A ‘smart’ bottom-up whole systems approach to a zero carbon built environment

ABSTRACT:

Since the energy crisis of the mid and late 70’s, society has been aware of the need for a built environment that uses less fossil fuel energy. The built environment accounts for a large proportion of global fossil fuel use, however, it may be argued that the energy and buildings agenda is not being addressed at the depth or scale needed to meet global and national carbon dioxide emission reduction targets. Most actions to reduce energy use in the built environment have mainly used a ‘top-down’ decision-making approach, from government and industry, with little end user engagement. Greenhouse gas emission reduction targets will not be met without providing the technological and socio-economic pathways for achieving them. The paper is divided into three parts. Firstly it discusses the need to reduce fossil fuel use and the apparent failure to transition policy into practice. Secondly, top-down and bottom-up approaches are reviewed, advocating a greater emphasis a ‘whole system’ bottom-up approach in delivering multiple benefit solutions. Thirdly, the concept of ‘smart’ is considered in relation to bottom-up with its implementation at a regional scale.

Keywords: zero carbon, energy and buildings, policy to practice, bottom-up, whole system, multiple benefits

1 Introduction

A workshop organised by COST (European Coorporation in Science and Technology) and the Directorate General Joint Research Centre of the European Commission on ‘The Role of City-Regions in the Achievement of a Low-Carbon Economy’ in Brussels in February 2016 concluded that the transition of low carbon policy into practice should be speeded up, with a greater connection between policy goals and their practical implementation (Jones et al, 2016). It considered that business as usual will not meet the political targets and that a systemic change is required rather than incremental change, not just in technology, but also in socio-economic processes and governance, and there should be a new balance between top-down and bottom-up solutions with an increase in emphasis on bottom-up activities. The World Energy Council has reported that, “No one, neither policymakers nor business leaders, believes that we can go forward with business as usual. Everyone realises that there is a need to move towards an entirely new, balanced, low carbon energy system. But in order to achieve this energy transformation, the energy sector needs a clear roadmap – one that can only be achieved by coming to a consensus and setting an internationally accepted target” (World Energy Council, 2015). The COP21 (COP21, 2015; European Union, 2016) Paris agreement focused on countries reducing their carbon dioxide emissions through a ‘bottom-up’ approach, with countries establishing their own targets, which is contrary to previous agreements, which relied on top-down directives. Throughout the agreement, it recognises the need to build capacity to ensure that targets will be met, and that policy driven emission reduction targets will not be achieved unless there is a clear transition route through to practice.

This paper discusses some issues relating to the implementation of low carbon policy into practice in the built environment. It argues that although low carbon policy is advancing, prioritising through a top-down policy driven approach is slow to deliver carbon dioxide emission reductions in the built environment, and that there needs to be a greater emphasis on bottom-up activities. It explores the terms ‘whole system’ and ‘multiple benefits’ in relation to a bottom-up led approach, and the broadening of the term ‘smart’ to include a ‘people centered’ focus to technology. Finally, it considers that a regional perspective is potentially the best way forward to ensure that low carbon policy is fully implemented into practice.

1.1 The need to reduce our dependence on fossil fuel

Concern over climate change, and the environmental harm associated with fossil fuel energy use, continues to grow. In May 2013, annual peak atmospheric levels of carbon dioxide level exceeded 400 parts per million (ppm) for the first time in three to five million years (BBC, 2015) and in

2016 annual minimum levels exceeded 400ppm (Kahn, 2016). At a global level, if fossil fuels continue to be burnt at a 'business as usual' trajectory, in a matter of a couple of decades, we will cross the 450 ppm level, regarded as the limit for keeping global warming under 2.0°C (IPCC, 2007). Sixteen of the seventeen warmest years on record have occurred since 2001, with 2016 globally the warmest year since records began in 1880, with average temperature across global land and ocean surfaces 0.99 ^{o}C above the 20th century average (GISTEMP Team, 2017).

At a local level, there is a growing concern over the pollution impact of burning fossil fuels. For example, frequent incidences of smog in some Chinese cities are reminiscent of the London smog episode when, between December 1952 and March 1953, some 13,500 residents more than usual perished (Bell et al, 2004). The World Bank has reported (World Bank, 2016), that globally each year, more than 5.5 million people around the world die prematurely from illnesses caused by breathing polluted air. In addition to the impact on health, these episodes have economic implications, as companies may not wish to expose their staff and families to the unhealthy environments that are becoming a common feature in our cities today.

