ECO-REGION NW

Sustainable Housing Construction Workshop Briefing Paper

CURE & SEI: 01-09-05

NOTE:

This Briefing Paper reports on work in progress jointly by CURE and the Stockholm Environment Institute. It aims to inform discussion at the Eco-Region NW Sustainable Construction workshop of September 2005. A final report will be prepared following this.

This paper is to be read in conjunction with the report by Building Research Establishment *Eco-Region NW – Final Report,* June 2005. This is available, together with other project materials, on the interim website http://www.art.man.ac.uk/PLANNING/cure/Eco.htm

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1 Summary

The Eco-Region NW Construction workshop aims to explore the scope of 'sustainable construction', priorities for achieving it, and ways to measure it. The Eco-Region NW is a resource flow and eco-footprint research project which is analysing the physical throughput of production and consumption in the North West region. Its results are based on the REAP interactive software toolkit, to be demonstrated in the workshop. Further details are on http://www.art.man.ac.uk/PLANNING/cure/Eco.htm

1.1.1 The issues

- We know that more housing is needed on a large scale across the region, and that this housing has potential to be vastly more sustainable and environmentally efficient.
- We also know from the ***ecological footprint*** measure, that we are using up the earth's resources at an accelerating rate. The UK government's goal for climate emissions reduction translates into a long term 75% reduction in resource use – i.e. a ***Factor Four*** reduction.
- Construction is the largest resource using sector, both in direct materials use and in the energy demand of its products. With rising costs of energy and waste disposal, and forthcoming Building Regulations and EU Directives, there will be increasing pressure on construction to raise its game. Many contracts will be let on environmental as well as financial performance.

The key question here is –

Can we meet Factor Four targets in construction and urban development?

One possible response is to be tested at the workshop. This is the '***Eco-benchmarking'*** scheme, at present an outline, to be demonstrated by the Eco-region NW project.

To test the Eco-Benchmarking scheme, and the implications of the Eco-Region NW results, we focus on the housing stock, and its construction and energy demand. Then we look in more detail at some key themes and questions on both the demand and supply sides:

1) Urban development and the housing stock – should we rehabilitate or rebuild, and does urban form and density matter, in the Regional Spatial Strategy and others? Two key questions are explored in the next section:

- How does housing density affect the impact of the development?
- What role will declining household sizes play in terms of environmental impacts?

2) Building design – what is the potential for new building forms and materials? As property is foremost a financial asset, the industry and its financiers is notoriously resistant to change. Two key questions are explored in the following section:

- How important is the durability and flexibility of design?
- What are the priorities in reducing the direct energy use of the house?

3) Construction benchmarking – how does the proposed Eco-Benchmark scheme relate to existing performance assessment of materials, elements, buildings and firms? This is outlined for discussion at the end.

For each of these themes the Eco-Region NW results so far are summarized in order to highlight the conditions, trends and possible alternatives. The REAP toolkit has been used to assess four key questions that relate to the development of future housing policy at the regional level. It is important to note that this is an interim assessment and will be further refined before the release of REAP in 2006.

1.1.2 Structure of this paper

In Section 2 we show a baseline assessment of the current situation in terms of the housing stock, using the REAP toolkit to produce an innovative analysis. This focuses on the impact of the average house in the region and relies on three main indicators (see the appendix or visit www.ecologicalbudget.org.uk):

- Material Flow Analysis
- Carbon dioxide emissions
- Ecological Footprint

The following Sections 3 and 4 provide further background and questions: on urban development policy on the demand side: and the impacts of construction on the supply side.

Section 5 contrasts the situation in the NW region with a current programme in the South East region for stabilization of the eco-footprint. The question is, could it happen here?

The final Section 6 outlines one application of this type of analysis in the shape of an ‘Eco-Benchmark’ scheme

2 Housing baseline

2.1.1 Housing trends

Today, there are roughly 2.9 million dwellings in the North West. In recent years roughly 20,000 houses have been built annually in the region. Net of clearance, the expectation is that almost 13,000 dwellings will be built in the region annually through 2016. That is, roughly 143,000 new houses over the next 11 years. If this level of construction activity continues through 2050, it will result in 585,000 new dwellings being built in the region – a 20% increase over today's levels.

2.1.2 Average house in the NW

The average house in the region has:

- 2.35 people living in it, 0.4 cats and 0.3 dogs.
- It consumes 9,127 KWh of energy, producing 5.18 tonnes of CO_2.
- It weighs about 150 tonnes with another 137 tonnes for the foundations
- It lasts for 60 years.
- It requires 0.50 tonnes of materials each year for maintenance and repair
- Most of the energy is derived from natural gas (66%) and electricity (24%)

Figure 1 provides a diagrammatic representation of the flow of materials into a house required for maintenance and maintenance as well the energy required on a yearly basis to provide space heating, hot water, lighting and energy for appliances and cooking. Please use this diagram to conjunction with the description below.

2.1.3 Material Flow & CO_2

Of the 150 tonnes required to build the average house, the majority is made up of concrete and stone. Over the 60 year lifetime of the building, theoretically, 4.8 tonnes of materials are consumed each year. An extra 0.50 tonnes is required on an annual basis to maintain the condition of the house and build extensions etc. Therefore, in total the average house requires 5.3 tonnes of products a year.

To build the average home produces 61 tonnes of CO_2. When disaggregated over the lifetime of the buildings, the CO_2 is approximately 1 tonne of a year. The yearly emissions of CO_2 emissions from maintenance and repair add another 0.19 tonnes of CO_2. However, the most significant emissions come from the operational use of the house. The direct energy produces approximately 5.38 tonnes per year. This is over 4.5 times greater than the emissions from construction and maintenance.

Significantly looking at construction of the house, it is not the materials that are used in the greatest quantity that have the greatest impact. Only 2 tonnes of constructional metal products are used in the building, however they have the greatest impact in terms of the CO_2

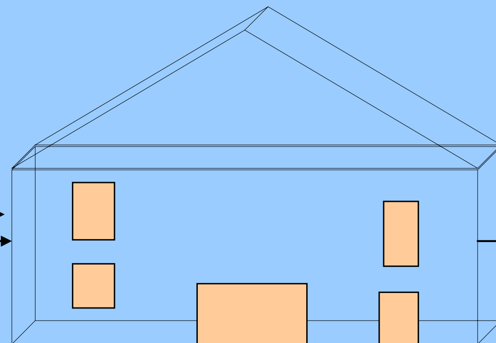
emissions. The emissions include the embodied energy in all the products taking into account all the indirect flows. Using an Input-Output structure has allowed us to take into the mining required to extract the iron ore, the energy to produce the steel and the transportation requirements[1].

[1] For further information on the methodology, please refer to REAP Report 2 “The Use of Input-Output Analysis in REAP”, available from http://sites.wwflearning.co.uk/data/files/reap-report-no-2-83.pdf

Materials for Construction	Materials (tonnes)
Other mining and quarrying	137.56
Structural clay products	19.60
Cement, lime and plaster	15.03
Articles of concrete, stone etc	105.78
Wood and wood products	7.82
Paints, varnishes, printing ink etc	0.69
Rubber products	0.11
Plastic products	2.10
Glass and glass products	0.99
Ceramic goods	0.76
Iron and steel	2.52
Structural metal products	2.00
Electric motors and generators etc	0.94

Materials for Maintenance	Materials (tonnes)
Other mining and quarrying	0.19
Structural clay products	0.01
Cement, lime and plaster	0.05
Articles of concrete, stone etc	0.16
Wood and wood products	0.05
Paints, varnishes, printing ink etc	0.01
Rubber products	0.00
Plastic products	0.02
Glass and glass products	0.00
Ceramic goods	0.00
Iron and steel	0.01
Structural metal products	0.00
Electric motors and generators etc	0.00

Direct Energy	KWh
Electricity	4,603.00
Coal	546.00
Gas Oil	73.00
Fuel Oil	1.00
Natural Gas	15,307.00
Solid Biomass	98.00
Other Fuels	1,642.00



	Electricity	Coal	Gas oil	Fuel oil	Natural gas	Solid biomass	other
Space heating	7%	50%	50%	50%	37%	100%	50%
Hot water	6%	50%	50%	50%	38%		50%
Cooking	25%				25%		
Lights and appliances	62%				0%		

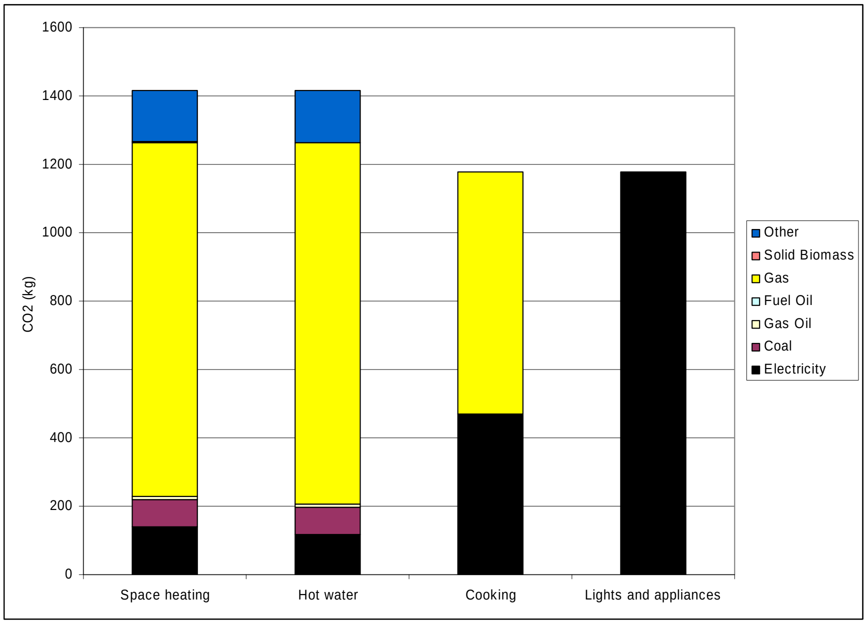
Materials for Construction	CO_2 (tonnes)
Other mining and quarrying	2.58
Structural clay products	3.68
Cement, lime and plaster	10.09
Articles of concrete, stone etc	8.03
Wood and wood products	5.27
Paints, varnishes, printing ink etc	0.35
Rubber products	0.12
Plastic products	2.70
Glass and glass products	1.73
Ceramic goods	1.47
Iron and steel	10.25
Structural metal products	13.60
Electric motors and generators etc	1.29

