Energy Sustainability in South Brent

A Report to inform the community on the options for saving Carbon Dioxide emissions

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Introduction

This report was produced initially to satisfy the requirements of the Open University T206 (Energy for a Sustainable Future) project "Energy Sustainability in a village". The overall aim is to examine the local situation and establish what steps can realistically be taken over the next 10 years to reduce Carbon Dioxide emissions arising from household energy use and is intended to support the growing interest in developing a fully sustainable community in South Brent. Some initial background is given on the local setting and on the reasons why reductions in Carbon Dioxide emissions are considered important to provide a common understanding of the key points. Throughout the detailed investigation of likely options, emphasis is given to the potential maximum savings that could be achieved by any particular measure along with the likely costs. These are then used to weigh up the effectiveness for South Brent of each proposal before concluding what should be done. It is hoped that this report can then be used to help Sustainable South Brent inform the local community.

Local Area

South Brent is one of the larger villages in South Devon and is located close to the Southern extremity of Dartmoor. The population was 2998 at the 2001 census with a total of 1171 households. Of these, about 800 are estimated to be within 1km of the village centre largely in terraced streets and small housing estates which were built from the 1960s to accommodate the increasing numbers of people who had relocated from elsewhere. The remaining houses are spread over the remainder of the total area of 3742 hectares as small hamlets and individual plots. Outside of the village centre, much of the land is quite steeply sloped and has traditionally been used for livestock. As a result the fields are small and lined by hedges, Devon banks or small areas of woodland with an estimated total wooded area of 10%. The river Avon runs close past the Western side of the village centre as it descends from Dartmoor. South Brent is on a strategic communication route and is positioned close by the A38 Devon Expressway and the main Exeter-Plymouth railway line runs almost through the centre although the local station was closed in 1964. Local facilities include Community and Health Centres, a Village Hall, several Churches and Public houses, a Post office, Primary school and a range of shops, several of which actively promote local produce.

The need to reduce emissions.

Before addressing how Carbon Dioxide emissions might be reduced it is important to be clear exactly why the current situation is unsustainable and what the consequences of inaction are likely to be. Firstly, all but 8% of annual UK current energy requirements[1] for all uses are obtained from fossil fuel sources mainly oil and natural gas but also some coal. Although there is some doubt about the exact size of global fossil fuel stocks, all ultimately are finite in extent while global demand, spurred on by the growing industrialisation of developing countries, is steadily increasing. Inevitably this will lead to a peak in fuel production and after that point energy demand cannot be met by fossil fuel supply alone. Some experts, including M. King Hubbard who correctly foresaw the peak in USA oil production in the 1970s, believe that oil production will peak within the next 10 years or so. Natural gas would last for a few decades longer but would not outlive some people already living. A "do nothing" approach will at the very least result in substantial price rises and probably also in severe supply shortages.

Additionally the combustion of fossil fuels is accompanied by the release of Carbon Dioxide (CO_2) into the atmosphere. CO_2 has long been known to have a greenhouse effect and there is an increasing body of evidence that the observed rise in atmospheric temperature over the last 150 years[2] is consistent with a parallel increase in CO_2 levels attributable to the accelerating use of fossil fuels since the Industrial Revolution. The effects of a continued rise in temperature cannot be precisely predicted but it is highly likely that there will be more frequent extremes of weather and rises in sea level. The disruptions these would cause across the world are likely to include major movements of population and disruptions to food supplies and it would be completely unrealistic to assume that South Devon could somehow be unaffected by global events of this nature. Devon County Council in its Climate Change strategy[3] considers that Climate Change will be a key driver of change within our community over this Century. As part of this policy, DCC is committed to finding means to reduce emissions in order to mitigate the effects of climate change.

While it is acknowledged that there is ongoing debate about what eventually constitutes a safe figure for CO_2 emissions, it is suggested that it does represent a reasonably practical yardstick of whether a particular activity is sustainable. Looking beyond the original OU remit, this also provides a means to incorporate issues outside pure energy considerations, such as waste and food production/transportation, into the overall assessment of what is truly sustainable. Ultimately therefore it is intended that this study will be able to help the community determine which actions at the individual and community level are worth taking forward.

Current South Brent Carbon Dioxide emissions

In seeking to establish how much CO_2 is currently emitted in the context of the energy and travel used by South Brent households, it quickly became apparent that 100% accuracy is not likely to be achieved nor necessarily desirable and some compromises will have to be made. This is because there is no source of data that provides detailed information on energy use for each household across the whole community. The Ashton Hayes Zero Carbon initiative, in a much smaller community of 300 households had a sufficiently large response (45%) to a household energy survey that a reasonably accurate extrapolation could be made. This is not currently an option for South Brent and instead the data used was taken from the closest available source but in some cases this will be National Statistics, usually published at the appropriate government department website. For example, the gas and electricity figures are published as an average figure per household by postal code area while car usage is given by region. A different approach would have to be used to measure the effectiveness of savings measures and changes in CO_2 emissions, probably requiring detailed household surveys.

The method, assumptions and results of this are at Appendix 1 and show an estimated overall annual figure of 13462 tonnes CO_2. The largest single component in the emissions is that arising from personal transport use at 37.3% with space heating next largest at 35.4%, 25.5% from electrical use and only 1.7% on public transport. This gives some indication of where the greatest potential for reductions lie and these are addressed in the following sections. As far as possible they are considered in order of likely financial cost.

Travel requirement savings

No travel data specific to South Brent could be located so the figures calculated here are based on overall UK statistics for car ownership, mileage, occupancy and proportion of use in various activities. This should capture all commuting, shopping and school journeys. The public transport component is very small because with 2 bus services providing a total of 24 stops each way a day, the capacity is very limited. Plans for reintroducing the railway station have yet to come to fruition but it is possible that this could happen within the 10 years being considered and some projections based on Ivybridge station are included here. Many of the travel proposals involve no investment in new technology yet offer a financial saving so are the first to be considered. The detailed calculations are at Appendix 2.

