Greening the Existing Housing Stock

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ABSTRACT

This paper considers the impact of the built environment in terms of carbon emissions and proposes an achievable method of enabling the reduction of those emissions. The energy used in constructing, occupying and operating buildings represents approximately 50% of greenhouse gas emissions in the UK. Emissions from the domestic building stock were responsible for 41.7 million tonnes of carbon (MtC) in 2004 - 27% of total UK carbon emissions (DEFRA, 2006). Domestic energy use represents a large proportion of total national energy use.

As one of the UK's leading industries, responsible for 8% of GDP and employing 1.5 million people, construction can lead the way in integrating sustainable development in all of its activities. Promoting sustainable construction is difficult, however, because of the industry's size and fragmentation. Even if the UK construction industry could raise its annual output by a third, the yearly rate of increase in the standing stock would only rise from 0.66 per cent to 1 per cent. A one per cent per annum replacement rate for the existing stock would mean that it would take 70 years to replace the entire stock.

This paper suggests that considerable savings of carbon emissions can be made through improvements to existing houses, however. It is demonstrated that energy efficiency measures, water saving measures and renewable energy technologies can offer significant savings on a home's energy costs and environmental impact. Potential carbon savings are identified and calculated. This paper considers the effectiveness of UK policy in promoting such measures and suggests a practical private sector method of encouraging their implementation. The measures proposed will have relevance in many other countries around the world.

GREENING THE EXISTING HOUSING STOCK

INTRODUCTION

The need to reduce carbon dioxide emissions and to conserve energy has become urgent. There are three things on which almost all climate scientists are now agreed. The first is that manmade climate change is real. The second is that we need to take action. The third is that, to avert catastrophic effects on both humans and ecosystems, we should seek to prevent global temperatures from rising by more than two degrees above pre-industrial levels (Monbiot G., 2006).

Global climate change and the need to reduce greenhouse gas emissions necessitates decisive and timely action to improve the energy efficiency and performance of housing (Horne, R. and Hayles, C., 2008). The energy used in constructing, occupying and operating buildings represents approximately 50% of greenhouse gas emissions in the UK. Emissions from the domestic building stock were responsible for 41.7 million tonnes of carbon (MtC) in 2004 - 27% of total UK carbon emissions (DEFRA, 2006). Domestic energy use represents a large proportion of total national energy use. It has risen from 25% of the UK total in 1970 to 30% in 2001 (Shorrock and Utley, 2003). It is clear that too many existing buildings are environmentally inefficient and do not make best use of limited resources such as energy and water. At present rates of growth, it might take until 2050 before cavity wall insulation is present in all homes for which it is suitable.

As one of the UK's leading industries, responsible for 8% of GDP and employing 1.5 million people, construction can lead the way in integrating sustainable development in all of its activities. Promoting sustainable construction is difficult, however, because of the industry's size and fragmentation. The construction business in the UK is responsible for nearly a third of all industry-related pollution incidents. Construction and demolition waste alone represented 72.5 million tonnes of total UK waste of 177 million tonnes (40.9 per cent) in 2000 (Martin and Scott, 2003).

The rate of construction in the UK is set to increase (assuming the 'Credit Crunch' of 2008-9 is a temporary or cyclical setback). The Government's *Sustainable Communities Plan* seeks to accelerate the current house-building programme and increase the house-building target by about 200,000 on top of the 900,000 new homes planned between 1996 and 2016 in the South East. This new emphasis on growth represents an opportunity to shift development towards delivering more sustainable homes and construction. Energy (and greenhouse gas) savings can be achieved by increasing building code stringency (Horne, R. and Hayles, C., 2008). Except over very long periods, however, we are dealing with a stock of housing in the U.K. In 2001, 24.5 million dwellings in Great Britain increased by only 161,900, the lowest level of completions for 54 years (Harvey & Jowsey, 2003). In 2008 the downturn in the housing market in the UK reduced the number of completions to 147,000. Even if the construction industry could raise its annual output by a third (which would be a considerable achievement) the yearly rate of increase in the standing stock would only rise from 0.66 per cent to 1 per cent. A 1 per cent per annum replacement rate for the existing stock would mean that it would take 70 years to replace the entire stock. For comparison, in Australia the number of dwellings constructed is approximately 162,000 per year, which is equivalent to almost 2 per cent of the existing stock of about 8.2 million dwellings. Here it would take 35 years to replace the existing housing stock.

