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Insulated Panels and the Sustainable Construction Agenda

A Kingspan White Paper

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Executive Summary

- The UK construction industry is now facing a substantial challenge. Changes in the built environment necessitate a level of innovation, the like of which has not been seen during the last 100 years!
- The sheer size of the industry and the associated environmental pressures arising from large material flows, plus the significant climate change impacts triggered by the way we construct and use buildings, has led to calls for adoption of sustainable construction techniques.
- Some in the industry have picked up the challenge, but there is a long way to go before best practice is adopted more widely. There is a measure of confusion around the meaning of sustainable construction and, as a consequence, accusations of 'green-wash' has at times emerged.

- There is a need to cut through the confusion associated with the sustainability agenda and the way this is applied within the industry. In a survey commissioned by Kingspan Insulated Panels (Kingspan) involving 131 construction Clients, Architects & Main Contractors: -

  - 56% believed that sustainable construction means using environmentally friendly products or materials from sustainable sources

  - The overwhelming majority of respondents do not allow sustainability issues to principally drive their building designs

  - Only 26% of respondents confirmed that these issues affected their brief to a large extent

  - Only 19% of respondents mentioned the importance of energy efficiency in buildings
- Having appraised the levels of engagement in the sustainable construction agenda, Kingspan will repeat this process periodically, complete an appraisal of its product range across the life cycle and further develop a dialogue with opinion formers. Kingspan's aim is to cut through the confusion by informing a wider debate surrounding sustainable resource use within the construction industry.
- It is hoped that the Construction Industry will respond by taking more account of key principles such as 'Sustainability', 'Sustainable Development' and what this means for 'Sustainable Construction'
- Sustainability is the 'capacity for continuance into the long-term future'. We define it in terms of the economic concept of wealth creation or 'capital'. Any organisation will utilise a combination of 5 capitals - natural, human, social, manufacturing & financial - to deliver its products and services.
- Sustainable Development is development that meets the needs of the present without compromising the ability of future generations to meet their own needs. While there is much agreement that sustainability (the end to which we aspire) is a prime goal for society to aim for, there is controversy about how to deliver sustainable development. The construction industry will be a key contributor to sustainable development whatever the definition, and Kingspan seeks to take an important lead over the coming years.
- Within this agenda there is an important conversation to be had about the sustainability of materials versus the management of consumption. Within the construction industry (as elsewhere) there has been a focus on the choice of material type, often at the expense of a more basic scrutiny of the consumption-related sustainability impacts. In a sustainable society we will need to address consumption and use patterns as well as material choice in order to make progress
- Today's materials-related problems are, to a large extent, the result of assumptions made during the Industrial Revolution that the supportive capacities and resources of the earth were limitless, and that economic growth depended upon stimulating consumption among a relatively low human population.

- Both assumptions are precisely reversed today, yet our economic and governance systems remain rooted in a predominantly linear (make-use-dispose), rather than the required cyclical (make-use-repair-recover for re-use) flow.
- Sustainable Construction is new building and refurbishment that promotes environmental, social and economic gains now and for the future. It comprises sustainable design, a sustainable construction process, a sustainable use phase and the management of the building at the end of life in a way which maximises the social and economic benefit of each unit of material resource used.
- As an example, industrial & commercial builds can show sustainability benefits from using offsite-engineered units (comprising two metal faces & a fully insulated core) as against on-site built up systems. There are advantages in terms of health & safety risk, life-time energy performance, quality, end-of-life management as well as on-site waste prevention.
- Sustainable construction requires a whole-life approach to obtain a true assessment of the impact of a particular building system. For insulated panel systems, there are questions about the choice of core materials and the panel skins. These are explored as they relate to the design, construction, commissioning, and the use-phase and at the end-of-life.
- Irrespective of which materials are chosen or what building systems are adopted, there is a need for a consistency of approach that supports the implementation of sustainable construction agenda – based on whole-life management principles.
- Kingspan intends to address its own sustainability challenges and also to inform the wider debate surrounding sustainable resource use within the construction industry
- This ‘White Paper’ prepared in conjunction with Caleb Management Services Ltd, a reading sustainability consultancy, is one of the first steps along this path and primarily focuses on: -

  - Raising awareness within the construction industry of the real sustainable development agenda

  - Providing an initial assessment of how current construction techniques fit this agenda

  - Reviewing the potential role of insulated panels and the issues that need to be managed by Kingspan and others

Introduction

For reasons that are set out in this document, the UK construction industry should consider its future well being with some trepidation. It is unlikely that the top 50 companies of the present day will be those of 2025. The degree of change in the built environment required by that time will inevitably force innovation on a scale not seen in the industry for the last 100 years.

In this White Paper, Kingspan Insulated Panels (Kingspan) and Caleb Management Services Limited (Caleb) jointly consider the source that is driving this change-process: - the UK sustainable construction agenda. We then summarise the approach that Kingspan is taking to address this agenda.

Kingspan is one of the foremost providers of thermal insulation products and services to the construction industry in the UK and elsewhere and intends to be among the leaders tackling the sustainable construction challenges that are now upon us. Caleb is a management consultancy with wide ranging experience in sustainable construction matters.

In Part 1 of this document, we set out the meaning of sustainability, sustainable development and how these concepts apply to the construction industry. In Part 2, we outline the issues to be considered when designing industrial and commercial buildings with insulated panels and their alternatives, before drawing overall conclusions about choices to be faced by the construction industry.

First, we briefly outline the context within which the sustainable construction agenda has emerged:

- The UK construction industry accounts for a turnover of over £30 billion annually, representing 8% of GDP and employs over 1.5 million people. The industry is also responsible for a significant material flow, generating 70 million tons of waste per annum, of which a shocking 13 million tons is material delivered to construction sites, but never used. 90% of national non-energy mineral extraction is supplied as materials into the industry.
- The level of environmental impact associated with this magnitude of material flow and waste has been an issue of increasing concern for a Government conscious of a need to act on a variety of environmental issues at both national and global level. The UK government is not alone in its quest to reduce the environmental impact in the building and construction sectors and other Governments around the world are following a similar path.
- Another key driver is a recognition that buildings (both new and existing) play a key role in curbing the future emissions of CO_2, since they currently account for about 40% of emissions in most developed societies More importantly, they offer major opportunities for savings. This has led to the introduction at European level of initiatives like the Energy Performance in Buildings Directive (EPBD) which will drive energy labelling, regular upgrading of Building Regulations and the promotion of renovation in the existing building stock when the Directive is implemented across the EU in 2006.
- Partly as a consequence of the growing policy interest, there has been much product-related, environmental hype about the comparative performance of materials. Those involved in the sustainable resource use debate, realise that the way materials are used is often much more important than the type of material selected. For all materials, the next sustainability revolution will lie in the pattern of use, not automatically in the choice of materials that may then still be used in unsustainable ways.

> 'The Royal Academy of Engineering, in a comparison between a building's construction costs and operational costs found a ratio of 5:200 for these stages'
>
> *Source: CPA response to Sustainable Buildings Task Group Report, May 2004*

Kingspan is engaging in this agenda both to understand where its current product portfolio lies and to help steer the debate towards a genuine treatment of sustainability concepts. In doing so, Kingspan is seeking to align its future product portfolio to meet the opportunities arising from the changes taking place in construction industry thinking (both in design and implementation)

Kingspan has elected to take a 10 year view on aligning the organisation to sustainable development principles.The company commissioned a survey[1] to establish the level of engagement of the industry with the issues of sustainability and the sustainable construction agenda. Believing that the agenda spreads far beyond the narrow issues of product specification, Kingspan has been surprised to learn, that:

- 56% believe that 'sustainable construction' means using environmentally friendly products or materials from sustainable sources
- The overwhelming majority of respondents do not allow sustainability issues to principally drive their building designs
- Only 26% of respondents confirmed that these issues affected their brief to a large extent
- Only 19% of respondents mentioned the importance of energy efficiency in buildings

In the short term, and in addition to the appraisal of the construction sector's level of engagement in the sustainable construction agenda, the company will also complete an appraisal of its product range across the life cycle and further develop a dialogue with opinion formers. The aim is to inform the wider debate surrounding sustainable resource use within the construction industry.