Materials for Maintenance	CO_2 (tonnes)
Other mining and quarrying	0.00
Structural clay products	0.00
Cement, lime and plaster	0.03
Articles of concrete, stone etc	0.01
Wood and wood products	0.03
Paints, varnishes, printing ink etc	0.00
Rubber products	0.00
Plastic products	0.02
Glass and glass products	0.00
Ceramic goods	0.00
Iron and steel	0.03
Structural metal products	0.03
Electric motors and generators etc	0.00

Direct Energy	CO_2 (tonnes)
Electricity	1.98
Coal	0.16
Gas Oil	0.02
Fuel Oil	0.00
Natural Gas	2.91
Solid Biomass	0.00
Other Fuels	0.31

Flows of Materials and Energy

In terms of direct energy use, while gas represents 66% of all the energy used it only accounts for 54% of the CO_2 emissions. Electricity use accounts for 24% of energy used and 37% of emissions.



In terms of the emissions by use, the four categories are reasonable similar. While considerably more energy is used for space heating, gas is usually used that has lower emissions of CO2 per KWh.

2.1.4 Ecological Footprint

The Ecological Footprint results paint a slightly different picture from CO2 emissions. The Ecological Footprint results have been shown below[2].

Summary All figures in gha	1 year Per HH	60 years Per HH	1 year Per Person	60 years Per Person
Building		0.49		0.21
Maintenance		0.13		0.06
Direct Energy		0.94		0.40
Total		**1.56**		**0.66**

The main message is the same story as CO2 emissions. Approximately 60 per cent of the Ecological Footprint is derived from direct energy use. Variation in the results exists when looking at the different materials used in the construction of the house. Because

[2] Please refer to the spreadsheet provided for a more detailed breakdown.

the Ecological Footprint takes into account both the direct land and land required to sequester the CO_2 emissions, timber has a higher Ecological Footprint than other products. Apart from this variation, the story is very similar to that of CO2 emissions.

2.1.5 Scenarios

To demonstrate the application of REAP a number of key questions relating to both the construction and maintenance of the house and direct energy use have been posed. So far, the analysis has underlined the importance of direct energy as the most significant contributor to CO2 emissions and the Ecological Footprint.

The questions that the scenarios are attempting to answer are:

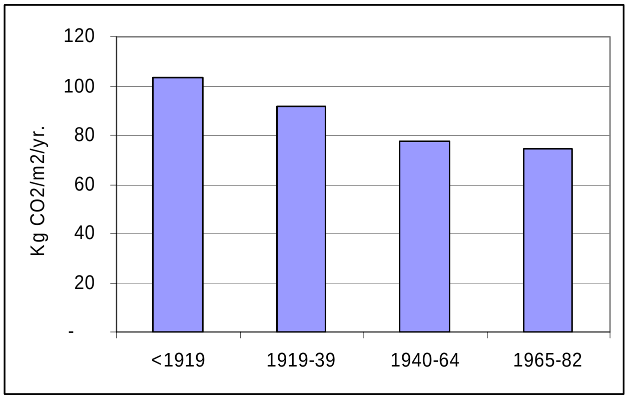
- How does housing density affect the impact of the development?
- What role will declining household sizes play in terms of environmental impacts?
- How important is the durability and flexibility of design?
- What are the most effective methods for reducing the direct energy use of the house?

2.2 Q1: Durability & flexibility

The following explores three critical issues, firstly the length that the building will last, the maintenance required on the building and the ability of the building to include new design features after construction to reduce operational energy use.

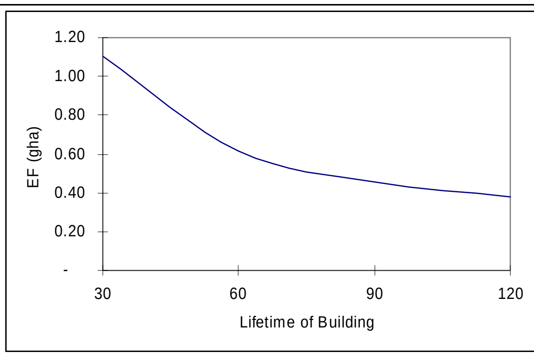
Many building built during the late 1800s still exist today. The rows of Victorian terrace houses have become a landmark of many British cities. The advantage with these houses is the fact that many are still standing as they were built to a high specification and have truly lasted the test of time. However, the operational performance of the houses has a lot to be desired. The following diagram represents the average energy requirements of different house ages[3].

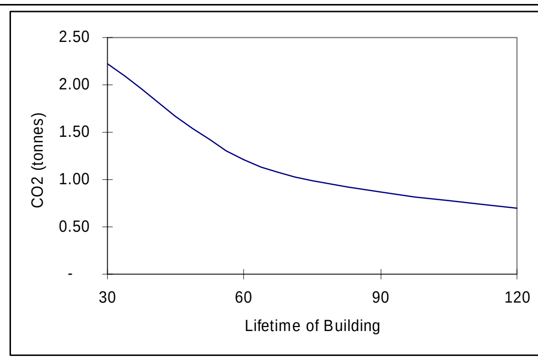
[3] Evans & Herring 1990



Interestingly, over a period of a hundred years we have only improved the energy efficiency of houses by 28 per cent.

The flexibility of Victorian houses to adopt design changes for greater operational efficiency is also extremely limited. One clear example is the fact that they are solid wall constructions not allowing cavity wall insulation to be used. The benefits of building sturdy houses, in terms of their CO2 emissions and Ecological Footprint can be seen below.





If a building was to last only 30 years, it would produce approximately 2 tonnes of CO2 a year. This would reduce to 0.70 tonnes for a building that lasted for 120 years. This saving of 1.3 tonnes of CO2 can be compared with the energy efficiency saving over the same period. If we assume that the average floorspace is 98 m2, the CO2 emissions of a 1900 house would be 10 tonnes per year, compared to the a 1982 house producing 7 tonnes, a saving of 2.8 tonnes per year.

In conclusion, the REAP analysis has demonstrated that the energy efficiency gains over the past century means that the extra energy required to build new efficient housing is beneficial in terms of reducing CO2 emissions and the Ecological Footprint.

2.3 Q2: reducing direct energy use

There are numerous possibilities to reduce the direct energy consumption of a house. Many of the options can be built into the design of the house. This is important as it might be more difficult to implement the necessary changes at a later stage and may require no lifestyle change by the occupants.

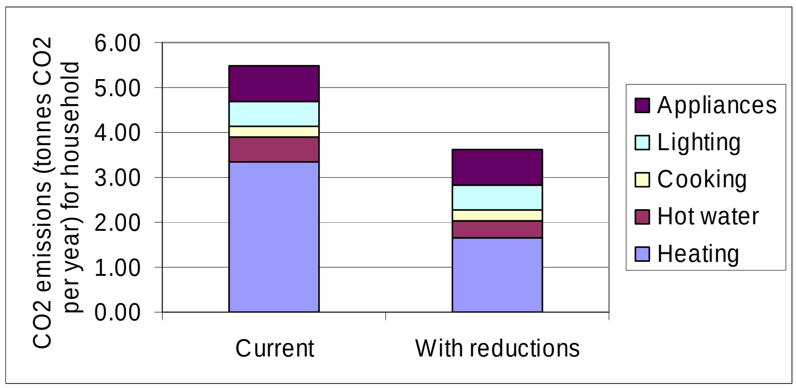
A few suggestions have been given below that demonstrate the benefit of a range of ideas. It is important to note that this is not an exhaustive list, merely a demonstration of some of the options.

The first list identifies a range of measures that could implemented as standard in a design process.

Implemented:

- Loft Insulation (100 – 200mm)
- Cavity Wall Insulation
- Draught Stripping
- Double glazing with low 'e' glass
- Floor insulation
- Gas Central Heating Controls
- Hot Water Tank Insulation
- Hot Water Tank Thermostat
- Primary Pipework Insulation
- Condensing Boiler

Results



Before	3.33	0.56	0.24	0.54	0.80	5.48
After	1.67	0.37	0.24	0.54	0.80	3.62

This suggests a saving in CO_2 emissions of 33%.

Interestingly, most of these options could be fitted retrospectively. The following scenario can also be combined with a renewable energy target. Currently, many local authorities are adopted the target of 10 per cent renewables in situ on new housing developments. This would bring a further reduction from 33% to 38%.

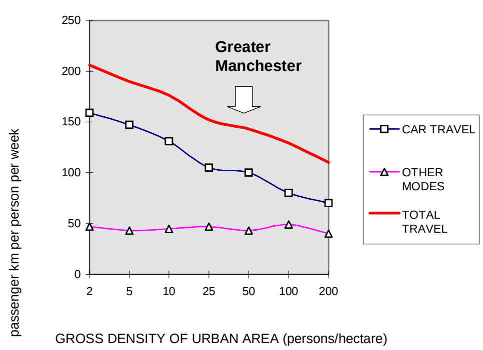
In conclusion, the REAP analysis has demonstrated that energy efficiency combined with the adaptation of a renewable energy target of 10% could bring about a 38% reduction in the Ecological Footprint.