Considerable savings of carbon emissions can be made through improvements to existing houses, however. Energy efficiency measures, water saving measures and renewable energy technologies can offer significant savings on a home's energy costs and environmental impact. This paper considers the effectiveness of such measures and suggests a practical method of encouraging their implementation.

GOVERNMENT POLICY IN THE UK

U.K. government policy is set out in a white paper on energy published in May 2007 (dti, 2007). This states that:

"Energy is essential in almost every aspect of our lives and for the success of our economy. We face two long-term energy challenges:

- *tackling climate change by reducing carbon dioxide emissions both within the UK and abroad; and*
- *ensuring secure, clean and affordable energy as we become increasingly dependent on imported fuel."*

The White Paper sets out the Government's international and domestic energy strategy in response to changing circumstances, addressing the long term energy challenges the U.K. faces and delivering four energy policy goals:

- to put the U.K. on a path to cutting CO2 emissions by some 60% by about 2050, with real progress by 2020;
- to maintain the reliability of energy supplies;
- to promote competitive markets in the UK and beyond; and
- to ensure that every U.K. home is adequately and affordably heated.

Two of those goals relate directly to the housing stock of the country, and if they are to be realised rapid progress must be made in the field of domestic energy efficiency. In Australia, energy used in buildings is a major contributor to total energy consumption and associated environmental impacts. In milder climates, however, building envelope features may not be as effective in life cycle terms, i.e. including the embodied energy of their manufacture (Matthews, T. and Treloar, G.J., 2001).

HOUSEHOLD ENERGY CONSUMPTION

Housing is a key aspect of the UK's challenging carbon targets for 2010 and 2050. Buildings contribute half of the UK's CO_2 emissions. The UK's homes contribute about 27% of the CO_2 emissions and energy consumption is rising. These emissions of CO_2 are attributed to the consumption of fossil fuels for the generation of power and heat, with around 80% for space heating and hot water (see Table 1). Energy efficiency has been identified in the Government's Energy White Paper (DTI, 2003) as the cheapest, cleanest, safest way of reducing carbon emissions. Existing housing may be refurbished to a high standard of energy efficiency and this has clear benefits to occupants through improved comfort and reduced running costs.

Table 1: UK Household Energy Consumption by End Use

Space Heating	60%
Hot Water	21%
Cold Appliances	3%
Consumer Electronics	3%
Cooking	3%
Lighting	3%
Wet Appliances	2%
Miscellaneous	2%

Source: Sustainable Development Commission 2006

Measures to improve the thermal efficiency of the building envelope depend on the type of construction of the building. Insulation, heating and ventilation measures should be considered in a combined package in order to avoid risks of condensation and fumes. There is a range of data and guidance available for the building stock of England (ODPM, 2003) and on appropriate thermal improvement measures from the Energy Savings Trust Energy Efficiency Best Practice Programme (EST, 2008).

Energy efficiency savings through improved thermal performance of building fabric could be outweighed by rapid increases in energy consumption from electrical appliance demands. The energy use of lights and appliances is increasing by 2% annually. It will therefore be necessary to promote energy efficient lights and appliances in order to reduce overall consumption which in turn may be met by the lower energy density available from the renewable sources (i.e. solar, wind and biomass).

HOME INSULATION

Up to 33% of the heat produced in U.K. homes is lost through the walls. Cavity wall insulation is quick, clean and relatively inexpensive to install. It will help create a stable temperature in the home, prevent condensation on the walls and ceilings and can also reduce the amount of heat building up inside the home during summer hot spells.

