Tackling Climate Change: The Practicality of Implementing Energy and Carbon Requirements in the New Residential Sector in England

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Abstract

This paper sets out the preliminary findings of a government funded Knowledge Transfer Partnership (KTP) between the School of Architecture & Landscape, at Kingston University London, and Clive Chapman Architects in Twickenham, London. The main aim of the project was for the architectural practice to gain in-house expertise in sustainable and environmental design and to develop and establish a specialist sustainability unit. The paper will examine how we tackle climate change in the new build residential sector in England and the practicality of implementing various requirements of the current and proposed UK legislation, sustainability codes, and local authority planning requirements. The paper briefly outlines the KTP project and the very significant benefits of knowledge transfer between academia and industry. It will focus on the global, national, regional and local requirements for energy strategy including building regulation requirements, sustainability codes and local authority requirements. A case study is described which takes an individual dwelling, typical of new housing in the UK, and models the impact of different design strategies on achieving the various requirements. This includes a description of the models that are currently being used to carry out assessments and the relative advantages and disadvantages of each. The design strategies tested include the use of different levels of fabric insulation and airtightness, ventilation strategies, fuel types, and renewable energy systems. These are then assessed against national, regional and local requirements and the impact on energy consumption and carbon emissions are quantified and presented. Preliminary findings of work already completed have shown that achieving higher levels of the Code for Sustainable Homes is prohibitively expensive and the funding systems for financial support from the Government are inadequate. The findings also show that the methods being used for quantifying energy and carbon emissions are fraught with problems and there are many conflicts in the interpretation of the requirements at different levels. As a result, there needs to be a more consistent set of guidelines at national, regional and local level, and a need for clearer definitions.

Keywords: climate change, building sector, energy, carbon emission requirements, implementation

1. Knowledge Transfer Partnerships (KTP)

1.1 Knowledge Transfer Partnerships (KTP)

Knowledge Transfer Partnerships are Europe's leading programme for helping businesses to improve their competitiveness, productivity and performance. KTP achieve this by helping organisations to access knowledge, technology or skills from the UK's knowledge base, which includes universities, further education colleges and research and technology organisations.

The knowledge sought is embedded into the organisation from the knowledge base through a project undertaken by a recently qualified graduate recruited to specifically work on that project (known as the Associate).

The Government encourages the formation of Partnerships by making a grant to the Knowledge Base Partner as a contribution to the costs of the KTP Project. The Company Partner also pays a share of these costs. This results in there being less risk for companies that want to invest in development through partnering with a knowledge base.

1.2 Aims of this Knowledge Transfer Partnership (KTP)

The demand for environmentally sustainable building design is presently driven by legislation and clients. In order to respond to this increasing demand and to remain competitive Clive Chapman Architects (CCA) collaborated with the School of Architecture & Landscape at Kingston University London (KUL).

This KTP will integrate sustainability into the architectural process and create a new business model that will introduce a new capability and expertise into the company.

2. The residential new building sector in England

There is now very strong evidence (IPCC, 2007) that since the late 1800s the earth's average surface temperature has risen by 0.74°C. Since this period, there has been an ever increasing consumption of fossil fuels as oil, gas and coal, significant deforestation, and the practice of farming methods that result in emissions of six principal greenhouse gases (UN, 1998): Carbon Dioxide (CO_2), Methane (MH_4), Nitrous Oxides (N_2O), Hydrofluorocarbon (HFC), Perfluorocarbon (PFC) and Sulphur Hexafluoride (SF_6).

The first reason for the current concern about climate change is the rise in atmospheric carbon CO_2 concentrations indicated in parts per million as shown in Figure 1.

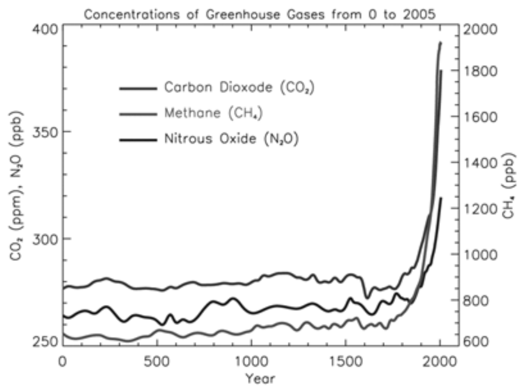

Figure 1: Concentrations of greenhouse gases from 0 to 2005 (IPCC, 2007)

The second reason concerns the speed of the recent warming. Average global temperatures have risen by 0.55°C since 1940. During the ice age and warm interglacial periods the mean temperature changed between 4°C and 7°C, however the process took about 5,000 years (IPCC, 2007).

In 2006 the UK was responsible for a total of 652Mt of CO_2 equivalent of greenhouse gas emissions (including Land Use, Land Use Change and Forestry) (DEFRA, 2008a). The UK Governments Department of Business, Enterprise and Regulative Reform has quantified the CO_2 contribution as accounting for 85% of these emissions (BERR, 2008).

