

Analysing the issue network of Zero Carbon Built Environments: combining quantitative and qualitative approaches

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Abstract

Environmental politics research frequently centres on the analysis of networks but predominantly from a qualitative perspective. This paper makes the case for combining quantitative analysis of policy networks alongside qualitative research. This enables the structure and form of the network to be considered and focussed attention then paid to how actors operationalise the network and give agency to the position of central nodes. This is explored through an empirical analysis of the issue network surrounding the zero carbon built environment agenda in UK in 2009-11. It demonstrates the diffuse yet clustered nature of the network and the importance of expertise claims, internal communication, resources, a unified voice and the organisational business model in shaping organisations' activities within the network.

Keywords: policy networks, zero carbon, built environment, social network analysis

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The emerging issue of zero carbon built environments

Climate change has achieved considerable political saliency at the international, national and local levels and the built environment has become a key focus within the climate change agenda at all scales. The latest IPCC report (from the Intergovernmental Panel on Climate Change) addressed the role of the urban environment (Metz et al., 2007); and within the EU and the UK attention has been paid to the role that the built environment can play in reducing carbon emissions (CEC, 2002, HMG, 2005, CLG, 2005).

The figure that has often propelled the built environment to centre stage is the claim that about half of all carbon emissions are associated with the use of buildings (GOS, 2008). This figure refers to the energy used in space heating or cooling of buildings, the lighting of buildings and the use of appliances within buildings. While the behaviour of occupants is centrally important in determining the level of energy consumption, the nature of the built environment – in terms of the design and construction of individual buildings, urban neighbourhoods and urban energy infrastructure – will be a key determining factor also. If one then factors in the importance of the layout and form of the built environment for influencing travel decisions and hence the carbon emissions associated with transport, this is an added reason for considering the built environment within the climate change agenda. And a third reinforcing reason is the use of resources involved in new urban development, including the embodied carbon associated with the production and transport of building materials and components.

Thus, for all these reasons, the built environment has become a major focus in considering how to reduce carbon emissions and hence mitigate climate change. The goal has increasingly been stated in terms of approaching a zero-carbon built environment. In the UK, the New Labour government announced in 2006 that all new housebuilding would be zero-carbon (in operational terms) in 2016, a goal to be achieved by a mix of planning and building control (CLG, 2006a); all new non-domestic buildings should achieve this goal by 2019. The incoming Coalition Government in 2010 has confirmed its commitment to these targets. While a Code for Sustainable Homes (CLG, 2006b) and a timeline for delivering the new housing targets by successively more stringent Building Regulations has been put in place, equivalent policy documentation for the non-domestic sector is still at the consultation stage (CLG, 2009).

As might be expected the push towards regulating for zero-carbon new development was met with some concern by the development industry. They argued for the need to provide a definition of what counted as zero-carbon development that was technologically feasible but also viable in commercial terms. Given that only part of the energy needs of a building can be reduced by designing the building to manage solar gain and incorporate more insulation into the built fabric, the debate about this definition has turned on how renewable energy generation can be incorporated into a development to meet other energy needs (CLG, 2008). In the UK the Merton Rule – named after the London local authority that first promoted it – sought to require developments to provide a proportion (initially 10% but often higher) of a development's energy needs through on-site renewable energy generation (Rydin, 2010). More recently, the definition of zero-carbon development that has been proposed by the UK Green Building Council has incorporated a suite of 'allowable solutions' that provide for a proportion of a development's energy needs to be met by off-site measures of different kinds (UK-GBC, 2008).

Behind these policy announcements and decisions lies considerable policy activity. As the prevailing paradigm of governance studies tells us, such policy activity is likely to involve a wide range of stakeholders in engagement with each other, typically understood through the metaphor of networks (Dowding, 1995; Rhodes, 1996; Stoker, 1998). This paper explores the zero carbon built environment agenda through the nature of such networks. The next section discusses the study of policy networks and develops a critique centring on the failure to analyse the form of such networks alongside network practices. It then presents the results of an empirical analysis of the zero carbon built environment issue network in the UK as of 2009-11. It shows how additional insights can be achieved through studying the form of such a network and integrates these with the results of more qualitative research on zero carbon built environment networks.

Studying policy networks

Contemporary governance theories adopt a network view of policy activity whereby governmental actors (including arms-length bodies as well as governmental organisations) join in a variety of partnership forms with non-governmental actors (from both the economic sector and civil society) in order to formulate policy and even to deliver it (Sørensen and Torfing, 2008). The advantages of such network governance are seen as: the early identification of policy problems and opportunities; the potential for devising flexible and appropriate solutions; the scope for aggregating useful information, knowledge and assessments to assist in policy development; the hope of consensus building “or, at least, for the civilizing of conflicts among stakeholders” (ibid, p. 13); and the reduction of implementation risks. To this list, Bevir and Rhodes (2008, p. 78) add the legitimacy that is conveyed by consulting in detail and depth with spokespersons for relevant interests.

Compston puts emphasis on the “resource exchange over public policy (policy decisions) as a

consequence of their resource interdependencies” (2009, p. 11), including veto power, information, cooperation with implementation, resources to the courts, political support and patronage.

The process of establishing governance networks is often described as one of institutional design (and redesign), embedding certain rules, values, norms and customary patterns of engagement within a collective of actors. This is an ongoing process; the institutions of network governance need to be continually remade, albeit often implicitly: “interdependent actors need to continuously constitute the network” (Hertin, 2008, p. 52). This has put an emphasis on power play and on discourse construction within specific networks (Hertin, 2008, p. 49) and a concern with how social capital is embedded in network relationships by the generation of certain norms, particularly trust but also reciprocity and mutuality (Rydin and Falleth, 2006).

However, this is to downplay an important feature of networks, that is, their structural form. A network is defined in part by its scale and hence the pattern of closure. As Schaap (2009) recognises, selective inclusion and exclusion of actors will shape the network by altering the connections and the inter-dependencies between actors. It is this detailed patterning of relationships between actors that constitutes the form of a network and it is this feature that has been given little consideration in most recent governance literature. This is despite the fact that the form of the network is the major influence on the transactions costs of inter-relations between actors and the desire to reduce such transactions costs is recognised as a major impetus for network governance. Peters (2008), Sørensen and Torfing (2008) and Klijn and Torfing (2008), Klijn and Edelenbos (2008) all discuss the importance of networks for reducing transactions costs but concentrate on the institutional features alone to explain this. Yet the opportunities for reducing transactions costs are unevenly spread across a network because of the patterns of relationships within the network, i.e. its structural form.