Society has been aware of problems associated with fossil fuel use since the 1970's, but their use has continued to rise. Since the start of the industrial revolution some 200 years ago, as societies develop economically, they lock themselves into fossil fuel energy supply. Society has become inefficient, and increasingly irresponsible, in the use of resources, and in particular energy. Change will be difficult, as modern economies have developed to be highly reliant of fossil fuels. Amory Lovins explains in his book 'Reinventing Fire' that the fossil fuel industry receives enormous subsidies, both directly and indirectly (Lovins, 2011). Numbers ranging from half a trillion to two trillion dollars for global subsidies to the fossil fuel industry have been cited in recent years (Kojima and Koplow, 2015). Despite talk of future limited resources and peak oil, there are more than enough fossil fuel reserves left to destroy the environment irreversibly, at least as far as current society is concerned. Many sceptics question our ability to be able to reduce carbon dioxide emissions without major harm to the economy and other backlashes, presumably with the assumption that we will have to deal with whatever climate change related problems happen when they arise.

Our dependence on the fossil fuel economy is also leading to serious issues of security of energy supply, and the enormous cost of importing energy. The European Union (EU) currently imports some 53% of the energy it consumes. The value of imports in 2013 was more than 1 billion Euros per day, with energy supplies from Russia accounting for 42% of EU natural gas imports and 33% of oil imports (Europan Union, 2016). The need to reduce our dependence on imported energy is closely aligned to the need to develop a low carbon economy within the EU. The low carbon economy is likely to be a major area of future growth, and one in which Europe may already be lagging behind China and US (Neuhoff et al, 2014). Although Europe has plenty of innovation, it has generally not been so successful at implementation in the market. Reasons may include, a lack of investment power in new technologies, and perhaps a 'lock-in' to the existing ways through complex procurement methods. This slow development of a low carbon economy is of a growing concern to the European Union and is a driver to its policy development.

Globally, the operation of buildings accounts for around one third of energy use and an equally important source of carbon dioxide emissions (IEA, 2015). The proportion is greater, some 62% energy use and 55% carbon dioxide emissions, if the infrastructures that support the built environment are included (Anderson et al, 2015). There are also huge amounts of energy use and carbon dioxide emissions associated with the construction of new buildings and their infrastructures, especially with the predicted rate of urban population increase, with an expected additional 2.5 billion people living in cities by 2050 (compared to the current 3.9 billion) (UN, 2014). The built environment is therefore key to a sustainable future and achieving global carbon dioxide emission reduction targets. It is also a sector that has considerable potential in reducing energy use and integrating renewable energy systems, utilizing existing technologies, at new build, where zero carbon and even energy positive performance is possible (Coma Bassas and Jones, 2015), and for the retrofit of existing buildings, where typically in the UK, 70% reductions can be achieved through deep retrofit measures (Jones et al, 2016).

Rising energy costs have a financial impact for operating buildings and there may be risks relating to the future asset value of buildings that are not sustainable and energy efficient. Poor performing buildings, in terms of energy use, are more likely to have environmental issues that can affect well-being and health, which in turn can affect productivity (World Green Building Council, 2013). However, there is a general reluctance, especially within the construction industry, to build and retrofit to sustainable and zero carbon standards. This may be linked to a lack of awareness and understanding of what can be achieved, and the full benefits of a more sustainable built environment. Globally, there appears to be little impact of climate change on construction, especially for large development projects, such as in the developing world. Policy aspirations seem unable to compete with the fast track 'minimum capital cost led' construction industry. As buildings have a relatively long life, their impact is long lasting. Therefore many of the buildings that we are currently constructing will soon need major retrofit, if we are to achieve a future zero carbon performance; or they will be demolished. In either case the cost, and the embodied energy and carbon, implications will both be high. Admittedly, not all buildings will be able to individually achieve zero carbon performance. For example, buildings located in high-density urban locations and the retrofitting of existing buildings. However, our future energy system should strive towards a zero carbon built environment as a whole, combining building integrated renewable energy, local distributed renewable energy generation, and an increasingly decarbonised central electricity and heat (gas) grid.

The current scenario of burning fossil fuels therefore impacts, not only at a global level, but also at national, local and individual levels, with serious economic, health and quality of life consequences. There is therefore an urgent need to reduce the dependence on fossil fuel, through more efficient use of energy, in combination with renewable energy supply. This is an area where the built environment has a major role, in relation to the design of new buildings, the retrofit of existing buildings, and the supporting built environment infrastructures. Whereas the energy industry is predominantly top-down supply driven and grid based, the built environment lends itself to a 'bottom-up' demand driven 'whole systems approach'. It can incorporate energy efficiency, and both building integrated and localised renewable energy supply and storage, and with a 'smarter' better informed end-user. A resistance to change at the top by the 'big' construction and energy industries, and a lack of awareness of what can be achieved at the bottom by end users, are perhaps the two major barriers to the transition to a zero carbon built environment.

1.2 Advancing low carbon policy

Regardless of the apparent slowness in its implementation, low carbon energy policy continues to advance. In March 2014, the European Commissioner for Energy, Günther Oettinger, stated that 'people's well-being, industrial competitiveness and the overall functioning of society are dependent on safe, secure, sustainable and affordable energy'. He followed on by saying that 'the energy infrastructure which will power citizens' homes, industry and services in 2050, as well as the buildings which people will use, are being designed and built now. The pattern of energy production and use in 2050 is already being set' (Günther Oettinger, 2014).