Data shows (DEFRA, 2008b) that the building sector accounts for 63% of this, and the residential sector is responsible for about 27% of the total CO_2 emissions in the year 2006.

The sources of the CO_2 emissions in residences in 2005 have been published (DCLG, 2007). The heating sector (water and space) is responsible for 73% of the residential CO_2 emissions.

In 2006, London produced a total of 50Mt CO_2 from the consumption of energy in the domestic, commercial, industrial and ground transport sectors. This amount of CO_2 emissions represents 10% of the total CO_2 emissions of the UK (excluding emissions arising from aviation) (DEFRA, 2008c).

In order to prevent catastrophic climate change and be on course for the Government's national targets, the Mayor's target for London is to stabilise CO_2 emissions in 2025 at 60% below 1990 levels, as shown in Figure 2. London therefore must save 33 million tonnes CO_2 emissions or 4% per year.

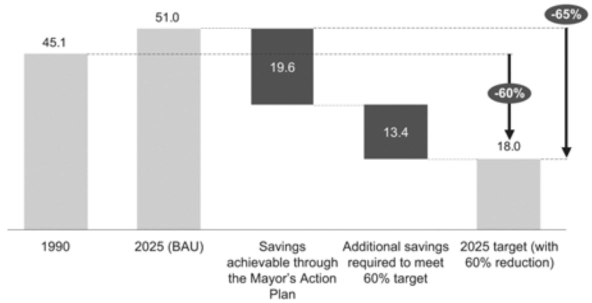

Figure 2: London's 2025 carbon dioxide reduction target (GLA, 2007)

3. International, national, regional and local energy strategy requirements

3.1 The international, national, regional, local levels

Different levels of hierarchy including international, national, regional and local intergovernmental/governmental institutions define energy strategies and set out targets for tackling climate change.

The UNFCCC is the overall framework for intergovernmental efforts to tackle the challenge posed by climate change. One of the earliest obligations of the UNFCCC parties is the Kyoto Protocol that came into force in 2005.

The core commitment under the protocol requires each committed industrialized country to ensure that its total emissions from the main six greenhouse gas sources (CO_2, MH_4, N_2O, HFC, PFC, SF_6) do not exceed agreed levels of emissions. The UK agreed in the Kyoto Protocol to cut its greenhouse gas emissions by 8% by 2012.

In order to implement the EU targets and greatly affect awareness of energy use in buildings and to lead to substantial increases in investment in energy efficiency measures within these buildings, the Energy Performance of Buildings Directive (EPBD, 2002) came into force in 2003.

The EPBD aims to ensure that new buildings meet the set requirements, make Energy Certificates available when buildings are constructed, sold and rented and to inform the users of buildings about methods and practices to enhance energy performance.

The Directive required all countries of the EU to transpose these EU targets into national law by January 2006.

In response to this directive, the UK Government set targets to cut the national CO_2 emissions by 80% by 2050. By 2020, 20% of the European Energy Consumption will be saved through improved energy efficiency and the renewable energy supplies will be increased by 10% by 2010, with an aspiration for this level to double by 2020.

To achieve these targets, the Government amended the Building Regulations (BR) Approved Document Part L in 2006 (ODPM, 2006) and currently is consulting on the changes that will come into force in October 2010. Compliance with BR is mandatory.

In addition to these changes the UK Government introduced the Code for Sustainable Homes (CSH) (DCLG, 2008) in 2007. The CSH is an environmental assessment method for rating and certifying the performance of new dwellings. The CSH rates dwellings for their environmental credentials from level 1 (enhanced sustainability) to level 6 (zero carbon).

Since May 2008 it has been mandatory for all new homes to have a CSH rating included in the Home Information Pack (HIP) as information to prospective purchasers of properties in England. For private dwellings it is currently possible to have a nil rated CSH certificate where an assessment has not taken place. All affordable housing has to currently comply with CSH Level 3 and is expected to comply with Level 4 from 2010.

On a regional level the Greater London Authority (GLA, 2004a) published it's Energy Strategy in 2004. The strategy aims to improve London's environment, reduce the capital's contribution to climate change, tackle fuel poverty and promote economic development by using less energy (being lean), using renewable energy (being green) and supplying energy efficiently (being clean).

The objectives arising from this strategy are 20% reduction in CO_2 emissions (relative to 1990 levels) by 2010. In the longer term, emissions will be reduced by 60% (below 2000 levels) by 2050. In addition, all major developments are expected to generate 10% of their energy needs from on-site renewable energy (where feasible). This target will be extended to 20% by 2020. The London Renewables Toolkit (STI, 2004) provides guidelines for planners, developers and consultants in order to integrate renewable energies into new developments.

Richmond upon Thames published it's Core Local Development Strategy (LBRUT, 2009a) in 2009. The Core Strategy sets out the Strategic Planning Framework of the borough over the next 15 years.