Formal network theorists, such as Barabasi (2002), have argued that specific forms of network – notably the hub-and-spoke (H&S) form – exhibit small world characteristics in which many nodes can be reached from many other nodes in only a few links and that these are most effective in minimising transaction costs across the network and encouraging the flow of information and other resources. This idea has not been explored with reference to policy networks but it suggests that the H&S form could facilitate dialogue and reduce the scope for distortions in dialogue through long and complex chains of communication. In practice, the hub would act as a network manager, managing communication towards mutual understanding and agreement. Such a network manager or hub could ease the move towards collaboration by minimising the transactions involved in negotiating compromises and in actors understanding each other. Similarly such a hub could help ease the transfer of knowledge in all its form through the network. This identifies a promising research agenda in terms of studying the density and structure of policy networks to considering how the form of that network may influence the resource exchanges that are central to the efficacy of network activity. This could encompass the study both of hierarchical networks with identified actors taking on brokerage roles and also informal networks of actors in contact with each other through policy work. To undertake such research requires a different kind of approach.

There has been a tendency for research on network analysis from within the governance tradition to be qualitative in nature, based on fieldwork involving interviews, document analysis and observation (e.g. Pennington and Rydin, 2000, Aars and Fimreite, 2005, Damgard, 2006, Parker, 2007, Compston, 2009). In their comprehensive survey of different types of network analysis, Berry et al. (2004) confirm that there has been a divide between formal network analysis, drawing on social network analysis (SNA), and work on policy networks. This conclusion rather misses the North American work on policy networks undertaken in the 1970s and 1980s (see Knoke, 1990), including that done on urban

community power structures (Hunter, 1953; Dahl, 1961; Laumann and Pappi, 1976) and national leadership (Dye, 1976; Bonacich and Domhoff, 1981). There is also the work on specific policy domains such as health, energy or labour policy (Laumann and Knoke, 1986 and 1987; Laumann, Knoke and Kim, 1985). More recently, a small body of work has emerged using current, user-friendly social network analysis software to extend the potential for quantitative analysis of policy networks (Krackhardt, 1990, Stokemann and Zeggelink, 1996, Christopoulos, 2006, Holman, 2008 and forthcoming). There is, therefore, a body of work that suggests the value of using SNA to conduct a more formal analysis of policy networks (see also Scheider, et al., 2003). Indeed, at the end of their review on network governance, Sørensen and Torfing (2008, p. 311) suggest that SNA could be usefully added to the network analysis “methodological bag of tools”. Such an approach would enable the distinction between networking and network governance that Damgard (2006) and Parker (2007) draw to be overcome (see also Berry et al. 2004).

The rest of the paper undertakes such an analysis in the context of the policy networks surrounding zero-carbon urban development. In particular the paper focuses on the network of fora involved in policy discussion of this issue; each of these fora could themselves be considered a network and thus this is a study of the meta-network or network of networks (Peters, 2008, p. 73) surrounding the discussion of policy for zero-carbon built environments. The meta-network comprises the actors representing themselves and organisations on these various fora and thus in contact with each other through the fora. This is an analysis of an issues network rather than a policy community as it does not involve actual implementation work or even necessarily policy formulation (Rhodes and Marsh, 1992). The emphasis is on discussion and the exchange of information during a formative phase in zero carbon built environment policy and, as such, reflects a network in development (Koppenjan, 2008, p. 144).

Methodology

The methodology combined a first stage of quantitative social network analysis (SNA) with a second stage of semi-structured interviews with representatives of organisations identified as central by the SNA.

The first step in the SNA was the collation of a database. It was decided to use the membership of the various working groups, etc. that have come together to discuss zero carbon built environments and to construct a meta-network comprising the connections between organisations involved in these working groups, etc. via cross-membership. The membership of each individual working group, etc. represents a network in itself but the total issue network on zero carbon built environments comprises all these groups and the linkages between them, and it was this meta-network that was the subject of the SNA.

Data was collected through a systematic search of web-sites, using a matrix of terms which were searched for in pairs. One axis of terms concerned fifteen different synonyms for aspects of sustainable construction and development: zero carbon development; low carbon development; low impact development; sustainable construction; zero carbon construction; low carbon construction; low impact construction; zero carbon housing; low carbon housing; sustainable housing; low impact housing; zero carbon housebuilding; low carbon housebuilding; sustainable housebuilding; and low impact housebuilding. The other axis covered seven different terms for the more-or-less temporary organisations that bring different actors came together in to discuss zero-carbon construction and development: Working Group; Team; Working party; Task Force; Taskforce; Committee; and Partnership. Sometimes this search revealed groups or fora directly; sometimes it revealed reports written by collectives that required further searching for the group responsible. The membership of

the groups was often recorded on the website or in the documents but sometimes it was necessary to search for minutes or similar documentation to find the membership. Usually people were listed along with their organizational affiliation; if this was not available then a search was made for the CV for the individuals and the organizational affiliation was defined as the main occupation listed. Occasionally people were on working groups as independents and then were listed in their own right. Wherever possible checks were made to ensure that the same forum was not going by two different names.

The search was undertaken during August-September 2009 and resulted in 53 different groups or fora being identified with 440 member actors. Subsequent examination of the data revealed that two of these fora and one organisation (concerned exclusively with steel) were disconnected from the main network and they were therefore removed from the main network, which therefore comprises 51 fora connecting 439 actors. The web search and this adjustment comprised the means of determining the boundary of the network.

