Appendix 1 – Overview of the Sadberge Energy Saving Project

Home Insulation and Efficient Heating

Sadberge households were invited to fill in a special Sadberge version of the Energy Saving Trust's Home Energy Check questionnaire. 121 households (39%) filled in the forms and received personalised reports from the Energy Saving Trust and the Sadberge Climate Change Working Group. Each participating household also received two free low energy light bulbs, provided by the Energy Saving Trust.

Where appropriate, households were referred to cavity wall and/or loft insulation grant schemes, and the Climate Change Working Group also set bulk purchase schemes for double glazing and energy-efficient central heating boilers.

To date:-

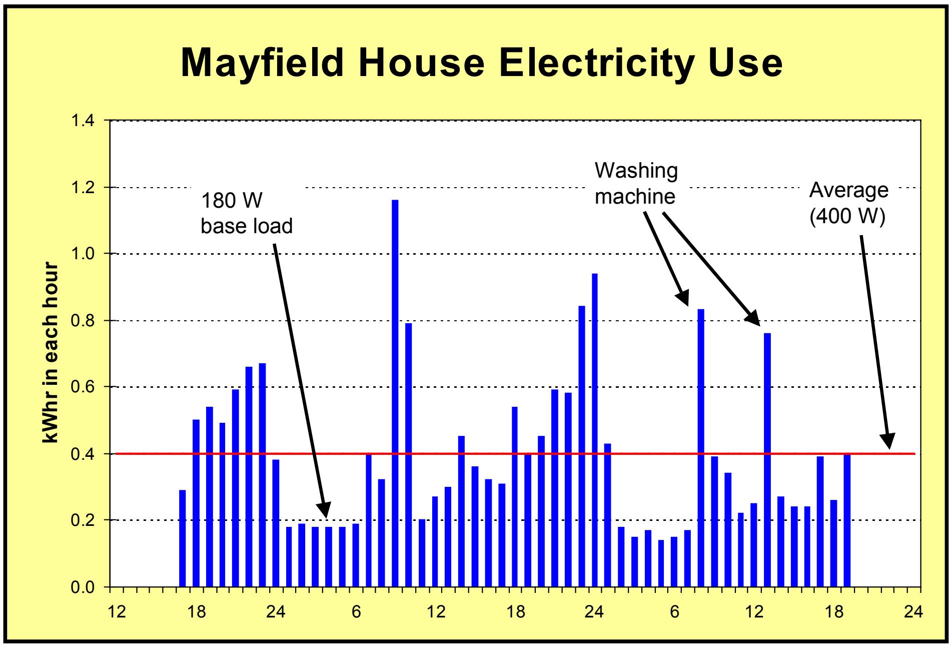
- 10 households have installed additional loft insulation through the grant schemes, and we know that other households have installed additional loft insulation on a DIY basis.
- 2 households have installed cavity wall insulation.
- 1 household installed double glazing through the bulk purchase scheme.
- 1 household installed a new central heating boiler and heating controls through the bulk purchase scheme.

Electricity Use Monitoring

With the aid of a grant from the O_2 "It's Your Community" fund, the Climate Change Steering Group bought ten Eco-eye real-time electricity monitors, which were lent out to Sadberge residents to enable them to investigate the way that they use electricity and to identify opportunities to make savings. As well as the Eco-eye monitor itself, each household was provided with a guidance note suggesting how to carry out the investigation, a checklist and, if necessary, assistance with generating a graph showing their pattern of electricity use.

There were two main aspects of the investigation:-

- Electricity use by individual lights, appliances, etc.
- The household's overall pattern of electricity use.



One important element in the investigation methodology was the identification of each household's "base load" electricity use, which is most easily measured as the rate at which electricity is being used between 2 a.m. and 6 a.m., when the only devices that are switched on are the ones that are switched on all the time. Given that using one watt continuously for a year costs about a pound, it is interesting to note that to date households have reported base loads ranging from 110W to 350W.

To date, 49 Sadberge households have borrowed smart electricity monitors and used them to investigate their electricity use.