The vision of Richmond upon Thames is to see a borough that is inclusive, that puts the environment at the core of its services, delivers high quality public services that reflect the needs of all its people, and addresses its challenges by harnessing the capacity of all its partners on the public, private, voluntary and community sector.

The Borough requires every new development to comply with its supplementary planning document, the Sustainable Construction Checklist (LBRUT, 2009b). The Checklist requires an excellent environmental rating for all new residences which is equivalent to a Code for Sustainable Homes rating of Level 3. The predicted site CO_2 emissions have to be reduced by at least 20% through the use of on site renewable energy. In addition, every planning application has to incorporate a sustainability statement.

3.2 Renewable energy technologies

All levels of hierarchy, from international to local, seek to implement the objective to cut greenhouse gas and/or carbon dioxide emissions. To implement these objectives the specific targets are to improve energy efficiency, to improve the energy performance of buildings and to incorporate renewable energy technologies; targets that are all interlinked with one another.

But on different levels of hierarchy the three targets are not approached holistically.

In addition, various terminologies and definitions are used for renewable energy technologies, including renewable energies, micro-generation, macro-generation to energy-generating technologies and the required percentages range from ‘where feasible’ to a compulsory 10% or 20%.

4. Typical new housing case study

4.1 The exemplary dwelling

The dwelling chosen for this research is a real development located in a suburban area in the South West of London. The dwelling is a detached property, comprising two storeys, with a total floor area of approximately $160m^2$.

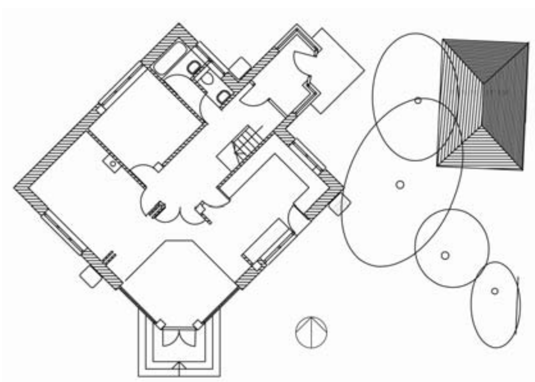

Figure 3: Site Plan and ground floor of exemplary dwelling, Architect James Deasley

4.2 The calculation model

All calculations have been performed with the National Home Energy Rating (NHER) Plan Assessor Version 4.2.28.

The NHER Plan Assessor software is government approved and authorised for Standard Assessment Procedure (SAP), Environmental Impact (EI), Target Emission Rate (TER), Dwelling Emission Rate (DER) calculations and for issuing Energy Performance Certificates (EPC).

In addition to the above the software predicts the annual energy consumption of dwellings based on BREDEM-12 (Building Research Establishment Domestic Energy Model) which is more comprehensive than the Standard Assessment Procedure.

4.3 The assumptions

It is assumed that the dwelling is naturally cooled, no secondary heating system is specified, no chimneys and open flues are present and in total three extract fans are installed in kitchen and bathrooms.

The heating systems tested include gas boiler, warm air (efficiency 100%), warm air with heat recovery (80%), biomass boiler, ground source and air source heat pumps and a communal CHP system. They are time and temperature zone controlled.

Appropriate systems to comply with the local planning requirement to offset at least 20% of the predicted CO_2 emissions by renewable energies have been tested.

The case studies therefore include renewable energy systems that are reasonable in a suburban context, such as photovoltaic elements, solar hot water elements, biomass boiler, ground source (efficiency 320%) and air source (efficiency 250%) heat pumps.

The two different types of construction tested for this case study are as follows:

1. The dwelling complies with Part L1A of the Building Regulations.

2. The dwelling exceeds the requirements of Part L1A. The Government will require all new housing to comply with CSH Level 4 by 2010 (for affordable housing) and 2013 (for private housing) and therefore the second range of case studies will achieve compliance with CSH Level 4.

Table 1: Assumptions made for the building systems and construction elements of type one and two

Building Element/Building System	*Type 1 – standard construction*	*Type 2 – improved construction*
Floor, external walls, roofs	*0.25W/m^{2}K*	*0.12W/m^{2}K*
Windows	*2.0W/m^{2}K*	*0.8W/m^{2}K*
Doors	*2.0W/m^{2}K*	*1.0W/m^{2}K*
Air tightness level	*9m^3/m^{2}hr @ 50Pa*	*5m^3/m^{2}hr @ 50Pa*
Transmission heat loss coefficient y	*0.08W/m^{2}K*	*0.08W/m^{2}K*

Boiler efficiency	*86%*	*90%*

4.4 Results of the analysis

4.4.1 Carbon Dioxide emission calculation methodologies

Different calculations are required to demonstrate compliance solely with the energy performance of new build dwellings. To prove compliance with BR AD Part L1A and to produce Energy Performance Certificates (EPC) for SAP-ratings, SAP 2005 calculations are required.