As with any such exercise, an element of discretion on the part of the researchers was involved and decisions had to be made at numerous boundaries. Reports that were written purely by collectives of academics, usually as part of a research project, were excluded. Secretariats were excluded if they were only operating in that capacity; where an organization acted as a secretariat and also was a member of the group in their own right, it was included in the database. Where one organization has been replaced by or absorbed into another organization, these were treated as one organization and their contacts merged. This particularly affected government departments. The Department of Business, Innovation and Science has replaced the Department of Business, Enterprise and Regulatory Reform (BERR) and the Department of Trade and Industry (DTI); the Department of Communities and Local Government (CLG) has replaced the Office of the Deputy Prime Minister (ODPM) and the Department of Environment, Transport and the Regions (DETR). The Departments of

Transport (DoTr), Energy and Climate Change (DECC) and Environment, Food and Rural Affairs (DEFRA) were maintained as distinct organizations despite partial overlaps because of their distinctive focus.

All the data was entered into an Excel spreadsheet recording the group, URL, date (usually of the associated report), organisation name, individual actor's name. The names of the organisations were then standardised using a dedicated JAVA programme. The data was translated from the spreadsheet to data language (DL) for entry into the SNA software UCINET, using Edgelist 2-mode. The format in which the network was entered was thus a bi-partite (or two-mode) network and dichotomized (i.e. all multiple entries turned in a 1) to remove any repeat entries, such as where more than one representative from the same organisation sits on a group. This created a matrix with binary entries (denoting actor/organization membership of the group or not). The resulting bi-partite network was transformed into a uni-partite (or one-mode) network and again dichotomized. A final check was conducted for any duplicate entries for one organization (say under an acronym and the full name) and the categories collapsed where necessary. The dichotomized bi-partite and uni-partite networks (jointly called the ZCBE network) were then analysed using UCINET centrality measures and other metrics.

As discussed below, this SNA identified a number of core organizations within the overall network. Representatives from the top six organizations were the subject of semi-structured interviews during the summer of 2011, together with a supplementary interview with a university colleague identified within the database. Wherever possible the names person identified in the database was contacted for interview. In total 10 face-to-face interviews and one telephone interview of up to one hour in each case were undertaken. These focused on how the organizations operated within the network and the way that information and knowledge circulated. The interviews were manually and/or audio-recorded and notes written

up immediately for analysis. A summary was returned to interviewees for feedback and comment.

The SNA results: the form and structure of the ZCBE issue network

Given the large number of organisations involved in the ZCBE issue network, visualisations (figures 1 and 2) did not convey much information. Instead it is necessary to turn to the metrics that SNA produces to understand the form and structure of the network.

[insert figures 1 and 2 near here]

The analysis of the bi-partite graph gives a picture of the role of the fora themselves. This had a density of 3.3%. Density is a count of all the ties in the networks as a proportion of all the possible ties and this figure suggests a rather diffuse network. Turning to centrality measures of degree (the number of links to/from the forum), closeness (the extent to which a forum has the shortest path to all others) and betweenness (which measures if a forum is on the shortest path from one element of the graph to another), Table 1 summarises the centrality scores for the rows in bi-partite graph, that is, for the fora. The top ten fora in terms of links (and hence membership), closeness, and betweenness are identified and the four that appear in the top ten under all three metrics are emboldened.

From this analysis, the most significant fora within the ZCBE issue network would seem to be Constructing Excellence and its Sustainability Forum. Constructing Excellence is a cross-sector, cross-supply chain organisation operating across the construction industry and its stakeholders. The next three most significant are:

- the EEPH working group on new build (reinforced perhaps by their working group on insulation); EEPH is a network of over 560 organisations from the public, private and voluntary sectors focused on the energy efficiency of homes;

- BRAC (the advisory non-departmental body established in 1962 to advise the government on building regulations and now designated a Scientific Advisory Committee)); and
- the UK Green Building Council, notably its Task Group on carbon reductions in new non-domestic buildings but reinforced by its Zero Carbon Task Group; the UK-GBC was launched in 2007 to provide clarity, purpose and co-ordination of sustainability strategy to the building sector with membership primarily from businesses across the industry.

Turning to the uni-partite version of the network, this provides a picture of individual organizations within the network. The uni-partite graph links organizations to organizations through the medium of common membership of the fora. Considering density for the uni-partite graph, there were 12,104 ties overall and a density of 6.3% (compared with the theoretical maximum of 100%). While twice that for the bi-partite graph, this is still a low figure. This reinforces the point that the ZCBE issue network seems very diffuse. However, considering the clustering coefficient for the network gives an idea of whether there are more densely connected parts of the network. The clustering coefficient comes in unweighted and weighted forms. The unweighted coefficient gives the average of the densities of the neighbourhoods around the actor or organisation; the weighted coefficient considers these densities in proportion to the size of that neighbourhood. Applying this to the uni-partite graph, give an unweighted clustering coefficient of 0.871; the weighted clustering coefficient was 0.553. So the ZCBE network has low overall density but is quite highly clustered.

Another way to consider the overall form of the network is to undertake a core-periphery analysis. For the uni-partite graph, this identifies the set of organisations that have a high density of ties among themselves by sharing membership of many groups in common. It separates these from another set with a low density of ties. How well the data fits the core-

periphery separation is measured by the fitness score, with 0 being an absence of fit and 1 a perfect fit. Conducting this analysis for the uni-partite graph produced 67 organisations in the core (15% of the total) but the fitness factors was only 0.343 suggesting that the network does not readily divide into a core and periphery; rather there seem to be specific local clusters. Thus the ZCBE issue network seems to be a diffuse and open network, encompassing many organisations and linking them together in multiple ways, with local clustering.

Looking at the geodesic distance statistics for the networks is one way of analysing how readily the organisations are linked together across the network. Geodesic distance is the number of links between organisations in the shortest possible walk from one organisation to another through the network. Calculating this for the uni-partite graph suggests an average distance between pairs of organisations that can reach each other of 2.406 links. Table 2 gives the frequency of different geodesic distances. Some 56% of the shortest links between actors only comprise one or two links; 97% comprise three or fewer links. This means that practically every actor can be reached from every other actor in three or fewer links. This is quite highly connected as a network. However, the distance-based cohesion (or compactness) measure is 0.456, in the mid range of the possible values from 0 to 1, where a higher figure indicates greater cohesiveness; the distance-weighted fragmentation (or breadth) measure is 0.544. Thus the network does not seem particularly highly compacted or cohesive.