The European Council has ambitious energy and climate change objectives for 2020, including: reducing greenhouse gas emissions by 20%, rising to 30% if the conditions are right; increasing the share of renewable energy to 20%; and, to make a 20% improvement in energy efficiency (European Commission, 2008). There is a long-term commitment for 80-95% cuts in emissions by 2050 (European Commission, 2011a). In March

2013, the European Commission published a Green Paper entitled, 'A 2030 framework for climate and energy policies' (European Commission, 2013), which proposed a range of actions to provide clear intentions for carbon dioxide emission targets beyond the current 2020 targets, and on route to the long term 2050 target. This 2030 policy framework aims to make the European Union's economy and energy system more competitive, secure and sustainable. It includes: reducing greenhouse gas emissions by 40% below the 1990 level; increasing the share of renewable energy to at least 27%, aimed to drive continued investment in the sector, thus helping to create growth and jobs; continued improvements in energy efficiency; reform of the EU emissions trading system, responding to the issue that it has had limited success; achieving competitive, affordable and secure energy with a set of key indicators to assess progress; a new governance system with a more centralized approach. The above new policy relates to evidence that, 'despite the importance of energy policy aims, there are serious gaps in delivery' (European Commission, 2010), and new technologies are being developed but they are not finding their way easily into the market. The policy is therefore intended to provide clear signals to investors and industry of the intention to drive towards the low carbon economy and to achieve economic growth in this area. These 2030 targets will need to be linked to the European Commission's Integrated Energy Roadmap (European Commission, 2011b). This requires an action plan that, includes, the energy challenges in a systems approach, consolidates and aligns the various existing technology roadmaps, covers the entire research and innovation chain, and with the need to balance the (sometimes competing) targets, considering technological, economic, environmental and social aspects. If implemented successfully, this could be a major driver to closing the apparent 'policy to practice gap'.

1.3 The failure of current policy?

Even though there are continual advancements at a policy level, at a practice level, are governments failing to deliver on climate change, and if so what are the issues? Governments are generally ready to commit to the climate change agenda. Reports from the International Panel on Climate

Change (IPCC) (Edenhofer et al, 2014) have frequently been referred to when developing government policy, but this policy appears to be slow to be implemented in practice. Even the Stern review on the economics of climate change (Stern, 2006), which identifies the enormous costs faced with dealing with climate change, does not seem to have significantly changed our behaviour.

The implementation of policy has in many ways seems to be uncertain and piecemeal. The future mix of centralised energy supply, nuclear, gas, coal, large-scale renewables, is unclear. With a likely increase, possibly up to 50% in the UK (Barton et al, 2015), in distributed electricity generation, it is uncertain how best to marry central and local 'distributed' generation. Large scale smart metering has also met with limited success both in terms of energy savings from the end user perspective and optimising operations from an energy supply viewpoint. And 'softer' schemes, such as carbon permits have not worked, possibly due to the recent economic climate reducing energy demand resulting in the low cost of carbon (Comberti, 2013). In the UK, the electricity supply industry has already recognized the need for a whole systems perspective to provide closer integration between transmission, distribution and the end user (IET, 2014) with a shift to localised and building integrated renewable energy generation.

There may be a number of contributing factors to this apparent failure of current policy in the context of large-scale energy supply and the built environment. Large-scale renewables are often perceived as relatively expensive, and there are difficulties in maintaining security of supply due to wind and solar power intermittency. Energy storage is developing but as yet there is no effective wide-scale storage to bridge any gap between supply and end-user demand available. Transmission grids for electricity are already fairly smart and efficient, but there are uncertainties around their ability and capacity to meet changes in future use profiles, for example, with an increase in electrical loads, for electric vehicles, heat pumps, and building appliance loads, and possibly an increasing shift to electrical based heating systems.

Energy efficiency applied to buildings to reduce demand is an obvious option, and there have been improvements through building regulations, for example, driven by the EU Directive for Energy Performance of Buildings (European Union, 2010). But not everything is regulated, and where heating and cooling loads have been reduced, appliance loads have steadily risen (Department of Energy and Climate Change (DECC), 2011). New buildings may eventually approach zero carbon, although for example in the UK, there still appears to be resistance to this, and considerable lobbying of government by certain sectors of the construction and energy industries, for example, 'the suspicion that the halting of Zero Carbon Homes and the ending of the Code for Sustainable Homes in the UK relating to the government's desire to remove 'Red Tape' as well as suspected lobbying from large house builders'. (Harper, A, 2016). The retrofit of existing buildings is still under-developed, and lacking suitable financial mechanisms, with schemes such as the UK's Green Deal for promoting the uptake of domestic energy efficiency proving to be unworkable and withdrawn in July 2015.