2.4 Q3: impacts of housing density

Much argument on urban form focuses on the linkage of urban size and density to transport and energy demand *(Fig 5.3)*.[4] The evidence is sketchy, there are many intervening factors,[5] and the effect of planning policy would have very marginal effects on travel demand.[6] Other things being equal the optimum pattern appears to be in free-standing medium-sized settlements of about 80-100 pph (persons per hectare) net, or 40-50 pph gross density. In fact this is already the average population density of Greater Manchester and the average for the urban parts of the NW region:[7] the travel intensity, or distance per person per week, of GM as a whole is 10% less than London, 50% more than Merseyside, and 15% less than the UK average for small cities. The satellite pattern and mixture of uses found in GM are also similar to the officially recommended 'dispersed nucleated' structure.[8] This is not to say that conditions are ideal in the NW, but that the impact of future development patterns should be tested against current baselines.

Such density-energy linkages can be extended to include energy use in buildings, the potential for combined heat and power (CHP), and urban food cultivation. The evidence here is very approximate but there seems to be a threshold at about 25 pph, beyond which increasing densities brings diminishing returns.

Fig 5.3 ***DENSITY & TRANSPORT :***



Estimated transport demand by average urban density: based on travel data & settlement analysis in UK cities & regions.
Source ECOTEC 1993, Owens & Cope 1995

[4] Owens 1987

[5] Stead, Titheridge & Williams 1999

[6] Breheny 1995

[7] ECOTEC 1993

[8] Breheny & Lock 1995

3 Impacts of construction

3.1 Environmental issues

In addition to consuming large amounts of raw materials, the construction sector is responsible for significant amounts of air, solid and waste emissions. In 2001, the total material consumption (TMC) of the UK house-building sector was 69 million tonnes (Table 4.0).

EA code	123 code	Industries	Total MF for the CONSTRUCTION of dwellings	Construction Materials
7	7	Other mining and quarrying	32,568,191	Spoil/fill, sand
34	51	Structural clay products	4,045,734	Bricks
35	52	Cement, lime and plaster	3,408,421	Mortar, plasterboard, plaster
36	53	Articles of concrete, stone etc	24,296,751	Concrete (mass/slab), hardcore, blocks, Mineral wool insulation
13	31	Wood and wood products	1,923,704	Windows/doors timber
25	42	Paints, varnishes, printing ink etc	199,899	Paint
30	47	Rubber products	47,446	Linoleum, membranes
31	48	Plastic products	563,565	Polyurethene ins. (HCFC), Windows/doors uPVC
32	49	Glass and glass products	255,714	Glass
33	50	Ceramic goods	185,194	Ceramic tile
37	54	Iron and steel	719,369	Steel, Reinforcing beams/lintels
41	57-61	Structural metal products	487,019	Aluminium
44	70-72	Electric motors and generators etc	286,366	
		Total MF	68,987,374	

Table 4.0: UK 2001 Construction sector material flows
Source: REAP

Carbon and other emissions released during the extraction and transport of raw materials are not normally added to the construction sector's carbon balance sheet, yet applying the 'user pay' principle allows us to see where the true responsibility for the original emissions lies. What REAP offers is a possibility to link market demand with environmental impact all the way along the supply chain.

As Table 5.0 shows, the construction sector purchases almost 80% of its total products and services from only 10 industrial sectors (including itself). Downstream in the cycle, the output of the construction sector can be broken down in to nine product types, with the main outputs being repair and maintenance of housing and new private commercial construction. The key observation from these results is that although new-build projects get most media and professional attention (especially commercial projects), repair, maintenance and refurbishment are much more significant consumers of construction services.

UK Top[1] 10 Sectors Construction Buys from (according to IO 123 classification) (Source: REAP Supply & Use)	Value (£) of Construction's Purchases (£ million) (Source: REAP Supply & Use yr 2000)	% of Construction Total Purchases	Product Types Sold by Construction (Source: construction stats: annual 2004; 2003 data / and year £2000)	Value of Output (£ million) (Source: construction stats: annual 2004 / 2003 data / and year £2000)
Construction	30,711	43%	Repair & Maint of housing	1,932
Articles of concrete, stone etc	4,506	6%	New construction: private commercial	1,853
Owning and dealing in real estate	3,586	5%	Repair & Maint: private	1,450
Renting of machinery etc	3,487	5%	New construction: private housing	1,370
Plastic products	3,381	5%	New construction: infrastructure	1,158
Other mining and quarrying	2,422	3%	New public construction excl infrastructure	927
Wood and wood products	2,215	3%	Repair & Maint: public	607
Architectural activities and technical consultancy	1,930	3%	New construction: private industrial	529
Other business services	1,745	2%	New construction: public housing	165
Structural metal products	1,605	2%		
Sum of Top 10	**55,589**	**79%**		
Construction Sector's Total Purchases (£ million) (Source: REAP Supply & Use yr 2000)	**70,692**			

Table 5.0 Upstream and downstream construction sector linkages

3.1.1 Material use of construction

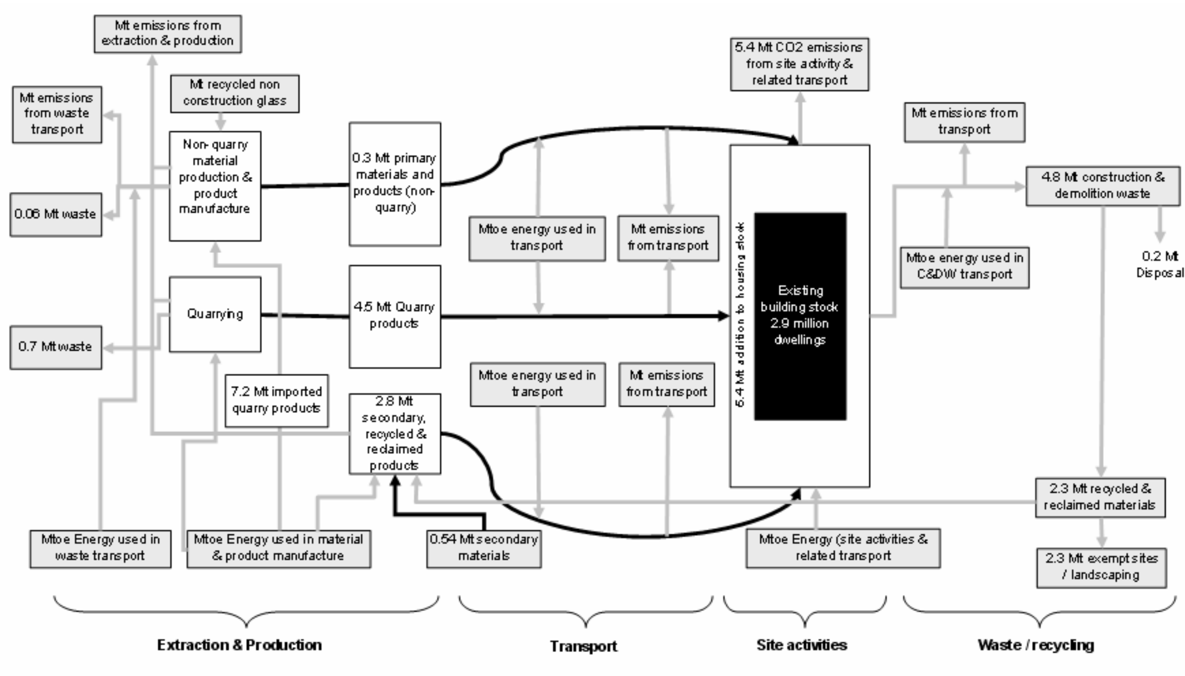
If we assume that material use is evenly spread in proportion to construction spending, then there is 25% in housing, 33% in commercial, 11% in public services, 12% in industry and 19% in infrastructure.

- Construction as a whole in the NW region uses 35 million tonnes of materials directly (DMC), and used 70 million tonnes in total material consumption (TMC). This equates to over 10 tonnes for every person in the region.
- The construction industry is by far the most mass-intensive of any sector: the direct material consumption is 53% of the regional total DMC from all activity and the TMC is 43% of the total from all activity.

Quarry products, including aggregates, sand, crushed rock and limestone, was by far the largest type of material flow, accounting for 50% of the total material consumption (TMC).

- Cement, concrete and plaster products are the next largest, at 15 million tonnes TMC.
- Slate, bitumen, stone and other non-metallic minerals are also at 6 million tonnes TMC.
- Metal and metal products of all kinds, were 1 million tonnes, and wood/wood-based products are 2.5 million tonnes.
- Raw materials make up roughly 90% of material inputs for the construction sector, while only 10% are recycled or secondary.
- The footprint of quarry material transportation is 7 times higher than the footprint for the production and use of the material.

Research by the Stockholm Environment Institute suggests that an average dwelling in the North West requires 151 tonnes of materials to construct. BRE's data suggests this figure is closer to 121 tonnes. Tanikawa (2005) calculated that a typical UK flat requires 141 tonnes of building materials to construct.



