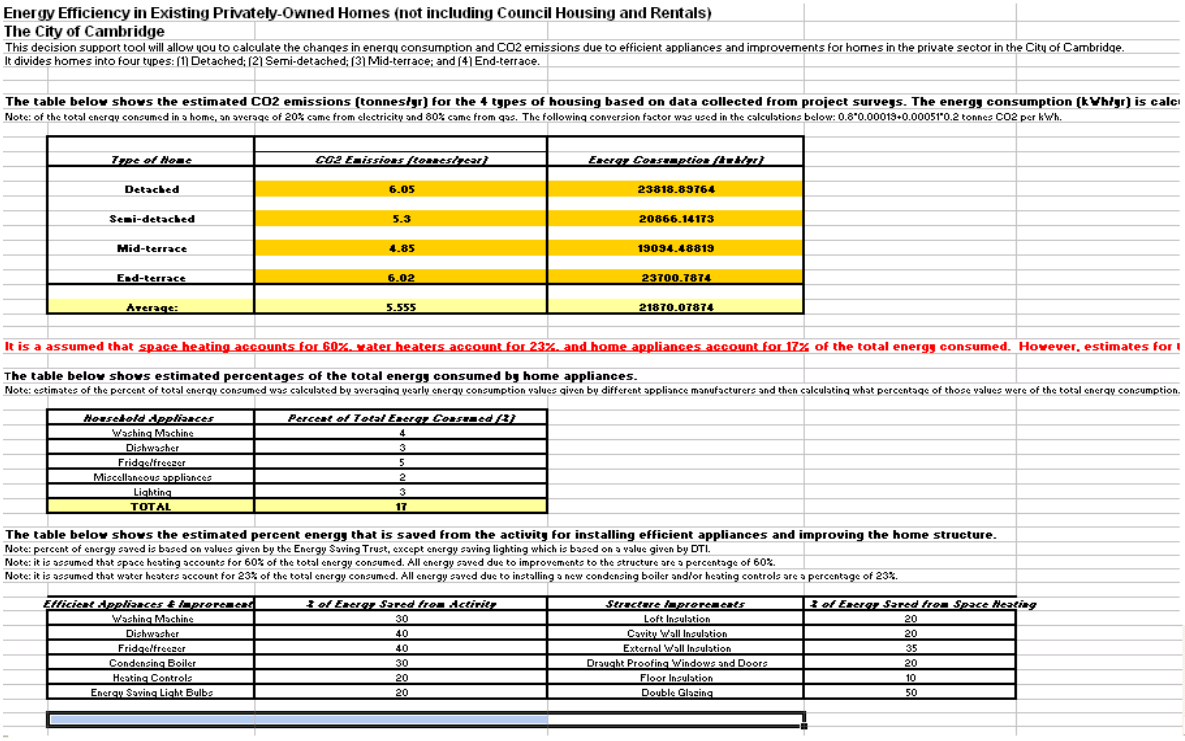
The effects of installing energy efficient appliances in homes was not evaluated in this study. However, homes equipped with appliances such as energy efficient refrigerators, washing machines, dishwashers and dryers can reduce household energy usage significantly (4). Installing a more efficient boiler, such as a high efficiency condensing boiler is important, as they waste the least amount of energy. The standard boiler converts 78% of the fuel into heat, compared to 90% for the most efficient boiler (4).

Switching to alternative energy companies also significantly helps to decrease carbon dioxide emissions from homes. Approximately 5% of total output from renewable sources such as hydroelectric, wind and solar are required of UK electricity suppliers (2). Switching to a green tariff can be a practical option for reducing personal carbon dioxide emissions, as all electricity used will be matched with energy produced from renewable sources (6). Companies providing this service include Ecotricity, Good Energy and Green Energy (6).

The final product of the study is a model that allows private homeowners within four types of household spaces - detached, semi-detached, mid-terrace, and end-terrace - to calculate the changes in energy consumption (kWh/year) and carbon dioxide emissions (tonnes/year) under different improvements to their homes. The model focuses solely on privately-owned residences; Council housing and private rentals were not included in the calculations (we did not have sufficient survey records for private rentals). To account for the differences in energy fuel sources within Cambridge City homes, three different EXCEL worksheets are provided: 1) one for combined electricity and gas as energy sources, 2) one for homes with electricity as the only energy source, and 3) one for homes with natural gas as the only energy

source.

To use the model, private homeowners can enter the improvements they would like to make for their homes into a table provided. They can then visualize the change in energy consumption (kWh/year) for each individual improvement as well as overall improvements to the total energy consumption (kWh/year). Once the energy consumption (kWh/year) is calculated, homeowners can also observe the savings in carbon dioxide emissions (tonnes/year), the carbon dioxide emissions (tonnes/year) prior to the improvements, and finally the percent reduction in carbon dioxide emissions (tonnes/year) from their homes.



Energy Efficiency in Existing Privately-Owned Homes (not including Council Housing and Rentals)

The City of Cambridge

This decision support tool will allow you to calculate the changes in energy consumption and CO2 emissions due to efficient appliances and improvements for homes in the private sector in the City of Cambridge.
It divides homes into four types: (1) Detached; (2) Semi-detached; (3) Mid-terrace; and (4) End-terrace.

The table below shows the estimated CO2 emissions (tonnes/yr) for the 4 types of housing based on data collected from project surveys. The energy consumption (kWh/yr) is calc

Note: of the total energy consumed in a home, an average of 20% come from electricity and 80% come from gas. The following conversion factor was used in the calculations below: 0.8*0.00019+0.00051*0.2 tonnes CO2 per kWh.

Type of Home	*CO2 Emissions (tonnes/year)*	*Energy Consumption (kWh/yr)*
Detached	**6.05**	**23818.89764**
Semi-detached	**5.3**	**20866.14173**
Mid-terrace	**4.85**	**19094.48819**
End-terrace	**6.02**	**23700.7874**
Average:	**5.555**	**21870.07874**

It is a assumed that space heating accounts for 60%, water heaters account for 23%, and home appliances account for 17% of the total energy consumed. However, estimates for t

The table below shows estimated percentages of the total energy consumed by home appliances.

Note: estimates of the percent of total energy consumed was calculated by averaging yearly energy consumption values given by different appliance manufacturers and then calculating what percentage of those values were of the total energy consumption.

