**Localism and Energy: Negotiating approaches to embedding resilience in energy systems**

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**Abstract**

Tensions are evident in energy policy objectives between centralised top-down interconnected energy systems and localised distributed approaches. Examination of these tensions indicates that a localised approach can address a systemic problem of interconnected systems; namely vulnerability.

The challenge for energy policy is to realise the interrelated goals of energy security, climate and environmental targets and social and economic issues such as fuel poverty, whilst mitigating vulnerability. The effectiveness of conventional approaches is debateable. A transition to a low carbon pathway should focus on resilience, counter to vulnerability.

This article draws from on-going work which evaluates the energy aspects of a Private Finance Initiative (PFI) project to refurbish and re-build a local authority's entire stock of sheltered accommodation to high environmental standards. Initial findings suggest that whereas more conventional procurement processes tend to increase systemic vulnerability, a user focussed process driven through PFI competitive dialogue is beginning to motivate some developers to adopt innovative approaches to energy system development.

**Keywords**

Resilience; Energy Systems; Vulnerability.

**Introduction**

Energy systems are a product of many interacting forces including socio-economic factors, resource availability and constraints, technological capacity and political aspirations. Energy policy making has to contribute to a number of interrelated goals such as energy security, climate change, environmental sustainability and fuel poverty reduction. This is immense challenge.

The drive in energy policy is towards a low carbon pathway. Such a drive acts to counter the inherent vulnerabilities of large scale interconnected systems. It embeds resilience, the counter to vulnerability. The term resilience used in this article draws from studies of social-ecological systems. Conceptually, resilience encapsulates how such systems are able to respond to disruptive challenges. It is a measure of adaptive capacity and ability to learn how to cope and adjust. In an energy system context this approach should be envisaged as a process of co-evolution where actors and technologies interact within a system to minimise vulnerabilities and maximise opportunities. However, it would be misleading to think of energy system evolution without intervention.

New technologies are needed and thought is needed of the interface between technology developer and the user. Users within the system need to learn how to use and interact with the system, as well as judge when and how to adjust the system to meet new challenges. Developers need to consider how best to meet user needs, as opposed to think solely of technological innovation for its own sake. This we consider as being an ‘Open Source’ approach where system developers and users recognise the need to be transparent and adopt principles that allow upward development and compatibility that, for example, devise common technical and operating procedures. Similar to The Open Source Initiative, this approach is aimed at developing a nexus of trust amongst stakeholders to facilitate dialogue and learning (Open Source Initiative, undated).

The starting point is recognising that a fundamentally different viewpoint is needed. Conventional energy systems rely on energy resources that have been produced, concentrated and stored over geological time. High energy density inputs characterise conventional energy production processes. A transition to a low carbon pathway relies on the use of renewable resources. Use of such intermittent low energy density resources requires a development strategy that is based on the principles of ‘capture/harvest-when-available’ and ‘store-until-required.’ Fundamental to this approach is high end-use efficiency and culture of energy conservation. This has implications for both the architecture of technologies and user capacity.

In conceptualising a resilient energy system, this article, first evaluates vulnerability in existing systems and argues that a resilient approach is an effective counter to vulnerability. Secondly it discusses resilience in social-ecological systems and relates this to energy systems and offers a working definition of a resilient energy system. Thirdly it elaborates an approach to conceptualising energy architecture that offers the potential to act a transition point to a low carbon pathway. Fourthly it draws upon on-going work in North Tyneside where the energy aspects of a PFI (Private Finance Initiative) project for sheltered housing, is aiming to create a pathway to a low carbon community. It then concludes.

**Vulnerability in existing energy systems**

Traditionally, energy system vulnerability has been viewed in terms of technical failure, accidents or operator errors (O’Brien, 2009). However, it is increasingly recognised that vulnerability is multi-dimensional and influenced by a wide range of interacting factors (WEC, 2008). Such factors can include system complexity, resource availability and constraints, diversity of energy supply, and political disruptions. The vulnerability of a system is the degree to which that system is unable to cope with these interrelated events (Gnansounou, 2008). Cascading faults in electrical grids for example, the 2003 blackout in Italy and the 2006 near black out in Europe (Vandenberghe, 2004; Dobson et al, 2007), can lead to severe economic and social costs. Vulnerability to faults is an unintended side effect highly centralized technologies (Lovins and Lovins, 1982). This inherent vulnerability of complex interconnected systems is understood (Alanne & Saari, 2006; O’Brien, 2009). However there are a range of other factors that add to this vulnerability, such as the availability of energy resources and the constraints of those resources.

Accessible reserves of conventional fossil fuels are diminishing. Though there are reserves of unconventional hydrocarbons (Odell, 2004) that could prolong fuel availability, without an effective method of capturing and storing carbon, the use of such resources will need to be balanced against climate concerns. Sustainable development aspirations require a diversity of energy resources. Renewables provide the opportunity to increase the diversity. Use is essentially local and renewable strategies contribute to sustainable development (Li, 2005). Others factors exacerbating vulnerability are secure access to energy supplies. The World Energy Council (WEC) defines energy security as an uninterruptible supply of energy, in terms of quantities required to meet demand at affordable prices (WEC, 2008). The distribution of conventional reserves makes access vulnerable to global geopolitical forces causing policy makers to focus on promoting security of energy supply (O’ Brien et al, 2007). Recent price fluctuations impact both industry and the consumer. This is particularly a concern for the fuel poor.