Resource flows in the North West Region's housing construction industry

Table 1.0: Construction material requirements for typical UK house

			REAP	BRE	
EA code	123 code	industries	Tonnes per new built house	Tonnes per new built house	Characteristic materials
7	7	Other mining and quarrying	68.1	27.4	Spoil/fill, sand
13	31	Wood and wood products	9.5	3.4	Windows/doors timber, Timber
25	42	Paints, varnishes, printing ink etc	1.2	0.1	Paint
30	47	Rubber products	0.3	1.2	Linoleum, Membranes
31	48	Plastic products	3.2	1.8	Polyurethene ins. (HCFC), Windows/doors uPVC
32	49	Glass and glass products	0.8	0.4	Glass
33	50	Ceramic goods	0.5	0.2	Ceramic tile
34	51	Structural clay products	3.9	15.8	Bricks
35	52	Cement, lime and plaster	10.6	13.4	Mortar, Plasterboard, plaster
36	53	Articles of concrete, stone etc	48.9	55.6	Concrete (mass/slab), hardcore, Blocks, Mineral wool insulation, Roofing tiles
37	54	Iron and steel	2.6	1.5	Steel, Rein. beams/lintels
41	57-61	Structural metal products	1.4	0.3	Aluminium
			151.1	120.9	

Table 2.0 Material Mass, Intensity of building (Traditional Brick Flat) (Source: Tanikawa 2005)

Area:84 m2 * 2 floors	Area / Number	Aggregate Sand &Gravel (ton)	Concrete* (ton)	Mortar* (ton)	Steel (ton)	Brick (ton)	Wood (ton)	Others (ton)	
1) Traditional Piched Roofs	170	-	-	7.3	-	-	3.9	1.7	Felt, Rockwool
2) Upper Floor	84	-	-	-	-	-	1.7	0.8	Plsdyrt Board
3) Concrete Grand Floor	84	16.1	8.1	-	0.3	-	1.0	0.1	Rockwool,
9) External Wall: Cavity Wall	325.5	-	16.4	16.3		56.7		3.5	Rockwool, Plasterboad, Paint
5) Internal Wall	273	-	-	-	-	-	1.1	5.1	Paint, Plaster Board
Total (ton)	140.1	16.1	24.5	23.6	0.3	56.7	7.7	11.1	
Density per total floor area (kg/m2)	**782**	**96**	**146**	**141**	**2**	**338**	**46**	**14**	

3.2 *Ecological footprint of construction*

The Ecological Footprint (EF) is an impact assessment and communications tool. It measures how much land and water area a human population requires, to produce the resources it consumes and to absorb its wastes. EF is measured in global hectares (gha), meaning that the land required is measured wherever it may be in the world. This can be put as global hectares per person (gha/cap), a rough measure of the total impact of our lifestyles and useful for comparisons. There are two main components:

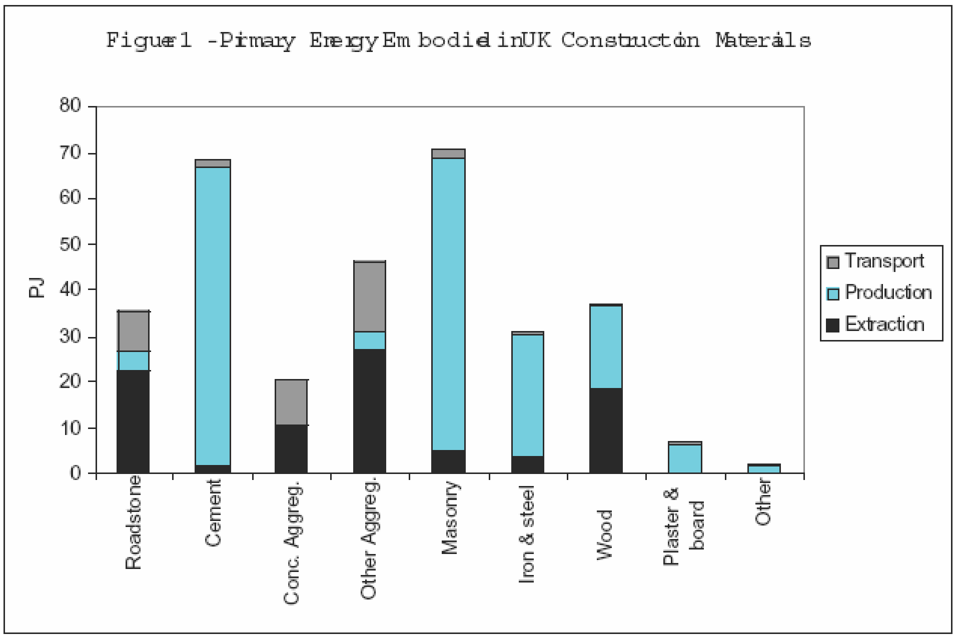
- The "land footprint" includes the area required to produce all the crops, forestry and other resources, together with land required to absorb pollution.
- The "energy footprint" represents the area needed to grow renewable resources to meet both energy consumption, and the energy in imported goods.

The construction sector in the region can be characterized by way of the EF metric as follows:

- o The total ecological footprint of the construction sector is 7.1 million gha, second only to the footprint of the food sector. The energy content of common construction materials and the reliance on virgin materials serves to drive the majority of the ecological footprint.
- o Most of the EF is taken up with 'energy land', reflecting the high energy intensity of key construction materials (cement, bricks, glass and so on), and the small proportion of renewable materials.
- o The total EF from all construction amounted to 7.1 million gha per year: the construction EF (energy demand & construction in housing / property) per

person was 1.0 gha per person (amounting to 17% of the total EF from all activity). The construction EF is growing at roughly 0.005 gha/cap per year.

- The largest material EF type was 47% with minerals, bitumen and other mineral products: these are both heavy and energy intensive.
- 24% of the construction EF is taken by quarry products, where most of the energy/emissions are involved with transportation.
- 14% of the construction EF is taken by cement and plaster manufacture, which are particularly energy intensive.
- Although bulky, construction materials are not so energy intensive as construction activity produced 23% of the total CO_2 emissions, and 17% of the total ecological footprint from all activity in the North West region.



Source: DETR (1998), BRE (1998) Database

3.3 Construction waste

The waste generated during construction and the deconstruction of buildings can be significant. A 2001 Government survey, found that the North West was the UK's third largest producer of construction and demolition waste (C&D), behind the South East and the South West. The region produced roughly 11 million tonnes of C&D waste in 2001, but the majority of this was recycled as aggregate or soil or reused on other sites for landscaping or engineering purposes.

In all, less than 4% was disposed of to landfill. Landfill has always been a cheap option for the large volumes of construction and demolition waste, and minimisation or recycling has usually been seen as a costly option. Spending on waste disposal is currently somewhere between 0.1% and 0.2% of turnover, a low figure which is explained by the fact that construction companies do not appreciate the potential impact of waste on the bottom line. However, with landfill prices set to rise dramatically, waste disposal costs could seriously threaten the industry's future profitability.

3.4 Targets & questions

A Factor Four improvement in resource efficiency is the general target, equating to a 75% reduction in resource use. For the construction sector, this will likely require dramatic improvements to both the way that resources are used, and reductions in the amount of materials consumed.

- Can we construct dwellings that require 75% less building materials (i.e. a 38 tonne typical house)?
- Will we require new construction materials or new methods of construction to achieve the target?
- What will these sustainable buildings look like and will they require PhDs to operate?
- Can we reduce transport requirements by three quarters through local sourcing of materials, compact urban design and denser development?
- Once built or renovated, can our houses run on 40% of current carbon budgets as required by the UK's 2050 CO_2 reduction target?
-

Clearly, achieving such a target will necessitate action from many stakeholder groups: government; the house-building industry; social housing providers; communities and local authorities; and building occupants.

4 Urban development

4.1 Stock profile

There are roughly 2.9 million dwellings in North West England including approximately 1 million in Greater Manchester. In the North West semi-detached houses and terraces account for over 70% of the housing stock. Dwellings built in recent decades are typically smaller (83 m^2), and built on smaller plots, than older housing (88 m^2) built before 1980.

The energy use in dwellings depends on the type of dwellings. Detached houses use the most (365W/^oC), with semi-detached using less (276W/^oC), terraced houses consuming even less (243W/^oC) and flats and maisonettes using the least (182W/^oC). The average detached house is three times as energy intensive as the average flat (Ravetz 1996). The average energy consumption per dwelling in Great Britain in 2001 was 80.8GJ, with the majority being for space heating (50.0GJ).

The ecological footprint associated with the energy consumption of a typical UK house is 0.607 global hectares per capita per year (gha/cap/yr), while a house built to 2002 building regulations has an in-use energy EF of 0.340 gha/cap/yr, an EcoHome with an 'Excellent' rating scores an EF of 0.229 gha/cap/yr), and a BedZED home outperforms them all with an in-use energy EF of 0.098 gha/cap/yr. The potential savings from a more efficient building stock (assuming all 2.9 million dwellings in the region are 'typical UK' as defined here) are significant as shown in Table 3.0.

Table 3.0: Ecological footprints of housing types

House type	EF (gha/cap/yr)	Total EF (gha/yr)	Saving over typical house (gha/yr)	Saving over typical house (%)
Typical (existing stock)	0.607	1.76 million		
2002 building regs	0.340	0.99 million	0.77	44
EcoHome (excellent rating)	0.229	0.66 million	1.10 million	62
BedZED	0.098	0.28 million	1.48 million	84

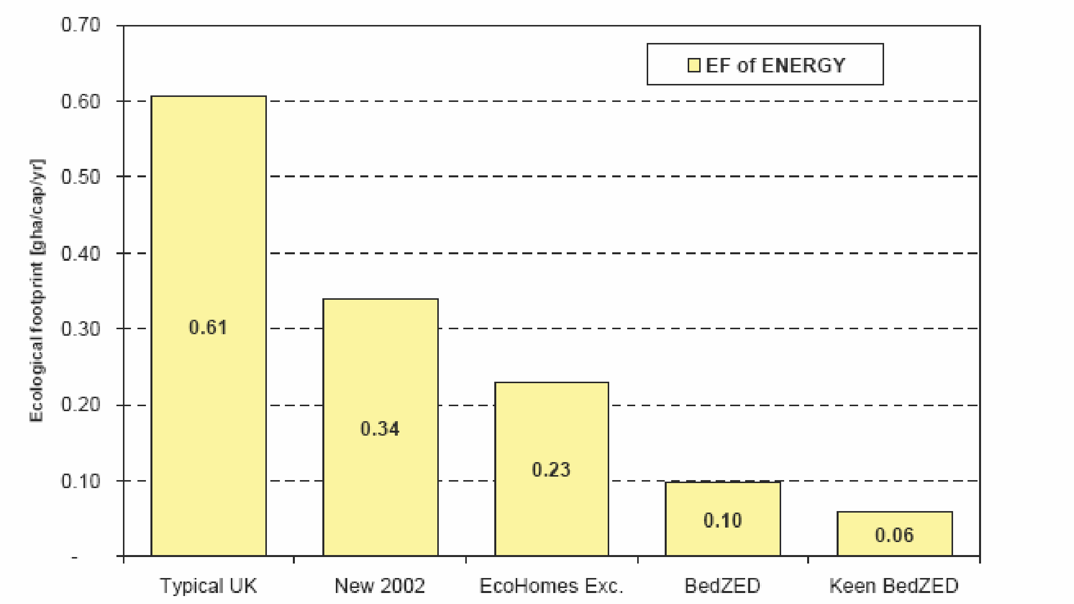


Figure 2: Ecological footprint of the component ENERGY for different scenarios of homes and lifestyles
Source: SEI. 2003. Sustainability Rating for Homes: The Ecological Footprint Component

Over one third of existing buildings can be considered 'young' as they were built post-1960, while 25% of the existing stock was built pre-1919. The age of the North West's housing stock is apparent with the 100-year birthday of a quarter of the region's houses. How long can we expect this older stock to perform?