This 'White Paper' is one of the first steps along this path and primarily focuses on:

– Raising awareness within the construction industry of the *real* sustainable development agenda

– Providing an initial assessment of how current construction techniques fit the agenda

– Reviewing the potential role of insulated panels and the issues that need to be managed by Kingspan and others

- **Part 1**
  Focuses on what we mean by 'Sustainability' and other related concepts as these apply to the construction, use and end-of-life management of buildings. This raises issues about sustainable resource use and common dilemmas around material selection.

  Part 2
  Focuses on industrial and commercial buildings and contains a brief review of current building techniques and their relative sustainability impacts. We then look at issues to consider when designing with Insulated Panels, before concluding with a summary about why these choices are important for industry.

[1] Lychgate Report: Sustainability Awareness and current practice; March 2004

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Part 1 : What we mean by: -

In this Section we set out our understanding of key principles and concepts commonly used when describing the need for us to live (and build) within a sustainable world

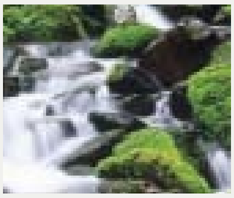
1.1 Sustainability

Sustainability can best be defined as the ‘capacity for continuance into the long-term future’. Anything that can go on being done on an indefinite basis is sustainable. Anything that cannot is unsustainable. Beyond that, perhaps the most helpful way of understanding sustainability is in terms of the economic concept of wealth creation or ‘capital’. Any organisation will utilise five types of capital to deliver its products and services. A sustainable organisation will maintain and, where possible, enhance stocks of capital assets, rather than deplete or degrade them.

These five capitals apply to every stage of the product or service lifecycle, including through the supply chain, during production or service creation, when products and services are delivered, used, and at the end of their life. A product or service will be based on an combination of all the capitals – built with human skills and knowledge, natural materials[2] and social structures, using machinery and infrastructure and financial investment

The five capitals are as follows[3]:

[2] Or man-made materials that can be readily absorbed, neutralised or re-used by the Earth’s ecological systems
[3] Adapted from: ‘The Sigma Guidelines: Putting Sustainable Development into Practice – A Guide for Organisations’ BSI, 2003

Type of capital	Description
Natural 	*What it means:* The natural resources (energy & matter) and processes needed by organisations to produce their products/deliver their services. This includes the extraction of *resources*, some of which are renewable (timber, grain, fish, water), whilst others are not[4] (minerals, fossil fuels); sinks that absorb, neutralise or recycle waste and processes, such as climate regulation and the carbon cycle, which enable life to continue in a balanced and healthy way *Why it is important:* All organisations rely on natural capital to some degree and have an environmental impact. All organisations, for example, consume energy & create waste
Human 	*What it means:* 'Human capital' incorporates the health, knowledge, skills, intellectual outputs, motivation and capacity for relationships of the individual. In an organisational context it includes the elements needed for people to engage in productive work and the creation of wealth, thereby giving a better quality of life. Human capital is also about dignity, joy, passion, empathy and spirituality *Why it is important:* Organisations depend on individuals to function – for instance, they need a healthy, motivated and skilled workforce. Intellectual capital and knowledge management are increasingly recognised as key intangible assets that an organisation can use to create wealth. Damaging human capital by abuses of human or labour rights or compromising health & safety has direct as well as reputational costs. Poverty prevents many people from achieving their full potential
Social 	*What it means:* 'Social capital' is any value added to the activities and economic outputs of an organisation by human relationships, partnerships and co-operation. Social capital includes, for example, networks, communication channels, families, communities, businesses, trade unions, schools and voluntary organisations as well as cultural and social norms, values and trust. Social capital *flows* from Human capital because it is the result of many individual actions and values that are combined to a positive end within communities and societies. *Why it is important:* Organisations rely on social relationships and interactions to help them achieve their objectives. *Internal* social capital takes the form of shared values, trust, communications and shared cultural norms that help people to work cohesively and so enable organisations to operate effectively. *Externally*, social structures help create a climate of consent and understanding, or a license to operate, in which trade and wider functions of society are possible
Manufacturing 	*What it means:* 'Manufacturing capital' refers to material goods and infrastructure owned, leased or controlled by an organisation that contributes to production or service provision, but do not become embodied in its output. (Tools, technology, machines, buildings and all forms of infrastructure) *Why it is important:* Manufactured capital is important for the sustainability of an organisation in two ways. *Firstly*, the efficient use of manufacturing capital enables an organisation to be flexible, responsive to market or societal needs, innovation and faster in getting its product and services to market. *Secondly*, manufacturing capital and technology can reduce resource use and focus more on human creativity, thus enhancing both efficiency and sustainability
Financial 	*What it means:* 'Financial capital' reflects the productive power and value of the other four types of capital and covers those assets of an organisation that exist in a form of currency that can be borrowed or traded, including (but not limited to) shares, bonds and bank notes. *Why it is important:* Financial capital is the traditional primary measure of business performance and success (the 'single bottom line') in terms of reporting performance to shareholders, investors, regulators and government. Sustainable organisations need a clear understanding of how financial value is created, in particular the dependence on other forms of capital. For measures of financial capital to truly reflect the value of other forms of capital, organisations must understand how to ascribe financial importance to them

[4] Strictly speaking, fossil Fuels are also renewable resources, but the renewal cycle runs over many thousands of years, thus to all intents and purposes making them a 'once only' resource for humans

1.2 Sustainable Development

Sustainable development has become one of the catch phrases of the past decade. Most people seem to think that it is a good idea; it is becoming enshrined in government and private sector policies internationally. However, there are at least 250 published definitions. Most are a refinement of the sentiment expressed in the original definition offered by the World Commission on Environment and Development in 1987, which is still generally accepted as addressing the core of the concept:

> Development that meets the needs of the present without compromising the ability of future generations to meet their own

Nonetheless, the variety of definitions shows that the concept is still contestable. For instance, some would argue that the definition is centred too greatly around human requirements rather than the requirements of the natural world. While sustainability (the end to which we aspire) does not require such a distinction, the definition we apply to sustainable development (the means) heavily influences the priorities we set as a society. Kingspan, like leading companies in other sectors, feel strongly that we can't afford to wait for such debates to reach their conclusion and that decisions being made in the construction sector have such relatively long-term impacts that they must be made now. This does not mean that the debate is unimportant, but does underline the fact that the construction sector will be a key contributor to sustainable development whatever the definition. This is why Kingspan seeks to take an important lead at this time.

Both the 1992 Rio Earth Summit and the more recent 2002 Johannesburg Summit (WSSD) emphasised that all parts of society have a role to play in meeting Sustainable Development challenges. It is also well understood today that business organisations, on account of their entrepreneurial roles, wealth generation roles and ability to generate/apply technological solutions are particularly well placed for tackling many (though not all) of the issues that need addressing urgently[5].

For organisations, there are some generic examples from the five capitals model[6] of what they can do to address sustainability challenges and opportunities.