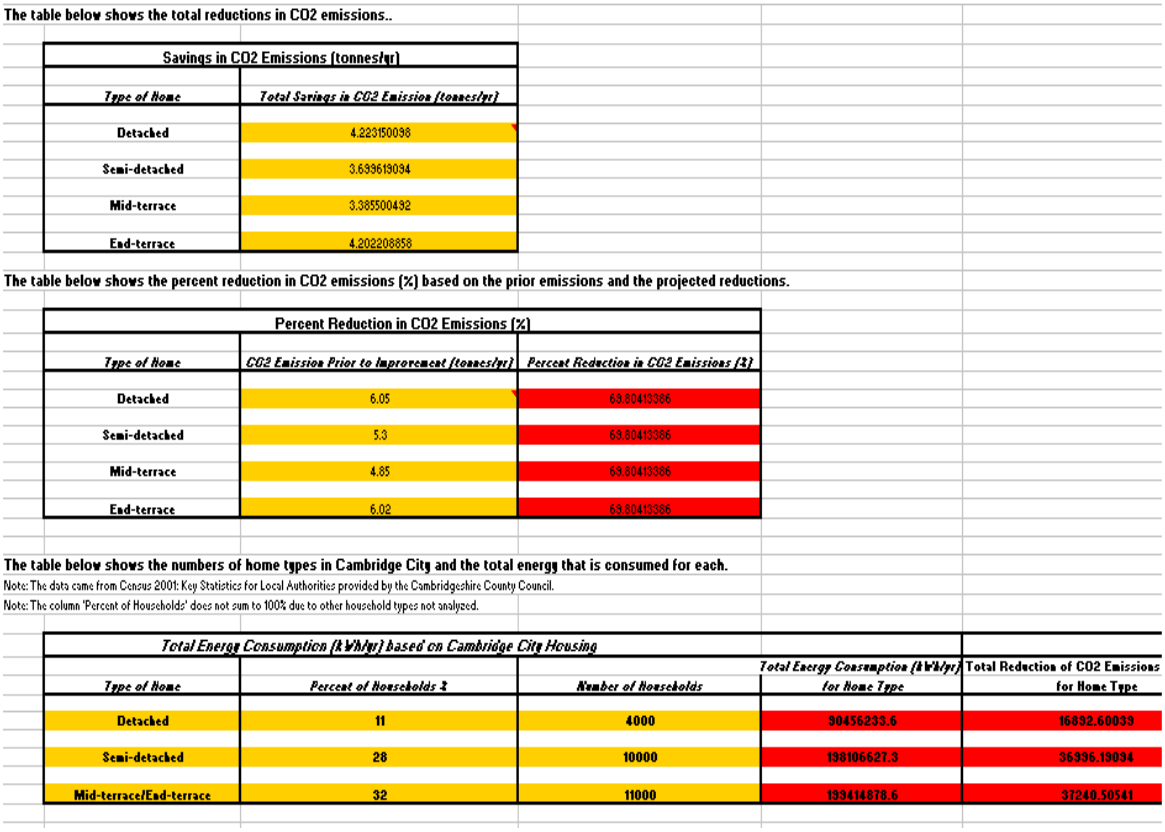
Household Appliances	*Percent of Total Energy Consumed (%)*
Washing Machine	4
Dishwasher	3
Fridge/freezer	5
Miscellaneous appliances	2
Lighting	3
TOTAL	**17**

The table below shows the estimated percent energy that is saved from the activity for installing efficient appliances and improving the home structure.

Note: percent of energy saved is based on values given by the Energy Saving Trust, except energy saving lighting which is based on a value given by DTI.
Note: it is assumed that space heating accounts for 60% of the total energy consumed. All energy saved due to improvements to the structure are a percentage of 60%.
Note: it is assumed that water heaters account for 23% of the total energy consumed. All energy saved due to installing a new condensing boiler and/or heating controls are a percentage of 23%.

Efficient Appliances & Improvement	*% of Energy Saved from Activity*	*Structure Improvements*	*% of Energy Saved from Space Heating*
Washing Machine	30	Loft Insulation	20
Dishwasher	40	Cavity Wall Insulation	20
Fridge/freezer	40	External Wall Insulation	35
Condensing Boiler	30	Draught Proofing Windows and Doors	20
Heating Controls	20	Floor Insulation	10
Energy Saving Light Bulbs	20	Double Glazing	50

A screenshot of the EXCEL model for estimating the effectiveness of home improvements on energy use and carbon dioxide emissions.



The table below shows the total reductions in CO2 emissions..

Savings in CO2 Emissions (tonnes/yr)	
Type of Home	*Total Savings in CO2 Emission (tonnes/yr)*
Detached	4.223150098
Semi-detached	3.639619094
Mid-terrace	3.385500492
End-terrace	4.202208858

The table below shows the percent reduction in CO2 emissions (%) based on the prior emissions and the projected reductions.

Percent Reduction in CO2 Emissions (%)		
Type of Home	*CO2 Emission Prior to Improvement (tonnes/yr)*	*Percent Reduction in CO2 Emissions (%)*
Detached	6.05	69.80413386
Semi-detached	5.3	69.80413386
Mid-terrace	4.85	69.80413386
End-terrace	6.02	69.80413386

The table below shows the numbers of home types in Cambridge City and the total energy that is consumed for each.

Note: The data came from Census 2001: Key Statistics for Local Authorities provided by the Cambridgeshire County Council.

Note: The column 'Percent of Households' does not sum to 100% due to other household types not analyzed.

Total Energy Consumption (kWh/yr) based on Cambridge City Housing				
Type of Home	*Percent of Households %*	*Number of Households*	*Total Energy Consumption (kWh/yr) for Home Type*	Total Reduction of CO2 Emissions for Home Type
Detached	11	4000	90456233.6	16892.60039
Semi-detached	28	10000	198106627.3	36396.19094
Mid-terrace/End-terrace	32	11000	193414878.6	37240.50541

A screenshot of results from the study, described in the text.

References

1. Energy Saving Trust (www.est.org.uk)

2. Cambridge City Council (www.cambridge.gov.uk)

3. Website on Cambridge Residential Energy (www.unc.edu/~dcrawfor/residential.htm)

4. Energy Saving Trust: Save Your 20% Guide (www.saveyour20percent.co.uk)

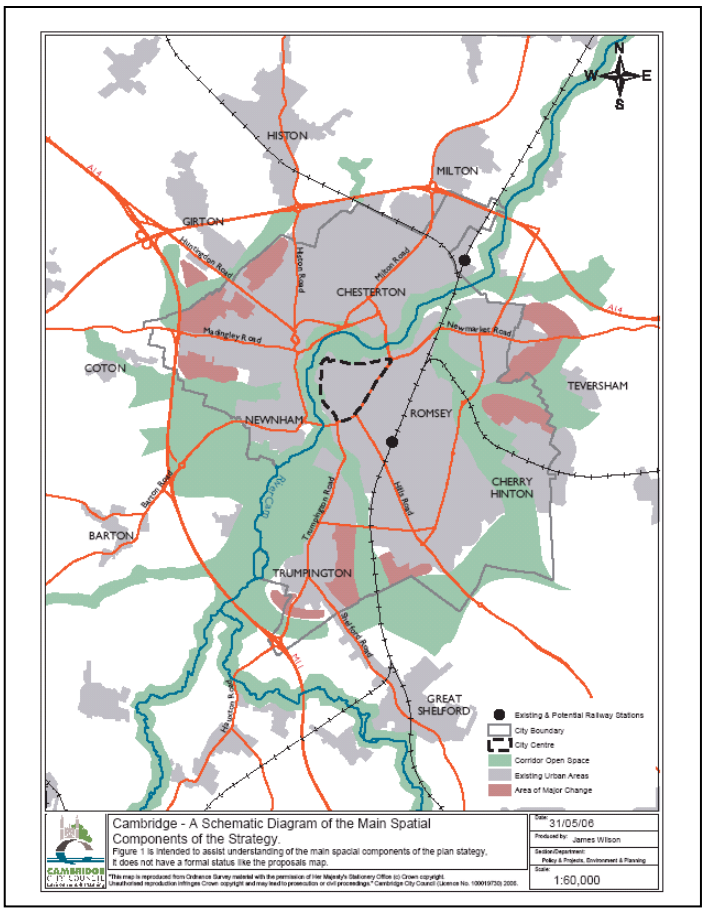
5. GB Energy (www.gb-energy.com)