For both verifications SAP determines the CO_2 emissions arising from the predicted energy demand including main and secondary heating, cooling, ventilation, fans and pumps and lighting. The CO_2 emissions arising from cooking and appliances are not accounted for.

The assumptions that are made for the secondary heating and the energy efficient lighting are different in the calculations for Part L1A and for the determination of the SAP-rating.

For Part L1A the calculations determine the CO_2 emissions of the actual dwelling (DER) and these are compared with those of a notional dwelling, defined as the Target Emission Rate (TER). To comply with BR, the DER has to be equal to, or lower than the TER.

For Part L1A it is assumed that a secondary heating appliance always meets part of the space heating demand. The fraction provided by the secondary heating system is in accordance with the definitions in SAP (BRE, 2008) as shown in Table 2.

Table 2: Fraction of heat supplied by secondary heating systems

Main heating system	Secondary system	Fraction from secondary
All gas, oil and solid fuel systems	all secondary systems	0.10
Micro-cogeneration	all secondary systems	see Appendix N
Heat pump	all secondary systems	0.10
Electric storage heaters (not integrated)	all secondary systems	
- not fan-assisted		0.15
- fan-assisted		0.10
Integrated storage/direct-acting electric systems		0.10
Electric CPSU		See Appendix F
Electric room heaters		0.20
Other electric systems		0.10
Community heating	-	0

Notes:

1. *See also Appendix A.*
2. *If an off-peak tariff is present, an electric secondary heater uses the on-peak tariff.*

Where a secondary heating system is fitted, the efficiency of the actual appliance is used. Where a chimney or flue is provided but no appliance is installed, then an efficiency of 20% is assumed where a gas point is located adjacent. If there is no gas point, an efficiency of 37% is assumed. Where no secondary heating system is fitted, electric room heaters are assumed with an efficiency of 100%.

For lighting, a fixed assumption of 30% low energy lighting is made by Part L1A, with a minimum of one energy efficient light fitting per $25m^2$ floor area, or one for every four fixed lighting fittings.

To determine the SAP-rating for EPCs, the Environmental Impact Rating (EI) and the Energy Efficiency Rating (EE) need to be calculated. The calculation procedures for both ratings are also based on the total CO_2 emissions (DER) and the total energy costs based on SAP respectively.

However, contrary to Part L1A, for EPCs secondary heating systems are calculated as designed for the dwelling. The efficiencies of the systems are as specified by the manufacturer. Where a secondary heating system is specified, the fraction from secondary heating is as indicated in Table 2 above. Where no secondary heating system is incorporated in the actual dwelling, the fraction of the secondary heating system is zero.

For EPCs the CO_2 emissions from lighting are based on an average energy consumption for lighting in UK houses of $9.3kWh/m^2$ if no low-energy lighting is used. The fixed lighting systems are taken into account by including a correction factor.

Therefore, the CO_2 emission results of Part L1A and EPC calculation procedures vary as indicated in Figure 4 but are expressed using the same terminology “DER”.

In addition, Figure 4 shows the CO_2 emissions based on the assumptions made by NHER. In comparison with the SAP 2005 calculation procedure for Part L1A and EPCs, NHER includes the emissions arising through cooking and electrical appliances in the dwelling.

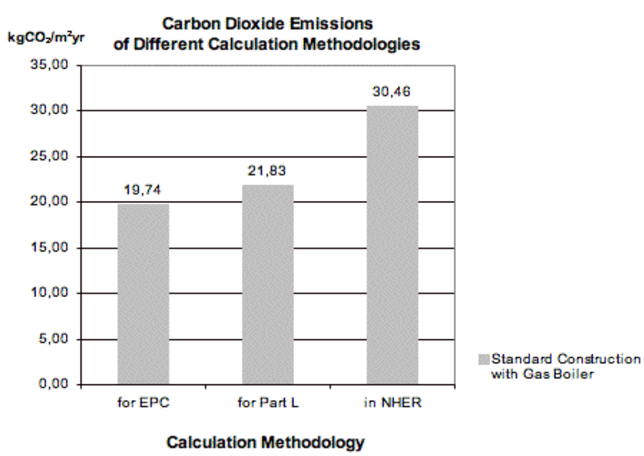

Figure 4: Calculated CO_2 emissions for house type 1 for EPC, Part L1A and NHER

4.4.2 Carbon emissions

Figures 5 and 6 demonstrate that the best heating option in terms of CO_2 emissions is not the best option in terms of energy demand.