Car Sharing. An obvious point to start looking for emission reductions is via car or lift sharing arrangements. The key statistic here is the current occupancy figure for commuting journeys. At 1.2, this means that, for every 5 cars leaving the village for work elsewhere every morning, only 6 people are actually being transported to work[4]. If two or more people currently travelling alone to the same area are able to coordinate their movements sufficiently to share a single vehicle then clearly fuel usage for those commuting journeys would halve as would the CO_2 emissions. Calculating the associated CO_2 production for the present and increasing occupancy levels shows that it would require 8 people to travel in those same 5 cars (occupancy 1.6) to achieve a 10% reduction in emissions. An important advantage of this measure is that, on the basis that travel costs are shared between participants, there is a negative financial cost to the car owners and also a reduction in car wear and tear if 2 or more car owners take turns. It will also reduce traffic congestion, allow participants to take advantage of any multi-occupancy traffic control measures and reduce demands for parking spaces at the destination.
The main disadvantage is some loss of flexibility to the participants and of course there have to be two or more people who want to go along roughly the same place at roughly the same time. Left to their own devices, the uptake of car sharing is likely to be quite limited but there have been local instances where there has been a reasonable uptake. A notable example is Derriford hospital where staff car parking charges have been introduced on single car users while car share scheme participants are exempted. This resulted in roughly a 30% reduction in car use. On the basis that most South Brent residents work elsewhere, such a penalty/reward system cannot be applied in the village but it is suggested that some improvement could be achieved by publicising the benefits and savings to the community and also explaining the existing free internet based methods of finding travel partners. As an example Devon County Council sponsor the website Carshare Devon at http://www.carsharedevon.com/ which can be tailored to specific groups such as a particular community.

Car Club. Here the concept is that members of the club pay an annual membership fee and also a charge for actual use of a club vehicle which has to be booked in advance. This pre-planning requirement has the effect of reducing actual annual mileage; some examples suggesting this can be as much as 30%[5]. While this might be too restrictive for many, it is a more efficient use of resources and would suit those who did not wish to replace their current vehicle, had difficulties with finding permanent parking or wished to only own one vehicle rather than two or more. If 100 drivers in the village switched to car club membership it is projected that there would be a reduction in annual CO_2 emissions of 54 tonnes.

Shopping travel. As can be seen from Appendix 2, a substantial proportion of average car mileage is for shopping. In the case of South Brent, although most food needs can be met from the village centre shops, it is likely that a substantial proportion of car owning households visit the large supermarkets at Lee Mill or Totnes on a weekly basis with an average return journey of 18 miles. If car owning households changed to only travelling to the large supermarkets on alternate weeks, this would reduce individual car CO_2 emissions by 160kg and the total by 152 tonnes. While it might be that the local shops cost slightly more, this revised pattern of shopping is counterbalanced to a considerable extent by reduced car use costs. Greater use of local shops would also encourage local shop owners to increase their ranges and their competitiveness and safeguard the viability of the village centre for the future.

Lower carbon intensity travel. The current UK average figure for CO_2 emission by cars is 170g per km. This has been steadily improving over the years largely because of the trend to change to diesel power which offers roughly a 15% reduction in fuel consumption compared with petrol engines at a small increase in the initial cost of the vehicle. Some internal combustion powered vehicles can achieve even better performance than this, notably hybrid electric drive type such as the Toyota Prius which makes more efficient use of the power from the engine to achieve around a 40% reduction. Hybrids do cost considerably more than conventional and are more complex to service although fuel savings may help to offset this. Their best performance is shown when in short slow journeys so it is unlikely that a hybrid would be appropriate for someone travelling long distances along the A38. Even greater efficiencies are achieved by changing to all electric power where the vehicle stores mains electricity in a battery. Allowing for the electrical transmission losses between mains generator and battery, electric cars can show an even greater improvement by a factor of as much as 2 to 3 greater reduction[6]. The disadvantage is that they are currently limited in maximum range to between 40 - 100 miles on a full charge and are not yet widely available. However, considerable development effort is being put into producing higher capacity batteries and electric cars may start to be a realistic option towards the end of the 10 year period.
Since most car owners change their vehicle perhaps every 6 years, a substantial proportion of the current vehicle stock will have changed by the end of the 10 year period. On the basis of an annual mileage of 8700, replacing a conventional petrol car with a diesel would save 470 kg of CO_2 while a hybrid would save 1.25 tonnes of CO_2 per year.

Another lower carbon intensity option would be to use public transport. To illustrate this, if 100 South Brent based car users commuted by bus instead for all their journeys to work in Plymouth, the total annual emissions saving would be 162 tonnes. If South Brent station reopened and 100 car users commuted daily by light train, the total emissions savings would be 178 tonnes.

Household Energy saving measures

Energy savings measures that reduce the amount needed to achieve a particular outcome make good sense and reduce the need to find sustainable energy sources in the first place. They are already commercially available and are relatively low cost. They include increasing the insulation of house lofts and in wall cavities, the use of modern high efficiency heating systems and greater efficiency in the use of electricity. The potential for these is covered in detail at Appendix 3.

Housing Insulation improvement. Without a detailed survey of the breakdown of local housing stock construction and current levels of insulation, some assumptions have had to be made. The starting point was data supplied by the South Hams District Council Housing Efficiency Officer from a District survey in 2003[7], supplemented by Building Research Establishment statistics. This indicates that about 26% of the housing stock has loft insulation below the 1990 standard of 150mm thickness of insulation. If all these houses were brought up to the 250mm standard, a saving of 0.6% on total CO_2 emissions arising from space heating would be achieved.

Similar calculations on cavity wall insulation show greater potential with 48% of houses with cavity walls estimated to not have insulation at present. In this case a 100% uptake would achieve a 2.7% reduction in total emissions. Uninsulated households taking advantage of both measures would achieve an annual financial saving of up to £370 on gas heating bills and an even larger saving for other heating fuels. This would mean that the cost of installation of around £250 would be paid back within 2 years. Other measures to reduce domestic heat loss include improving draught proofing and changing to double glazing in windows.

Draught-proofing is even more cost effective and is the key means to control heat lost through ventilation and an example calculated at Appendix 3 shows annual savings of 547 kg per household.

Improving the glazing standards of windows can also make a useful contribution but is not calculated in detail because of the large proportion of houses are already double glazed, often to simplify maintenance. Installation costs are also high relative to the emissions savings that would be achieved.

Replacement with higher efficiency appliances. Every household has a number of appliances that consume energy at a greater rate than the most efficient designs. In some cases, such as water heating boilers, regulations now require that any replacement is of the more efficient type. In other cases there is no compulsion to change but they are labelled to show the relative efficiencies of the different models. Because of the considerable energy input required to manufacture most appliances, normally replacement should only be considered when the performance of the older model has deteriorated too much to be worth using or has become unsupportable through lack of spares.

Compact Fluorescent Lights(CFLs). National statistics show that currently around 16% of domestic power consumption is consumed on lighting where around 80% of all light bulbs are conventional filament devices while only 20% are CFLs, even though the latter require only a fifth of the power and have much longer lives ensuring that their higher purchase costs can usually recovered within a few months. If the proportions of these types of lights were exchanged, this would result in a single household saving emissions of 259kg and a total for South Brent of 311 tonnes.

