INCORPORATING SOLAR ENERGY INTO A SUSTAINABLE HOUSING DEVELOPMENT STRATEGY IN UK

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ABSTRACT

The Housing Corporation is committed to effectively implement a viable sustainable agenda in the social housing sector and the Housing Associations are being encouraged to improve the environmental performance of their new and existing homes. The reduction in energy consumption achieved by using passive solar designs contributes to a reduction in CO_2 emissions, and hence slows down the increase in global warming. Passive solar incorporated houses designed for solar gain produce energy savings of up to 10% when compared to non-solar houses. Solar voltaic panels (PV) over a year, provide a household with 30-50% of its electricity needs and is suitable for urban and rural environments. Even though there are many examples of innovative social housing where solar power is used as an alternative energy source here and Europe, the UK housing industry seem to be cautious about using it extensively in their developments. This paper will investigate the potential the UK domestic sector has in incorporating solar energy into a sustainable housing development strategy. It will examine whether the long term benefits outweigh the initial costs incurred in terms of the economic and environmental savings that can be made or whether it is not really a practical solution for some geographical locations. It will also examine whether such a strategy could contribute, in terms of energy savings, to a sustainable refurbishment strategy of the large stock of existing stock and whether skills and technology development could contribute to this process.

Keywords: Housing Development, Housing Strategy, Innovative Social Housing, Solar Energy, Sustainable Housing

1. BACKGROUND AND CURRENT CONTEXT

The Housing Corporation and Scottish Homes, committed to effectively implement a viable sustainable agenda in the social housing sector, have initiated drives for the development of a sustainable energy future. By adding sustainable policy into their corporate strategies, the two bodies are actively encouraging all Housing Associations to develop Sustainability Action Plans. ‘Solar systems suitable for urban and rural environments could over a year provide a household with 30-50% of its electricity needs. In the UK, it can reduce the water heating costs by up to 70% over the course of a year. Solar heat systems reduce the impact on the environment and an average domestic system can reduce carbon dioxide emissions by up to one tonne per year (equivalent to one car)’ (Energy Saving Trust, 2003). In the social housing sector there is greatest potential for innovative maintenance and refurbishment. A strategy that incorporate solar energy could reduce the resident’s electricity bills, have less impact on the environment; and enable the residents to make a personal contribution to the battle against climate change and to building sustainable communities. A grid-connected solar Photovoltaic (PV) array coupled with efficient use of the solar electricity generated; create a low impact solution for a sustainable energy future. Once the capital cost has been paid, a solar PV system generates free, inflation-proof electricity in the heart of the community for more than 30 years. Due to the high prices associated with solar systems they have not played a significant part in the social housing sector, but as interest and development improves this could change. The importance of PV in sustainable, socially-mixed construction projects is beginning to be demonstrated and acknowledged but the full potential is not reached yet.

The construction, maintenance and operation of homes and buildings are responsible for nearly 50% of CO_2 emissions in the UK (Sustainable Development Commission, 2005). Photovoltaic technology was found to be one of the practical renewable energy options that can be implemented in exploring new ideas and innovations for cutting primary energy consumption. It could be implemented not only to obtain electricity, but to protect the environment, create local jobs and shape the ambience of our urban spaces. The new building-integrated PV products can now form part of the fabric of a building; providing quality building products that have the added value of supplying clean, sustainable electricity supply within the existing urban environment. Energy Review (Feb 2002) suggests that any long-term framework for British energy "needs to consider the role of renewable energy, including solar water heating, especially in electrically heated buildings and Building Integrated Photovoltaic (BIPV) have the most potential". It has been highlighted that these are currently expensive, but are already economic as an alternative to expensive cladding.

Many countries have tried to advance PV technology through their own initiatives. Countries, including Germany, Japan, the Netherlands, Norway and the USA have initiated programmes of government investment, in collaboration with industry, which have lead to thousands of solar electric homes being built around the world. 'For example; Germany's "1,000 roofs" programme launched in 1990 has resulted in more than 3,000 houses being fitted with solar electric panels; So much so that the Government went onto introduce a 10,000 roofs programme and between 1990-1996, they quadrupled' (ESRU, University of Strathclyde). Germany has established themselves as world leaders through such measures and extensive research, development and technological developments. UK and Scotland, does not currently have a suitably large home market to display its expertise in PV technology or the financial incentives to develop this market further.