Type of capital	Examples of generic goals
Natural	• Ensure that all mined materials are used efficiently within cyclic systems[7]. • Reduce energy dependence • Systematically reduce dependence on fossil fuels and use renewable resources instead • Eliminate the accumulation of human-made substances and products in nature – substitute all persistent and bio-accumulative compounds with substances that can be easily assimilated by natural systems • Eliminate waste. Re-use, recycle or re-manufacture where possible
Human	• Create an enabling environment for learning, innovation and sharing of knowledge • Create opportunities for varied and satisfying work • Implement diversity policies that enable an organisation to access the variety of human talent and eliminate discrimination
Social	• Support the development of the community in which the organisation operates • Provide safe, supportive living and working conditions, including family-friendly policies • Minimise the negative social impacts of products and services and maximise the positive
Manufacturing	• Develop flexible or customised production techniques that reduce resource use • Work towards zero-waste and zero-emissions production systems • Form partnerships within the supply chain and customer base to make more efficient use of resources and develop or improve products and services
Financial	• Organisations' financial measures should reflect the value of the other four capitals • Value intangible assets (brand, reputation) to better understand their contribution to shareholder value • Internalise environmental costs & benefits and assign a economic value to them

[5] See 'Professional Partnerships for Sustainable Development: A foundation course in sustainable development for professionals' – Institution of Environmental Sciences; 2001
[6] This model is consistent with other methods of framing Sustainable Development challenges – such as Triple Bottom Line, Natural Step etc.
[7] For a definition of this, go to 1.3, Page 11

1.3 A materials dilemma

Several influential commentators (of which Caleb is one) have noted that there has been increasing focus on the choice of material type, often for short-term reasons, and often at the expense of a more basic scrutiny of the consumption-related sustainability impacts. Indeed, sometimes the choice of material can adversely affect overall consumption even when the choices are seen as more environmentally benign in the short-term than other options.

It's less what you use and more how (and why) you use it.....

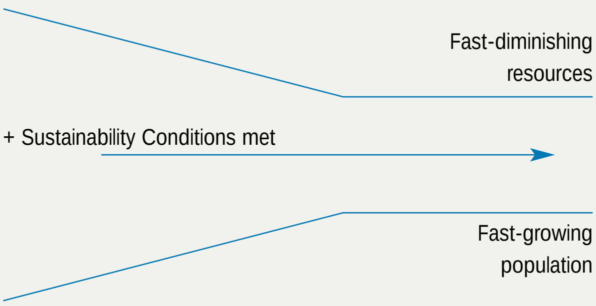
Accordingly, in a sustainable society, we need to address consumption and use patterns as well as material choice in order to make progress. This is particularly relevant if we consider for a moment that the typical person in the western world consumes up to 50 times more resources than the average person in the developing world.

'The carrying capacity of global resources is thought to equate to about 2 billion people with current Western Lifestyles. Hence, with a 6 billion + population and a developing world aspiration to attain this lifestyle, we are on an inevitable course of dramatic depletion of resources'

Source: The Natural Step: Stepping Stones; July 2002

Unless alternatives to current resource flow patterns are devised, environmental pressures will result in irreparable damage to environmental systems and their capacities to support people in living healthy and fulfilled lives.

The 'Funnel' illustrates the 'squeeze' arising from diminishing resources and increasing population



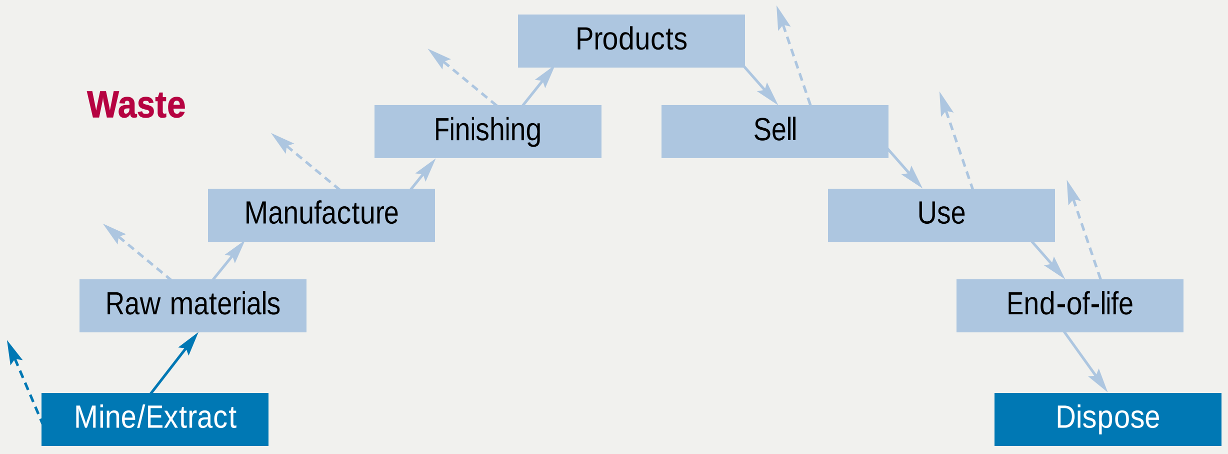
One of the features of the Sustainable Development 'journey' is then a need for us to become much more intelligent about the way we use [natural] material resources and make the most appropriate material choices. With manufacturing capital, for instance, the way we utilise material resources is often the root cause of their sustainability impacts, largely dissociated from the type of material we are using.

Persistent materials can, in some applications, make a deliberate contribution towards sustainability through their durability and potential for recovery and reuse or recycling. 'Green' materials can fail to make such a contribution, particularly if they are less durable, have less potential for recovery or are used in the same old way we used materials they replaced. (A 'green' piece of timber, for instance, when tossed into a landfill site as part of a mixed waste stream, stops being quite so 'green'). It is, thus, often over-simplistic to say that a material is 'bad' without questioning our culpability in the way we use it and treat it at the end of its life.

1.3 A materials dilemma continued

Persistence and Durability – two sides of the same coin?

Today's material-related problems are, to a large extent, the result of assumptions made during the Industrial Revolution that the supportive capacities and resources of the earth were limitless, and that economic growth depended upon stimulating consumption among a relatively low human population. Both assumptions are reversed today, yet our economic and governance systems remain rooted in predominately linear model of resource use, i.e. make, use and dispose.

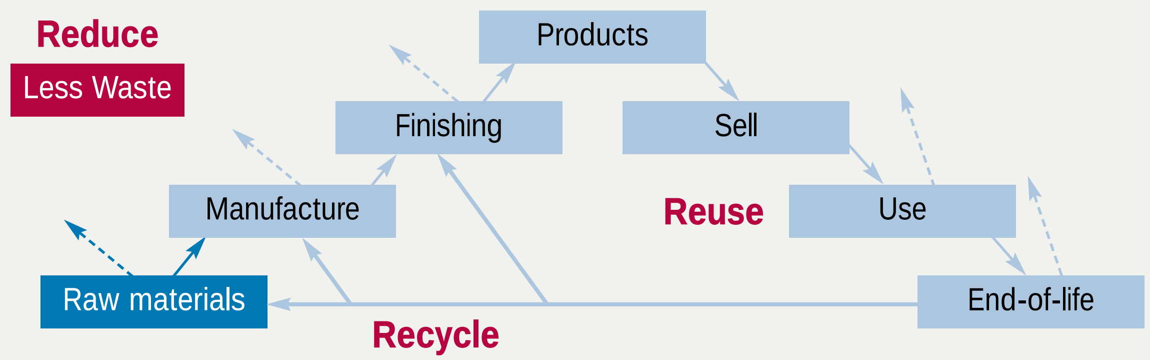


Linear resource flow[8]

Such linear use patterns differ from nature's cyclic and sustainable resource flows, within which 'wastes' are reused as the resources for subsequent processes. Accumulation of pollutants, destruction of ecosystems, wastage, and reinforcement of the inequitable distribution of resources and impacts are consequences of continuing linear patterns of resource use.

Converging the concepts of 'wastes' and 'resources' is of major importance in achieving sustainable resource use patterns. Throwing away scarce, relatively pure, resources at the end of a product's life does not make economic, let alone environmental, sense.

A transition from a linear to a cyclical economy, will be the outcome of a more resource starved future, or where the costs of dealing with the consequences of linear resource flows (waste, bio-diversity loss, etc.) become prohibitive. Strategically, it increasingly makes sense for organisations to show leadership and prepare their products and markets for that future.