Solid walls lose heat more quickly than cavity walls, but because they are solid there is no easy way to insulate them. A possible solution to this is external and internal wall insulation. Solid walls can be insulated by applying internal wall insulation. External wall insulation involves adding a decorative weather-proof insulating treatment to the outside of your wall. The thickness of the insulation needs to be between 50 and 100mm and is usually installed where there are severe heating problems or the exterior of the building requires some form of other repair work, providing the opportunity of adding insulation.

Draught proofing can also be effective. In a typical UK home 20 per cent of all heat loss is through ventilation and draughts. Draught proofing is an easy, cost-effective way to reduce heating bills. Most materials are available from DIY stores. Loft insulation is also a very effective way of reducing heating bills. As much as a third of space heating costs could be lost through the roof of a building. The current UK government advice is to insulate the loft to a depth of 270mm.

Insulating the hot water tank can also be effective. Fitting a British Standard 'jacket' to a hot water cylinder will cut heat loss by around 75% and save money on household bills.

Double and secondary glazing of windows reduces heat loss from homes. By trapping air between two panes of glass, double-glazing creates an insulating barrier that reduces heat loss, noise and condensation. Double-glazed windows come in a variety of styles but there may be restrictions on a house due to age and location. Fitting double-glazing when existing window frames need replacing will save time and money. In countries with bigger windows, such as Australia, the payback time for installation of double glazing will be shorter. Table 2 provides a summary of energy efficiency improvements from insulation measures.

Table 2: Average Costs and Savings from Typical Energy Efficiency Improvements (UK)

Measure	Annual Saving (£/yr)	Installed Cost (£)	Installed Payback (years)	DIY Cost (£)	DIY Payback (Years)
Cavity Wall Insulation	£130 - £160	£260	1-2	-	-
Internal Wall Insulation (i)	£270 - £340	>£40/m^2	-	-	-
External Wall Insulation (ii)	£290 - £350	> £1,800	5-6	-	-
Loft Insulation (0-270mm)	£180 - £220	£230	< 1	> £275	1-2
Loft Insulation Top Up (50–270mm)	£50 - £60	£240	4-5	> £200	3-4
Draft Proofing	£20	> £75	4	> £50	3-5
Floor Insulation (iii)	£40 - £50	-	-	> £100	> 2
Filling Gaps Between Floor & Skirting Board	£10 - £20	-	-	£20	1
Hot Water Tank Jacket	£20	> £5	< 1	> £10	< 1
Primary Pipe Work Insulation	£10	-	-	£5 - £10	1-2
Double Glazing	£100	£6,000	60	-	-
Total	£510 - £600**	£6,945*			
Total (without Double Glazing)	£410 - £500**	£945			

Notes: Costs are approximate, (i) Assumes best practice 0.45 W/m2k, (ii) Assumes best practice 0.35 W/m2k, (iii) Floor insulation represents the cost of insulation only, *Price includes DIY costs where applicable
**The costs and paybacks shown are approximate, are provided for illustrative purposes only and are based on a gas heated semi-detached house with 3 bedrooms & cavity walls. Installed Costs assume that installation is undertaken by a professional installer and are subject to a discount from an energy supplier. Some of savings may be taken in increased comfort.
Source: Energy Saving Trust 2006

Boiler Replacement can also be effective. Boilers account for around 60 per cent of all domestic CO_2 emissions. Using a high efficiency condensing boiler with heating controls could save between £190 and £240 a year, and significantly cut a home's CO_2 emissions.

Savings on lighting and appliances assume replacing an average appliance purchased new in 1995 and being replaced with an Energy Saving Recommended model of similar size, and an electricity cost of 10.41p/kWh.