6. Energy Watch (www.energywatch.org.uk)

7. Cambridgeshire County Council (www.cambridgeshire.gov.uk/community/census/Householdsanddwellings.htm)

3. Home Energy Efficiency in Future Residences: Projected Carbon Emissions and the Cambridge Local Plan, 2006

According to the newly adopted Local Plan for Cambridge, 12,500 new homes will be constructed between 1999 and 2016 to meet the city's growth and development needs. Housing designs will vary depending on market demand: 1-2 bedrooms flats, semi-detached houses, etc. Residential development is intended to be mixed-use, very similar to that found in the new Cambourne community, located eight miles outside of Cambridge.



The Cambridge Local Plan, 2006 contains details on likely locations of new housing.

It is possible to estimate the impact of carbon dioxide emissions from Local Plan development by using energy efficiency data from new Cambourne homes as a standard for the projected 12,500 new Cambridge residences. The British government measures home energy efficiency via the SAP Energy Rating system, which is based on costs for space and water heating. The average SAP rating of a Cambourne home is 96, based on a scale of 0-120. As the average SAP score of existing residences in Cambridge is 53, these new homes are quite energy efficient by comparison. A SAP of 96 yields 2.19 tonnes of carbon dioxide annually per household, corresponding to approximately 9,727 kilowatt hours (kW-hr) of energy consumed each year. These values are a factor of 2 to 3 below those for existing homes in Cambridge (see results of Section 2).

If it is assumed that all new homes constructed under the Local Plan attain a baseline SAP score of 96 (excluding any additional energy efficient features), then the 12,500 new homes would produce a total of 27,392 tonnes of carbon dioxide annually. Based on this calculation and the current residential emissions estimates for Cambridge from DEFRA (296,000 tonnes in 2003), this new housing scheme would contribute 8.47% of total residential carbon dioxide emissions and 3.19% of Cambridge city emissions from all sectors. (Source: Defra Regional and Local Carbon Emissions, 2003). These calculations assume that all other factors in a home (such as appliance efficiencies) remain constant.

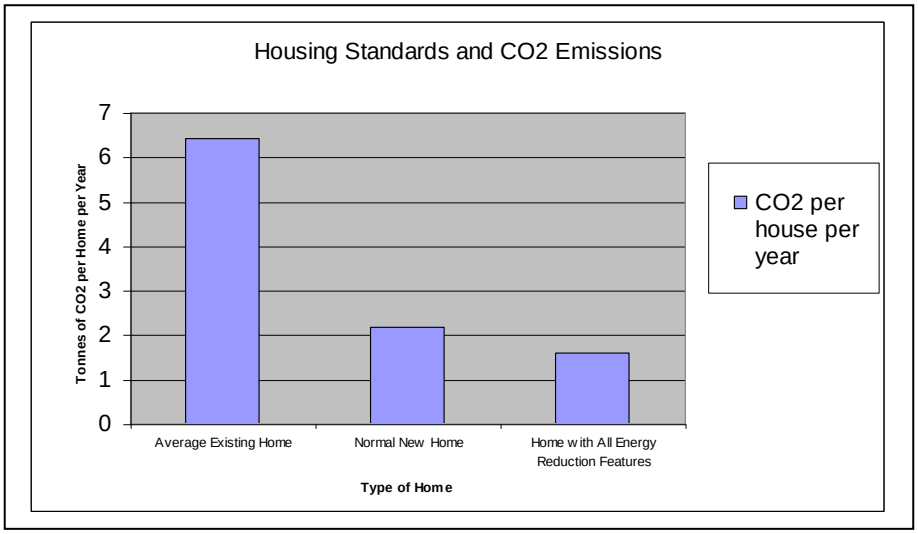
Although all new buildings under the Local Plan are required to "be constructed in a sustainable manner," these building standards are not quantified. Chapter 8 of the plan does require development proposals larger than 1,000 m^2 or 10 dwellings to provide at least 10% of total energy requirements via on-site renewables. However, developers do not have to abide by this standard if they can demonstrate that compliance is impracticable and/or economically unfeasible (New Local Plan, chapter 8). Therefore, this 10% rule is considered in this study to be an additional Low Carbon Home feature above and beyond the SAP baseline of 96, rather than a standard feature of new homes. For example, if all other factors remain constant, adding such a feature would reduce annual new household carbon dioxide emissions by 9%.

Total projected carbon dioxide emissions from these 12,500 houses could be further reduced if other Low Carbon features are included in construction. These features include A Grade appliances, energy efficient lighting, and 10% on-site renewable energy generation. For example, if a standard new home were to implement all energy saving features, then total household carbon dioxide emissions would decrease by 28%. When added to the previously mentioned reductions, this would be a 76% reduction of carbon dioxide emissions per new home compared to those from an average existing home in Cambridge.

Section 8.41 of the Local Plan describes projected energy use from these new 12,500 houses as "sustainable" in the context of the UK pledge to reduce CO_2 emissions by 60% before 2050. However, Ashwell Property Group and Bidwells Planning – two major players involved with Local Plan housing construction – have no sustainable or EcoHome housing schemes planned for this development. Mr. David Bentley of Bidwells Planning in Cambridge explained that when development groups invest in sustainable housing they rarely receive adequate returns on their investments (meeting, 25 July 2006). He also opined that energy efficiency building standards generally are driven by regulations rather than consumer demand or developer initiative. If this is the case, then perhaps the Local Plan's renewable energy "requirement" should be less flexible.

To better understand the relationship between consumers, developers, and sustainable housing in Cambridge, a survey of Cambridge citizens was conducted. A majority of those surveyed (68%) stated that energy efficiency would be a top priority for consideration if they were on the market for a new home. In addition, most individuals either already had or expressed interest in having various energy efficient features installed in their homes. Loft insulation (94%) and double-glazed windows (90%) were particularly popular and desirable features. Some survey participants expressed dissatisfaction with the weight and light quality of energy efficient bulbs,

while others explained that price and location largely determine home-buying decisions. Still, almost everyone was concerned with energy efficiency and lower electricity bills. The attitude of most of those surveyed regarding sustainable housing was "If I had the money, I'd do it." There is certainly strong interest in energy efficient housing, and therefore based on these results, Ashwell, Bidwells, and other developers should market their homes with efficiency standards in mind.



