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Community Energy Aggregator

Final Report to Technology Strategy Board

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Technology Strategy Board

Project Monitoring form

Final Report

TSB FEASIBILITY STUDIES COMPETITION

Company name:	Buro Happold Ltd
Project title:	Developing a viable business model for neighbourhood governance of smart electricity grids and demand side management
Project number:	131429

FINAL REPORT and APPENDICES

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Glossary

Term	Definition
Balancing services	These are services that can be provided by both generators and consumers to assist the National Grid in balancing instantaneous supply and demand. National Grid makes payments for these services to those opting to participate. Mechanisms for this include: frequency response; fast reserve; and short term operating reserve (STOR). The minimum threshold for participating in this market is fairly high (eg 3MW for STOR) so smaller entities need to go via a commercial aggregator.
Capacity payments	The Electricity Market Reform bill includes provision for 'capacity payments', which could supersede the existing demand side balancing services paid by National Grid (see 'balancing services'). This mechanism aims to ensure that there is sufficient capacity to meet peak demands as power stations are taken out of service and intermittent generation increases.
Demand side response (DSR)	Shifting the time at which electricity demand takes place, in response to an external request (i.e. from the National Grid, or a commercial aggregator as intermediary). The net energy use over the whole day remains the same.
Distributed generation	Small scale electricity generation entering the electricity network at low voltage, at a place where the network was not designed to take input (e.g. solar PV on the roofs of houses)
Distribution Network Operator (DNO)	An entity that owns and operates a section of the distribution network (ie for electricity transported at voltages of 132kV and less). There are currently 7 main DNOs in the UK plus a number of smaller Independent DNOs.
Institutional Analysis and Development (IAD) Framework	Institutional Analysis and Development (IAD) Framework was pioneered by Elinor and Vincent Ostrom and is the product of multiple collaborations among researchers from around the world who are interested in understanding how individuals behave in collective action settings and the institutional foundations that inform such arrangements. Institutions are defined within the IAD Framework as a set of prescriptions and constraints that humans use to organize all forms of repetitive and structured interactions. These prescriptions can include rules, norms, and shared strategies.
Intermittent generation	Electricity from sources such as wind power, which do not generate continuously, and cannot be switched on and off when required.
Low Carbon Networks Fund (LCNF)	The LCN Fund allows up to £500m to support projects sponsored by the Distribution Network Operators (DNOs) to try out new technology, operating and commercial arrangements. The aim of the projects is to help all DNOs understand how they can provide security of supply at value for money as Britain moves to a low carbon economy.
National Grid	The entity that owns and operates the electricity transmission system. This is the high voltage network that transports electricity from generators to substations where the voltage is stepped down for delivery through the distribution networks to end consumers.
Smart cities	The use of data, communication and control technology, to automate interactions between different parts of city infrastructure and people. There are currently no fully 'smart' cities, but many of the component technologies already exist, and technology companies such as IBM, Siemens and Toshiba are making significant investments in further developing these technologies.
Smart meters	Electricity meters which provide minute-by minute readings, and transmit these automatically to the energy company, as well as showing them to consumers through a user interface. This reduces meter reading costs for the company, allows variable tariffs that incentivise off-peak use of electricity, and gives users the information required to respond to these price signals.
Short Term Operating Reserve (STOR)	This is one of a number of 'balancing services' for which National Grid will pay (see 'balancing services'). Under the STOR arrangements, National Grid pays a 'rent' (termed availability) for STOR capacity, and pays a usage charge (utilisation) when the reserve is needed, such as during demand peaks, or when large power stations fail. It is generally provided by commercial operators with flexible generation (eg stand by diesel generators) but can also be provided through demand response (ie load reduction on request).
Triad	This is another of the balancing services paid by for by the National Grid. Generators or those with flexible demand are rewarded if they generate or reduce load at the three points of peak demand on the electricity system, between November and February each year. Around ten 'triad warnings' are issued during this period for participants to respond.

1 Project overview

1.1 Overall problem addressed and significance

Community energy organisations are seen by many as having the potential to help address a number of key challenges which the UK is likely to face in the coming years. These include: the mitigation of climate change; energy security; reduction in inequalities of access to basic energy needs (fuel poverty), local resilience to energy shocks, accountability, democracy and empowerment in relation to energy provision, and ensuring that innovation in technology is driven by peoples' needs.

Technological innovation will make an important contribution to delivering a low carbon, equitable and resilient energy future, but this must take place alongside development of innovative institutions, governance and business models.

The initial objective of the study was to develop a viable business model for community management of demand side response (DSR). This was broadened to include the development of a community electricity microgrid, as the value in this system became apparent over the course of the project.

1.2 Impact

Community management of DSR was broken down into three themes: DSR, community management, and business models. Each of these themes address the challenges listed above in the following ways:

Demand side response

- DSR can impact climate change mitigation by reducing carbon emissions of the electricity system through enabling greater penetration of intermittent renewable generation, as more flexible demand is better able to accommodate fluctuations in generation
- Rewarding people fairly for changing the timing of their electricity demand can help address fuel poverty and better engage people in energy issues. These actions can also reduce overall system costs by 'flattening' the national demand profile

Community management

- Can have positive impacts on social cohesion and energy literacy by:
  - making energy 'discussable'[1], increasing energy literacy, 'materialising' energy
  - making the concept of a 'smart' system work for citizens and democracy
  - increasing deployment of distributed renewables at local level, and thereby bringing economic value to the community
  - empowerment leading to greater engagement and motivation in relation to climate change policies
  - developing institutions for local resilience – the ability to respond to emergency/changes through local decision making processes
  - treating energy as a 'commons' so that the structure of the energy system is qualitatively similar to the structure of the climate problem

[1] Catney, P., Dobson, A., Hall, S. M., Hards, S., MacGregor, S., Robinson, Z., Ormerod, M. and Ross, S. (2013) 'Community knowledge networks: an action-orientated approach to energy research', Local Environment, Routledge, 18(4), pp. 506–520.

Business model

- Impacts from a viable business model would primarily be associated with:
  - supporting local jobs and other economic benefits
  - enabling social, socio-technical and non-technical innovation
  - improving local skills in relation to business management and energy technology
  - generating an independent source of income that is not reliant on grant funding and therefore more sustainable in the long term

2 Outline and approach of study

2.1 Outline of the study

The study aimed to test the potential for developing a viable business model for community managed DSR and an electricity microgrid. This involved understanding a number of areas:

- People's willingness to participate in demand response activities at home
- The value chain for electricity demand response, including National Grid, Distribution Network Operators (DNOs), suppliers, and commercial aggregators
- The regulatory framework, and regulatory barriers to implementation
- The activities and cost structure of a social enterprise which could implement this system
- Potential partners and stakeholders who may be interested in implementing the developed business model

2.2 Approach adopted during feasibility study

- Literature review on the background of potential benefits of the proposal
- Understanding the context of the electricity system and demand response market in the UK through interviews with key stakeholders
- Review of current research in this area, both at theoretical / academic level and at deployment level through Ofgem's Low Carbon Networks Fund (LCNF)
- Developing business models that include community managed DSR based on a 'business model generation' framework[2]
- Developing institutional frameworks for community resource management based on principles developed by Elinor Ostrom[3]
- Building relationships with potential partners for further development of this proposal

2.3 Collaborators

The feasibility study was led by Buro Happold, but included input and work by a number of collaborators which was key to the successful delivery of the project.

Knowle West Media Centre (KWMC): Local charity based in South Bristol working on digital media development and exclusion, and training for young people. KWMC contributed by:

- Hosting and facilitating two focus group sessions
- Input to preparation of workshops for focus group sessions

[2] http://www.businessmodelgeneration.com/
[3] Ostrom, Elinor (1990). Governing the Commons: The Evolution of Institutions for Collective Action. Cambridge University Press. ISBN 0-521-40599-8.

- Recruiting participants to these sessions
- Hosting and organising a stall during the Bristol Green Doors open day
- Hosting and organising evening session with Knowle West / Filwood Neighbourhood Planning Forum

Daniel Quiggin: PhD researcher modelling future electricity systems and a founder and co-director of Demand Energy Equality. His contribution included:

- Extraction of relevant data from models developed through his PhD research
- Analysis and representation of household demand profiles and required energy behaviour changes within STOR based DSM energy market.
- Input to preparation of workshops for focus group sessions
- The presentation of household demand profiles to the participant households.

Matthew Leach: Director of Centre for Environmental Strategy, University of Surrey. His contribution included:

- Academic guidance and review of the project

A number of organisations were interviewed during the course of the project, providing valuable insight and an opportunity to test ideas. These include:

- Commercial / technology: Kiwi Power, Moixa Energy, Good Energy, Western Power Distribution
- Regulation / governance: Ofgem, DECC, Knowle West /Filwood Planning Forum, Bristol Energy Cooperative
- Data: Energy Savings Trust

2.4 Change of scope from original proposal

The stakeholder engagement sessions did not go into the planned level of detail, due to the steep learning curve required for participants to engage with the concepts being introduced. This in itself was a useful learning point. The sessions did provide a valuable insight into people's responses to, and level of understanding of, demand response.

The business model developed is qualitative and wider in scope than originally envisioned, as the original narrow business model was found not to be viable.

3 Deliverables and outcomes achieved

A number of deliverables are included as Appendices to this report. These demonstrate the research and innovation carried out as part of the feasibility study and are outlined below.

3.1 Background

The background research resulted in the development of the following documents.

- A summary of the literature review undertaken to support this work is provided in Appendix A.
- Stakeholder map, showing the objectives and motivations of key stakeholders in the electricity system (Appendix B)
- Analysis of the current and proposed electricity system using Elinor Ostrom's IAD framework. This critique utilises an analytical tool used for the consideration of 'common pool resources' to identify likely success factors and potential difficulties in the institutional development required for community managed DSR (Appendix C)

- Understanding of the value of DSM. This identifies where the monetary flows are, as well as current limitations on the monetary value of DSM (Appendix D)
- Review of ongoing UK research on smart grids, demand response and community solutions, including that funded by the LCNF, and the EVALOC project. This identified that although considerable attention was being paid to energy use behaviour and technology (e.g. smart meters), there was far less research on schemes managed by the community themselves. There was also a lack of research that tested holistic, integrated community electricity systems (see Appendices E and F)
- Interviews with key stakeholders. This provided evidence used both for developing understanding of the electricity system and evaluating the viability of community managed DSR (see Appendix G)

3.2 Engagement

A number of community engagement activities were carried out. These included:

- Two focus group workshops in South Bristol hosted by the Knowle West Media Centre, and with input from Daniel Quiggin (see collaborators in Section 2.3)
- Three stalls at events, where people were asked to complete surveys
- A workshop with members of the Knowle West / Filwood Neighbourhood Planning Forum and other key local organisations
- A review session with core members of the Bristol Energy Network
- A review session with directors of the Bristol Energy Cooperative

These activities provided evidence that was broadly supportive of the development of community managed DSR, and included several original findings. The qualitative findings from the workshops, and a summary of the survey results are included in Appendices H and I.

3.3 System model

A number of potential value chains were explored during the development of a business model for community managed DSR. These value chains were then brought together into one overall integrated system model, which combines benefits from time of use and bulk buy tariffs; from distribution, demand response and peak demand management; and from generation and storage activities. The greatest benefit of this integrated system model is an institutional and physical arrangement to maximise the value to the community of electricity generated and consumed within the community. The system also includes the creation of value for the community through innovative tariffs and provision of demand response and management for external parties. This system model is explained further in a number of diagrams (see figures and appendices as referenced below).

- System model concept and system model canvasses (see Appendix J)
- Community managed DSR business model review (Appendix D)

4 Findings

- There is significant interest from a number of expert stakeholders in developing community approaches to demand side response. These stakeholders range from central government (DECC) to communities themselves. They also include commercial entities which see the potential value of aggregating individual energy demand at community level to minimise transaction costs and benefit from economies of scale.