Energy saving recommended bulbs work in the same way as fluorescent lights. An electric current passes through gas in a tube, making the tube's coating glow brightly. Traditional bulbs waste a lot of their energy by turning it into heat. Each energy-saving bulb can reduce UK domestic electricity bills by up to £9 a year (EST, 2006). They also last, on average, up to 12 times longer than ordinary light bulbs.

Savings assume replacing a 100W tungsten filament lamp with a 20W Compact Fluorescent Lamp (CFL), an electricity cost of 10.41p/kWh and 1114 hours of use per year. Hours of use is based on research undertaken into domestic lighting use and is the average usage for the two most used lamps in the average house.

Refrigeration is an area where UK households spend over £1.5 billion worth of electricity every year, on cooling and freezing. Since fridges and freezers are on 24 hours a day, seven days a week low efficiency appliances cost a lot more to run. Refrigeration products that display the energy saving recommended logo meet or exceed specified energy efficiency requirements and are backed by the Government. The logo is a guarantee that the product will save energy, cost less to run and help the environment.

More than 90 per cent of homes in the UK have a washing machine and 40 per cent have a tumble dryer. Washing machines do, on average, an amazing 274 cycles a year. But the amount of wasted electricity from inefficient machines is exorbitant. This consumption could be cut by up to one third by using an energy saving machine. Using a 40°C wash cycle rather than 60°C means you use one-third less electricity. Reduce the wash to a 30°C cycle and the amount of electricity saved (and money) will be even higher. And modern washing machines are just as effective at lower temperatures. Laundry products that display the energy saving recommended logo meet or exceed specified energy efficiency requirements and are backed by the Government. The product will save energy, cost less to run and help the environment.

Almost one in three households in the UK now has a dishwasher. A dishwasher does, on average, about 250 cycles per year so an energy saving model could save about £20 per year in electricity costs. To run a cycle on an inefficient appliance costs around 16p but to run the same cycle on an energy saving machine will cost only 9p, saving 7p per wash. Energy saving dishwashers save on water consumption, so are doubly good for the environment! Dishwasher products that display the energy saving recommended logo meet or exceed specified energy efficiency requirements and are backed by the Government. Table 3 summarises the savings that can be made by using energy efficient appliances.

Table 3: Energy Saving Possible by Efficient Appliances

Appliance	EU Energy rating	Saving/year (up to)
Fridge freezer	A+ or A++	£45
Upright/Chest Freezer	A+ or A++	£35
Refrigerator	A+ or A++	£20
Washing machine	A	£10
Dishwasher	A	£20
Boiler replacement		£190-£240
Total		£310-£470

Savings for A++ cold appliances are on average, £6/yr greater.
Source: Energy Savings Trust 2006

WATER TECHNOLOGY

Water is a finite resource and severely limited in some parts of the UK, although generally the public perception is that water is plentiful. Households use half of the water publicly supplied in the UK (Environment Agency 2001). Table 4 shows the breakdown of household water use in percentages. The average consumption per capita is 154 litres per day. It is estimated that a reduction of 30% of this consumption is achievable (SDC 2006). Mains water has an embodied energy of approximately 0.5kWh/m3 (including pumping, supply and treatment).

Table 4: UK Household Water Consumption by End Use

Toilet	35%
Personal Washing	20%
Kitchen Sink	15%
Washing Machine	12%
Wash Basin	8%
Outdoor Use	6%
Dishwasher	4%

Source: Sustainable Development Commission 2006

Key Water saving measures include:

- Metering to monitor demand and raise awareness of waste
- Use of water efficient fittings – low flow taps and showers, low flush WC's
- Devices that alter the operation of existing fittings, such as tap inserts
- Use of water efficient appliances – dishwashers and washing machines
- Leak detection
- Opportunities for grey water and rainwater recycling (i.e. water butts)
- Behavioural measures: turning off taps, wider "water consciousness"

The costs and benefits of a variety of water saving measures are shown in Table 5. The average price of mains water has been calculated as one penny per ten litres by the UK Environment Agency.

