ENERGY EFFICIENCY SOLUTIONS FOR BUILDINGS

Gill Kelleher, BASF Sustainable construction advocate

BASF is the world's leading chemical company. Its chemical products are used in almost all industries, from electronics and agriculture to consumer goods and construction.

By 2050 it is estimated that the world population will grow to about nine billion and 75 per cent of those will be urban dwellers. This is a challenge that demands new concepts for housing and construction.

As a leading provider of raw materials, systems and solutions to the construction industry, BASF is working with industry to increase the energy efficiency and lifespan of buildings, developing solutions that reduce the amount of resources needed for construction and contribute to greater living comfort. Our insulation materials, concrete admixtures and many other products help significantly to reduce carbon emissions generated by buildings over the course of their lifecycles. According to the Intergovernmental Panel on Climate Change, by 2030 around 6.5 billion metric tones of CO_2 emissions could be saved globally in the area of housing and construction as a result of investment in efficient technologies. As a reliable partner to the construction industry, it is our goal to help increase this contribution to climate protection.

We understand sustainable construction as the process of developing built environments that balance economic viability with preserving resources, reducing environmental impacts and taking social aspects into account.

As a result, BASF construction experts are actively engaged in Green Building Councils and work closely with architects, planners and urban developers to create housing for all types of climates and diverse architectural traditions. In the UK we have partnered a number of organisations to provide data and evidence for industry to demonstrate the savings which can be achieved from adopting energy efficiency measures.

UNIVERSITY OF NOTTINGHAM CREATIVE ENERGY HOMES PROJECT: AFFORDABLE, LOW CARBON HOUSING

The objective for the BASF House, Nottingham, was to design an affordable, practical, low Carbon home. At the outset the target was for the house to have an energy consumption of $15kWh/m^2$ (meeting Passivhaus standards). The highly insulated fabric of the building (specified U-value for walls of $0.15W/m^2K$) is considerably in advance of current Building Regulations and the structure was designed to demonstrate a cost-effective approach to meeting Level 4 of the Code For Sustainable Homes.

The first principle was to design the fabric of the house to be well insulated to minimise energy loss. A combination of insulation materials demonstrated the range that exist in today's market.

Since its completion in 2008 the house has been occupied by both University staff and students and has been carefully monitored as part of the University's research into building with low carbon solutions and the impact of occupier behaviour. Data from the building's sophisticated monitoring equipment have evaluated energy consumption, and a range of climatic conditions in the house from the temperature and relative humidity to the lighting, solar radiation and ventilation. The occupants were electronically tagged to create a record of their living patterns. An important aspect of the house's evaluation was to test the general comfort and practicalities of the house and how it affects the occupants.

Initial monitoring data indicate that the house is beating the target of $15kWh/m^2$ and achieving as little as $10kWh/m^2$.

. . . savings from adopting energy efficiency measures . . .

SUMMARY OF MATERIALS USED

The lower floor and foundations were built using the BASF Neopor® insulated concrete formwork (ICF) system to provide high thermal mass. Neopor, a lightweight, expandable polystyrene (EPS) contains graphite, which considerably enhances the insulation capacity. Blocks of Neopor were assembled to create the shape of the building, including window and door openings. The core was then filled with a pumpable concrete.

For the first floor a prefabricated timber insulated sandwich panel system (SIPS) was used, containing BASF rigid polyurethane insulation.

SIPS was chosen because of the high insulation factor, outstanding air tightness, light weight and the ability to prefabricate off-site non-rectangular shapes – ie for the gable walls. The roof was also constructed of SIPS to demonstrate the versatility of BASF heat management solutions used within the steel coatings.

The result is that the walls and roof structures have a U-value of 0.15W/m^{2}K combined with high air tightness. The South facing aspect of the house consists largely of glazing in order to capitalise on passive solar gain.

The structure also considers the important issue of heat management. As new buildings have to be highly insulated to meet the Code for Sustainable Homes, the energy required to cool these houses down is a concern.

To overcome this issue a modified plasterboard incorporating Micronal® Phase Change Material (PCM) has been used internally within the house. Micronal PCM is made of polymer capsules containing a special wax mixture which stores latent heat. When the temperature rises above 23°C, the wax melts and the phase change material absorbs heat. When the temperature drops, the wax solidifies and heat is emitted.