1.1 The current building stock in UK

A report by the DTI (2001) 'Constructing the Future' examined the future needs of the UK's built environment and made a number of recommendations including: the promotion of 'smart' buildings and infrastructure; improvements in the health and safety of those employed in the construction industry; enabling supply chain integration; investing in people; improving existing built facilities; exploiting global competitiveness; embracing sustainability; increasing investment returns; and the need to plan ahead. In addition to the recommendations the report also outlined the changing demands that would be placed on the built environment (population demographics, knowledge based working practices, climate change etc) and suggested specific actions around whole life thinking and the use of alternative energy sources, advanced technology, materials and processes which would be needed to address them. Indeed, with respect to the improvement of existing built facilities the report called for the development of innovative processes, technologies and components for the maintenance, repair and refurbishment of the built assets identifying in particular the potential for new technologies and 'intelligent' products to improve living and working environments and enable information feedback to improve construction quality.

The UK has a fairly mature building stock and if a significant change in energy consumption trends is to be implemented, this must clearly consider the existing building stock. New buildings only add some where between 1% and 5 % of to the total building stock each year (Wigginton et al, 2002). Intelligent application of advanced 'smart' facade technology in conjunction with innovative environmental systems can result in significant energy savings and – at the same time – improvement of indoor comfort. 'It has been shown that, when designed carefully, innovative systems do not represent additional initial building costs. Running costs are lower and energy costs can be reduced by approximately 30% compared with conventional solutions' (Kragh, 2001).

1.2 Domestic building stock and energy use

In UK, domestic sector energy use has risen more rapidly than the overall energy use. In 1970 it represented 25% of total UK energy use. By 2001, this figure had increased to 30% (BRE, 2003). The size of this proportion, and the fact that it is growing, emphasises the importance of improving energy efficiency in the housing stock. Energy usage is increasing in the domestic sector due to the increase in the number of households and the expectation of a higher level of service from electrical appliances, heating systems etc. In common with commercial office buildings, space heating is the main energy consumer in the domestic building sector (Figure 1) and accounts for a large proportion of total national energy consumption.

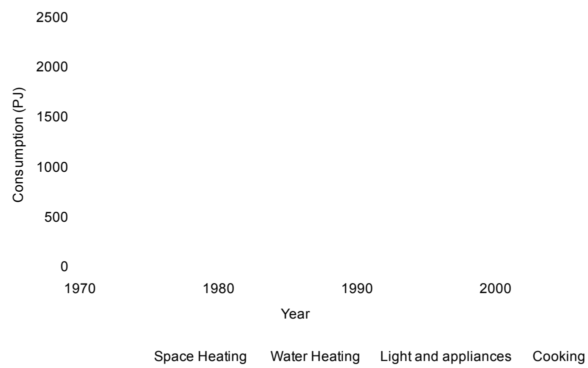

Figure 1: Domestic energy Consumption by end use (BRE Domestic Energy Fact File 2003)

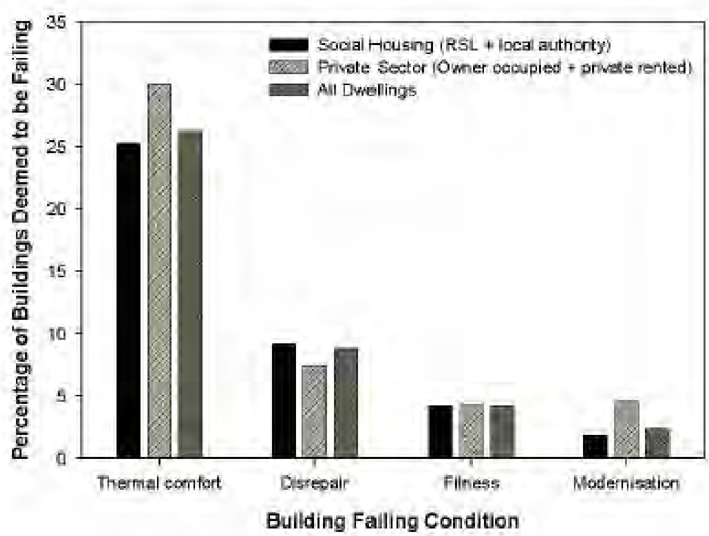

Figure 2: Percentage of UK dwellings failing to meet the expected standards in 2001. (EHCS, ODPM, 2001)

