Tower Power

Final Report

May 2018

Community Energy Scotland led this

Scottish Government funded trial of Tower Power,

along with partners

Our Power, Energy Local, TMA and City of Edinburgh Council.

APPENDICES:

GLOSSARY

Communications module / comms module - the new software developed by Energy Assets for insertion into the EDMI smart meter, to communicate the data to and from third parties
CAD – Customer Access Device
Dashboard – the online page where trial participants can see their own energy use, their share of the renewable energy and the savings made, along with those of the club collectively
DCC – DCC Ltd – the company contracted by BEIS to establish and manage the data and communications network to connect smart meters to the business systems of energy suppliers, network operators and other authorised service users of the network
DSR – Demand side response – where energy users agree for their loads to be switched on or off in response to grid requirements
EDMI – a smart meter which was used in the trial, which has more 'smart' capability than existing SMETS accredited meters
HHrly – Half hourly
Home hub – the 'black box' provided by OEM which has capability for enabling automatic DSR
LoRa – is the technology which enables low power, wide area communication between remote sensors and gateways connected to the network
MOP/MAP – the contracting company that installs the meter (Meter Asset Provider - **MAP**) and operates/maintains it (Meter Operator -**MOP**)
PVGIS – a free online tool that estimates the solar electricity production of a photovoltaic (PV) system at a particular postcode.
SMETS - Smart Metering Equipment Technical Specifications (a government standard for meters)

1. Project Aims

1.1 Background: The situation for customers in urban high density housing areas on prepayment meters

As of December 2015, Ofgem[1] identified that there were 4.5 million prepayment electricity accounts in the UK, with a significant proportion of these households being vulnerable economically. 36% of all housing or 886,000 homes in Scotland are either tenements or other flats[2]. 71% of homes in Glasgow and 67% homes in the City of Edinburgh are flats[1]. 18% of flats use electricity as their primary heating fuel.

Until now there have been very few community-based renewable energy projects within urban areas in Scotland, and even fewer in areas of high density housing and with prepayment customers in particular. The Tower Power project was conceived to provide a solution to these communities who often suffer from expensive electric heating systems in their homes and are unfairly charged a higher price for the electricity through use of a prepayment meter, but have little bargaining power in the energy market.

The overall aim of the project, as set out in the original application form, was to reduce poverty amongst residents of multi-rise housing by putting the community in control of energy supply and use, including sharing use of renewable energy generation. The aim was also to reduce energy costs through bulk purchase of power through a community-led alternative to the established model of electricity supply where each tenant buys power directly from a supplier. The project sought to identify ways to remove the unfair system whereby those most at need of an affordable tariff are charged substantially more for their energy as a consequence of being on prepayment metering.

This project combined an investigation and development of:

a) The technical tools required to aggregate household usage data for prepayment customers and to remotely access this data; providing access to cheaper prices, alongside new opportunities for local generation and demand response services.

b) Testing a community development approach based on empowering community members to lead a local Tower Power Supply company, and assisting individuals to switch to a Community Services Company (CoSerCo).

A short animation was produced as part of the project which illustrates the above aims of the Tower Power project and how it would work. This animation can be viewed online at https://www.youtube.com/watch?v=TEZ4U9u1E8Q

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[1] http://www.gov.scot/Resource/0053/00532144.pdf1 https://www.ofgem.gov.uk/publications-and-updates/ofgem-sets-prepayment-price-cap-protect-over-four-million-households-least-able-benefit-competition

[2] http://www.gov.scot/Publications/2017/12/5401/348226, accessed March 2018

[3] http://www.gov.scot/Resource/0053/00532144.pdf

Whilst the overall aim of the project did not change, technical and regulatory challenges faced during the implementation of this project meant that the project scope had to adapt several times and finally to focus in on finding a metering solution that would allow prepayment customers to benefit from the model envisaged under Tower Power.

Section 4.2 outlines the final scope agreed. Section 5 then reports on work done against this final scope.

2. **Partners involved in the project and their roles**

Initially, Community Energy Scotland, Comas and Glasgow City Council developed the Tower Power concept under Phase 1 of the Local Energy Challenge Fund, from June 2015 to Feb 2016. This phase 1 of the project identified a community need, carried out a demand and benefit analysis, investigated onsite renewable energy opportunities and included business model development.

For Phase 2 of the project City of Edinburgh Council joined the project consortium together with Tempus Energy as the Energy Supply partner. Phase 2 was the demonstrator phase.

A breakdown of the projects partners involved within the consortium over the Phase 2 period (hereon in referred to as the project for the purposes of this report) is detailed within Appendix 1.

Whilst Community Energy Scotland, Glasgow City Council and City of Edinburgh Council remained as project partners there were unavoidable changes to the project consortium over the course of the project as detailed below:

Shortly after the Brexit vote in June 2016 Tempus Energy announced that they could no longer remain within the UK Energy market. This created an immediate significant risk to the project as Tempus had offered a very favourable tariff and were focusing their business model around the opportunities that came from demand-side response market. Finding a suitable replacement energy supply partner was not an easy task. Future Energy were identified and came on board, but it soon became clear that their operational systems were not advanced enough for Tower Power's needs and it proved very difficult to get sufficient engagement from them in the project. Our Power came on board as the energy supplier project partner in April 2017. We worked with them for the remainder of the project, to take forward a metering trial and develop the business model. Our Power has a focus on tackling fuel poverty and a client group that includes substantial numbers of prepayment customers.

Although engaged with the project from concept stage, TMA only came on board as official project partners in March 2017 to fill the technical and industry level gap left as a result of not having an energy supply partner in place at that stage.

Comas was lead partner for the development phase of the project and was led on the community engagement work in phase 2 of the project. Their role was to help establish a community-based services company (CoSerCo), carry out the community engagement work necessary at the project location in Dumbiedykes in Edinburgh; and find customers who would join the scheme. In the period April 2016 to February 2017 good progress on community engagement work was achieved. However, the technical challenges (in relation to finding an energy supplier to work with and the regulatory and metering challenges) that were taking place in parallel to the community work grew more problematic. In February 2017 the decision was made by the project consortium that the project could not continue as originally planned with full scale implementation of Tower Power and Comas withdrew from the project partnership, having produced a very useful Learning Paper for the project (see Appendix 2). Key elements of this learning are outlined in section 7 of this report.

It was necessary to reshape the project consortium and bring on board additional resource and learning from Energy Local who were making progress on a comparable project in Wales aggregating community energy purchasing (though not with prepayment customers).

The project consortium and the roles of each partner remained the same throughout Year 2 of the project and were as follows:

Community Energy Scotland; Lead partner responsible for all project management and reporting, technical support to and direction of all project work streams including liaison with technical contractors (Energy Assets, ePOWER and Open Energy Monitor), project communications.

Energy Local; Technical support to project work streams relating to metering and regulation, including liaison with Energy Assets, ePOWER and Open Energy Monitor.

Our Power; Supply of electricity to trial participants, putting in place contractual agreements with meter operator and feeding into business development discussions.

TMA; Data Collection/Data Aggregation services to the project, and ensuring compliance to industry processes

The City of Edinburgh Council; Although most of CECs contribution to the project was in Year 1 they provided valuable input and discussion to the project through Project Steering group meetings. They also contributed £150,000 match funding to the project.

Glasgow City Council; GCC has kept a watching brief on the progress and outcomes of the project and have been kept briefed as a member of the Project Steering Group.

3. Project management and governance system

Community Energy Scotland was the lead agency but worked in close partnership with the project partners, reporting to a Project Steering Group which met every two months. The Steering Group had representatives from the following agencies:

- Community Energy Scotland (chair)
- Our Power
- Energy Local
- TMA
- The City of Edinburgh Council
- Glasgow City Council

The Steering Group tackled key strategic issues. Community Energy Scotland coordinated work delivery among partners and reported on work progress and financial management to the Steering Group and to the funders.

At the outset of the project a Project Advisory Group was established to provide specialist input to the project. A valuable meeting was held between PAG members early on in the project (August 2016) and since then various members have been approached for individual input on particular issues or challenges experienced throughout the project. The Project Advisory Group comprised:

- University of Strathclyde
- Thames Heat and Power
- Our Power
- Scottish Federation of Housing Associations

Monthly reports were provided by Community Energy Scotland, bringing together reporting on work done by partners, providing updates on work progress and financial reporting to Local Energy Scotland for the Scottish Government.

4. Summary of work done in Tower Power June 2016 – November 2017

4.1 Main outcomes over the period

The original aim of the project has remained unchanged throughout, however the project scope changed four times during the course of the project, to take account of technical and regulatory obstacles. Challenges and changes are to be expected with innovative projects and have provided the team with valuable learning that can be shared with other innovative local energy projects as described in section 7.

Please see Appendix 1 which shows the main project work streams and milestones over the course of the two years of the project with the outputs highlighted in yellow. It also shows which partners we worked with at each stage.