The general lack of success associated with the above policy driven large-scale initiatives is perhaps partly due to their 'top-down' approach and general lack of integration across the various initiatives. Top-down policy driven aspirations may not always be followed up with the necessary technology pathway delivery mechanisms (Rayner, 2010). This can be a major contributor to the problems associated with driving carbon emissions down and achieving and more secure energy supply and demand system.

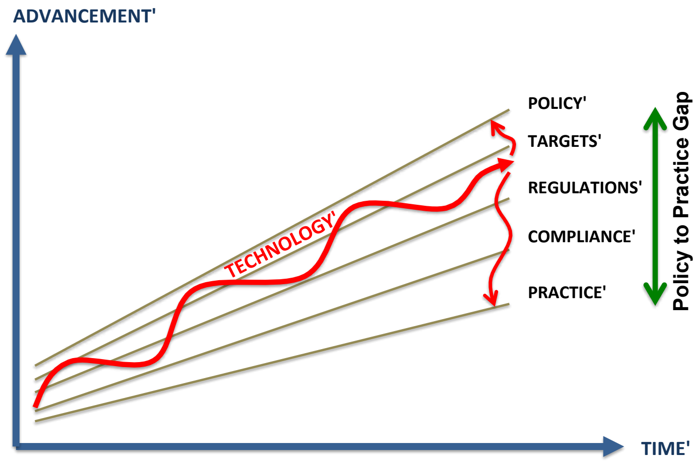

Figure 1. Illustration of gap between low carbon policy and practice

In relation to the UK's built environment, the gap between low carbon policy and practice appears to be widening, with targets, regulation, compliance with regulations, performance in-use, all seeming to lag behind policy advancement and technology developments. Figure 1 illustrates the route from policy to practice. Although long-term targets for carbon dioxide emission reduction are fixed, shorter term targets are often put back due to uncertainties in their implementation, and perhaps lobbying from sectors of industry that are opposed to change. For example, studies have indicated that 'the resistance and resilience of coal, gas and nuclear production regimes currently negates the benefits from increasing renewables deployment' (Geels, 2014).

Regulations lag behind for similar reasons and not all aspects of energy use are regulated. Compliance with regulations lags behind the introduction of new regulations, either intentionally through periods of grace facilitated by allowing advanced planning applications (for example, in the UK, schemes may be registered years before they are built, so they avoid building to current building regulations), or due to a lack of understanding within the industry. And then at the end of the 'pipeline', performance in use is often not achieved in practice. This 'performance gap' between design and actual use (Zero Carbon Hub, 2014) may relate to a number of reasons, such as : buildings not operated as designed due to wide variations and changes in patterns of use; poor design and workmanship; general lack of understanding of how to integrate low carbon technologies into the existing planning, design and construction, processes and practices. Low carbon technologies are being developed, especially at building and community scale, but they are often slow to feed up into policy and down into practice. In some cases, current regulations and accreditation schemes lock the industry into old technologies, as new ones wait for approval (Seto et al, 2016).

It is accepted that not all countries will experience the same slow progress towards a low carbon built environment, and there are good demonstrations of low and zero carbon built environment projects in all countries (Jones P et al (eds), 2014) but rarely are these demonstrations scaled up to widespread adoption. Identifying and validating good practice solutions and scaling them up is now the challenge for industry, government and research institutions in relation to the transition to a zero carbon built environment.

2 Transition to a zero carbon economy

2.1 Top-down', 'bottom-up' approaches

Top-down and bottom-up terminology is increasingly used in relation to the transition to a zero carbon future. However, it is often loosely defined, in relation to both scale and implementation. For example, in policy terms, top-down may refer to international agreements, whereas the actions of individual countries may be regarded as bottom-up, as in the case of the COP21 agreement. From a project based perspective, top-down may relate to regional devices, for example, planning or building regulations, whereas bottom-up may be the actions of designers or communities. It might be argued that most low carbon policy is driven by a central 'top-down' energy supply led approach. From a built environment perspective, a top-down approach may represent the actions and interests of big government and big industry, for example, in relation to grid based energy supply and national and international carbon emission reduction targets. On the other hand, a demand-led ‘bottom-up’ approach represents more the interests of the end user, whether individuals, organisations or communities, in relation to their specific building and built environment needs.

There is currently a growing interest in bottom-up solutions to reduce energy demand and carbon dioxide emissions, in response to the slow delivery of top-down driven initiatives. Walloth considers bottom-up solutions may be regarded as ‘fast’ with a triggering and adaptive role, in comparison to the ‘slow’ framing and guiding role of a top-down approach (Walloth, 2012). Bottom-up initiatives may be led by local organisations that may more readily use innovative financing approaches and new business models to tackle barriers from a grass-roots level. In the context of social innovation Bergman suggests that bottom-up might generally be carried out by less powerful actors, related to behavior and lifestyle changes, new forms of governance and business, and new technologies (Bergman, 2010). Bottom-up innovation may be defined as innovation generated by civil society (individual citizens, community groups, etc), rather than government, business or industry. A bottom-up approach may deal with distinct and detailed technical information, for example, that might combine energy efficiency and cost at a sectorial and regional scale, or may be user-led social innovation for addressing climate change (Hoogwijk et al, 2008). Morten et al proposes a Doing, Using and Interacting (DUI) mode, relying on informal processes of learning and experience-based know-how, rather than a Science, Technology and Innovation (STI) mode, which is based on the production and use of codified scientific and technical knowledge (Morten et al, 2007).