Water heating. In the case of water boilers, the oldest generation of heaters achieved efficiencies of as low as 65-70% in converting the energy of combustion into raising the water temperature. Techniques such as condensing the water vapour that arises during combustion gives an appreciable improvement in efficiency and a condensing boiler offers an efficiency of as much as 90%[8]. For a single house this would represent a saving of 4333 kWh or 823 kg CO_2. If the typical economical life of a gas boiler is around 15 years it follows that over the 10 year period about 66% of boilers would be replaced in the normal course of events. Assuming about 25% are already higher efficiency, this would produce an energy saving across the village of around 494 tonnes of CO_2.

Refrigerators and other appliances. Useful savings can also be achieved when considering electrical appliances such as refrigerators. The most efficient modern units require around 170 kWh annually while older models can be as much as 2 to 3 times more demanding. As these appliances usually have relatively short lives, perhaps 5 years, it should be possible for virtually all households to be using a high efficiency model by the end of the 10 years. Judging from typical catalogue prices, high energy efficiency does not imply high price and the only real barrier to a 100% uptake is individual priority of selection criteria and awareness of the issues. This can be extended to other appliances such as washing machines. Looking at the range of performances of models in a recent catalogue, a saving of around 60kg per appliance could be made for refrigerators, washing machines and dishwashers if replacement models were chosen that offered high efficiency. If followed in say 75% of South Brent households this could produce an annual emission reduction of around 100 tonnes.

Renewable Energy

There are several natural resources that could be exploited in South Brent at domestic or community level to generate renewable energy and make a substantial contribution towards reducing emissions. These are hydro, wind, solar and biomass and they will be considered in more detail below. A key financial aspect is that renewable electrical energy attracts additional payment to the producer via the Renewable Obligation Certificate (ROC) system as part of UK government encouragement of the development of this type of energy.

Hydro power. There are records showing the existence of water mills on the Avon for over 400 years. Although the water at Avon Dam reservoir some 5km from the village centre is intended for domestic consumption, the maintenance of the river environment requires a minimum level throughout the year and therefore there is a guaranteed continuous flow further downstream, offering some hydro power potential. Proposals to upgrade hydro power at Avon dam itself would be owned and controlled by the water Authority and are not considered further since this would not be a community resource. Apart from the need to establish an acceptable level of water abstraction to avoid damage to water based wildlife, hydro power is a clean, quiet source of power with minimal impact on the environment.

Downstream, there has been a working waterwheel at Lydia Bridge for over 25 years. It is rated at 3.5 kW and reports around 17000 kWh generated annually equating to a capacity factor of over 50%. 500m further down, the existing weir and leat at the Brent Island site offers a promising site for a community project. A pre-feasibility study conducted by Devon Association of Renewable Energy (DARE)[9] predicts that annual power generation is likely to be around 26000 kWh, equating to an emissions saving of about 11.4 tonnes. The cost calculations for a 25 year project at Appendix 4 show that this scheme would require around £900 additional annual funding to cover the shortfall but it should be noted that once the capital cost had been repaid it would make a steady profit thereafter. Since the pre-feasibility study, attention is now being paid to a site further downstream with a higher water head and recent government proposals in the Energy Bill encouraging micro power might increase the earned value of ROCs, substantially improving the financial viability of such a scheme. Before such a project could become reality, considerable work would have be done to address the numerous technical issues concerning environmental and visual impact and power supply connection before the Environmental Agency and Dartmoor National Park Authority would give water abstraction and planning consent. Further smaller scale installations could in principle be installed along the run of the river to supply individual households but, unless the landowners can carry out much of the work themselves, costs are likely to limit the uptake of such schemes.

Wind Power. Local lore has it that the ruins of an 18th Century windmill are to be found on Brent Hill, providing a precedent for the reintroduction of wind power. As this site would by modern standards have too great a visual impact it is not considered further but the many local hills offer other possibilities.

The main advantage of wind power is that is a commercially available means of generating renewable energy with minimal associated CO_2 emissions. Providing each turbine can be located at a suitable site that makes the most of the available wind and is within a reasonable distance of where the electricity will be used, it is one of the cheapest renewable resources current technology can deliver at between 5 to 10p per kWh. Although the electricity cannot be stored and wind power is unpredictable in terms of precise forecasting of the level of power output, the stronger winds over the winter months generally ensure that the average seasonal output follows the level of demand. Detractors claim that this intermittency and unpredictability means that wind power cannot replace conventional power plants. However, it must be understood that the National Grid already handles far greater levels of variation in demand and supply and the relevant authorities have made it clear that wind could supply at least 20% of total Grid capacity without any fundamental problem arising[10]. The recent announcement to massively expand plans for off-shore wind farms spread around the country also means that the likelihood that wind power is not available from at least part of the national network is considerably reduced. In our case, the 1500MW Atlantic Array proposed for the Bristol Channel would be a very significant energy supply but, with current timescales for planning approval and construction, realistically this is only likely to be delivering energy around 2017 or 2018 and substantial growth in on-shore wind development is very much part of our Regional energy plans.

For a local wind power project there a range of other potential issues which will need to be addressed: visual impact, noise, blade flicker, impact on bird and bat movements, damage to archaeological sites, and also interference to existing TV, radio and radar transmissions. These all require appropriate studies and mitigation measures if likely to be a problem. The most promising local site that should minimise many of these is at Marley Thatch where the land owner has proposed a joint development with the community, one option being for each partner to fund a refurbished 225 kW turbine which is 46 m high. The initial wind speed predictions show an average 6.5 metres per second at 25m above ground level which should support an annual power generation of 493 MWh per turbine with an emission saving of 219 tonnes. At current ROC values, this could potentially raise £24,334 in surplus funds annually. Alternative figures for a smaller 70kW turbine with considerably lower visual impact and smaller capital costs have also been calculated. Providing a load factor of at least 22% is achieved and the power generated can be sold at a total with ROC credits of around 9p per unit, this would achieve at least some profit. This site is close by the main National Grid pylon line and a telephone mast so has minimal visual impact. A photomontage below gives some idea of this.

In the Marley Thatch case the site is already heavily affected by the pylon run and the expressway noise but the remaining issues would need appropriate clearance before the proposal could be taken forward towards planning consent.

An 18kW alternative project which, because of its size, would probably be much more certain to get planning permission is also calculated. This would achieve an annual energy output of 39 MWh and a CO_2 emission saving of 17 tonnes. However, the economics on this scale are insufficient to bring it into profit and it would need a subsidy, equating to £219 per tonne of CO_2 to balance the books.