1.3 The Decent Home Standards

The housing stock in UK is old. Of the 21.1 million dwellings in 2001, 39% (8.1 million) were built before1945, and 21% (4.4 million) before 1919. Nationally, the social housing sector has a much younger profile with 19% built before 1945 and 48% built post 1964. According to the English House Condition Survey in 2001 there were 7 million non decent dwellings (33%) in the UK residential sector. There are four criteria given for a dwelling to be defined as ‘decent’: meets the statutory minimum standard, in a reasonable state of repair, has reasonable modern facilities and services, provides a reasonable degree of thermal comfort. Of the 7 million non decent homes, 5.6 million dwellings do not provide a reasonable degree of thermal comfort, 1.9 million fail through disrepair, 900 thousand are unfit and 500 thousand do not have modern facilities and services.

The most common reason for a dwelling being non decent is failure to provide a reasonable degree of thermal comfort which further illustrates the importance of thermal comfort to the building occupants (Figure 2). The government's current policy is by 2010, all social housing to achieve decent home standards but reviews done by the Energy Trust appear to conclude this is unattainable (Energy Review, 2003).

2. SOLAR ENERGY IN UK

The UK receives annually on average around half the amount of energy from the sun per square foot as countries on the equator. One of the reasons solar has not been seen as a viable option for the UK is that it has been seen as a very land hungry technology and having to cover the whole of the UK with solar cells in order to generate any significant power (EERU, Open University). The reality is different and the potential for using roof tops and walls for solar cells is very large and PV cells can be used as cladding material, thus reducing some building costs and offsetting the cost of the cells. The cost has always been a major constraint in using solar PV. Nevertheless, as with some other forms of alternative energy, costs are falling and the technology is becoming more efficient at a steady rate.

During the 1970's there was a boom in sales of roof mounted solar collectors in the UK. The flat plate solar heat collectors could typically cut domestic fuel bills by a half. But it soon became apparent that the overall economics were not that attractive; commercial systems had payback times of five to ten years or more, and unskilled workers undermined consumer confidence. The boom consequently faded, although many enthusiasts continued with DIY units. The 1980's saw something of a renewal of interest, following the oil price increase. 'Local councils responded with council houses being retrofitted with solar assisted heating and several new solar council house projects being initiated. By the end of the Greater London Council's reign in London, there were more than 200 solar houses in use and the new city of Milton Keynes had more than 300 solar housing projects' (EERU, Open University).

2.1 Solar PV Domestic installations

The size of a solar system required to provide electricity for a typical home varies, depending on a number of issues; the power you need, the type of cell used, roof space available and budget. It is measured in size according to the number of electrical units it would produce in an ideal environment. The smallest system size usually installed on a domestic property is 1 kilowatt peak (KWp). This means that in ideal conditions the system would produce 1000 watts at any given time when operating in optimum conditions. In the UK, a 1 kWp system is expected to produce at least 750 electrical units - kilowatt hours - annually. The average household in the UK uses approximately 3,300 kWh every year. Therefore a 2 kWp system will produce nearly half of the yearly requirements and avoid around 650 kilograms of carbon dioxide emissions (DTI Energy Saving Trust- Solar PV).

2.1.1 Cost and maintenance

Prices for PV systems vary, depending on the size of the system to be installed, type of PV cell used and the building on which the PV is mounted. For the average domestic system, costs can be around £4,000-£9,000 per kwp installed with most domestic systems usually between 1.5 and 2kwp (DTI Energy Saving Trust-solar PV). Solar tiles cost more than conventional panels and panels that are integrated into a roof are more expensive than those that sit on top. In a major roof repair carried it is worth exploring PV tiles as they can offset the cost of roof tiles. Systems connected to the national grid require very little maintenance, generally limited to ensuring that the panels are kept relatively clean and that shade from trees has not become a problem. The wiring and components of the system should however be checked occasionally by a qualified technician. For stand-alone systems, i.e. those not connected to the national grid, further maintenance is required on other system components, such as batteries.

3. DEVELOPING A VIABLE STRATEGY TO INCORPORATE SOLAR ENERGY TO THE HOUSING SECTOR

To achieve successful and sustainable commercialisation, solar building products must meet three important criteria, namely minimum cost, maximum performance, and demonstrable durability.

3.1 Durability Assessment

Accurate assessment of durability is of paramount importance to assuring the success of solar thermal and building products and directly addresses three important criteria (Kohl, 2003).