In summary the key outputs of the project during the period June 2016 – November 2017 are:

- Extensive community engagement was carried out in the Dumbiedykes estate in Edinburgh, through Comas our partner for the community engagement. This was done through door knocking, community newsletters, letters to residents and input through other existing groups and activities used by residents. This raised awareness of the potential benefits from the Tower Power model and as a result 28% of residents were contacted and of these 38% showed an interest in Tower Power. Training and briefing for local community leaders also built up their knowledge on energy issues and some relevant energy debt and energy saving advice was given by Comas staff during the project period. Unfortunately, due to the technical difficulties in other aspects of Tower Power, including finalising a metering solution and the regulatory barriers affecting the planned Tower Power model, we were not able to go to a full sign up stage with residents. Appendix 2 is the 'Lessons from Community Engagement' report written by Comas which summarises the activities done and the very useful learning achieved, which will be an excellent resource for any future projects delivering a Tower Power type model in a similar situation.

- However, despite problems with full sign-up of residents as mentioned above, the project did achieve the development of a constitution for and formal registration of the Community Services Company (CoSerCo), which was required for running the community energy service in the tower block in the Tower Power model. This material can also be used as a starting point for a CoSerCo in any future community wanting to deliver this model.
- 117 smart electric heaters were procured by the City of Edinburgh Council and installed in homes in the Dumbiedykes estate and these have continued to run successfully in the homes, providing potential for residents to take advantage of any future options presented in a smart energy system in the future, such as responding to time of use tariffs or use of electricity during cheap periods of the day and providing Demand Side Response (DSR) services.
- Metering options appraisal was carried out and this resulted in a much clearer picture of what the requirements would be for a final solution and identified 2 possible solutions to the issue neither of which were off-the shelf options and would require some development.
- A readily understandable and attractive animation and website were produced explaining the model and the potential benefits from it. This included an online dashboard for individual participants to be able to view their own energy use and their access to shared renewable energy, as well as similar data for the full energy club. This will again form a very useful starting point for adaptation for any future community wanting to develop the Tower Power model.
- Tower Power looked at a range of options for installing solar power to be shared between residents in the Dumbiedykes tower blocks. These included installation on the roofs of a number of the tower blocks, all of which had multiple owners of the roof as the flats were not all City of Edinburgh Council (CEC) owned; and installation on the roof of the Comas shop. The tower block roof option had a number of challenges including the requirement to get permission from all owners regardless of their interest in participating in the scheme (and in some case their mortgage companies) and the high cost of erecting scaffolding on the tower block for the installation. We made arrangements with CEC for installations to take place while they had scaffolding for other refurbishment work however this window of opportunity was lost due to the delay with the metering solutions for the project and the major challenge of working with all owners. The Comas shop option would not have provided sufficient space to generate sufficient energy to serve the number of residents involved. Overall, taking into consideration all the options, the costs for solar installation including the cost of loan finance meant that the returns on the solar generation were going to be too small (even with the benefits arising from sharing of the energy between Tower Power participants) and seen to be too risky in the wider context of the metering challenges. Project partners therefore agreed to step back from this element of the project.
- Input was made to 7 different events and relevant policy fora, to explain the aims and progress of the project and to put the issues being addressed (enabling prepayment customers living in fuel poor, from high density urban housing estates to access renewable energy and reduced tariffs through collective energy purchasing) on the agenda of statutory agencies, social housing providers and policy makers.

Overall, the first year and a half of the project developed the thinking and learning which will inform future implementation of Tower Power type energy clubs, as well as the information and constitutional resources that would be needed and could be adapted for such clubs in the future.

This period of the project also put the needs of high density urban areas, with high levels of fuel poverty and use of prepayment meters, on the 'low carbon future smart energy system' agenda of various agencies. These agencies included the two largest Scottish City Councils, a major housing association grouping and a number of academic institutions as well as the Scottish Government. We raised the questions: How can these communities benefit from access to renewable energy and reduce their energy costs? What opportunities might there be for reducing the carbon footprint from heating in multiple-occupancy buildings, through the sharing of renewable energy generation? How can residents in shared ownership housing blocks share renewable energy generation assets and energy? Our work also highlighted the technical and regulatory barriers that the UK and Scottish Governments and Ofgem need to take into account when looking at how the future 'smart energy system' evolves to ensure inclusion of these types of customers.

4.2 Final agreed scope of the project December 2017 – March 2018

At the break point review meeting on 12 December 2017 between Tower Power partners and Local Energy Scotland, the following final scope was agreed for the period 12 December 2017 – 31 March 2018. The bulk of the report that follows focuses on explaining our outcomes and outputs during this final period of the project.

The final scope covered the achievement of the following:

1. EDMI advanced meter installed in a small pilot of existing Our Power customers' homes
2. Communications module tested and implemented in these meters as proof of concept of remote data access and prepayment functionality
3. Collecting energy use data for a month through these meters, with ePOWER analysing the energy use data and matching it to solar generation data, to demonstrate the sharing of local supply of the renewable energy among participants
4. Developing and demonstrating Demand Side Response (DSR) capability with the use of these meters, including finalising the scheduler for the DSR for the quantum heater
5. Evaluating the business model using the data generated or other relevant available data, to test whether aggregation is of advantage to prepayment customers in the Tower Power model including in relation to:
    - Aggregation per se - does bulk buying mean that people could secure a better tariff than they would on the open market
    - Local supply from renewable energy being available to pre-payment customers through this aggregation model
    - Manual DSR
    - Automated DSR

The final scope did not include any direct focus group activity with customers.

An outline of the proposed metering solution:

Ideally we would have aimed to use a SMETS2 meter (all of which have full prepayment capability). However the normal route for extracting data from a SMETS 2 meter via the DCC[2]does not provide the functionality needed for aggregation on a community basis or for DSR management – two significant requirements for Tower Power. It is likely that this functionality will become essential in the future for meters. Energy Assets would have therefore had to build a 'Consumer Access Device' (CAD) to extract real-time half hourly data directly from the meter via a communications portal. This data would be sent to the Data Collector directly for settlement and provided to ePOWER to enable fair sharing of local renewable power; provide support the supplier for billing purposes; and to display to the customer. The consumption data would be communicated using Wi-Fi or LoRa.

Unfortunately, this above solution was not possible within the timescale remaining in the final scope period for Tower Power as:

- SMETS 2 meters were not yet available and so the prepayment functionality was not ready during the project period. The schedule is being continually delayed.
- A fully compliant CAD would have had to complete the Smart Metering Device approval process through DCC, which takes several months and cannot be carried out without SMETS 2 accreditation.
- DCC had to be functioning in Scotland to enable the CAD to be paired with the smart meter and it was unclear whether the DCC would be in a position to communicate with a meter to pair the CAD even once it had achieved certification. As the smart meter roll-out has suffered many delays, it was imprudent to rely on the DCC communications infrastructure being in place and capable of the particular functions that we needed within the time constraint of 31 March 2018.

We therefore proposed an interim metering and communications solution that would include:

Figure 1: EDMI advanced meter

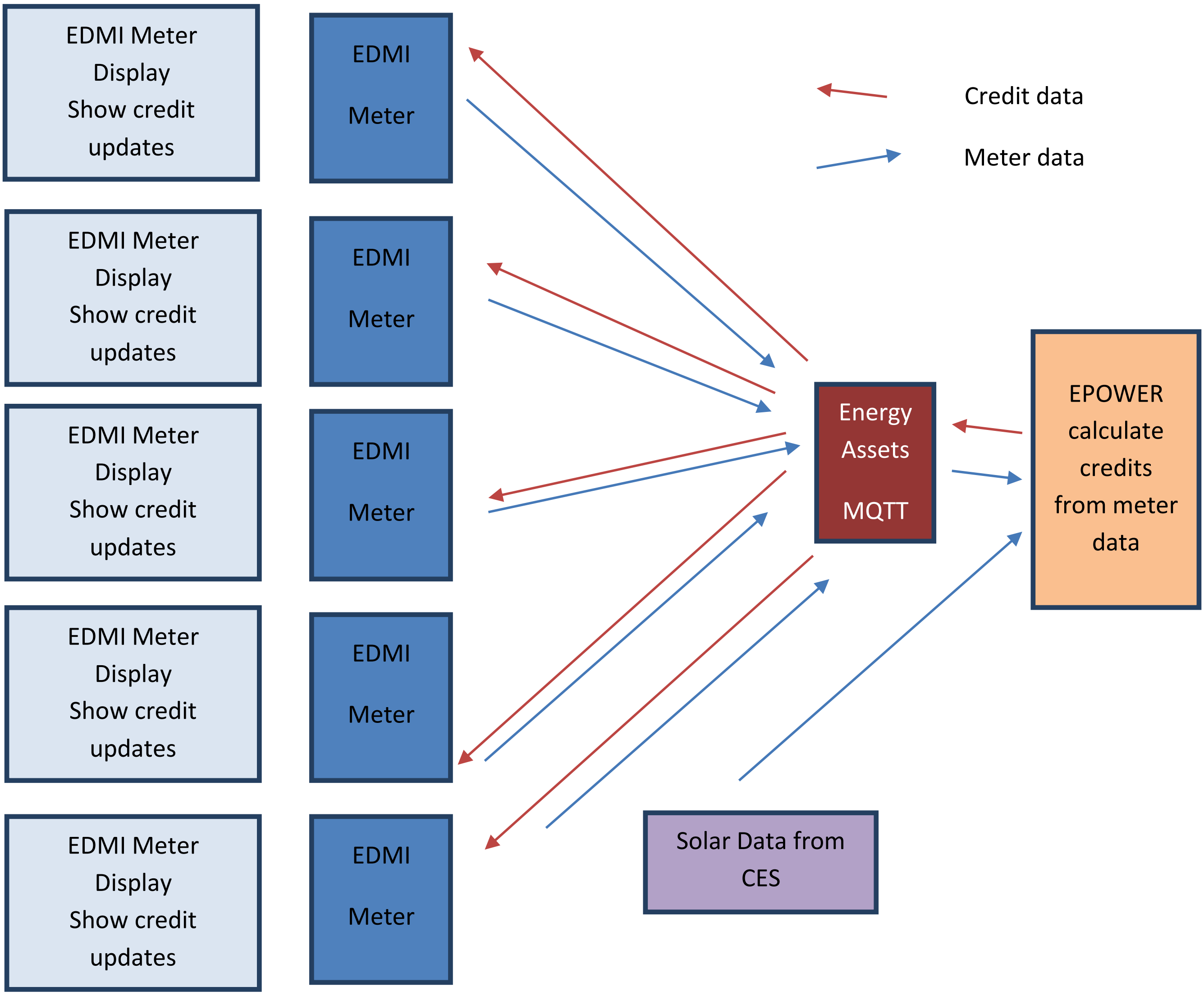
- Installing an advanced EDMI advanced meter that can collect energy use data on a half hourly (HHrly) basis and which has a prepayment setting which records the total credit for a customer and how the credit reduces with usage, according to a Time of Use Tariff depending on the time of day and a standing charge
- Developing a software module with an alternative/parallel communications system that would communicate the energy use data from the meter to a third party (in this case ePOWER) and enable each customer to have their own personal display showing their energy use and credit information.
- ePOWER using the extracted HHrly energy use data to match with renewable energy generation data and calculate the credit that each customer should receive once a day using the above data on allocated solar power cost per customer. This credit data then

[2] Smart DCC Ltd is the company contracted by BEIS to establish and manage the data and communications network to connect smart meters to the business systems of energy suppliers, network operators and other authorised service users of the network

being sent back to the MQTT[3] server so that the individual meter's credit can be updated and the information on credit appear on the customer's own display daily.
- Demonstrating the communications methods that would be used.
- In parallel demonstrating the DSR linked to the advanced EDMI meter
- Demonstrating with TMA that the data provided from the meter is adequate for settlement

It was agreed that the TMA demonstration for settlement of the HHrly data would be done separately from the formal data flows from the meters, for formal settlement by TMA. Figure 2 below illustrates the approach outlined above, showing how the energy use data and the credit data flows would occur. Please also see Appendix 3 Quick Start Guide to WiFi meter, which outlines the final capability of the meter and communications module that was developed by Tower Power.

Figure 2 – Metering and data communications solution developed in Tower Power



[3] *MQTT is a machine-to-machine (M2M)/"Internet of Things" connectivity protocol. It was designed as an extremely lightweight publish/subscribe messaging transport. It is useful for connections with remote locations where a small code footprint is required and/or network bandwidth is at a premium.*

5. Report on achievement of project December 2017 – March 2018: planned outputs and outcomes

5.1 Half Hourly Settlement meter - development of EDMI based communications model for prepayment customers

One of the foundational aspects of the project in terms of technology was to have a 'half-hourly settlement grade' electricity meter that had the various capabilities needed, especially the ability to handle prepayment customers. There is no such meter available 'off-the-shelf' and, after evaluating various options, we decided that it was best to take a meter that was certified to provide half-hourly settlement data and then add on the other functionality required for Tower Power.

Working with *Energy Assets*, who install and support meters, mainly for industrial clients, we developed the plan to write bespoke code that could reside in one of their communications modules on the meters. These communications modules fit within the meter and communicate with the core meter module. It can extract data from the meter and adjust various parameters. The add-on module links by Wi-Fi to the internet to securely send and receive data and instructions with a central server.

This plan was delivered with a communications module developed and deployed in the trial participants' EDMI meters. It has a simple web interface that can be quizzed by the householder to view power, energy consumed over various periods and the credit amount. The standard display on the meter itself can also display this data although it is very much less user-friendly than the web interface (and the meters are often not in accessible positions). The data was also made accessible to *ePOWER* who handle the data for the purposes of the 'Tower Power club' and for this trial, cumulative meter reading data was sent to *settlement* and to *Our Power* for billing.

This communications module that was developed and fitted to the EDMI provides data for a specific community and generation asset within 24hours enabling local balancing, DSR and inclusion of those on prepayment meters.

This is a significant improvement on the SMETS 2 meters which are currently incapable of providing this kind of data at present, and do not have the communication system set up to gather data from a small subset of meters each half-hour. The module developed also addresses the limitations associated with the patchy coverage of mobile telephony infrastructure at meter locations in cellars, behind thick walls and inside high density buildings, as well as for remote locations.

The full technical spec and capability of the software installed in the EDMI meters is outlined in Appendix 3.

Figure 3 on page 14 is a technical summary of the metering and data flow elements and Tower Power project elements that have been achieved by the various parties. Each amber box identifies an aspect of the project, with the lead organisation responsible marked in the bottom right corner. The blue arrows indicate data flows. The householder is included as a blue shape marked 'User'. Rectangles with a solid black outline represent aspects that were developed and fully implemented during the live trial in 2018. Rectangles with dashed outlines indicate aspects that were progressed during this phase of the project but not fully accomplished in the live trial for various reasons as detailed elsewhere in this report. Other items listed in each box are elements that would need to be delivered in a fully functioning live trial for a Tower Power energy club with prepayment customers and HHrly settlement.

Energy Assets were responsible for sourcing, modifying, installing and operating the meters (top-left box). The blue rectangle represents the communications module that EA developed, and fitted to the EDMI advanced meters used for Tower Power participants. It included a web interface for local use and the all-important elements of prepayment functionality as set out in Appendix 3.

TMA (top-centre), the DC/DA were able to use the Wi-Fi and internet communications links to download data from the EDMI meters but, for this trial the energy was not settled on a half-hourly basis and the meters continued to be billed on a monthly basis using cumulative readings.

Our Power (top-right) was the licensed supplier to the trial participants and provided all of the components listed in the box using standard arrangements. Discussions were held with them regarding development of a special tariff, the additional arrangements with MOP and DC/DA and how to handle the balancing and other use of system charges.

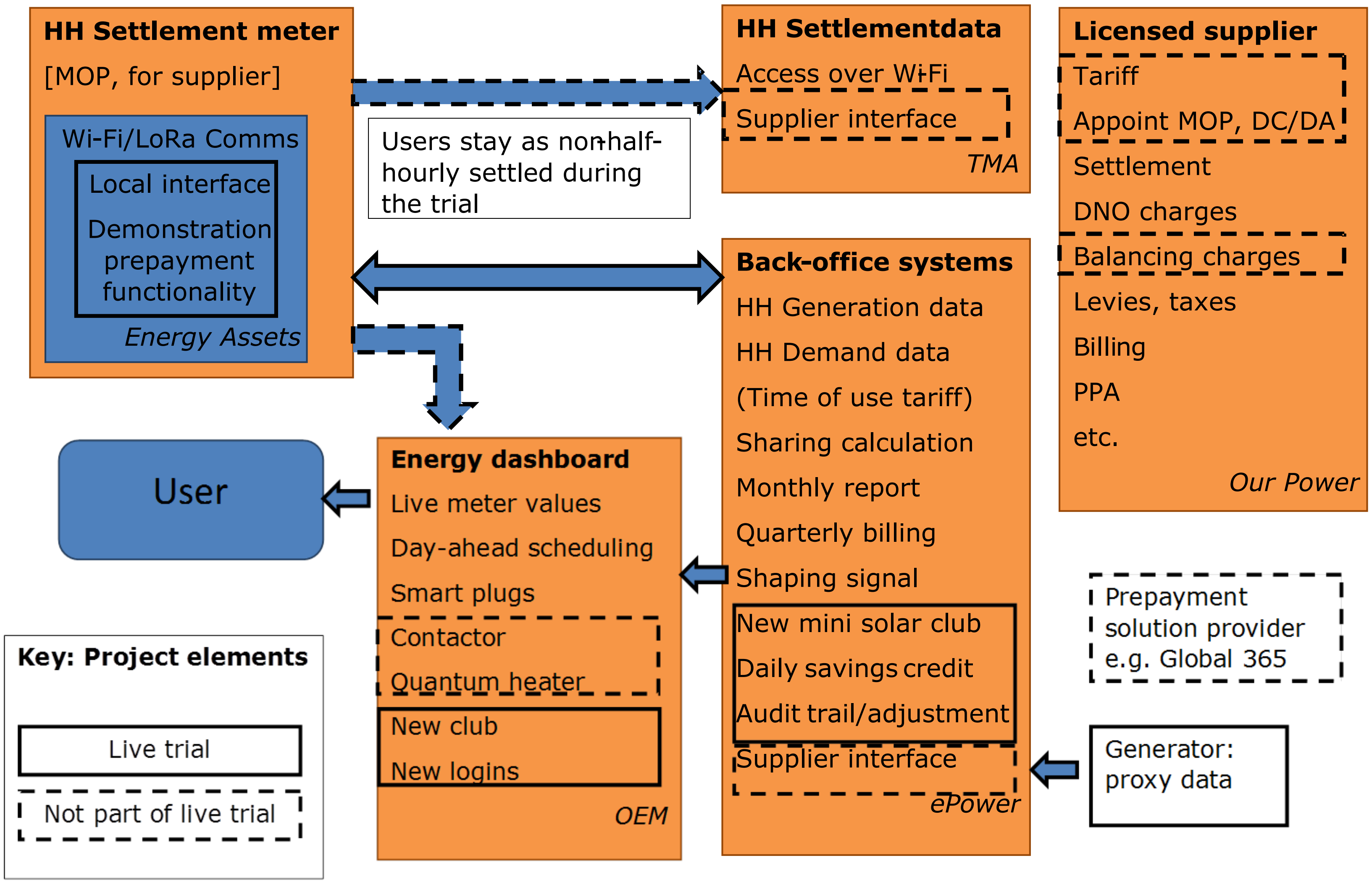
OEM (bottom-left) provided the energy dashboard online, setting up a new club and issuing new logins to each of the trial participants who could see both their own data and that of the club.