In phase 2 of the electricity use monitoring, the Climate Change Steering group lent out plug-in electricity monitors that enabled householders to investigate the electricity used by individual appliances such as fridges, freezers, washing machines and dishwashers. As with phase 1, guidance notes and worksheets were also provided.

Low Energy Light Bulbs for Over 70's

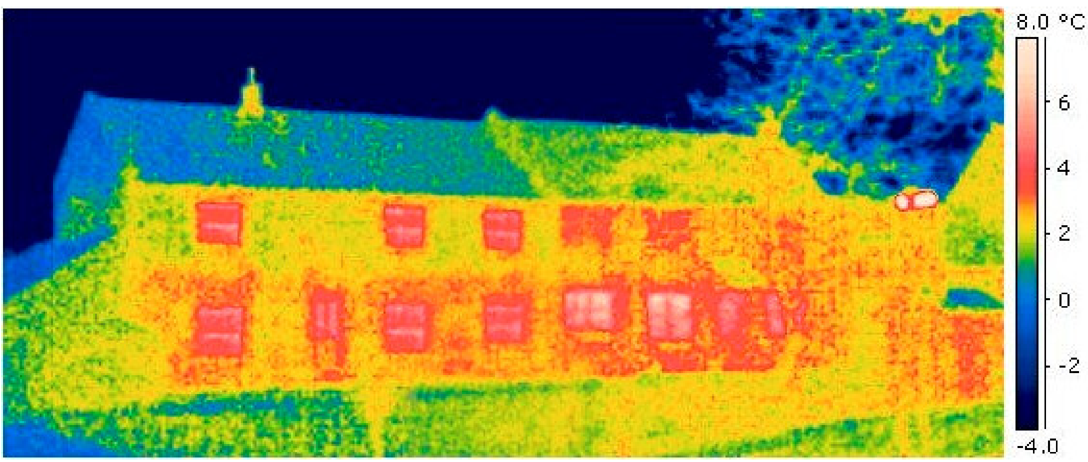
The Climate Change Working Group distributed free low energy light bulbs – provided by EDF Energy – to Sadberge households with at least one member aged over seventy.

Low energy light bulbs were distributed to a total of 61 households.

- 60 households each received four light bulbs.
- 1 household only wanted one light bulb.

Infra-Red Photographs

In order to raise awareness of heat losses and the advantages of effective insulation – "Do you know how much heat your house radiates into the night sky?" – the Climate Change Working Group arranged to borrow an infra-red camera from a local company and offered to take thermal images of Sadberge houses during a cold night in February 2009. 23 households took up the offer. Some of the infra-red images can been viewed on the Sadberge web site at www.sadberge.org.uk.



Solar Water Heating

As a result of information provided by the Climate Change Working Group and the Energy Saving Trust, one Sadberge household installed a solar water heating system.

Appendix 2

INDICATIVE BUDGET

<u>Electric car club</u>						
Electric cars	8	@	£20,000	=	£160,000	
Data acquisition systems	8	@	£1,000	=	£8,000	
Charging stations	8	@	£500	=	£4,000	

Total for electric cars					£172,000	35%
<u>Smart meters</u>						
Electricity meters	300	@	£100	=	£30,000	
Gas meters	300	@	£100	=	£30,000	
Web site development					£2,000	

Total for smart meters					£62,000	12%
<u>Heat pumps</u>						
Ground source heat pump systems	2	@	£10,500	=	£21,000	
Air source heat pump systems	8	@	£7,000	=	£56,000	

Total for heat pumps					£77,000	15%
<u>Solar water heating systems</u>						
Solar water heating systems	12	@	£3,500	=	£42,000	

Total for solar water heating systems					£42,000	8%
<u>Solar photovoltaic systems</u>						
Solar photovoltaic systems	12	@	£9,800	=	£117,600	

Total for solar voltaic systems					£117,600	24%
<u>Village hall</u>						
Double glazing					£12,000	
Solar photovoltaic system					£14,000	

Total for the village hall					£26,000	5%
Project management					£5,000	1%
Total for the Sadberge Carbon Reduction Project					**£498,100**	

Note 1: In the case of the heat pump systems, the solar water heating systems and the solar photovoltaic systems, the budget is for an 70% subsidy of the cost of each system. The householder will pay the remaining 30% of the cost.

