The University of Warwick

ENERGY, CLIMATE AND BUILDINGS – THE DYNAMICS OF CHANGE

Which processes help sustainable building to happen Faster?

Chris Butters

This paper discusses challenges of energy policy for more effective delivery of sustainable and energy efficient buildings. Solutions have long existed but they are spreading only very slowly. In contrast to a prevalent focus on technological solutions, recent experience suggests the need for more attention to the processes and dynamics of change.
With regard to energy efficiency and, more broadly, sustainable building, countries are at very different stages of development; policies need to be adapted both to prevailing contextual realities as well as tailored towards facilitating more rapid progress. Opportunities, drivers and barriers are discussed briefly. In particular, we ask if experiences of successful processes of change can be transferred to developing countries. Examples such as the passivhaus movement in Europe highlight the local and cultural nature of the contextual dynamics involved.
The UK funded ELITH research program (1) addresses sustainable low cost housing solutions in the context of hot climate developing countries. The ELITH program concludes in mid-2016; this document is a review and discussion paper.

INTRODUCTION

Reducing energy use and climate emissions in the built environment is a priority worldwide. At the scale of *individual buildings* this comprises two elements, new build and refurbishment. At the *urban* scale, less discussed here, it similarly concerns both new cities and equally, the daunting task of restructuring existing ones, both as regards transports, spatial zoning, energy systems and other infrastructures.

In regions such as Europe and North America refurbishment of existing buildings to an energy efficient standard is a high priority, since the pace of new build is slow, typically only around 1% annually – hence the saying, *most of tomorrow's buildings are already built*. In many developing countries the situation is different. Urbanisation is rapid and often plagued by insufficient knowledge, regulation or control over what is built. The cities of these regions are therefore fast locking themselves into major future energy and emission problems. Buildings that are only a few years old, as well as the urban layouts, are often of a poor energy standard and can be said to need efficiency improvements already. Rapid growth has often been at the expense of local environments and, ultimately, of living quality too: "*Hong Kong's first large-scale sustainability research initiative (2) has revealed the astonishing deterioration of the environment. The main environmental problems are associated with over-concentration due to high-rise and high-density development, and include poor air quality, water depletion, noise, and excessive waste production*" (3). At the same time, many improvements to current design and building practice are quite simple and cost little if at all more.

In Europe, refurbishment of thousands of 1960's and 70's apartments, typically of 3 to 6 storeys, is a large task. In China on the contrary many blocks of that type, dating from as recently as the 1990s, are already being demolished and replaced at breakneck speed by high-rise blocks. Just one example of the predominance of new build: "At the time of the survey, almost 80% of the residential construction projects in Xiamen Island were built after 1990, whereas only 6.7% of the

construction was built before 1980" (4). The speed of such change leads to missed opportunities to avoid future energy/climate impacts. Pressures of rapid urban expansion and economic growth often result in hasty planning and avoidance of strict requirements which may be felt to hinder growth.

Yet it is not the knowledge that is lacking. Even without aiming for state of the art performance, energy requirements in buildings can be halved with fairly simple measures. There are excellent exemplar buildings to be found in all parts of the world, including in developing countries. Zero energy and zero emission buildings (accepting some vagueness in definitions) are already a reality. But this is simply not happening on a wide scale. At the same time, there is now a worldwide political consensus on rapid cuts in climate emissions. But rapid progress, of the kind now widely endorsed by politicians, seems improbable, both in developed and developing countries, albeit for different reasons. The main challenge today is, we suggest, not one of *technological advances* but one of *delivery*.

PROCESSES OF CHANGE

The potential savings - *avoided future impacts* – of preventive action are without doubt very large. Recent European buildings provide useful benchmarks. In *passivhaus* for example, energy reductions of 70 to 90% are being achieved for only small incremental costs. At the community scale, recent European eco-neighbourhoods and city districts achieve similar results as shown in fig. 1 and 2.

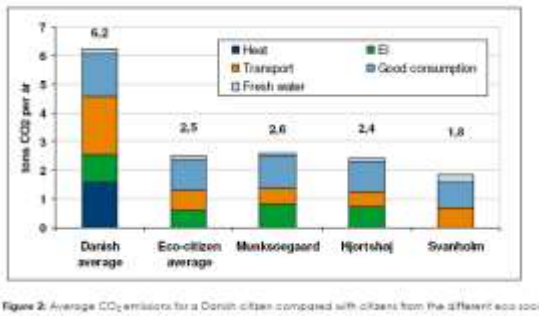


Fig. 1. Danish ecocommunities achieve around just one third of the national ecological footprint. Sources: GEN Europe + Pøyry AB (5). Note: the misleading word "good" refers to "consumer goods"

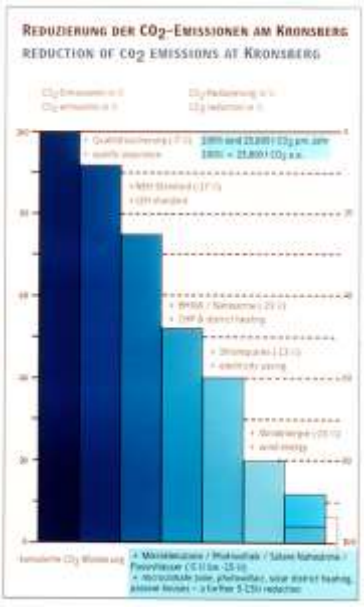


Fig.2 (right). Urban scale: reduction towards zero carbon footprint of the Kronsberg area, Germany (6). By 2010 the area had emissions of about 80% less than conventional cities.