This innovative material enables a 1.5cm thick plasterboard to contribute a thermal storage capacity identical to that of 7cm concrete or 9cm brickwork. It allows a lightweight construction to capitalise on the temperature stability benefits of high thermal mass – contributing to more comfortable living conditions and better energy efficiency.

The first floor and roof area required a lightweight, durable, waterproof cladding. Colorcoat Urban® by Corus was selected. Traditional roofing materials absorb solar energy, generating heat that is transported by thermal conduction into the roof and by convection to the surrounding air. The Colorcoat Urban steel cladding system uses BASF's coil coating PLASTICERAM®, this has superb UV durability and corrosion protection while also achieving maximum solar reflectance.

THE BRE VICTORIAN TERRACE PROJECT

The UK Government has a legally binding commitment to reduce CO_2 emissions by 80% by 2050. To meet this target it has to ensure that existing buildings are made more energy efficient. The UK's housing stock releases 150 million tonnes of carbon dioxide per year, with older buildings contributing disproportionately. The Government has therefore put in place a country-wide energy efficiency programme, recognising that refurbishment of the oldest housing stock is essential.

In collaboration with BRE (Building Research Establishment) at its headquarters in Watford, BASF materials were used to transform a disused Victorian stable block into three energy efficient terraced homes fit for 21st century living. The target was to improve the energy performance rating of the building from band F to band A/B.

INTERNAL AND EXTERNAL INSULATION SOLUTIONS

Over a third of the energy heating a property escapes through the external walls. Old solid wall, hard-to-treat buildings such as the BRE Victorian Terrace are most affected. Through participation in this project, BASF has demonstrated innovative products and solutions that tackle a number of the issues facing the refurbishment market.

> . . . glazing to capitalise on passive solar gain . . .

The finished development now houses an Information Centre where Visitors are able to learn about best practice refurbishment, including the latest processes, materials and technological advances to treat existing homes.

One of the walls of the presentation room was internally lined with rigid polyurethane insulation. Magnesium oxide boards were adhered to an 80mm Polyisocyanurate (PIR) insulation board consisting of a foam core with two low emissivity facers. This achieved a U-value of 0.22W/m^{2}K.

The South wall of the presentation room presented additional challenges. The wall was very unstable so a number of structural repairs had to take place before all the existing plaster was removed. WALLTITE® spray foam insulation was then sprayed directly onto the rough, bare brick substrate to a thickness of 100mm without the need for primer or levelling coat. The strength of WALLTITE helped to consolidate this very unsound surface. WALLTITE is a closed cell foam. Its structure helps to control the movement of vapour and moisture throughout the building, reducing the risk of mould and condensation. At a thickness of 100mm, WALLLTITE achieved a U-value of 0.25W/m^{2}K.

> . . . refurbishment of the oldest housing stock is essential . . .

An added performance property of WALLTITE is the air tightness of the system. Air leakage accounts for 25-50% of heat loss. WALLTITE has no joints and has a measured air leakage value of 0.0033 @ 50 pascals m3.h-1.m-2 per BSRIA. Further performance was achieved by eliminating thermal bridging via studwork or framing. The whole surface area of the wall was sprayed seamlessly and then finished with gypframe studs before applying plasterboard.

Three of the walls were insulated with an External Thermal Insulation Composite System (ETICS) consisting of 150mm thick insulation boards made of BASF's Neopor expandable polystyrene (EPS) and the Heck® external render system. Neopor insulation boards were fixed to the outside of the building and covered with an alkali resistant reinforcing mesh, scrim adhesive and a final decorative finish. This layered method reduces heat loss and prevents water ingress.

It is not only the walls that need consideration. Uninsulated floors can produce as much as 15% of heat loss from a building, while effective waterproofing is essential for a building of this age.

The floor was therefore made fully waterproof using BASF's Thoroseal® Super which was lapped up the walls to form a damp proof course. Styrodur® C, an insulation board, was chosen to meet the thermal insulation requirements, with the substrate then being finished with PCI Novoment® Z3, a fast track screeding solution with rapid cure capabilities. The result is an overall floor U-value considerably less than the target of 0.22W/m^{2}K in the Building Regulations.