Table 5: Cost and Benefits of Retrofit Water Efficiency Measures

Retrofit Measure	Annual Savings (% of Total Household Consumption)	Annual Savings (£/yr)	Cost of Appliance and Installation	Payback (years)
Ultra Low Flush WC	14.3%	£32.15	£40 - £80 (subsidy)	2.0
Meter on Change of Occupancy	6% - 9%	£16.86	£71 - £250	9.5
Variable Flush Retrofit Device	7.8% - 8.7%	£18.55	£20 - £40	1.6
Low Use Shower	3%	£6.75	£30 - £50	5.9
Cistern Displacement Device	2.2%	£4.95	£0.80 - £2.00	0.3
Low Use Taps	1.3% - 2.3%	£4.05	£15	3.7
Efficient Washing Machine	0.7% - 1.4%	£2.36	£20 - £40 (subsidy)	12.7
Efficient Dish Washer	0.4% - 0.6%	£1.12	£20 - £40 (subsidy)	26.7
Total	35.7% - 41.5%	£86.79	£217 - £517	4.2

Note: Assumed 4 person household – 616 litres/day: possible 220 – 256 litres saved: Average Reduced consumption 378 litres/day.

Source: Sustainable Development Commission 2006.

INTEGRATED RENEWABLE ENERGY

Further savings are possible through the installation of micro-generation technologies. These systems may be installed in existing buildings and are applicable in all regions of the UK. The costs and benefits of these technologies are listed in Table 6. High initial (capital) costs can deter households from investment. Therefore uptake of these technologies is largely driven by grant programmes. In light of this fact, the DTI recently announced proposals for the *Low Carbon Buildings Programme* (DTI, 2006).

Table 6: Costs and Benefits of Micro-Generation Energy Technologies

Micro-Generation Technology	Cost	Saving/yr	Cost of Savings (£/tonne CO_2 Saved)
Micro CHP	£2,500-£3,500	£150	Approx £600
Solar Water Heating	£2,000-£3,000 for - 4m^2	£35-£100	£130-£600
Wind Turbine	£1,500 - £3,000	£150-£300	£195 - £220
PV	£2,000-£4,000 - 5m^2	£32	£550-£1,100
Ground Source Heat Pump	£800-£1,000 per kW heat		£30-£350

Source: Department of Trade and Industry 2006

THE LOW CARBON BUILDINGS PROGRAMME

Under phase one of the UK Department of Trade and Industry's low carbon buildings programme grants totalling £10.5 million will be available to householders and community organisations for micro-generation technology. A further £18 million will be made available to public, not for profit and private sector organisations for medium and large scale micro-generation projects. The low carbon buildings programme will provide grants for micro-generation technologies to householders, community organisations, schools, the public and not for profit sector and private businesses. The grants available are listed in Table 7.

Table 7: UK Low carbon Buildings Programme: Grant Regime

Technology	**% Grant available**
Solar photovoltaics	Maximum £3,000 per kWp installed, up to a maximum of £15,000 subject to an overall 50% limit of the installed cost (exclusive of VAT)
Wind turbines	Maximum £1,000 per kW installed, up to a maximum of £5,000 subject to an overall 30% limit of the installed cost (exclusive of VAT)
Small hydro	Maximum £1,000 per kW installed, up to a maximum of £5,000 subject to an overall 30% limit of the installed cost (exclusive of VAT)
Solar thermal hot water	Maximum £400 regardless of size subject to an overall 30% limit (exclusive of VAT)
Heat pumps Ground / water / air source	Maximum £1,200 regardless of size subject to an overall 30% limit (exclusive of VAT)
Bio-energy	
1.Room Heater/Stoves automated wood pellet feed	Maximum £600 regardless of size subject to an overall 20% limit (exclusive of VAT)
2. Wood fuelled boiler systems	Maximum £1,500 regardless of size subject to an overall 30% limit (exclusive of VAT)

Solar water heating – systems comprise solar collectors (evacuated tubes or flat plates) a heat transfer system (a fluid in pipes) and a hot water store (e.g. a domestic hot water cylinder). A $4m^2$ collection area will provide between 50% and 70% of a typical home's annual hot water requirement in the UK.