- Many previous and ongoing studies have addressed elements of our proposed concept, but not in an integrated or holistic manner.
- There are a number of different aspects to demand side management and the benefits it can provide to different parts of the electricity system. The ability of participants to obtain value for these benefits also differs:
  - Transmission (National grid): balancing services are rewarded by commercial arrangements already in place and operated widely across the UK. Participants are mostly commercial / industrial, due to the scale required for participation in the balancing services market. Even commercial and industrial users of electricity usually deliver demand response through commercial aggregators in order to achieve scale requirements.
  - Distribution (DNOs): avoided costs of system upgrade on particular substations can be passed to participants in demand side response however this value is not standardised and systems are at the testing / experimental stage. Participants in trial projects include domestic customers.
  - Supply: no system exists or is being tested for the clear identification and valuation of any benefit arising from demand side response.
  - Regulation: it is not possible to buy or sell electricity without a supply license. A full supply license has onerous requirements, making it unsuitable for community and small organisations. The Ofgem initiative to enable smaller players to enter the electricity, Licence Lite, is being trialled by the GLA, but requires partnership with a licensed supplier and is proving challenging even for such a large organisation. This makes peer to peer electricity sales, or bulk buying of electricity impossible under current regulations.
- Demand side management could provide other benefits in the future as new technologies and approaches are introduced to the system. DSM could help to:
  - Transmission: manage the impact of more large wind (intermittent) and nuclear (baseload) supply. Daniel Quiggin's PhD research has shown that significant domestic demand side management may be required for balancing an electricity grid that achieves the UK's 2050 carbon targets[4]
  - Distribution: manage the impact of clusters of electric vehicles, solar PV and electric heating on distribution networks
  - Smart Meters: achieve their full value
- The original concept of income from existing National Grid balancing services, managed through an existing commercial aggregator, is not currently financially viable due to the dilution of the incentive as applied to a number of individuals within a community (see Appendix D). Similarly, value at distribution level is likely to be low.
- There could be greater value associated with a community based electricity infrastructure management institution that took an integrated approach to a wider variety of activities such as optimisation of local electricity storage, demand response, demand reduction and distributed generation.
- There are likely to be significant social, environmental and infrastructural benefits to developing an integrated community energy management institution, but further study is required to better understand these.
- There is a lack of understanding of the electricity system amongst 'the public', which would be addressed as part of a proposal for a pilot study.
- The institutional analysis and development (IAD) framework developed by Elinor Ostrom and colleagues for the management of 'commons' can be applied to developing urban community electricity systems (see Appendix C).
- Survey respondents were more interested in the positive contribution their actions would make than by 'keeping up with the neighbours'. There was a willingness to share data on electricity consumption with community institutions, but less willingness to share individual data with all individuals in the community.

[4] Presentation given to Buro Happold by Dan Quiggin on findings arising from his PhD research. Not yet published.

- Some people felt that community activities would motivate them to participate in demand response, whilst for others this made no difference. This was especially true of leisure or replacement-social activities such as watching TV.

5 Expected impact and next steps

This study has shown that a community managed smart grid will have most value if it is carried out as an integrated solution for a neighbourhood, optimising the interaction of electricity generation (PV, micro CHP etc), electricity storage (batteries which could be in EVs, fuel cells, hydrogen), automated DSR, and behavioural or habit change DSR.

Achieving this through a community organisation could significantly increase the extent of behavioural DSR, and other types of active household participation, through greater trust and the value of 'making energy discussable'. It could also have added benefits of absolute reductions in energy demand, through raising awareness of and engagement with energy.

The integrated proposal described above, and in further detail in Appendix J is challenging given the number of different stakeholders, technologies, commercial and regulatory arrangements. However, the benefits of working across these systems could be significant and support all aspects of the 'energy trilemma' faced by the UK; climate change, fuel poverty and energy security.

This study sets an agenda for both further research and for regulatory change.

A vision for a pilot study has been developed and is described in Appendix J. Taking the idea forward, would require:

- A fund to use as an incentive for behaviour change beyond the value which is currently available in the market.
- Partnership with companies already acting in this space. We have built a number of relationships with potential partners through the process of carrying out this feasibility study, and are confident these can be built upon.
- Partnership with technology firms who would be interested in testing their products as part of our project. Either: permission from Ofgem to test ideas that are not permitted under current regulation. Or, further investigation into existing alternative mechanisms that would allow a pilot project to take place under current regulation. It is expected that the process of the pilot project will contribute to the case for making the required regulatory changes, through evaluation of the environmental and social impact.

6 Lessons learned

- Useful lessons were learned regarding stakeholder engagement in relation to energy systems and their complexity, particularly in relation to the concept of demand side response.
- The business model developed is qualitative and wider in scope than originally envisioned, as the original narrow business model was found not to be viable.
- The competition process was relatively straightforward; being allocated a Monitoring Officer was helpful and enabled queries to be resolved speedily and effectively.

- We were able to work with a much wider range of stakeholders than originally envisaged and all parties were willing to participate and support the study. Having the TSB 'brand' helped as did attending the Collaboration Nation event in July.

7 Summary

This study has shown that implementation of community managed DSR as a single activity is not currently financially viable due to regulatory barriers, institutional arrangements and the difficulties of identifying and monetising the value of the services provided to the different parties within the system[5]. However, it was clear that the concept of a community institution for energy management is of interest to a number of stakeholders, and could provide significant social, environmental and infrastructural benefits. From the understanding accrued and research carried out during the study, an outline for an integrated community electricity system has been developed instead. This integration is expected to deliver greater value to communities by making technology work together, and by making institutions work for the community. Details of this system model, as well as a proposal for a pilot study to test and develop this model further are given in Appendix J.

[5] Ofgem: Creating the right environment for Demand Side Response, 2013
https://www.ofgem.gov.uk/ofgem-publications/75245/20130430creating-right-environment-demand-side-response.pdf

Appendix B Stakeholder diagram

In order to deliver greatest value from the system, the various stakeholders, and their motivations, were explored. The results of this exercise are displayed below in Figure 1.

It is clear that there is considerable complexity and a large number of stakeholders involved in the system. This highlights the necessity of considering the motivations of all involved, especially when the objectives of different stakeholders are aligned or opposing. This exercise informed the rest of the study, by helping to design a system model that sought to align the motivations of as many stakeholders as possible, whilst seeking to resolve potential conflicts.

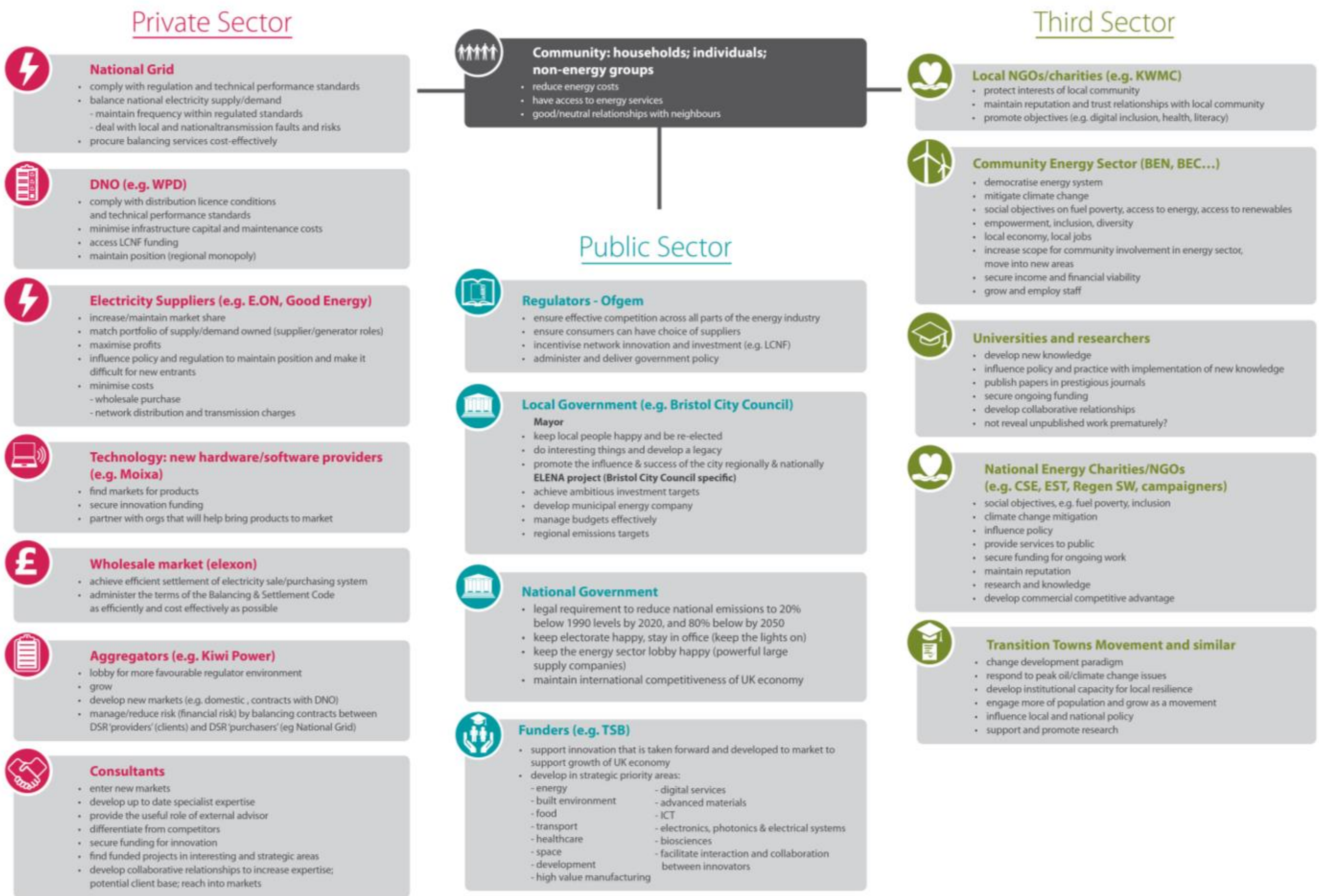

Figure 1- Diagram listing stakeholders and their motivations in a community managed electricity system.

Appendix C Community Resource Management

Introduction

In the development of a community system for managing resources, we have used the IAD framework developed by Elinor Ostrom. This framework was developed initially in the context of community scale management of resources, but has since been generalised to a variety of other institutional contexts. The framework has been applied to the current UK electricity system, as a framework for critiquing what is not working with it, and has also been used to design an innovative community management institution.

The IAD framework

The IAD, or Institutional Assessment and Development framework developed by Ostrom, is outlined below. It consists of eight 'design principles', which were derived from analysis of a large number of case studies.

Note on terminology

The term 'appropriation' denotes use of a resource by 'users' or 'appropriators'. The terms 'user' and 'appropriator' are used interchangeably.

The term 'provision' refers to activity that provides, creates or maintains a resource. This could include demand response behaviours, providing capital for the installation of renewable energy, or making available the battery of an electric car to the local microgrid system.

Design Principles

1A User boundaries: Boundaries between users and non-users must be clearly defined

1B Resource boundaries: Clear boundaries are present that define a resource system and separate it from the larger biophysical environment.

2A Congruence with local conditions: Appropriation and provision rules are congruent with local social and environmental conditions.

2B Appropriation and provision: The benefits obtained by users from a common-pool resource (CPR), as determined by appropriation rules, are proportional to the amount of inputs required in the form of labour, material, or money, as determined by provision rules.

3 Collective-choice arrangements: Most individuals affected by the operational rules can participate in modifying the operational rules.

4A Monitoring users: Monitors who are accountable to the users monitor the appropriation and provision levels of the users.

4B Monitoring the resource: Monitors who are accountable to the users monitor the condition of the resource.

5 Graduated sanctions: Appropriators who violate operational rules are likely to be assessed graduated sanctions (depending on the seriousness and the context of the offense) by other appropriators, by officials accountable to the appropriators, or by both.

6 Conflict-resolution mechanisms: Appropriators and their officials have rapid access to low-cost local arenas to resolve conflicts among appropriators or between appropriators and officials.

7 Minimal recognition of rights to organize: The rights of appropriators to devise their own institutions are not challenged by external governmental authorities.

8 Nested enterprises: Appropriation, provision, monitoring, enforcement, conflict resolution, and governance activities are organized in multiple layers of nested enterprises.

Analysis of the current UK electricity system

The IAD principles have been applied to the current UK electricity system, as a framework for a critical review.

1A Clearly defined user boundaries

The people who have access to electricity are metered. It is difficult to steal electricity from the grid through illegal connections.

1B Clear boundaries of resource system

As a human-made system, the electricity system is clearly defined. However, it is connected with other resource and environmental systems, such as fossil fuel extraction, and the climate. One could draw the system boundary to include the fossil fuel supply chain, or the fossil fuels after they have arrived at a power station, or only electricity once it has been generated.

2A Congruence with local conditions: Appropriation and provision rules are congruent with local social and environmental conditions.

The current national electricity system is the same around the country, and does not vary according to local energy generation potential conditions (e.g. very windy areas), or specific local needs (e.g. greater need for energy in colder microclimates, different levels of affordability for different people). However, the system has been in place for a long time, and local social conditions are adapted to it.

In some places, provision rules are not congruent with local environments. For example, in the Scottish islands there is very high potential for generation of wind power, but generation is restricted due to lack of capacity in national grid transmission infrastructure.

2B Benefits of appropriation and provision inputs are proportionate

People pay money to purchase electricity. Tariffs are generally lower for those who buy large quantities (e.g. commercial electricity costs are lower than households), households generally pay a standing charge that does not relate to the amount they consume, people on pre-payment meters pay higher rates, and generally the first few units of electricity consumed are more expensive than the next few. This may have some reflection on billing and distribution costs, but does not provide for basic needs to be met affordably, and does not incentivise behaviour which would reduce overall system costs, e.g. keeping peaks low.

3 Collective-choice arrangements: Most individuals affected by the operational rules can participate in modifying the operational rules.

Individuals have almost no say in modifying the rules of the system. There are numerous protests regarding aspects of the electricity system, from fuel price and anti fuel poverty campaigns, to campaigns against the use of shale gas and climate change. Consumer interests are protected by regulation of the market through Ofgem, which is accountable to policy, which is accountable through the democratic process of the country, but there is very little potential for users of electricity to change the rules.

4A Monitoring users: Monitors who are accountable to the users monitor the appropriation and provision levels of the users.