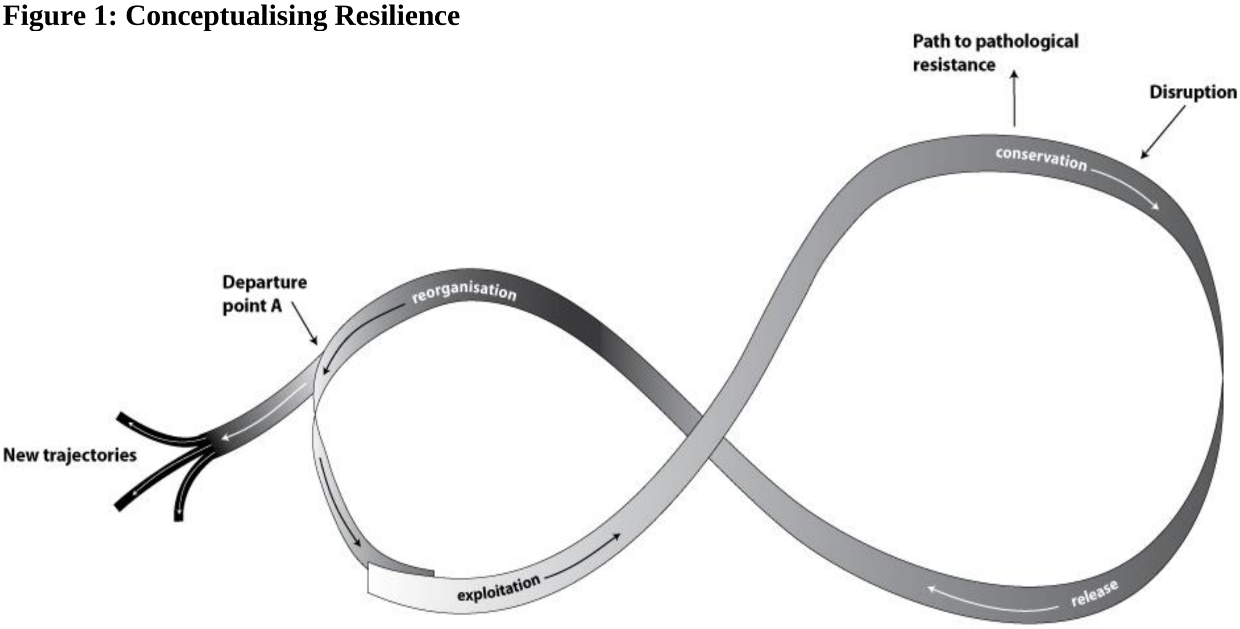
In order to counteract vulnerability inherent in a conventional energy system, the move towards a low carbon pathway provides an opportunity to develop a resilient approach. This is important as resilience is a proactive approach that acts as a counter to vulnerability.

**Resilience**

Resilience is used in number of disciplines and broadly means the ability to withstand and adjust to disruptions whilst still retaining function. The resilience approach is a dynamic and system orientated process that views adaptive capacity as a core feature of resilient social-ecological systems. In the event of a disturbance a resilient system will use its adaptive capacity to adjust to the new conditions so that it is able to persist (Smit and Wandell, 2006). There is a considerable literature in various disciplines on the concept of resilience ((Bonnano, 2004; Buckle *et al*, 2001; Adger, 2000; Arthur, 1999; Holling, 1973).

Holling (2004) describes the dynamics of resilient systems as interacting processes as shown in Figure 1. Energy system evolution exhibits these dynamics.

**Figure 1: Conceptualising Resilience**




**Notes**

The transition from exploitation sees the use of a resource (eg biomass) and technology development to meet needs.

Disruption is the recognition of new resources (eg fossil fuels) and the release is the beginning of a shift to the new resource.

Reorganisation are changes driven by new ideas or technologies for use of the resource.

Departure point A is the shift to a new trajectory where a new resource requires fundamental reorganisation

These new trajectories continue in same fashion. The original cycle can continue. For example biomass still used today in the Developed World, but mainly for effect.

Resilience of the system is the ability to respond to disruptions. The path to pathological resistance is a combination of barriers that prevent change where the underpinning resource base is overexploited.