Standard new home construction methods can significantly reduce energy use and carbon dioxide emissions compared to existing homes in Cambridge.

One company that does market energy efficient homes is Countryside Properties, a specialised developer that builds sustainable communities around the UK. Their Accordia development, located on Brooklands Avenue in Cambridge, has enjoyed recent success – more than 85% of homes have already been purchased. Accordia has been awarded an EcoHomes rating of 'very good' through the Building Research Establishment's Environmental Assessment Method (BREEAM), although their overall SAP scores are very similar to those of new Cambourne homes. With an average price over £900,000 per house, however, Accordia's EcoHomes are unfeasible for most Cambridge residents (although it must be noted that those homes are also quite large- approximately double the square footage of most Cambridge homes). However, Countryside has demonstrated that it is possible to successfully build and market energy efficient homes in a large-scale development.

In summary, construction of 12,500 new homes under the Local Plan will account for 3.19% of Cambridge citywide carbon dioxide emissions – a significant although not dominant source of carbon dioxide. Therefore, it is recommended that City Council policies within the residential sector focus primarily on upgrading existing residences. However, the dynamic between existing and future housing may change over time, as the possible future installation of air conditioning units in new homes will considerably increase carbon dioxide emissions from that sector. Ms. Linda Clare of Countryside Properties reported that she receives daily inquiries about the presence of air conditioning (AC) in new Accordia homes. As summer temperatures and demand for AC continue to rise, EcoHome and energy efficiency features will become increasingly important considerations in new home construction.

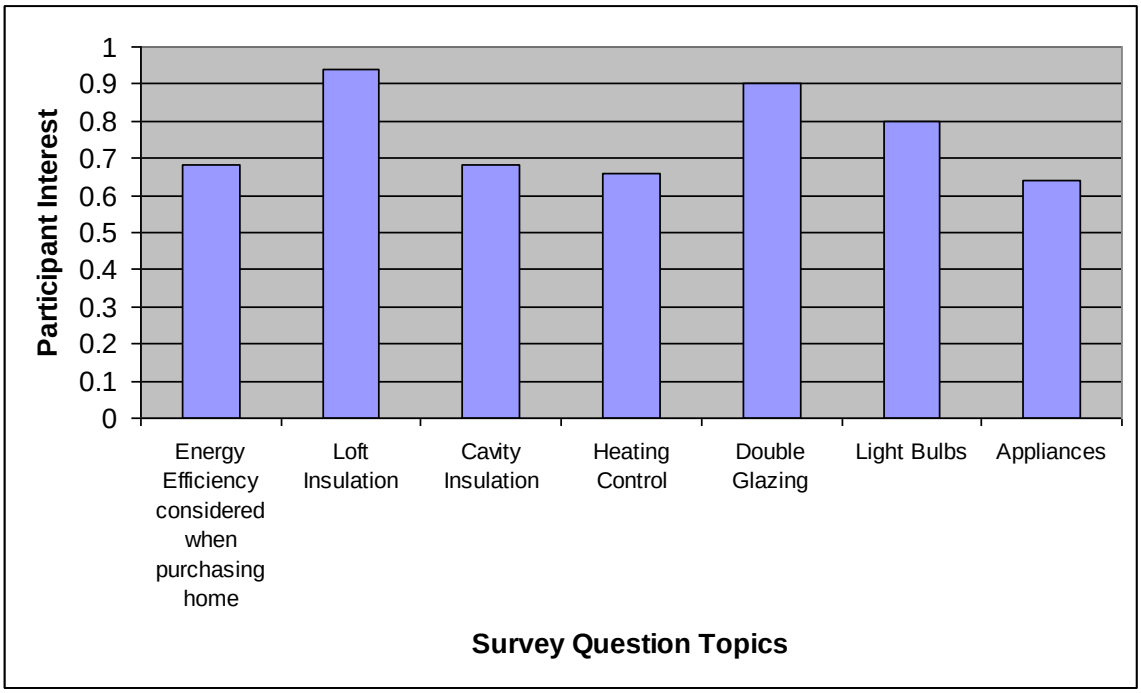
Predicted New Home Stock After Selecting Energy Saving Features	
Estimated kWh per home per year	25848.95
CO2 Emissions per home per Year (including lights and appliances)	4.71
Total CO2 Emissions per year from 12500 New Local Plan Homes (tonnes)	58887.94
Percent New Plan Homes in Cambridge Once Completed	21.43%
Existing Cambridge Residential C02 Emissions (tonnes)	296000.00
Percent of Future Residential CO2 Emissions from New Plan Homes	16.59%
Total CO2 from Cambridge (tonnes)	832000.00
Percent of Future Cambridge Carbon Emissions from New Plan Homes	6.61%

% CO2 Reduction from Previously Estimated New Homes	
26.63%	Per Household

Features to Choose	Type 1 if Installed, Zero if Not Installed
Lightbulbs	1
Refrigerator/Freezer	1
Dishwasher	1
Washing Machine	1
Boiler	1
Dryer	1
On-Site Renewables (10%)	1

A screenshot of the EXCEL tool developed to assess the impact of different interventions on home energy performance and carbon dioxide emissions for new construction.

A question arose as to whether such energy efficient homes would find a market demand. The results of a survey to determine the market amongst Cambridge citizens is shown below:



4. The Role of Car Clubs in Reducing Carbon Dioxide Emissions from Transport

In order to meet the city's emissions reduction goals, cuts must be made across all sectors, including transport. A few of the strategies being considered for making cuts in transport are the use of biodiesel, increased use of cycles, and car clubs. This project focuses on the latter strategy.

A car club is an organization that allows members to access to a car without the upkeep or financial burden of owning a private vehicle. The members pay a monthly fee as well as a mileage fee for use of the car, when it is available. The cars are reserved through a central website that organizes all the cars in a given area. The cars are checked out from a specific parking place and returned to that location at the end of the time. The company Carplus has found that, in the UK, every car in a car club replaces 4.5 cars already on the road. In terms of carbon dioxide emissions, overall vehicle miles driven will be reduced, thereby reducing the overall carbon dioxide emissions from cars.