Towards a Cyclic Use of Material Resources[9]

Rather than signalling the demise of the mining industry, this diagram shows that sustainability pressures will increasingly manifest themselves as economic and public pressures to mine less intrusively, to use mined resources more prudently and efficiently, and to reuse resources already in use by society in such a way as to get the maximum social benefit per unit resource used. Tomorrow's economic opportunities will lie more in cyclic than linear resource use patterns.

[8 & 9] Source: 2020 Vision Series No. 4: Towards the Sustainable Use of Material Resources; TNS-UK; June 2002

1.4 Sustainable Construction

Sustainable Construction is[10]:

'New building and refurbishment that promotes environmental, social and economic gains now and for the future'

Sustainable construction can be characterised as having 'Design', 'Process' and 'Product[11]' components and we will here look at each of these in turn.

Sustainable Design

Most new buildings have a design life of many decades. Decisions taken now will impact on communities, occupiers and the environment for many years to come. Proper consideration needs to be given to the durability, form and adaptability of new structures (and also of retrofits/refurbishments).

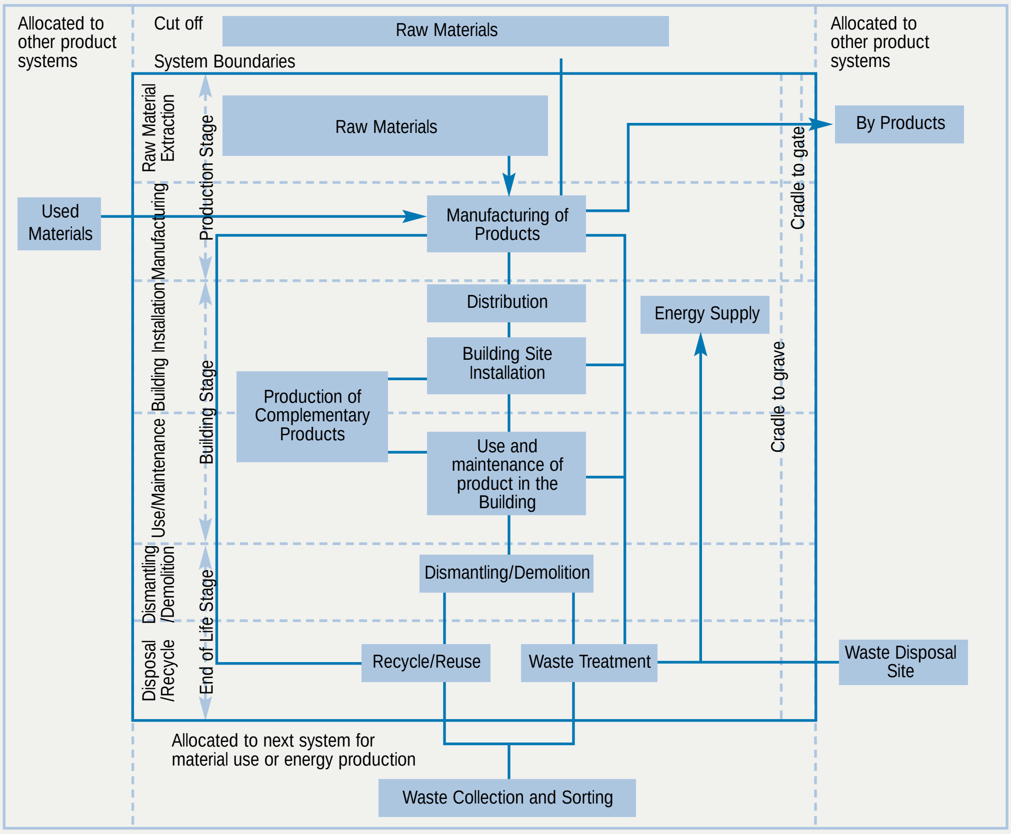
In order to assist the implementation of key sustainable construction measures a *Whole Life Costing* approach should be taken. This can be defined as:

The systematic consideration of all relevant costs and revenues associated with the acquisition and ownership of an asset

Essentially whole life costing (WLC) is a means of comparing options and their associated costs and income streams over a period of time. Costs to be taken into account include initial capital or procurement costs, opportunity costs and future costs (including the external costs referred to earlier in the five capitals model description in 1.1).

Design processes should maximise Community Involvement - Communities should be informed about, and involved in, the planning and design of buildings in their area which should be safe, secure and, in the case of public buildings, accessible to all.

Design should allow the implementation of favourable construction techniques – The latest environmental techniques should be specified – to save energy, water, material and waste during the development's construction, operation and decommissioning phases. Construction and Demolition waste has been identified as a priority waste stream by the European Union and is likely to be targeted for additional waste management legislation in the future. Additionally, under the Integrated Product Policy (IPP) banner, a range of measures are emerging to oblige producers to take responsibility for the fate of their products across the life-cycle.



Linear resource flow[8]

Life Cycle Assessment promoted within IPP Environmental Product Declaration proposals

[10] Future Foundations: Building a better South West; 2002

[11] i.e. the building itself

By promoting the use of high quality materials that are compatible with the local built environment, developers can add value to homes and commercial developments. A high quality design can also significantly reduce the level of crime and the fear of crime as well as the other sustainability impacts.

Future designs should meet community safety and anticipate climate change and should enhance local character. They should also prioritise the use of local and natural/recycled materials (or if not, materials that clearly have 'compensating' characteristics – e.g. – fitness for purpose, re-usability, recyclability).

Construction Process

The UK strategy for more sustainable construction[12],'Building a better quality of Life' (2000), suggests that there are some key challenges including the minimisation of waste, energy use and water use in the *construction process*, the avoidance of pollution, the preservation/enhancement of biodiversity and generally the management of environmental impacts and relationships with neighbours. Key issues to consider at any given site are[13]:

Where it is at: Sustainable Construction starts well before the first stone is laid. The ability to understand a site, and its surroundings is a key challenge. This includes thinking about how a site has been used in the past and could be used in the future.

The Sense of Place: The relationship of the site with special landscapes. Bio-diversity and cultural heritage needs to be considered.

Movement & Connection: How people get to and from a new development strongly influence its sustainability.

Sharing information: For sustainable construction to become a reality, stakeholders need to understand how it will contribute to environmental, social and economic goals.

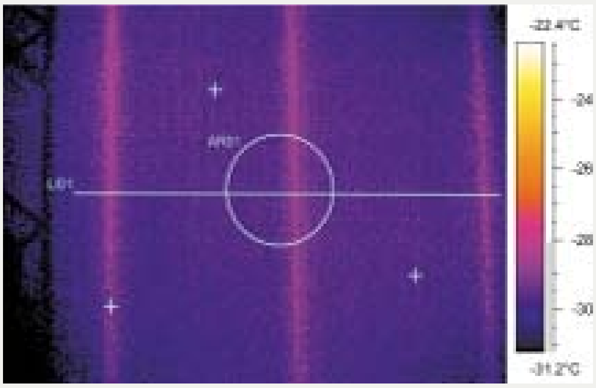
Community Engagement: Sustainable developments will involve people and communities in their planning, design and construction. Developers as project promoters are expected to start by considering what local communities' needs are, who will be affected by the project and how they can best be involved in decision making.

Using local labour in construction: Construction projects depend on the availability of a skilled workforce and employment of local people in these projects plays an important part in protecting and strengthening the local economy.

Use of local materials: Using local materials in construction can contribute to the relative sustainability of a project and can lead to local identity and distinctiveness.

Recyclability/Renewability of Building Materials: Architects consider the suitability of materials in terms of strength, aesthetics, durability and adaptability. Increasingly they will also have to consider the impacts on the environment, the economy and the community and how materials fulfil the requirements of cyclical resource use.

Energy efficiency in construction & Operation: A major contributor to CO_2 emissions is the use of non-renewable energy during the production of construction materials, energy used to put the building up, energy consumed in the building over its life-time and its decommissioning.