Wind power at the domestic level is also possible and turbines from as little as 1kW are available commercially. However, it is doubtful that such small installations would be cost effective for most houses in the parish, especially in the village centre, because they will be too close to the ground to experience much wind. There would also probably be issues with DNPA as the planning authority over the impact on the nature of the village. A 6kW installation at Higher Davidstow has been in operation for 3 months and is predicted to generate about 18000 kWh annually. This should therefore save 7.8 tonnes of CO2 and there are a number of similar sites away from the village centre.

Solar Power. Of the two ways of exploiting the energy from the sun, the more common is to use direct sunlight on an absorbent panel, usually roof mounted, to heat water which is then circulated via a heat exchanger through the domestic hot water tank. This requires a suitable unshaded south facing position, usually on the roof, to mount the solar panel. For a typical house a 4 square metre panel should provide virtually all hot water requirements during the summer. The example at Appendix 4 shows however that the output is 5 times smaller in winter than summer and therefore there will be little impact on energy consumption in the peak demand season. Such an installation would save about 1260 kWh of heating energy and about 240 kg of CO_2 per gas-fired household, more for other fuels. However, some houses will not be suitable because of roof aspect, shading or, in the case of “Combi” boilers, because there is no hot water tank. Taking this into account, a first estimate would suggest that perhaps a third of the households in the area could employ a solar panel. Current numbers fitted will be low – perhaps 20. In principle therefore solar water heating could yield a total emissions saving of around 96 tons. However, the financial cost at £1221 per tonne of CO_2 saved is relatively high. Uptake could be encouraged if bulk buying arrangements could achieve a reduction of cost.

Solar energy can also be exploited through photovoltaic (PV) cells, again as panels mounted on the roof. These cells generate a direct current (DC) voltage when exposed to light. This can be converted into mains electricity and fed into the mains to earn ROCs or used in the household to save buying from the grid in the first place. Completely clean and silent in operation and requiring minimal maintenance, they need a suitably oriented roof and, for maximum efficiency, strong sunlight. Apart from the visual impact, which can be reduced by using special tiles, the main disadvantage at present is the very high cost required for the typical Silicon based PV cell - at least 10 times as great as large scale onshore wind power at current prices[11]. They also have the same inherent issues as solar thermal in that the output in winter is much lower and unlike hot water, electricity cannot be readily stored so normal mains supply is still needed at night. PV panels would also be competing for the same roof space as solar thermal. At present these disadvantages would outweigh the benefits and PV is not likely to be an immediate solution to emission reductions.

However, a recent announcement has been made that Copper Indium Gallium diSelenide (CIGS) based PV cells are being printed onto metal foil on a commercial scale at a predicted cost of 1 US $ per Watt. This is a very substantial drop in prices and, if it proves to be true and sustainable, then it has the potential to allow every house with a suitable roof area to generate about 25% of its current annual electrical power requirement at very low additional cost while saving perhaps 679 kg per household or about 271 tonnes for the village. It is understood that there are supply issues with the rare element Indium so it is likely to be some time before it is clear whether this can be expected to be truly available on a large scale.

<u>Biomass</u>. Biomass describes the organic material that arises from plant growth cycles and animal wastes. Dedicated energy crops are not considered in this report because the local agricultural land has not been used for this type of harvest. However, as mentioned in the description of the local area, there is a considerable proportion of wooded area within the parish and most of the outlying properties stand on extensive plots. There is therefore a considerable amount of leaves, branches and dead plants generated every year. At present some of this will go into the SHDC "Brown" bins for collective composting, some is taken by individuals to the Ivybridge Tip facility to go in the Green skip and the remainder is composted or allowed to rot on the individual properties. In all these cases the majority of the carbon content of the organic material will eventually become CO_2 as the result of aerobic composting. Some, through anaerobic decomposition will release methane to the atmosphere instead and this is an even more potent greenhouse gas than CO_2 by a factor of 20. Burning this biomass therefore does not increase CO_2 emissions over what would have happened anyway and, by reducing methane production, may even achieve a reduction in climate effect. Some calculations, based on the annual garden waste produced by a moderate sized house in South Brent suggest that, after sufficient drying to make it suitable for combustion, at least 370 tonnes of biomass fuel could be generated annually from garden waste.

If this material can instead be used in a Combined Heat and Power plant (CHP) such as that at the BedZED London development, the calculations at Appendix 4 show that all the electrical and heating requirements of a small housing estate could be met and also achieve a saving of at least 178 tonnes of CO_2. Because biomass can be stored for at least a few months, this form of renewable energy is viable all year round. It would require sufficient space for drying and storage and also combustion needs to be carried out at high temperature to ensure that the products meet emission regulations. This will make the initial costs high but should become more economic once biomass supply arrangements are established.

In addition to garden waste, there is a considerable area of woodland within the South Brent area which could be exploited for its resources. There is potential for a quantity of wood to be harvested on a sustainable basis and converted into woodchip fuel for use in heating plant. It should be stressed that the Forestry Commission and wildlife conservation groups encourage such management of woodland because, with a sympathetic approach, this can achieve greater biodiversity than that seen in many local unmanaged areas.

A DARE report on sustainable options for heating the Old School Complex assesses that a $80kW_{th}$ woodchip boiler would require annually about 30 tonnes of fuel to replace 123,000 kWh of gas, saving 23 tonnes of CO2. While this is a much larger plant than is required for a normal house, it would be an option for any small housing development. Smaller scale methods for individual houses would require small logs or wood pellet fuel which is made from compressed sawdust. Logs are a readily available fuel, the only issue being that they need to be kept dry. Pellets are manufactured in a specialist process requiring expensive plant and at present is only done at a few places in UK, all well away from South Brent. Because sawdust is relatively bulky for its energy content, this is likely to make it uneconomic to convert the waste from local wood industries such as the saw-mills at Marley and Rattery into pellets unless local facilities can be established. The recent planning application for a saw-mill at Huxham's Cross at Dartington includes plans to eventually produce pellets and this could potentially be the catalyst for developing a local supply.

Biomass could also be exploited on a larger scale to generate electricity by using the methane arising from Anaerobic Digestion (AD) to fuel an adapted engine which would then turn an electrical generator. The Holsworthy AD plant has been operating in North Devon since 2001 with a maximum output of about 2.1 MW and the waste heat can in principle also be exploited – more usually in adjacent agricultural facilities such as greenhouses. The biomass is in part from animal manure as well as supermarket food waste and potentially some crop material with an overall radius of intake of about 6 miles. A similar plant would be entirely feasible in the South Hams and could be considered to contribute towards emission reductions if it took some of its biomass supply from the Brent area.