Bottom up "small scale interventions have been termed tactical urbanism, characterized by their community-focus and realistic goals" (Berg, 2012). A bottom-up change and improvement may come from people "using" the city and working at a local level. Batty writes that ‘cities grow and develop upwards from the bottom and all attempts to plan a city in its complexity are destined to change heavily under the requests of all the people who pass through its streets every day' (Batty, 2006). It has been suggested that rather than smart cities the focus should be on the "smart citizen", and the city viewed as a system of systems (Hemment and Townsend, 2013).

Top-down and bottom-up may be perceived in relation to producers and consumers. From a governance perspective this could relate to government and citizens, with top representing 'the few' and bottom representing 'the many'. From a policy level, top-down might represent international policy on carbon emission reduction, whereas bottom-up might relate more to the implementation of innovative low carbon technologies on specific projects. Bottom-up movements associated with climate change are often driven by public-private collaborations on a national, sub-national and regional level, and they should help create a more favorable environment for top-down actions (Global Agenda Council on Climate Change, 2012). This implies that the more bottom-up achieves, the less pressure on top-down. In that sense, both approaches are mutually reinforcing and inherently complimentary with each other and need to co-exist to achieve the needed transformations.

Certain kinds of top-down visions have been heavily criticized for being dictated by commercial interests, and that they entail questions of control and privacy. Rayner writes that we should abandon the idea that climate change policy requires a universal framework, and that we should not set grandiose emissions targets without any plausible technological pathway for achieving them (Rayner, 2010). He suggests that national and local targets for installed technology would provide a more realistic and verifiable mechanism for achieving emission reductions than global targets.

Technology 'lock-in' has also been associated with top-down approaches, where government incentives and various assessment schemes require accreditation of new technologies before they can be recognised

(Seto et al, 2016). These can prove expensive, introduce time delays, and may exclude small local companies from technology supply chains. Top-down solutions are often implemented through generalised procurement arrangements and framework contracts, which are more likely to adhere to minimum standards and regulations. Adopting a bottom-up approach can be less prescriptive in the use of such schemes, encourage improvements from minimum standards and regulations, and deal with problems at the lowest possible level of decision-making. This places the end-user at the heart of decision-making and innovation.

However, from a policy maker's perspective, one can appreciate how 'messy' and risky (in terms of delivery) a bottom-up approach might seem. Despite its drawbacks, there appears to be a preference for a top-down approach, using existing industry and financial structures. So it seems that, although bottom-up has potential advantages in moving the low carbon agenda forward from a people perspective, bottom-up alone lacks the holistic vision to deal with major national issues at hand. They maybe generally perceived as disparate in nature and short term. Bergman states that the problem of social, bottom-up, low-carbon innovation is the difficulty in assessing outcomes, and that it is hard to quantify the effects of a phenomenon that is not standardised or traded, and which might include potentially nebulous outcomes (Bergman et al, 2010).

The concept of 'middle-out' has been suggested (Janda and Parag, 2011) as an optimum combination of agency and capacity, linking top and bottom, with agency being the ability, and capacity the resource to carry out projects. Community groups may be well placed to act as middle-out agents that can deliver the economic, environmental and social benefits associated with renewable energy but that they need appropriate organisational structures. Such an example of what might occupy this middle ground in the UK, might be a 'not for profit' Community Interest Company (CIC) which might work with energy suppliers or government through various energy efficiency schemes, but primarily represents the interests of consumers. One such example in the UK is Warm Wales, which was established in 2004 and is the oldest CIC in Wales. It aims to provide homes with affordable warmth and to alleviate fuel poverty, working closely with the public and private sectors to maximise funding opportunities to enable energy efficiency schemes (Jones, 2013).

To summarise, it appears that top down lacks penetration and its motives are bound up in the status quo. No matter how hard the top-down pushes, unless there is a bottom-up demand, delivery will be slow and initiatives blocked. Whereas, although bottom-up may be disparate and messy, it may be more likely, with the help of middle-out agents, to initiate the changes in delivery mechanisms and spread the vision that will create demand.