The monitoring of usage of electricity takes place through metering, which is controlled by electricity supply companies. These are not accountable to the users of the electricity, but to their shareholders, although they are regulated by Ofgem.

4B Monitoring the resource: Monitors who are accountable to the users monitor the condition of the resource.

The condition of the electricity system is monitored by the national grid, which must maintain the frequency and voltage within certain boundaries. This is highly regulated, and must be kept stable, in order to avoid a blackout. Users do not participate in the monitoring. Monitoring of the wider resource (e.g. renewable energy, fossil fuels) is not included in the system, and there is no feedback from the availability of fossil fuels to users other than through price signals. Price of electricity, however, is made up of a complex variety of factors, and does not provide information in a way that allows preventative action by users.

5 Graduated sanctions: Appropriators who violate operational rules are likely to be assessed graduated sanctions (depending on the seriousness and the context of the offense) by other appropriators, by officials accountable to the appropriators, or by both.

It is very difficult for appropriators to violate operational rules, as there are no limits to how much any user can consume, as long as they pay for it. Users who get into debt can be cut off their electricity supply.

6 Conflict-resolution mechanisms: Appropriators and their officials have rapid access to low-cost local arenas to resolve conflicts among appropriators or between appropriators and officials.

Any conflict resolution takes place through the legal system. Electricity supply companies have much greater power than users/appropriators.

7 Minimal recognition of rights to organize: The rights of appropriators to devise their own institutions are not challenged by external governmental authorities.

There are high barriers to developing local electricity institutions. Users of electricity are not able to sell directly to each other, as selling and buying electricity requires an electricity supply license, which is onerous and expensive. The distribution and transmission networks are controlled by large companies which can refuse connection. This is partly due to infrastructural and technical issues, such as the cost of reinforcement of local and national grids, but is also due to the institutional, commercial and regulatory arrangements. Household users are treated as individuals, and a ‘community’ is not recognised as a unit, so it is not possible to bulk buy electricity to achieve economies of scale.

8 Nested enterprises: Appropriation, provision, monitoring, enforcement, conflict resolution, and governance activities are organized in multiple layers of nested enterprises.

There are no layers of nesting, as household consumers purchase electricity directly from national electricity suppliers, on a competitive market, and are not able to organise into consumer groups to bulk buy. The distribution system is somewhat nested, with the national transmission grid as a separate entity to the regional distribution network operators.

Development of a Community Smart Grid

The IAD principles were then used to develop an institutional design for a community smart grid. This institutional design is to be tested through the proposed pilot project.

1A Clearly defined user boundaries

The users of the system would need to actively choose to participate, and become members of the system. This would involve some form of contractual agreement.

User boundaries may also be defined geographically (e.g. households attached to one substation), through communities of interest (e.g. members of existing community groups).

1B Clear boundaries of resource system

The resource system includes all electricity consumption/demand, storage and generation assets owned or managed by individual members, or the community institution. These may be geographically collocated, or associated through a 'virtual' aggregation system.

The local microgrid resource system is linked to the external national electricity system, and there are flows of electricity and data between the local and the national system, mediated by the Community Energy Aggregator (CEA) institution.

2A Congruence with local conditions: Appropriation and provision rules are congruent with local social and environmental conditions.

Tariffs, incentives, and allocation of benefits and costs can be set to achieve local objectives, including reducing fuel poverty or raising money for local projects.

Provision of electricity is aligned to local resources, e.g. insolation, windspeed, biomass space for storage of batteries or locating of CHP or other electricity plant. It also takes into account the local distribution and transmission constraints, but aims to find ways around these constraints where possible.

Rules build on local culture, social capital, and levels of energy literacy, and seek to develop these.

Local value is maximised, but the microgrid is connected to the wider system. e.g. obtaining investment from outside the community where required, exporting electricity from areas with high renewable potential.

2B Congruence between provision and appropriation rules

Electricity generated by local renewables, and the storage capacity of batteries in buildings or electric vehicles, use of fuel cells or hydrogen for storage, are pooled in a local system. The owners of these assets receive value proportional to what they have provided to the community system.

Activities such as demand response behaviour and making appliances available to automated switching are rewarded proportionately to individual participation.

Investment in the community enterprise is rewarded through a return on investment.

The coordination, analysis, contract negotiation, maintenance and appliance control work is carried out by paid staff of the community energy aggregator, creating local jobs.

3 Collective-choice arrangements: Most individuals affected by the operational rules can participate in modifying the operational rules.

Individuals and households can make decisions within the Community Level One (CL1) groups for matters affecting that group (e.g. visibility of information, aggregation of data, whether they can see individual household energy use, allocation of value for assets and activities within the group, allocation of value to community benefits).

The community level one groups send a representative to the CEA, to make decisions on matters that affect all the level one groups, e.g. allocation of value between the groups, negotiation with external sources of value (e.g. National Grid, DNOs, supply companies), and lobbying of national government and provision of evidence for regulatory development.

4A Monitoring users: Monitors who are accountable to the users monitor the appropriation and provision levels of the users.

Smart metering is used to monitor electricity usage, generation and utilisation of storage. This sends data to a processing unit run by the CEA, which is accountable to the users through the CL1 groups.

CL1 groups can decide how much detailed information is provided to individuals, e.g. showing each household's consumption data to all other members of the CL1 group, or showing only averages. The processing unit uses algorithms agreed by the members to allocate value to individuals and households, based on their monitored appropriation and provision levels.

4B Monitoring the resource: Monitors who are accountable to the users monitor the condition of the resource.

The condition of the assets in the system is monitored by employees of the CEA. This includes monitoring for general maintenance, and day to day monitoring for the purposes of optimisation of the system, e.g. charge level of batteries, instantaneous power output from renewable generators, and demand level of buildings, as well as availability of demand response.

The processing unit also receives external input, with information about the condition of the external resource, i.e. the national electricity system. This provides signals regarding the value of exporting electricity from the microgrid to the national grid, or importing from the national grid to the microgrid for local storage.

5 Graduated sanctions: Appropriators who violate operational rules are likely to be assessed graduated sanctions (depending on the seriousness and the context of the offense) by other appropriators, by officials accountable to the appropriators, or by both.

Cost effective mechanisms for graduated sanctions for any violations of rules will be developed by the CL1 groups, bearing in mind the need for sanctions to consider the seriousness and context of any offense. The CEA will provide support, advice and a forum for discussion and mediation in the process of developing these sanction mechanisms.

6 Conflict-resolution mechanisms: Appropriators and their officials have rapid access to low-cost local arenas to resolve conflicts among appropriators or between appropriators and officials.

Building of trust and relationships between members of the CL1 groups and CEA are expected to develop over time. Conflict resolution support from expert facilitators and community conflict resolution organisations will be made available during the pilot stages, and skills in conflict resolution built in to the CEA as it develops. In the longer term, a budget for calling in these services will be reserved within the running costs of the CEA.

7 Minimal recognition of rights to organize: The rights of appropriators to devise their own institutions are not challenged by external governmental authorities.

This system requires support and cooperation from a number of external authorities, including:

Ofgem: giving permission, and developing the regulatory framework to enable community electricity management

DNOs: providing payments for the value of avoided grid reinforcement achieved by local microgrids, supporting the infrastructural development of the microgrid, and providing external services in connecting microgrids to each other, and to the national network. It is likely that the DNO will continue to own and maintain the wires within the microgrid, at least in the early stages, so their collaboration will be important.

National Grid: the CEA will manage the importing of electricity from the national grid in such a way as to respond to national grid balancing services requirements, and also to the capacity market, when this becomes operational.

National Government, in particular through the Department of Energy and Climate Change: to provide policy support for any regulatory changes required.

Local Government: many local authorities have plans to develop their own energy services companies, or other energy related activities. Their endorsement of a community managed and owned electricity microgrid will therefore be crucial to its success. There could also be significant benefits in collaborative working or partnership between a local authority owned energy company and a community owned microgrid company.

8 Nested enterprises: Appropriation, provision, monitoring, enforcement, conflict resolution, and governance activities are organized in multiple layers of nested enterprises.

To build trust, a sense of personal connection and community will be important. This requires members to be part of groups of a size that enables personal relationships with the majority of members of that group. For this reason, Community Level One groups of approximately 50 households will form the primary unit of governance, and be brought together in the Community Energy Aggregator which will provide economies of scale and expert services, as well as carrying out the negotiation with third parties. In the longer term, further higher levels of aggregation could be developed, e.g. a city wide or regional or national network of community energy aggregators, but this is not required in the initial stages.

Conclusion

This analysis informed the concept development for the system model described in Appendix J, and the organisational structure shown in Appendix D, figure 2.

Appendix D – Business model analysis

Business Model:

We have considered a number of alternative business models, some of which have been modelled quantitatively, with a number of assumptions, whilst others have been developed qualitatively due to insufficient information.

Sources of revenue

These business models consider a variety of scenarios for possible income, now and in the future, and can be summarised as follows:

A: Possible under current regulatory system and commercial arrangements

1. Income from existing national grid mechanisms of STOR and Triad payment, with a small scale community aggregator contracting with a commercial aggregator such as KiWi power. This has been modelled quantitatively, and shows limited income (see quantitative analysis below for details).

2. Income from DNO payments for reducing fault risk on networks from overloading at peak hours. This is an area of innovation, with some existing trials (e.g. KiWi power with UK Power Networks). This could be modelled more accurately using more detailed information from KiWi power. At present, demand shifting is understood to be of limited value to DNOs, other than under specific geographical constraints.

The combination of the two activities described above does not provide significant income, and is unlikely to be a viable business model for an organisation to both meet its overheads and provide sufficient incentive to participants.

B: Requiring modifications to regulatory system and commercial arrangements

3. Income from supplier, through modification of demand profile to provide value with respect to demand profiles the supplier is required to meet. This would require wholesale electricity settlement for domestic users to be carried out in relation to actual demand profiles, as measured using smart meters, rather than with deemed demand profiles as currently happens. The value of this activity could be significant, but has not been quantified precisely. This could potentially be coupled with bulk buying of electricity from a supplier at reduced cost due to economies of scale to the supplier.

4. Income directly from the electricity wholesale market. This is similar to income from a supplier, but may require the community energy aggregator to become an electricity supplier, unless there is significant change in regulations. This could be coupled with direct purchasing of electricity from the wholesale market. There are major barriers to entry to the electricity markets as a supplier with Ofgem's 'Licence Lite' proving difficult to implement (it is currently being tested by the GLA).

5. Income from the Capacity Market, which is being developed by DECC, for which the first auction is due to take place in 2014. This option has been modelled quantitatively, and shows a similar limited income to option 1 (see quantitative analysis below for details).

C: Possible depending on future energy system trends

6. Income from DNO for managing a portfolio of energy supply and demand assets (a mix of distributed generation, electrical heating, electric transport, and storage). Increase in deployment of these technologies, particularly with likely local concentrations, could lead to significant constraints to DNOs. Active management at a local (e.g. substation) level with significant new distributed generation and demand could therefore be of significant value to DNOs, of a different order of magnitude to at present day. This is an area with a number of ongoing studies.

Other activities possible under current regulatory system:

7. Collective switching (similar to Bristol Switch and Save, and similar initiatives, with collective negotiation of better deals from electricity suppliers, but retaining individual household to commercial supplier contracts).
8. Renewable installation (following the model already well developed by a number of community energy enterprises)
9. Electric car club, with removable two way batteries, which are charged at times optimised for electricity demand balancing services and local storage of local distributed generation.
10. Absolute reductions in energy demand, through increased engagement of members with energy, by making electricity 'discussable' and material, and through educational activities.

Other activities which would require changes in regulation

11. Community shared grid, to share batteries, generation and demand management in a localised grid. This could be a new DC private wire, or a virtual 'private wire' making use of the existing DNO AC grid, and alternative metering aggregation procedures.

Organisational structure

The organisational structure proposed is outlined in Figure 2. This primarily relates to options involving demand side response.