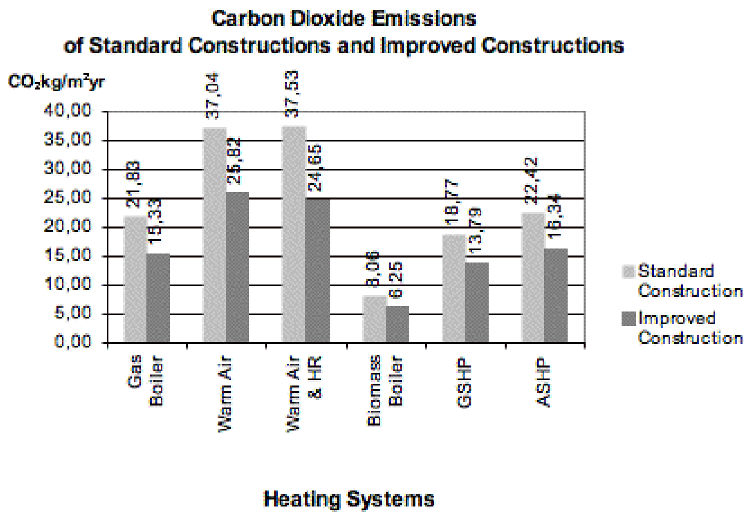

Figure 5: CO_2 emissions for different heating strategies for house types 1 and 2

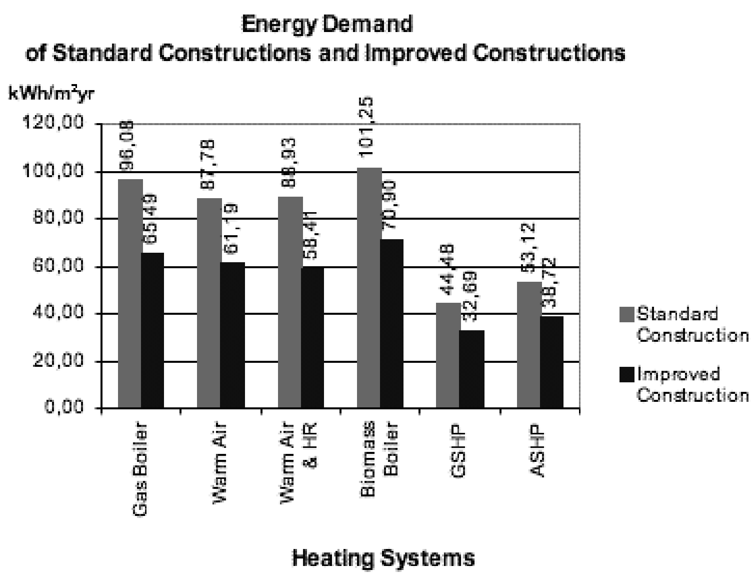

Figure 6: Energy demand for different heating strategies for house types 1 and 2

The biomass boiler has for both construction types the lowest DER but the highest energy demand. Whereas, the options with ground source heat pumps (GSHP) as heating systems show the best performances in terms of energy demand but have average DERs.

These differences are as a result of the factors SAP uses to convert the energy of the fuel into CO_2 emissions. Wood pellets for biomass boiler emit 0.025kgCO_2/kWh and electricity, the fuel for GSHPs, emits 0.422kgCO_2/kWh.

Therefore the definition of the DER as a decisive factor to conserve fuel and power is in conflict with the target to implement energy efficient heating solutions. Furthermore it is likely, that in the near future the proportion of electricity generated by renewable energy systems will increase and therefore the current heating systems running on electricity will have lower CO_2 emissions in the future.

4.4.3 Cogeneration

One target of the Mayor of London (GLA, 2004b) is to improve the use of efficient technologies, such as Combined Heat and Power (CHP) systems. Gas CHP systems are defined as Low or Zero Carbon Technologies in the CSH (DCLG, 2009) but are not recognised as renewable energy systems as defined in the London Toolkit (STI, 2004).

Therefore, gas CHP systems can award credits in the Energy 7 “Low or Zero Carbon Technologies” criterion in the CSH, but gas CHPs do not count towards the 20% renewable energy requirements of some Boroughs.

According to Grinfeld (BSD, 2009) CHP systems achieve 30% higher efficiencies than systems that produce heat and electricity separately.

In addition, Figure 7 shows that the CO_2 emissions of a communal gas CHP systems calculated according to the Part L1A and NHER are the lowest of the systems tested.