Traditional building practice evolved slowly on the basis of trial and error, innovation and experience. Given today's energy and climate agenda it must evolve rapidly. Can this be achieved? Since the construction sector accounts for 30-40% of the problem (7) there will be increasing pressure in all countries to change building practice, including mandatory standards. But in many developing countries, imposing let alone enforcing energy efficiency requirements is seen as premature if not impossible. It is therefore useful to ask: what dynamics and processes have enabled the spread of low energy solutions, including successful building codes, in some countries. By understanding these historical processes one may perhaps devise strategies for developing countries to move towards building codes and sustainable practices more rapidly. Naturally, approaches will have to be very different in different cultural contexts.

This paper therefore briefly addresses the following:

1.The *processes, drivers and dynamics* behind the emergence, and relatively successful spread, of energy efficient building practice in European contexts
2.Barriers and lessons to be learned from both successful and less successful initiatives
3.What processes could apply in developing countries; observations on transferring experience.

TOWARDS ENERGY EFFICIENCY: THE DYNAMICS

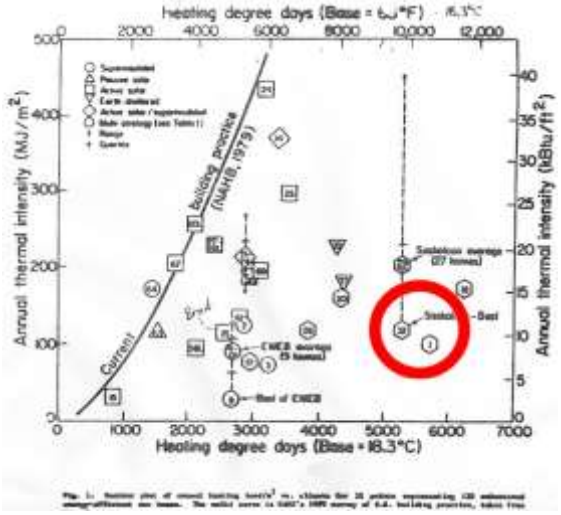
The following is a very brief summary of the progress of the energy efficiency agenda in buildings in Europe and North America.

The energy issue was sparked by environmental awareness in the 1960s, Rachel Carsons's book *Silent Spring* (8) often being cited as a forerunner. It was reinforced by the oil shocks of the 1970s. Influential publications such as *Limits to Growth* (9) Club of Rome, 1972) and Amory Lovins' *Soft Energy Paths* (10), 1977) attracted attention but little practical action. An early focus was on *alternative*, i.e renewable, energy rather than on energy efficiency. Exemplar green buildings produced by pioneers aroused fairly wide interest (fig. 3), but the ideas did not spread, particularly as oil prices fell to low levels again. In addition, the environmental focus was initially mostly on motor vehicles and industrial pollution not on buildings. The large role played by the building sector was little understood until considerably later.

Why has change been so slow? The first nearly zero energy buildings were built and tested successfully long ago; in Saskatchewan, Canada, where the climate is as cold as that of northern Norway, *passivhaus* performance was achieved as early as 1979 as shown in fig.4.

Fig.3. An early passive solar eco-house. Steve Baer, USA, 1970s. Source: S.Baer.

Fig.4 (right). Canadian houses in near Arctic climate achieved passivhaus standard, 30 kWh/m2.year, of which over half is for hot water – in 1979. Source: (11).



Circled in red: the Saskatoon, Canada superinsulated houses. Source Lawrence Berkeley Laboratory, USA.

Designers, clients and the construction industry itself are reluctant to change unless innovations correspond to widely perceived needs or advantages in the market - and to political goals. This was not the case in the 1980s. Green building remained very much a minority interest. The goal of sustainable development arose following the 1987 Brundtland Report (12) and the 1992 Rio conference (13). Energy, and in the 1990s climate change, came into focus, with many reports and policy papers being written, yet still attracting limited public and political priority. Although pioneering researchers such as Sweden's Thomas Johansson had already urged the need for radical downscaling of global resource use, and shown it to be possible (14), environmental policy remained a minority concern. The 1992 Rio conference, in particular its "Agenda 21" declaration, acknowledged that broad backing is essential for sustainable development; political leadership cannot channel major efforts into such agendas without sufficient popular backing.

Hence, we have seen that *voluntary guidelines* for environmental products, including consumer appliances and green buildings, often become the first step in the process of change. Experience slowly accumulates. Interest grows. Only when new practices have been shown to be achievable - without major costs - can authorities take the step of making *binding* regulations. This is not only the process in typical democracies; public understanding and acceptance play a large role in most societies.

THE PASSIVHAUS MOVEMENT

Our question is how more rapid change can be encouraged. One experience of *the dynamics* of such change can be found in the pioneering Vorarlberg region of Austria and in southern Germany, where the *passivhaus* trend developed (15). It is a remarkable story. Led by a small number of pioneer designers, the movement developed first by example and informal guidelines. A minority of eco-committed clients created an emerging market. Local builders then learned and refined the solutions. By around 2005, the impressive energy results were apparent. Initially only applied for houses, other building types such as schools and offices were soon achieving the same results, with energy use less than a quarter of conventional buildings. We have a reservation that this one-sided focus on reducing the operational energy needed for heating has led to a somewhat narrow approach rather than diversity; but the success of the *passivhaus* in operational energy terms has been spectacular. The *passivhaus* approach has, within just a decade, become the basis for building regulations in the entire EU. In addition EU policy states that future requirements will soon be even stricter – *nearly zero energy* - thus serving notice to designers and builders of the direction of future requirements,

In Norway for example, building regulations included strong environmental *recommendations* already in the 1980s, but binding requirements for energy efficiency were only slowly tightened – until the success of the *passivhaus* movement became apparent. The agenda then moved extremely swiftly. By the time of the EU Directive of 2012 (16), summarised and reviewed in (17), it had become accepted that zero energy or emission building – if not always well defined – should be the required norm within less than ten years. This was an unusually rapid change of paradigm. How, then, did this dynamic happen?