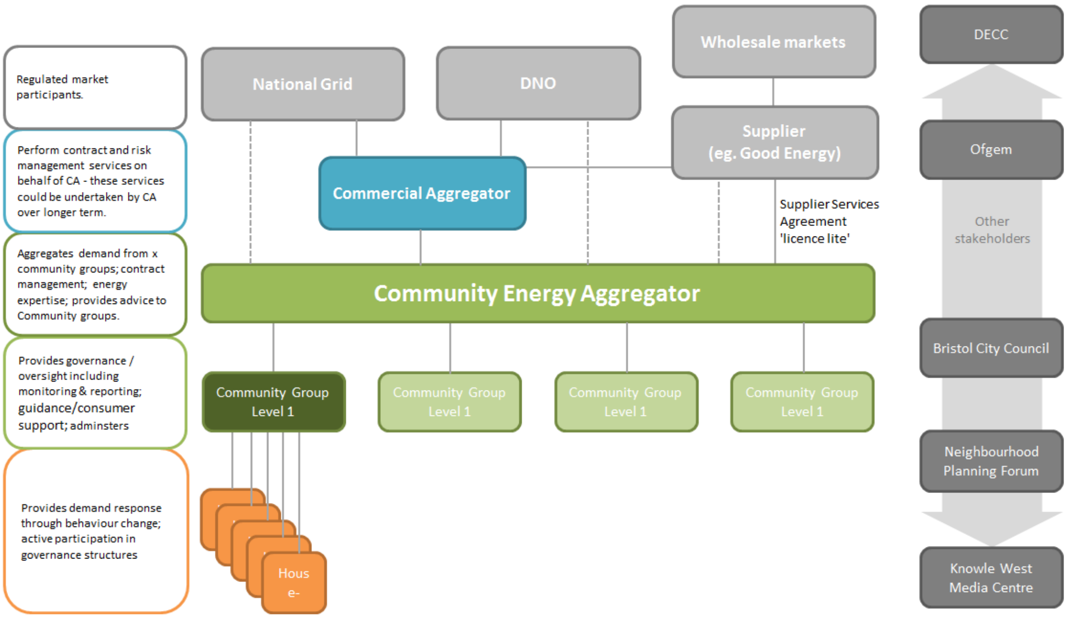

Figure 2 - Organisational structure for Community Energy Aggregator

Quantitative Analysis

For business model option 1: STOR and Triad

This model assumes:

- 50 households per 'Community Level 1' unit
- 15 Community level 1 units in the Community aggregator
- Energy price rising at 3% above inflation
- Typical household peak load of 850W[6]
- % reliable average reduction in peak load of 15%
- Salary of £20,000fte
- staff hours of 3.5 hours/week
- No of STOR events participated in annually: 25
- Average duration of STOR events: 2 hours
- Annual hours available for STOR: 500
- Payment from Kiwi Power per 50kW capacity: £500 per year (net of fee)
- Kiwi fee: 50%

[6] IHS Global Insight: average residential demand across all 26 million residential customers is around 0.8kW to 1kW at peak times but this hides a wide degree of diversity (source: IHS Global Insight. Demand Side Participation Report for DECC. July 2009. P.37)

- Number of Triad events achieved: 3
- Availability price: £9.13/MW/h
- Utilisation price: £250/MWh

Results

- Gross income (triad plus STOR) for Community Aggregator: £2800/year
- Net income after staff costs and overheads: £573 (year 1)
- Income passed on to the 50 houses in the community level 1 groups: £38 per community level 1 group = £0.8 per household

For business model option 5: Capacity Market

Assumptions:

- 1-7 as per business model 1
- Kiwi fee 20%

With Capacity market payment at £75/kW, this results in

- Gross income (triad plus STOR) for Community Aggregator: 7,100/year
- Net income after staff costs and overheads: £3,500(year 1)
- Income passed on to the 50 houses in community level 1: £230 per community level 1 group = £4.7 per household

With Capacity market payment at £29/kW (lower end of expected scale)

- Gross income (triad plus STOR) for Community Aggregator: 2,700/year
- Net income after staff costs and overheads: £19(year 1)
- Income passed on to the 50 houses in community level 1: £1.2 per community level 1 group = £0.2 per household

Conclusions

There is not sufficient income available in the current system for a viable business to be set up for community demand response aggregation. However, the concepts developed here could become viable in the future, as the mix of supply in the UK electricity grid changes to include more intermittent and renewable generation.

The regulatory framework which responds to these changes in infrastructure has the potential to be either supportive or unsupportive of community demand management. The potential benefits of local institutions for energy, in terms of 'materialising' energy, allowing collaborative or supportive activity between neighbours, and normalising energy saving behaviour, could be important, but quantifying these is beyond the scope of this feasibility study, and is a topic for further research.

Appendix E Gap analysis of LCNF projects

An overview review was undertaken on several Low Carbon Network Fund (LCNF) projects, which is presented in Table 1. From each project summary, it was recorded which of the following broad subject areas the project included in its scope: 'household behaviour', 'community structures', 'data & hardware' and 'business model'. Where a project is deemed to have included one of the above subject areas in its scope, the corresponding box in Table 1 is coloured green. The participating DNO and focus area of each project were also noted.

Abbreviations

WPD = Western Power Distribution

NP = Northern Powergrid

ECN = E.ON Central Networks

SPEN = Scottish Power Energy Networks

ENW = Electricity North West

UKPN = UK Power Networks

SSEPD = Scottish & Southern Energy Power Distribution

Key

	Subject area
Subject area included in project scope	(green)
Subject area not included in project scope	

Project name	DNO	Household behaviour	Community Structures	Data & hardware	Business model	Focus area
Hook Norton Low Carbon Community Smart Grid	WPD	■		■		Demand response, smart grid
Community Energy Action	WPD	■	■	■		Community demand response
Customer-Led Network Revolution	NP	■		■	■	Demand response
E On Milton Keynes Smart 2020	ECN			■	■	Smart grid
Ashton Hayes Smart Village	SPEN	■	■	■		Demand response, smart grid
Energy Control for Household Optimisation	WPD	■		■	■	Demand response
Capacity to Customers	ENW			■	■	Demand response
SoLa Bristol	WPD			■	■	DC networks
Low Carbon London	UKPN			■		Demand response
Seasonal Generation Deployment	WPD			■	■	Smart grid
Accelerating Renewable Connections	SPEN			■		Energy storage
Demonstrating the Benefits of Monitoring Low Voltage Network with Embedded PV Panels and EV Charging Point	SSEPD	■		■		Electric vehicles, energy use
Demonstrating the Functionality of Automated Demand Response	SSEPD			■		Demand response
Trial Evaluation of Domestic Demand Side Management	SSEPD			■		Demand response
My Electric Avenue (I^2EV)	SSEPD	■	■	■	■	Electric vehicles
Northern Isles New Energy Solutions	SSEPD					Energy reduction
Thames Valley Vision	SSEPD	■		■	■	Automated demand side response

Table 1 – Subject area gap analysis for selected LCNF projects.

Appendix F – Review of selected LCNF projects and EVALOC project

A more detailed review was undertaken on a selection of the most relevant LCNF projects' scope and objectives, which included: 'Customer-led Network Revolution', 'Ashton Hayes Smart Village', 'Hook Norton Low Carbon Community Smart Grid', New Thames Valley Vision', 'My Electric Avenue'. Also included in the review was the EVALOC project (a research project by a consortium of universities studying six Low Carbon Community Challenge (LCCC) projects). The findings of the review, and the relevance of the various projects to this study, are summarised below:

Tariffs

Customer-led Network Revolution (CLNR) are testing a range of tariffs: time of use (TOU) tariffs (both static and dynamic), direct control tariffs and specific tariffs for customers with different LCTs. They aim to identify the costs of different types of customer flexibility.

New tariff arrangements have the potential to alter a community's demand profile through behavioural change, which has been identified as a potential source of income from DNOs.

Data: monitoring and communications

Ashton Hayes are carrying out real time monitoring of the LV network, including metering both on generation sources and at secondary substation feeder level.

Hook Norton are installing power line communications (PLC) technology in the LV network for measuring and data aggregation, and also testing existing monitoring products for HV and LV substations. They are using these installations to explore control systems for monitoring and managing the LV network. It is also an aim to demonstrate a mini smart grid telecommunications network. They are also taking this further by developing a customer interface, possibly a web portal, to communicate with customers.

In contrast with the other projects, New Thames Valley Vision (NTVV) are aiming to reduce the need for LV demand monitoring in planning LV networks, by using customer profiling of energy use in tandem with mathematical techniques.

All these aspects of monitoring are relevant to development of an integrated energy solution – in particular, aspects of customer profiling and a community interface.

Generation, distribution and storage

In Ashton Hayes, there will be significant additions of wind, PV and CHP onto the LV network, but it does not seem there will be investigation into managing distribution on a substation level.

Focussing solely on EVs, My Electric Avenue has possibly the most innovative line of investigation. They are seeking to prove the efficacy of a technology that monitors and controls the EV charging within a substation area so that the demand never exceeds the substation limit. This involves both the technical aspects of installing monitor-controllers at substations and active sockets at customer locations, the social aspects of attitude and behaviours towards external control of EV charging. Their aims are to identify range of networks where this technology is appropriate, and to appraise the ease of installation.

As part of the investigation into using customer profiles and mathematical techniques to inform LV network planning, NTVV are evaluating the capacity of power electronics and electrical storage to buffer the effects of LCT on LV network, with the view to avoiding the need for costly network reinforcement.

CLNR are trialling primary and secondary Enhanced Automatic Voltage Control (EAVC), Real Time Thermal Rating (RTTR) and storage network equipment, with monitoring and control systems.

Whilst none of these studies are trialling the envisioned future scenario of technologically managed generation, storage and demand on a substation area that includes substantial numbers of renewable generation sources and EVs, they all cover options for different parts of the technological solution. A noticeable seeming absence is the active involvement, and observation thereof, of communities in these solutions.

Demand response

Hook Norton are undertaking a domestic scale demand response trial.

NTVV are investigating demand response with large commercial and SME customers, seeking to identify the extent for impact, and which customers will be flexible and early adopters.

Overall, demand response is a noticeably smaller aspect of these trials than data and distribution. However, the extent for impact and flexibility from demand response for all customers, both domestic and commercial, will be an important component of the envisioned holistic energy solution.

Energy use behaviour and public engagement

Ashton Hayes are investigating innovative demand side management techniques in order to assist behavioural change in both domestic and public properties.

Hook Norton are developing a framework for engaging communities about their low carbon aspirations.

My Electric Avenue, as part of their investigations into EV use, are seeking to learn about customer driving and charging habits.

NTVV are seeking to understand the behaviour of different customer groups, to assess whether solutions can be applied between customer groups (e.g. domestic, SME). They are investing in a "high street presence" to inform the public of progress and communicate benefits of the project.

As already mentioned, CLNR are compiling customer generation and demand profiles for a cross-section of customer and demographic groups.

EVALOC are seeking to understand the role of community groups in changing energy behaviours and reducing energy use. This involves several aspects: what barriers or limits to a community approach exist, how community organisations can best monitor and communicate their own effectiveness, how to transfer knowledge between communities, the role of community events in social learning, and the role of in-home displays (IHDs) in awareness and energy use.

Understanding energy behaviour and affecting behavioural change remain topics of key interest for investigators. It is the study of the interface between communities and energy which is the new research likely to be of most relevance to developing a holistic energy solution.

Appendix G – Summary of expert interview data

Content is taken from 11 interviews:

4 Academics (Philipp Grunewald, Alex Rogers, Matt Leach, Sarah Higginson)

1 Regulator (Ofgem)

1 Charity (Energy Saving Trust)

1 Independent (Robin Morris)

1 Aggregator (Kiwi Power)

1 DNO (WPD)

1 Energy technology company (Moixa Energy)

1 Energy supplier (Good Energy)

The content of the interviews is presented to answer 3 questions:

1. What's the point of a community managed DSR scheme?
2. What are the likely constraints on such a scheme?
3. What would be the likely features of such a scheme?

Under each of these headings, content is arranged under 5 themes:

- Economic
- Technical
- Social
- Political
- Legal

The learning from the interviews is summarised in **Error! Reference source not found.** on the following pages

Table 2: Summary

	Economic	Technical
What's the point?	• Business model proven in commercial aggregator case • Reducing base demand reduces electricity costs • Opportunity for renewable energy providers to make supply more secure • Precedent for communities to pay for improvements using scheme	• Compatible with EV fleets in future • Compatible with higher renewables and/or nuclear National Grid baseload • Potential to eliminate need for energy storage • Data benefits for DNO operations.
Constraints?	• Erosion of marginal gains if demand reduction becomes more commonplace • Retail market organisation of electricity network hinders alternative initiatives • Reliability of demand reduction promises is critical for scheme value	• Recent overall reduction in domestic demand – predicted to continue decreasing • People are typically thought to be unflexible • It is only 'wet load' that is both flexible and has a significant power demand • Difficult to know the overall situation of houses in an area • Who will make use of the large amounts of data? • Issues around delay of smart meter data transmission • Scale required is 100s to 1000s of households • Requires an electronic exchange platform • DECC programme aims for all homes and small businesses to have smart meters by 2020

Scheme suggestions?	• An aggregator business model: already proven for business customers • Substation hardware required for aggregation is costed at £200 manufacture, £650/yr metering and controls • Set peak demand reduction targets based on historical data • Annual payments to customers • Any scheme should make it cheaper not to generate power • High critical peak pricing • Demand response warning a day in advance • High price differential • An alternative business model: communities fulfil a requested demand profile	• Integration of a community managed EV fleet • 'Gridkey unit' substation power monitoring • Simple messages to inform residents of required actions • Building level aggregation • DC microgrid system • "Alertme" mobile monitoring and reporting • To deal direct with National Grid would require a group of ~10,000 homes • Pre-programming of air-con thermostats • Algorithms to determine allocation of rewards • Modelling to help predictions of a scheme • 'Wizard of Oz' simulated system before installing hardware in trial • Event frequency: balancing response rate against the potential for behavioural change through repetition