Table 1: Initial CO_2 Emissions for Cambridge

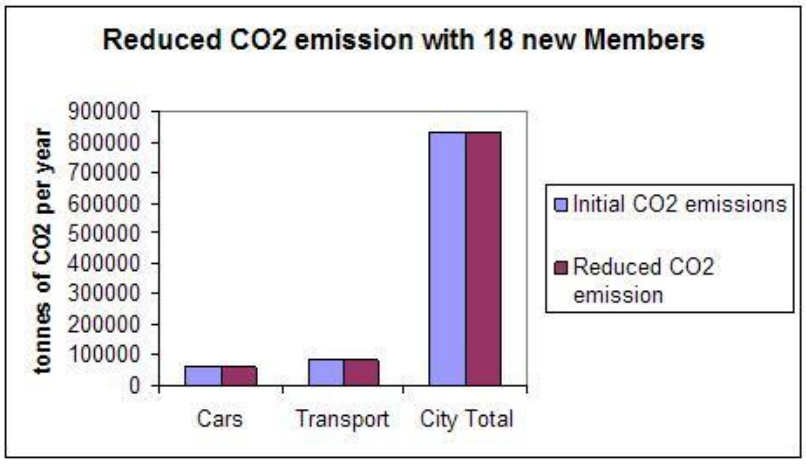
	Tonnes of CO_2
Cars	61456.8
Transport	87000
City Total	832000

Transport currently accounts for 87000 of the 832000 tonnes of carbon dioxide emitted annually in Cambridge, with 61457 tonnes per year from cars. Data are from the DEFRA report for 2003.

There are two types of start-up methods typically used when beginning new clubs. The first is core sites and organic growth. This method involves identifying the site in Cambridge of highest potential, and implementing car clubs at this site. The car club is then allowed to grow "organically", which means that more cars are purchased on an "as needed" basis, as the demand for cars grows in the area. Future sites would branch off from this main site. This scheme is financially safer and requires less start-up funding than the second method of development: ambitious start-up and expansion. The strategy is to buy several cars and form an extensive network of sites where cars are available. This method is more risky, from a financial stand point. If the car club does not succeed as expected, the loss is greater than the organic growth (1). The advantage of the approach is that any new market often requires some threshold of availability of a product before there is significant buy-in by the public. For the city of Cambridge, organic growth appears to be the most feasible option.

Situation 1

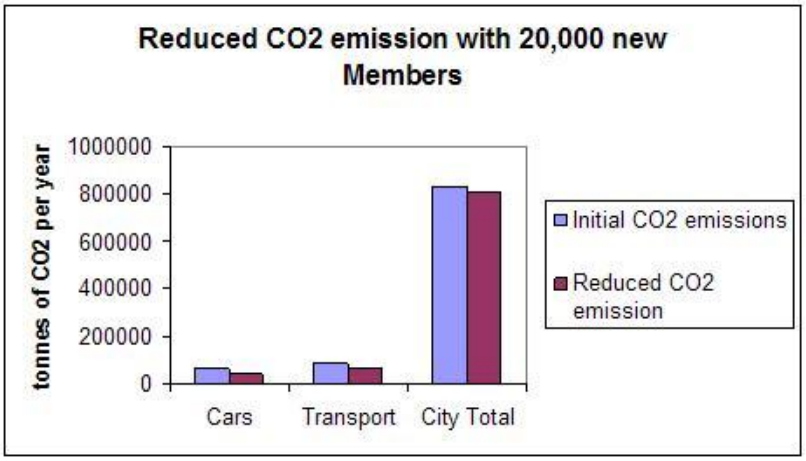
If Cambridge made an initial purchase of 4 cars, it would potentially replace the use of 18 existing cars, a net reduction of 14 cars. This is based on the assumption that CarPlus is correct that car clubs will reduce every 4.5 cars in use to 1 club car. The DEFRA report on Local and Regional CO2 Emissions Estimates for 2003 is the source for the total emissions from transport and for the City of Cambridge (2). The emissions allocated to cars are 70.46% of total Transport emissions, based on the model produced by UNC-CH students in 2005. The current emissions from cars is therefore 61,456 tonnes of carbon dioxide (87,000 tonnes for transport times 0.7046), and 832,000 tonnes per year for the entire city (3). Following the initial start-up, Car Plus states that members reduce their mileage by 55%. Assuming that each person in Cambridge drives 10,819 km per year prior to car club membership, each member will drive 5960.45 fewer km per year after joining. The reduction in carbon dioxide estimated is based on a car with a fuel efficiency of 28 miles per gallon; this results in a release factor of 203 grams of carbon dioxide per km. For a car club with 18 members and 4 cars, this is a reduction of 21 tonnes of carbon dioxide per year (5960 km x 203 g/km x 18 / 1,000,000 g/tonne). This amounts to a 0.03% reduction in the emissions due to cars in Cambridge (21/61457 = 0.0003 or 0.03%). The reduction of emissions for the entire transportation sector would be 0.02% (21/87000 = 0.0002 or 0.02%). The reduction for the overall carbon dioxide emissions in Cambridge would be 0.002% (21/832000 = 0.00002 or 0.002%). The figure below shows the reduction in emissions for an initial start-up of 18 members.



Situation 2

While the above calculations and graphs are useful for understanding how car clubs might reduce emissions in Cambridge with a small initial investment, we must also consider different growth scenarios that could occur in a Cambridge car club. In order to try to get a grasp on how many members it would take to make a significant impact on the overall emissions for the city, we calculated the emissions reduction for a situation where 20,000 Cambridge citizens joined a car club. Once again using the 4.5-to-1 cars assumption, the number of cars in Cambridge could potentially be reduced by 1,297 cars. A fleet of 377 cars would be needed to accommodate this membership. If this were to happen, the overall reduction in carbon dioxide emissions would be 23,333 tonnes per year. This would amount to a 36.97% reduction in

emissions from cars, a 27.36% reduction from the entire transport sector, and a 2.86% reduction in overall emissions from the city. The following figure displays the emissions changes with 20,000 members.



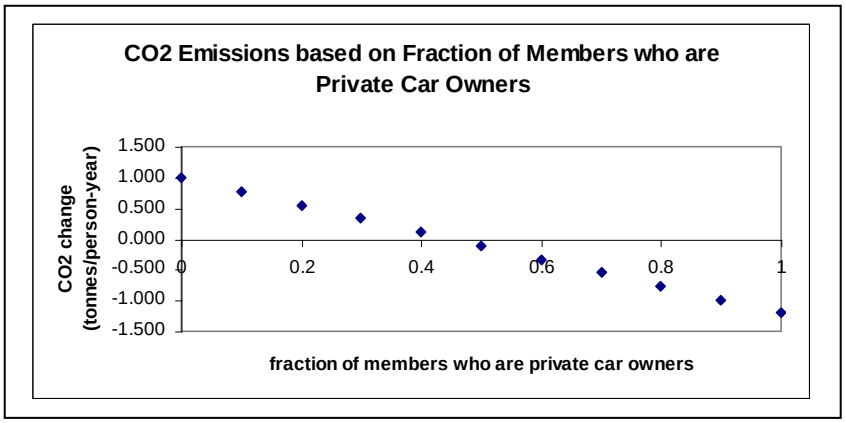
We next assessed what kind of impact smaller growth increments would have on carbon dioxide emissions. We calculated the emissions reduction using car club memberships of 100, 200, and 1000 members. The results were: with 100 members, there would be a 0.19% reduction in emissions from cars, a 0.14% reduction in the transport sector, and a 0.014% reduction in overall emissions from the city; with 200 members there would be a 0.37% reduction in emissions from cars, a 0.27% reduction in the transport sector, and a 0.029% reduction in overall emissions from the city; and with 1000 members there would be a 1.8% reduction in emissions from cars, a 1.4% reduction in the transportation sector, and a 0.14% reduction in overall emissions from the city. The table below shows the changes in emissions for various membership levels.