- Permits analysis of life cycle costs by providing estimates of service lifetime, operation and maintenance costs, and realistic warranties.
- Understanding how performance parameters are affected by environmental stresses (for example by failure analysis) allows improved products to be devised.
- Mitigation of known causes of degradation directly results in increased product longevity.

3.2 The cost implications

Solar technology has a long way to go before establishing itself competitively with conventional electricity and other renewables. Photovoltaic technology costs typically range from 60-70p/kWh and is viewed by the government as a long term project with anticipated price by 2020 of 10–16 p/kWh based on the current learning rate and market growth rate, with the possibility of becoming cost competitive with retail electricity in the UK around 2025 - current costs for onshore wind in good sites are in the region of from 2.5–3.0 p/kWh and around 8p/kWh for energy crop (British PV Association). The British Photovoltaic Association aims to increase the market penetration of PV to 15% by 2010, by installing a 300MWp capacity within the UK. If such a venture were to prove successful there would be potential for turnover of £1.2 billion and employment increase in the PV sector to around 19,000 by British companies.

A snapshot of case studies from Energy Saving Trust illustrate that the cost for installing a solar system is high and is not currently in the domain of the social housing sector unless substantial grants, subsidies and incentives are provided. With very limited maintenance and refurbishment budgets Housing Associations are finding it difficult to invest in solar energy systems.

Case Study	Overall Cost	Grant Value	Estimated kWh per year	Estimated £ saved per year[1]	Estimated kg CO_2 saved per year[2]
1	£13,230	£6,430	1620kWh	£97.20	696.6kg
2	£9,030	£4,515	1,080kWh	£64.80	464kg
3	£9,891	£4,945.50	1,080kWh	£64.80	464kg
4	£22,957.61	£12,209.81	3058.5 kWh	£183.51	1315kg
5	£7,896	£3,688	720kWh	£43.20	309.6kg
6	£8,339	£3,840	960kWh	£57.60	412.80
7	£9,030	£4,515	1,080kWh	£64.80	464kg
8	£11,387	£5,694	1620kWh	£97.20	696.6kg

Table 1: Energy saving trust Solar PV demonstration case studies
1 – Assumes 6p/kWh　　2 – Assumes 0.43kg/kWh

3.3 Performance Improvements and Cost Reductions

A number of areas have been identified for performance improvement of solar systems which would in turn reduce the cost. 'The key performance improvements were identified as involving being 'low' or 'matched' flow systems (2-4 g.s-1.m-2.). Absorber design was one area where collector costs could be reduced – with low flow designs providing opportunities for absorber cost reduction. Costs of low-flow fin-tube absorbers could be reduced by reducing the amount of material necessary for the tubes and fins. Low-flow systems also make the use of smaller diameter piping and even non-metallic flexible piping is a possibility, reducing both equipment and installation costs. Cost reductions arising from the use of these 'dream systems' were estimated to be in the order of 18 % to 39 %' (ESRU, University of Strathclyde).

3.4 Development of solar building envelope components

In a viable solar energy strategy relevant to the domestic sector, particular emphasis must be given to the assembly and integration of high performance, novel and complex solar components into functional building envelope elements. Those assemblies may incorporate highly insulating glazing/frames, anti-reflecting or chromogenic switchable glazings, photovoltaic windows, solar shading devices and other daylight components. Research and development should allow for product comparison, selection and in building simulation tools. This will also enable cost benefit studies to be performed and performance criteria to be defined for new products such as 'Semi-Transparent Photovoltaic Modules' represents the coming of a new era in photovoltaics for buildings. Due to the semi-transparency, it can be used in lieu of architectural glass for many applications and the photovoltaic module uses sunlight to generate clean electricity to power a building's electrical needs (Zahedi, 2005). Thin Film Solar Cells, Glass Modules for facades and glass roofs are multifunctional for the shell of the building. In addition to energy generation, they offer a large number of functions which fulfil the demands of a modern solar architecture.