	Social	Political	Legal
What's the point?	• Increased community value • Part of a more holistic, integrated energy solution	• Appeal to policymakers through community approach	
Constraints?	• Long term commitments from communities required to be worthwhile for DNOs • Capacity/reliability of volunteers over long term • How to influence behaviour – the effect of money quantity is thought to be negligible • Distraction of community focus and novel institutional arrangements • Necessity of an opt-out mechanism • How to link community thinking to providing external value • How a scheme fits into wider community energy projects	• DNOs are viewed as conservative. People are not accustomed to engaging with them • Community schemes can strengthen an existing community, but cannot create one from scratch • Energy is an essential good – it's a sensitive issue	• Security of supply is a responsibility of the DNOs • Ofgem permission would be required for a scheme that would be in lieu of upgrading hardware • Household data security • Necessity of an opt-out mechanism • Security of supply and customer protection are priorities for Ofgem • LCNF initiatives are pushing the boundaries of current commercial arrangements
Scheme suggestions?	• For community selection, priority on good working relationships. • Second priority, minimise the number of business users involved. • Trial with a workplace community • The need to materialise energy and focus on practices rather than motivations		• Encouraging precedent for data security in that businesses are already involved in aggregator schemes • Cloud data

Appendix H – Summary of qualitative findings from focus groups

- **Boiling the kettle and cooking were always the activities which people were averse to changing.** Although these represent relatively low total energy consumption, they are very peaky due to the associated high electrical loads and therefore do cause problems.
- **TV watching is not only an activity of entertainment, but also one to make people feel safe, not lonely.** This was particularly mentioned in winter evenings. It's something 'on in the background' for comfort, otherwise people might be on their own in the house. Possible community events would overcome this problem.
    - Watching TV to catch your favourite programme - has this changed with the rise of on-demand
- **Mix of response to community way of doing things** . One participant was sure she would be happy to be completely flexible with demand, and that collective/community action would make no difference. Others thought it would be much easier to do with support of community. Good response to community activities as a way to reduce individual demand also.
    - Think we should treat this outcome carefully, attendees and Knowle west in general is a very community motivated area
- **In order to achieve a successful trial do we need to engage with wider issues – systems map of the interactions which could positively or negatively affect the project.**
    - **Need to engage with employers**. One participant, immediately supported by another, said 'if you're going to implement this in Knowle West, are you going to talk to our employers? because if you want us to go home to do our washing in the middle of the day, you need to persuade our employers to let us have 20 minutes in the middle of the day to go and hang up our washing, and things like that.
    - **Possible link with 21 hours week initiative (New Economics Foundation)**
    - **Need to consider modern entertainment activities** – Do our modern pastimes require greater energy demand? What about board games, reading, outside sport, etc. Some comments were that kids won't be happy unless watching TV, and that they used to play in the street.
- **Trust in the energy companies was an issue** – "if we reduce their profits by managing our demand won't they just raise the price anyway?"
- **People not so motivated by financial benefits/payments** – more interested in community re-investment. However could be to do with the groups involved again.
- **Short notice turn off events causes chaotic lifestyles**– could add an element of chaos to people's lives. This was seen as a problem.
- **The people who have the most potential to make an impact are those who are least sustainability minded**

Appendix I – Discussion of survey results

Summary:

Overall, respondents were slightly more willing to change the time they use appliances as a community than individually. This was strongest for watching TV, followed by cooking and using the kettle. The appliances with most flexible demand time were washing machine, tumble dryer, and dishwasher, which had a low influence of community activity. Less than half of respondents were willing to change their time of use for cooking and kettle both individually and as a community. Less than half were willing to change their time of use of TV individually, but over half as a community.

Some differences in understanding of questions by respondents were noted during the survey process, and may have affected results. There was also potential for other sources of bias, such as selection bias, self-selection bias and influence of the person delivering the survey. These, along with the small response size of 41, limit the strength of the conclusions that can be drawn.

Method

Surveys were distributed on four occasions:

- at focus group sessions in Knowle West Media Centre, to a total of five respondents (Tuesday 24th September, 12.30pm and 6pm)
- at a Green Doors open day stall at Knowle West Media Centre (Saturday 28th September, 10am-3pm)
- at a British Energy Challenge event stall, under a Bristol Energy Cooperative banner, on Thursday 10th October, 11am-3pm)
- at the Bristol Energy Cooperative AGM (Saturday 13th October, 10am-3pm)

The survey was modified between instance 1 and 2, and between instance 2 and 3 and 4. Details of modifications can be found in 'notes on survey development' document.

The surveys themselves are all saved and available.

Analysis:

The number of positive responses for willingness to change time of use of each appliance were counted across all participants. For each appliance, the number willing to change time of use individually was compared to the number willing to change time of use as a community. This was normalised across the number of respondents for each appliance, as some appliances had no response (primarily due to this appliance not being present in the household).

For the frequency with which respondents would be willing to make a big effort to switch things off, respondents had to choose one option. The responses from the focus group sessions were not used, due to evolution of the question phrasing. The percentage of respondents willing to switch things off up to a certain frequency per year is displayed as a bar chart.

The average level of motivation for each motivating factor suggested was calculated, with a five point scale with a zero score for a neutral response, and positive or negative responses given scores between -2 and 2.

For the questions regarding access to data and privacy, the % of respondents with a 'yes' response for each option was tabulated. Respondents could answer yes to more than one answer, which was appropriate for the first question 'who do you think should be able to see data about when you use electricity?', but in hindsight was not such an appropriate phrasing for the second question, 'If your street is doing an energy use challenge together, what information would you like to see about how others are participating?'.

Results

The results of the survey are displayed in the graphs below.

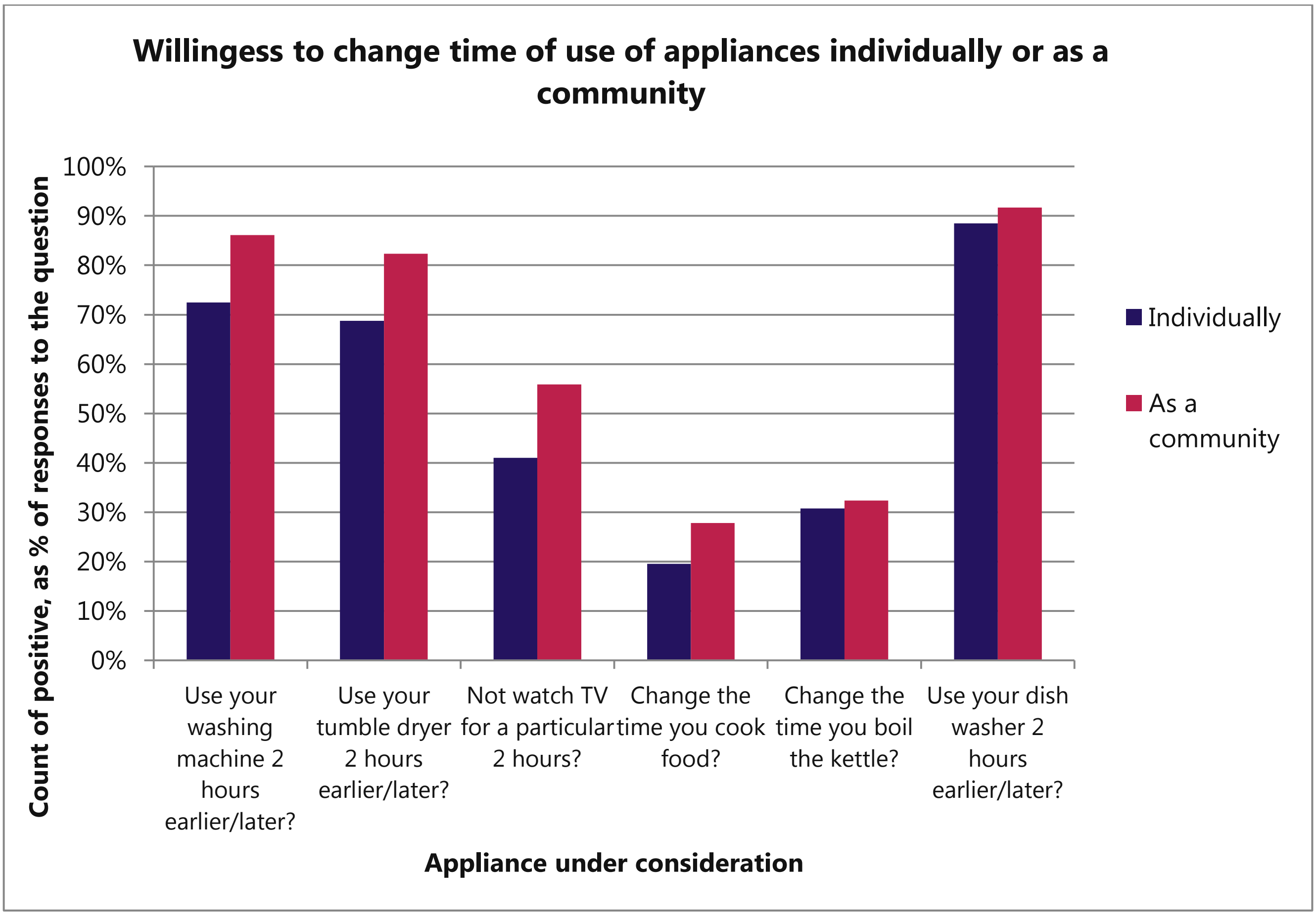

Figure 3: Willingness to switch off particular appliances, individually and as a community

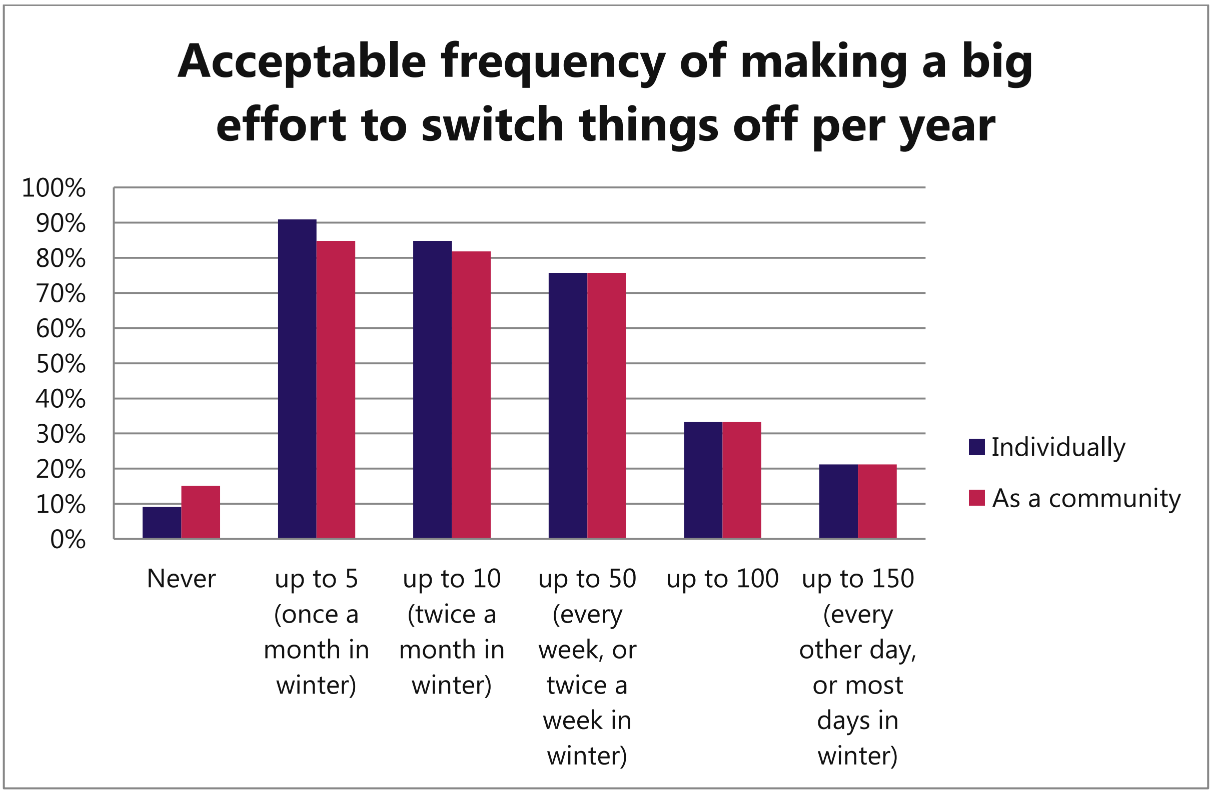

Figure 4: Frequency acceptable for big switch off effort, individually and as a community, events per year