Dwelling age

North West		
All tenures	n (000s)	%
pre 1919	752	25.8
1919-1944	572	19.6
1945-1964	588	20.2
post 1964	1,007	34.5
Total	2,919	100

Source: 2001 English House Condition Survey

4.2 Regeneration and demolition

Although the existing stock of houses in the North West will continue to meet most of the demand over the next 20 years, high levels of maintenance and refurbishment will be required to keep the stock fit for use. Lack of investment will lead to more abandoned homes and increased levels of house-building. Housing provision numbers show that roughly 13,000 houses (net of clearance) will need to be constructed in the North West annually.

Strategic Planning Authority	Annual Average Rate of Housing Provision Net of clearance
NW Metropolitan Area and Regional Poles and Inner Cities	2,990
Manchester	1,350
Salford	530
Liverpool	1,110
Rest of Former Counties of Greater Manchester, Merseyside, Halton, Warrington	4,310
Shire Counties	5,490
North West Total	12,790

Source: RPG13

As an indication of the magnitude of the housing problem in the region, 21 of the 88 deprived areas that qualify for Neighbourhood Renewal Funding and regeneration are in the North West (more than any other). The regeneration process varies from location to location and the implications for material and energy use can be both negative and positive.

Under its Decent Homes Programme, the Regional Housing Board emphasizes the need to rehabilitate, rather than simply add to, the regions housing stock. That is to say, housing associations should repair and modernise their stock in areas of continuing demand ahead of subsidising new housing or non-core activities. The RHB sees the potential for use of off site manufacture (OSM) to increase supply of affordable homes, and building low cost energy-efficient quality homes that do not compromise build quality but significantly reduce development times.

More efficient new homes can save energy over the long-term, but require materials and energy to construct, and may generate waste and transport costs if demolition is necessary. Refurbishment may not achieve the same energy savings as new build, but the social and resource conservation benefits can also be significant.

Case study: refurbishment versus new build of office buildings

BRE compared the relative impacts of refurbishment and re-development of office buildings. Environmental impacts related to the construction materials themselves, transport, maintenance and disposal of building fabric, operational energy consumption costs over a 60 year period, and eventual demolition of the building. The results suggest a 20% saving in environmental impact through refurbishment, and 12% saving in whole-life costs, due largely to savings in materials needed for new build, as well as avoided demolition costs.

4.3 Policy agenda

4.3.1 Regional Spatial Strategy & Housing Strategy

The RSS has several levers with which to direct the construction sector. It encourages use of previously developed land, re-use of disused buildings and land, and building at higher densities where practicable. Building at higher densities which reduces land take, and makes some services that are important for sustainable communities, such as transport, more viable, may be viewed by some developers as an opportunity to sell more floorspace for a given development footprint. The RSS Policy DP3: Quality in New Development – requires new development to demonstrate good design quality. This means innovative design that results in eco-friendly and adaptable buildings with improved energy and materials efficiency.

4.3.2 UK Carbon Reduction Targets

Under the Kyoto Protocol the UK has a greenhouse gas reduction target of 12.5% of 1990 levels by 2010, as part of a European Union collective target of an 8% reduction. The UK has gone much further and committed to voluntary 20% and 60% reductions by 2010 and 2050, respectively. Buildings contribute almost half - about 46% - of the UK's CO2 emissions, while our homes alone contribute about 27%. The residential sector must therefore play a key role in carbon reduction initiatives if the UK is to meet its targets. Energy consumption, via direct consumption or embodied energy, by the construction sector is also important in view of UK CO_2 reduction targets.

There is good potential for improving energy efficiency in homes as numerous proven technologies exist. However, the uptake and effectiveness of these technologies relies on the personal behaviour of millions of households, local authorities, various players within the construction cycle, appliance and fuel supply industries, not to mention the Government. The current trend has residential energy consumption increasing, due largely to an increase in the number of households, and increased consumption for appliances and lighting.

4.3.3 Aggregates Levy

To encourage efficient use of a valuable resource, the Aggregates Levy was initiated. In England, nearly one quarter of primary aggregates is used in the construction of roads and one fifth is used in the construction of housing, these two being the major uses of primary aggregates. In the North West region of England in 2001, one quarter of primary aggregates was sold for use in concrete whereas another quarter was sold for use as fill material in construction, the two uses making up half of the total sales for that year. The levy is payable on all primary aggregates and in its early stages has improved the commercial feasibility of using minestone and other demolition materials as aggregate.

4.3.4 Questions

There are many questions for discussion:

- Which is better for sustainable regeneration from a CO_2, EF or material intensity perspective – rebuilding or rehabilitation, renovation versus new build?
- How can the Regional Spatial Strategy be used to reduce material and energy consumption?
- What are the barriers to constructing buildings with greater energy efficiency, and how can they be overcome?
- How can the re-use of aggregates and demolition materials be encouraged? What are the barriers?
- Energy labelling of houses is around the corner, what are the possibilities for material and EF intensity labelling of dwellings?
- Given that flats and terraces consume less energy and require less materials to build, should we set policy to encourage people to live in these smaller dwellings?

5 Footprint stabilization

5.1.1 Experience from the SE region

This section contrasts the situation in the NW with that of the South East, where the Regional Assembly has agreed to implement a programme for 'stabilization' of the regional eco-footprint, as follows:

> Over the Plan period, per capita use of natural resources will stabilize and begin to reduce, supported by increased efficiency of resource use in new development, the adoption of existing development, the extensive use of sustainable construction techniques and corresponding changes in public attitude and behaviour. Relevant authorities will achieve a stabilization of consumption of resources and aim for a reduction in absolute levels of consumption in the long term with an aim to stabilise the South East ***ecological footprint*** by 2010.

> In particular, authorities should require Eco-Homes 'very good' as a minimum standards for all new housing and adoption of BREEAM 'very good' standards in all new commercial developments.

The full report is available on http://www.southeast-ra.gov.uk/southeastplan/

However, the SE Plan is proposing to increase the rate of housebuilding and infrastructure provision, in order to cope with a projected rate of population growth of 0.5% per year and economic growth of 3% per year. At the same time, personal consumption of energy intensive products, food, air travel and others continues to increase rapidly. This suggests that radical measures may be needed to achieve the target of stabilization.

5.1.2 The stabilization target

The overall policy target can be interpreted in terms of three main objectives:

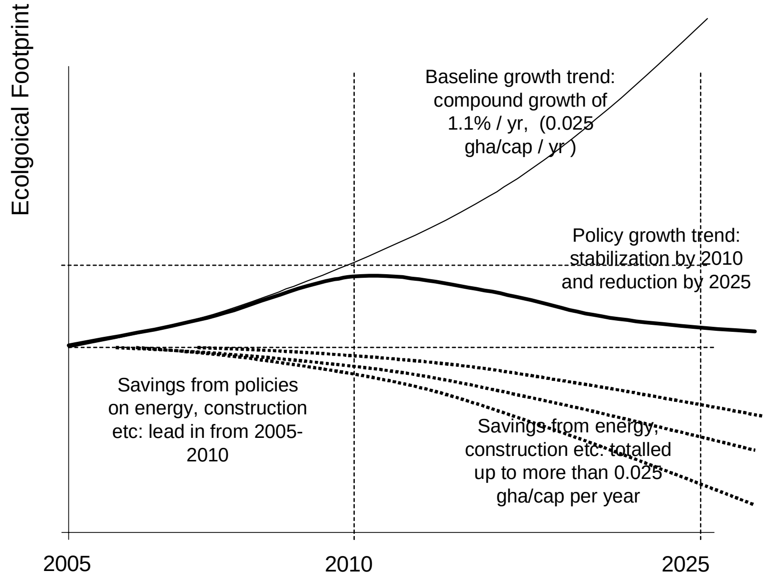
- The first objective is to ***stabilize the growth in EF from housing***, as the direct remit of the SE Plan.
- The second objective is to ***stabilize the EF in the wider built environment***, including other building types and transport, i.e. sectors where the SE Plan would have significant influence.
- A further objective is to ***stabilize the EF across all activities and consumption*** in the region as a whole: i.e. outside the scope of the SE Plan as such. This third agenda is not reported here.

The stabilization target is set at a notional 2010: however it is likely to involve the phasing in of an ambitious programme of low impact construction for housing and property, and radical upgrading of the whole of the building stock.

Therefore the stabilization target is calculated in terms of a 5 year and 20 year policy programme. Assuming that a pro-active start is made within a 5 year period on a full scale programme of low energy / low impact construction and rehabilitation, this is likely to result in the stabilization of the EF growth curve by 2010.