Thermographic Image of Insulated Wall Panel

Other factors: There are a number of other factors to consider in the design & construction processes – including Employee Health & safety, Pollution from transport and from construction materials, water consumption, light pollution, noise pollution during construction, noise insulation for use-phase, waste management, community safety and more

Construction Product

The 'Product' that emerges from the construction process is the Building as an asset that has been completed in a more or less sustainable way. However, the overall sustainability profile of this asset depends on 1) the way it is built and, at end of life, decommissioned/demolished (see below) and 2) the way it will be used during its useful life (see next sub-section 1.5 'Sustainable Buildings')

The Way it is Built: In buildings developed along sustainability principles, there is the opportunity to maximise natural lighting and ventilation, thus immediately improving energy performance and comfort when compared to many traditionally built assets. Another option is to 'downsize' the mechanical & electrical services, when benefiting from the better thermal performance of the building envelope. Again, this results in better energy utilisation and thus saves running costs

[12] From DTI Sustainable Construction Brief: 2003
[13] Adapted from Future Foundations: Building a better South West, 2002

1.4 Sustainable Construction continued

New and refurbished *sustainable* buildings are therefore likely to have the following characteristics: - Well insulated; air tight structures; efficient, responsive heating and controls; Appropriate glazing and shading; controlled ventilation; energy efficient lighting and appliances; passive or energy efficient cooling; efficient water heating; user involvement during design, remaining committed and knowledgeable during use; passive solar design, with renewable energy incorporated as all the above are optimised. Such buildings need to achieve maximum energy efficiency; maximum user health, satisfaction and productivity at minimum whole life cost.

The Sustainable Buildings Task Group[14] has identified the improvement of Building Regulations, Planning, and Refurbishment of existing Building Stock and provision of information, construction product labelling and fiscal incentives as major areas of activity to achieve sustainable buildings. The Group also recommends the adoption of a Code for Sustainable Buildings (CSB) to 'provide a single, coherent and consistent framework for industry, clients and the public sector to construct buildings with the higher levels of environmental performance than those stipulated by regulation'[15]. The CSB should be based on BREEAM, but also incorporate new targets for resource efficiency (energy, water, waste material use).

The Sustainable and Secure Buildings Act is designed to bring sustainability within the Building Regulations; energy and water use in new and refurbished buildings should be improved significantly as will resource efficiency and waste management. The thinking behind this Act is that the Building Regulations, if properly enforced and improved to include sustainability goals (statutory minimum level of resource efficiency in buildings), would go a long way towards achieving sustainable buildings.

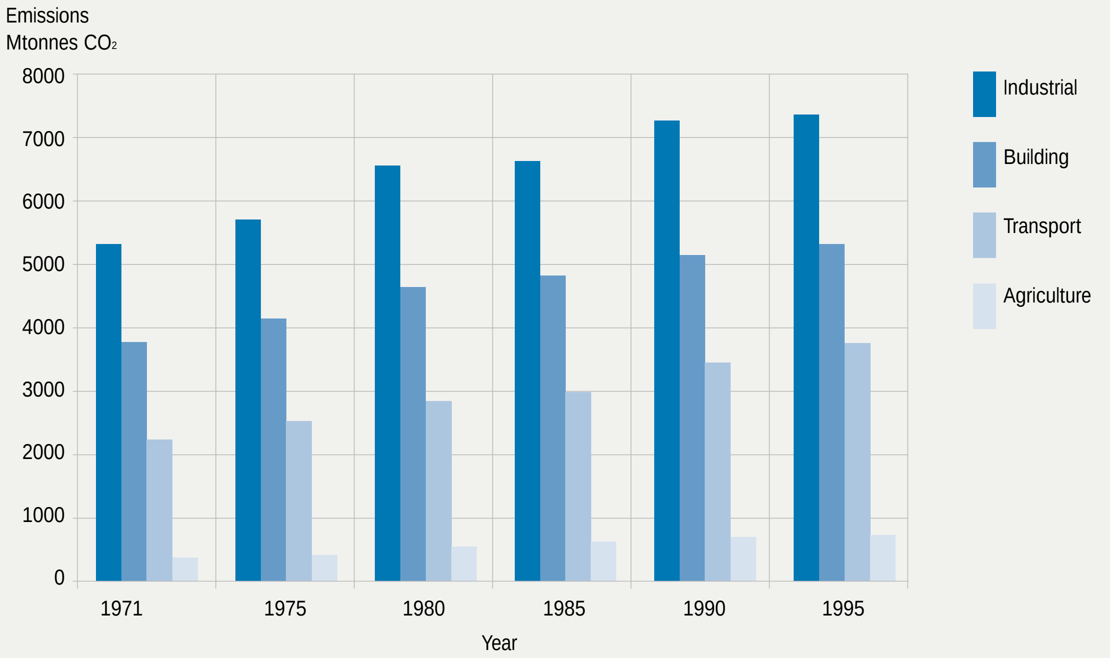
An important part of sustainable construction is the consideration of buildings as 'systems' that have an environmental (also economic and social) impact throughout their life. We need to evaluate the material choices that are made when creating buildings. On the whole, it is desirable to use secondary materials, design for re-usability or recycling and therefore seek to close the material flow 'loop' at the points of decommissioning and demolition.

Materials are typically still used as part of a *linear* resource flow, creating an enormous amount of waste. However, as said already, the in-use characteristics of any given material within the building system will be the key differentiator.

[14] Set up in 2003. Tasked with advising the Government on practical and cost effective measures to improve the sustainability of buildings

[15] Better Buildings – Better Lives: Sustainable Buildings Task Group Report; 2004

Growth in Global Sectoral Carbon Dioxide Emissions (1971-1995)



1.5 Sustainable Buildings

A building may well have been built along sustainable lines and be subject to eventual proper end of life management. True sustainability performance however also requires that it be *used* sustainably. This is particularly relevant if we consider that buildings are responsible for up to 40% of energy used in OECD countries[16] (Organisation for Economic Cooperation and Development).

As part of the commissioning stage and beyond, there needs to be a commitment from the designers and/or builders to ensure/confirm that occupiers fully understand how to operate and optimise the building, services and, occasionally, the grounds. Depending on circumstances, new or unfamiliar technologies may well have been installed – like solar screens, 'weather-vane' ventilators, grey-water harvesting systems, reed-bed water purification, and so on.

There may even be a more overtly symbiotic link between the building, services and the surrounding grounds, in terms of layout for shading or noise control, for instance. All of these features need to be understood and there needs to be a capability to maintain the 'relationship' between the parts in order not to lose functional benefits.

Another key feature of operating a sustainable building is the need to adopt 'sustainable procurement' measures, including, for instance, the sourcing of 'green' electricity[17], employing local labour for key services (security, cleaning, catering, grounds maintenance etc) and the sourcing of any canteen supplies from local/organic suppliers

Following on from the Sustainable and Secure Buildings Act, there may eventually be a requirement for active waste reduction, re-use and recycling targeted at building occupants. Assuming that facilities for easier waste separation were provided by designers and builders, there still needs to be a commitment to undertake these tasks directly or via contracts

At the building's end-of-life, or as part of major refurbishment before changes of use, there should be a commitment to re-use or recycle the maximum amount of equipment and material, in order to improve the social benefit per unit material resource – and thus contribute to the building's sustainability.

Some aspects of sustainability are now being applied within the buildings/construction industries. The Government's Energy White Paper and Action Plan, together with tightening Climate Change targets, continue to drive numerous government and other initiatives[18] to improve the overall energy efficiency. Part of this is also designed to make building occupiers (and others) more aware of energy performance issues and options.

In January 2003, European Directive 2002/91/EC on the Energy Performance of Buildings (EPBD) was ratified. UK legislation implementing the directive is being introduced and this will drive energy labelling, regular upgrading of Building Regulations and the promotion of renovation in the existing building stock when the Directive is implemented across the EU in 2006.