2.2 Bottom-up 'whole system' with multiple benefits

Bottom-up is more likely to provide a 'whole system' approach, which can result in multiple benefits in terms of both cost and value (Jones, 2017). For example, reducing a building's energy demand, can lead to affordable warmth, alleviate fuel poverty, improve health, and reduce local air pollution. This can lead to costs savings for government, in relation to health and social services, and for industry, in relation to increased productivity through healthier working environments (Davis Langdon, 2007; Johnson Controls, 2012). Green buildings increasingly have a higher asset value and meet social corporate responsibility targets (World Green Building Council, 2013). Bottom-up, due to its localised nature, may also associated with socio-economic benefits, including, a more supportive community, creating jobs, improving productivity and generating local industries. Multiple benefits follows the up-cycling concept of 'more good' (Mcdonough and Braungart, 2013), with top-down approaches generally following the 'less bad' concept. Sustainability should not just about avoiding problems; rather it is about promoting a better quality of living. This is potentially more engaging and comprehensive in relation to the needs of the inhabitants of the built environment. The concept of regenerative sustainability is inherently based on a 'bottom-up approach, with an overall net-positive approach to sustainability. Cole argues (Robinson and Cole, 2015) that over the past half century, our response to complex environmental problems has been led by a negative approach, focusing on scarcity and sacrifice, making things ‘less bad’, with little attention to social dimensions, and rarely recognizing cultural, political and other processes. Regenerative sustainability is directed towards contributing positive outcomes, and is systems-based and place-based, considering the interconnections within and between, ecological, social and economic systems at various scales, but with an emphasis on local thinking, experience and delivery.

Whole Systems thinking not only includes integrating technologies and architecture from a people perspective, including both the designers and the users of the built environment, but also links to government regulations and industry needs, spinning out bottom-up activities through the so-called knowledge triangle of research, industry and government. Reed discusses whole systems thinking (Reed, 2007) as a collective experience of the design team, continued stakeholder engagement and, a ‘conscious processes of learning and participation through action, reflection and dialogue’, rather than evaluating the achievement of specific, easily quantifiable features or measures. Hoggett suggests that ‘instead of focussing on a centralised, top-down, approach to system design, operation and policy making/regulation, based around large and in some cases inflexible technologies, the system should be optimised from the bottom up (Hoggett, 2017). Thackara writes that systems can have properties as a whole, it turns out, that are not explicable in terms of the sum of the parts that scientists once studied in isolation (Thackara, 2015).

Affordability and buildability are two main drivers within the building design and construction process, linking to economics and skills considerations. Building regulations are needed to drive innovation and encourage new innovative high value products from industry, while controlling unsustainable increases in construction and development costs.

So a whole systems approach does not draw a boundary around the technical solutions, but cost and value, skills and supply chains, and regulations should also be thought of as forming part of the overall ‘whole system’.

The emphasis should therefore change, from reducing harm and damage, to creating net-positive outcomes, in both environmental and human terms, at the building and neighbourhood scale. A whole system bottom-up approach is potentially easier to communicate the positive ‘multiple benefits’ message, whereas a top-down approach tends to be more based on a message of avoiding problems. People may more readily adopt actions that are perceived to lead to benefits of a clean, healthy, productive built environment, than the less tangible concept of ‘saving the planet’.

3 Smart energy future

3.1 Broadening the concept of ‘smart’

Top-down and bottom-up approaches need to be integrated in a ‘smart’ way. Up to now, and in relation to energy and the built environment, the term ‘smart’ has generally been associated with large-scale energy supply and distribution systems, and the wide-scale application of smart meters and (often complicated). It is related to technology rather than its use. These generally have top-down characteristics, based on large-scale standardized solutions. Glasmeiera and Christopherson discus big industry selling different visions of ‘smart’ and products to achieve the smart vision, though technologies may prove ill-suited to solving the problems that lie at the heart of improving the quality of urban life, and that poverty may not feature strongly on the agenda of smart city planners (Glasmeiera and Christopherson, 2015). Rees suggests that we are ‘too clever by half but not nearly smart enough’ (Rees, 2014), implying that we are clever at developing technology but not smart in the way we use it.

However, the smart concept may be visioned through more human centred bottom-up activities, at building and community scale, through the design of buildings in relation to their specific location and use. Table 1 suggests a comparison of bottom-up and top-down features. From a technology related point of view, a smart bottom-up approach may be associated with a range of characteristics. For instance, it may be predominantly people controlled rather than IT (information technology) controlled. There is evidence that people will accommodate new technology if they can retain some degree of control (Parkhill et al, 2013). A smart people based approach will value local knowledge, inviting in the creativity of people to develop solutions that become 'owned' and 'maintained' by the community, and that inspire engagement and understanding. A top-down approach generally imposes standardised solutions on people that might not always be a 'good fit'. A bottom-up approach lends itself to simple solutions rather than complex, and can readily accommodate a whole systems approach, rather than be one-off component based. Both top-down and bottom-up might include a mix of traditional energy and renewables. Top-down may need large-scale energy storage, which may take time to develop, whereas bottom-up can have relative easier access to current storage technologies, both thermal and electrical. Security of supply is becoming a major concern with top-down, whereas bottom-up can incorporate a high level of autonomy, combining renewables and energy storage as a whole system.