This all points to a form of structure within the overall ZCBE network in which certain links play key roles in maintaining connectedness across the network, i.e. an approximation of the hub-and-spoke form. If the network was a small world as strictly defined within graph theory, then the distribution of the frequency of links to the various nodes would be a power law; as Figure 3 illustrates, the ZCBE network is not a perfect small world but the pattern of frequency of links suggests a few nodes or organisations with many links and many nodes

with very few; this is a form that can reduce transactions costs and maintain interconnectedness across the network.

[Insert figure 3)

So which are these lynch-pin nodes or organisations? Turning to the analysis of the relative position of the different organisations within the network, a range of statistics can be derived from analysing the uni-partite graph that corresponds to the ZCBE bi-partite graph. Freeman Degree Centrality measures the number of links to and from an actor in a symmetrical uni-partite matrix of the sort considered here (i.e. the links between organisations). Freeman Betweenness Centrality measures the extent to which an organisation in the network is on the shortest paths between other actors or organisations. Bonacich Centrality or Eigenvector is a measure of the importance of an organisation in a network. It is calculated by assigning relative scores to all the nodes in a network (i.e. the organisations) on the basis that connections to other high-scoring organisations contribute more to the score of a specific organisation than equivalent connections to low-scoring organisations.

Table 3 gives these highest scoring organisations in the ZCBE issue network according to these three centrality measures. This suggests that across the different measures, the most prominent organisations are the BRE, EST and CLG (and its predecessors); these all feature in the top five for all three indicators. Taking the top ten suggests that RICS, HBF and BIS (or its predecessors) are also significant organisations within the network. Two of these six organisations are governmental departments, one dealing with planning and local government (CLG/OPDM/DETR) and the other with the construction industry (BERR/DTI – now constituted as BIS). The other four comprise two agencies, one professional body and one industry body. BRE was originally a governmental body with a history tracing back to 1917. However, it was privatized in the 1997 after a period as an Executive Agency. It now operates on a commercial basis providing training, research and knowledge dissemination,

but its profits are gifted back to the BRE Trust. EST is an independent organisation focused on the reduction of carbon emissions. It provides free advice and information and emphasizes its impartiality, drawing funds from the UK government, devolved governments in Wales and Scotland and the private sector. HBF is primarily a representative organization for the housebuilding industry although it also represents Registered Social Landlords (or housing associations), suppliers and profession service providers to the housebuilding industry. And the RICS is the professional body representing surveyors and the property profession more broadly. This suggests that these six organizations may play an important role within the network and suggests the need for further investigation of their activities.

Network analysis can also consider structural holes and the position of different organisations within the network to bridge such holes (Burt,1995). The analysis identifies the ‘constrain’ parameter for different organisations within the uni-partite graph; a lower constrain figure indicates a higher potential to overcome holes in the network; this has been terms greater social capital by some analysts (van Liere, 2004). Running this analysis suggests that the top five organisations in terms of potentially bridging holes are (in descending order): BRE, EST, CLG (and its predecessors) and RICS and UCL (in joint fourth). The first three confirms the above findings of the significance of these organisations within the overall network. While RICS and UCL have been identified by centrality measures as significant within the network, it would seem that they could play a potential bridging role by virtue of their specific location within the network.

So in summary, the network analysis suggests that the ZCBE issue network has low overall density but is highly connected. This apparent contradiction is explained by the network being quite clustered; the analysis suggests that the key fora are Constructing Excellence and its Sustainability Forum, together with working groups of the Energy Efficiency Partnership for Homes, BRAC and the UK Green Building Council or at least some of its Task Groups.

Meanwhile the key organizations are consistently the BRE, EST and government department covering planning; followed by HBF, RICS and the government department representing the construction industry. These are more concrete findings than it is possible to arrive at through a snowballing technique or qualitative research alone, particularly given the significant size of the overall meta-network that has developed around the zero-carbon built environment issue. However, it remains to be understood how the issue network is operationalised in practice and whether the central positions within the network occupied by the identified key organizations are actively used by those organizations to influence the overall network. The centrality of organizations gives them the potential to act as hubs for information and intermediaries in terms of information flows. Such potential may not, though, be taken up by the organizations in question. This was the focus of the interview stage.

The interview results: operationalising the ZCBE issue network and managing information flows

The interview stage concentrated on understanding how the most central organisations within the network revealed by the SNA actually operated and, in particular, how they sought to influence the flow of information around the network, given that one potential role for central or hub organisations is the transfer of such knowledge resources. A network of the structure described by the SNA has the potential to ease transfers across the network but this depends on key nodes playing their role effectively. In a network with social actors as nodes this depends on how the actors operate and whether they choose to use these central positions to speed transactions or, indeed, whether they block such transactions. Only qualitative research can reveal this.

Looking across the interviewees there is some evidence for the ZCBE issue network operating so as to facilitate flows across organisations. Almost all those interviewed said that they were approached to provide other contacts and thus acted as hubs of contact information within the broader network. It should be remembered though that individuals, not organisations attend the various fora. Thus the extent to which individuals liaise with others within their organisations is also important for the flow of information around the network. Several of the organisations interviewed reported difficulties in internal communication. This was not simply due to the size of the organisation but also related to diversity and complexity. Furthermore member organisations can also lose internal connectivity when members and officers are both used to attend fora. While informal communication within organisations tended to dominate outside of government, governmental departments had structures in place internally and across Whitehall to enhance communications, although their effectiveness was judged variable. Communication often depends on individual civil servants actively seeking to interest others in their own agendas and on cross-membership of groups inside governmental departments.

Almost all interviewees also saw the zero carbon fora as mainly consolidating their existing contacts, adding a few new contacts only at the margin. This suggests that the extensive network of zero carbon built environments was mainly bringing new organisations and people in at the periphery and that the key organisations – as revealed by the SNA – were already embedded within policy networks. Reference was made to a small core of people who appeared at most network events; “quite incestuous” was used as a descriptor. These findings suggest that while the structure of the ZCBE issue network may suggest a form that would enhance flows across the network, this potential may be partly delivered but also inhibited by problems of intra-organisation communication and consolidated nature of the

links between the central organisations. The analysis can be developed by considering each of the six most central organisations in turn.