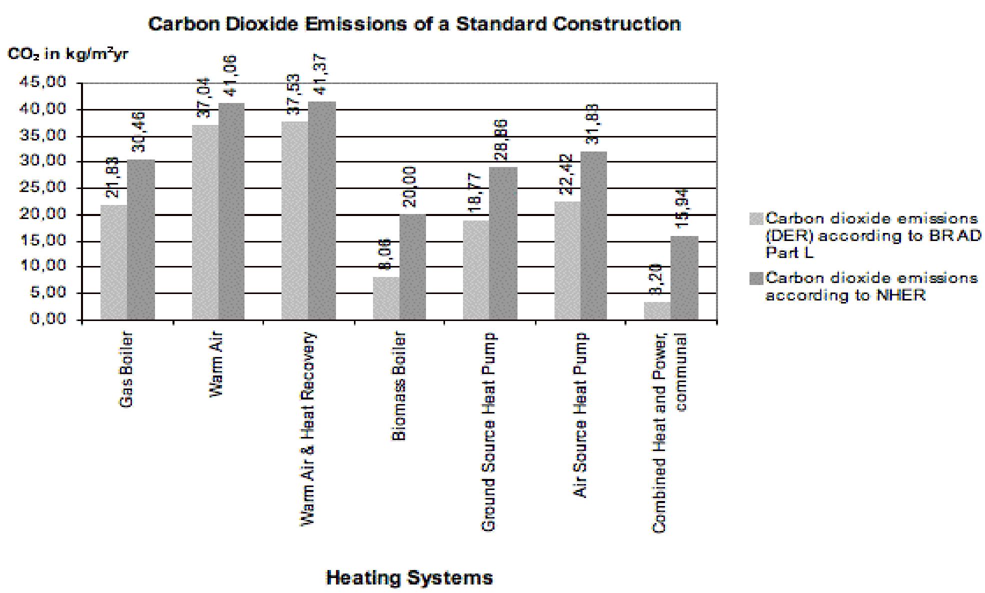

Figure 7: CO_2 emissions of different heating strategies including gas CHP of house type 1

Gas CHP systems are therefore significant energy saving measures, although in practice they are not often incorporated, as the capital costs for CHP systems are higher than those of gas boilers and in order to receive planning permission, additional investments have to be made for the incorporation of renewable energy systems.

4.4.4 Electricity consuming systems

Figures 5 and 6 show, among other things, the energy and CO_2 performances of warm air heating systems with and without heat recovery (HR).

The warm air heating systems have the highest CO_2 emissions of the systems tested. However the energy demands of both systems are less than those of the biomass boiler and of the gas boiler, because of the 100% efficiencies of the electricity consuming systems. Again it is not reflected in the CO_2 conversion factors applied by SAP that more electricity will be generated by renewable technologies in the future.

In addition, figures 5 and 6 show that the HR system reduces the CO_2 emissions and the energy demand in the case of the improved construction, whereas the HR slightly increases both in the standard construction as the system is running on electricity. Therefore the more airtight the building construction, and the higher the thermal resistance of the building materials, the higher the savings achieved through the HR.

The principle of the HR system is to preheat supply air, using the heat from the extracted air. Therefore HR systems act in the same way as air source heat pumps. Nevertheless HR is not recognised as renewable energy technology, whereas ASHPs are on international level.

4.4.5 Renewable energy technology/LZC calculation methodologies

On a national and regional level a rating against the CSH Assessment is required, although where an assessment has not taken place, a nil-rated certificate is allowed.

The CSH Energy 7 criterion awards credits for the incorporation of Low or Zero Carbon Technologies (LZC). To demonstrate compliance with Ene 7, the CO_2 emissions of the actual dwelling are compared with those of a “Standard Case”, as defined in the CSH Technical Guide (DCLG, 2009). The Energy 7 spreadsheet tool helps facilitating the required calculations.

However, on a local policy level a similar requirement, to offset the predicted CO_2 emissions by at least 20% on-site renewable energy systems, becomes a mandatory criterion.

The systems that are accepted as renewable energy vary on different levels and a generic definition is hard to find. In order to demonstrate compliance, complex and confusing calculations are required:

To establish the total CO_2 emissions of the dwelling, the CO_2 emissions must first be calculated with SAP 2005. The procedure then requires the Energy 7 CSH calculation tool to establish the additional CO_2 emissions through cooking and appliances, which are not reflected in the SAP 2005 calculation procedure. These total predicted CO_2 emissions form basis for the determination of the required 20% offset through renewable energy systems.

To determine the CO_2 savings achieved through the incorporated electricity generating renewable energy systems, the CO_2 emissions of the actual dwelling are compared with a base case with the same dwelling design and the same heating system, but without the electricity generating systems. This calculation becomes even more complex if the renewable energy systems incorporated provide heat instead of electricity.

Furthermore, as can be seen in Figure 8, the amount of energy generated from additional renewable energy technologies increases with improved construction in the case where the heating system is the renewable technology, e.g. GSHP, ASHP, biomass boiler. That is, if the basic design of the building is better, then the amount of renewable energy technologies that has to be incorporated into the development to achieve the 20% requirement is greater. This clearly, does not promote good basic design.