Table 1: Comparison of top-down and bottom-up approaches

	TOP-DOWN	**BOTTOM-UP**
Characteristics	IT controlled Corporate owned Complex Component approach Mix of renewables + traditional Large scale storage Security of supply Government / industry investment Transient jobs External profit	People controlled People owned Simple Systems approach Mix renewables + traditional / energy positive buildings / community schemes Building / community storage Semi-autonomous + grid back-up Individual + crowd investment, subsidies Local jobs Local / regional profit

Issues	Future grid Future energy mix Security of supply intermittency National strategy	Regulation and incentives Better understanding Regional strategy
Targets	CO2 emissions Resource depletion	Quality of life Affordability Health and comfort
Needs	Link smart-down with smart-up, flexible not rigid links Regional – national links Transition to low carbon – mix of fossil fuel and renewables Integrative cost and performance models	

There are also potential socio-economic factors to consider. Investment for top-down activity is often large-scale through government or industry, whereas bottom-up can be funded by individuals, or maybe by some form of community or 'crowd investment'. Bottom-up solutions may therefore be people owned rather than corporation or government owned. Projects involving top-down may be more likely to be linked to transient employment, especially for initial capital works, whereas bottom-up may more likely use a local workforce, developing skills within the community. The investment for top-down may be external to the location, with profits going outside, whereas bottom-up can be based on local investment with the benefits retained within the community and region.

There is a range of issues associated with the two transition approaches. For top-down, the issues are associated with future grid structures, future energy mix, security and intermittency of supply, and the development of a national strategy. Bottom-up issues include, regional regulations and incentives, better understanding by people, and are more linked to the development of a regional strategy. Also, the targets are different, with top-down mainly focusing on quantifiable factors, such as carbon dioxide emissions and resource use, whilst the targets for bottom-up might be more qualitative, including quality of life, health and well-being, and affordability. A future national energy strategy needs to be linked with regional strategies, combining top-down with bottom-up solutions, which need flexible rather than rigid relationships. Cost and performance models are needed at both ends, and these should also be integrated with each other.

In developing a future smart energy strategy it may prove easier to lead with smart bottom-up, as this can be tackled sooner, through specific individual projects. This will take pressure off top down solutions, making them more easily achievable. Also, the more qualitative nature of bottom-up may prove more acceptable to people, in relation to the potential multiple benefits of improved health and quality of life, compared to the somewhat remote global targets of top-down. The transition to a smart future needs to respond to people's need for an affordable, secure and safe society, and clever technology can only be applied in relation to smart, when the basic needs of end users have been provided for.

3.2 A regional approach

It may prove advantageous to tackle the transition to a zero carbon economy at a regional scale, where top-down and bottom-up approaches can be best integrated. The Smart Energy Regions COST Action TT1104 highlighted a range of European activities relating to a regional approach (Jones et al, 2014) and produced a manifesto for a zero carbon future built environment (Jones, 2016x). At a regional scale, there is often devolved government decision making, with the subsequent development of policy through, for example in the UK, building regulations and planning guidance. Issues resulting from government's policy aspirations can be followed up through regional research and development activities. Although large-scale energy supply policy may be decided at a national level, associated planning issues and smaller scale energy supply is generally handled at a regional level, bearing in mind the likely future increase in local distributed energy generation. A regional approach may also prove more effective in developing demand-side management, the development of low carbon technologies and processes, and how collaborative research across the region's universities through specific projects can help government and industry take forward the low carbon agenda (Jones et al, 2015).

There has been little attention to how the various issues across policy and practice can be 'joined-up'. An overall zero carbon strategy should link government policy to business opportunities; technology advances, training and awareness raising, and issues relating to cost and value. This may be best addressed at a regional scale, where there is autonomy, understanding and decision-making that take account of specific regional attributes. This could align with the Smart Specialisation Initiative in England, and which is part of a European wide initiative (Department for Business Innovation and Skills, 2014). The initiative 'seeks to ensure that proposed actions are based upon sound evidence that properly reflects the comparative advantages of the physical and human assets of particular places in the global economy. It emphasises the need to ensure that activities are fully integrated in the local economy and its supply and value chains'.

A smart energy region can benefit from the combined roles of the 'knowledge triangle' of government, industry and academia in delivering the low carbon agenda to individuals and organisations. Government needs to implement policy through regulations, guidance and incentives, giving clear signals to industry of its future intentions. It needs to be aware of what industry's strengths and aspirations are in relation to supplying goods and services to the region and exporting from the region. Government's commitment to raising standards can drive forward technical and financial innovation and competitiveness, encouraging industry and academia partnerships. Industry needs to plan for future changes. Industry has a diverse range of interests in relation to pushing forward the low carbon economy. Not all industries resist change, as implied earlier as a characteristic of some 'big industries'. Manufacturing and consultancy services often welcome change as it can result in new and high value markets. However, building developers and the energy utilities tend to be more conservative, and may associate change with increased costs and loss of profit. They also tend to have more influence on government decisions. Government therefore needs to take a considered and balanced approach to industry 'lobbying', and look at the wider societal and economic benefits of a green economy. Academia in general has two main interests; firstly, research partnerships with industry can drive forward innovation and assist industry with developing new products; secondly, research leads to improved understanding of low carbon technologies and applications, which can then be disseminated through education and training programmes.