If the target is interpreted as ***"stabilization by 2010 of the EF at 2001 levels",*** this implies a reduction from 2005 values back down to 2001 values. In this case we could anticipate the EF rising from 2005-6, then levelling off in 2007-8, then starting to reduce back to 2001 levels by 2009-10. On the face of it, this outcome does not appear very feasible, given the inertia of the planning system, construction industry and so on. In practice there is enough room in the current quality and uncertainty of the data, so that changes within the 5 year period are not feasible to measure accurately in any case.

The conclusion is therefore that a strategic policy-oriented approach will be more effective, based on the phased implementation of a 20 year strategy. This can incorporate some 'easy wins' in the short term, which may include awareness raising and training, and simple technology initiatives as in section 1.3.



Fig… stabilization framework

5.2 Trends and targets

5.2.1 General trends in eco-footprint

- The EF of the UK on average has risen from 3.81 gha/cap in 1961 to **5.35gha/cap** in 2001, equivalent to an average annual growth rate of **0.85** percent.
- The EF in 2001 of the SE region was **6.09** gha per person, or 14% higher than the UK average.
- The total amount of land required to sustain the inhabitants of the SE region was 49.2 million ha, roughly 25 times the land area of the region.
- In the SE region, two thirds of the total EF is required to absorb CO_2 and other climate emissions ***("energy land")***. One third of the total EF is actual physical area needed for infrastructure, crops, forestry etc, somewhere in the world ***("real land").***

- Taken together, shelter (31%), transport (22%), and goods (19%) account for over 70 percent of the “energy land” EF, while sustenance (48%), goods (23%), and shelter (10%) account for over 80 percent of the “real land” EF.
- The total EF is calculated as the sum of shelter, transport etc, and each of these has its own range of growth forecasts. The ‘High’ growth forecasts would result in EF values in 2010 and 2026 of **6.42 and 7.85** gha/cap, respectively.
- The ‘Low’ growth scenario for the same years results in EF values in 2010 and 2025 of **6.33 and 7.38** gha/cap, respectively.
- The growth rate to 2026 under the ‘High’ growth scenario is estimated as 1.27% per annum, the ‘Low’ growth rate is 0.96% per annum (i.e. a slight reduction).
- **The mid-point average can therefore be estimated at approx. 1.11% per annum growth in total EF per capita, or 0.068 gha/cap per year.**

SUMMARY OF BASELINE TRENDS

Bottom up calculation. All figures per capita unless otherwise stated		**annual growth EF / cap @2005**	**EF 2005**	**EF 2010**	**EF 2025**	*long range EF 2050*	**% of total EF in 2005**	**% of total EF in 2025**	**compound growth rate 2005-25**
housing energy / cap growth	gha/cap/yr	-0.001	0.59	0.58	0.57	*0.56*	10%	8%	**-0.16%**
housing construction / cap growth		0.000	0.23	0.23	0.21	*0.19*	4%	3%	**0.00%**
services bldgs energy / cap growth		0.001	0.26	0.27	0.29	*0.33*	4%	4%	**0.50%**
services bldgs construction / cap growth		-0.003	0.46	0.45	0.42	*0.38*	8%	6%	**-0.54%**
surface transport / cap growth		0.008	0.53	0.57	0.71	*1.04*	9%	10%	**1.50%**
air travel / cap growth		0.013	0.25	0.32	0.66	*2.25*	4%	9%	**5.00%**
subtotal urban development		***0.024***	**2.32**	**2.42**	**2.86**	**4.75**	*38%*	*38%*	**1.04%**
other / food / consumables		*0.043*	*3.77*	*4.02*	*4.74*	*5.26*	*62%*	*63%*	**1.15%**
total EF / CAP baseline trend (SE Plan low growth)	gha/cap	**0.068**	**6.09**	**6.44**	**7.59**	**10.01**	100%	102%	**1.11%**
TOTAL EF baseline trend (SE Plan low growth): incorporating population growth	1000 gha	***830***	*49999*	*54284*	*69497*	*101002*			***1.66%***

5.2.2 Trends in urban development

Here we focus on the key features of the ‘urban development’ activities, as these are mainly within the scope and remit of the SE Plan:

- As above, the total EF per capita in the SE region is growing at an estimated 1.11% per year compound growth = **0.068** gha/cap per year (central estimate).
- This total includes ***urban development*** (energy demand & construction in housing / property: surface & air travel): and ***other*** (energy supply, food, consumables, other).
- The urban development EF is nearly 40% of the total EF, and is growing at approx 1.06% per year = **0.025** gha/cap per year
- Of this figure of 0.025 growth per year, about half is due to the rapid growth in air travel, and another third is due to surface transport at a somewhat slower rate of growth.
- The remainder of the 0.025 growth is due to energy & construction in housing & property = **0.005** gha/cap per year approx.

- Although the building stock and EF of housing & property is growing, and may grow faster under the SE Plan, the population is also growing, so that the EF per capita change is relatively small.

All the figures quoted above are generally in EF / capita, which factors out any change in the total population: i.e. the population growth has no effect on the EF / capita.

If we include the effect of population growth in the region at approx **0.54% per year**, then this adds about **0.5%** per year on top of the other growth trends. About two thirds of this is due to demographic change, and one third due to inward migration, mostly from other regions of the UK. Therefore the **total EF** in the region is growing at about **1.66%** per year: if this trend continues, the total EF could double by 2050.

Each of the above growth trends has been calculated assuming the ***lower growth*** option in the SE Plan of 25,500 dwellings per year.

- If the ***higher growth*** option of **32,000** houses per year is assumed, then the effect on the baseline EF in energy & construction is to add **0.005** gha/cap per year on to the baseline growth trends in housing construction and housing energy demand, i.e. an increase of about one fifth, all other things being equal.

5.3 Policy options

5.3.1 Options for stabilization: energy in housing

This section involves the core activity of the SE Plan in housing policy, and its potential to directly influence the energy efficiency of new and existing housing.

	SUMMARY of DOMESTIC ENERGY OPTIONS	**annual growth EF / cap @2005**	***savings growth EF/cap @2005***	**EF 2005**	**EF 2010**	**EF 2025**	*long range EF 2050*	**% of total EF in 2005**	**% of total EF in 2025**	**compound growth rate 2005-25**
	Summary of policy options shown as EF / cap: with "savings" from baseline trend									
B2a	**existing hsg stock to EEC standard**	-0.006		**0.59**	**0.56**	**0.47**	**0.40**	**9.6%**	**6.2%**	**-1.07%**
	savings on baseline		*-0.003*		*0.01*	*0.05*	*0.07*			
B2b	**existing hsg stock to "40% house" standard**	-0.011		**0.59**	**0.53**	**0.39**	**0.39**	**9.6%**	**5.1%**	**-2.08%**
	savings on baseline		*-0.007*		*0.04*	*0.14*	*-0.09*			
B3b	**new housing @25.5k: to Ecohomes 'excellent'**	0.001			**0.01**	**0.03**	**0.05**		**0.3%**	
	savings on baseline		*-0.001*		*0.00*	*0.02*	*0.04*			
B3c	**new housing @25.5k: to BedZed2 standard**	0.000			**0.00**	**0.01**	**0.02**		**0.1%**	
	savings on baseline		*-0.002*		*0.01*	*0.03*	*0.07*			
C4	**effect of higher growth @32k**	0.025			**0.12**	**0.50**	**1.12**		**6.6%**	
	savings on baseline		*0.005*		*-0.03*	*-0.10*	*-0.23*			
	note negative "savings" = increase									
C6	**total hsg @25.5k combined "40%" & BedZed2**	-0.012		**0.59**	**0.52**	**0.37**	**0.22**	**9.6%**	**4.9%**	**-2.25%**
	savings on baseline		*-0.010*		*0.06*	*0.20*	*0.35*			

To meet the EF stabilization target in the urban development sectors, we need to identify savings as shown on the summary table above (the results refer to the ***low growth*** scenario of 25,500 dwellings per year, unless otherwise specified):

- The **existing housing** stock of 3.4 million dwellings contains the largest opportunities for reducing EF. If the stock was fully upgraded with basic energy efficiency measures, the saving would be about **0.003** gha/cap per year, or one eighth of the target.
- For **new housing**, any policy effect is less significant, simply as after 20 years the new housing is still a small fraction of the total housing stock. If new housing was built to the Eco-Homes 'excellent' standard the saving would be **0.001** gha/cap per year, a small part of the target saving.
- If new housing was built to the low / zero energy "BedZed" standard, the saving would be about **0.002** gha/cap per year, or about one tenth of the target saving.
- The most effective policy is the "40% house" upgrading programme, combined with demolition and replacement of a third of existing housing, with all new housing at zero or very low energy standard. This is the full programme recommended by the Oxford University Environmental Change Unit as meeting the UK's climate emissions aspirations, and is envisaged to be phased over a 45 year period. If applied to the SE region it would involve doubling the new build rate to **51,000** new dwellings per year, half of which would then replace existing dwellings. Overall this would result in an EF savings trend of **0.011** gha/cap per year, providing nearly half of the target savings in urban development.
- It is recognized that this rate of demolition and replacement may be politically very challenging. However it might also offer huge opportunities for rebuilding more 'sustainable communities' in both environmental, and economic and social terms, (if there was a clear way forward in doing so).
- If the existing stock was upgraded to the full "40% house" specification of Oxford University, but without any demolition or replacement of existing

housing, the savings would be lower at **0.007** gha/cap per year, or nearly 1/3 of the target.