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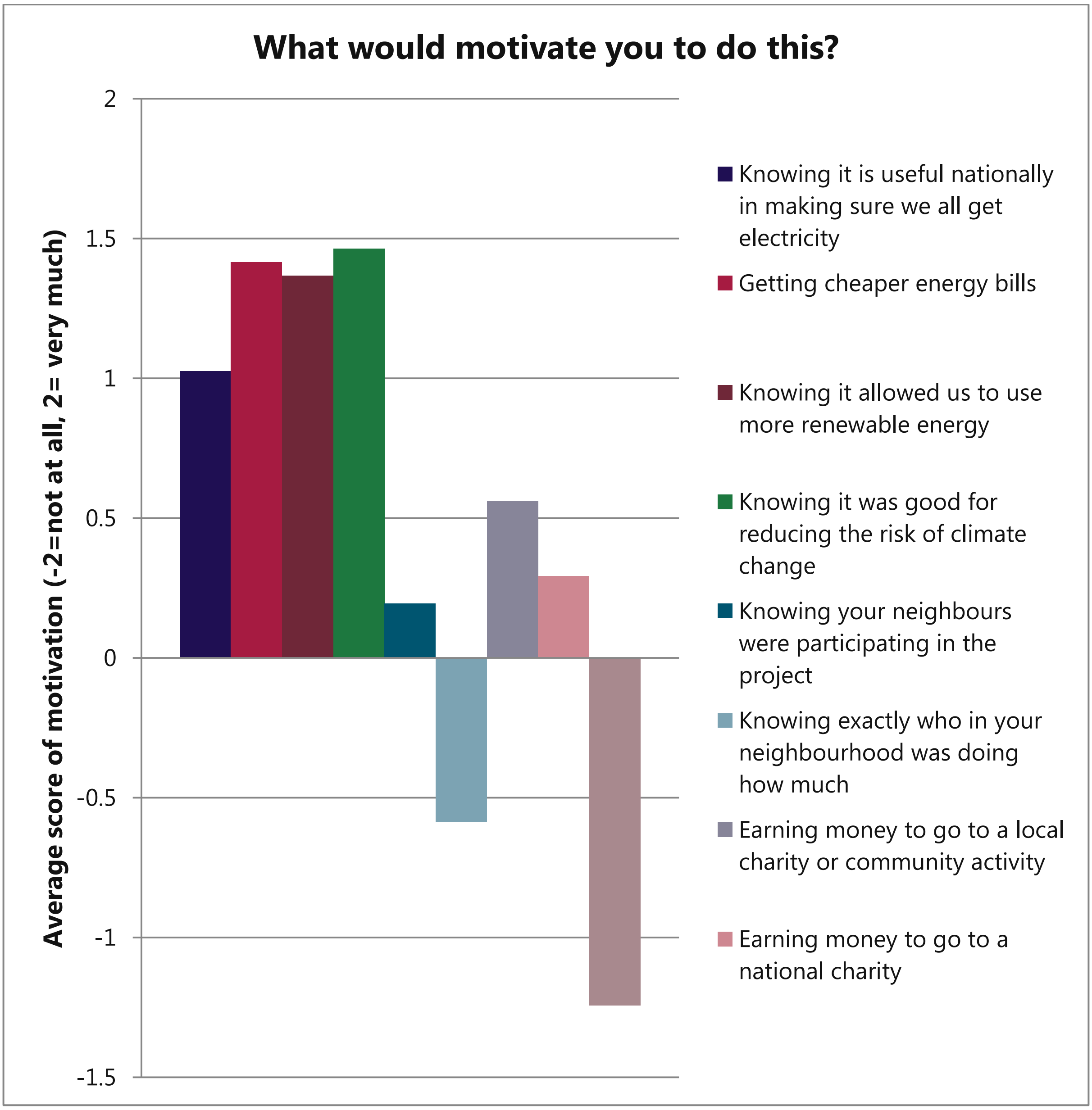


Figure 5: Motivations for energy demand response

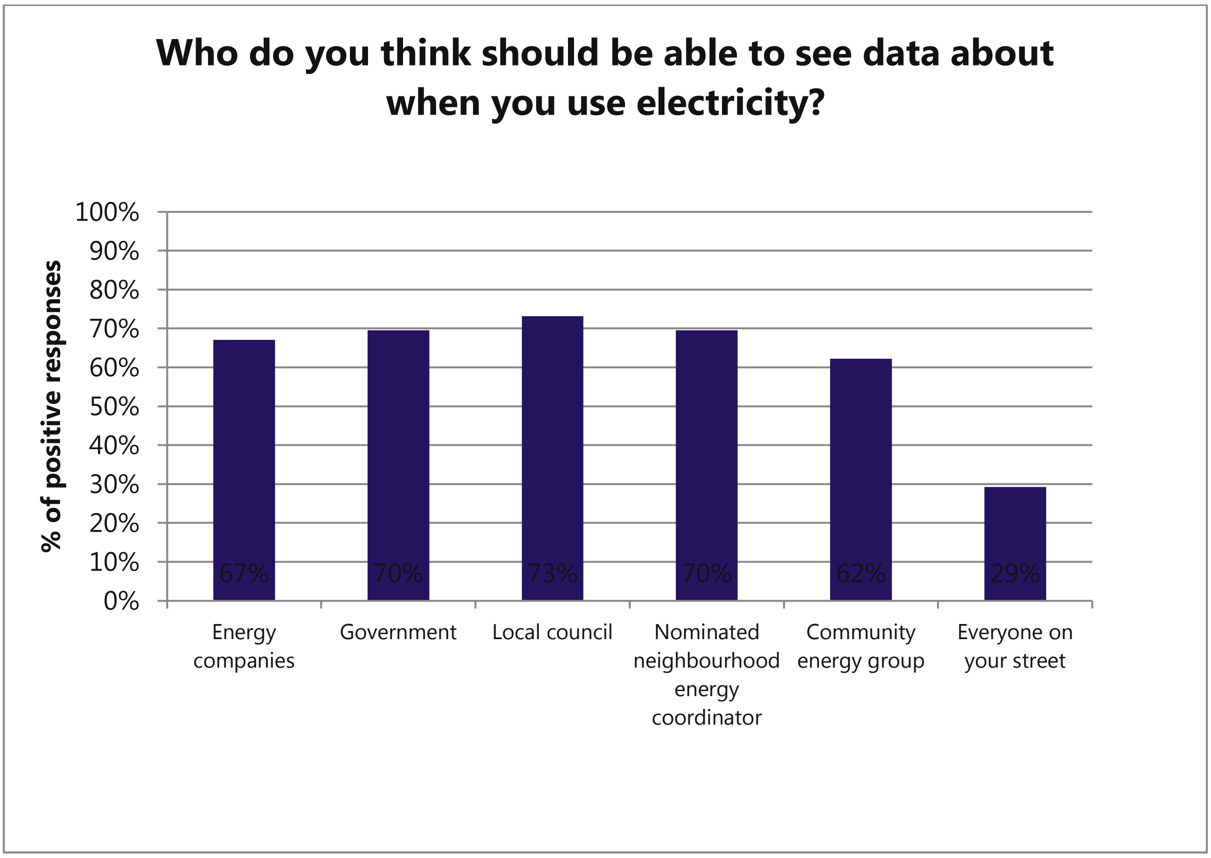


Figure 6: Who should have access to data

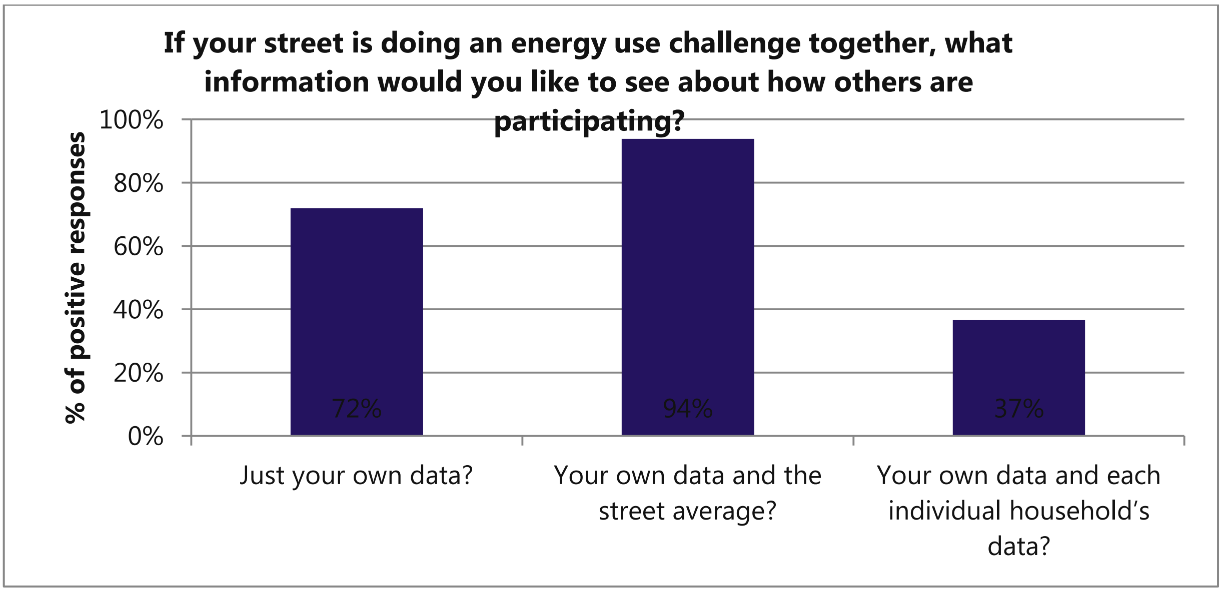


Figure 7: Information wishes on street

Discussion

Overall, there was a high willingness to change the time of use of washing machine, tumble dryers, TV and dishwasher, and a low willingness to change the time of use of cooking and kettle. There was generally an increase in willingness to change time of use of appliances as a community relative to individually, which was strongest for TV, followed by cooking and using the kettle. These last two still had a low willingness to change time of use, but higher than individually.

Regarding frequency with which respondents were willing to make a big effort to switch everything off, the majority (80-90%) were prepared to participate in some extent of big switch off behaviour, whether as an individual or as a community. 75% of respondents were still willing to switch off up to 50 times a year, but this fell sharply to only around 30% for switching off up to 100 times per year.

Respondents were less motivated by community based motivations than by individual/national/global motivations. Reduced bills and reduction in risk of climate change were the most popular motivations. This result is likely to have been biased due to the selection bias, pre-selecting respondents who were interested in energy issues and sustainability.

Regarding data, the institution which most respondents felt should have access to their energy use data was the local council, at 73%, relative to 67% for the energy companies. Only 29% of respondents felt that people on their street should see data about their electricity use, whereas responses to all of the other options were above 60%. Over 90% of respondents would prefer to see their own data and the street average, rather than just their own data, or individual households' data.

Limitations

There were several points of influence for bias:

- Selection bias, due to the location of stalls where the survey was carried out
- Self-selection bias
- Influence of person delivering survey
- Influence of level of previous knowledge of respondent
- Perspective of respondent (one respondent answered the community questions from their perspective of how likely the wider community would be to be motivated in participating. This was potentially due to their role in a political position, used to considering public opinion as an external variable, rather than answering as an individual in the community)
- Self-reporting – respondents were asked the research question directly, and this may not accurately represent how they would actually behave
- Sample size: there were a total of 41 respondents overall. The sample size is not known, as people passing by a stall were able to voluntary choose to respond or not.

Conclusions

Overall, there is a slight increase in willingness to participate in demand side management as a community relative to individually. This difference is strongest in relation to more social energy uses, such as watching TV, cooking food, or boiling the kettle. These are typically the energy demands which policy makers see as inflexible, which indicates that a community solution could potentially unlock a larger demand response.

The majority of respondents (between 80-90%) would be willing to be involved in a big switch off scheme at all, with the majority of those (around 75% of respondents) being willing to make a big switch off effort up to 50 times a year (every week, or twice a week in winter).

Some respondents were willing to share their individual household data on energy use with their street, but this was only 29%. Over 60% of respondents were willing to share data with energy companies, the government, the local council, a local community energy group and a nominated community energy coordinator, with the city council as the most popular. This indicates that a community aggregator would be likely to receive a positive response to providing data.

A total of 93% of respondents would like to see their own electricity use alongside the street average. Only 36% would like to see the data of everyone on their street individually.

Appendix J – Pilot study proposal

This section outlines the community managed electricity system developed during this study, and a describes a proposal pilot study to test such a system.