Source: Adapted from Holling, 2004

In the conservation phase, the dynamics are technology combinations and management to use and sustain a resource base, for example, biomass. Disruptions, such as new technologies or management regimes can lead quickly to the release phase where recognition and incorporation leads to reorganisation and then exploitation. This is building complexity to use and sustain the system. Providing the system is able, through its adaptive capacity, to overcome barriers to change, such as customs and practice, that is, it does not become too complex, a situation Nelson et al (2007) describe as being pathologically resistant to change, it is able to respond to disruptions. Factors influencing ability to change are rigidity where, for example, adherence to poor or misguided practice leads to over exploitation of the resource base. Ultimately this could lead to collapse. Successful responses to disruptions, for example in the UK, the transition from biomass to coal with new technologies emerged for transport (from horse power to steam power) and the shift to petroleum and the emergence of the internal combustion engine and the growth of personal transport. The resilience of the system is the ability to respond to disruptions and innovations and develop new trajectories. A key aspect of the dynamics of resilient systems is learning; that is learning from and learning how.

The fossil fuel dynamic is now confronted by two major disruptions – diminishing reserves of non-renewable fossil fuels and climate concerns. Realising solutions to these must be within a sustainable development context. This raises a question of whether the complexity and interconnectedness of the current dynamic, means it is pathologically resistant to change.

Dynamics in resilience thinking imply that barriers must be overcome or removed. Current system architecture can be characterised as a supply- side dominated by top-down gigantism, concentrations of social power and environmental degradation and a demand side that is inefficient with largely passive consumers (Jiusto, 2009). Sustainability, though an almost universal mantra, is constrained by user interpretation. For example, OECD (Organisation for Economic Cooperation and Development) argues that neoliberalism provides the framework for sustainability; but this is maintenance of the Status Quo (Hopwood et al, 2005). OECD nations are heavily dependent on imported fossil fuels, vulnerable to geopolitical disruptions. Despite some initiatives in renewables OECD will remain heavily reliant on imported fossil fuel. Policy in the EU (European Union) is focused on increasing and expanding interconnectedness which will increase vulnerability (O'Brien, 2008). Responses to the climate challenge are premised on market-based approaches. The EU ETS (Emission Trading Scheme) has not delivered any meaningful reductions. It is likely that any Kyoto successor will be based on this failed approach.

There is no global energy shortage – there are sufficient renewable resources. The challenge is capturing these and using them effectively. Top down gigantism is premised on high energy density resources transported to point of production. Renewable technologies are best realized at point of use. This is a drive to de-centralization. Conceptually, resilience is not focused on what is missing (needs and vulnerabilities) but on what is present (resources and adaptive capacity) (O'Brien et al, 2006). Resources and adaptive capacity are knowledge, skills and physical resources available to respond to disturbances. The transition to a low carbon pathways is best realized where resilience underpins processes of adjustment to counter vulnerabilities and exploit beneficial opportunities to maximize social well-being.

Resilience building is a learning process at all levels. Institutional learning empowers at the local level and strengthens governance. This is negotiation not imposition. Strategies are needed to respond to and cope with disruptive challenges. Resilience recognises that there is no steady-state or end result. It is process without end that has, at its core, the notions of entitlements and governance (O'Brien, 2008). These notions can be used to establish a working definition of what we mean by a resilient energy system:

"A resilient energy exhibits adaptive capacity to cope with and respond to disruptions by minimizing vulnerabilities and exploiting beneficial opportunities through socio-technical co-evolution. It is characterized by the knowledge, skills and learning capacity of stakeholders to use indigenous resources for energy service delivery."

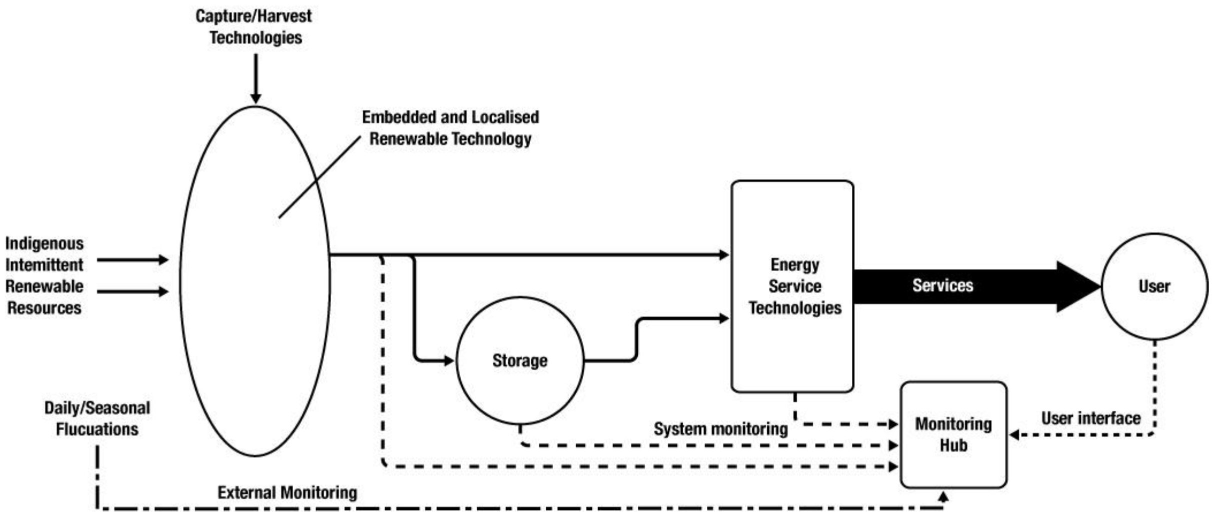
This definition allows us to conceptualise a resilient energy system.