The *passivhaus* pioneers built on the experiences of the 1970s, including a broader ecological agenda than just energy, but the movement emerged at a time when external conditions and public awareness had moved on and were becoming far more favourable. Whereas energy prices still played only a minor role, the climate agenda in particular had become a major driver. This favourable condition is to a large extent now in place worldwide; although the recurring fall in energy prices (as at present, in 2015-2016) tends to disturb the impetus provided by the climate agenda.

It should be noted that official building codes only pose *minimum* requirements. They do not encourage *advanced* solutions, which must be incentivised in other ways. The *passivhaus* standard was initially completely voluntary. Only when sufficient momentum, and results, were achieved, was it adopted for official standards. One may compare this dynamic to that of kitchen appliances and other eco-friendly products. These were supported by environmental organisations and bought, initially, only by eco-consumers despite higher prices; an idealistic and voluntary process. What was initially a *revolutionary low energy* fridge – developed by Jorgen Norgaard in Denmark in the 1970s (18) – eventually indicated the standard for *minimum* energy efficiency requirements. The *technological* modification was in fact quite easy. But it took over 30 years to become common practice. This was in advanced countries where research, public information and governance are of a high standard. What, then, are realistic perspectives for rapid change in developing countries which lack resources, skills, institutions and governance capacity?

Another relatively successful story is that of the building certification scheme BREEAM in the UK (19). Others such as LEED in North America and CASBEE in Japan are influential but have to date attracted less application. These, too, are basically *voluntary* systems for achieving more energy efficient and "greener" buildings (and other products), above and beyond what is required by law. Buildings are rated into different classes such as gold, platinum etc., or as good, excellent, outstanding. Despite some

inherent weaknesses and a certain "box-ticking" tendency, these have greatly advanced awareness of energy and associated issues in the building industry in countries such as the UK. By demonstrating that higher performance can be achieved, they also influence government policy as to minimum *obligatory* standards. Similar green building "guides" are now available in some developing countries too but are not widely applied due to lack of interest, resources or both.

One can thus point to relatively successful moves towards sustainable building with significant market penetration with the *passivhaus* trend, in Switzerland with *MINERGIE*, or in the area of commercial and other buildings with the BREEAM system – which has now certified over two million buildings. There are also successful stories of change towards sustainability at the local level (20). Both carrots and sticks, local factors and public policy, can be discerned in various forms in those narratives. The overall rate of change is still slow, but there are positive lessons to be learned. Can such successes be reproduced elsewhere?

The well-known case of the phasing out of CFCs in the 1980s demonstrated a somewhat different dynamic; once they had been recognised scientifically as a problem, international consensus and ensuing legislative action was achieved quite easily because alternative technical solutions were readily available. This is seldom the case; easy substitution is an exception. Or is it? There is reason to say today that energy efficiency measures in buildings are easily available, and economically worthwhile. What other factors are hampering market penetration?

AGENTS AND DRIVERS OF CHANGE

The four main potential agents of change in this field are government, the construction industry, building and design experts, and the public (fig.5). All four are essential and the process may not advance if any one of them is missing.

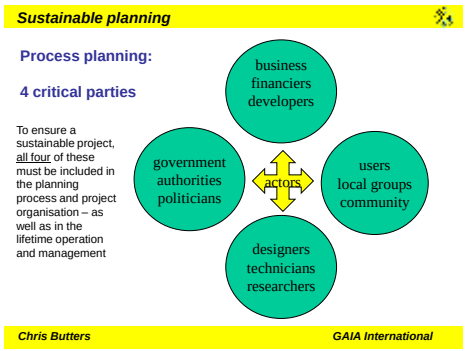


Fig.5. The four agents of change. Source: the author.

Fig.6 (right). Existing urban buildings can also be refurbished right up to zero energy standard. Zurich, architect Karl Viriden Partners. Source (21).

The *initial drivers* behind green architecture were pioneers in North America and Europe – a bottom-up, voluntary process amongst two of the above agents: designers and a small public. It involved much unfunded research; which of necessity included many failed good ideas too. This initial phase attracted broader support due to the oil shocks of 1973 and 1979, with much research on green building, renewable energy, energy analysis and more. In the 1980s interest dwindled. Yet some work continued. Typically, designers such as the author's GAIA architecture group in Norway and elsewhere (22) continued to develop green solutions for a small number of clients, until the much broader and global focus on environment, plus that on climate, emerged in the 1990s.

As a *second phase* driver came the official, top-down agenda of sustainable development. Aided by both environmental movements and science, this fostered public awareness about energy, climate and hence

green building. An increasing body of research lent weight to the process. The top sustainability issue today is the global climate agenda. In this phase, the third of the above four agents, namely the authorities and public policy, come into play. There was no such driver to move the process in the 1980s – even though *the same results were being achieved* in low energy buildings.

Fig.7. The political level: The Aalborg + 10 Declaration: 500 mayors for sustainable cities. Source: ICLEI (23)

The *third phase driver*, which is now slowly coming into play, is the fourth of the above agents – the market itself. In almost no case has the *construction industry* itself – neither developers, financiers, materials producers or real estate business – been a proactive driver for green building. It is however essential to involve the industry. Processes in Europe show the importance of local factors. The Vorarlberg case shows an unusual dynamic, where designers and builders, plus clients and the timber industry, have close links thanks to a small, intimate micro-regional culture. It illustrates how the process of change depends on a local dynamic which fosters innovation. Characteristics included a small regional context with close ties, a good skills base, a tradition of cooperation, and not least a group of innovative individuals. These leaders were also good communicators (24). The Scandinavian case, again somewhat exceptional, is that of a consensus society where private and public sectors, as well as "establishment" and "radical" forces, tend to engage in dialogue and cooperate quite closely. The construction industry there joined the sustainability trend quite soon and with genuine engagement. In the UK, where major private housing developers have much power, there is a large gap between political rhetoric and business and arguably rather more empty talk; in such cases industry needs to be coerced to a greater extent. All three examples tell us that there is no ideal solution and show the great importance of local cultural factors.