ePOWER (bottom-centre) pulled the data from the meters and computed the required solar energy sharing figures for the dashboard. To do so, it set up a new mini solar club, calculated daily savings credits and maintained an audit trail to test and ensure accuracy and compliance, including remote updating of credit to the communications module in the participants' EDMI meter prepayment modules.

Generation data was supplied into the calculations and discussions were had with prepayment providers but there was no need to involve them in the live trial as the participants remained on credit billing.

CES as project manager coordinated the recruitment of trial participants and ensured the required data access permissions were secured, managed the meter installation logistics with participants, and ensured the contracting required for the trial was in place. EL oversaw the development and testing of the communications module with CES, the set-up of the energy club and the energy club calculation and credit system, working with ePOWER, OEM and EA on these. Both CES and EL worked on the DSR elements.

Figure 3 Summary of Tower Power metering and data flow management achievements



5.2 Recruitment of Our Power customers and setting up the 'Tower Power club'

The deliverables agreed at the December review meeting had a very tight timeframe and so it was agreed with LES that we would focus on finding existing Our Power customers if possible and if not, others who would be willing to switch to Our Power straight away. As we were at this stage not planning to implement a complex site it was not necessary for the trial participants to be located within the same geographical area. Also, as we were not going to implement a fully compliant prepayment smart meter we were also looking for customers on regular contracts and not on prepayment systems. A call was therefore put out to all CES staff and all Our Power staff, to find existing customers or willing switchers in the central belt of Scotland, for ease of meter installation, and once a review was done of the fit of the existing metering arrangements in each of these homes, we identified 5 homes that fitted the requirements of the pilot in terms of metering and location, though unfortunately none were existing Our Power customers. One of the selected homes had their own solar generation.

Information was sent to these five volunteers, to seek their written permission to have the meter fitted and to access their half-hourly data for use by the project. All volunteers then applied to be Our Power customers and this process was completed, with all volunteers being registered customers with Our Power by mid-February. The group included 3 homes in Edinburgh, 1 in Perth and 1 in Elgin.

The details of everyone's MPANs were collected, and together with the meter installation details, were sent to ePOWER for setting up the 'Tower Power club' with these customers. This then formed the basis for ePOWER to receive half hourly energy use data from each of the meters and to calculate the matching share of solar energy that would be allocated to each of the customers.

A 'MOP-lite' contract was exchanged between Our Power and Energy Assets, with EA taking on the management of the meters.

5.3 Installation of meters and support information for customers

Energy Assets were responsible for installation of the EMDI meters, with the newly developed software already installed in them.

Installation included both a standard Engineer ensuring the meter was properly installed and technical input from the EA team which had developed the software, to enable the Wi-Fi-based communications to be activated so that data could be accessed straightaway. Four successful installations were achieved on 23 February 2018 and data from these four meters was accessed from 23 February. Unfortunately, due to the heavy snowfall in Scotland in the week of 26 February, the final meter installation planned in Elgin on 28 February was not achieved and rescheduling of this installation meant that it could not be achieved before the end of March. This final installation was therefore cancelled and only four homes were included in the final club.

Each of the volunteers were given the technical information booklet (Appendix 3) which instructed them on how to operate the communications module to access their personal data, showing their energy use, credit levels, etc. as outlined. They were also briefed on the importance of not turning their Wi-Fi off, so that data could be continuously transmitted.

5.4 Testing of the communications functionality and access to data from the installed EDMI meters

For details of how the communications module interacts with the data collector and data aggregator (in this instance TMA) see Appendix 4.

For aggregation of community energy use and local energy generation it is essential that meters can support cost effective near real time half hourly consumption and generation data. This data is used for billing and settlement purposes as well as feedback to customers through the dashboard. Prior to the communications module being installed within trial participants' meters the functionality of the module and its ability to access data were tested in a variety of locations as detailed in figure 4 below.

Figure 4 Meter testing requirements and outcomes

Meter /Data Requirements	Outcomes
The meter must be capable of communicating in areas of poor mobile coverage	For the project trial this was achieved by use of participants' Wi-Fi and broadband connection. The EDMI meter also has capability for the data to be carried over a longer-range, lower data-rate LoRa network.
Trial participants must be able to view their individual and aggregated data	Done via Wi-Fi network in the form of a local webpage which can be viewed on a smartphone, tablet or computer. The webpage is provided by OEM, pulling data from ePOWER. EA prepared a user guide to help householders to 'discover' their meter on their home Wi-Fi network. [Appendix 3: Quick Start Guide to Wi-Fi meter 1.4.pdf] The guide also describes the push-buttons on the meter and the built-in display, including the five annunciators.
Enable a third party (data service provider) to access data from the trial meters	Energy Local developed a process and provided support to ePOWER, to enable them to access consumption data from meters. This was integrated by ePOWER, under EL guidance, to populate their databases with half-hourly consumption data for the Tower Power participants. Half-hourly generation from the nominated solar generator was collected by an API call with integration over aligned 1800 second periods, from the OEM emoncms platform.
Offer daily credits to the meter to realise the benefits from local renewable energy matching	The meter communications module includes well-developed functionality to support this capability. EL developed a methodology to calculate and to apply daily renewable energy credits and provided support to enable ePOWER then to apply this credit to meters. The meters include protection against 'replay' attacks, which could be used to try and obtain repeat credit. This protection has been tested and has been shown to work. Communication with the meters is encrypted, to protect against attempted fraudulent interaction.
Testing of firmware updates	Three sets of meters were available during the project for testing: a) two development meters, which enabled testing of firmware updates – one of these was at Energy Assets labs and one installed in a friendly location in the field; b) two meters installed in Bethesda during December 2017 – to prove reliability of the communications; and c) the four meters installed in the Tower Power trial customers' homes, to

	prove the prepayment functionality, user interface and additional communications to support local renewable credit.
Recording data at HHrly intervals	Trial customers' meters have remained as non-half hourly for formal settlement purposes, however the internal meter templates have been configured to enable consumption data to be recorded at 30 minute intervals, aligned with the settlement periods. The meter provides the permanent storage location for this data. Consumption data was then requested for an arbitrary time and date and for a number of consecutive settlement periods. Consumption data was also published by each meter, every 4 hours. The client and server relationship is managed by an MQTT broker. The MQTT-spy[4] client has been used, in a Java 8 Runtime Environment.

A glossary of commands was prepared by Energy Local, to confirm the meter interactions with Energy Assets developers. [Appendix 5 MQTT command glossary v1.1.pdf] This document also lists the meter registers and describes their contents and whether they can be read and/or written. For example, the local Wi-Fi password cannot be read back from the meter.

Energy Local prepared a functional test matrix, to guide the testing of the core meter functionality. [Appendix 6 WiSEMT test matrix v2.0.pdf]

The project carried out periodic tests to audit whether the remaining credit balance shown on the meter was correct when checked against the expected remaining credit on the standing charge and the deductions as a result of the cost of the energy used. These tests showed that the credit calculation process and credit adjustment mechanism were working correctly.

5.5 Renewable generation and matching of renewable energy to energy use

In line with the aims of the Tower Power project, urban sources of renewable energy were considered as a source of renewable energy generation data for the Tower Power club, as we did not achieve installation of solar panels on the Dumbiedykes buildings. A live feed of solar generation was used to simulate a dedicated installation and as this was not available for a full 12-month period, this actual output data was also blended with modelled generation (as explained in more detail in section 6 below). All this generation data was integrated across half-hour settlement periods.