BASF's Micronal phase change material (PCM) was incorporated into the ground floor presentation room to contribute to the temperature management of the space. In this installation, the PCM was incorporated into a suspended ceiling tile system.

These projects are designed to demonstrate how energy efficiency can be built into the structure of homes – whether at the construction stage or as part of refurbishment projects. Visitors are welcome to both sites. These are two projects in which BASF has collaborated and research continues to provide evidence of how chemical solutions can contribute to sustainable buildings – whether they are for commercial, industrial or domestic use.

For further information on this and other demonstration projects, go to www.basf.co.uk/ecp1/Solutions_UK_Ireland/Construction

ENERGY EFFICIENCY: THE ROLE OF SMART METERS

Ashley Pocock
Head of Industry Change, Regulation and External Affairs, Smart Metering Project, Transformation, EDF Energy

The Meeting also heard from Ashley Pocock, Head of Regulation for Smart Metering at EDF Energy.

Among the points he made were the following:

The target is for the installation of smart meters in all homes and small commercial businesses to be completed between 2015 and 2019.

This will involve 34m properties, over 50m gas and electricity meters, and 50m other technical devices, including displays and communications equipment.

The Government has pledged to deliver a National Communication Network, combining 3 super-regional networks a central data hub.

The meters will allow for a seamless transition between different energy suppliers, and will support different payment modalities. One immediate benefit is that it will no longer be necessary to have estimated bills – a great source of customer dissatisfaction.

For most consumers £ is more intelligible than kWh, and so this is how the information will be displayed. There will not be an output revealing the CO_2 footprint of generation.

When the customer signs up to acquire a meter, there will be three phases – a pre-installation consultation, then the installation itself, and a follow-up later to ensure comprehension and satisfaction.

It is clear that tariffs affect demand, but nonetheless an impact assessment suggests that savings overall will be small – less than 3% anticipated from increased sensitivity by consumers to the energy they use.

In order to achieve more, further changes in behaviour will be needed. Since the largest proportion of domestic energy is used for heating, consumers may have to get used to lowering thermostats, and of course improving insulation.

Even where families are living in identical houses, there can be significant variation in patterns of energy consumption. For example retired people have a comparatively flat pattern throughout the day. A family using, for example, hair dryers will have a noticeable peak early in the day.

Finally, although the benefits should be clear, no one will be compelled to accept such meters if they do not wish.

Additionally, there will be strict regulation to control external access to domestic data and to ensure both privacy and security are maintained by all providers and users of this unique, complex and extensive infrastructure.

ENERGY EFFICIENCY

Roger Kemp
Lancaster University

Energy policy in the UK is faced with three conflicting demands: security of supply, affordability and environmental impact: politically, all are important. Failure to keep the lights on or shortages at petrol stations can be toxic to any government. A sudden rise in electricity, gas or road fuel prices creates unwelcome headlines and consumer protests. All recent governments have committed to reducing carbon dioxide emissions, as well as the oxides of sulphur and nitrogen, blamed for the acid rain that had destroyed many North European forests, as well as ground level pollution in cities.

The scale of the challenge faced by policymakers in resolving this trilemma can be

. . . shortages at petrol stations can be toxic . . .

