TECHNICAL COMPATIBILITY OF FUTURE LOW CARBON HOUSING

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1 NEW REQUIREMENTS TO FUTURE SCOTTISH BUILDING INDUSTRY

1.1 European legislation for economy growth

The Lisbon Agenda[1] was prepared to help raise the competitiveness of EU with USA and Japan. Economic growth is one of the key pillars in the document. The research and development in all European countries should be boosted to achieve the dynamic, knowledge based economy.

As stated in the recent European Parliament's communication document: "*innovation comes from people, and only people - scientists, researchers, entrepreneurs and their employees, investors, consumers and public authorities — will make Europe more innovative* "[2]. Lisbon Partnership for growth and job has put innovation and entrepreneurship at the centre of the economy growth and called for decisive and more coherent action by the participants. As new competitors are emerging and challenges are getting bigger, the European Union (EU) must not only sustain the recent positive trend, but further improve it. While the economic crisis risks reducing available resources, from previous recessions, prioritising investment in research and innovation is possible and can play a key role to enable a sustainable economic recovery.

The European Economic Recovery plan (2008)[3] has selected the priority areas to deepen the Lisbon Strategy, which include work with small and medium enterprises (SMEs), as they can be used as a source for innovation, invest into knowledge, as universities and research institutes should not be restricted from working together, promote low carbon and energy efficiency technologies, as energy and CO2 reduction are the key requirement for the world future.

The UK Government as part of the country development has set a target that all newly built homes must meet a zero carbon standard. Zero carbon target takes a three stage approach to reducing carbon emissions: reduce energy demand; reduce emissions associated with energy use during the occupancy; investing in carbon reduction solutions to be used in the household.

1.2 Scottish economy and future housing requirements

The current enterprise sector faces unique challenges in the need to develop new products to comply with future regulatory market drivers for low carbon housing. The Scottish Government's Sullivan Report[4] on future low carbon building standards and housing supply targets asks for a combined market demand for innovative products. The construction enterprise sector will require to make changes in technology, innovations and partnerships to meet low carbon economic drivers and comply with new forthcoming statutory regulations in 2010, 2013 and 2016.

The recommendations for future Scottish housing made in the Sullivan report are shown in Table 1. The first steps have already been taken towards the low carbon future housing, when the changes to Building (Scotland) Regulations were introduced in 2010.

Table 1. Expectations for Scottish domestic housing	
Change in energy standards for domestic buildings	2010 (low carbon buildings) 2013 (very low carbon buildings)
Backstop levels of U-values and airtightness for building fabric should be improved	2010
Sound insulation requirements in Building (Scotland) Standards to be enhanced	2010
Net zero carbon buildings (i.e. space and water heating, lighting and ventilation)	2016/2017
The ambition of total-life zero carbon buildings	by 2030

1.3 Changes in Building (Scotland) Standards

The Building (Scotland) Amendment Regulations 2010 came into force on October 1, 2010[5]. This has resulted in changes to mandatory standards and associated guidance.

The new **Section 6: Energy** now includes the requirement for airtightness testing of all new dwellings built from 2011. The methods of calculation of U-values for the different elements of the building were amended, and the updated figures for standard U-values were offered. These changes directly affect the way the houses are built, the building time and cost, and also may require providing the dwellings with additional mechanical ventilation in cases of very tight envelopes being built.

In **Section 5: Noise** the sound insulation values measured for internal (laboratory testing) and external (site testing) partitions were increased to achieve better insulation performance in the newly built residential dwellings. This amendment to the sound insulation values affects the sizes of the partitions, and overall footprint of the new house, building costs and time, etc. The list of partitions was provided by Building Standards division. The number of partitions which would now satisfy the amended regulations has reduced as less current constructions satisfy new requirements. New constructions were introduced to the list, most of them either have wider lateral dimensions or additional insulation measures like SoundBloc plasterboard or thicker quilt required to achieve new performance.