In practice in future, a Tower Power type club could equally provide households with access to other types of local renewable generation, including micro hydroelectric generation, small wind or anaerobic digestion, not just solar.

Matching demand to local generation

A 'fair sharing' algorithm was developed and has successfully been used by an Energy Local project in Wales for more than a year and so this algorithm was used in the Tower Power project too. Energy Local supported ePOWER in implementing this for Tower Power, enabling them to integrate the function with their database. The matching and sharing of renewable power among participants was

[4] http://kamilfb.github.io/mqtt-spy/ MQTT-spy 1.0.0 Build 3 and Build 5 (Beta), available under Eclipse Public Distribution License.

calculated daily. In the case of missing data, estimates were used. In each half-hour period, where there was generation available, this was fairly shared among club members based on their pattern of energy use, as described in Appendix 7.

5.6 Demand-Side Response scheduler testing and proof of concept

The unit pictured in figure 5 below is the *home hub* used on this project. It was sourced from Open Energy Monitor (OEM) and is a Raspberry Pi computer with bespoke software to communicate with the OEM dashboard, allow users to set scheduling preferences and control various loads by sending instructions over the home Wi-Fi to the linked devices.

Figure 5 Home hub emonpi unit: approximate external dimensions 94 x 63 x 32 mm

The unit is capable of 'over-the-air' software updates for upgrading the operating system and has been configured to communicate with smart sockets and the inbuilt controller of Quantum heaters, reading the state of charge and temperature of the bricks and the air. It can also control an OpenEV charging station (although that was not demonstrated on this particular project). For further information of additional functionality of the *home hub* see Appendix 8.

The unit was tested to show how it controls loads by means of a contactor or smart socket. Separate software, developed for the Tower Power project, enables it to control a Quantum heater and to read back the state of charge. This functionality was used to test the switching on and off of the quantum heater.

Tower Power used the scheduling capabilities of this *home hub* to enable testing of more sophisticated scheduling of when the Quantum heater could be switched on and off in response to customer preferences, time of use tariff incentives and availability of cheap power through renewable generation sharing. The generation forecast profile was produced on the ePOWER server and was made available on a day-ahead basis so the customer could see it on the dashboard. The signal takes into account both forecast generation and forecast demand as well as off-peak hours.

There will clearly be potential efficiency savings and/or comfort benefits to be gained from improved heating controls, since the charging of a heater at the start of the Economy 7 period was not designed with optimum heating performance in mind. Scheduling with weather compensation enables the thermal charging of electric heating to start later and forecast of local generation and demand creates the opportunity for top-up during the daytime.

Within the Tower Power project, the *home hub* was used to control both smart and standard electric storage heating. Although switching of the standard heaters was achieved in both lab and home situations, a real life site for the switching of smart heaters could not be found within the timescales of the project and therefore this was (successfully) demonstrated only within a test location.

Remote scheduling of smart heaters has been achieved in other projects (e.g. ACCESS) but under Tower Power the system was interacting with the in-built intelligence within the Quantum heater rather than over-riding it. This resulted in a much more robust and efficient remote switching control system.

Interactions with intelligent heaters

During the project, a workshop set up with Glen-Dimplex and OEM successfully configured a transceiver to interact with a Quantum storage heater. Some additional software was developed to provide the ability to switch the heater on and off via radio link with a response time of a few seconds. It was also demonstrated that the (heating) state of charge, core temperature and desired charge level could all be read from the heater controller.

An emonpi unit was supplied for field testing on Mull using heaters decommissioned from the ACCESS project. Once paired, the set up was managed remotely by OEM to conduct successful additional field tests ensuring that the quantum heater responded as anticipated and needed. More work would be needed to be done to strengthen the security encryption and to interface with the new Quantum software being deployed in recent units.

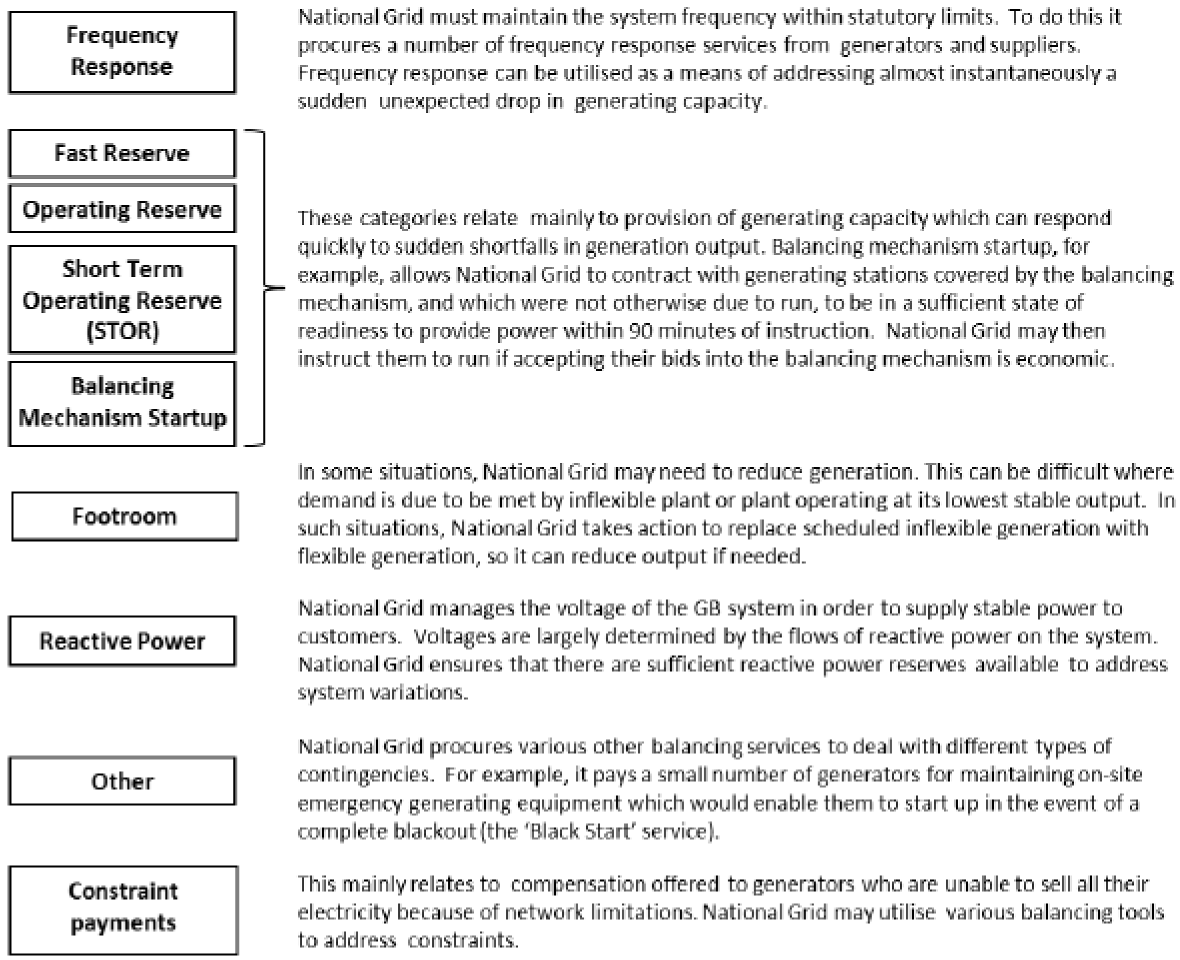
Combined with forecasts and room temperature information, this offers a very rich set of parameters around which heating efficiency and comfort could be optimised.

Demand response

One method of extracting value from DSR installations is to provide services to the National Grid through their various frequency response and balancing services contracts. The DSR loads need to be aggregated into fairly large banks, typically at least 1MW and, depending on the particular service provided, respond within a particular timescale; from seconds to minutes. The future of these services is being discussed and it is likely that different opportunities may emerge, as in the table below.

If in future, initiatives such as Tower Power groups are contracting to provide demand-side response they need to be able to prove they have delivered the response. To enable that they have to have a settlement grade meter that can read both the instantaneous power demand and the half-hour consumption data.

Figure 10: Types of Balancing Services



Source: National Audit Office

5.7 Summary of the Tower Power outcomes from December 2017 – March 2018

The table below summarises the achievements outlined in sections 5.1 – 5.6 above, in the format of the original agreed project Outcomes for the Tower Power project.

Outcomes			End of Project Progress
1	Project is tested and live trial ready	Proof of concept and the business case is made. Components and systems have been tested so the aggregation project is ready to engage with a community and roll out, as a next stage, as a live trial in people's homes	An aggregation trial was completed which demonstrates the local balancing of energy for prepayment customers. Roll out is not yet possible due to the technical and regulatory barriers as identified within this report.