Clearly there still is a long way to go to improve building sustainability. In the next Section, we take a closer look at key challenges arising as part of the construction process

[16] Environmentally Sustainable Buildings – Challenges and Policies. OECD Publications. 2003. (ISBN 92-64-19825-3) – No 52709 2003)

[17] There are numerous providers of this type of service, and they either guarantee that all the kilowatts bought are directly provided from renewable sources, or more usually, that these are indirectly provided by virtue of guaranteed investments in renewable that are made by the provider

[18] See: www.thecarbontrust.co.uk/energy/pages/home.asp

Part 2 : Constructing Industrial and Commercial Buildings Sustainably

The purpose of this section is to explore the implications for sustainable construction of different building techniques for industrial and commercial buildings through the comparison of Built-up System and Insulated Panel techniques.

Definitions

What we mean by –

Technique	Description
Built-Up System	Built-up system - Site assembled system comprising a number of components and layers mostly used for commercial and industrial roof and wall systems.
Insulated Panel	Insulated panel system - Lightweight factory made building panels that combine two high-density facings bonded to either side of a low-density insulation core (mostly used in commercial and industrial building roof, walls and facades).

Method

From the previous Section, a number of issues can be distilled that have a particular bearing on building processes and sustainability. These issues are converted into indicators and are then matched against two types of building techniques under consideration. Within the indicator/techniques matrix we allocate qualitative 'scores' (-/0/+) based on relevant criteria. The scores and indicators are then explored to help us analyse/distil the key conclusions.

Indicators & Criteria

We have chosen a set of indicators for our scoring exercise. These have emerged from our assessments in Part 1 of this paper and serve as a useful proxy measure of the sustainable construction issues covered.

We have allocated a set of scores based on the following criteria:

+ = Positive impact
0 = Neutral - neither positive or negative
– = Negative impact

The net-effect is that mostly (-) means a negative sustainability impact; mostly (0) means a neutral sustainability impact and mostly (+) means a positive sustainability impact.

Choosing the indicators:

Indicator	Meaning	Justification
Durability	• Applies to materials & buildings • Measure of long-term wear & tear	• Durable materials or buildings offer good social benefit per unit resource • Whole life costs lower
End-of-Life: Potential for material recovery, re-use, recycling	• Degree to which cyclic processes are applied when decommissioning buildings – turning waste into 'resources' • Offers further social benefit per unit raw resource used	• End-of-Life management is a important element in responsible material management;
Health & safety risks	• Health & safety risks at the construction site	• Construction activities can entail high H&S risk; • Any off-site manufacture in factory conditions has advantages here
Life-time energy performance	• Applies to Buildings and denotes its performance in terms of energy consumption and associated emissions	• Important aspect of providing high social benefit per unit of resource used • Good performance means less fuel use; • Reduces Building's emissions and operating costs
Local labour: use of	• Relates to construction process - the number/proportion of local labour used at the site	• Important part of sustainable construction • Provides value within the community or neighbourhood.
Longevity	• Applies to materials and buildings • Denotes the length of time these can be used	• Good longevity provides good social value per unit resource • Favours Insulated panels
Pollution (from materials)	• Certain synthetic materials have a short or long term impact on users within buildings in terms of their emissions (formaldehyde etc)	• This is emerging as an important component of 'in-use' performance • Can affect the well-being of occupants.
On-site waste	• Covers the waste generated at a construction site	• Advantages here for Insulated Panels; off-site manufacture in factory conditions
Quality	• Standard of how good something is as measured against other similar things • Relates to durability • Applies to materials and buildings	• Off-site manufacture enables working to better tolerances • Advantageous against on-site techniques, where quality is often an issue
Resource productivity	• The 'productiveness' of a material/building per unit resource used;	• Low weight & high strength materials enhance resource productivity if they are durable and when materials have secondary uses at end-of-life
Time on site	• Amount of time needed to complete specific tasks at the construction site (as opposed to off-site fabrication)	• Time is money • Time on site costs more than time in a factory setting because of the complex logistics that are harder to oversee or control
Whole life cost	• The cost of a building over its total life cycle from construction, use, demolition	• Important measure of sustainable construction • Gets away from short term cost measures typically associated with 'First-Cost' approaches; • This enables better management of long term issues

The following table illustrates how the two techniques compare when evaluated against these indicators. Inevitably, this assessment is a generalisation of the reality and there will be examples of both types of construction which will contradict the allocation given. Nonetheless, the prime purpose of this analysis is to give an example of how “sustainability thinking” can be applied in the practical environment.

Indicator	Built-up Systems	Insulated Panels
Durability	–	+
End-of-Life mgmt.	0	+
H&S Risk	0	+
LT Energy Performance	–	+
Local labour: use of	0	–
Longevity	0	+
Pollution from materials	0	0
On-site waste	+	+
Quality	0	+
Resource productivity	0	+
Time on site	0	+
Whole Life Cost	0	+

Key for Criteria:
+ = Positive impact
0 = Neutral
– = Negative impact

The following table provides some of the rationale that has been applied in reaching the assessments given. Other factors could have also been considered, such as the transport efficiency of bringing pre-assembled products on to site.

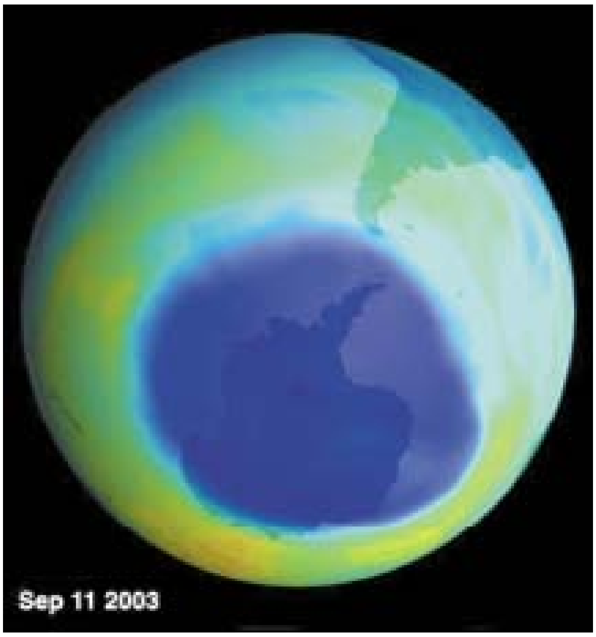
Indicator	Built-up Systems	Insulated Panels
Durability	– Negative • Possibility of poor workmanship compromising durability	+ Positive • Integrated system with less possibility of moisture ingress
End-of-Life mgmt.	0 Neutral • Ability to segregate materials • High labour intensity	+ Positive • Demountable as a unit • Potential for re-use • Can potentially recycle using existing facilities • Can directly incinerate with energy recovery
H & S Risk	0 Neutral • More personnel required on-site to complete assembly • Longer periods working at height	+ Positive • Less risk owing to off-site manufacture or assembly in controlled factory conditions • Better trained staff
LT Energy Performance	– Negative • More components leading to higher potential embodied energy • Possibility of poor workmanship leading to lack of integrity and moisture ingress	+ Positive • Integrated system with less possibility of moisture ingress and degradation of thermal insulation performance
Local labour: use of	0 Neutral • Relatively labour intensive process	– Negative • Relatively fast and efficient process using minimal labour
Longevity	0 Neutral • More components means that higher failure rate is likely	+ Positive • Panel systems are constructed to high quality and are naturally durable • Fewer component elements and tighter factory based specifications contribute to better longevity
Pollution from materials	0 Neutral • Applies equally	0 Neutral • Applies equally
On-site waste	+ Positive • Waste levels variable depending on-site practices	+ Positive • Minimal on-site waste owing to the delivery of panels to correct size
Quality	0 Neutral • Potential variability owing to quality of on-site workmanship	+ Positive • Good, because systems are planned and designed for fitting together • Off-site manufacture of panels in factory quality controlled environment (eg ISO 9000).