The development, and joint ownership, of the understanding of low (and eventually zero) carbon regions is fundamental to future government and industry thinking. In order to achieve this, it is important that decision makers and their advisers have the appropriate information for short and long term decision making, and that there is public engagement and awareness. The built environment can therefore act as major focus for the transition to a zero carbon future through regional activities.

4 Conclusions

It is not surprising that there is a huge resistance to changing to a zero carbon economy, and it is difficult to envisage how the last two hundred year's dependency on fossil fuels can be turned around in the relatively short time available to avoid serious climate change impacts. There are multiple barriers, all largely associated with a resistance to change and a lack of awareness about what benefits change can bring. These barriers exist at a government, industry and citizen level, and a single top-down vision is unlikely to succeed in delivering policy into practice. However, the economic benefits of a low carbon economy are huge, with opportunities for both wealth and job creation. There are other 'softer' qualitative 'multiple' societal benefits through improved quality of life and local economic opportunities.

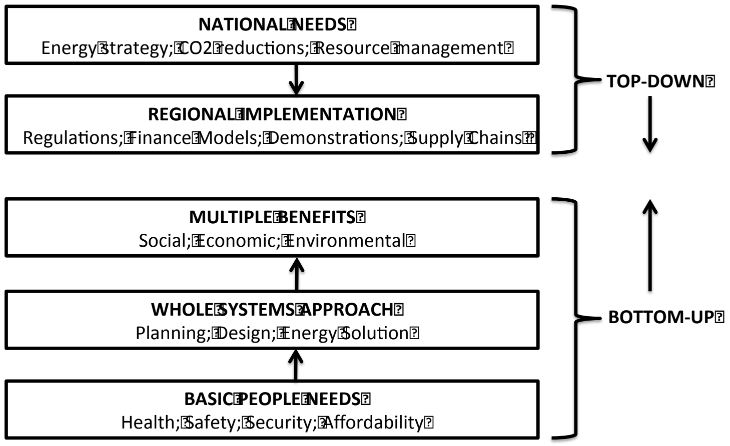

Figure 2 A bottom up led transition to a zero carbon built environment

Figure 2 illustrates the transition to a zero carbon future combining bottom-up action with top-down support, identifying benefits that directly impact on people, such as health, safety, security and affordable energy. This can be achieved through a whole system approach, linking planning, design and energy systems, to provide multiple 'value added' benefits associated with quality of life, productivity, jobs. Top-down support relates to meeting National targets for CO2 emissions, energy future strategy and resource management. An emphasis on bottom-up will make top-down targets easier to realise, and potentially reduce stress on the energy grid system. It will also provide greater autonomy and security to householders and building operators.

Although figure 2 implies that National and Regional activities are regarded as top-down, this is relative to the National situation. In pan-European terms, National activities may be regarded as bottom-up, as with the implementation of COP21, and from a National perspective, some Regional activities may be regarded as bottom-up, for example the formation of Building Regulations.

The implementation at a regional basis, where a region represents some level of legislative and fiscal autonomy (for example, Wales), will need support, for example, from building regulations, finance models and supply chains, that are relevant to the region. There will need to be a systemic shift in energy supply and demand thinking, taking into consideration politics, economics, ecology, and lifestyle. It will require new forums for engagement and exchange of knowledge, skills and experience and the renegotiation of energy supply relations between top-down and bottom-up camps. So-called middle-out agents may provide an organisational vehicle to engage with both bottom up and top down actors. Regional governments can set examples through demonstrations, but demonstrations should not be an end by themselves, but integrated into scaling up good practice.

The largest potential early win is to reduce energy demand in the built environment, and this can provide a bridge to the low carbon future. Most of the technologies required already exist and are readily available. A whole systems approach will optimise their use for specific project applications. We must accept that delivering reductions in energy and carbon dioxide emissions should also achieve beneficial cost and socio-economic added value 'products' in the development of regional built environment programmes, linking the low carbon agenda with economic growth.

Finally, the concept of 'smart' should not be confused with 'clever'. Clever can be thought of as technology and IT related. Smart is more about engaging with people, placing the end-user at the centre of decision making, through the concept of 'consumer as king'. A smart bottom-up approach can place a more positive spin to promote the low carbon agenda. Rather than the 'less bad' global agenda of climate change, it focuses more on the 'more good' local agendas related to cleaner environments, economic and social benefits, together with healthy, comfortable, productive energy efficient buildings.

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