		Percentage of CO2 Reduction		
Number of Members	Tonnes of CO2 (per year)	Cars	Transport	City Total
18	21.42	0.033	0.025	0.003
100	119.01	0.185	0.137	0.014
200	238.02	0.370	0.274	0.029
1000	1190.09	1.849	1.368	0.143
20000	23801.80	36.971	27.358	2.861

Situation 3

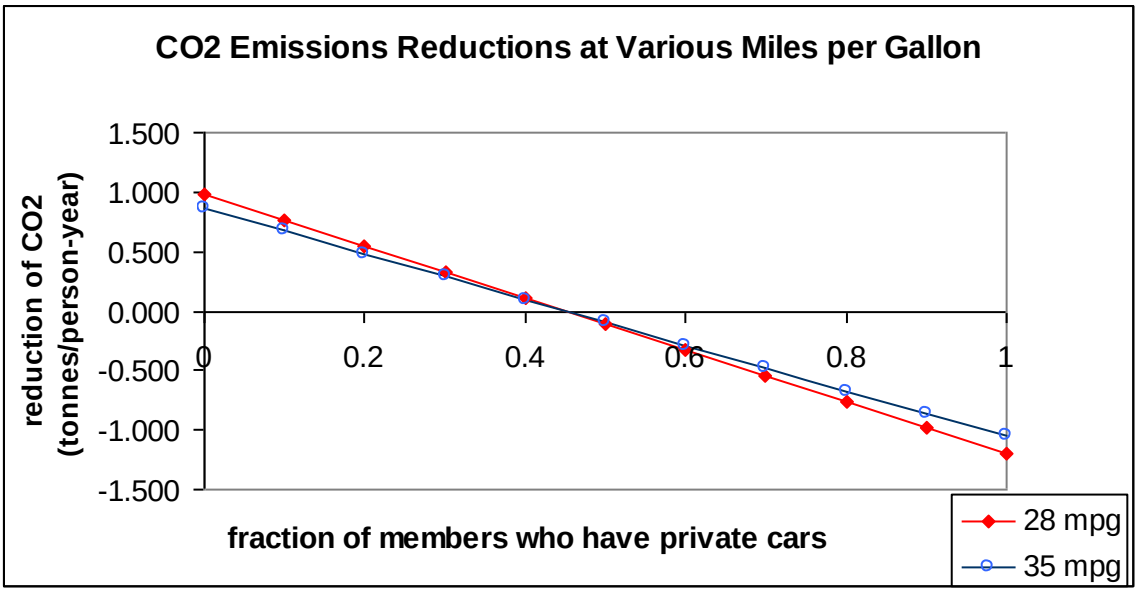
The two situations above assumed that every member of the car club was previously a private car owner. The final situation considered is based on the possibility that some of the members of the car club previously used modes of transport that did not release any carbon dioxide, such as cycling and walking. This could potentially result in a net increase of mileage driven per year in the participating population, thereby increasing carbon dioxide emissions associated with their transport.

It is assumed that each private car owner emits 2.19 tonnes of carbon dioxide per year (see the calculations in Situation 1); each member of the car club emits 0.99 tonnes per year (45% of the 2.19 tonnes). Note that a person who did not drive a car prior to joining the car club increases their emissions annually by 0.99 tonnes. The figure below shows the change in carbon dioxide emissions as the fraction of people joining the car club, and who did not drive a car prior to joining, changes.



In this figure, a positive value on the x-axis indicates an increase in carbon dioxide emissions on average for the population joining the car club; a negative value indicates a reduction. Note that at least 45% of the car club members must have been car owners prior to joining for car clubs to produce any decrease in carbon dioxide emissions.

The influence of MPG values for the cars in the car club is shown in the figure below:



Conclusions

Car clubs have a very limited impact on the overall carbon dioxide emissions for the city. Even with a membership of 1000 citizens, car clubs would only reduce the city's overall emissions by 0.14% per year. Therefore, car clubs should not be considered an effective strategy for meeting the city's carbon reduction goals. Another important

conclusion to note is that at least 45% of car club members must have previously been private car owners in order for there to be an overall reduction in carbon dioxide emissions. While car clubs may not be an effective tool for meeting the city's carbon dioxide emissions reduction goal, they should be considered as a tool for reaching other goals, such as providing citizens with affordable transport.

References

1. Car Plus (2006). *Cambridge scoping study.* Car Plus.

2. Good, J. King, K. Passant, N. et al.(2003) *Local and Regional CO2 Estimates for 2003.*Oxan, DEFRA.

3. Reducing Carbon Dixoide Emissions in the Transportation Sector of Cambridge . *Carbon Dioxide Reduction in Cambridge* . Retrived 2 August 2006.

5. Assessing Awareness and the Effectiveness of Current Information Campaigns

Every year Cambridge citizens emit approximately nine tonnes of carbon dioxide into the atmosphere. The City Council of Cambridge recognizes the significance of this statistic and in response has founded The Cambridge Environment Centre, which has declared the city of Cambridge the "Sustainable City." Through various publicity methods, the Centre strives to educate citizens about the key role they (the citizens) play in climate change. The current project focused on obtaining some form of measurement that would indicate the success of the Centre's environmental publications, as well as its impact on the attitudes and behaviors of the city population. The research focused primarily on publications and awareness assessment in regard to climate change and carbon dioxide reduction. The methods for assessing effectiveness of materials and research information were sought through professionals within the world of journalism, communications, advertising, and public health.

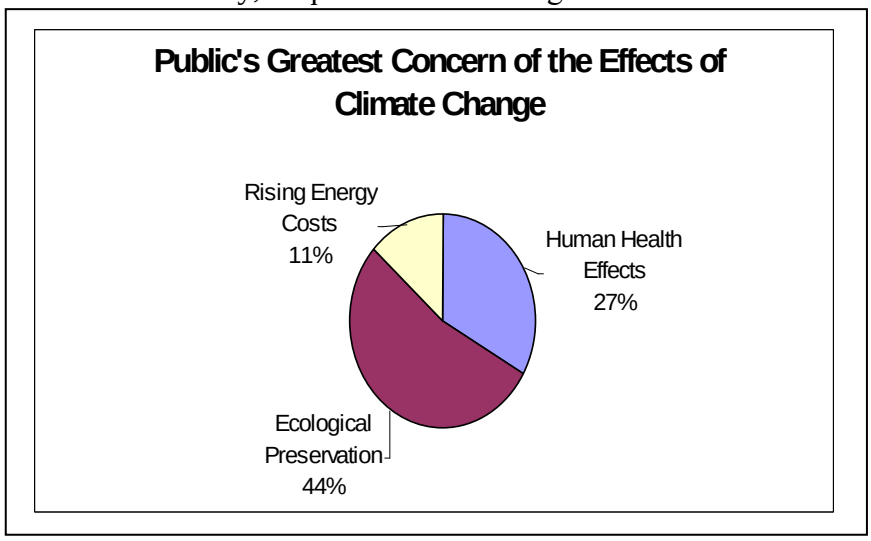
Using information from researched social marketing strategies, we created two surveys, one targeted to the general public and one for individuals who voluntarily expressed interest in the Cambridge Environment Centre by joining post mailings and email lists. The general public survey focused on personal concerns relating to climate change, daily energy efficiency practices, and individual assessment of the Environment Centre. In contrast, the mail lists survey asked questions that gauge the reactions and success of publications produced by the Sustainable City. General public surveys were conducted at various locations around town and during the Big Weekend at Parker's Piece in July 2006.