	SUMMARY of URBAN DEVELOPMENT OPTIONS	annual growth EF / cap @2005	*savings growth EF/cap @2005*	EF 2005	EF 2010	EF 2025	*long range EF 2050*	% of total EF in 2005	% of total EF in 2025	compound growth rate 2005-25
	Summary of policy options shown as EF / cap: with "savings" from baseline trend									
D2	**low impact construction in hsg @25.5k**	-0.007		**0.23**	**0.20**	**0.10**	**0.09**	**3.8%**	**1.4%**	**-3.93%**
	savings on baseline		*-0.005*		*0.03*	*0.10*	*0.09*			
E2	**low energy services buildings**	-0.001		**0.26**	**0.25**	**0.21**	**0.16**	**4.3%**	**2.8%**	**-1.06%**
	savings on baseline		*-0.004*		*0.01*	*0.08*	*0.17*			
E4	**low impact services construction**	-0.010		**0.46**	**0.41**	**0.27**	**0.24**	**7.6%**	**3.6%**	**-2.66%**
	savings on baseline		*-0.007*		*0.04*	*0.15*	*0.13*			
F2	**road traffic stabilization**	0.002		**0.53**	**0.54**	**0.60**	**0.65**	**8.7%**	**7.8%**	**0.59%**
	savings on baseline		*-0.006*		*0.03*	*0.12*	*0.39*			
F3	**green transport programme**	-0.006		**0.53**	**0.50**	**0.48**	**0.40**			
			-0.012		*0.07*	*0.23*	*0.64*			
F4	**green air travel programme**	0.008		**0.25**	**0.29**	**0.45**	**0.95**	**4.1%**	**5.9%**	**3.00%**
	savings on baseline		*-0.011*		*0.03*	*0.21*	*1.30*			
	Combined total of other options	**-0.005**		**1.73**	**1.69**	**1.63**	**2.10**	**28.5%**	**21.5%**	**-0.30%**
			-0.033		*0.14*	*0.66*	*2.08*			

5.3.2 Options for stabilization: urban development

This section involves domestic construction, other property construction and energy demand, and transport by surface and air. "Other property" includes a wide range of commercial and public buildings (industrial buildings appear only indirectly in the 'consumables' accounts). Transport is allocated on the basis of the location of the consumer: for instance, for 'air travel' we do not include international hub passengers changing at Heathrow, but we do include flights by SE residents from other regional airports.

The logic is that these are activities and sectors where the SE Plan may have significant influence, if not total control (although this may be particularly indirect in the case of air travel). The projections assume that the current rate of property construction continues, and that the SE region generally follows national trends in surface transport and air travel.

- ***Housing construction***: a programme of low impact design, specification and demolition waste recycling could be phased in across the industry, over a 20 year period. Although the evidence on construction impacts is very patchy, the savings trend could be approx **0.005** gha/cap per year, or one fifth of the target.
- ***Energy demand in property:*** there are opportunities in upgrading the existing stock efficiency by 20% over 20 years, and building new stock to the BREEAM 'very good' standard. The result would be a saving trend of **0.004** gha/cap per year, or nearly one fifth of the target.

- ***Property construction:*** there is a similar logic to domestic construction: the potential efficiency gains are lower, but the volume of construction is higher. The result could be savings of approx **0.007** gha/cap per year, or over one quarter of the target.

6 Construction benchmarking

6.1.1 Need for benchmarking

As sustainability issues permeate deeper into construction supply chains, environmental regulations are becoming tighter, clients are demanding greener buildings, and energy, material and waste management costs are increasing. In order to remain in compliance, attract and satisfy clients, and reduce its operating costs, the construction sector will need to develop better ways to benchmark its performance with regard to energy and material consumption, and waste emissions.

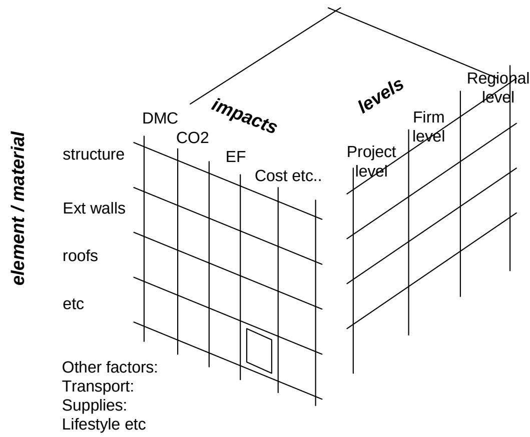
To help developers, designers, builders, planners and others, the Eco-Region NW is developing the components of a forthcoming ***'Eco-benchmark'*** system. These are based on extensions of systems which are already in use around the industry, including:

- BREEAM / Eco-homes assessment method
- Eco-profiles / Eco-points
- Construction Products Association KPIs
- BRE Envest

The notes below are in order to outline the concept of this scheme, illustrated with some samples from the REAP calculations and database.

6.1.2 Benchmarking framework

The proposed framework is shown as a kind of Rubiks Cube, with 3 main axes:



- Element / material breakdown: covers common building materials grouped by common elements and specifications
- Impacts – environmental / economic: the environmental impacts of material flow, eco-footprint and CO2 production are generated from the REAP modelling system, which includes for both direct and indirect impacts. The economic data are to be supplied by the industry.
- Level: the same underlying database informs each of the main levels, i.e. element / material level: building level: firm / sector level: regional level. Each of these levels has its own index point: e.g. the building level is indexed against finished floorspace: the firm level is indexed against output: the regional level is indexed against household / dwelling numbers.

6.1.3 Element / material assessment

The added value of the Eco-Region NW system is:

- Material flow analysis (MFA) eco-footprint analysis (EFA) and CO2 emissions are reported in one common format, including for both direct and indirect impacts
- This enables direct comparison of building design specification and procurement options.
- This is most closely related to the BRE Eco-profiles / Eco-points and Construction Products Association systems.
- The indexing is geared to the function of the element, i.e. m2 of walling or roof area: or for materials, indexed to tonnes.

Primary Construction Materials (year 2000)	tonnes of material consumption	total CO2 of material consumption (t)	total EF of material consumption (gha)	DMC / TMC ratio	CO2 per TMC (t)	EF per TMC (t)
0						
Total mass of quarry products	2200	2318	600	0.57	0.18	0.05
Total mass of wood products	16	12	3	0.43	0.32	0.08
Total mass of finishes, coatings and adhesive products	2	14	4	0.14	0.93	0.24
Total mass of plastic products for construction	12	69	18	0.15	0.91	0.24
Total mass of glass products for construction	93	156	40	0.30	0.51	0.13
Total mass of ceramic products for construction	7	4	1	0.77	0.21	0.05
Total mass of bricks and other clay-based products for constru	303	84	22	0.77	0.21	0.06
Total mass of cement, concrete and plaster products for constr	4246	592	153	0.85	0.27	0.07
Total mass of stone and other non-metallic mineral products	317	1057	273	0.33	1.08	0.28
Total mass of metal products for construction	720	2870	742	0.12	0.32	0.08
Total mass of cabling, wiring, lighting	45	45	12	0.33	0.33	0.08
total materials / EFA	**7961**	**7220**	**1868**	**4.75**	**5.27**	**1.36**

Sample summary sheet from project assessment

6.1.4 Building / project assessment

This is most closely related to the current BREEAM / Eco-Homes assessment tools, and is to be designed as an extension to them. It provides a more specific quantitative assessment of the sustainability of the building design and construction, in relation to the regional and UK targets for material use, waste management, climate emissions and eco-footprint.

- The use of CO2 and eco-footprint enables direct comparison between building construction and in-use energy demand.
- It also enables direct comparison between building impacts and other built environment impacts e.g. from site works, transport, food supplies, building supplies.
- Overall this will be of value to property managers of housing or other building stock. When calibrated with the BREEAM / Ecohomes schemes it may be used in the future as a tender / contract condition.

6.1.5 Firm / sector assessment

The firm level assessment is geared towards the industry i.e. construction as an economic sector, in relation to other industries which buy from or sell to construction.

- It uses the range of outputs from the REAP and REEIO modelling systems, in particular to identify the material flow from other sectors which is consumed by the construction sector.
- It can then index that consumption in terms of dwellings or floorspace produced, GDP or GVA utilized, capital investment etc
- The sector level indices are then a reference point and template for more detailed firm level assessments, to be targeted towards particular kinds of outputs, e.g. proportions of housing, industrial, civil engineering etc

6.1.6 Regional assessment

This is focused on the agenda for urban / regional planners, environmental managers, economic development agencies and so on. It will help with policy issues such as:

- Environmental impacts of the Regional Spatial Strategy: with policy options on housing stock management, urban regeneration, urban form & density, building types and so on.
- Direct implications for regional supply and demand strategies in minerals & construction waste.
- Other implications for regional supply and demand strategies in energy & water.
- Setting of achievable regional targets for overall environmental sustainability.

100% construction materials (i.e. these materials can only be used for constr

EA code	123 code		Construction related to actual rentals for housing	Construction related to imputed rentals for housing	Maintenance and repair of the dwelling	Construction related to other (non-construction) HH consumption categories
7	7	Other mining and quarryi	242,127	553,005	536,422	3,419,082
34	51	Structural clay products	15,032	34,409	27,010	106,175
35	52	Cement, lime and plaster	21,701	49,042	143,794	405,998
36	53	Articles of concrete, ston	161,780	369,374	435,761	1,721,495

Multiple use materials (i.e. these materials can be used for other purposes th

EA code	123 code		Construction related to actual rentals for housing	Construction related to imputed rentals for housing	Maintenance and repair of the dwelling	MF related to other HH consumption categories (construction share unknown)
13	31	Wood and wood product	16,180	36,851	142,196	465,797
25	42	Paints, varnishes, printin	2,403	5,419	15,058	95,741
30	47	Rubber products	908	2,050	3,205	79,175
31	48	Plastic products	5,883	13,370	42,917	281,214
32	49	Glass and glass products	2,454	5,500	7,952	162,367
33	50	Ceramic goods	1,548	3,490	4,413	107,463
37	54	Iron and steel	8,546	19,145	21,950	539,715
41	57-61	Structural metal products	4,018	9,026	13,981	209,673
44	70-72	Electric motors and gene	3,800	8,478	7,990	180,799
		Total MF	**486,380**	**1,109,160**	**1,402,650**	**7,774,693**

6.1.7 Questions

- Can the industry report the resource intensity of its outputs or operations?
- Will we be able to compare the ecological footprint per floor area of a flat in Manchester against a semi-detached terrace in rural Cheshire?
- Should we add an ecological footprint or carbon intensity value to building labels?
- What demand will there be for buildings with relatively high standards of energy efficiency?
- What is the prospect of "EcoHome" pilot projects becoming the norm for new build in the United Kingdom?
- Of what use are sector-level EF, CO_2, MFA, waste metrics for construction firms?