Achieving the target

The individual savings from all the proposals mentioned above are added together at Appendix 1 and summarised in the table below. If all the calculated proposals were to achieve 100% uptake the total resultant emission savings is 3219 tonnes representing a 23.9 % reduction. Such a large uptake would be currently unlikely, particularly those for car sharing, supermarket journeys and most insulation measures. Increasingly realistic 50% and 25% uptake figures, with roughly equivalent car occupancy, are also offered but these produce emission reductions of 13.8 % and 8.3 % respectively. In principle it might be reasonable to expect measures that quickly pay for themselves, such as cavity wall and loft insulation, to be adopted by a majority of householders. This would apply even more to measures that actually save money such as car sharing but the current car occupancy levels show that car users tend to put convenience above cost.

Effect of emission reduction measures			
Proposal	Maximum annual Saving	50% implementation/1.5 occupancy	25% implementation/1.4 occupancy
Boiler	494	247	124
Car Lift share	396	317	226
Cavity wall	363	182	91
Biomass	328	164	82
CFL	311	156	78
NanoSolar PV	271	136	68
Large Wind	219	219	219
100 train commuters	178	89	45
Draught proofing	154	77	39
Local Shop	152	76	38
Improved appliances	100	50	25
Solar hot water	96	48	24
Loft insulation	75	38	19
Car Pool	54	27	14
Small wind	17	17	17
Hydro	11	11	11
Total Saving /tonnes	3219	1852	1117
Percentage reduction on current emissions	**23.9%**	**13.8%**	**8.3%**

However, over 10 years many things can change. At the moment the current oil price has been well above $80 per barrel for almost 6 months and many official predictions are now proving inadequate. This price has only ever been exceeded in real terms during the Iran-Iraq war in 1980, yet there is no such crisis now only a steadily increasing global demand. There is therefore a very high probability that the price of fuel will substantially increase over the 10 year period. If a shortage of supply does prove to be the underlying reason, this can be expected to drive the price up even higher and, as the UK fuel blockades of 2000 demonstrated, it only requires a small interruption to supply to create very difficult conditions. Such a scenario would of itself bring about a very considerable change in behaviour because individuals would no longer have a reliable, convenient and cheap source of energy and would have no alternative but to look at measures such as sharing or use of public transport. Recent large increases in prices for gas and electricity show that we cannot afford to relax in these areas either and the imperative to economise on what we use and replace what we need with Renewable Energy has never been more obvious.

The virtually unprecedented sequence of Government decisions in the last two months on off-shore wind, planning law, new nuclear plant and the European renewables targets have set many challenges that, if properly followed through, will dramatically transform the country's production and use of energy. It must be remembered that virtually all this work will actually be funded and carried out by private industry.

Additionally there is an increasing likelihood that government measures will be introduced over the period which will discourage current patterns of behaviour and encourage more sustainable methods of travel and energy consumption. Congestion charging and higher or new taxes on fuel, high carbon intensity vehicles and out-of-town supermarket parking are all under active discussion. All of these would act to increase uptake of the proposed reduction measures although it is difficult to predict by exactly how much.

Some measures depend on existing trends, such as the replacement of low efficiency appliances by new more efficient models and the length of the report period is long enough to ensure that a high proportion of change will take place. If electricity and fuel prices also continue to rise at the same time, individual purchasers are more likely to put greater emphasis on energy efficiency as a key requirement when buying a replacement.

There is therefore an important role for leadership and group or community encouragement in achieving what are otherwise challenging targets to reduce emissions. A good example was seen in Austria where strong local self-help groups supported bulk buying of solar hot water installation kits and provided training and other encouragement towards cheap do-it-yourself solutions. Global Action Plan EcoTeams are another group support method that encourages people to work together towards achieving reductions in emissions. These approaches could be usefully investigated by Sustainable South Brent as a proactive way to ensure a high uptake of the proposed savings measures.

Conclusions

An estimate has been made of the current levels of CO_2 emissions by South Brent in the domestic energy and travel context. A number of proposed savings measures have been considered as methods to reduce these emissions. However, in order to meet even a 10% reduction target it is clear that no single measure would be enough and savings need to be found in every area of consumption as well as taking advantage of every feasible method of generating or exploiting renewable energy. A high level of uptake of these measures by individual households is needed if the targets are to be achieved. Several measures are low cost or even offer an immediate saving in financial terms but are not currently adopted to any great extent because most people currently prefer flexibility and convenience over environmental cost and sustainability. While external influences such as increasing energy prices and legislation will probably provide some drive towards making savings, there is a need to find ways of encouraging change towards reducing energy demand wherever possible. This is a role that Sustainable South Brent is well placed to promote.

References and acknowledgements:

1. Energy Systems and Sustainability: power for a sustainable future. Godfrey Boyle et al, 2004 OUP page 71.

2. Energy Systems and Sustainability: power for a sustainable future. Godfrey Boyle et al, 2004 OUP page 15.

3. A Warm response - Our Climate Change Challenge. A Devon County Council Strategy for 2005 …. and the foreseeable future. DCC September 2005. Page 1.

4. Vehicle statistics taken from National Statistics website at www.statistics.gov.uk/Statbase/Expodata/Spreadheets/D7231.xls and Devon County Council "Devon Facts and Figures at www.devon.gov.uk/dris/census/transport.html

5. Managing Transport energy: Power for a sustainable Future James Warren 2007 OUP page 52 (average car CO_2 per km)

6. The 21st Century Electric car. Eberhard and Tarpenning, Tesla Motors 19 July 2006 at www.evworld.com/library/Tesla_21centuryEV.pdf visited 14 Sep 07.

7. E mail from SHDC Household energy efficiency officer, Roger Pearson 22 August 2007 as separate document.

8. Energy saving in buildings. Everett and Herring 2007 OUP page 37.

9. Hydro desktop study for Brent Island South Brent, Devon Richard Pymm 24 August 2007 DARE.

10. "Wind Power in the UK" Report by the Sustainable Development Commission 2005 at http://www.sd-commission.org.uk/publications/downloads/Wind_Energy-NovRev2005.pdf visited 5 Jul 07. Page 26

11. Annex D 2010 Levelised Technology costs and Current and Projected Supply from Reform of the Renewables Obligation DTI consultation paper issued 23 May 2007 at http://www.dti.gov.uk/files/file39497.pdf visited 4 Jul 07.