The BRE was revealed as the single most important organisation within the network. It presents itself as a source of expertise and is considered by some to have a great depth and longevity of knowledge in key areas. As the government's technical advisor on the Code for Sustainable Homes (with the benefit of a five-year contract) and as administrator of key accreditation schemes such as BREEAM and CSH (derived from the BRE's own Eco-Homes standard) it is clearly a key player in zero carbon networks, a major stakeholder with access to government decision-makers. However, the BRE's reliance on income-generating business has affected its role as independent knowledge broker. A view repeatedly expressed was that the BRE's knowledge base had deteriorated over the years and that to some extent they are living on past intellectual capital. More significantly their independence is in question because of their profit-making activities, where they are seen by some as having cornered a part of the ZCBE market. Thus there is a strong economic rationale for BRE's involvement in networking in order to understand the direction that policy and regulation are going and to develop further business. Tensions can arise because they are competing with some businesses represented in fora and impacting on other businesses through their regulatory role, e.g. where they classify specific construction products. It is not always clear when they are representing government and when they are acting for the BRE. While they are recognised as having a unique position with regard to data on the energy and broader sustainability performance of developments, instances occur where they appear to fail to share data, even seem to be hoarding it or seeking to access others' data. Thus the BRE does not always act as a simple knowledge broker or ready conduit for information, largely because of the business model that sustains it.

The Energy Saving Trust was regarded as an independent body, offering a useful link to local government and with effective communication skills. Some consider the EST able to underpin the zero carbon agenda with expertise on carbon accounting but others point to the extensive use of sub-contractors limiting the depth of its in-house expertise. The EST claims an active role in instigating the zero carbon housing policy (via a presentation to the then Minister, Yvette Cooper) and progressing it through involvement in various fora, particularly government-led fora focussed on policy change. However there has been a history of internal tensions over the EST's focus and some regard the organisation as primarily a government delivery agency. It is now affected by loss of government funding and effective privatisation. All these points suggest that the presence of the EST on many fora may not reflect its effectiveness as a knowledge broker, with again its business model affecting its claims to expertise and independence.

The HBF, as the main lobby group for the housebuilding industry, may be considered as the body within the 'top six' most likely to be influenced by sectional interests. Certainly the HBF were widely regarded as a very effective body, a key stakeholder and a major voice for the industry. It both represents and lobbies on behalf of its membership. The HBF has good coverage of the potential membership, which gives it legitimacy in terms of speaking for the industrial sector. It has considerable financial resources and active engagement from that membership when needed. It is very active in a variety of fora because that is its *raison-d'être* as a lobby group and it cannot afford not to be involved given that zero carbon policy affects the viability of its membership. But it appears that the HBF took a decision to work with the zero carbon agenda and actively engage in networking to influence that agenda. It claims to have been involved in the zero carbon homes policy from start, after its Executive Chairman attended an overseas study trip with then-Minister, Yvette Cooper. Thereafter the HBF took a decision to be "up for the journey" and to commit to the policy given apparent

cross-party support; it sought to bring the membership in line with this approach and emphasised the importance of having a single message on the agenda, so much so that one interview described it as a “cracked record”. There has now been a shift in personnel within the HBF from planning to more technical construction expertise in recognition of the importance of the zero carbon agenda. The HBF was influential in setting up the 2016 Task Force in 2007, passing this over to CLG so that government could bring together all the key stakeholders and generate collective ownership of the problem; it now chaired jointly by the Housing Minister within CLG and the HBF Chief Executive. This role is perceived as built on a long history of partnership and dialogue with government (Rydin, 1986). It is seen as well connected to both ministers and civil servants and of knowing who to speak to on any issue; civil servants also seek out their views of likely market response to a policy. Thus the HBF seems to play a central role in brokering the network but its role in terms of information flows is more limited. It relies heavily on the market expertise of its member and its evidence base can be considered quite shallow.

The Royal Institution of Chartered Surveyors came out as the most prominent professional body in the social network analysis. It has a range of benefits: a central London location, financial resources from its extensive membership, and access to the multi-disciplinary expertise of its members. They have also been proactive and selective in aligning themselves with key aspects of the sustainability agenda, prioritising involvement in fora concerned with measurement, valuation and appraisal where they feel they can add value and where other bodies have left a gap. However, they also have sought to incorporate expertise from financial and legal professions where necessary; by comparison the other professions, such as the Royal Town Planning Institute (RTPI), Royal Institute of British Architects (RIBA) and Chartered Institute of Building Services Engineers (CIBSE) may be considered to have defined their roles more narrowly. The RICS has actively sought engagement with

government and stressed their public interest and research remit in seeking a legitimate voice in public policy debates, rather than presenting themselves as primarily lobbying on behalf of members although they also stress the potential for dissemination to their membership. This is part of a process of trying to “get an edge” amongst groups within the zero carbon networks. However, this positioning strategy does not necessarily lead to them acting as effective knowledge brokers; some consider them to be rather protective and less effective at collaboration within networks.

Turning to the two governmental departments highlighted by the SNA, a clear contrast emerged. The Department of Communities and Local Government (and its predecessors) has played a central role not only in participating in fora concerned with the zero carbon agenda but in actively creating and managing certain networks. In terms of participation, the very large number of invitations necessitates prioritising on the basis of the significance of the forum for delivering government policy and communicating that policy to the largest audience and the most important organisations. In terms of managing networks, this has been seen by civil servants as a core part of their work, as part of the consultation process with relevant stakeholders. It is a way of accessing expertise with limited internal resources - getting people “who knew stuff” involved – and influencing the implementation of policy. CLG has then played a role in raising differing views, coordinating discussion and generating agreement in parts of the zero carbon agenda. Since 2010 CLG has been affected by staff loss and churn and, from some perspectives, deskilling. They have moved away from driving or managing networks and are expecting networks – particularly industry-led networks – to work together under their own direction. There was some agreement that this was not working well as yet.

The Department of Business, Innovation and Science (and its predecessors) was considered to take a very different role. It follows debates closely but tends not to be very vocal within

fora, with the emphasis on feeding back internally within government. It does not appear to actively seek to manage networks, having the view that it is up to industry to act on implementing policy and that it won't hold the industry's hand. It is seen as having particularly strong links to the Treasury. Currently staff constraints mean that BIS civil servants are highly selective in which fora to attend. It currently has a clear focus around the deregulation agenda and the need for reality checks on policy.