Results from the general public survey, in which 33 individuals participated, indicated the Cambridge Environment Centre is not reaching a significant percentage of the Cambridge population. Some of the questions presented to the general public inquired about their knowledge of the Cambridge Environment Centre. 85% were unaware of the Centre's existence. 1% has in fact visited the Cambridge Environment Centre. In relation to these responses, 76% think the city of Cambridge has not presented the issue of climate change in a manner that engages people in conversation. 3% of participants (i.e. one participant) had picked up materials from the Environment Centre around town, and this individual was motivated to change their lifestyle (of course, the visit to the Environment Centre may have been to obtain materials to support a prior decision to institute change- i.e. obtaining the materials may have been an effect rather than a cause of changes).

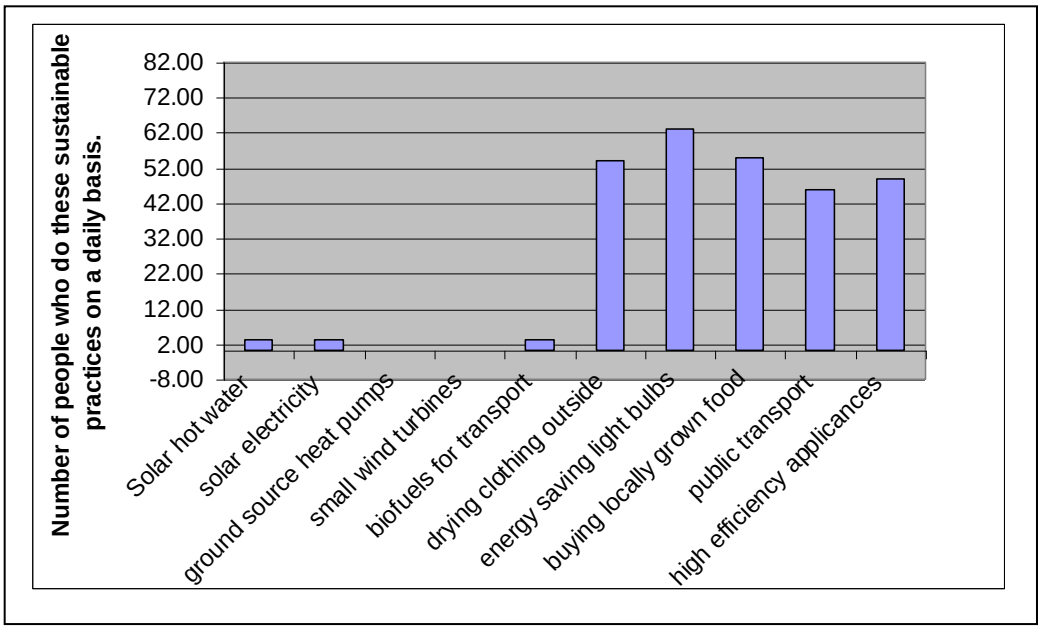
Additionally, participants were asked to list where they receive most of their information on climate change. 58% receive most of their information from television media and 27% specified the internet. Given this fact, we propose, and a Cambridge citizen personally suggested, the Centre utilize these resources to more effectively reach a larger portion of the population. Due to unavoidable modern societal habits, the spread of information via media such as television, videos and the internet will undoubtedly prove more successful than existing Centre materials.

Mail-list surveys, received through the Centre, yielded 52 responses, most of which displayed strong support for the concept of a Sustainable Cambridge. The Centre has been visited by 62% of the survey participants who learned of it's location by

newsletters (most significantly 'Cambridge Sustainable City') friends, The Harambee Community Centre, and other publications. However, 33% were unaware of its existence. Although Cambridge Sustainable City's website offers accessible information, 67% of those surveyed have not visited the site. On the other hand, those who have visited it said it was presented in a convincing manner. When asked if the CRed goal, or the city's goal, of reducing carbon emissions by 60% by the year 2050 is feasible for Cambridge, 63% believe this is possible. It is important to note that a significant contingency are skeptical of the community's collective effort; this doesn't mean they are skeptical of the goal of a 60% reduction, but rather that they are skeptical of the willingness of community members to make the needed changes in carbon dioxide emissions. Conversely, to quote one Cambridge citizen's comment following this question: "Being Cambridge, YES!!" As Cambridge has a strong reputation for academic leadership and social integrity, the Centre ought to advertise needed change by drawing on the community's pride in this intellectual tradition.



According to combined results of both surveys there are three issues which



Cambridge citizens feel are the greatest concerns of climate change. 44% of the 82 people surveyed chose ecological preservation as their first concern; human health was selected by 27%, and rising energy costs by 11%. Other options presented were

agricultural productivity and fuel shortages, however, neither were chosen as a primary concern by any survey participants. When asked what societal considerations related to climate change will inspire change in their daily lifestyles, 48% said the quality of life for future generations was their highest consideration, 28% selected financial benefits, and 15% chose avoiding detrimental health effects. Focusing campaigns directed towards these more highly ranked issues will therefore have the greatest chance of changing behavior. Evidence that members of the Cambridge community support the claims above is exemplified in the following statement by a Cambridge citizen: "When are we going to come to our senses and live more sustainably – for the sake of our children and our children's children?"

We found through a question on both surveys, which addressed the current energy saving practices of the population, that Cambridge citizens are participating in actions made readily available to them. For example, most individuals do some degree of the following at work or home: drying clothing outside, using energy saving light bulbs, purchasing local produce, using public transport, and purchasing high efficiency appliances. Less of the population recorded use of these resources: solar hot water, solar electricity, ground source heat pumps, small wind turbines, and biofuels for transport. More advanced technology is understandably expensive, but those interested expressed through the surveys difficulty in obtaining information on alternative energy sources. To assist citizens in overcoming such difficulties, the Centre could provide home-owners, through post-mail and public displays, with names and contact information from alternative energy providers and simultaneously simplify the progression towards energy efficient life practices.

