Socially Engineered Sustainability

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Abstract

The use of the SUSTAINABILTY word has been manipulated to a point where in most circumstances it is meaningless. Companies, PR spin doctors and governments have all cherry picked discrete items to add strength to their usually flawed arguments.

To achieve a genuine sustainable future, it requires a totally holistic approach to the way in which social economic models are formed. Currently, the world population lives on 3.4 planets. This type of lifestyle cannot continue.

Sustainability encompasses many complex issues of embodied energy, carbon emissions, etc. in a very sensitive model. Current world governments are not yet focussing on the core issues.

In Britain around 30 percent of our annual energy consumption is consumed by the domestic house and when the work place is added, around 45 percent of the total is used. The newly introduced Building Regulations Standards are actually increasing the amount of energy needed by the country.

A future well designed and engineered environment can save about 50 percent of the energy used by current best practise. However, far greater savings can be made by adopting a holistic integrated socially engineered model. The paper lays out a balanced approach for achieving a sustainable future for society.

Overview

Professional building designers are becoming actively engaged in producing buildings which try to help to reduce carbon emissions with low ongoing energy demands. The underlying driving force for this is the Kyoto Agreement and the need to try to limit the rate of Climate Change.

Carbon emissions are directly related to the rate of Climate Change and have been acknowledged by many governments as the world's biggest long term problem. This issue has a greater impact on the world than aids, famine or even wars!

The benefits of sustainable building designs are being limited by continuing poor social economic structure "life style" and town master plans with legislation which limit the ability of the urban designer to create sustainable social eco-systems.

The development of low environmental impact buildings is now becoming commonplace with the building industry. Many projects which are specified as being "green" only pay lip service to being environmentally sensitive in order to gain the acceptance of the masses. However, many of these developments are working very hard to improve their environment credentials.

A philosophy which naturally creates a sustainable building design is an approach which produces a series of jigsaw ideals which will need to be judged, altered, assembled and administered for each specific project. The ideal being to produce a project suitable for each specific location.

The ideals will need to be tuned for the region, specific site location, urban and rural context in conjunction with whether the project is new build or refurbishment. The development should aim to have a low fabric embodied energy with a very limited need for external energy sources during its life and have a low environmental impact.

The basic building ideals for sustainability :

- Minimizing the Constructional Embodied Energy/ CO2 Emissions.
- Minimizing the Working Life CO2 Emissions.
- Eliminating the Buildings need for Fossil Fuels Energy.
- Building Components Locally Produced To Limit Impact on Road Network.
- Limiting the Requirement for Central Services, Water, Sewage, Electricity, Gas.
- Prioritizing Land Ground Footprint Area Usage.
- Limiting and Managing the Waste Produced by the Building in Use.
- Building to Produce a Minimum of 15% of its Energy from Renewable Sources
- Future Proof Form to Allow Additions of New Emerging Viable Energy Sources
- Design with the Topography and Geology and Site Specific Constraints
- Carefully Choice of Equipment and Location Within the Building.

The headings listed are all known and repeatable by most responsible people within society. Many people conscientiously follow these typical guide lines in a responsible manner to minimize the environmental impact of their development. The adoption of these ideals will contribute to energy savings and a reduction of carbon emissions.

This paper questions the focus of these commonly set goals as being not efficiently directed. To many people this statement will seem absurd and misplaced. A preamble of energy efficient developments and normal ones needs to be reviewed to gauge the global benefits of a more appropriate social economic structure.

It is possible to create carbon negative buildings which, over fifty years, actually create a positive balance. ZED, ie Zero Energy Developments are starting to be built in a very real manner.

Some examples of modern buildings which have aspects of good sustainable characteristics are briefly listed for cursory inspection. The Conference Building at the Earth Centre in Doncaster was formed by the Architect, Bill Dunster, structurally engineered by MLDE and the services engineered by Arup.

The building could be described as an extreme project, especially for a public building. It was conceived to create about 60% of its own energy from green sources and be built from 80% recycled materials. The basic characteristics being a super insulated form with very low air infiltration levels combined with heat recovery on a passively driven ventilation system and a 500m3 water inter-seasonal thermal store.