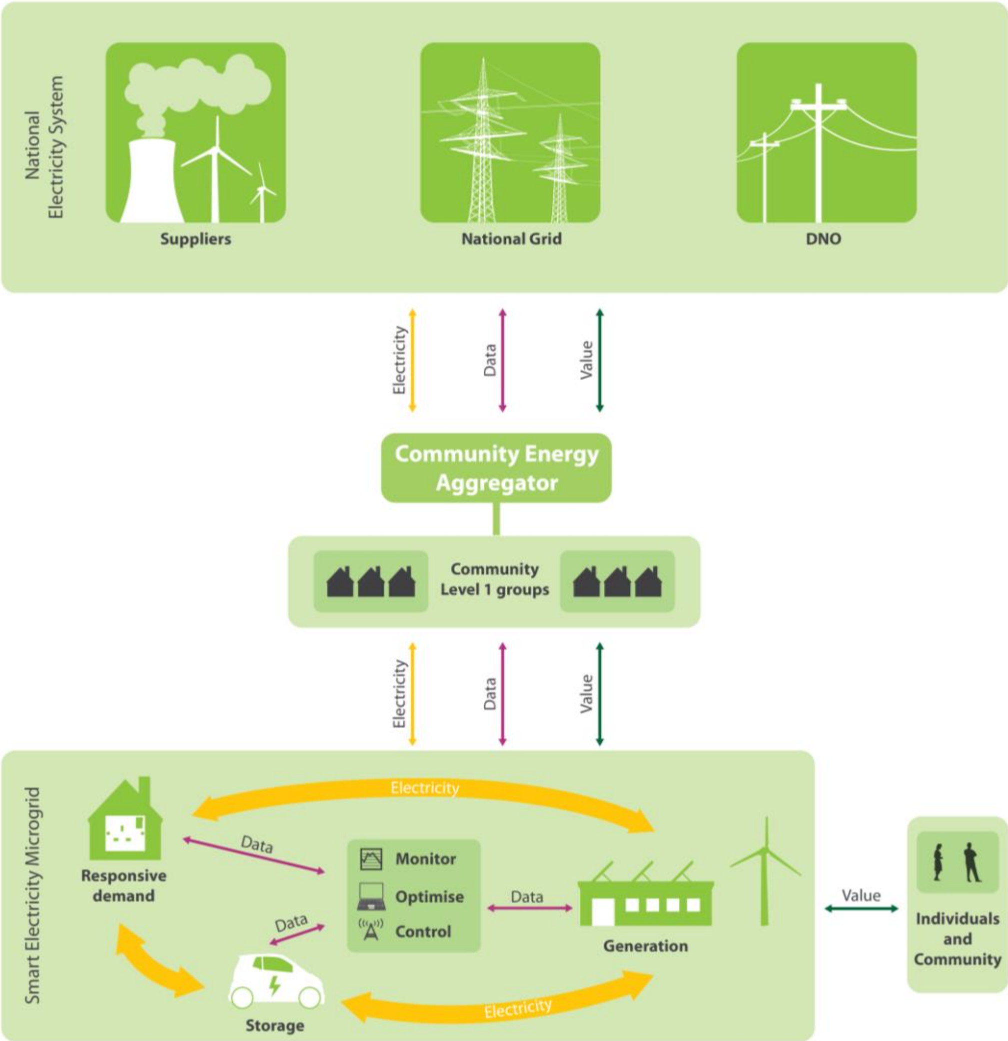
A system model of the proposed electricity system is given in Figure 8. The system model shows the participants, as well as the flows of electricity, data and value.

Figure 8 shows how the proposed system might operate. The community energy aggregator will function as an interface between the national electricity system and the smart electricity microgrid, and a body to deliver value to the various participants. This diagram is intended as a high level overview of the system, as a complementary aide to the more detailed explanatory text in this appendix.

The system was developed to provide a holistic range of electricity services, because we believe – based on both observations from case studies and theoretical considerations – that a more integrated system will deliver greater value for participants. Several components of the future electricity system (for example, electric vehicles, dispersed generation and electrical storage) offer the potential to deliver value more effectively when operating as an integrated system. The system outlined below offers a realistic vision of what such a system might be.

To provide more detail on the operation of this system, we have adapted the concept of a "Business model canvas" (from www.businessmodelgeneration.com) to this scenario, and compiled a "system model canvas" for certain interactions within the system. These interactions involve the flow of value between the CEA and other participants in the system: the supplier, the DNO and National Grid, and the microgrid. These system model canvasses are given in Figure 9, Figure 10 and Figure 11.

The purpose of these canvasses is to identify the components required for the system to function, including, but limited to, the business aspects of operation. As with the system model, these canvasses are intended to function as stepping stones on the way to a more detailed plan (which lies outside the scope of this study). In the meantime, they provide evidence that system put forward here provides value to a number of stakeholders, and merits further development.



National Electricity System
Suppliers, the National Grid and DNOs make contracts with the Community Energy Aggregator for local demand management activities, which helps balance the national grid and support the deployment of renewable generation.

Community Energy Aggregator
The Community Energy Aggregator is directly accountable to households and local businesses, and manages the local microgrid for them. It also negotiates with external parties to maximise value for the community, and respond to external signals for demand response. This provides local employment.

Smart Electricity Microgrid
Local smart control of electricity generation, demand and storage minimises flow of electricity into and out of the local microgrid. This keeps value circulating in the local community.

Figure 8 – The system model for the proposed community managed energy system.

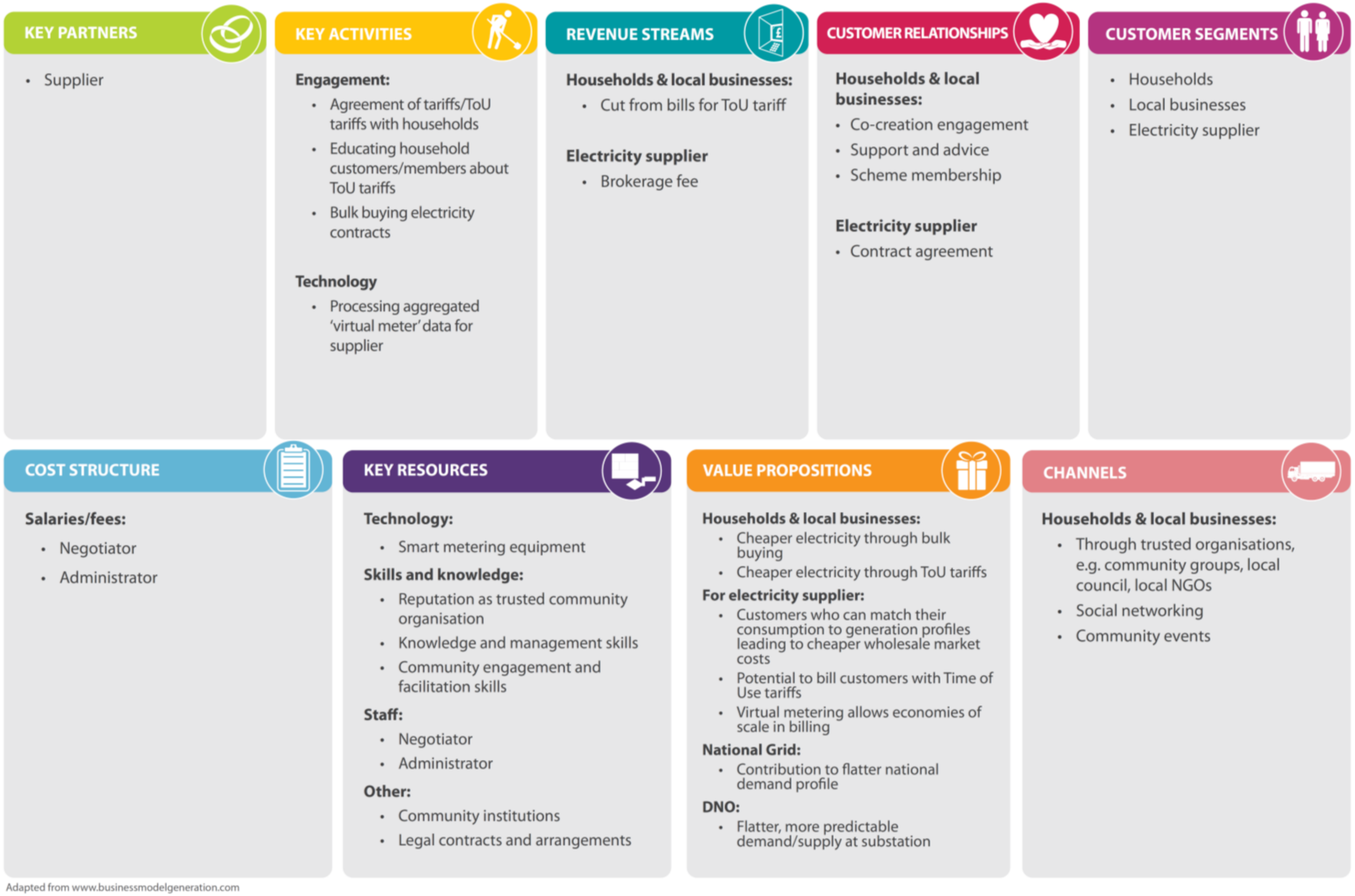


Figure 9 - The system model canvas for the interaction between the CEA and suppliers. Adapted from www.businessmodelgneration.com

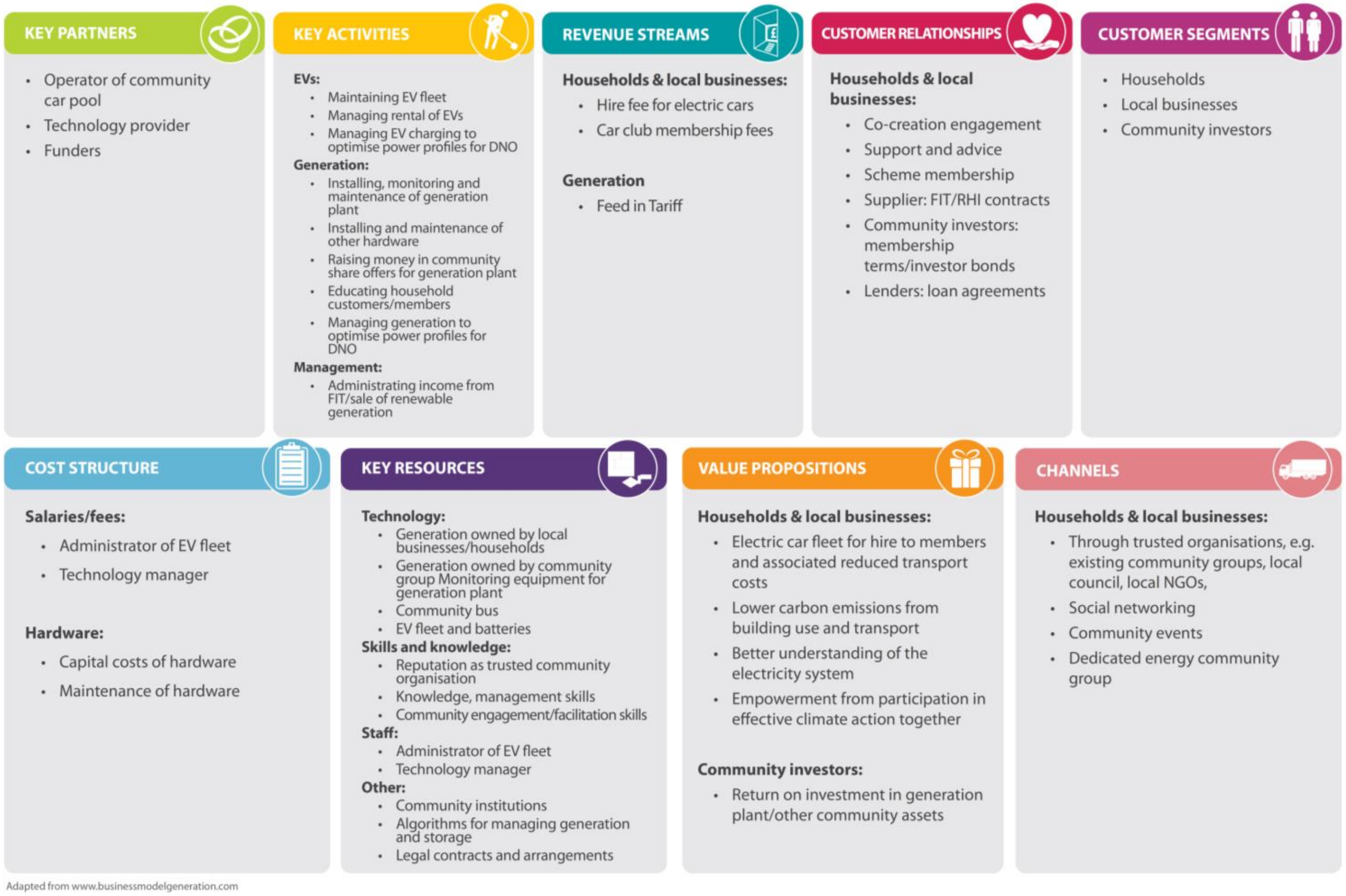


Figure 10 – The system model canvas for the interaction between the CEA and the microgrid. Adapted from www.businessmodelgneration.com