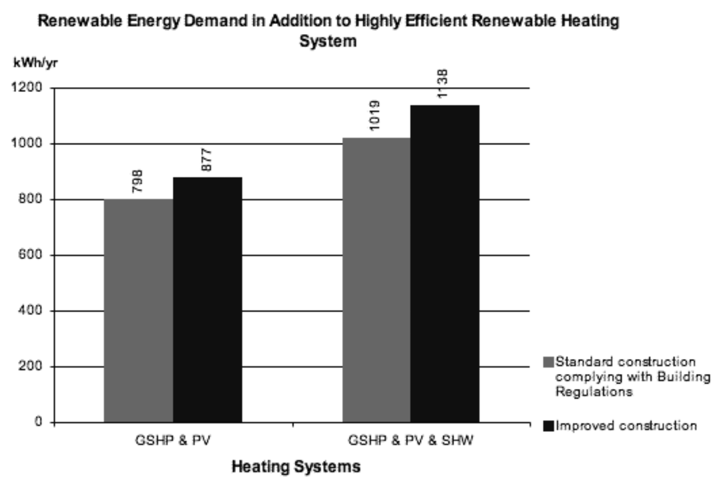

Figure 8: Amount of energy produced by the renewable energy technologies incorporated to house types 1 and 2 to meet the 20% renewables requirement

4.4.6 Costs

The costs for the additional sustainability requirements arise through improved building construction, improved building services, the costs for the renewable energy technologies and the procedure for the CSH assessment and certifications.

From experiences it can be seen that the additional costs of achieving CSH Level 4 and to incorporate 20% renewable energy systems to a typical dwelling range between £10K and 15K.

Figure 9 shows the predicted CO_2 emissions and payback periods for various renewable systems. It is assumed that the costs for the full installation of PV elements are £5,800, of solar hot water elements are £795, of a biomass boiler are £5,000, of an ASHP are £5,000 and of a GSHP are £12,000.

It can be seen that the biomass boiler has the shortest payback period time of 5 years and the GSHPs and ASHPs have the longest payback periods of 24 years. The installation of a GSHP is complex and therefore cost intensive. Although the ASHP has low capital costs itself, the contribution of the heating system towards renewable energies as defined by the Borough, is very low. This is because firstly, the efficiency of the system is fixed at 250% by SAP 2005 even though the CoP of the systems are better according to manufacturers, and secondly the ASHP running on electricity is compared to a base case with a gas boiler to constitute the % renewable energies. Therefore additional renewable energy systems have to be included which generate additional costs.

The best system in terms of CO_2 emissions is the communal CHP. With the gas boiler the CHP has the second shortest payback period of 11 years. But the additional costs of the CHP system itself have not been included, as the gas CHP is not recognised as a renewable energy system.

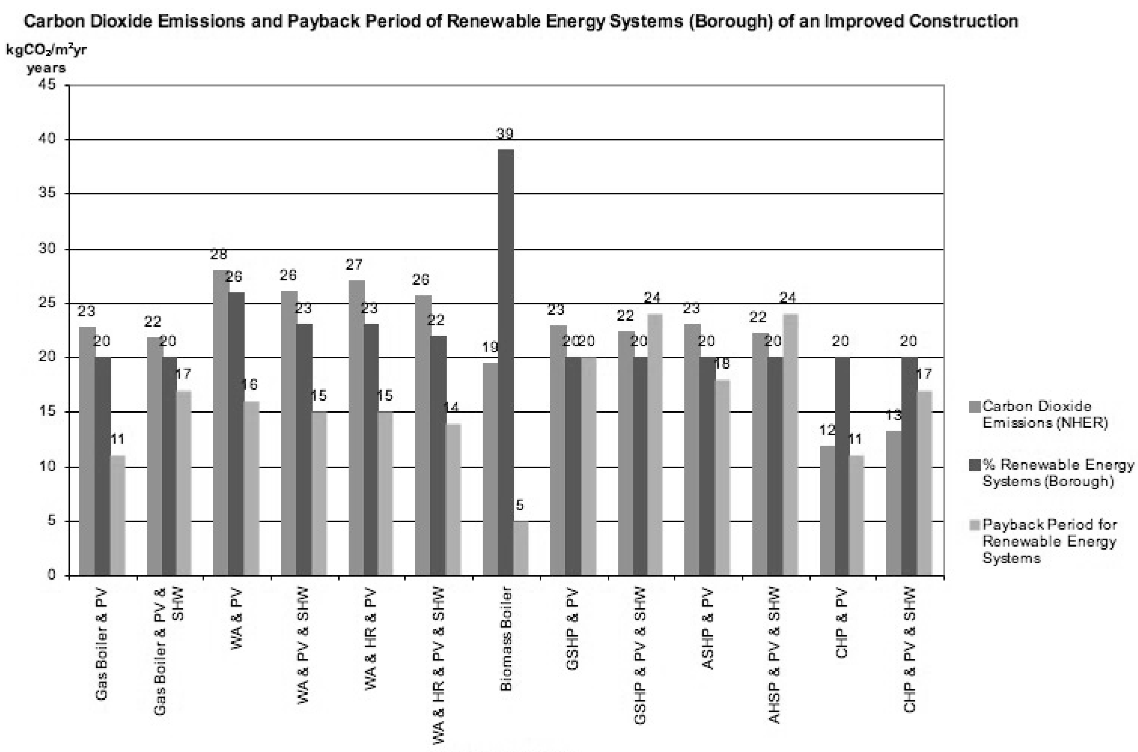

Figure 9: Predicted CO_2 emissions (NHER), the contribution towards % renewable requirement of the Borough and the payback periods of different renewable energy systems of house type 2

To overcome the financial barriers several schemes have been put into place by the UK Government. Until 2011 grants are available under the Low Carbon Building Programme for Low or Zero Carbon

Technologies for new build residential developments. Under the Renewable Obligation certificates can be sold to energy suppliers for each MWh generated. Stamp Duty Exemptions up to 4% are available for the first acquisition of zero-carbon homes.