South Brent Domestic Greenhouse Emissions Estimate

Average energy consumption per household from mains supply

Electricity/ kWh	6660	Source	South hams Middle Layer Special Output Area 002
Gas/kWh	19500	Source	Transco for Post Code TQ10 and TQ9

Costs and Emissions of different fuels

Fuel	Cost £/kWh	kg CO2/kWh
Electricity		0.43
Gas	0.04633	0.19
Oil		0.25
LPG		0.214
Coal		0.32
Wood		0.01

Source Guidelines for Company Reporting on Greenhouse Emissions Annexes updated July 2005 at www.defra.gov.uk/environment/business/envrp/pdf/envrpgs-annexes.pdf

Households breakdown

Total households		1200
Households with Gas heating		800
Households using other fuels		400
Oil	70.0%	280
LPG	15.0%	60
Coal	7.5%	30
Wood	7.5%	30

Estimated breakdown between fuel types requiring confirmation by survey for accuracy

Annual energy and emissions breakdown

Fuel	No houses	kWh/house	kgCO2/house	Fuel cost/house	Total CO2 by fuel/tnne
Electricity	1200	6660	2864		3437
Mains Gas	800	19500	3705		2964
Oil	280	19500	4875		1365
LPG	60	19500	4173		250
Coal	30	19500	6240		187
Wood	30	19500	195		6
				Total CO2 for all Household energy/tonnes	**8209**

Transport Energy

Total CO2 car emissions(see travel sheet)/tonnes	5018	Total CO2 Bus emissions /tonnes	235	**Total CO2 emissions arising from transport/tonnes**	**5253**

TOTAL CURRENT DOMESTIC GREENHOUSE GAS EMISSIONS FOR SOUTH BRENT

Domestic Energy	8209	Domestic transport	5253	**Total current Greenhouse gas emissions**	**13462**

Effect of emission reduction measures

Proposal	Maximum annual Saving	50% implementation/1.5 occupancy	25% implementation/ 1.4 occupancy	Cost per tonne CO2	Saving as a percentage of total current emissions
Boiler	494	247	124	£182	3.7%
Car Lift share	396	317	226	Saving	2.9%
Cavity wall	363	182	91	Saving	2.7%
Biomass	328	164	82		2.4%
CFL	311	156	78	Saving	2.3%
NanoSolar PV	271	136	68	£12	2.0%
Large Wind	219	219	219	Profit	1.6%
100 train commuters	178	89	45		1.3%
Draught proofing	154	77	39	Saving	1.1%
Local Shop	152	76	38	Small	1.1%
Improved appliances	100	50	25	saving	0.7%
Solar hot water	96	48	24	£1,221	0.7%
Loft insulation	75	38	19	Saving	0.6%
Car Pool	54	27	14	Saving	0.4%
Small wind	17	17	17	£219	0.1%
Hydro	11	11	11	£76	0.1%
Total Saving/tonnes	3219	1852	1117		
Percentage reduction on current emissions	**23.9%**	**13.8%**	**8.3%**		

SOUTH BRENT TRAVEL RELATED CO2 EMISSIONS

Basic Data

Car Data

Number households	1200
Average car ownership per household [1]	1.32
Percent South Hams households with a car [1]	81
Average annual car mileage [2]	8770
Average annual commuting mileage [2]	2770
Average fuel consumption litres km-1	0.09
Kilometres per mile	1.61
average kg CO2 per litre for 4 wheel vehicles	2.5
Cost per litre fuel	£1.03
Current average car occupancy [3]	1.2
Average car occupancy 7 people in 5 cars	1.4
Average car occupancy 15 people in 10 cars	1.5
Average car occupancy 8 people in 5 cars	1.6
Average household mileage for shopping [4]	1815
Average household mileage for leisure [4]	2526
Revised shopping mileage if forego 24 supermarket journeys annually	1383
Total annual tonnes CO2 for South Brent private vehicles	5017
Total annual tonnes CO2 for South Brent commuting journeys	1585
Total annual tonnes CO2 for South Brent other journeys	3432

Bus and Train Data

Ivybridge Population	10000		
South Brent population	3000		
Ivybridge station movements [5]	60000		
SB equivalent movements	18000		
Bus movements per day	24		
Average passengers per bus [6]	5		
Average bus journey miles	30		
Car CO2 per mile/kg	0.36		
Bus off peak CO2 per km [7]	0.13		
Bus off peak CO2 per mile	0.21		
Train CO2 kg per km [7]	0.054		
Train CO2 kg per mile	0.087		
Estimated train journey miles	18		
Bus peak CO2 per Km	0.066		
Bus peak CO2 per mile	0.1063		
Annual Bus emissions (6 days per week to allow for reduced	235		
Single train journey emissions kg	1.6	Annual train emissions for 100 people using train instead of car for commuting	72
Annual train emissions tonnes	28.2	Equivalent car emissions at 1.2 per car	250
Annual bus emissions for 100 people	87.983	Savings from 100 car users going by train	178
		Savings from 100 car users going by bus	162

Savings from increased car sharing

Total annual tonnes CO2 for commuting journeys at 1.4 occupancy	1358	CO2 Saving	226	Reduction in annual vehicle emissions commuting	4.5%	Potential fuel costs saved per participating household	£206.71
Total annual tonnes CO2 for commuting journeys at 1.5 occupancy	1268	CO2 Saving	317	Reduction in annual vehicle emissions	6.3%		
Total annual tonnes CO2 for commuting journeys at 1.6 occupancy	1188	CO2 Saving	396	Reduction in annual vehicle emissions	7.9%		

Savings from reduced Supermarket use

Tonnes CO2 saved by greater use local shops per car owning household	CO2 Saving	0.16
Total tonnes CO2 saved via reduced food shopping travel by car owning households	CO2 Saving	152

Savings from Car Pool

If second car is substituted by car share with 30% reduction from current 5000 annual miles, mileage saving is	1500	Emissions saving/kg	543	Total emissions saving for 100 cars/tonnes	54

Savings from opening South Brent railway station

Equivalent car journey mileage to projected annual train movements	270000			CO2 savings using train instead/tonnes	97.8		

Data sources

1 Devon Facts & Figures - Census 2001 - Car ownership at www.devon.gov.uk/dris/census/cars.html
2. National Travel Survey 2006 Data tables at http://www.dft.gov.uk/pgr/statistics/datatablespublications/personal/mainresults/nts2006/ visited 14 Sep 07 Table 6.
3. As for 2 but table 6.2
4. As for 2 but derived from Table 7.1
5. Ivybridge Rail Users group report of 60296 movements April 2006 to April 2007 via www.firstgreatwestern.info/coffeeshop/
6. Rough estimate from personal and family observation living next to bus stop!
7. Managing Transport Energy James Warren 2007 OUP page 34