At the urban level, the leaders of well-known sustainable developments such as in Malmo city in Sweden similarly stress the importance of local factors, some of them quite banal – for example, *continuity* within both the expert groups and the political leadership. Another strong driving force has been the effect of local employment crises. Another, in the Swedish context, has been strong *top down support* from government for sustainable policies. Sweden has exhibited progressive energy thinking and policy since the 1980s. Importantly, this top down approach included involving both the public and industry. Again, this is easier in a consensual society where government leadership is generally accepted rather than viewed with suspicion or resistance.

Experience in Europe shows clearly that the market for sustainable buildings does not emerge by itself, without sufficient science and public support as well as *strong public policies*. Politicians have often given the market conflicting signals, for example as to future subsidies for renewable energy. Germany's proactive – and consistent – policies on renewable energy are an example of quite successful market stimulation. Various instruments such as energy taxes, grants, ecolabelling and stricter emission requirements have been definite drivers.

Inertia or resistance to change can be found all societies; hence it is often said that only some form of profound crisis stimulates change. All sectors tend to resist change. It may be noted how *ecolabelling* of products has followed the same dynamic, facing initial resistance or apathy, and moving from voluntary

guidelines promoted by environmental NGOs from the 1960s onwards to official, mandatory standards and legislation in the EU today – such as the Products Directives and the Directive on Ecodesign (25).

Supported by research and exemplar building programs, it has thus become possible for Europe to develop detailed guidelines, benchmarks, design software, and later regulations, for energy efficient buildings. New building products then follow quite rapidly; showing that technical change by the industry is possible fairly rapidly. In Scandinavia, for example, whereas we initially had to import products from Germany, *passivhaus* type energy windows and wall elements were produced locally within about five years. This shows how industry can innovate quickly when pushed to do so.

Effective drivers vary in different cultural and socio-political contexts. Whilst the initial or main drive may come from any of the four main groups, it is essential that *all four* be involved in order for change to occur rapidly.

STRATEGY AND POLICIES

Many elements form part of a successful strategy. Most are obvious; but it is their detailing and coordination that counts and there have been many disappointing initiatives. Key elements are research, pilot constructions, dissemination, market interventions, capacity building, education of officials, decision makers and the public. Developing country situations in particular require large HRD inputs since the process presupposes sufficient planning and administrative structures as well as reasonably good levels of professional knowhow, training and public awareness. The following are brief notes on some of the main arenas of action for change.

Technical research and innovation is important but, we would argue, should not be overvalued; research funding is too often linked to an economic goal of creating and selling new products. We *already know* many solutions for zero energy or zero emission buildings. What we do not seem to know, is *how to get there* - at a reasonably rapid rate. Many of the basic principles have been known for decades. This applies as much to urban planning as to individual building design; even though some features such as embodied energy have not been highlighted until more recently. Energy policy and research should recognise that *technological* innovations are of limited use, if the governance and implementation conditions needed to achieve even modest rates of *delivery* are lacking.

Economic and fiscal instruments can include rewards such as tax relief for achieving documented benchmarks, rather than punishments. Both carrots and sticks are needed¸energy pricing may be used to influence consumption, for example applying higher tariffs for consumption above certain thresholds. A wide range of instruments have been used with varying success. As noted these can easily be poorly targeted, too bureaucratic, or too little to stimulate change. Subsidies must be sufficient to make low energy practice attractive to the very influential private sector developers. Lessons are to be learned from Europe in achieving an effective balance between these. Often the incentives are not enough – or else are withdrawn too early, before a market is established. On the other hand, if rarely, public incentives may be *too much*. Under the Carter administration in the USA around 1980, for example, solar energy was subsidised so much that products appeared which could never become profitable in a normal market (fig.8).

Building codes as well as non-binding guidelines are a key instrument. In developed countries energy requirements have been introduced to apply also to retrofits or additions over a certain minimum size. Introducing energy regulations can have far larger effects in developing countries where new build is predominant. Given the climate and energy agenda there is little doubt that energy efficiency codes will quite soon be introduced in all countries. There are strong arguments in favour of early introduction of recommendations or voluntary codes, as well as certification systems such as LEED, BREEAM and CASBEE. Similar systems are being introduced in developing countries (26). They prepare the ground for later introduction of mandatory standards and provide a key step in a longer process - of mind-set change, not quick results.

Support programs and initiatives are most useful where there is an existing local dynamic. This requires tailoring initiatives to specific target groups or communities rather than a diffuse approach by central policymakers that has often seen disappointing results in Europe. Good solutions can spread only if they are implemented and communicated through *strong local actors*. This, the fundamental message of Local Agenda 21 – think globally, act locally – has been proved many times. The most determined green builders and local sustainability initiatives have succeeded with little or no financial support; but many good ones have faded away where only modest support would have sufficed.

Fig.8. Too complicated solar systems, Minneapolis USA 1981 – payback time several hundred years ... Source: the author.