Note 2: The project management costs are the first year's administration costs of the community interest company (e.g. bank charges, audit costs, etc.), plus the costs of communicating with Sadberge residents (e.g. printing flyers, hire of meeting rooms, etc.).

Appendix 3 – Personal Transport

In 'commuter dormitory' communities, personal transport makes a significant contribution to carbon dioxide emissions and there are good reasons to believe that worthwhile reductions in carbon emissions can only be achieved if we make fundamental structural changes to the way in which we own and use cars. There are a number of key obstacles to reducing the carbon impact of personal transport in commuter dormitory communities:-

- Journey patterns are so diverse and fragmented that public transport is simply not a practical option for most people, and there are only very limited opportunities for lift sharing.
- Although the majority of trips are local journeys with only one or two people in the car, many of these trips are made in large cars because people buy cars large enough for the relatively few occasions when they want to carry more passengers or luggage.
- Although electric cars would be ideal for the majority of trips, people will not choose to buy electric cars because (a) they are still very expensive and (b) their limited range makes them unsuitable for the occasional long journeys that people wish to make.
- The economics of car ownership push people towards making journeys by car rather than by train, bus or coach.

Sadberge is primarily a commuter dormitory village. During the preparation of the Sadberge Parish Plan, more than 75% of Sadberge residents filled in questionnaires that aimed to gather information about subjects ranging from the demographics of the parish to residents' needs, opinions and aspirations. Analysis of the questionnaire responses revealed that approximately 80% of Sadberge residents are commuters. Each weekday morning, a typical Sadberge resident drives out of Sadberge to go to work in Darlington, Teesside or elsewhere, returning in the evening.

It is clear that if we are going to make a significant reduction in Sadberge's carbon dioxide emissions then we are going to have to get away from the current situation where people are making their journeys in individual petrol or diesel cars.

At least in the short-to-medium term, public transport is not likely to be a practical option, and there are only very limited opportunities for people to share lifts. This is because (a) the Sadberge commuters are travelling to a very wide range of destinations, and (b) many of those destinations are not close to major centres of population that can be served effectively by buses and trains. See the example in the box to the right.

We believe that this is a common situation for rural communities. The availability of cheap personal transport – i.e. cars – has meant that many people have chosen to live in pleasant rural villages some distance from their place of work, and that village residents make a great variety of individual point-to-

Example to illustrate why public transport is not likely to be a practical option for many Sadberge commuters.

One Sadberge resident works at a chemical manufacturing site on the outskirts of Billingham.

The AA web site's route planner says that going by car takes just under 20 minutes.

According to the Directgov journey planner, travelling by bus would involve taking one bus to Darlington town centre, a second bus to Middlesbrough and a third to Billingham before walking for about ten minutes. The trip would take nearly two hours .... and the earliest possible arrival time would be 10:28 a.m. Even if the buses ran earlier and more frequently, there is no likelihood that the resident would be prepared to change from a 20 minute car journey to, say, a 90 minute journey involving two changes of bus.

It is not likely that there will ever be a direct bus from Sadberge to Billingham because very few people would wish to travel between these two locations.

Car sharing is not an option, because no other Sadberge resident works at the same place.

point journeys rather than common journeys that could be made by group transport.

Accepting that public transport is unlikely to be a practical option for many 'rural commuters', the best way of reducing carbon dioxide emissions would be for as many journeys as possible to be made in small electric cars. There are, however, a number of issues preventing this from happening.

One major issue is that people generally buy cars to meet their most onerous need. So if someone believes that they are occasionally likely to need to transport four or five people – even if this is only going to happen a few times in each year and the vast majority of the journeys will be with only one or two people in the car – then they will buy a car with space for five people. Similarly, although someone may in principle be willing and able to make his or her daily home-to-work journeys in a small car with a limited range, he or she also will almost certainly need access to a car capable of doing occasional long distance journeys. Therefore, they will not be willing to buy an electric car with a range of 100 - 150 miles.

The result is that many local journeys – including the majority of home-to-work journeys – are made by one person in a large petrol or diesel car.

We suggest that the solution is a car club that gives people access to electric cars for local journeys and to (a smaller number of) petrol or diesel cars for their occasional longer journeys.