3.5 Research Development and Marketing

Research has indicated that the following housing would have the greatest potential to benefit from solar systems (EST, Energy Savers Fife, 2003): households with four or more people; South East to South West roof orientation; adequate accommodations for solar water heating systems; electric water heating; and a pitched roof, although the feasibility study indicates that this is not an essential criterion. It is also important to review the market and to identify companies, who are innovative and committed to research and development to improve their solar products. These include:

- Examining and analysing various so that the customer has the flexibility to choose the most suitable.
- Investigating legal issues, barriers as well as planning issues in relation to solar systems,;
- Researching the state of housing locally to gauge the need for energy efficiency measures and the suitability of solar systems for housing
- Examining the potential positive impact on employment and identification of appropriate training
- Developing new products and services that go further than just providing energy alternatives

A strong after sales service is needed in order to help householders get the most from their system. Many are unsure of how the systems operate and need reassurance and advice on what to expect. Advice regarding the best pattern of consumption will also help to use the system efficiently. Lack of awareness of the benefits of solar water heating is apparent and a strong marketing campaign is required to overcome this.

3.6 The role of the government

'Britain is losing out to countries that have created a large home market, by introducing market stimulation measures and low manufacture costs' (British PV Association). Countries such as Germany, the Netherlands, Japan and the USA have created programmes in order to establish a market for PV technologies and offset the high costs, which has led to employment opportunities in the PV field, as well as associated professions. The lack of market demand in the UK is one of the major factors preventing the growth of PV and subsequent employment, in the UK on a larger scale. There is a need for more government investment and new policy, alongside commitment from industry to provide a driving force for a future domestic market, which would lead to, increased employment opportunities.

In 1999, the DTI provided funding for a field trial of 100 domestic PV installations and raised awareness of PV technologies, but much greater effort is needed for systems to be mass produced which will lead to significant savings. More widely available subsidies are needed for this technology to become market competitive, and this will include a favorable buy out rate for the electricity generated. Funding is on the increase for PV technologies and as awareness increases more people may become interested and willing to invest in the technology.

The Government's Solar Photovoltaics (PV) Major Demonstration Programme - which is administered by the Energy Saving Trust, provides funding of between 40 and 50% for the installation of solar electricity panels for both domestic and commercial applications. There is also a clearly defined grant supported programme for the new build and refurbishment of social housing stock. The aim of the programme has been to kick start the UK market for solar PV, by demonstrating the long-term potential of the technology.

4. CONCLUSIONS

The Government is committed to expanding its supporting programme for renewables including research, development, demonstration and dissemination. The main current hurdle preventing large-scale manufacture in the UK is the current market or lack of it. The understanding and potential of photovoltaic is improving but further research and development is required to capture cost reductions. It is important that strong partnerships are established between industry and government. Increasing environmental concerns and the need to achieve emission reduction targets should help the technology to become further established as a marketable and economically viable product.

There are four million homes maintained and managed by housing associations and local authorities responsible for improving their existing stock, and are increasingly encouraged to work sustainably (Sustainable Homes, 2003). It is seen that in the current status of refurbishment only minimum standards are met and the social housing sector has much to learn from all the new and innovative technologies that can be implemented in improving the environmental performance of the dwelling. Case studies on social housing maintenance and refurbishment (Sustainable Homes, 2003) demonstrate that the current know how in the social housing sector is not up to date and can benefit from new smart and intelligent technologies. The need to meet 'Decent Homes' provides an excellent opportunity to make sure improvements are carried out to reduce harmful environmental effects, in particular in the use of energy, water and materials.

The easiest way to improve environmental performance is through energy and water efficiency and since solar energy is a more environmentally friendly and sustainable methods of generating electricity, long term benefits and low environmental impacts should be considered in comparison to the initial high capital cost. The technology is reliable, relatively simple to install and easy to maintain. Considering the expertise that exists in the UK, the main reason for PV not to be so popular is, electric power generated from PV is too expensive to compete in Scotland and the UK due to the low prices of fossil-fuel, nuclear and even wind power. In depth analysis of costs suggest that most costs have reduced, in particular the installation and monitoring costs, which could be a result of the widening skills base and early identification of problems. Overall system component costs have fallen slightly but module cost has risen slightly. Research and analysis indicates that BIPV will approach cost effectiveness sometime after 2020 (British PV Association).

There are also other barriers in trying to implement sustainable processes in social housing. It is essential that the home occupiers and the stakeholder groups attitudes towards these technologies are considered as these would determine the success of the actual application of the technology. While the economic criteria; initial capital cost and lack of funding can be overcome by many alternatives there are more complex issues in knowledge, awareness, social and cultural criteria that will take longer. The new application methods should identify socio cultural barriers; likes and dislikes, misconception of environmental features, and come up with a guide which emphasizes on more effective communication between residents of environmental schemes and housing associations.

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