**Conceptualising a Resilient Energy System**

Conceptually a resilient energy system brings together two actor groups, broadly those that own and use energy producing technologies and those that develop and deploy those technologies. The starting point for elaboration is the household. From a technology perspective end-use efficiency is vital. Capturing intermittent and diffuse renewable resources is a considerable challenge and it makes little sense to use them inefficiently. Existing technologies can deliver buildings that require virtually no space heating. This along with embedded and localised systems, such as community owned renewable technologies to supplement embedded capacity, can supply needed energy services. There are demonstration examples of autonomous or off- grid developments. Intervention is needed to ramp up standards for new build and refurbishment. Similarly, higher standards are needed for fast-turnover products such as household appliances.

Where the user is able to interact with energy capture and use and manage resources to meet needs then it can argued that this is a resilient energy system; that is one where human adaptive capacity is able to use indigenous resources to meet needs. Autonomy of this kind eliminates many of the vulnerabilities discussed earlier. This approach, shown in Figure 2, relies on technological development aimed at capturing and using indigenous renewable resources effectively and the willingness of the user to manage these resources within recognized constraints.

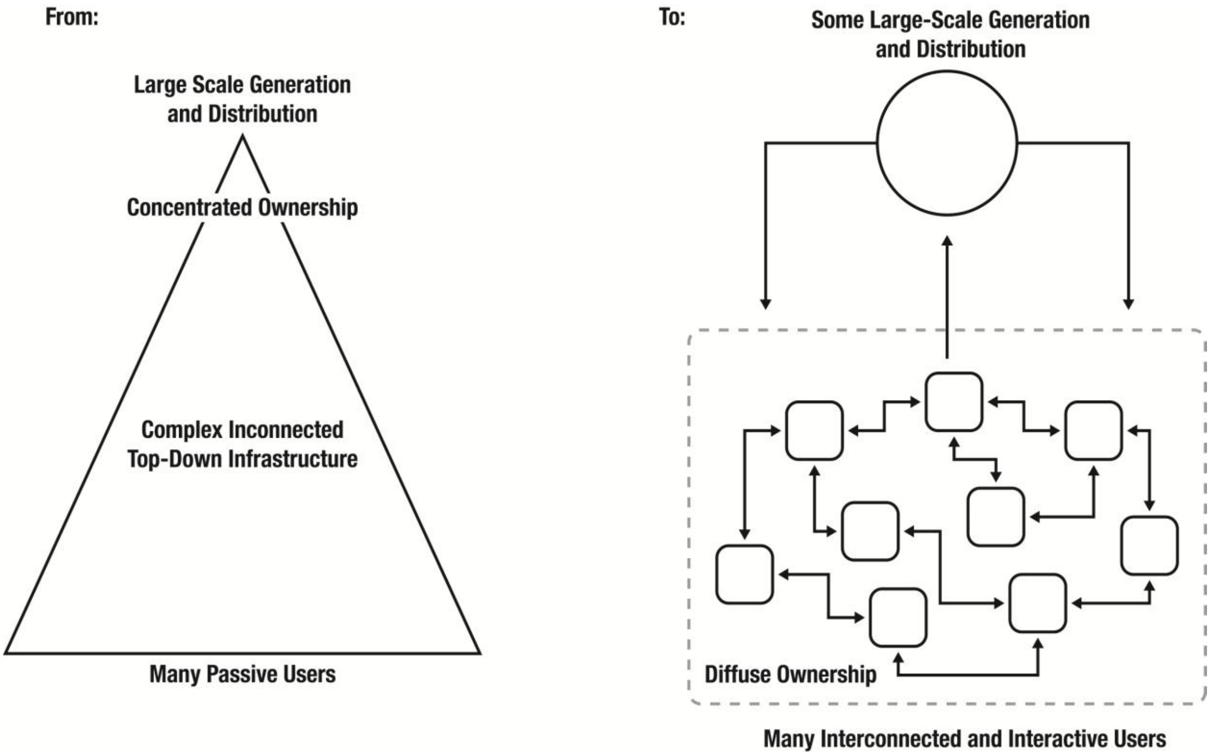
**Figure 2: Conceptual Representation of a Resilient Energy System**




Though energy is vital to every aspect of human endeavour, the household represents a key part of human culture where many energy services are needed, such as heating, lighting, hot water and cooking. In Figure 2 energy resources are captured and/or stored, either with embedded or localised technologies. The user interface provides information that enables the user to balance the energy service need to either available or stored resources. The technological challenge is to design a system that produces, over a period of time, more energy than is needed. Storage provides a buffer against source variability. Resilience thinking implies some degree of over-design to cope with variability.