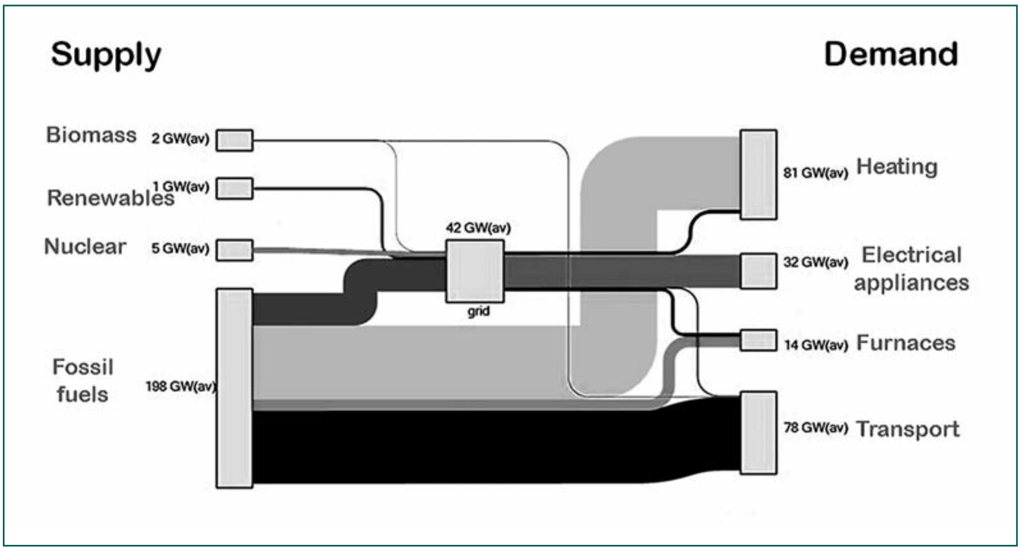

Figure 1: UK energy flow diagram 2008[i]

seen in Figure 1, which shows the supply and demand of energy in the UK when the Climate Change Act 2008 was passed.

On the left are the four main sources of energy – fossil fuels, nuclear power, renewables and biomass. On the right are the uses made of energy – transport, furnaces and other high temperature uses of heat, electrical appliances and low temperature heating. It can be seen that the major energy flows are from fossil fuels to transport and heating.

The diagram shows average values throughout the year; although many uses of energy are reasonably constant, most of the heating load is taken during the winter months and, predominantly during the early morning and early evening, the peak load can be more than three times the average.

From the point of view of the consumer, it would be convenient to be able to keep the utilisation side of the diagram the same but to change the supply side to more secure low-carbon sources. A glance at the numbers shows the impossibility of this approach. The peak load (heating and electricity) in winter is 250GW which is equivalent to 100 nuclear power stations or 100,000 large wind turbines. As well as changing the source of supply, we have to reduce the

. . . peak load can be more than three times the average . . .

amount of energy we use – hence the importance of energy efficiency.

If the UK is to get near the targets in the 2008 Act, we have to tackle the two big sources of CO_2 – transport and heating. Both are hugely challenging but transport is probably the easier of the two. One could envisage widespread adoption of electric vehicles and a major shift to electrically-powered trains and trams, all powered by renewable or nuclear energy. Aircraft and the remaining HGVs, which require more energy than could be stored in batteries, could be fuelled by biofuels derived from agricultural waste and algae or other plant material that do not compete with food crops when food shortages will be increasingly commonplace.

Although we can envisage a technical solution to decarbonising transport, the politics and economics would not be straightforward. We are accustomed to owning a car that is used daily for a 20 mile commute but that can also be used for a 200 mile weekend trip to a remote farmhouse or a 2000 mile family holiday. Asking people to reorganise their lives to use short-range EVs for the daily commute and public transport for longer trips might not be a vote-winner. Expanding the rail system to cope with greatly increased peaks of Christmas and holiday travel, while maintaining subsidies at an acceptable level and providing a financial incentive for people to use the low-carbon alternative to a car, would be more challenging.

If the political challenge of decarbonising the transport sector at an acceptable cost is "difficult", the problems with domestic heating are even greater. In the last 50 years we have moved from homes in which we switched on heaters only in occupied rooms and it was normal to wear a sweater indoors to the expectation that buildings are centrally heated and our choice of indoor clothes is dictated by fashion, not the weather.

When constructing new buildings it is possible to build in high-performance insulation and heat exchangers to warm incoming fresh air from the air being extracted. With good design it is possible to build homes that require almost no external sources of heat. However, there are no readily-available technical solutions for installing low-carbon heating in existing buildings and most of the houses that will be in use in 2050 have already been built.