Basic Data

		Standard semi detached house of 5m x 6m x 4.5m	Ceiling area	50	U value full standard [3]	0.16		U value brick cavity wall pre	1.7	Volume/m^3	135
			Wall area	61	Annual heat loss at full standard	207		U value brick& block cavity	1		
Households	1200	Degree days [1]	1794	Annual household gas consumption/kWh	19500	Households with GCH	800	U value cavity wall insulation	0.45		

Savings from Loft Insulation

		% total stock [4]		U value Loft/Wm2C-1	Current ceiling heat loss/W C-1	Annual Loft Heat loss/kWH	Energy saving at full standard	House CO2 saving/kg	Max possible CO2 saving/kg	Annual fuel saving per house	
Pre1919											
None	22	19.29%	51	1.9	57	2454	2248	427.0	21751	£104	
<45	3		7	1.42	42.6	1834	1628	309.2	2148	£75	
<90	12		28	0.6	18	775	568	108.0	3000	£26	
1919 - 1944		19.00%									
None	11		25	1.9	57	2454	2248	427.0	10709	£104	
<45	7		16	1.42	42.6	1834	1628	309.2	4935	£75	
<90	18		41	0.6	18	775	568	108.0	4432	£26	
1944 - 1964		23.95%									
None	4		11	1.9	57	2454	2248	427.0	4908	£104	
<45	4		11	1.42	42.6	1834	1628	309.2	3554	£75	
<90	10		29	0.6	18	775	568	108.0	3103	£26	
Post 1964		37.76%									
None	0		0	1.9	57	2454	2248	427.0	0	£104	
<45	7		32	1.42	42.6	1834	1628	309.2	9808	£75	
<90	13		59	0.6	18	775	568	108.0	6361	£26	
		Total houses worth improving	**310**						Max possible saving/tonnes CO2	saving at 25% uptake	saving at 50% uptake
									75	**19**	**37**

401kg CO2 saved per year at a capital cost of insulation to full standard of £250 [6] over 25 years at 8% interest costs £24 per year but £98 annual fuel saving makes this an overall saving of £74 or £74/0.4 = minus £185 per tonne CO2 saved. This changes to a cost of £4/0.4 = £10 per tonne of CO2 for loft already at <90mm existing insulation

Savings from Cavity wall insulation

housing stock with cavity walls	Percent cavity [5] walls already insulated		Houses with potential for cavity wall insulation	Uninsulated wall loss per house kWh	Insulated heat loss per house	Energy saving per household	House CO2 saving/kg	Max possible saving/tonnes CO2	saving at 25% uptake	saving at 50% uptake
71.56%	32.31%		581	4465	1182	3283	624	**363**	**91**	**181**

820kg CO2 saved per year at cost of cavity wall insulation of £350 [6] over 25 years at 8% interest costs £33 per year. Annual cash saving on 4316 kWh at 4.633p = £200 so overall saving is £167 or minus £167/0.82 = minus £204 per tonne CO2

Savings from draught insulation

Annual heat loss at 2 Air Change per Hour	3836	Annual heat loss at 0.5 ACH	959	Household heat saving from draught insulation/ kWh	2877	Household CO2 emission saving/kg CO2	547	Household financial saving	£133	Villlage emission saving/tonnes	**164**

Savings from Higher efficiency boiler

household gas consumption/kWh	Actual heat energy transferred to water		Gas consumption with 90% efficient boiler	Households assuming 25% current uptake		Energy saving per household	House CO2 saving/kg	Max possible saving/tonnes CO2	saving at 25% uptake	saving at 50% uptake
19500	13650		15167	600		4333	823	**494**	**124**	**247**

823kg CO2 saved per year at cost of condensing boiler installation of £3000 [6] over 15 years at 8% interest costs £351 per year less fuel savings 4333 x 4.633p = £351 - 201 = £150. This gives a cost of £150/0.823 = £182 per tonne CO2 saved.

Savings from Compact fluorescent lights

Proportion Filament lights	0.8	Proportion CFL lights	0.2	Current annual household lighting use/kWh	1056	Future annual lighting power/kWh	453	Future household saving/kWH	603	Household Emissions saving/kg	259
Future Proportion filament	0.2	Future Proportion CFL	0.8	Annual power if all filament/kWH	1257	Annual power if all CFL	251	Annual Household saving	£48	Emissions saving/tonnes	**311**

Savings from Higher efficiency appliances(7)

machines worst annual energy	304	Washing machine best use/kWH	170	Annual saving with best/kg CO2	58
Refrigerator worst annual energy use	401	refrigerator best use/kWh	204	Annual saving with best/kg CO2	85
worst annual energy use/kWh	321	Dishwasher best use/kWh	176	Annual saving with best/kg CO2	62

Data Sources

1. Energy Saving in Buildings Everett and Herring 2007 OUP page 29.
2. Gas consumption data per household by postcode via National Grid website at http://www.nationalgrid.com/NR/rdonlyres/9AAEDED6-8E56-41D1-A6CB-D308476F
3. U values derived from data provided by South Hams District Council Housing Efficiency Officer Roger Pearson. See Roger Pearson e mail.
4. Domestic Energy Factfile (2006) Owner occupied Local Authority Private rented and Registered Social Landlord homes, Building Research Establishment Utley an
5. Domestic Energy Factfile 2003 otherwise as for 4 but Table 12 for Cavity wall data
6. Costs of all work derived on known examples recently carried out for relatives.
7. Annual energy use taken from Argos Summer 2007 catalogue

Appendix 4: Renewable energy calculations.