Indicator	Built-up Systems	Insulated Panels
Resource productivity	0 Neutral • Energy consumption in the use-phrase dominates and is susceptible to poor workmanship and moisture ingress	+ Positive • Controlled manufacture and installation leads to less waste • Consistent in-use performance • Greater possibilities for re-use
Time on site	0 Neutral • Construction process more complex than with panels • Significantly more time spent on-site	+ Positive • Minimal time at site • Progress on-site is less weather dependent.
Whole Life Cost	0 Neutral • Offers benefits over other traditional techniques but can be susceptible to moisture ingress	+ Positive • Use of highly durable materials • Easy to achieve high quality installation • Have less in-use impact and, if treated correctly at end of life, internalise more of the costs

Conclusions from this scoring process

- Bearing in mind the caveats already given, the overall sustainability performance of insulated panels appears to be better than for built up systems.
- This is particularly caused by the advantages in the construction process, the life time energy performance of the building, end of life management options (with certain caveats) and the whole-life costs of the building.

Good end-of-life management of existing panels helps deal with the ozone hole



Selecting an Insulated Panel System

General Points:

- Sustainability/Sustainable construction principles require a whole-life approach to obtain a true assessment of the impact of a particular building system. Below, we summarise the issues that arise during the life-cycle of a building constructed with insulated panels and list the key issues that should be considered in the first year (Design, Construction, Commissioning); during the building's use (Typically 30 – 60 years with appropriate refurbishment) and at End-of-Life (Decommissioning, Demolition, Material Recovery for further useful applications)

Core materials:

- The core materials for insulated panels can vary significantly depending on application. Options can include:
- Rock Fibre
- Glass Fibre
- Polyurethane (PUR)
- Polyisocyanate (PIR)
- Extruded Polystyrene (XPS)
- Expanded Polystyrene (EPS)

First Year Considerations (Design, Construction and Commissioning)

- Which of these cores offers the lowest overall embodied energy?
- Is the significance of density accounted for when making embodied energy calculations?
- How significant is embodied energy as a proportion of the energy demand of the overall life-cycle?
- Will there be other chemical emissions during manufacture (e.g. blowing agents)?
- Are there other resource constraints influencing the choice of core material?
- Do any of the core selections provide additional thermal resistance benefits for a specific design (e.g. in limited spaces)?
- Can the core material meet the fire performance required by the application?
- Do the fire performance requirements take account of environmental consequences of fires?
- Will the choice of core material be affected by the external environment (e.g. high or low temperature, high humidity etc.)?
- What are the weight implications of the core material selection? Is there an impact on structural steel requirement to support the panels? Will there be a greater need for lifting equipment?
- What level of training will be required for site personnel?
- How long will the site construction take?
- Are there aspects of the core material selection, which will lead to reduced waste levels on site?
- Will air tightness performance be affected by core material choice?

Use Phase Considerations (Durability ,Longevity, Functionality, Energy Efficiency)

- Does the choice of core material influence the durability of the panel (e.g. dent resistance, structural integrity when temperature cycled etc.)?
- What aspects of the core material's performance could be subject to deterioration over time?
- Will the choice of core materials take account of in-door emissions (e.g. formaldehyde)?
- Are there design features that could minimise such deterioration and, if so, what cost do they add?
- What influence does the choice of core material have on the ability to re-vamp the building during its lifetime without having to replace all the panels?
- What is the predicted loss of thermal performance over time for the core material in question? Is the decline susceptible to the external environment of the panel?

End-of-life

- Will the choice of core material make it more likely that the panel can be re-used at the end-of-life?
- Will there be specific components of the core material requiring special treatment at end-of-life (e.g. blowing agents)?
- If so, are there likely to be facilities available to provide such treatment within the locality of the building? Will such treatment be economic?
- Will the choice of core material affect the ease with which the panel skin can be recycled?
- Will there be weight advantages, which could make dismantling at end-of-life, easier?
- What will be the downside if the panels are land-filled?
- Will incineration with energy recovery be an option within a municipal solid waste incinerator (MSWI)?

Panel Skin:

First Year Considerations (Design, Construction and Commissioning)

- What implications will the choice of panel skin have on the load-bearing characteristics of the panel (e.g. adhesion to core material)?
- What influences will the choice of panel skin and, in particular, its profile have on the likely losses during the construction phase?
- Is there a choice of panel skin and which will be sufficiently aesthetically pleasing to promote the wider use of panels?
- Will the choice of panel skin (and its colour) affect the thermal performance of the building (e.g. as in US cool-roofs)?
- Is there a potential for incorporating roof top gardens in order to promote wider biodiversity in built-up areas?

Use Phase Considerations (Durability ,Longevity, Functionality, Energy Efficiency)

- What influences will the choice of panel skin and, in particular, its profile have on the likely product life of the panel?
- If coatings are involved, at what frequency will re-coating be required?
- Is the panel skin sufficiently flexible to allow re-modelling of the building during its lifetime without the wholesale replacement of panels?

End-of-life

- Will the choice of coating on the panel skin affect the ability to recycle the skin material?
- Are there an specific chemical waste issues associated with the materials used as coatings?

- How easily can the panel skins be separated from the core materials at end of life?
- Does the choice of panel skin significantly affect the ability to re-use the panel?
- Are there any weight implications or other design characteristics associated with the panel skin selection that could influence end-of-life management?

Of course, whatever the answers to this series of questions happens to be, it is very unlikely that the preferred panel will be self-selecting. The decision will not only be dependent on design and components of the panel itself, but the application to which it is being put. There will be additional considerations based on the location of the building including the local planning environment, population density and end-of-life management amenities. One of the particular challenges of any such analysis is predicting what facilities will be in place in 30-50 years time.

Consistency of approach is a critical aspect of reaching appropriate conclusions within the sustainable construction agenda and decision frameworks such as those offered in Kingspan's Design Handbook for Insulated Panels will become increasingly important.

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Do these Choices matter? – Overall conclusions for the industry

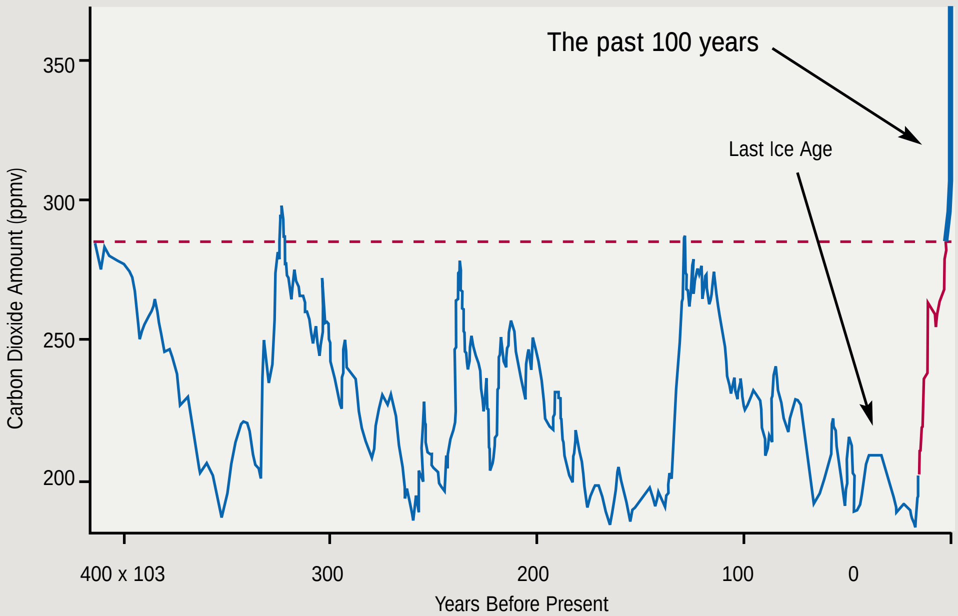
Environmental impacts

As global and local environmental pressures become ever more pressing, regulators are increasingly being challenged by the significance of the construction sector in influencing outcomes.