There are therefore strong internal rationales for how individual organizations operate within the ZCBE issue network and this affects the way that potential connectivity is operationalised and how information flows are managed. This relates to two different purposes of the network, which were articulated by the interviews. Some emphasised their role within fora in brokering compromises and generating a consensus, seeing this as essential for forward movement on the agenda. Others emphasised the need for policy and decisions taken in fora to be based on the best knowledge or evidence; for this group, compromise could be sub-optimal. Some representatives at fora were seen as there to lobby for their particular association and, as such, their information was compromised; supplier associations were particularly mentioned as prone to such bias.

There was a related split between interviewees in views about the flow of knowledge and information around networks. Many saw the operation of vested interests as inhibiting such a flow and a strong forum chair was seen as necessary to counteract the influence of conflicting interests and to prevent posturing at network meetings. These interviews often mentioned the best location for the transfer of information as outside the formal meetings, at coffee, on the way home or by contact after the event. But others did see some potential for the sharing of knowledge within the networks. They emphasised the small size of the core community of organisations (or of a sub-set in a working group) and the benefits of cross-membership by organisations of several different fora. The potential prisoners' dilemma in sharing

information (i.e. information sharing would benefit all but the cost to individuals prevents it occurring) could be broken by the recognition of a common challenge even in the context of market competition by organisations. The tension between information sharing as a basis for decision-making and more politicised negotiation between interests remains though at the heart of the operation of this network.

The setting of the targets for all new housing to progress towards zero carbon status is an example of this tension. It is clear that the setting of targets was a strong impetus to action within the network, both 2016 target for all new housebuilding to be zero-carbon and the more immediate requirements that all social housing meeting Level 3 of CSH. This pushed zero carbon development up the agenda for organisations and created a strong rationale for them to become involved in fora. However, some saw the targets as diversionary of effort – particularly from the important task of retrofitting the existing stock which was effectively sidelined – and to have achieved little beyond the ongoing and established strengthening of the Building Regulations. Others though saw the existing discussion of the Building Regulations to have been subject to positioning by key interests and considerable circularity of discussion. The targets led to new fora for discussion and some saw that discussion as productive and involving new organisations, previously excluded and now newly exposed to the zero carbon agenda. But others pointed to the difficulty of getting “old”, pre-existing knowledge into the new structures and the duplication of effort in having to input the same knowledge into new groups.

Since the original SNA research was undertaken a new organisation has emerged to act as a central network actor, the Zero Carbon Hub (ZCH), a non-profit company with representation from across industry who steer five workstreams. Originally established in June 2008, it is perhaps surprising that the ZCH did not emerge as a key organisation within the network analysis. This is due to its relative youth at the time of the original data collection and that

some of its functions were still be undertaken by the Green Building Council under various task groups, etc. Since then the interviews suggest that the ZCH has emerged as a more significant player. . Interviewees generally considered the ZCH to be effective in bringing organisations together with strong leadership and a track record of consensual working. It is broadly considered to be a “force for good” in terms of circulating information and progressing debates. However, in line with the above identified tension, some critiqued its emphasis on achieving compromises as affecting the treatment of its evidence base. As with the BRE and EST before them, they have now lost governmental funding which may affect their future working; main funds currently come from the National House Building Council and RobustDetails, a HBF spin-off company.

Conclusions

The research reported here has demonstrated the value of using SNA to identify both the overall structure of a policy network and the key organizations occupying a central position within that network. By using a web-based but rigorous means of identifying network members, a much larger network was identified that would happen with qualitative research based on a snowballing technique. Snowballing might have missed many of the organizations included in the database analysed here and would have sought a cut-off point well before all 439 actors were identified. Furthermore the SNA was able to analyse such a substantial network, producing results could not have been achieved through qualitative research using thematic analysis alone. However, it is also important to understand how these organizations operate within the network and whether the potential for brokering and information flows offered by a central position are actually used to these ends by social actors. This can only be revealed through discussion and questioning in interviews and, methodologically, the paper

makes a strong case for the combination of quantitative SNA of policy networks alongside qualitative work on key organizations and their agency (see also Crossley, 2010).

In the case of the ZCBE issue network studied, the SNA identified a diffuse network with significant points of clustering that suggested a potential 'hub-and-spoke' structure and associated ready circulation of contacts and information through key central organizations.

The issue network on zero carbon built environments has, therefore, considerable potential to enable policy discussion based on a considerable flow of information. The SNA also highlighted which were the key organizations within the network. Six such organizations were highlighted: BRE, EST, HBF, RICS, CLG and BIS. The qualitative analysis reinforced that all these organizations were used to provide information to other organizations on relevant contacts and sources of information. It also identified that acknowledged claims to expertise were relevant in enabling these organizations to act as hubs within the network.

However the qualitative analysis revealed that not all of these organizations were using their central position to advance connectivity and information flows across the network. Internal communication, available resources, a unified mission and associated 'voice' and the business model for the organization were all important in shaping the role that the organization took within the network. Where an organization was well resourced, had mechanisms in place to ease internal communication and avoided a fragmented identity, it was better placed to act as an effective information hub; and vice versa. The business model was important in determining how an organization treated information. For some, their functional role was to engage in knowledge dissemination; for others exclusive access to information was the basis of their economic activities. The perception of an economic motive to hoarding information negatively affected the trust with which an organization was regarded within the network and therefore the willingness of others to engage with that organization.

In conclusion, network form and structure, organizational features and behavior within the network and the sectoral interests of network members all work together to shape the effectiveness of the zero carbon built environment issue network in exchanging and circulating information essential to policy development.