Fig.9. Buildings that produce more energy than they need… Plus-energy housing, Freiburg, Germany 2004. Source: author, see (27)

Civic movements and NGOs can play a key role. In Scandinavia, NGOs are encouraged and partly funded by government even if they oppose public policies. The case of the Vauban ecodistrict in Freiburg, Germany (28) demonstrates the essential agency of local civic organisations in keeping such projects alive over many years – a proof of the *leitmotif* of Agenda 21. The users are the only ones who can, ultimately, *sustain* development. However, in many countries civic participation is not strong. Successful top-down programs have often made deliberate efforts to stimulate bottom-up activity. This includes support to SME's in the construction sector with focus on low energy building and low embodied energy materials; and supporting NGOs as purveyors of civic awareness. In some contexts this can have the added advantage of avoiding suspicion attached to state-led interventions.

Exemplar buildings are essential; there are few better ways to persuade neighbours, the public, the media or sceptical politicians than real-life examples. In this regard the lessons learned – the mistakes as well as the successful features – are equally important. But the effect of pilot projects on the market is slow, as witnessed by the very slow spread of low energy building, even when successful, at least until the *passivhaus* movement. The first nearly zero energy buildings date from the 1970s, and "plus-energy" buildings have existed for over a decade (fig.9).

Public building: In many OECD countries the state deliberately plays a leader role by commissioning energy efficient public and community buildings. This also stimulates the building industry market. State and local authorities are often the largest commissioners of construction nationally. Public planning offices can play a leading role in research and methodology development. Examples (29) are the process-oriented *Kvalitetsplan* for the Western Harbour development in Malmo (30), or the Climate Calculator tool developed by the Directorate of Public Construction in Norway. (31)

Education and training: higher education within planning, architecture and engineering as well as for the building trades is essential; but even now it rarely has a strong sustainability focus even in OECD countries. Key actors such as property investors, developers and the real estate sector are often neglected. Early education during schooling into understanding energy, resources and consumption is equally important. – as in the exceptional Childrens' Ecocity project (fig.10).

Local culture and context are keys to successful delivery – to a larger extent than is often recognised, despite long experience in "failures"". Changes in building practice, such as for energy efficiency, must be selected in consideration of whether they can be introduced without major modifications in the knowhow or customs of end-use consumers and of the building industry in question. This requires a less theoretical approach and a good grasp of local building practices.

Fig. 10. Education: teaching children to design their own sustainable city. The Childrens Ecocity project, GAIA Edinburgh (32)

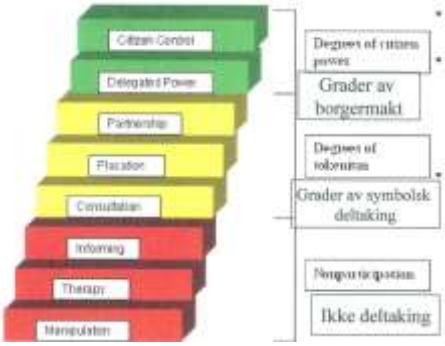


Fig.11. The Ladder of Participation, developed by Sherry Ortner, USA.

Public and grassroots: There can be no successful dissemination of sustainable practice without public understanding and support. For this reason, there has been much focus on participatory methods of planning. This requires particular skill; there are lessons to be learned from poor participation processes where the involvement of users is more symbolic than real and where stakeholders have developed "partnership fatigue" at being constantly invited to exercises that do not offer genuine empowerment (fig.11). In some developing countries such as India, grassroots traditions are strong, in others not. Some very successful sustainability initiatives both for buildings and whole communities have been entirely participatory. The "fossil free" island of Samso, with a population of 4,000, converted to 100% renewable energy within only 10 years, with the participation of most of the population (fig.12).

Fig 12. Local sustainable community: Samso, Denmark achieved 100% renewable energy within 10 years. Source: (33)

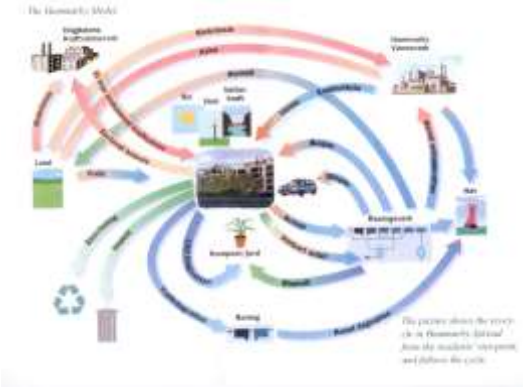


Fig.13 The "Hammarby Sjostad model" for integration of urban resource cycles, Stockholm, Sweden. Source: (35)

BARRIERS TO CHANGE

Business and the construction industry are primarily concerned with the bottom line of profitability, but there are increasing win-win opportunities in green business. The broader goal, which includes corporate social responsibility, is - in the American expression – the "triple bottom line" of *people, planet, prosperity*. Influential property and construction business leaders, as well as organisations such as the international Green Building Council, now play a strong role. Ideally there should be close cooperation between industry and the authorities. Industry often has the expertise as well as the capital, plus the ability to move more quickly than official institutions. Such cooperation is quite good in

some countries, as in Scandinavia where industry is also quite transparent and accountable. It is often industry itself that develops standards for new products or legislation for pollution emissions. The industry initially resisted *passivhaus*. Faced with mounting evidence that *passivhaus* type buildings worked, were not that difficult, and cost only a few per cent more than current practice, this opposition has almost vanished. Instead, businesses are hastening to be at the front of the field. This also highlights the usefulness of a pragmatic approach, examining current building practices to find the low hanging fruits, win-wins, or where there are low barriers to changes

Sociological and cultural barriers are widespread; both construction habits, and perceptions that concrete is more desirable than adobe, or that air conditioning is an essential status symbol. Barriers to change are often far from purely economic or rational. These issues are insufficiently studied within engineering or within the energy and climate sectors (35). There is also a persistent "value-action gap" between what people want and what they actually do. These as well as the many other reasons for inaction are discussed in several reports (36).