As an example, the Energy Performance in Buildings Directive (EPBD) has emerged in EU as a means of saving at least 70Mtons of CO_2 emissions per year. However, the likely annual saving will be significantly greater than this if the market transformation aspects of the Directive are effective. The implication of possible carbon trading for the commercial building stock could take things even further. Even at its minimum, the EPBD should contribute at least a quarter of the required greenhouse gas emission reductions by 2008-2012 (the first commitment period of the Kyoto Protocol).

The fact that the EPBD was one of the fastest pieces of legislation to be introduced at EU level indicates the urgency with which regulators are now treating the environmental impacts of the built environment. The pressure to transform the market will only increase in the coming years.

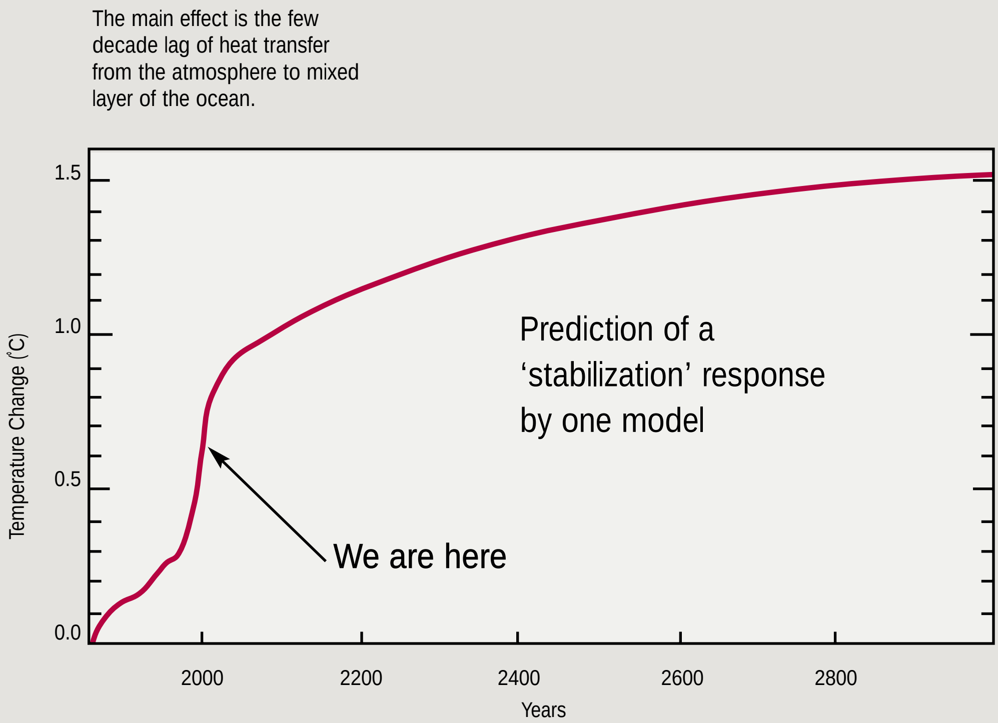
Carbon dioxide Bubbles Locked in Ice Reveal the History



It is well established that there is more carbon dioxide in the atmosphere today than there was in the past half million years - probably more than in the past twenty million years (IPCC, 2001).

It is well established that there is more carbon dioxide in the atmosphere today than there was in the past half million years - probably more than in the past twenty million years (IPCC, 2001).

Stabilization: The climate has significant ‘inertia,’ because the oceans and ice lag behind the atmosphere. If we were to stabilize the concentrations (not emissions) of all GHG and aerosols at present levels tomorrow, here’s the kind of thing that would occur.



The rise in global mean temperature following stabilisation of greenhouse gas concentrations at present-day levels

In the past 150 years, a global average temperature change of about 0.6 degrees Celsius has been observed.

To whatever extent the change may be due to human activities, the inertia of the system means that stabilization of all concentrations now would imply a further future change of roughly comparable size (e.g. perhaps as much as 0.6 degrees).

Source: Slide extracted from Susan Solomon’s[19] presentation to the Earth Technology Forum, 2003

The future market will belong to those building product suppliers, architects, designers and who can adapt to this new agenda.

[19] Co-chair of Working Group I of the Inter-Governmental Panel on Climate Change (IPCC)

Economic impacts

- Historically, one of the major barriers to such market transformation has been first cost. With property developers often not responsible for wider lifecycle costs, the incentive to invest in lifecycle issues has been absent.

- One of the impacts of market transformation is the likely stigma that may become attached to such first cost approaches in future. If schemes such as BREEAM, the EPBD and Environmental Product Declarations take full effect, it will be possible to ascribe immediate property value to well designed and performing buildings.

- If the UK construction industry can respond to these trends, particularly with innovative building solutions, it will be placed well in an increasingly globalised marketplace. The converse, however, is also true in that the UK construction industry could be exposed as never before to international competition as the technological element becomes an increasing part of successful solutions.

- At present, the UK's investment in R&D within the construction industry is a pitiful 0.15%. This has to change.

- Ironically, not all technological solutions will have to be more expensive at the point of use. This is particularly the case where increasingly rare (and costly) on-site labour and time can be saved.

Social impacts

- The most obvious social impact of market transformation will be a better and more comfortable built environment. The quality of building practices should improve to the extent that 'calling back the builder' should be a thing of the past.
- There will be a substantial impact on the construction workforce, with the on-site trades continuing to dwindle, while new technological and enforcement roles emerge. Enforcement remains a critical success factor in any market transformation driven by a legislative framework and governments need to face up to the political consequences.
- Above all, the most obvious social impact will be protection from the social ravages of environmental catastrophe. Insurance claims are already on the rise as climate change takes its toll. The social cost of carbon is now a well-documented phenomenon[20] and other environmentally driven indices are likely to emerge over the coming years.

In conclusion, the UK construction industry has to consider its future well-being with some trepidation. It is unlikely that the top 50 companies of the present day will be those of 2025. The degree of change in the built environment required by that time will inevitably force innovation on a scale not seen in the industry for the last 100 years.

Kingspan intends to become a leader in addressing this agenda.

[20] Clarkson and Deyes Estimating the Social Cost of Carbon Emissions, - Government Economic Service Working Paper No. 140, 2003

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Kingspan welcomes the support of Caleb in producing this document and helping in broader areas of strategy.

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Caleb Management Services is a leading UK consultancy in the field of building energy efficiency, sustainable construction and the wider sustainability agenda. Much of this work is as a policy advisor to Governments and their agencies.

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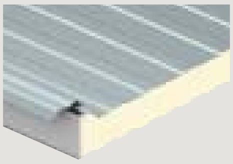

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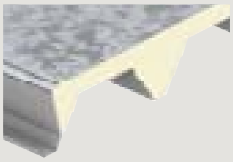

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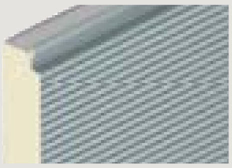

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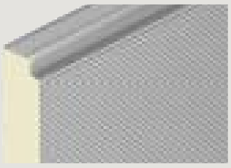
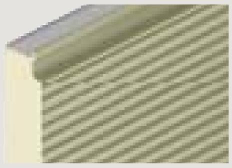


KS600, 900
& 1000 CX
Convex



KS600, 900
& 1000 WV
Wave

KS600, 900
& 1000 LS
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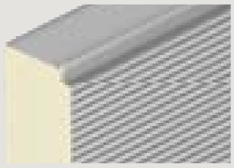

KS1000 RW
Trapezoidal

Controlled Environment Systems

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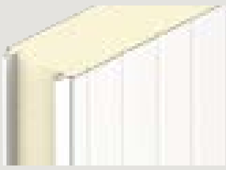
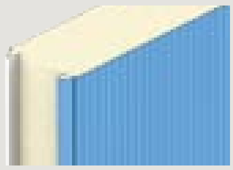


KS1100 CS-FL

KS1100 CS-MR



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