From April 2010, a Feed-in-Tariff will be paid for every kWh of electricity generated by renewable energy systems and a Renewable Heat Incentive is announced to be launched by 2011.

However, the financial incentives are complex and refer to terminologies such as renewable energy systems, energy-generating technologies, energy-saving technologies, micro-generation, macro-generation and low or zero carbon technologies, which is confusing, and they cover only a fraction of the costs of a sustainable new building.

5. Conclusions

To implement the energy and CO_2 requirements in the new residential sector in England, three strategies are pursued: to go easy on resources (be lean), to improve energy efficiencies of systems (be clean) and to use non-fossil fuels (be green).

The implementation of these three strategies is regulated by the mandatory BR Part L1A and the optional CSH on national policy level and the mandatory supplementary sustainability planning documents on regional and local level.

The study undertaken shows firstly, that these regulations are not in line with each other and vary from Region to Region and from Borough to Borough. Their implementation therefore becomes confusing and unnecessarily complex.

Secondly, the applied methodology of implementing the strategies “be lean” and “be clean” are confusing and conflicting.

In order to demonstrate compliance with BR and to produce EPCs, SAP calculations are required.

The case studies show, that the SAP calculation used to predict the CO_2 emissions of a dwelling disregard the energy demand of cooking and electrical appliances. The predicted emissions that are used as evidences for BR compliance and that form the basis for SAP-ratings are therefore unrealistic.

Furthermore, both calculation procedures (BR, EPCs) use the same terminology “Dwelling Emission Rate”. But the calculations are based on different assumptions that result in two different emission rates which is confusing and a potential source for errors and confusion.

In addition, the SAP tool does not reflect in its calculation that the heating systems that run on electricity and therefore are more energy efficient than conventional gas boilers, such as GSHP, ASHP and warm air systems, will be less carbon intensive in the future, as a higher proportion of electricity will be generated by non-fossil fuels. The currently high carbon conversion factors for electricity result in high dwelling emission rates. Although more energy efficient, it is likely that these systems are not considered as heating systems. But these new dwellings will be the building stock of the future.

Thirdly, the study indicates that the methods applied to implement the strategies “be clean” and “be green” are conflicting and their definitions confusing.

A clear definition of “renewable energy technologies” is hard to find and different terminologies, such as “low or zero carbon technologies”, “micro-generation”, “macro-generation”, “energy saving technologies” and “energy generating technologies” are used.

For example air source heat pumps are not listed as renewables in regional guidelines, but are considered as renewables on national level, and, heat recovery systems, that use the same principles as ASHP are not recognised as renewable systems at all.

In order to determine the mandatory planning requirement of some Boroughs, that is to incorporate 20% renewable energy technologies on site, the calculation procedure is confusing. Firstly a clear definition is required, and as the study shows, the calculation methodology advantages lower quality construction standards. Secondly, the calculation conflicts with the CSH Energy 7 “Low or Zero Carbon Technologies”, which addresses a similar, but by definition, different requirement, by partly using the Ene 7 calculation tool and partly following its own calculations.

Furthermore, the case studies show that the cogeneration of heat and electricity with a gas CHP system is more energy efficient than their separate production. However, gas CHP systems are not considered as renewable energy systems and therefore do not count towards the requirement to incorporate 20% renewable energy technologies on-site. Therefore, costs for the CHP and the additional 20% renewables are often the criterion to reject this more energy efficient system.

In conclusion, the implementation of the energy and carbon requirements in England is unnecessarily confusing, complex and therefore time-consuming and generating costs. To overcome these barriers and to make the implementation of the national energy and CO_2 requirements successful, a number of recommendations can be made:

1. Regulations are required that are valid on every policy level in England and the UK respectively.

2. The calculation procedures for compliance with BR and to provide EPCs need to be adjusted. In order to give a more realistic prediction of total CO_2 emissions these calculations require including the energy demand for cooking and electrical appliances.

3. The required evidences should be based on the predicted energy demand of the dwelling expressed in kWh/m^2yr, rather than on the CO_2 emissions in kg/m^2yr. This will allow overcoming the conflicts between the energy efficiency of systems and the fuel type of the systems.

4. One terminology and a clear definition of "renewable energy technologies" needs to be agreed upon, that is valid in England and the UK respectively. Simple and clearly defined calculation procedures are required to demonstrate compliance with these renewable energy requirements.

5. The financial incentives need to be made more transparent and easily accessible in order to overcome the financial barriers.

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