Car ownership economics and use of public transport

The costs of owning and running a car can be split into two categories:-

- Fixed costs are incurred irrespective of the distance driven. These include depreciation, road tax, insurance, time-based servicing, etc.
- Variable costs are proportional to the distance driven. These include petrol and mileage-based servicing.

The problem is that when a car owner is deciding whether to make a journey by car or by public transport (e.g. train or bus) he or she is basically comparing his or her share of the full cost of providing the public transport service with the variable cost of using his or her car. In fact, most car owners would compare their share of the full cost of the public transport service (as represented by the ticket price) with just the petrol cost of going by car. This makes going by train, bus or coach appear very expensive in comparison with going by car.

The problem can be avoided if people get access to cars via a car club – where they pay the full costs of their actual use of the club's cars – rather than owning their own individual cars.

Sadberge Car Club – Objective and pricing structure

It is important to note that the Sadberge Car Club will have some significant differences from existing – mainly urban – car clubs, and that this will have some important implications on the way that it is set up and operated, and particularly on its pricing structure.

Conventional car clubs are primarily aimed at people who are able to make the majority of their journeys by public transport and who only need access to a car very occasionally. These car clubs can therefore operate with a fairly high ratio of members to cars, and their cars generally have fairly low utilisation rates. The main benefit mechanism is that each car club car enables several car club members to avoid the fixed costs of owning a car. For example, if ten people each need to use a car for one hour per week then a single car club car would enable all ten people to avoid the fixed costs of car ownership, and the car would be used for ten hours per week.

By contrast, the main objective of the Sadberge Car Club will be to substitute the maximum possible number of 'electric car miles' for 'petrol / diesel car miles'. This means that it will be necessary for the majority of the club's electric cars to be used by people who need to use a car on a regular basis. As was explained above, this applies to the majority of the Sadberge commuters.

The pricing structure for the Sadberge Car Club will include the following elements:-

- For occasional car users, there will be the usual format of time and distance pricing, with time rates on an hourly or daily basis.
- For regular car users, there will be an option to book priority use of a particular car for a year. This will be similar to leasing a car for a year, with the exception that the regular user will be able to (a) use other club cars – including the larger, petrol car(s) – at the normal 'occasional use' rates, and (b) the regular user will be able to make 'their' car available to other car club members when he or she is not using it, and will receive a rebate when it is used by other members.

  In the booking system, a car allocated to a regular user will be shown as 'booked' except when the regular user declares it to be available. (By comparison, a conventional car club car is shown as 'available' except when someone has booked it.) The fact that the regular user only gets a rebate if the car is used by another car club member will give him or her an incentive to declare the car available as soon as he or she knows that he or she will not be needing it over a particular period of time (e.g. when he or she is away on holiday).

Our current thinking is that all but one of the Sadberge Car Club's electric cars will be allocated to regular users, with the remaining electric car and one petrol or diesel car being available for occasional users. (In fact, we may make special arrangements for the petrol or diesel car to get regular use while still being available to car club members when needed.)

The fact that the Sadberge Car Club will be aimed primarily at getting electric cars used by regular car users means that it will be able to – and will need to – have considerably more cars than a conventional car club serving occasional car users. A conventional car club serving Sadberge would probably only be able to support a single car.

We recognise that with this structure of car club we are planning to do something innovative and different from what has been done before. We believe that our proposed approach:-

- will be successful in substituting 'electric car miles' for 'petrol / diesel car miles',
- fits with the Low Carbon Communities Challenge role as a research initiative, and
- will contribute to the objective of helping government and local communities to understand how best to deliver the UK transition to low carbon living.

Appendix 4 – Heat Pumps

In Chapter 27 of 'Sustainable Energy – without the hot air' David MacKay outlines five energy plans for Britain in the year 2050. All five of these plans assume that "old buildings (which will still dominate in 2050) are mainly heated by air-source heat pumps and ground-source heat pumps". Unfortunately, there is a problem that may make it difficult to get heat pumps installed in our existing housing stock within the next forty years. If Sadberge is selected to participate in the Low Carbon Communities Challenge, we will investigate and demonstrate a possible way of overcoming that problem.