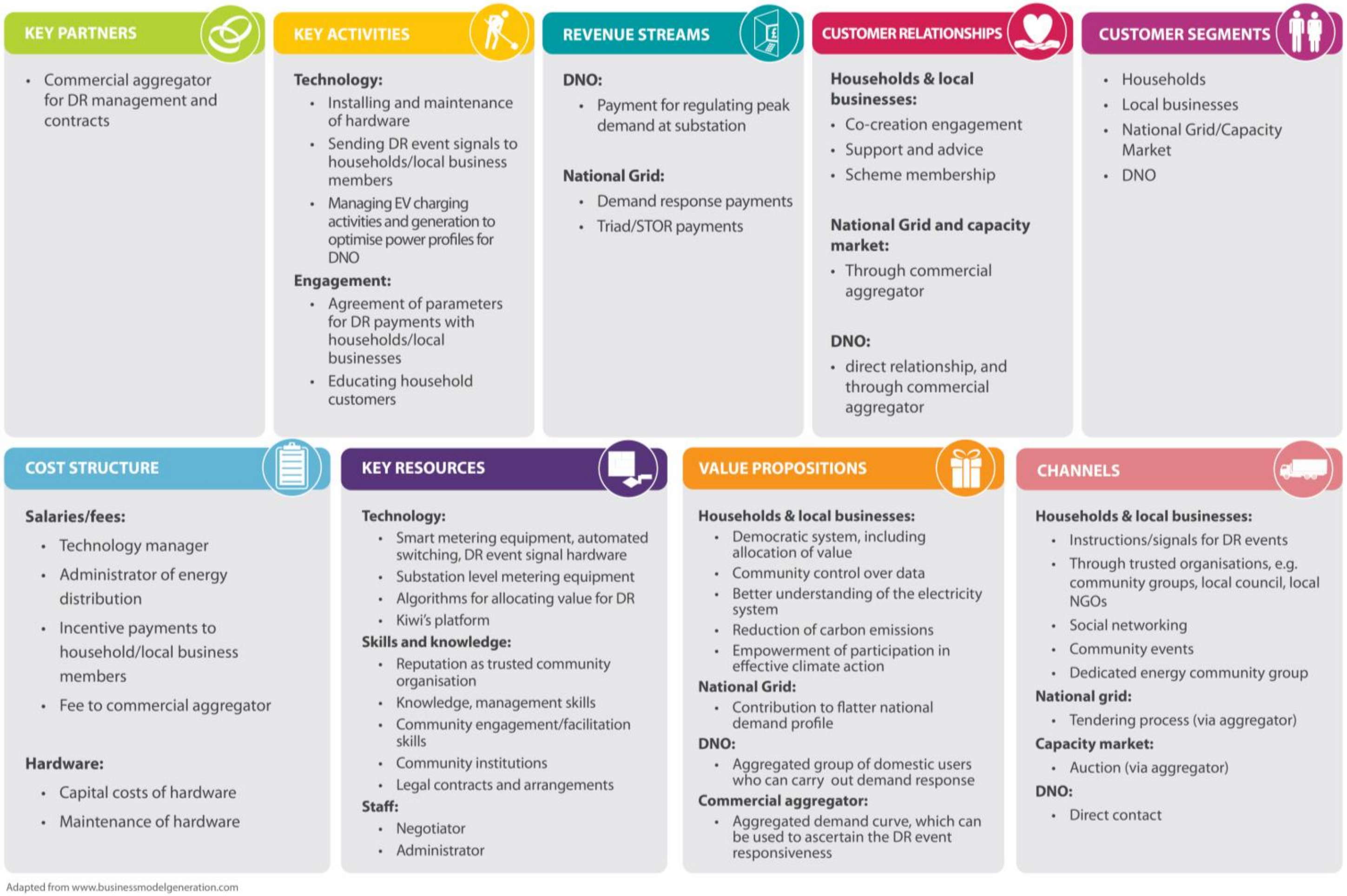


Figure 11 - The system model canvas for the interaction between the CEA and the National Grid and DNOs. Adapted from www.businessmodelgneration.com

Following on from the description of the system model given above, Figure 12 shows a proposed organisational structure for a large scale pilot project to test the system model. This pilot would not be at full commercial scale, but would be large and complex enough to test all of the features of the proposed system model.

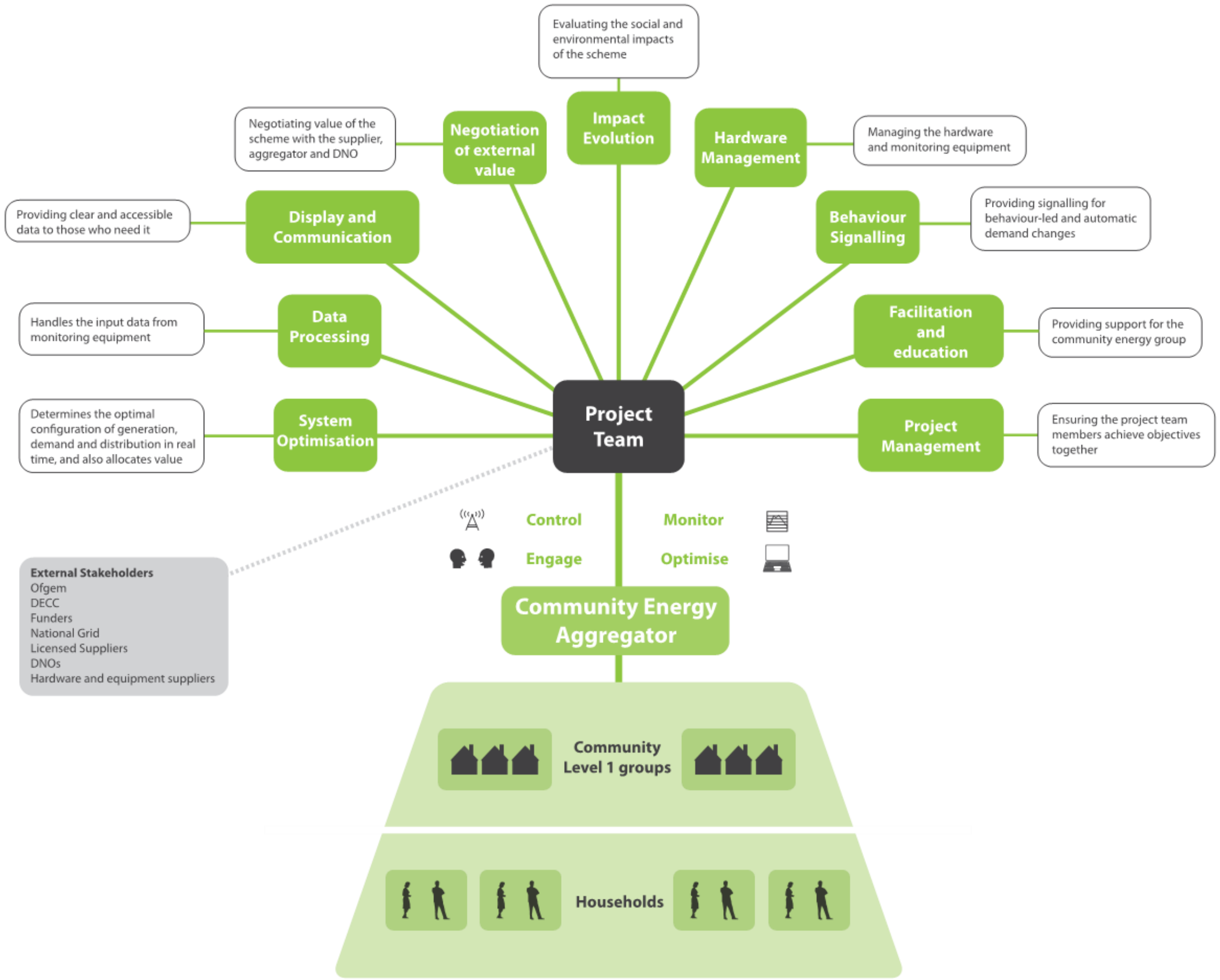


Figure 12 - Pilot project organisation structure

Organisational structure

The organisational structure shown in Figure 12 is described below:

The central organisation is a community energy aggregator (CEA), consisting of a number of households.

The groups of households are 'Level 1' groups, consisting of around 50 households – and thereby corresponding to around 150 individuals. The households in each group of households share a common identity, whether of location, being on a particular substation, or as a community of interest. They are not necessarily geographically united. The interaction between the groups of households is facilitated by a chair from the CEA. It is possible that these households would need to purchase electricity from the same supplier, depending on the pathway taken by the pilot study.

The CEA itself will be responsible for the institutional operation of the CEA. The pilot study will be delivered to the participants (i.e. the households in the CEA) by a consortium of partners, comprising the project team. The activities of the project team will be fully funded by R&D funding for the purposes of the pilot study. The CEA will be a community social enterprise, either new or a subsidiary of an existing one, and will work as part of the project team consortium initially. In the long term, the CEA will continue to run the project in a more commercial way.

The project team would also need to engage with and maintain good relationships with a number of external stakeholders, as shown on the diagram.

Roles

- System optimisation

Determine the optimal configuration of generation, demand and distribution in real time, and also implement the allocation of value to the contributions of participating households using suitable algorithms. This also takes into account external factors (e.g. demand related requests from DNOs and the National Grid). It is the role of the CEA to facilitate an agreement amongst the participating households upon the principles behind the allocation of value.

- Data processing

Handle the input data from monitoring equipment, manage a central computer which processes inputs from the different components of the system and act upon the real time optimisation decisions determined by the 'system optimisation' partner. For example, this could include sending out signals to households for demand response behaviour, carry out automated control of certain household devices and control battery charging/discharging. This partner would also provide information regarding options for allocation of value to the CEA, to support their decision making process.

- Behaviour signalling

Provide signalling for behaviour-led and automatic demand changes.

- Display and communications

Provide clear and accessible data to those who need it, including, but not necessarily limited to, the participating households. The groups of households decide what information to display to whom.

- Negotiation of external value

Negotiate payments from other parties in the electricity system for whom the system delivers value – including, but not limited to, DNOs, National Grid and suppliers. This will also require legal and contractual expertise.

- Impact evaluation

Evaluate the social and environmental impacts of the pilot study, using data from the monitoring system as well as other techniques.

- Asset management

Manage the hardware and monitoring equipment. This includes generation plant, electricity storage in batteries, electric vehicles or by other means and smart meters.

- Facilitation and education

Provide support for the community energy group. This could include explaining governance structures, and providing facilitation and democratic skills training.

- Project management

Ensure the project team partners achieve objectives together.

Long term project timeline

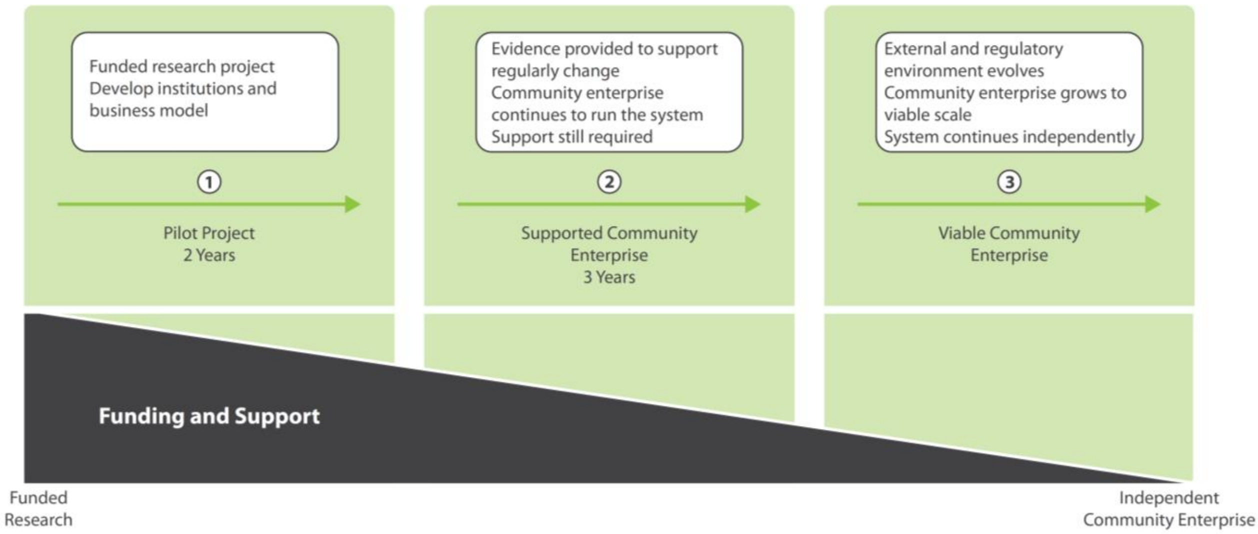


Figure 13 – Development timeline.

The aim of the pilot study would be to test the proposed system model, to deliver the potential value identified to the participating parties. The proposed study moves beyond other current and past research, in that it tests an entire system solution, rather than isolated components. The development timeline in Figure 13 illustrates the three stages foreseen in the development of the concept from a fully funded pilot project to a self-sustaining community enterprise. Thus, such a pilot study could accelerate the development of low carbon communities, and hence the development of a UK low carbon economy.

Suggested Next Steps to Develop and Implement Pilot Study:

- Negotiate external parameters (e.g. with supplier/commercial aggregator)
- Develop interface of hardware with the monitoring, optimisation and control (MOC) system.
- Develop MOC that can interface with:
    - hardware
    - ownership data for all assets
    - external value parameters as decided by 'Level 1' communities/CEA
    - information display
    - 'Level 1' communities/CEA requests for information
    - automatic control of appliances, battery storage and controllable generation
    - signalling to members for behaviour based DR
    - provision of data to external parties for billing purposes
    - provision of data to 'data geekery' group
- Preparation of initial presentations and facilitation of setup of 'Level 1' communities and CEA. Options which these groups will need to consider include:
    - potential for automatic peak restriction on house (externally controlled)
    - Different ways of allocating value from ownership of assets (generation, storage, EV, heating, etc)
    - Hard/soft commitments to respond to DR requests
    - Social events among Level 1 groups to build trust/relationships
    - Competition between Level 1 groups
    - Display of information (anonymised, confidential within Level 1 group, individual, average...)
    - Social equity tariffs, e.g. tariff that charges less for first XX units of electricity, and more for further units as a 'luxury' price?
- Purchase and installation of hardware
- Recruitment of members/participants in project

- It is likely that an artificial additional incentive will be required externally, as income from supplier/aggregator may not be sufficient incentive. One parameter to be tested at the end could be to ask participants if they would be willing to continue with the system if the extra incentive was removed, and to attempt to gradually move to an incubated early stage commercial situation, from a supported pilot situation.

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