The Rural Zed project was carried out by the same team. It offers a MMC form of construction, timber frame with added pre-engineered thermal mass and high levels of insulations combined with passively driven ventilation systems.

The Kindersley Centre at Sheepdrove is a more mainstream sustainable building by Alec French & Partners and MLDE. It utilizes the excavated chalk from below the building to form some of the load bearing walls. The building is extensively constructed from timber and has good environmental characteristics.

Typical energy in use loads for ZED buildings are:

Electrical 1 Bed Flat 2250kWh/yr----------Heat 3302 kWh/yr
Electrical 2 Bed Flat 2600kWh/yr----------Heat 3864 kWh/yr
Electrical 4 Bed Townhouse 3530kWh/yr-------Heat 4380kWh/yr

Offices

Electrical—54kWh/m2/annum (6W/m2)
Heating----- very low indeed, passive gains almost sufficient.

The ZED fabric values are already meeting the 2050 requirements.

The electrical services loads on conventional office building based on the BSRIA Rules of Thumb 2001 are:

Lighting ----------10 - 12 W/m2
Small Power---------- 15 -45 W/m2
Air Conditioning----- 60 W/m2
Passenger Lifts-------10 W/m2

Conventional offices, in electrical load terms, require around 50 W/m2 to run, and air conditioned ones around 110 W/m2. If a building has an occupancy density of around ten square metres per person to run then the energy demand is between 0.5 to 1.1 KW/person. This occupancy level should be the benchmark standard and is far less than most offices which are around 15m2/person.

The production of alternative green energy in lieu of conventional fossil based supplies are not at present in broad terms as financially economic as the conventional sources. Grants can in some cases reduce the magnitude of the discrepancy to an acceptable level. However, in very energy efficient buildings where the need for energy has been significantly reduced then green energy supplies can produce a workable solution.

Alternative Green Energy Supplies

- Solar Panels
- Evacuated Tubes
- PV's
- Wind Turbines
- Ground Energy (thermal boreholes)
- Methane Harvesting
- Bio-Mass
- Water Turbines
- Passively Driven Heat Recovery on Ventilation Systems

The appropriateness of any of these green energy sources will significantly depend on the characteristics of the individual site. The constraints will differ between new build and refurbishment, an example of this can be demonstrated with PV's. PV's as an add on to an existing building are presently not justifiable under economic grounds. However, the incorporation of PV's into glazed elements within a new building can nearly be viable on a straight commercial basis if grants are obtained to offset some of the costs.

The amount of power generated from a crystalline type PV is around 100 kWh per year per m2. This equates to around 11 W/h per m2, which is just about able to run the lighting load for the building.

Wind turbines do produce energy even in fairly still air conditions. However the output from modest local site turbines is not enormous and is only really suitable for running the lighting and small power loads of a building. An indication of the performance of typical small to medium sized turbines is given for reference purposes. Commercial small turbines are generally available between 0.6 kW to 15kW. A 6kW turbine on a nominal 10m mast with a site wind speed of 5m/s will generate around 11622 kWh per annum, which equated to 1.3 kW/h throughout the year. If green electrical energy is being used to run a building then extreme care must take with the energy demand in order for the source to make a meaningful contribution to the total demand level.

Water turbines are also starting to become more widely used and common in developments. This type of energy source is highly site specific with a very limited application. The number of UK based medium sized turbine manufacturers is extremely limited and most installations are supplied from Europe. One project which MLDE are currently carrying out is a 1.0m diameter low head turbine in a small office complex. The output, in energy terms, from this is around 44 kW. Water driven turbines do generate reasonable levels of energy sufficient to run fairly large buildings

The recovery of energy through a passively driven controlled ventilation system is an extremely efficient way of reducing the heating load on the building system. Simple heat exchangers which allow the exhaust air to preheat the inlet air supply avoid the dumping of large amounts of energy directly to the outside atmosphere. A built "tight" fabric strategy in conjunction with a well design controlled ventilation system provides a similar level of energy saving as the one created from the direct fabric loss reductions of super insulated envelopes.