Attempting to balance the trilemma of security of supply, affordability and environmental impact has resulted in more than a decade of policy paralysis, punctuated by occasional bursts of political hyperactivity in pursuit of one of the three, while conveniently ignoring the others. In 2008, the Climate Change Act prioritised reductions in CO_2 emissions – Coalition promises to be "the greenest government ever" followed this line. Five years ago, new nuclear power stations were seen as crucial to keeping the lights on; legal challenges,

. . . a major shift to electrically-powered trains and trams . . .

the repercussions of the tsunami deluging Fukushima, together with private sector reticence to carry financial risk ensured none has been started. Recent campaigns to cut prices by opening up the energy market and encouraging consumers to switch suppliers seem to have forgotten last year's plan, which encouraged suppliers to form long-term relationships with customers, investing in insulation and energy saving measures, recouped by lower energy use over the following years.

Since the Energy white paper 2003: *Our energy future: creating a low-carbon economy* there have been half a dozen major restatements of energy policy but little to show on the ground; we still burn large amounts of coal and run our cars on petrol and diesel, much as in 2003. Energy infrastructure is a long-term business; power stations cost many millions, take several years to build and have a life of 40 years. Companies considering whether to invest seek a degree of policy continuity. If companies are expected to fund the massive investment needed in new energy infrastructure from their own resources, they need assurance of future profits.

. . . more than a decade of policy paralysis . . .

One of the largest areas of contention is the extent to which policy should focus on reducing CO_2 emissions. Most people accept the fact of climate change, although the extent to which this is caused by anthropogenic CO_2 emissions may be open to debate. The government has signed up to the objectives of the 2008 Climate Change Act and other measures to reduce CO_2 emissions and the Climate Change Committee (CCC) produces carbon budgets for years ahead which represent increasingly incredible extrapolations of current policies. With more than 100 MPs formally opposing wind farms, and growing support for shale gas, it is increasingly difficult to see a consensus supporting the CCC plans.

. . . Asking people to reorganise their lives . . .

Recent government initiatives have been to reduce retail energy prices and to improve the efficiency with which it is used. *The Khazzoom-Brookes postulate* (sometimes referred to as the *Rebound Effect*) states that if energy prices do not change, cost effective energy efficiency improvements will inevitably increase energy consumption above what it would be without those improvements. The corollary of this is that, to use the market mechanism to reduce CO_2 emissions, inflation-adjusted energy prices (including taxation) have to rise faster than efficiency improves.

If governments oppose energy price rises, what alternatives are there to reduce overall energy use? One mechanism, which has been successful in reducing car emissions, is regulation. Under EU rules, supported by UK taxation policy, car manufacturers have been forced to improve the fuel efficiency of cars so there is now a range of vehicles with emissions below 100gCO_2/km. Engineers in the industry reckon that further improvements to 80 or even 60gCO_2/km might be possible but, if this is not to lead to long term increased car use, this has to be accompanied by a comparable fuel price increase.

. . . more than 100 MPs opposing wind farms . . .

If holding down gas use by increasing prices is not politically acceptable, the alternative could include more intrusive regulation, perhaps by individual carbon allowances or the imposition of maximum thermostat settings, or more draconian and retrospective building standards. If neither regulation nor price increases is acceptable, we are running out of options to limit energy use and CO_2 emissions.

For the last decade politicians have talked about taking "tough decisions": in energy policy they have studiously avoided taking any decisions. Partly this policy vacuum is based on a misguided belief that "the market" will make sound strategic decisions in the absence of government policy.

What should an energy policy include and what should be the dividing line between the public and private sectors? Of critical importance, government needs to have a coherent vision of what it wants to achieve in terms of security of supply, affordability and emissions and a long-term strategy to implement this vision: how many days demand of gas storage, how many power stations of what types, what proportion of electric vehicles, what penetration of district heating, etc, etc. This is a national strategy, requiring agreement between ministries, which cannot be left for the markets to decide. Once the strategy is determined, the private sector can deliver what is needed and would be expected to bear the risk if they fail to deliver. However, what the private sector cannot be asked to do is to carry the risk of the government's strategic vision.

Creating coherent energy policies requires an understanding of how the different components of energy systems interact and how these relate to other policies, including those on land use, transport and taxation. In the absence of coherent policies, we risk missing all three of the objectives of security of supply, affordability and environmental impact and simply increasing energy efficiency will not deliver the policy objectives we seek.

i Diagram from: Generating the Future, The Royal Academy of Engineering, 2010.

. . . imposition of maximum thermostat settings . . .