Institutional barriers include weak planning and governance structures and insufficient knowhow. There are important structural issues too, such as property markets and legal systems. For example, those who construct and sell buildings are often not the ones who will have to pay the future energy bills. Similarly, in the UK there is little incentive for the landlords of the many rental homes to do energy retrofits, since it is the tenants not they who will benefit. In China, urban land is only leased, not owned, which seems a major factor discouraging a long term view; buildings will be built in a less careful way and not maintained towards the end of the lease period. This kind of institutional barrier – the *split incentives* issue raised by the World Bank and others - is critical in sustainable development.

Financing and ownership are, naturally, key barriers. Financing of energy efficient new build as well as retrofits can be stimulated by public incentives, and this has been done with some success – such as subsidies for new windows, insulation, heat pumps, solar panels etc. However, these incentives are often too little to trigger substantive action. They have often been either poorly focused, such as uncritical subsidising of poor quality heat pumps - or overlooking *priorities* such as insulation - or too bureaucratic. There are certainly lessons to be learned from these errors. Ownership is another common barrier; programs can be made for public buildings, but it is difficult to imagine all or even most owners in streets of several hundred houses retrofitting within a short period of time, for simple reasons of personal consumption choices and inertia.

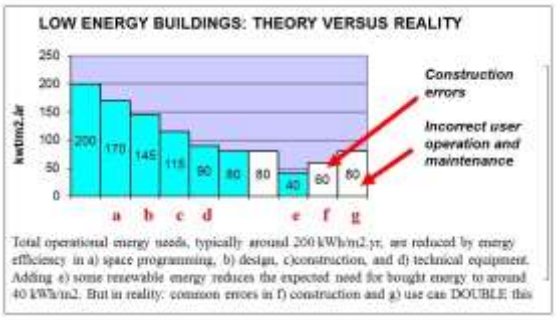
There are many policy documents addressing the above considerations. However, none of the above are *technological* barriers. The human dynamics require far more attention if we are to succeed; this is a critical pointer for future work in developing countries.

LESSONS LEARNED

An important lesson emerging from energy efficiency work in Europe is that results are often much less than estimated. Inefficiencies can occur at all stages of the process, from design to installation to operation. In particular, user behaviour as well as inefficiencies by builders tend to reduce the potential savings appreciably, as illustrated in fig. 14. Actual energy use in *passivhaus* buildings can be double what was calculated. This puts policy leaders in the position of making unrealistic promises, and building owners in the position of having far longer payback times than expected. Reasons for this have been analysed in post occupancy (POE) surveys (37), and include both user behaviour, installations that are not user friendly, and an over-reliance on technical estimates and efficiencies. For example, a very large Swedish study found the average efficiency of ventilation heat recovery systems to be, far from the expected 70%, less than 30% (38). Not least the "prebound effect" is coming into focus (39). If this is the reality of real people, it highlights the inadequacy of theoretical efficiencies. These pitfalls demand serious attention.

Above all what emerges is the importance of a local dynamic; opportunities and barriers are local by nature. A good dynamic is often partly fortuitous and usually based on strong individual initiatives.

Simple factors such as continuity, often a problem in democracies, may be pivotal – as is stressed by experience such as in Malmo and Freiburg. Strategies are applicable at certain stages of development. If for example it is too early, for whatever local reasons, to introduce building codes, the key is to prepare the ground for codes to be acceptable at a later stage, through awareness building, pilot projects and knowledge enhancement plus voluntary recommendations. One must build the first rung of a ladder in order to facilitate the next rungs.



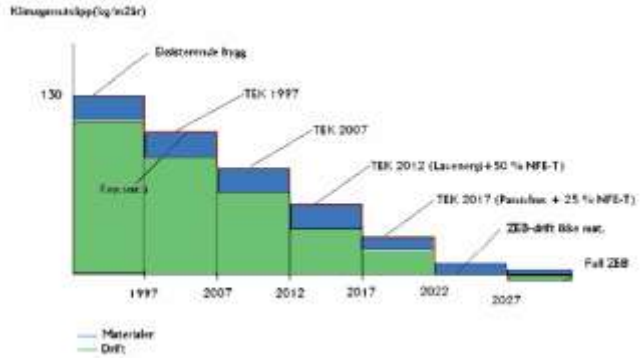
Minna Sunikka-Blank & Ray Galvin:

Introducing the prebound effect: the gap between performance and actual energy consumption

Building Research & Information, 40:3, 260-273. *UK, 2012*

Figs. 14 and 15. In real life, due to human factors the achieved energy savings may only be half what was estimated. «… the result of a narrow technical focus may be far less energy savings than expected, and a far longer payback times for consumers than promised». Sources: the author fig. 14, BRI fig. 15 (39)

For developing countries, there are also important emerging trends to be noted in recent European and North American experience. The initial narrow focus on *operational* energy has moved towards a broad approach including areas such as life cycle analysis, natural ventilation and embodied energy; plus the carbon perspective. For example, it is now recognised that the embodied energy of construction materials, once thought to be minor, may be over 50% of the total life cycle energy picture.



As buildings develop towards nearly zero operational energy (green), the embodied energy (blue) will become the predominant factor.
Source: *Anne Grete Hestnes, NTNU Trondheim, Norway 2010 (40).*

To what extent can *technical* experience be transferred? Solutions are specific for different climates and cultures, but the same *basic principles* apply. The focus on operational energy has as noted shifted to a broader view including embodied energy (or carbon) as well as the big role played by non-technical and behavioural issues. “The technology driven approach creates the risk of poor user orientation or conflicts with indoor environmental quality” (41).