The current carbon emission for an office equate to 0.2 Kg to 0.48 Kg of carbon per hour per person which produces an annual total of 0.88 Tonnes of Carbon per year for a basic office to around 2.1 Tonnes for a corporate headquarters building.

These figures can be easily manipulated in either direction and should be taken indicatively.

Under current Building Regulation criteria around 50% of the buildings total energy loss takes place through uncontrolled air percolation. Therefore, simply to improve the U value of the design above specified levels only addresses half the problem.

The air permeability of buildings under current standards is only based on a pressure difference of 50 pascals which, in real terms, is too low a value. Decreasing uncontrolled air percolation would only cause a fraction of the cost increase caused adding additional insulation thickness. To limit the thickness of insulation required to meet the required energy loss also makes better use of the building land.

The ventilation strategy and control of such to provide a comfortable environment cannot be left to be accounted for by uncontrolled air leakage losses in well sealed buildings. The ventilation strategy should be natural, non mechanical where sensibly possible and easily adjustable by the occupants, not a sealed straight jacket! Informed occupiers should be allowed, encouraged and trained to tune the internal environment.

Most current buildings are more poorly designed in Building Physic's (environmental) terms than their Roman counterparts of two thousand years ago!

It takes three times as much energy to cool a building per degree centigrade as to heat it. Modern light weight air tight sealed buildings over heat rapidly. The bias in the new Building Regulations between Part L & E actually tends to create light weight building designs. These buildings rapidly overheat in summer and therefore have a greater overall energy demand and increase the countries need for more power.

This fact seems to be supported by the result of the UK annual CO2 emissions which have actually increased by around 1%. To meet the Kyoto agreement the CO2 output should be falling significantly year on year. It is believed that the agreed targets cannot be met without a significant change in overall strategy.

A thermally heavy weight building will operate at least four degrees cooler in summer and around four degrees hotter in winter than a similar light weight structure. Heavy weight buildings fabric temperature will only alter by a few degrees between winter and summer, producing a stable environment.

If a person travels around twenty five miles to and from work each day by a petrol driven car then the annual output of carbon dioxide from the fuel use alone is around 2.5 Tonnes/annum/person. The number of miles travelled using fossil fuels must be minimized.

A business/society which relocates staff close to their work spaces helps strengthen society and builds robust happy communities. Apart from the many social and economic advantages, the benefit to the environment is enormous. In real terms a greater reduction in carbon dioxide emissions can be made by eliminating fossil fuel travel than most other potential building savings which can be made.

It is very useful for indication purposes to create a rough table for the basic carbon emissions for a typical office. This comparison in the first instance will not include waste production, repair and maintenance and other such factors at this stage, only primary elements will be considered.

Indicative Carbon Emission Ratios for Working Offices

Typical Example of Office Annual Carbon Emissions Per Person (assumed 10m2 space)

- Commuting to Work , Car (twenty five miles to/fro per day)----------2.5Tonnes
- Working Space Emissions for 10m2----------1.2Tonnes
- Construction Embodied Energy Assume Shared Over Fifty Years-------0.4Tonnes
- Business Car Travel (6000 miles)----------1.2Tonnes

Total Basic Annual Office Carbon Emission per Person----------5.3 Tonnes

These figures can be significantly manipulated in value. However, the basis of the conclusions drawn from them will not alter with regard to their importance and consequence.

The use of timber within construction has the benefit of locking up carbon dioxide from the atmosphere, which will significantly help to combat global climate change. Timber is a very good and environmentally sensible building material in many countries. However, each cubic metre of timber used within the construction only locks away during its growth period around 0.75 Tonnes of carbon dioxide. If this is compared with the amount created by driving to work, then the damaging environmental impact of petrol driven cars can be clearly seen.

The distance travelled between work and home should be minimized and support the use of good public transport. Businesses should strongly lobby governments to create safe cost effective and viable alternatives to private transport. Relocation of staff near to their working base avoids the reliance on any transportation network. Grants provided by governments to help businesses achieve this would yield better results than spending more money on transport.

It is likely that £10 Billion spent on grants to companies could help relocate around 1Million commuters and their families. This would lessen the need to travel and reduce the need for governments to spend on road building and repair programmes. The added benefit of building less road area is that the land could then be released for other use for either man or nature.