The starting point for building resilience within new and existing stock is conceptualising building-technology combinations that will maximise resource capture. Many combinations are possible (autonomous, interconnected at street or area level and so on) that will begin to impact system architecture. For example, in the electricity sector, this means a shift from concentrated ownership of generation and distribution capacity and many passive consumers model to a more democratic model with many stakeholders as shown in Figure 3.

**Figure 3: Conventional and Distributed Energy Systems**




As well as addressing a number of systemic vulnerabilities of current structures such changes can generate space for new forms of ownership and governance. We do not advocate a single model but argue that the principal driver for resilience building, predicated on entitlements and governance, is learning. Learning must be broad based and not limited to a training function, for example, how to use or install particular renewable technologies. Learning is required in two areas. Firstly, for users a social learning context where experiences, ideas and environments are shared in a process of iterative learning (Keen et al, 2005). Social learning can embed good practice, for example, energy efficiency through use of visual displays, understandable energy use information and on-going agency support (Darby, 1999; 2006). Well informed individuals or groups making visible their actions in response to climate change by, for example, installing or embedding renewable technologies on their premises or homes can reinforce positive behaviour in others (Milinski et al, 2002; Kierstead, 2006; Wood and Newborough 2006). This is capacity building of users. Secondly, a deutero-learning context where stakeholders (such as technology producers, development companies and agencies, public and private institutions and support agencies) recognise that a shift from single (error correction or doings things better) to double loop learning (doing things differently) is required (Rotter, 1982; Bandura, 1989; Senge 1990; Easterby-Smith et al, 1999; Ormrod, 1999).This is capacity building and institutional development for stakeholders. For both groups learning processes need to share a common goal, which is energy system sustainability, where policies and practices promote system evolution to provide services in socially just and environmentally sound ways (Jiusto, 2009). Transitions in energy system evolution have precipitated significant socio-economic change. A transformation to a sustainable energy system is also likely to have a significant transformative impact (Scheer, 2007; Jiuosto, 2009). The interaction of these learning processes is shown in Figure 4.

**Figure 4: Learning Modes and Low Carbon Pathway Projections**

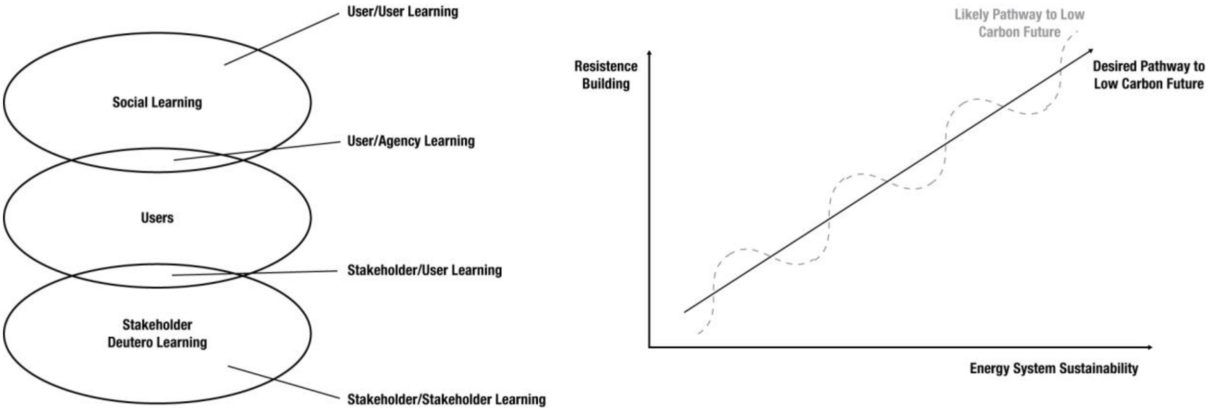



Figure 4 shows the interactions that have a number of equally important aims. First, building user capacity is a necessary step, not only in familiarising users with new forms of energy production and management, but also in feeding back to stakeholders data on system interaction. Capacity building should not be limited to technology awareness, but should also raise awareness of the wider environmental context. In Figure 4 this represented by the overlap between 'Users' and 'Social Learning'. Second is the social learning space, the 'over the fence' interactions with other users where experiential learning would feature. Informal experience sharing is important for capacity building and for promoting social cohesion and well-being. This is represented in the 'Social Learning' area of Figure 4.

Third is the user/stakeholder interaction, shown in Figure 4 as the overlap between 'User' and 'Stakeholder Deutero-Learning' around user experience (what was good, what was bad and why). This interaction would provide valuable input for a range of stakeholders enabling them to learn how to do things better as well as differently. This stage could be problematic as it is necessary that the direction of travel is user-led as opposed to technology-driven. Stakeholder-stakeholder interactions would drive innovation, for example between developer and technology producer over design issues for embedding and maximising renewable capture.

This is important for two reasons. The first is important for wider dissemination where information is available to a wider audience. This will promote a culture of learning and interchange. The second is a move to smaller intelligent systems and micro-grids based on 'Plug and Play' approaches. This allows system evolution as users gain confidence in both the technologies and their ability to manage them (Watson et al, 2006, Abu-Sakarkh, 2005). Linking the user to the energy system in an active and participatory way begins to establish the connections between climate policy, energy security, reduced environmental degradation and social well-being.