Targeting each community sector, such as transport, residential, and industry, seeking out the dominant decision makers within each sector and supplying them with information pertinent to their interests will yield awareness in the most important centres of decision-making in Cambridge. For example, when addressing industry, the Centre needs to establish a relationship with Cambridgeshire Chambers of Commerce. They can expose countless industries to environmentally friendly and most importantly, economically desirable actions. If the Centre presents energy efficiency in terms money savings, businesses will be more likely to make the switch!

The most effective vehicle for creating public awareness and eventual change is by "generating buzz!" Ideas translate best through human interaction. Word of mouth seems to inform populations as readily as publications. A Cambridge citizen commented that "flyers aren't helpful." Several people praised the green tents at the Big Weekend Festival. They expressed further interest in seeing Cambridge City Council participate in other such events. Visual learning such as this would be more useful to help train citizens in adopting another lifestyle, rather than continued provision of brochures. Perhaps creating a DVD or television program that follows the average day of a low-emission lifestyle, highlighting the enjoyment experienced through sustainable choices for that individual, could influence the public in an innovative manner.

The key findings of the surveys are that:

- 1% have visited the Cambridge Environment Centre
- 58% receive climate change info from TV media

- Putting environmental education on TV would reach a larger population
- 27% receive info from the internet
- 76% think the city of Cambridge has not presented the problem of climate change in a manner that engages people in conversation
- 85% were unaware the Cambridge Environment Centre exists
- 3% have picked up publications from City Council around town
- 100% were motivated to change as a result of these publications!

6. Establishing a Town-Gown Carbon Dioxide Reduction Initiative

The objective of this project was to assess the structure of environmental research, education and outreach at the University of Cambridge and constituent Colleges, and then to formulate a strategy for a joint Town-Gown climate change partnership with City Council and other sectors of Cambridge.

Higher Education Carbon Management Programme

The initial focus of the project was on determining steps the University and Colleges had already taken with respect to carbon dioxide reduction and climate change policy. The University has joined an ongoing program of the Carbon Trust called the Higher Education Carbon Management Programme. As in CRed, this program commits the University to locating practices and policies that will reduce its carbon emissions by 60% by the year 2050. The Higher Education Carbon Management Programme strategy allows a great deal of flexibility for the University in developing a carbon management plan best tailored for its needs.

A first, and significant, first step by the University was the decision in 2004 to purchase Scottish & Southern renewable energy. This resulted in an immediate reduction, by approximately 60%, in the total carbon dioxide emissions from the University operations (not the Colleges). Student organizations such as the CUSU Green group, however, have been critical of such an investment due to the unpredictable market for this particular hydroelectricity, leading to the possibility that price fluctuations in this source could drive the University to move back to more traditional fuels, effectively negating the carbon emissions reduction. They also cite the continued lack of taking additional measures to reduce carbon emissions, and argue that the University mustn't simply consider the purchase of renewable energy a significant reduction in emissions, if the campus continues to waste resources and energy. However, it is evident from meetings with Martin Whiteland of the University that there are, in fact, significant energy-saving measures being taken in University buildings and transport systems.

While the Higher Education Carbon Management Programme presents a good opportunity for the University to move forward on reductions in carbon dioxide emissions, it contains no formal feature of creating carbon dioxide emissions inventories or tracking progress towards specific targets.

University Relations Initiatives

Analysis of the University's infrastructure shows that any citywide partnership will require additional ties with the 31 independent colleges, as the latter do not necessarily participate in the University sustainability initiatives. Similarly, there is at present a significant disconnect between University Estate Management offices and the academic aspects of the University. There is an opportunity to create at the University of Cambridge the kinds of Greening the Campus efforts found worldwide at college campuses, in which the material and energy aspects of the campus are used as "living laboratories" for the student body in energy and sustainability courses and

research. Such an effort at Cambridge would also provide a natural point of contact between the University, City Council and other sectors of energy use in the city.

Three initiatives to create such an integrated education, research and outreach mission for carbon dioxide reduction are proposed:

- A fieldwork program supported by various departments in the University, with climate change research as the focal point. This program would provide students opportunities, with appropriate academic credit, to conduct applied research and outreach projects in the City of Cambridge in collaboration with the Environment Centre of City Council. The focus of the projects should be on developing and assessing strategies for carbon dioxide reductions in the local area, and/or assessing the potential impacts of climate change on local environmental, health, etc metrics.

- A student-led organization that unites the colleges to engage the issue of climate change on both the collegiate and University levels. At present there are several student groups, but none of these yet affects significant changes in carbon dioxide emissions from the Colleges. This new organization (or perhaps enhancement of an existing organization mentioned later) would be driven by student projects, linked to the first recommendation above, but would have both participation by and support of key University and College administrators so recommendations can be translated into concrete actions aimed at reduction of carbon dioxide emissions fro University and College infrastructure.

- Networking all of the students, environmental organizations, and faculty expressing interests in leading the charge on climate change. This will require some form of list-serve, centralized location for an office, limited support staff, web site, etc. It is proposed here that the Cambridge Environmental Initiative could play a supporting role in creating this network, drawing on its existing structures.

The following select departments at Cambridge University contain faculty and students that might provide a sound basis for the initiatives mentioned above due to their current research and teaching around the theme of climate change (potential points of contact are provided):

- **Dept. of Architecture** – Koen Steemers (Prof. Of Sustainable Design) kas@cam.ac.uk

- **Dept. of Engineering** – Peter Guthrie (Prof. Of Engineering for Sustainable Development) pmg31@eng.cam.ac.uk

- **Dept. of Geography –** Hans-F. Graf (Prof. Of Environmental Systems Analysis) hans.graf@geog.cam.ac.uk

- **Judge Business School –** Dr. Chris Hope (Director of the Undergraduate Program) c.hope@jbs.cam.ac.uk

The most effective method of bringing the individual colleges together with the University to jointly address the issue of carbon reduction and sustainability is through activism of a student organization. A student group (either already in

existence or newly formed) that directly deals with these climate change issues, and is comprised of members and supporters at every one of the University colleges exercises influence over individual college operations through interactions with the college bursars. With the help of these bursars, students can gain the interests and support of the independent colleges. Such a student-led organization should form the student component of any city-wide climate change initiative. There are several student organizations already in existence that would serve as excellent hosts, and provide powerful student support for this campaign:

- **CUSU Green** – Aneaka Kellay (Main Green Officer) green@cusu.cam.ac.uk

- **Ethical and Environmental Committee** – Helena Wright (Environmental Awareness Officer) environmentalawareness@cusu.cam.ac.uk

- **CU Energy Network** – Ronan Kavanagh (President) rk331@cam.ac.uk

- **Roots and Shoots** – Freija Glansdorp (CU President) fgg20@cam.ac.uk

- **CU Environmental Consulting Society**- Emilia Melville (Secretary) ejm58@cam.ac.uk

Some combination of the CUSU Green and the CU Environmental Consulting Society appears optimal to serve in this role.