Solar photovoltaic (PV) systems generate electricity from sunlight. Small-scale PV modules are available as roof mounted panels, roof tiles and conservatory or atrium roof systems. A typical PV cell consists of two or more thin layers of semi-conducting material, which is most commonly silicon. The electrical charge is generated when the silicon is exposed to light and is conducted away by metal contacts. In Germany, the application of PV is at least 10 times greater than in the UK both at domestic and commercial level. This is due to a combination of government support and reduced costs of installation of the systems. The reduced costs arise because the large scale installation of PV has pushed prices down sharply. A typical 3kw PV system costs about £17,000 in Britain but less than £10,000 in Germany, where prices have halved in the past seven years and it is estimated they may do so again in the next seven. The government support is fundamentally due a policy termed the "feed-in tariff" (FIT). Anyone generating electricity from solar PV, wind or hydro gets a guaranteed payment of four times the market rate - currently about 35p pence a unit - for 20 years. This reduces the payback time on such technologies to less than 10 years and offers a return on investment of 8-9%. The cost is spread by generating companies among all users and has added about one cent/kwh to the average bill, or an extra €1.50 (£1) a month.

Micro-wind turbines convert wind to electricity. The most common design is for three blades mounted on a horizontal axis, with the blades driving a generator (directly or through a gear-box) to produce electricity. Most systems are mounted on a tall mast, but building-mounted turbines are now starting to come onto the market.

Micro combined heat and power (CHP) - these technologies use natural gas as a fuel but provide electricity as well as heat. The two main systems use either reciprocating engines or Stirling engines. Fuel cells are also an alternative source of power.

Ground source heat pumps use the warmth stored in the ground to heat fluid circulating through pipes, a heat exchanger extracts the heat and then a compression cycle (similar to that used by refrigerators) raises the temperature to supply hot water for heating purposes. Air source and water source heat pumps operate in a similar fashion using temperature differentials in the air and water (these types of heat pump are not quite as efficient as ground source heat pumps).

Biomass stoves and boiler systems can provide space and/or water heating from burning wood (pellets, chips and logs) and non-wood fuels. The biomass fuels are derived from forestry products, energy crops (willow and miscanthus) and waste wood products (sawdust, pallets or untreated recycled wood).

The Renewables Obligation (RO) is the UK Government's main mechanism for supporting generation of renewable electricity. Support is in the form of electronic certificates called Renewable Obligation Certificates (ROCs), one certificate being issued for each megawatt hour (MWh) of renewable electricity generated. The price of a ROC is set by the market and could be as much as £40. Zero carbon content electricity has a value and energy producers have to buy ROCs. This effectively shortens the payback periods for renewable electricity generation schemes.

Readily available heat and power are taken for granted in developed societies. As we become less tolerant to fluctuating temperatures in our homes and more reliant on products requiring electricity, demand for heat and power is likely to grow even in the face of increasing strides being made in greater energy efficiency. Yet the context to this growing demand is one where the UK will no longer be a net exporter of oil and gas, where there is increasing urgency in the need to tackle climate change and rising energy prices are hitting the most vulnerable. Meeting these challenges will require a portfolio of measures, including energy efficiency, renewable energy and other low/zero carbon energy sources. Micro-generation technologies have significant potential as a part of this portfolio.