Outcomes			End of Project Progress
2	Prepayment meter is ready for use by aggregated customers	The software required for an add-on prepayment system to an EDMI meter has been developed which is suitable for an aggregated customer. The EDMI meter also allows use of a user interface for consumers to monitor their consumption in a more sophisticated way that adds to the capability of industry standard SMART meters. It will incorporate capability to factor in savings from matching with local generation, and be able to work with a home hub to enable demand side response.	A communications module for a prepayment meter was developed and used in practice in four people's homes. This has been proven to successfully extract and communicate real-time half hourly data from meters for both settlement and billing purposes. The communications module was also successfully tested for allowing meters to be credited remotely for local balancing benefits to be realised.
3	The electricity supplier understands the steps required to aggregate meters in half-hourly settlement, has prepared their systems to deliver aggregated local supply and is ready to offer a tariff.	Actions required by the supplier (Our Power) include creating automatic data processing paths, reaching agreements with turnkey supply service providers, and readying customer service systems. Our Power will also have investigated the various tariff options, and be able to offer a suitable tariff for live trials.	Our Power has worked successfully with us to deliver the trial with four of their customers, with back-office support from ePOWER for the energy club and renewable energy sharing management. If rolled out this arrangement with a third party (ePOWER) which carries out much of the back office (data analysis and billing) function on behalf of the supplier is likely to remain. The areas where savings can be made and how this could relate to a local tariff are detailed in section 6. Discussions with Our Power show that they are interested in further investigating a tariff of this kind if we could provide evidence of affordable customer acquisition at scale and savings on costs at scale. However, they would not be in a position to develop such a tariff for at least a year.
4	Potential for savings to individual consumers from being in an aggregated project are shown.	Data collected, (as appropriate when reviewing project progress) from suitable, individual customer profiles so that the benefits to particular customer archetypes can be shown, alongside average aggregated community benefit. Currently (July) there are monitors installed in 5 properties and CES expect another 5 participants from within the focus group can be found.	See section 6.1 and 6.3 for more detailed discussion of this. Appendix 9 provides data on the energy demand from a number of homes though few of them were from electrically heated homes. We had hoped to supplement this with related data from electrically heated properties ideally in the central belt of Scotland. However, a gap has been identified in the availability of half hourly demand data for electrically heated properties with prepayment meters.

Outcomes			End of Project Progress
5	Potential savings from local supply and aggregation calculated, using aggregated monitoring data and household usage profiles.	Live renewable energy generation feed used to model benefits from matching local generation and/or demand side response.	Data analysis was completed to show matching profiles - see section 6.2. However, a gap has been identified in the availability of half hourly demand data for electrically heated properties with prepayment meters as mentioned above. As we did not have a tariff agreed with Our Power, a full financial analysis was not possible.
6	An aggregation home hub is developed that delivers Demand Side Response.	It will have the ability to switch simple and smart storage heater systems, alongside housing the customer display. This would allow best use to be made of time of use tariffs.	Completed the development and testing of this and it worked to standards required.
7	Involvement, learning from, and consultation with typical potential consumers has improved usability for them of the meter and aggregation home hub interface.	Engagement will be through focus groups and, as appropriate, working with willing pre-payment customers. Depending on project and funding status at review point in Nov/Dec, some testing and troubleshooting of equipment in situ in people's home may take place; if willing and informed parties are content with this and it's approved beforehand by LES.	This outcome was removed from the project following the December 2017 review. No focus group work was done as a result.

6. Data Collection and analysis

6.1 Data collection

Refining and testing the Tower Power concept relied upon the collection and analysis of the following two sets of data:

1. Household consumption data, on a half hourly basis and for flats that are electrically heated and on prepayment meter supply
2. Local community energy generation, on a half hourly basis

The quantity and quality of data provided would determine the accuracy of the models that we produced. The main barriers to our data collection were as follows;

- We did not have a live demonstration with electrically heated properties in Dumbiedykes
- We were not able to install solar generation on the Dumbiedykes buildings so did not have direct renewable energy generation data from that source
- Given the timescales available within the project from December 2017 – March 2018 we could not collect sufficient (12 months') data for energy use in the homes where we installed the EDMI advanced meters nor access to solar generation data on these homes

We therefore searched for sample data from other sources, to use for the data and Tower Power business modelling.

6.1.1 Household Electricity consumption data:

6.1.1.1 Context:

No half hourly data for electrically heated properties with prepayment meters could be found despite extensive attempts to find it from housing associations, research institutions and other projects both in Scotland and wider in the UK.

We did though identify various sources of electricity consumption data to better understand real-life consumption profiles and habits (to strengthen the Tower Power modelling) as described in the following sections. We also tested data communication routes and developed methods of collecting, processing and displaying the data.

In collecting data, we have considered the need to emulate not only net energy use (i.e. the difference between total annual energy demand and total renewable generation production) at a property but also variations in the value of electric power by location, time of day and across different seasons. Energy use can fluctuate quite widely according to weather, plant failure and fuel prices, etc. and we have tried to take this into consideration.

Data and models are needed to determine the typical, likely or actual match between generation and power consumption each day for the Tower Power modelling. Since there are strong seasonal patterns for both demand and generation, this match should be considered at least on a basis of the season. This is better done month-by-month using average figures. Where actual data is available, calculations for each day will provide more detail of the real-life variations over a day or over a week in matching. Where the generation and demand are located near to each other and the data-sets cover the same time period, it is possible to analyse for weather-dependency. Actual generation data is useful in establishing example patterns of variation in output. For example, this could be seen as negative correlation when a sunny day suppresses lighting or heating demand but would result in higher solar generation.

Only when these models or matching of data have been used, can the potential impact of local renewable supply and time-of-use tariffs be assessed accurately.

Use of actual demand data from a wider population would enable the distribution of benefits to be explored, rather than just reporting on average values. This can be important to establish whether some households would be likely to lose out under proposed arrangements.

Note on time resolution of data

Whilst it can be useful to look at energy consumption data at an 'every few seconds' level, this is not relevant to matching demand and generation in a local community. Electricity meters integrate power consumption and generation over periods of half an hour. In the electricity industry, these half-hour intervals are known as settlement periods. Power for domestic situations is bought, sold and traded in settlement period blocks.

In light of the above explanation on the value of collecting a range of relevant data but also the difficulties we encountered in finding relevant data, three different sets of electricity consumption data were collected and analysed.

6.1.1.2 Project data use:

Individual dwelling monitoring

Early in the project, we installed *Open Energy Monitors (OEMs)* in various 'friendly' locations to track high-frequency, near-real-time consumption data and develop the communication and calculation systems to appropriately display this. '*Dashboard'* displays were developed for each dwelling and a '*community dashboard'* displayed aggregated consumption and renewable energy generation and indicated whether there would be surplus generation to be consumed by loads under a *Tower Power* mechanism. These monitors used home Wi-Fi connections to communicate data back to the host website and collected data at up to 10-second granularity.

Whole-block monitoring

Monitors were set up on one of the blocks of flats in the Dumbiedykes estate. These used different equipment that was not dependent on a friendly, local Wi-Fi network to transfer the data. Three feeder cables were monitored, each supplying five or six flats with the aim of gathering data on the variation in electricity use across the day, especially the switching of off-peak heaters. The data gathered (shown in Appendix 9) unfortunately did not display the diurnal or weekly demand patterns that might reasonably be expected to result from groups of residential apartments.

When approached informally, the equipment manufacturers were not able to offer an explanation on the measurement values that have been obtained from the present arrangement of monitor clamps.

The whole-block monitoring has revealed some clear patterns of off-peak loads switching off around dawn. The power consumption at 0300hrs is consistently high and either remains high until about 0600hrs or drops dramatically to a much lower level. There are clear, brief times of high consumption throughout the day, consistent with expected high demand from energy use in kitchens.

However overall the quality is mixed and on this basis, it was determined that unfortunately this data was not suitable for use in the modelling for Tower Power.

Settlement-grade meter data

The Tower Power project included the development of communications software by Energy Assets, which was then uploaded to EDMI advanced meters for demonstration in prepayment mode.

As explained in section 5, four such meters were installed in participant houses on 23 February 2018, for the purpose of demonstrating the calculation and application of local renewable energy credits to meters with prepayment functionality. These meters recording electricity consumption for each half hourly settlement period from 23 February – 31 March 2018. The data has been accessed remotely by Energy Local and by ePOWER. This live data feed has been successfully used to demonstrate daily calculation of local sharing of renewable energy generation and therefore the renewable energy credit system in Tower Power.

We have not though used this half-hourly energy consumption data for any of the modelling exercises because the data only covers a period of five weeks at the end of the project. The properties were also selected as being profile 01 customers, i.e. those without an off-peak circuit and therefore would not be representative of electrically-heated flats. This was done as we did not have time in the short period from January – March 2018 to generate enough representative data to use in the modelling.

However, the installation of the meters in these flats proved vital as they enabled us to successfully test the use of the new meter software prepayment mode functionality and the remote management and communications enabling crediting of the meters.

These units performed well and even in the event of a communications failure (such as the Wi-Fi being turned off by the resident), the data was retained in the meter and subsequently transferred without any loss of data.