<u>The problem</u>

A conventional central heating system works by using a gas-fired boiler to heat water to 70 - 80°C and then circulating that water around the house to radiators, where heat is transferred to the air in the various rooms.

As a first approximation, the rate at which heat is transferred from the water to the air depends on (a) the temperature difference between the water and the air and (b) the surface area of the radiator.

Heat pumps have to do work to move heat from a cold location (i.e. the air or ground outside the house) to a warm location (i.e. the water in the heating system inside the house). As the temperature difference between outside and inside increases, the work required to move a given amount of heat increases and the heat pump's coefficient of performance (COP) decreases. Therefore, for efficiency reasons, heat pumps are run with the minimum practical temperature difference between outside and inside. Since the outside temperature is beyond the heat pump owner's control, this means keeping the inside water temperature as low as possible, and heat pumps generally only produce heating water at temperatures up to about 55°C.

When the water temperature is 55°C rather than 70 - 80°C, a larger heat transfer surface area is needed to provide the same rate of heat flow from the water to the air in the room. For this reason, heat pumps are usually used in combination with under-floor heating systems, which have very large effective surface areas.

Installing an under-floor heating system in a new build or during a complete refurbishment of an existing building is relatively straightforward, but very few householders will be willing to undergo the very extensive disruption involved changing from radiators to under-floor heating in an existing home. (Apart from anything else, it would involve moving out of the house for several weeks while all the floors are taken up or dug up and re-laid, plus a total redecoration of the whole house.)

If heat pumps can only be installed in new builds and houses undergoing complete refurbishments then it will <u>not</u> be possible for the majority of domestic heating to be done by heat pumps by 2050.

The obvious solution is to find a way of integrating heat pumps with existing 'gas-fired boiler and radiators' central heating systems.

At first sight, it seems straightforward to set things up so that a heat pump and a gas-fired boiler work in tandem. The heat pump should be able to provide domestic hot water and to deal with the limited heating required during the warmer months of the year. Then, when the required heating rate exceeds the transfer capacity of 55°C water in the existing radiators, the gas-fired boiler can be brought into action to boost the water temperature from 55°C to 70 - 80°C.

Unfortunately, it is not that simple. The problem is that a heat pump requires the water returning from the radiators to be at least 8 - 10°C cooler than the water that it is delivering to the radiators.

As soon as the gas-fired boiler steps in the returning water temperature goes too high and the heat pump is unable to make any contribution to the heating.

Proposed solution

We suggest that there are a number of elements to the solution of the problem of integrating heat pumps with existing central heating systems.

A precursor to the solution is to ensure that the house in question is as well insulated as possible.

Then, the first part of the solution is to find ways of increasing the effective radiator area without causing decorative disruption unacceptable to the householder. This may involve replacing some original radiators with new double panel radiators, or in some cases installing a second radiator in series with an existing radiator. Some radiators may already be oversized for 70 - 80°C water, and account should be taken of the fact that some rooms (e.g. bedrooms) do not need to be kept as warm as other rooms (e.g. living rooms).

Next, although a heat pump and a gas-fired boiler cannot share the heating load at any given time, with the appropriate control philosophy it should be able to arrange for them to 'time-share' the heating duty. For example, with a conventional gas-fired central heating system the control timer is generally set to switch on the heating, say, an hour before the householder is due to return from work. With a combined heating system the heat pump would start bringing the temperature up several hours before the householder is due to arrive home, with the gas-fired boiler only intervening at a late stage if the heat pump is unable to bring the house up to the required temperature.

If Sadberge is selected to participate in the Low Carbon Communities Challenge, we use funding from the Low Carbon Communities Challenge to subsidise a number of demonstrations of heat pumps integrated with existing 'gas-fired boiler and radiators' central heating systems. In particular, we will aim to:-

- Identify best practice in integrating heat pumps with existing central heating systems. This will include how best to increase the effective radiator area and how to design and implement the heating control system.
- Quantify the extent to which a heat pump can take the heating load off a gas-fired boiler, and thereby reduce carbon emissions.
- Understand the best approach to getting householder acceptance of this type of integrated system.