To promote the use of renewable, reusable and regeneration energy technologies for domestic dwellings, the new Section 7: Sustainability was submitted for consultations. The new section will incorporate the lifespan and whole life costing for the products used for built environment, use of the micro-renewable energy technologies, environmental impact on the country etc. When completed, this section will consist of the requirements similar to Code for Sustainable Homes in England and Wales, but incorporated into the legislation rather than being used as recommendations.

1.4 Current Issues in construction industry in Scotland

The most popular construction type in Scotland is timber frame; around 80% of all houses built in Scotland are made of timber. Timber frame buildings are expected to be the largest new housing sector in the future. Table 2 shows the demand of Scottish housing against the current supply, which is strongly affected by the severe economic downturn for the construction industry from the beginning of 2009. Together with the issue of shortage of houses expected to be built, the shortage of skilled builders will become a problem in the coming years. It is expected to have a skill shortage of up to 8% by 2016, with increase towards 16% by 2024.

Table 2. Housing sector demand	
Increase in households by 2031	400,000
Waiting lists & transfers (current)	202,000
Target for next 21 years (per year)	30,000 to 35,000
Annual house supply / production (2010)	25,000
Demolition / year (2010)	4,000
Shortage of housing supply expected (per year)	9,000 to 14,000

2 LOW CARBON BUILDING TECHNOLOGIES: THE WAY TO DEVELOPMENT IN SCOTLAND

Integration into future "whole house" systems needs technical coordination, support, assessment and creation of enterprise partnerships. If Scotland-based companies fail to develop the low carbon building products, then the 6bln GBP annual housing market will be sourcing these products from non-Scottish companies. Development of new innovative construction products is currently lacking the support from concept stage to market outreach. Small and medium enterprises (SMEs), which are expected to provide the innovative products, have shortage of the theoretical knowledge, test facilities, product development expertise and regulation compatibility. This sector requests continuous support which will help individual companies, and, more importantly, help enterprises to join into integrated product partnerships.

The project named Low Carbon Building Technologies Gateway (LCBTG) started on 1st of June 2010 to establish an innovation pathway for building technologies by enabling the development and integration of research and development, and allowing the final products to be taken into demonstration in Scotland based houses[6].

An overall support to small and medium enterprises will be provided by Product Innovation experts at Edinburgh Napier University. The main aim of LCBTG project is to help to provide solutions on technical compatibility for low carbon housing built based on new regulations. As 80% of the buildings in Scotland are built using timber frame, the main focus of the project is on the innovations to be used in timber frame constructions. The support will be given in two phases. First phase is to provide advice, assessments, feasibility studies and prototype testing to the concepts of new products. Second phase is to install new systems in the innovation park, where the full scale testing and regular monitoring of the product performance can be conducted. The additional support to the companies will be given in patent initiation, creation of animations for marketing literature and advice on further funding applications.

The project is set to support various innovations, from closed panels manufactured off-site to micro-renewable devices, from large roof or window systems to new connectors, fixings or straps which will allow reducing work on site or improving the performance of overall building by reducing the number of units used.

The experts' area of knowledge covers all major sectors of Building (Scotland) Regulations such as energy, structure and noise. The support will be given to a number of projects for development of technologies to be used in products, systems or services applicable to Low Carbon housing in Scotland and across UK and EU.

3 EXAMPLE OF SOLUTION FOR NEW ENERGY TARGETS

Energy is a bespoke driving requirement to achieve the reduction in carbon emissions, but it is not the only factor which should be taken into consideration. Current building products such as fire socks, wall ties, insulation blocks, etc were originally designed for one specific technical function (heat loss, structure or thermal insulation). However future products must be developed to meet the energy targets and also comply with other regulatory standards. They also should be developed to be robust, and less dependent on the on-site workmanship skills.