1. Brent Island hydro project

Basic Data: Usable flow[1] Q $0.42m^3 s^{-1}$, Working head [1] H 3.6m, Efficiency η 80%, Waterflow capacity factor [2] 50%, Value of ROC per MWh [1] £85, Capital costs £30000 [2], Life of project 25 years, annual maintenance costs [2] £300

Maximum Power output in kW = 10 x η x Q x H [3] = 10 x 0.8 x 0.42 x 3.6 = 12.1 kW

Annual power generated = 12.1 x 0.5 x 24 x 365 = 26490 kWh = 26.5 MWh

Annual income from sale of electricity = £26490 x 85/1000 = £2252

Annual costs. £30,000 at 8% interest rate over 25 years costs £94 per £1000 annually

Annual outgoings are £(94 x 30) + 300 = £3120

Annual shortfall = £3120 – 2252 = £868

Annual CO_2 saved = 26490 x 0.43 kg = 113907 kg = 11.4 tonnes CO2

Cost per tonne CO_2 saved = £76.20

2. Wind.

a) Marley Thatch small scale (18kW)

Basic Data: Capital cost of turbine and installation [2] £55,000, Annual maintenance costs [2] £600, load factor 25%, value of ROC £85, Project life 15 years

Annual electricity generated = 18 x 0.25 x 24 x 365 = 39420 kWh = 39 MWh

Annual CO_2 saved = 39420 x 0.43 = 16951 kg = 17 tonnes

Annual Capital repayment at 8% interest rate = £(55 x 117) + 600 = £7035

Annual income from generation = £(39 x 85) = £3315

Annual shortfall = £7035 – 3315 = £3720

Annual cost per tonne CO_2 saved = £3720/17 = £219

b) Marley Thatch large scale (225kW)

Basic data: Capital cost for refurbished second hand £150,000 [2], Annual maintenance £1250 [2], 15 year project, ROC at £85, Capacity factor 25%

Annual electricity generated = 225 x 0.25 x 24 x 365 = 492,750 kWh = 492.75 MWh

Annual CO_2 saved = 492,750 x 0.43 = 219 tonnes

Annual capital repayment at 8% interest = £(150 x 117) = £17550

Total annual costs = 17550 + 1250 = £18800

Annual income = 492.75 x 85 = £41884

Surplus income = £41884 – 17550 = £24334

3. Solar Power

a) Water heating

Basic Data: Solar panel area 4 m^2, Collection efficiency 30%, Annual total radiation [4] (45 degree slope) 1053 kWh m^{-2} , June total radiation [4] 143 kWh m^{-2} , December total radiation [4] 29 kWh m^{-2}, Installation cost [4] £3000, annual maintenance £70, installation life 25 years, Gas costs per kWh [5] 4.633p.

Heat energy transferred to hot water tank in June = 143 x 4 x 0.3 = 171.6 kWh

Heat energy transferred to hot water tank in December = 29 x 4 x 0.3 = 34.8 kWh

Annual energy transferred to hot water tank = 4 x 1053 x 0.3 = 1264 kWh

Annual CO_2 saving from natural gas heating system = 1264 x 0.19 kg = 240kg

Annual capital repayment costs at 8% interest rate = £94 x 3 = £282

Annual fuel cost savings = 1264 x 4.633/100 = £58.56

Total annual costs = £282 + 70 - 59 = £293

Cost per tonne CO_2 saving = £293/0.24 = £1221

Assuming 33% of South Brent houses have suitable roofs for solar water heating, a total of 1200/3 x 240kg = 96 tonnes CO_2 saved.

b) Photovoltaic.

Basic data: As for solar thermal plus standard intensity is 1000 W m-2, CIGS NanoSolar printed PV arrays at 1 $ per Watt and 15% efficiency (claimed December 2007) Electrical power charged at 10.206 p per kWh

A 1m2 array would generate 1053 x 0.15 = 158 kWh per year and would have peak power of 1 x 1000 x 0.15 = 150 W. Hence it would cost $150 or £80.

Assuming all electricity generated by the array is used in the house, a practical household installation with a 10 m2 array would generate 1580 kWh annually and save 10.206 x 1580 = £161 in cost and 0.43 x 1580 = 679 kg CO2 emissions.

If the total PV installation cost £1800 (£800 for PV material plus £1000 for roof mounting and mains connection) and lasts 25 years, at 8% capital interest, the annual costs with minimum maintenance are £94 x 1.8 = £169. Hence this installation would cost £8/0.679 = £12 per tonne CO2 saved.

If the same 400 houses in South Brent that would have had solar thermal had PV instead then 400 x 0.679 = 271 tonnes CO2 would be saved.

4. Biomass

Basic data: Energy content of green waste after drying to 20% moisture level 10GJ per tonne. Fresh moisture content 60%. Individual plot of 200m^2 garden plus 30m Devon bank produced approximately 18 loads of 25kg garden waste and 10 60kg car loads to Ivybridge tip annually. Ivybridge Tip average monthly green waste input 75 tonnes for 9 months of year.

Individual plot produced (18 x 25) + 600 = 1050kg green waste (60% moisture) = 630kg (20% moisture)
630 kg waste burnt at 75% efficiency produces 10 x 0.63 x 0.75 = 4.725 GJ of potentially usable heat. This is 1313 kWh

Assuming 50% of South Brent households produce this much waste, there would be 600 x 630 kg = 378 tonnes of usable biomass fuel annually and this gives a total usable annual output of 600 x 1313 = 787800 kWh.

If this fuelled a Combined Heat and Power plant (CHP) working at 20% efficiency conversion to electricity and 75% of heat output was circulated to houses then this would replace:

> 787800 x 0.2 = 157560 kWh of electrical power generation saving 0.43 x 157560 = 67.8 tonnes CO_2
> and 787800 x 0.8 x 0.75 = 472680 kWh of space and water heating requirement. If this replaced gas heating, this would save 472680 x 0.19 = 89.8 tonnes CO_2

At current consumption rates, 24 houses require 158400 kWh electricity and 468000 kWh water and space heating.

600 households making 10 garden rubbish visits to the Ivybridge trip per year travel 13 x 600 x 10 miles = 78000 miles. This causes 78000 x 1.6 x 0.09 x 2.5 = 28080 kg = 28 tonnes CO_2.

Assuming all this waste could instead be collected, dried naturally and then used in a CHP for a 24 house or larger estate with a 5% allowance for transport energy, there would potentially be an annual saving of (89.8 + 67.8) x 0.95 + 28 = 178 tonnes CO_2

If a similar amount of biomass is collected from woodlands this would save the same amount of CO_2 (89.8 + 67.8) x 0.95 = 150 tonnes

Data sources:

1. Devon Association for Renewable Energy Hydro desktop study for Brent Island 24 August 2007, Richard Pymm.

2. E-mail and discussions Edward Chapman, owner Lydia Bridge water wheel and coordinator of Sustainable South Brent Community Energy working Group with wind power figures based on recent discussions with industry representatives.

3. Renewable Energy: Power for a Sustainable Future, Godfrey Boyle, Oxford University Press, 2004 (Equation 2b Page 156)

4. Renewable Energy: Power for a Sustainable Future, Godfrey Boyle, Oxford University Press, 2004 (Page 26)

5. N Power domestic gas bill dated 11 August 2007. Includes VAT at 5%.