**Failure of current policy**

Current government energy does little to promote small scale, decentralised, renewable sources of energy. It favours centralisation and large scale generating technologies (Pollitt, 2010). The UK does have significant potential for renewable energy generation, for example wind, but large scale renewable energy generation will significantly raise electricity costs and result in cost variance (Pollitt, 2010). Such policies do not promote a resilient energy system and act to increase the vulnerability of end users. This concentration on remote centralised sources of energy, renewable or not, also removes the end user from the energy generating process, which acts to lower understanding of the energy system, and the importance of reducing demand.

Moving towards a low carbon pathway will require a mix of standards for new build and incentives for existing stock. The reliance on the Building Regulations, in particular Part L (Conservation of Fuel and Power) as a means reduce energy demand, and increase the take up of renewable and sustainable energy systems, places the emphasis at the single building/house level. The same is true of existing building environmental assessment methods such as BREEAM and the Code for Sustainable Homes. If we are to move towards a low carbon community, we need to encourage and reward community-scale solutions.

There is also a disconnect between the performance of buildings ‘as designed’, and their performance ‘as built’. In the residential sector, emerging evidence suggests that actual $CO_2$ emissions from new buildings are almost double the emissions predicted at design stage (CarbonBuzz, 2010). Professional bodies such as the Royal Institute of British Architects (RIBA) and the Chartered Institute of Building Services Engineers (CIBSE) acknowledge the importance of Post Occupancy Evaluation (POE) as an essential means to gain understanding of the relationship between building design and performance (RIBA 2008). However, in practice POE is rarely undertaken. This raises the issue of whether POE should mandatory.

**Linking to a PFI Project for Sheltered Housing**

Developing and building resilient energy systems as part of the transition towards low carbon communities is a key challenge for local authorities. Councils have a statutory obligation to reduce $CO_2$ emissions and break the cycle of fuel poverty for key social vulnerable groups such as the elderly, infirm or very young. However, increasingly the financial resources of local authorities are restricted, causing councils to search for alternative financing instruments to enable investment in services and infrastructure such as waste collection, street lighting, education facilities, new and refurbished social housing and energy systems (Quack, 2007; 4ps, 1998).

One funding and procurement mechanism which has become increasingly used to deliver public buildings and infrastructure is the Private Finance Initiative (PFI). Initially used to procure large infrastructure projects such as roads, hospitals and prisons, the scope of PFI has expanded to include the building of schools and housing. This section explores the processes being used in an on-going Housing PFI project in the North of England which aims to remodel a local authority’s sheltered housing provision to provide high quality, decent homes which reduce an elderly communities vulnerability to energy prices and energy system shocks.

**The Private Finance Initiative**

The PFI model relies on turning the planning, construction or refurbishment, financing and operation of public buildings to the private sector (Broadbent & Laughlin, 2005; Bennett & Iossa, 2006). Under PFI Contractual periods are usually assigned for between 20 and 25 years with the local authority remitting an annual compensation for the work to the operator (Bing et al., 2005). The main idea is that the private sector is incentivised to provide efficient public services by relying on private capital at risk (Hill & Collins, 2004). Investment under the UK PFI makes up between 10 and 15 per cent of the government’s yearly investment in public services (PUK, 2008) and as of 2008, there were over 400 operational projects across England, mostly schools and hospitals followed by transport projects, fire and police stations, prisons and waste and water projects (HM Treasury, 2003; PUK, 2008).

With regard to housing, initially, the government saw PFI as a means to improve the quality of housing and deliver its ‘Decent Homes’ agenda which mandates that all homes should be ‘warm, weather-proof and have reasonable modern facilities’. Over the last few years housing PFI has developed from projects which deliver Decent Homes through straight refurbishment to schemes where regeneration is the primary objective. Now, many schemes do not only focus purely on the provision on council housing, but also aim to facilitate wider regeneration of areas, including homes for sale.

Many authors have suggested that PFI can and should be used as a mechanism to drive the construction sector towards greater sustainability (Office of Government Commerce, 2002; BRE & Cyril Sweet, 2005; Yates, 2007). Indeed, as PFI is increasingly being used to deliver new and refurbished social housing, there is an opportunity to lever some of resilience building concepts discussed earlier in this paper. One of the problems inherent in attempting to utilise small scale, distributed energy systems, is their high capital cost and long pay-pack periods. The long term nature of PFI contracts, typically 25-30 years, should mean that the whole life costs of maintaining the asset should be taken into account during design and construction (Hill & Collins, 2004). This in turn should make capital investment more attractive as the long term costs are greatly reduced. Additionally since 2006 there has been a system of 'Competitive Dialogue' used in complex contracts where there is a need for the contracting authorities to discuss all aspects of the proposed contract with candidates (OGC, 2006; Wall & Connolly, 2007). This dialogue process presents an opportunity for both parties to discuss sustainability and renewable energy objectives, and for local authorities to ensure that their long term commitments are taken into account.