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Figure 1 Bipartite ZCBE graph

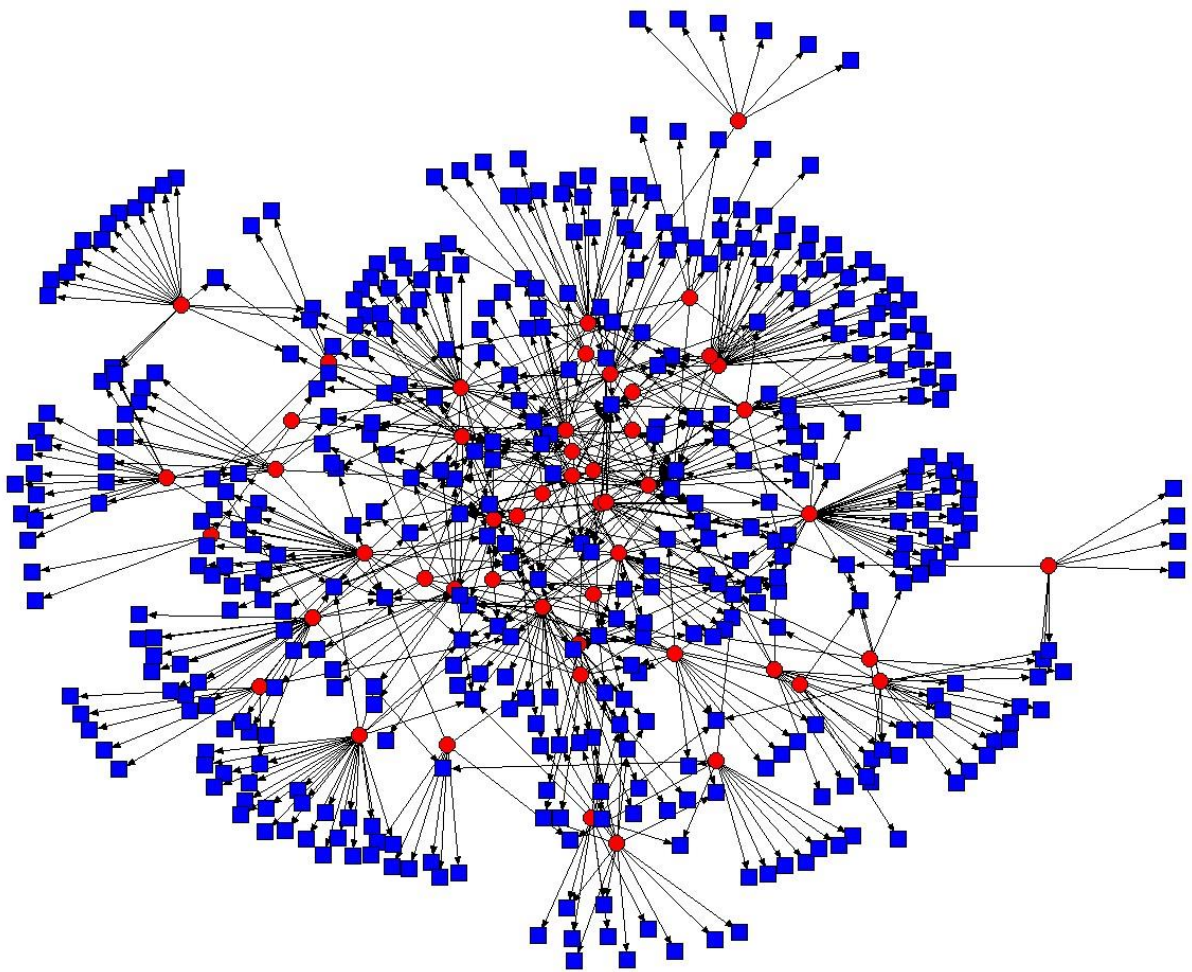


Figure 2 Uni-partite ZCBE graph

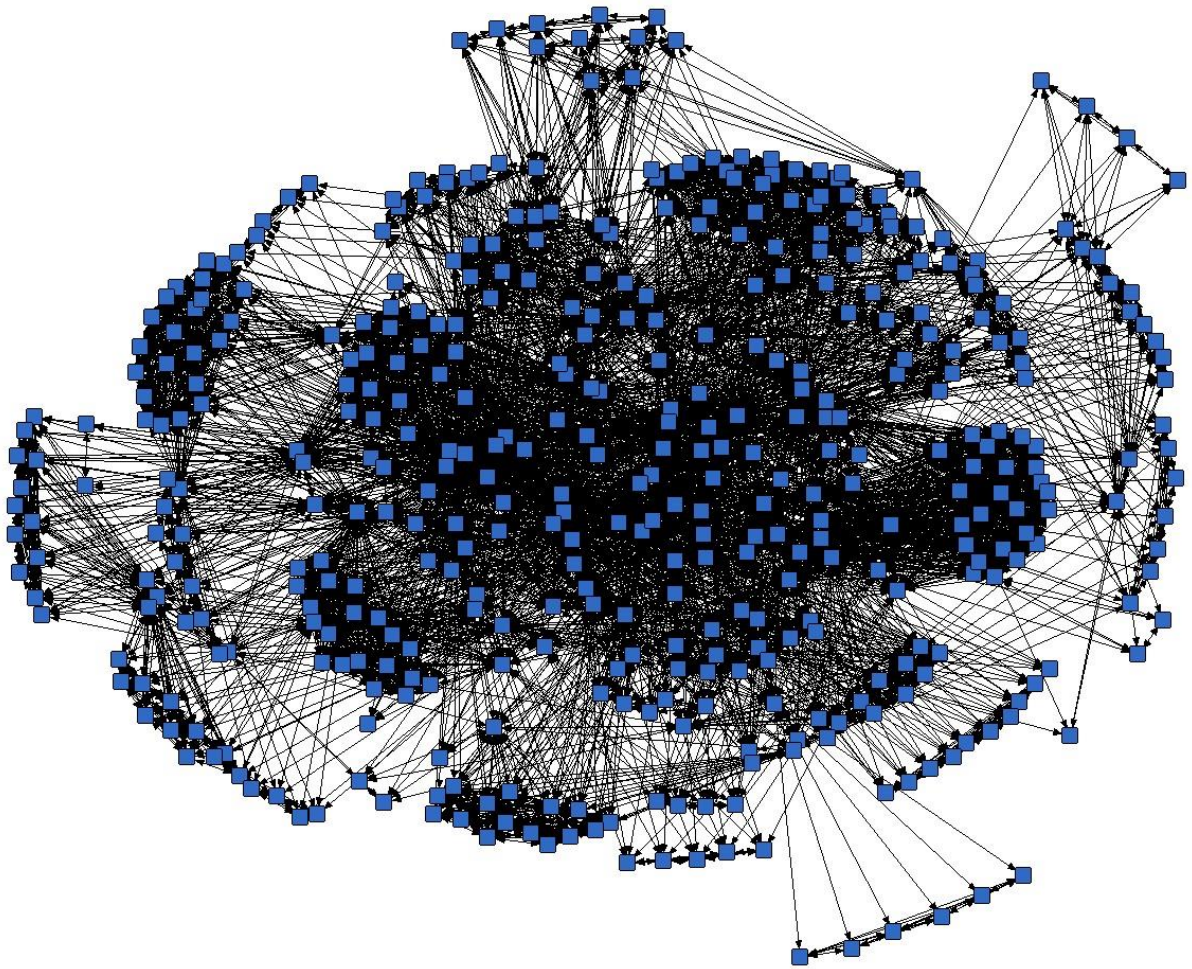


Figure 3 Frequency of links within uni-partite ZCBE graph

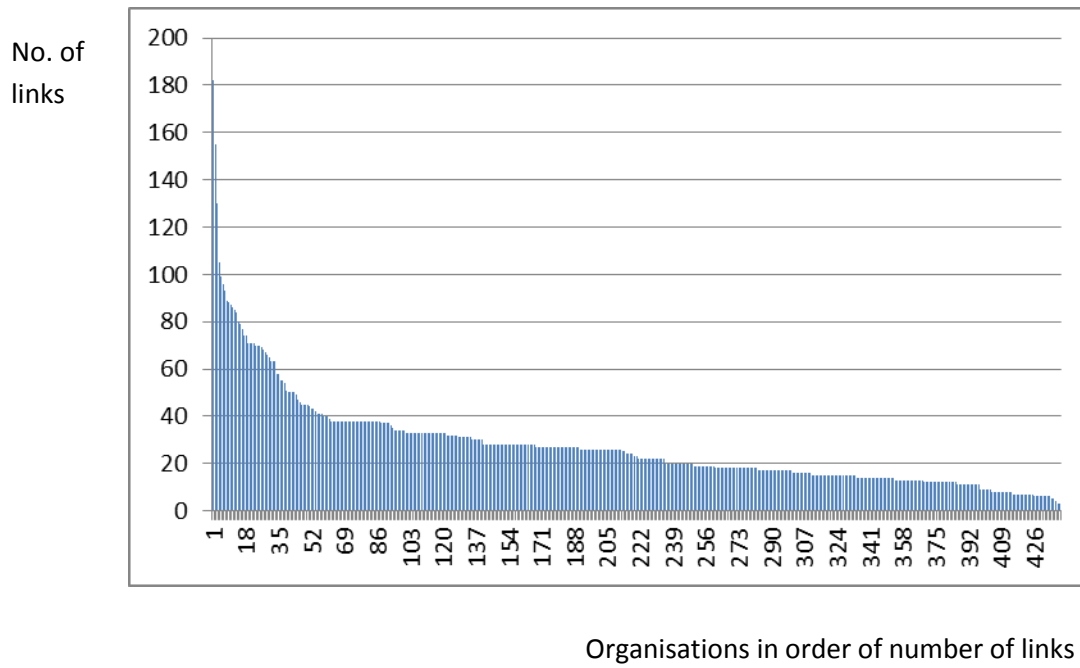


Table 1 Centrality scores for the forums (rows) in the bi-partite ZCBE graph

Rank	Degree	Closeness	Betweenness
1	Sustainable Procurement Task Force	Constructing Excellence Sustainability Zone Sustainability Forum	Constructing Excellence Sustainability Zone Sustainability Forum
2	Energy Efficiency Partnership for Homes Working Group (EEPH): New Build Group	Building Sustainably Report	Sustainable Procurement Task Force
3	= Constructing Excellence Sustainability Zone Sustainability Forum = Building Regulations Advisory Committee (BRAC)	Green Building Council (UK-GBC) Carbon Reductions in New Non-Domestic Buildings Task Group	EEPH Working Group: New Build Group
4	EEPH Working Group: Insulation Group	Calcutt Review Expert Panels	BRAC
5	CIBSE Energy Performance Group	UK-GBC Zero Carbon Task Group	UK-GBC Carbon Reductions in New Non-Domestic Buildings Task Group
6	= UK-GBC Carbon Reductions in New Non-Domestic Buildings Task Group = UK-GBC Pay As You Save Task Group	= UK-GBC Pay As You Save Task Group = EEPH Working Group: New Build Group	CIBSE Energy Performance Group