7 Appendix

7.1 What is an ecological footprint?

An Ecological Footprint estimates a population's consumption of food, materials and energy in terms of the area of biologically productive land or sea required to produce those natural resources or, in the case of energy, to absorb the corresponding CO2 emission generated, using prevailing technology. This land could be anywhere in the world and as a result, the ecological footprint is measured in "global hectares". Data for ecological footprint calculations will come from the Ecobudget Project data calculations.

Ecological Footprints can be measured for a country, region, city, town or even at the level of an individual.

The UK average ecological footprint is about 5 hectares/per person (1999 figures). This means that the average UK resident requires approximately 5 hectares of land to supply them with all their necessary resources, their transportation needs and the use and disposal of those resources.

A sustainable ecological footprint or 'Earth Share', taking into account the protection of biodiversity, is approx 2 hectares per person.

WWF-UK has done some interesting work on Ecological Footprints including comparing footprints of different nations/continents and the Living Planet Report 2004 (816 KB).

7.1.1 What are the components?

Footprint will be broken down into the following components:

- Food Supply
- Domestic mineral consumption.
- Transport systems
- Infrastructure development.
- Domestic solid waste disposal and methane emission from landfill.
- Domestic energy use and water.
- Road construction
- Housing
- Commercial energy use.

A global hectare is one hectare of biologically productive space with world-average productivity. In 2002 the biosphere had 11.4 billion hectares of biologically productive space corresponding to roughly one quarter of the planet's surface. This includes 2.0 billion hectares of ocean and 9.4 billion hectares of land. 1 global hectare is a hectare representing the average capacity of one of these 11.4 billion hectares. Global hectares allow the meaningful comparison of the ecological footprints of different countries, which use different qualities and mixes of cropland, grazing land, and forest. For comparative purposes an ecological footprint is usually expressed in gha per person. Once all global hectares of bioprucdtive land and sea are divided by the total global population, we end up with our fair earth share - 1.8 gha.

Why is ecological footprint based on consumption?

The Materials Flow and Ecological Footprint Analysis assesses material consumption and its impacts based on where the benefit is experienced. It includes imports of all kinds consumed in a region, anything produced and consumed in the region, and other activities that are of benefit to a regions residents such as air travel. It excludes exports. As many industries and supply chains are increasingly global in scale, this is the most meaningful and comprehensive analysis.

What is the difference between 'real land' and 'energy land'?

Real land is actual land or sea area, sometimes called bioproductive land or sea, used to provide materials, food and other biomass. Energy land is forested land required for the absorption of CO2 emissions from energy use. An ecological footprint is made up of both real land and energy land.

Isn't ecological footprint too simplistic?

Footprint methodology is being improved all the time and part of WWF's wider programme is about establishing a Global Footprint Network to share / standardise footprint methodology.

The footprint methodology used in Ecological Budget UK enables footprint to be calculated and used at a regional / local level, based on National and regional data.

At present footprint calculations are an underestimate of our global impacts. Although greater accuracy is important, we need to act on what footprint is showing us now and start to take action. We shouldn't wait until we have accuracy up to the 10th decimal place!

For further details, visit WWF's Ecological Footprint Programme

7.2 Capital to revenue ratio

The comparison of one-off construction impacts to operational impacts is dependent on the method for conversion of capital costs to revenue costs. This of course is a major question, with many possible approaches, both financial and environmental. The key issue is that the building lifetime is unknown at the point of construction: and that there are different interest or discount rates which might be applied.

For illustration purposes, a table is shown below which shows the effect on Net Present Value (NPV) of different discount rates (interest rates) over different lifetimes, from 20 to 100 years. These NPVs are then converted to simple payback periods (i.e. the years taken to pay back the initial investment at simple growth). This table shows a feasible range of assumptions:

- A cautious assumption on building lifetime of 40 years, with a more market-focused discount rate of 10%
- A generous assumption on building lifetime of 100 years, with a PSBR typical rate of 3% annual interest.

With this combination of assumptions, and with simple paybacks ranging from 38-19 years, it can be assumed that a middle-of-the-road ratio would be a 30 year payback period. Therefore we assume for the purposes of this study that one-off construction impacts can be divided by 30 for comparison with operational impacts. This ratio is then applied to the construction impacts reported in the previous section.

Table 6.0 NPV and payback scenarios

	discount rate					
lifetime years		20	40	60	80	100
amount		1000	1000	1000	1000	1000
NPV	3.00%	553.68	311.80	178.43	94.83	51.39
NPV	6.00%	311.80	103.67	30.84	9.83	
NPV	10.00%	148.64	26.08	3.33		
simple	3.00%	1.81	3	6	11	19
payback	6.00%	3.21	10	32	102	
equivalent	10.00%	6.73	38	300		

7.3 Summary of results

7.3.1 Eco-footprint

Ecological Footprint Results

Building	1 year Per HH	60 years Per HH	1 year Per Person	60 years Per Person
Other mining and quarrying	1.17	0.02	0.50	0.01
Structural clay products	1.48	0.02	0.63	0.01
Cement, lime and plaster	2.65	0.04	1.13	0.02
Articles of concrete, stone etc	2.99	0.05	1.27	0.02
Wood and wood products	11.90	0.20	5.07	0.08
Paints, varnishes, printing ink etc	0.43	0.01	0.18	0.00
Rubber products	0.14	0.00	0.06	0.00
Plastic products	2.65	0.04	1.13	0.02
Glass and glass products	0.30	0.01	0.13	0.00
Ceramic goods	0.21	0.00	0.09	0.00
Iron and steel	1.83	0.03	0.78	0.01
Structural metal products	2.86	0.05	1.22	0.02
Electric motors and generators etc	0.50	0.01	0.21	0.00
...Total	**29.14**	**0.49**	**12.40**	**0.21**
Maintenance				
Other mining and quarrying	0.00		0.00	
Structural clay products	0.00		0.00	
Cement, lime and plaster	0.01		0.00	
Articles of concrete, stone etc	0.00		0.00	
Wood and wood products	0.08		0.03	
Paints, varnishes, printing ink etc	0.00		0.00	
Rubber products	0.00		0.00	
Plastic products	0.02		0.01	
Glass and glass products	0.00		0.00	
Ceramic goods	0.00		0.00	
Iron and steel	0.01		0.00	
Structural metal products	0.01		0.00	
Electric motors and generators etc	0.00		0.00	
...Total	**0.13**		**0.06**	
Direct Energy				
Electricity	0.34		0.15	
Coal	0.03		0.01	
Gas Oil	0.00		0.00	
Fuel Oil	0.00		0.00	
Natural Gas	0.51		0.22	
Solid Biomass	0.00		0.00	
Other Fuels	0.05		0.02	
...Total	**0.94**		**0.40**	

Summary All figures in gha	1 year Per HH	60 years Per HH	1 year Per Person	60 years Per Person
Building		0.49		0.21
Maintenance		0.13		0.06
Direct Energy		0.94		0.40
Total		**1.56**		**0.66**

7.3.2 Climate emissions

Carbon Dioxide Results

Building	1 year Per HH	60 years Per HH	1 year Per Person	60 years Per Person
Other mining and quarrying	2.58	0.04	1.10	0.02
Structural clay products	3.68	0.06	1.57	0.03
Cement, lime and plaster	10.09	0.17	4.29	0.07
Articles of concrete, stone etc	8.03	0.13	3.42	0.06
Wood and wood products	5.27	0.09	2.24	0.04
Paints, varnishes, printing ink etc	0.35	0.01	0.15	0.00
Rubber products	0.12	0.00	0.05	0.00
Plastic products	2.70	0.05	1.15	0.02
Glass and glass products	1.73	0.03	0.74	0.01
Ceramic goods	1.47	0.02	0.63	0.01
Iron and steel	10.25	0.17	4.36	0.07
Structural metal products	13.60	0.23	5.79	0.10
Electric motors and generators etc	1.29	0.02	0.55	0.01
...Total	**61.17**	**1.02**	**26.03**	**0.43**

Maintenance		
Other mining and quarrying	0.00	0.00
Structural clay products	0.00	0.00
Cement, lime and plaster	0.03	0.01
Articles of concrete, stone etc	0.01	0.01
Wood and wood products	0.03	0.01
Paints, varnishes, printing ink etc	0.00	0.00
Rubber products	0.00	0.00
Plastic products	0.02	0.01
Glass and glass products	0.00	0.00
Ceramic goods	0.00	0.00
Iron and steel	0.03	0.01
Structural metal products	0.03	0.01
Electric motors and generators etc	0.00	0.00
...Total	**0.19**	**0.08**

Direct Energy		
Electricity	1.98	0.84
Coal	0.16	0.07
Gas Oil	0.02	0.01
Fuel Oil	0.00	0.00
Natural Gas	2.91	1.24
Solid Biomass	0.00	0.00
Other Fuels	0.31	0.13
...Total	**5.38**	**2.29**

Summary		
Building	1.02	0.43
Maintenance	0.19	0.08
Direct Energy	5.38	2.29
Total	**6.59**	**2.80**