What interventions are most useful in other countries? One may broadly distinguish two types of country, those that are already fast developing and those that are as yet less developed (with reserve as to the conventional concept of development). Awareness is often limited, as are available skills and resources. In many countries planning and building regulations are non-existent or not enforceable in practice. Countries like our ELITH partners China and Thailand have regulations for public buildings, including for energy efficiency, but not for the private sector. And imposing regulations may be seen as hampering economic growth. In countries like Uganda and Tanzania there are as yet none at all: given weak planning and governance capacity, a common view is that regulations will not be feasible for many

years to come (42). Even given resources, many strategies may not be feasible in local contexts. As one study of possible strategies in the Chinese city of Ningbo concludes - "the discussion of suitable countermeasures shows that only enhanced supervision strategies are currently applicable" (43).

It is not transfers of *technical* knowhow which are in question here, that is if anything the easier part. More difficult, but arguably more important, is transferring understanding of what *dynamics* of change will promote energy efficiency. What processes could be successful in countries such as China and Thailand – or in ones like Tanzania and Uganda? Two defining characteristics of the former countries are that strong government action is possible, and that considerable technical capacity exists. In contrast, two characteristics of the latter two countries are weak governance and a low level of knowhow.

In research, training and information, countries such as China and Thailand have high levels of skills and quite ambitious activities. However, key actors such as housing authorities, property investors and developers are often neglected. Dialogue with these is difficult but has been prioritised by us. In our African partner countries there is far less training and educational capacity at all levels and this has therefore been a key concern of the ELITH work there.

Fast growth is far from only positive. The example of the "Tiger Economies" highlights what may lie ahead on the development path and the opportunities in taking early preventive action. There is now a large body of research from countries such as China, yet it seems fair to say that most *applied* state of the art research and development in energy and climate building issues has been within the OECD. Hence, for countries at the bottom of the "development pyramid" there are as many lessons to gain from countries such as China, as there are for both groups from experience at the top of the pyramid.

Trends in Europe provide clear signals for developing countries: there is an increasing body of legislation regulating products according to sustainability criteria, including building products. There is also a growing trend away from fossil fuel-based and energy intensive materials. For example there are now large EU programs devoted to researching bioplastics made from plant materials. This is a particular opportunity for many developing countries where such materials are widely available.

CONCLUSIONS

This paper addresses sustainable built environments, with particular consideration of the dramatically increasing energy use and climate emissions of the new urban populations in the cities of developing countries. However, whilst over half the global population is or soon will soon urban, we must not forget the rest – the rural contexts, as well as the millions living in slum conditions; these are "the other half" and, not least, are often those with the most pressing needs. Their *energy and climate* impact is small, as of now, but their living and health conditions are poor and demand equal attention. Living conditions might be dramatically improved, also avoiding increases in energy use, through simple refurbishment interventions at a low cost.

The climate agenda sometimes appears to be a diversion, with many reports and global conferences but little action. In our view most of the advisable actions would be good policy and good common sense, *with or without a climate problem*. Such qualities as traffic free streets, less air pollution, better indoor environments, less deforestation, more green space, more recycling, healthy building products, and low or even zero energy bills for consumers, are all good solutions regardless of climate.

Leading institutions like the World Bank are increasingly aware of the gap between possibilities and realisation and the need to focus on issues of delivery (44). We need to explore the interface between technical research, policies and delivery processes. Financing, whether public or private is naturally a major barrier everywhere, but doubly so in developing countries; even though many studies including the influential Stern Report (45) show how much energy, emissions and money could be saved through action now as opposed to delaying. Processes of change need as much market-led dynamics as possible, but one cannot deny the absolute limitations of liberal market economics in delivering sustainability.

This paper briefly highlights processes, drivers, barriers and dynamics that can foster, or hinder, change towards sustainable building. This complex field encompasses perceptions, technologies, market forces, policies and cultural dynamics of many kinds. Solutions exist and have long done so, but are spreading only very slowly. The urgency of sustainable building ranges from issues of poverty to ones of energy security and global climate. Our underlying postulate is that there is a need for far more focus on *processes and dynamics of change* in order to speed up the transformations required.

…….

Acknowledgement:
This document is an output from a project co-funded by UK aid from the UK Department for International Development (DFID), the Engineering & Physical Science Research Council (EPSRC) and the Department for Energy & Climate Change (DECC), for the benefit of developing countries. The views expressed are not necessarily those of DFID, EPSRC or DECC. Grant number: EPSRC EP/L002604/1.

Rio 1992, Agenda 21: "For sustainable development to succeed, it must be anchored, and implemented, locally". A book of successful examples. Ed. C. Butters et al.,The Ideas Bank Foundation, Oslo, Norway 2010 (29). (downloadable pdf on the web)

SOURCES

In addition to work within the ELITH program this article builds on 15 years work with sustainable building and urban development in a mainly Scandinavian and European context, involving extensive dialogue with designers, researchers, authorities, community and political decision makers, and longstanding exchanges of experiences with leading sustainable designers and urban projects. The following is preliminary and not intended to be a full nor fully consistent bibliography

(1) ELITH – *Energy and Low Income Tropical Housing*. See acknowledgement; www.elith.eng.cam.ac.uk/

(2) Barron, W. and Steinbrecher, N. (1999) *Towards Sustainability?* Centre of Urban Planning and Environmental Management, University of Hong Kong, Hong Kong,

(3) Xing Quan Zhang (1999) *High-Rise and High-Density Compact Urban Form: The Development of Hong Kong*. Centre of Urban Planning and Environmental Management, University of Hong Kong, Hong Kong.

(4) Hong Ye, Kai Wang, Xiaofeng Zhao∗, Feng Chen, Xuanqi Li, Lingyang Pan. *Relationship between construction characteristics and carbon emissions from urban household operational energy usage*. Energy and Buildings 43 (2011) 147–152.