Non-project related potential half-hourly consumption data from electrically-heated flats in Scotland

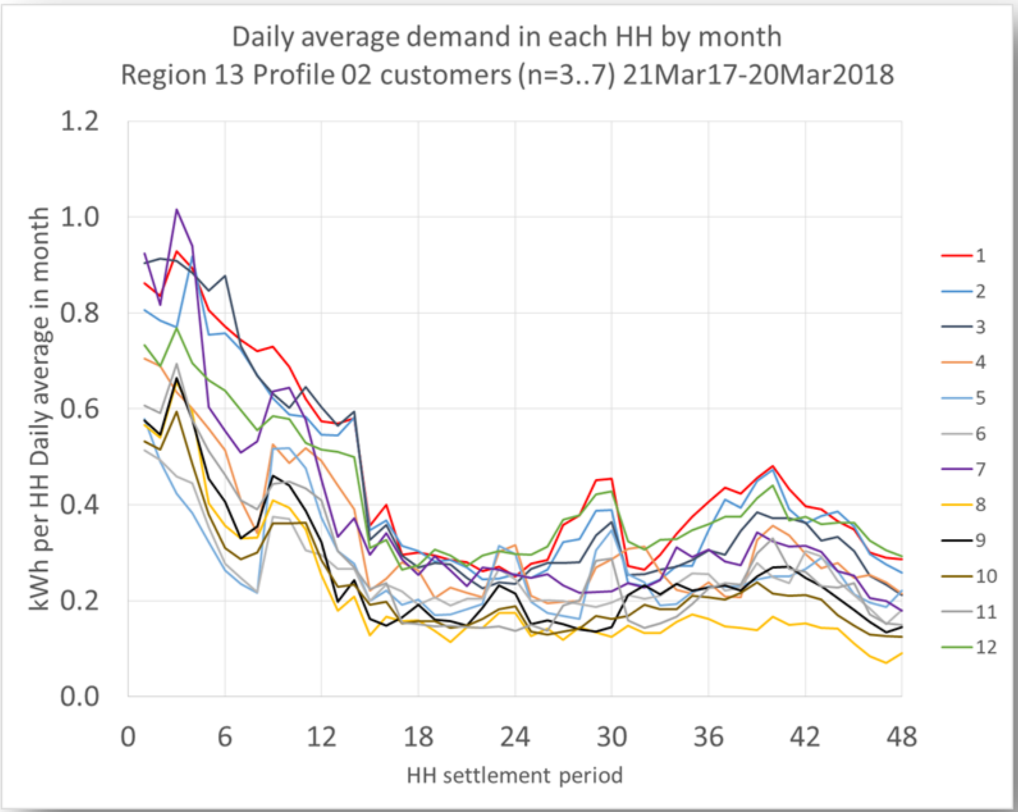
Understanding the pattern of electricity use in flats with storage heaters is important when we are trying to model the matching of energy use against generation as in the Tower Power model. The above mentioned whole-block monitoring has given us a certain amount of insight into this but the data quality has not been as high as we would have liked and so we have not used this data in the modelling. In light of this we contacted several organisations including Home Energy Scotland, Changeworks, a number of universities (DeMontfort University, Heriot Watt University and Edinburgh University) and housing associations (including the Wheatley Group which is a major social housing association grouping in Scotland) for any further sources of relevant half hourly data from electrically heated homes, but none were able to help. It was also found that the UKERC Energy Data Centre had no pertinent datasets. It is acknowledged by those we contacted that this is an area where research is needed and this is a useful finding to come out of the Tower Power project.

Proxy data – half-hour consumption

Two sources of proxy data were therefore considered and used for the modelling: The primary source of data is the half-hourly consumption for participants in the Bethesda Energy Local pilot in Wales which has been running for over a year. Secondly, data from the SWELL project in Oxfordshire has been used to assist with examination of potential for demand-response matching to local generation. See Appendix 9 for more detailed presentation of the SWELL data.

Figure 6 below shows data from the Bethesda pilot. For the period December 2016 – July 2017, there were three profile 2 customers in the Bethesda pilot. This number increased to 7 by August 2017. The individual consumption patterns show quite significant variation, as expected. The average demand by half hour for this group is shown below.

Figure 6 – Half hourly energy use data over 12 months in the Bethesda pilot in Wales



This data provided a useful baseline for matching to solar generation. There has been no intervention to adjust the operating times of heating away from the standard Economy 7 periods for region 13. It can be seen that the mid-day demand is generally rather low, just at the time when solar generation is expected to be at its maximum.

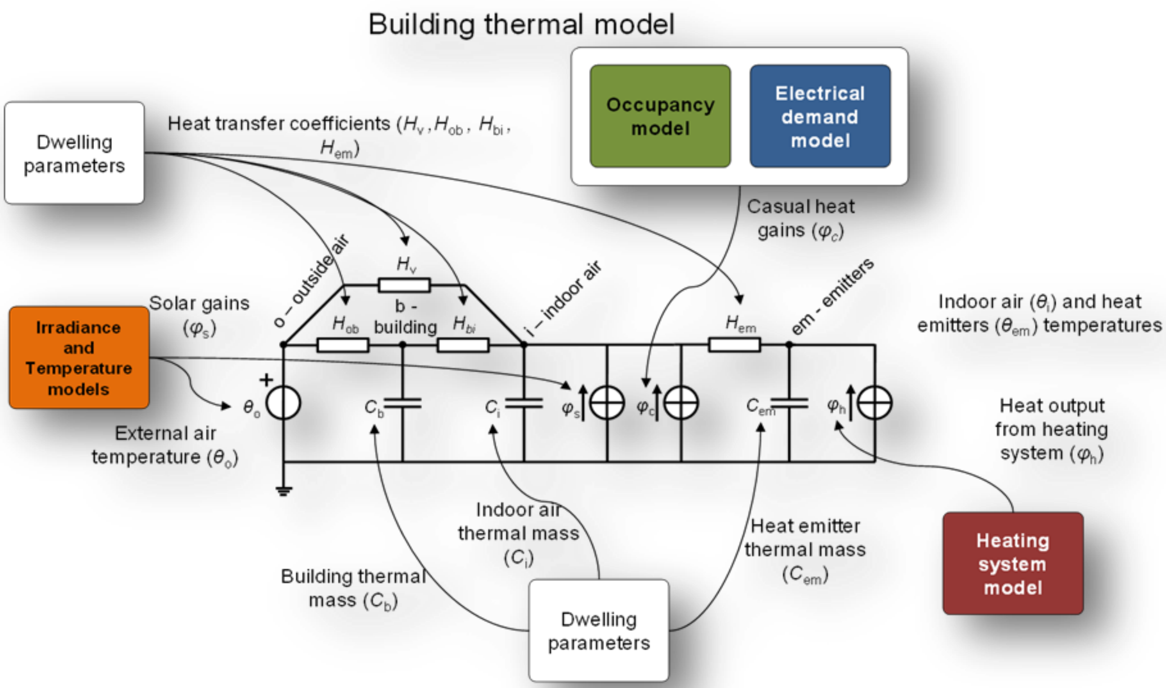
The collective demand is dominated by water and space heating requirements and the daily shapes follow typical seasonal patterns. Overnight heating/hot water load is higher in colder months. The evening peak demand is higher during darker evenings and lowest in the summer holiday period. There is a significant increase in demand around school finishing time during when GMT clock time prevails. The small local peak in demand is more prevalent around midday in the summer months. Data was averaged in each half-hour period for the whole twelve months and then scaled to represent the average demand from seven profile 2 customers in the region.

The properties in north Wales will not exhibit the same thermal performance as flats in the central belt of Scotland. Also, the prevalent weather patterns and external temperature will not be the same, but seasonal variations in temperature would be expected to share some similarities.

Alternative models considered for profiling demand

We also considered alternative models for profiling demand with the most obvious demand model to consider being CREST[5]. This incorporates a number of elements, including a building thermal model. This is illustrated below in figure 7.

Figure 7. CREST Building thermal model - Loughborough University



It has been confirmed with the lead author of CREST that the model does not incorporate the apartment/flat building type (though some work is currently being done on this for research into CHP communal networks); nor does it include electric-only heated properties. This means that further development work would be needed before CREST could be effectively used for the Tower Power modelling.

[5] https://dx.doi.org/10.17028/rd.lboro.2001129, accessed March 2018

In summary, the main source of energy demand data which has therefore been used in the Tower Power model to represent the half-hourly energy demand is from the Bethesda residents.

6.1.2 Data collection - Hawick PV generation data-set

As we did not achieve installation of solar generation in Dumbiedykes as part of the Tower Power project, the output from one domestic solar PV generator near Hawick was monitored from late July 2017 to March 2018 to gather the required data for modelling. The installation is 3.5kWp with a 3kW continuous maximum output. The panels were roof-mounted at an angle, with the orientation of roughly 15 degrees east of south.

Generation was logged every ten seconds and then aggregated into half hour data blocks. Individual missing half-hour data was represented by an average of the half-hour values on either side. There were a few missing periods of more than one hour, where missing data was substituted by actual data from the same times on an adjacent day. This is considered useful data to represent solar generation potential in the central belt, including fluctuations in output according to cloud cover. The data is time-coincident with some of the demand data from Bethesda, however the generation and demand are not co-located, so effects of local weather are not accounted for in the data matching (for example, it might have been sunny in Hawick but cooler and wetter in Bethesda at that time).