**Case Study: Quality Homes for Older People**

The idea that PFI can and should be used as a mechanism to increase sustainability, transition to a low carbon community and increase community resilience is being tested on a PFI housing project in the North of England. North Tyneside Council, faced with the problem of how to replace its ageing sheltered accommodation, made the strategic decision to bid for central government PFI funding. The authority was successful in its bid and was awarded just over £112M to contribute to the procurement of high quality, sustainable homes. The project, titled Quality Homes for Older People, is aimed at refurbishing and rebuilding all sheltered housing in the borough, and aims to reduce overall energy use, reduce greenhouse gas emissions and maximize potential for renewable energy in line with climate change goals and renewable energy targets set out by central government and the local authority's policies. The project also aims to meet the Social Care targets of the authority by reducing the number of elderly people vulnerable to fuel poverty and extreme weather events such as heat waves and cold winters.

Early in the project, the authority recognised that it lacked the knowledge, expertise and experience in renewable energy systems and sustainable building and rather than follow the conventional route of using external consultants to fill the knowledge gap, the project team initiated a Knowledge Transfer Partnership (KTP) with Northumbria University. The aim of the KTP is to build capacity and knowledge in the local authority with regard to specifying and operating low carbon renewable energy technologies, knowledge which will disseminate through the local authority to encourage greater take–up of decentralised renewable energy systems by private developers and home-owners. The KTP has effectively replaced the conventional approach of using external consultants meaning that the knowledge, skills and capacity built up during the project will remain within the local authority rather than with external consultants. This in itself is beginning the process of building resilience and countering vulnerability.

**Methodology**

The PFI process is being examined through the analysis of all relevant project material, such as meeting minutes, local authority output specification documents and PFI bidders plans and specifications. The researcher is embedded within the council's PFI team and is carrying out interviews with project staff members and undertaking a participant observation study. The ultimate aim is to understand the impacts of certain actions on the sustainability of the project, and develop a toolkit to enable future PFI projects to maximise the opportunities to enhance the sustainability of their developments.

## Initial Findings

The initial findings or the project suggest that there are a number of advantages which PFI can offer over traditional procurement methods with regard to increasing the sustainability of developments as a means to reduce community vulnerability.

### *Competitive dialogue*

The competitive dialogue process is beginning to focus the attention of some developers on innovative approaches to energy system development. Early in the project, it was clear that sustainability and the need to reduce carbon emissions and fuel costs were not high on bidder's agendas. However, following initial meetings where the importance of sustainability was made clear to bidders, and it was also clear that the authority had a degree of knowledge of requirements, they began to engage with the process and discuss possible solutions such as the establishment of Energy Service Companies (ESCOs) and using innovative building techniques to reduce building energy demands.

The presence of dialogue has allowed the project team to explain the rationale behind the local authority's decision to promote decentralised low and zero carbon renewable sources of energy, as well as offering developers specific local information and knowledge as to what resources are available through detailed feasibility studies.

### *Consultation*

Throughout the procurement process, the council is engaging fully with both existing sheltered housing tenants, as well as potential future tenants, through a series of focus groups which the developers also have the opportunity to participate in. This engagement has increased to capacity of residents to articulate their needs and requirements to developers, as well as increasing their understanding of the importance of energy conservation. Bidders have been surprised at the level of understanding and engagement in the issue of sustainable energy provision from an elderly user group, many of whom are subject to the very vulnerabilities discussed previously such as fuel poverty and the risks associated with disruption of supply. This has led developers to take a more inclusive approach with tenants, meeting with them regularly to better understand their specific needs and develop their energy strategies from the bottom up. This has been seen throughout dialogue where bidders have sought to tailor their energy systems to meet the specific demands of an elderly user group.

### *Specification and Evaluation*

The output specification is arguably the most important document in the procurement of a project through PFI as it is the basis on which the local authority and its stakeholders state what they need to achieve from the services and any associated facilities to be provided. The Output Specification details what needs to be achieved, not how it is to be achieved. By ensuring that sustainability targets, aspirations and good practice are fully articulated in the specification, the local authority can drive the development of sustainable energy systems. In the case of North Tyneside Council, the output specification is being developed to mandate the need for renewable energy feasibility studies, POE, minimum BREEAM standards and other good practices to be carried out. These aspirations can then be linked to the Payment Mechanism which dictates the terms at which the successful PFI Company is remunerated throughout the lifetime of the project. It is envisaged that this will incentivise developers to achieve the standards by imposing payment deductions should standards agreed not be achieved.