(5) LØS / Pøyry AB, *Reduction of CO2 from 3 different eco-villages in Denmark,* LØSNET no. 61-62, December 2009, Denmark, see also www.gen.ecovillage.org

(6) Kronsberg, http://www.hannover.de/Media/01-DATA-Neu/Downloads/Landeshauptstadt-Hannover

(7) This figure is to be found in many sources, including IEA, UNEP, etc.

(8) Rachel Carson, *Silent Spring*, USA 1962. (50th Anniversary edition Houghton Mifflin Company; 2002)

(9) Donella H. Meadows, Dennis L. Meadows, Jorgen Randers, William W. Behrens III, *The Limits to Growth*, Universe Books Club of Rome, USA 1972.

(10) Amory Lovins*, Soft Energy Paths,* Harper Colophon, USA 1979.

(11) Ribot and Rosenfeld, *Measurements of Low Energy Houses in the USA and Canada*, Lawrence Berkeley Laboratory, USA 1979..

(12) World Commission on Environment and Development, *Our Common Future*, Earthscan 1987.

(13) UNCED, *United Nations Conference on Environment and Development*, Rio *de Janeiro* 1992*, see* http://www.unep.org/documents.multilingual/default.asp?documentid=78&articleid=1163

(14) Johansson, T.J., Goldemberg J. et al., *Basic Needs and Much More with 1kW per Capita*, Ambio, Royal Swedish Academy of Science, Stockholm 1985, and many other seminal publications.

(15) see for example the Passivhaus Institute, Darmstadt, www.passiv.de

(16) EU Directives 2002/91/CE, Directive 93/76/CEE et al.

(17) Xavier Garcıa Casals, *Analysis of building energy regulation and certification in Europe: Their role, limitations and differences*, Energy and Buildings 38 (2006)

(18) Norgaard, Jorgen and Tom Guldbrandsen, *The Next Generation of Appliances: Visions for Sustainability*. Springer, Berlin 1998, and many other seminal publications since the 1970s.

(19) see www.breeam.com

(20) Butters C. et al., *Nordic – Success Stories in Sustainability*, The Ideas Bank Foundation, Oslo 2012.

(21) Butters C and Bente Leland, *Fra Passivhus til Sunne Hus*, GAIA Agenda forlag, Oslo 2012.

(22) see www.gaiaarkitekter.no www.gaia-ecotecture.eu and www.gaiagroup.org

(23) ICLEI, Local Governments for Sustainabiity, see www.iclei.org

(24) Oliver Loewenstein, *What Vorarlberg did Next*. Fourth Door review. http://www.fourthdoor.co.uk, UK 2009.

(25) EU Product Directives, see www.ec.europa.eu/environment/ipp/epds *; EU Ecodesign Directive* see http://ec.europa.eu/growth/industry/sustainability/ecodesign/index_en.htm

(26) For a discussion of this in the China context see W.L. Lee, Hua Chen, *Benchmarking Hong Kong and China energy codes for residential buildings*, Energy and Buildings 40 (2008)

(27) Solarsiedlung, Freiburg, see www.rolfdisch.de

(28) See www.vauban.de

(29) Butters et al (ed)., *Signals - local action – success stories in sustainability,* The Ideas Bank Foundation, Oslo 2010, pdf at www.iu.folkehogskole.no/.../e6ac6ddc303f0202cbf14c6d5d35210c.pdf

(30) City of Malmo, *Quality Programme Bo01* City of Tomorrow, Sweden 1999*, see* www.energy-cities.eu/IMG/pdf/BO01_EN.pdf

(31) Statsbygg, Norway see www.klimagassregnskap.no

(32) see www.gaiagroup.org

(33) Samsø Island, Denmark, see www.energiakademiet.dk

(34) Hammarby Sjöstad model www.energy-cities.eu/.../Sustainable_Districts_ADEME1_Hammarby.pdf

(35) E. Shove, *Beyond the ABC: climate change policy and theories of social change*, Environment and Planning A 42, 2010.

(36) Eds. Martin Kemp, Josie Wexler, *Zero Carbon Britain 2030, a New Energy Strategy*. Centre for Alternative Technology, UK 2010.

(37) Fionn Stevenson, Isabel Carmona-Andreu, Mary Hancock, *The usability of control interfaces in low-carbon housing*. Architectural Science Review, UK 2013.

(38) http://www.byggvarlden.se/nyheter/energi_miljo/article88331.ece , Sweden 2011.

(39) Minna Sunikka-Blank & Ray Galvin: *Introducing the prebound effect: the gap between performance and actual energy consumption*, Building Research & Information, 40:3, 260-273, UK 2012.

(40) Anne Grete Hestnes, *The Norwegian Approach*, ZEB conference Aalborg, 2010. See [15]http://files.portal.aau.dk/filesharing/download?filename=aau/nvc/zeb/~/pub/konference2010/praesentationer/Anne_Grete_Hestnes_The_Norwegian_Approach.Aalborg.pdf

(41) Evert Hasselaar, *Health risk associated with passive houses: An exploration*, Indoor Air 2008, 17-22 August 2008, Copenhagen, Denmark - Paper ID: 689

(42) Communications with ELITH partners KMUTT in Thailand and NHBRA in Tanzania.

(43) Jian Yao, Neng Zhu, *Enhanced supervision strategies for effective reduction of building energy consumption - a case study of Ningbo*. Energy and Buildings 43 (2011) 2197–2202

(44) Dr. Ashok Sarkar, World Bank Senior Energy Adviser, Washington, personal communications.

(45) Stern, N., *Stern Review on The Economics of Climate Change*, HM Treasury, London 2006.

…….