THE WAY FORWARD

Rising fuel prices and greater environment awareness are encouraging buyers to pay close attention to a home's running costs and the impact of them on the planet. In the UK Energy Performance Certificates became compulsory for anyone selling their home after 1st August 2007. When homes are sold or rented, this information must be made available by the seller or landlord to buyers or tenants. Making this information available to home buyers will influence property values. In addition 80% of home buyers want to know if their home is environmentally friendly. New research from the Energy Saving Trust has found that nearly 70% of British residents believe that energy efficiency is important when buying a home (Energy Savings Trust, 2008). Almost half (45%) are willing to pay up to £10,000 more for an environmentally friendly home. Sellers are choosing insulation, modern water heating boilers and double glazing over frivolous fixtures and fittings to add real value.

Homeowners are much more likely to adopt the measures outlined above if:
a) they believe their actions will be economically beneficial to themselves, and
b) the costs can be spread over a period of time during which savings can be made to considerably offset those costs. Of course the problem is how to persuade home-owners to undertake these measures. In Australia, North America and Germany there is an established energy service industry composed of companies that provide consultation and assistance to households and businesses wanting to make their buildings, appliances, industrial processes, etc more energy efficient. An Energy Services Company (ESCO) is a firm that can identify and oversee the installation of energy saving projects in commercial facilities. After a thorough energy audit the ESCO enters into a contract to reduce energy consumption by a specified percentage through technical efficiency measures (Kellett, 2006). The fee charged is based on the energy savings achieved. Reduced energy bills and reduced environmental impact result.
Of course applying this model to residential property would be difficult because of the lower cost savings (and therefore lower fees) involved. But there could be scope for this type of arrangement in blocks of apartments or in housing associations for example.

For individual households it may well be that the financial sector holds the key. Financial institutions could offer an 'Energy Saving Advance' (ENSA) as a further advance of £5000 - £10000 over ten years to existing mortgage holders. This could be made in conjunction with advice on possible grants to offset costs. It would be paid for in large part (if not all) by savings on energy bills and would add value to property by increasing energy efficiency. The risk to the finance providers could be reduced by only offering ENSAs to existing mortgage holders with substantial equity, although as the schemes prove successful (and credit conditions improve) this could be relaxed. In addition there would be considerable public relations benefits for finance companies as they demonstrate environmental credentials by providing ENSAs.

CONCLUSIONS

The potential impact of the measures proposed in this paper is enormous. The Energy Saving Trust calculated savings of CO_2 as:
Energy Efficiency Improvements - 18.6 million tonnes (walls and loft insulation, draft excluders and new boilers);
Microgeneration - 50 million tonnes (100TWh electricity possible by 2020.
Total potential CO_2 savings are, therefore, approximately 68.6 million tonnes per year. These figures assume energy efficiency improvements and microgeneration installation to approximately 9000 homes with the lifespan of the measures being 10-40 years depending on the technology employed.
The initial introduction of a financial instrument (ENSA) as outlined in this paper would obviously be at a lower level of market penetration than the total potential identified above. However, if only 0.5% of the potential home improvements and microgeneration installations were to take place then 350,000 tonnes of CO_2 would be saved every year! Moreover, the wider effect of this strategy would be a very positive effect on public opinion and the development of the housing refit industries. The ongoing improvement in confidence improvement in confidence and lowering of prices of the utilised technologies would have positive consequences far beyond these identified carbon savings.
The built environment can play a significant role in reducing greenhouse gas emissions through regulation of new building and by improving the efficiency of the existing housing stock. Household energy consumption is significant in contributing about a quarter of UK CO_2 emissions and energy efficiency is an effective way of reducing this impact. This paper has identified and quantified a number of areas in which energy savings can be made. Further savings are possible by adopting domestic micro-generation technologies. Government initiatives in the form of grants and Energy Performance Certificates are an encouragement to the residential sector to reduce carbon emissions, but added impetus might come from new financial sector instruments that follow the example of commercial energy service companies in providing finance to undertake energy efficiency and micro-generation measures paid for by the resultant savings in costs. Such an initiative would seem to offer a way forward in greening the existing housing stock more rapidly than relying on the very gradual replacement of existing properties.

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