***Contextual Factors***

During the course of the work, it has become clear that the actions described above, can drive the environmental aspects of PFI procurement, however conversations with the projects external advisors who are veterans of many PFI projects, reveal that it is more often the contextual factors such as political leadership and organisational priorities that decide sustainability outcomes. It must be recognised that sustainability is not apolitical and it is the interpretation within a political context that determines the level of commitment (Hopwood et al, 2005; Mansfield, 2009). Though in the UK sustainability has merged with neoliberalism, there is some space at the local level for local leadership to establish goals within a sustainability context. It is becoming clear, that the organisational values and aspirations of both the Council's PFI team, and the local authority as a whole, will have a significant bearing on the sustainability outcomes of the project. It is here that the role of learning becomes critical. By building capacity with regard to renewable and sustainable energy systems, as well as sustainability as a whole, into the Council PFI team, wider advisory team and throughout the local authority, it is hoped that sustainability as a goal will become embedded both in the project and more broadly.

**Discussion**

In the co-evolution of socio-technical energy systems for a transition to a low carbon pathway, it is possible to articulate a number of principles underpinning a resilient energy system, namely; appropriateness, based on indigenous renewable resources, capacity enhancing, adaptable and upgradable and easy to repair and maintain (O'Brien et al 2007). In resource-dependent activities some human and natural systems are able to recover from disruptions (Tompkins & Adger, 2004). However in the case of the resource-dependent energy system, both the erosion of the fossil fuel resource base and the adverse effects of its use, require a sustainable approach. Building resilience into the energy system is an iterative learning with the user group of an energy service. Social learning in this context can drive change (Keen at al, 2005)

The appropriateness of the energy system to a particular user group, the elderly, is driving the choice of technology. Elderly people in sheltered housing require a consistent thermal environment as they are susceptible to extremes in both heat and cold. They also require low temperature heat emitters and thermostatically controlled hot water supplies to reduce the risk of burns and scalds (Hope, 2008). In addition, distribution systems such as underfloor heating which work better with the kind of low temperature heat provided by some renewable energy systems, remove the need for obstructions, such as traditional radiators, which can cause harm to people with mobility issues or conditions such as dementia.

Utilising the indigenous renewable resources such as wind, solar and geothermal, available within North Tyneside, the project aims to minimise vulnerability to external shocks such as fluctuating energy prices, system disruptions and outages, as well as maximise well-being of residents. This is a positive step towards meeting climate and fuel poverty targets whilst enhancing energy security.

It is increasingly recognised that a population of passive users is not the solution to solving the many faceted aspects of addressing climate change problems. It is a common problem needing social engagement to define solutions. Engagement can be a powerful tool in building social capital when it is focused on learning and acquiring knowledge, though it should not be regarded as panacea (Ballet et al, 2007; McElroy et al, 2006). Enhancing social capital is builds capacity for resource management (Pretty, 2003). In this case the focus is on diversity within the energy system which builds resilience (Stirling, 2009). By using decentralised renewable energy technologies, smart metering, and a participatory approach to stakeholder engagement during competitive dialogue, North Tyneside Council is enhancing the capacity of both staff and tenants. This builds resilience in the energy system.

A resilient energy system should be adaptable and upgradeable to allow it to develop along with the community. North Tyneside's PFI output specification requires developers to 'future proof' the buildings using Plug and Play and 'Open Source' principles. The aim is to allow the addition and expansion of renewable energy systems as they become more economically viable. Post occupancy evaluation on buildings constructed early on in the contract period will help to inform buildings built towards the end.

With regard to repairs and maintenance anecdotal evidence suggests that many early renewable energy installations suffered from being tied into single repairs and maintenance providers. If the provider subsequently goes out of business, it is often difficult to find a new provider who is willing to take on the system or understands how to maintain it. The result has been a multitude of biomass boilers and CHP systems sitting unused with the back-up natural gas boiler taking the lead. The council is investigating 'Open Source' principles as a means of developing facilities management contracts which enable energy systems which can be repaired by a wide range of facilities maintenance operatives, rather than relying on a single developer or firm.

**Conclusion**

It is clear that North Tyneside Council has begun to see the evolution of processes that could embed resilience into PFI the procurement process and deliver a sustainable PFI model which can be applied to future projects both locally and nationally. We do recognise that building resilience into the energy system will be challenging. Arguably the current trajectory of system evolution is heading to a point where it is pathologically resistant to change. The danger is that this could lead to collapse, or at least, to hardship and suffering for many. Energy security, a diminishing resource base and climate concerns are the signals that a new approach to energy system development is needed. Whether or not this can be achieved in a market based system that favours gigantism is questionable. However there are some signs of an increase in smaller more localised approaches. The challenge is for policy-makers to act on the signals for change and start to devise policy solutions that can transform the energy system. In Denmark, Netherlands and Germany there is considerable involvement in wind power, facilitated through incentives, a sympathetic planning system and a flexible banking supportive of small scale projects. Though there is some movement in the UK, a more radical policy approach is needed if we are to make a more resilient energy system. There must also be recognition that much broader involvement is needed as users, as evidenced in North Tyneside, can provide valuable insights. However this can only happened where local leadership recognises that it must doing differently to make inroads into meeting climate goals, promoting energy security and tackling fuel poverty. The Status Quo is not an option. Thinking from a resilience perspective allows an approach to a low carbon future where shared solutions, developed through learning, can make a sustainable energy future a reality.

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