7	Royal Commission on Environmental Pollution (RCEP)	One Million Sustainable Homes Task Force	EEPH Working Group: Insulation Group
8	Calcutt Review Expert Panels	2016 Task Force	Calcutt Review Expert Panels
9	= EEPH Working Group: Heating Group = Housing Forum: Sustainable Improvement = National SUDS Working Group	= Sustainable Buildings Task Group = DCSF Zero Carbon Task Force	Building Sustainably Report
10		= BRAC	UK-GBC Zero Carbon Task

		= SDC- Sustainable Buildings report	Group
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Table 2 Frequency of geodesic distances for uni-partite ZCBE graph

Geodesic distance	Proportion
1 link	6.3%
2 links	49.5%
3 links	41.5%
4 links	2.7%

Table 3 Centrality scores for uni-partite ZCBE graph

Rank	Freeman's Degree Centrality	Freeman Betweenness Centrality	Bonacich Centrality
1.	Building Research Establishment (BRE)	BRE	BRE
2.	Energy Saving Trust (EST)	EST	EST
3.	CLG/ODPM/DETR	UCL	CLG/ODPM/DETR
4.	Home Builders Federation (HBF)	Inbuilt Consulting	BERR/DTI
5.	Royal Institution of Chartered Surveyors (RICS)	CLG/ODPM/DETR	WRAP
6.	University College London (UCL)	CABE	HBF
7.	BERR/DTI	BERR/DTI	South-East England Development Agency (SEEDA)
8.	Waste and Resources Action Programme (WRAP)	HBF	RICS
9.	Hoare Lee Consulting Engineers	RICS	Office for Government Commerce (OGC)
10.	Inbuilt Consulting	Hoare Lee Consulting Engineers	Construction Skills