3.1 Non-compatibility issue between energy and noise

Building (Scotland) Regulations in Section 6 energy state as follows: "*Recent research has established that previously unanticipated heat loss can arise via air movement, within a cavity separating wall, from heated areas to points out with the insulation envelope. To limit heat loss, a separating wall cavity should have effective perimeter sealing around all exposed edges and in line with insulation layers in abutting elements which separate the dwelling from another building or from an unheated space. Further reduction in heat loss can be achieved where the cavity separating wall is also fully filled with a material that limits air movement.*
In addressing this issue, regard should be paid to the need to limit noise transmission (see section 5: Noise)."[5]

Initially the effect of heat loss was established for masonry cavity buildings and described in full details in Leeds Metropolitan University report[7]. Series of experiments conducted in the laboratory in Edinburgh Napier University confirmed that similar effect exists in timber frame systems[8].

The introduction of effective perimeter sealing and fully filling of the cavity may have an adverse effect on the sound performance of the partition, depending on the type of construction. The effect of each of the energy measures to the sound insulation of various types of constructions has to be investigated before any recommendations can be made to the industrial sector.

3.2 Fully filled cavity in sheathed timber frame cavity wall

To demonstrate possible effect of fully filled cavity to the sound insulation of the sheathed party wall with 50 mm cavity, the tests were conducted in the close to real site conditions. Sound insulation tests were conducted on a party wall between two rooms (volume: 43 m^3) constructed at the BPAC test facility (Hangar 17), Glenrothes, Fife.

The tested wall construction consisted of two leaves of 89 mm depth timber frame with insulation between studs across 50 mm cavity, sheathed on the cavity side with 10 mm OSB the wall panels, finished each side with two layers of 15 mm Soundbloc plasterboard. The cavity fill conditions were varied during the test series. In the first test series the cavity was empty. In the second test series, the cavity was fully filled. The results are shown in Table 3. In both instances the results were compared with new Building (Scotland) regulations.

Table 3. Effect of fully filling of cavity on sheathed timber frame cavity wall

Cavity filling condition	Required performance (Building (Scotland) Regulations), $D_{nT,w}$, dB	Measured performance, $D_{nT,w}$, dB
Empty cavity	56	68
Fully filled cavity	56	67

It was demonstrated by the experiment that for this type of construction fully filling of the cavity has no detrimental impact on the acoustic insulation for airborne sound transmission, when compared to the empty cavity.

3.3 Fully filled cavity in sheathed timber frame cavity wall with perimeter isolators

Additional tests were conducted to investigate the effect of perimeter sealing of the cavity wall to its sound performance. The investigation of possible materials which can be used for perimeter sealing was conducted separately (see, i.e. Internoise' article[8]). The bitumen-based Icopal isolation membranes were chosen for these tests.

The tested wall construction consisted of two leaves of 89 mm depth timber frame with insulation between studs across 50 mm cavity, sheathed on the cavity side with 10 mm OSB the wall panels, finished each side with two layers of 15 mm Soundbloc plasterboard. The perimeter of the party wall was isolated with Icopal membranes. In the first test the cavity was empty. In the second test the cavity was fully filled. The results are shown in Table 4, where compared with new Building (Scotland) Regulations.

Table 4. Effect of fully filling of cavity on sheathed timber frame cavity wall

Cavity filling condition	Required performance (Building (Scotland) Regulations), $D_{nT,w}$, dB	Measured performance, $D_{nT,w}$, dB
Empty cavity with perimeter isolator	56	68
Fully filled cavity with perimeter isolator	56	67

The wall as tested clearly passed the new Building (Scotland) regulations with and without perimeter isolation. It was also demonstrated by this test series that for this type of construction fully filling and perimeter isolation of the cavity has no detrimental impact on the acoustic insulation for airborne sound transmission.

The above results can only be used for the described type of construction. The other types of timber frame constructions should be investigated separately.

4 FUTURE WORK

Low Carbon Building Technologies Gateway will run for three years (2010-2013) and will provide continuous innovation support to construction product SMEs and enterprise partnership development from "proof of concept" using product innovation expert group to "market outreach" arranging the strong links between product manufacturers, architects and builders.. By the end of the project the new changes to Building (Scotland) Regulations are expected to be introduced to set up a new target of very low carbon buildings.

The products developed and supported under this project will contribute to the growth of Scottish Economy.

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