This type of approach would need careful developing. However, when the magnitude of the problems currently being created by "Climate Change" are considered, the implementation of such a strategy is quite easy, if there was the political foresight to do so.

If a Zero carbon emission building is designed and procured which over fifty years produces more green energy than the combined embodied building fabric energy and the total day to day running energy without a well grounded green travel plan or a sound social economic structure then the overall benefit is significantly limited.

The time should come quite soon when companies and families consider the total Carbon emissions for running the business and getting staff to and from their workplaces and will operate monthly carbon accounts which will be audited by inspectors.

The above broad brush summary of primary carbon emissions from a 10m2 of work space, (ie that needed for one person) for an occupied building, these heads clearly illustrate the need for an holistic review for the running of offices and home or creating master plan strategies for new towns and modern methods of living.

Travelling to work by fossil fuelled cars, even relatively modest distances can generate about 40% of the total carbon emissions created by the office! Walking to walk has significant social, health and environmental benefits.

If fossil fuel car journeys can be eliminated then in broad terms the office carbon emissions can be reduced to around 1.6 Tonnes per person for a normal office and considerably lower for a well designed "Virtual Office" & home.

It is important to locate the office and staff close together to minimize travel, irrespective of the form of transport proposed. It is justifiable in both carbon and financial terms to build new offices close to accommodation centres than to continue in present business locations and to stop the social trend to travel from anywhere to anywhere to work.

Regional based divisions do function well on an environmental and social basis. Planning legislation would need to be changed significantly to allow a more mediaeval town structure to be created. This type of structure combined with modern communication systems which support "virtual office" working provide very sustainable life styles.

The embodied energy of a building when spread over a fifty year life is quite limited when compared against the other issues. The efficient in-use running energy of the building does further contribute to the reduction in carbon emissions. Well designed and carefully operated buildings/ equipment can produce a reduction of around 50 to 75% of the in-use carbon emissions from the building, which yields a saving of around 0.6 Tonnes/annum.

If the will and focus for extreme savings were created by governments, this would need social structure changes, legislation changes, significantly diminished travel, better designed offices with "virtual" operation by the use of technology, total carbon reductions of 80%, ie 4.1 Tonnes/annum per person could be achieved on current output level. This magnitude of saving is achievable and society would be much happier and communities would also be safer places in which to live.

Carbon footprints can be worked out for each organisation. This will become necessary when carbon taxation and inter company carbon trading takes place.

Carbon quotas will be traded as a commodity!, being bought and sold on the world exchange markets.

A visionary holistic working and living strategy will yield the greatest benefits on ALL assessment scales, be it social, economic or environmental.

Summary

The content of the paper has highlighted the typical carbon emissions for running offices, embodied energy for the construction of buildings and the impact of fossil fuel travel to and from work. These items have been generically discussed in a broad and open frame work to allow an understanding of the subject to be grasped.

The current Building Regulations are actually increasing the energy use of buildings and indirectly encourages the need for energy hungry cooling systems. However, even if this were not the case the replacement rate of building stock is around 2% per annum and therefor has a very limited benefit in the short term. It should be remembered that around 45% of the total energy demand for the country is used in running the buildings.

It can be see that building designers can reduce the energy demand of new buildings by 50% with care. If all the building stock were transformed today to this standard only a 20% reduction in UK total energy use and carbon emissions could be achieved.

The social economic structure of society must change to meet any meaningful reduction in carbon emissions. The need to use the fossil driven car must be eliminated. The loss of fuel tax would need to be redistributed to other areas. The resultant reduction in car emissions would save around 50% of the UK total carbon emissions if air travel is ignored. If road building programme budgets were spent on relocating people to their workplaces then significant real reduction in carbon emissions would be achieved.

If society lived and worked in the same town significant benefits can be gained. Legislation and planning strategies would need to be changed to achieve this. The improvement in IT links in the last few years can create "Virtual Office Desks" whilst not being present within the HQ. Socially the towns would be better places to live, staff would be more productive, healthier and happier.

Governments could create a platform for this to happen if they were wedded in stopping the rapid climate change mechanisms currently active.