Extension of Hawick based PV data-set using modelling

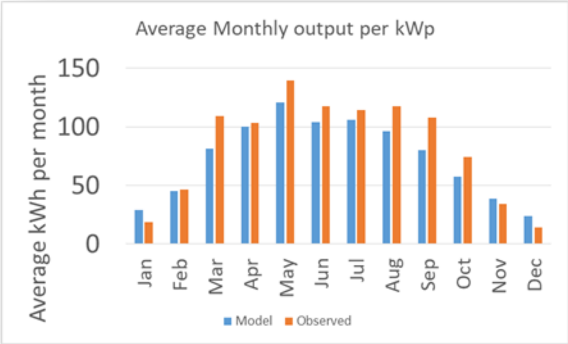
To give us generation data for a full 12-month period, for the periods where there was no data from the Hawick solar generator, the PVGIS[6] modelling system was used to synthesise data to represent average generation output over 12 months in the EH41 postcode area, including the daily maxima and typical monthly generation figures for a rooftop system installed in Edinburgh. As the data for April – July 2017 was modelled, this means that the variation between clear skies and cloudy days is not represented during that period. The comparison between actual and model PV generation data are shown in Appendix 9, for both the monthly and daily figures and do not show major discrepancies. The daily irradiance patterns in each month were used to synthesise an average generation profile. Using modelled data does not dilute the findings very much, as we looked at average match between generation and demand. The data does not though capture coincident weather conditions for demand (in Wales) and generation (in Hawick).

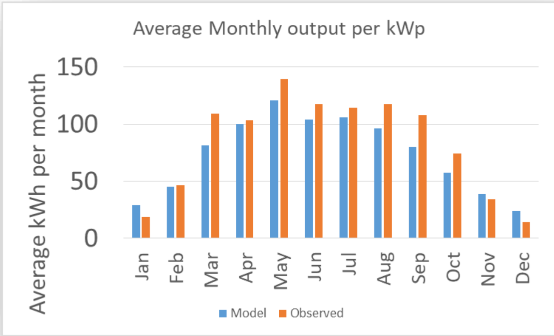
Seasonal variation for solar PV panels in Scotland is more pronounced than for panels located in Wales, owing to the higher latitude.

East Lothian PV generation data-set

Further solar generation data was available (which had been used in modelling in the early phases of Tower Power work) covering the twelve-month period from 1 Feb 2012. The installation was in the East Lothian EH41 postcode district. Generation data was summed into half-hour periods. The overall generation of 998kWh per kWp was about 13% above the predictions from the PVGIS model as demonstrated in Figure 8 below.

Figure 8: Comparisons of EH41 based solar generation data vs PVGIS modelled data





Using both the above data sets, solar generation output was mapped against the corresponding days for the Bethesda demand data and scaled for different installed capacities of solar PV as outlined below in section 6.2.

6.2 Data Analysis and the Tower Power data modelling

Having outlined in section 6.1 the various sources of data we investigated, here we outline the actual data used and the modelling process with the resulting analysis.

6.2.1 Internal models

A simple model was used to determine the potential savings for pooling local generation and demand in the Tower Power energy club arrangement. In this we used local demand data from the Bethesda project which are matched on a half-hour by half-hour basis with generation data (the two sets of actual generation data – the Hawick data and the EH41 data - with PVGIS modelled data).

6.2.1.1 Findings from combination of Bethesda demand data and the solar generation data

Demand data from Bethesda was used for the period 21 March 2017 – 20 March 2018. Solar generation from the Hawick solar PV unit covered the period from the end of July 2017 - 20 March 2018. The PVGIS -modelled average values were used for April – July 2017.

The demand was represented as an average figure per household. In the model, the installed solar capacity was adjusted to explore the impact on the match between generation and demand, the proportion of demand met and the resulting net export of solar power. Solar generation data were scaled relative to a 3.5kWp installation in order to assess the optimum amount of generation per household.

Figures for March 2018 demand are above seasonal norms, owing to air temperatures being below the seasonal norm early in the month.

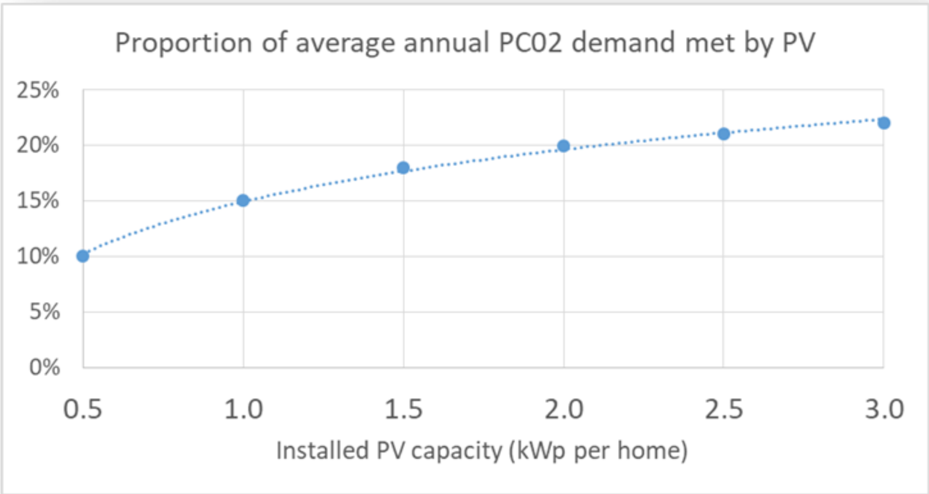
Figure 9 below summarises the annual match between average household demand using the Bethesda data, against solar generation from the Hawick and PVGIS data, for a range of installed solar PV capacities. The total annual demand is 37.9MWh for the seven households

Figure 9 – Percentage of matched energy demand and solar generation from Hawick/PVGIS modelling, at different scales of installed PV – tabular presentation

Installed PV capacity per household (kWp)	% Demand met by local PV	% Generation used	PV coverage of demand	% PV available for export
0.5	10%	93%	11%	7%
1.0	15%	72%	21%	28%
1.5	18%	57%	32%	43%
2.0	20%	47%	42%	53%
2.5	21%	40%	53%	60%
3.0	22%	35%	64%	65%

The data in Figure 9 shows that maximised use of solar power is achieved where there is a low installed capacity. The proportion of demand which is met in this arrangement is small, ~10%, making it much less attractive to the household. Larger generation capacity can be installed, to increase the share for each household. Figure 10 below shows the same data in graphical form.

Figure 10 - Percentage of matched energy demand and solar generation, from Hawick/PVGIS modelling at different scales of installed PV – graphical presentation



For more detailed analysis of the matching of demand and solar generation on a monthly basis, please see Appendix 9.

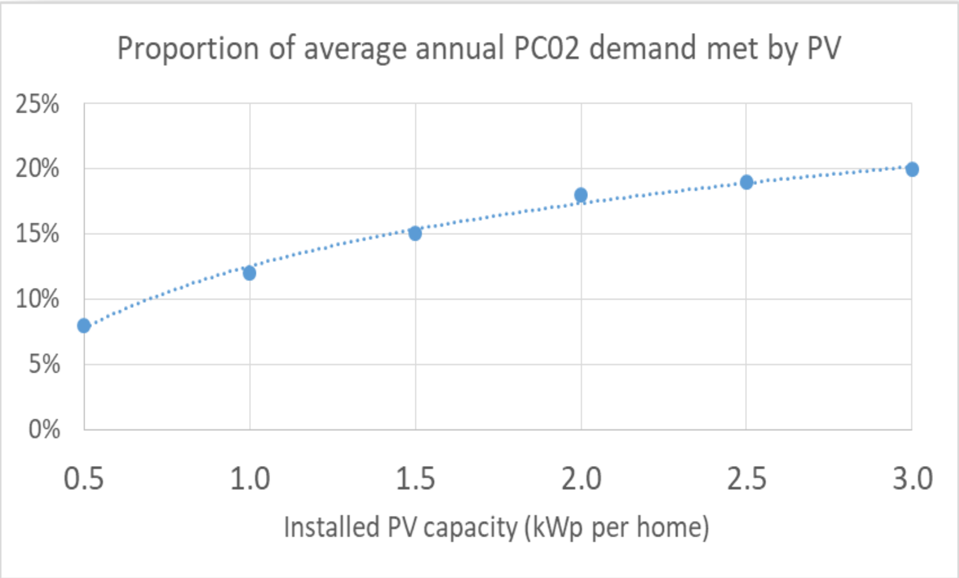
There is scope for additional efforts to match demand from electric space and water heating against the under-utilised generation. This is explored further in Appendix 9 in the demand-response section, using the findings from the SWELL project.

6.2.1.2 Findings from combination of Bethesda demand data and East Lothian generation

Figure 11 – Percentage of matched energy demand and solar generation from EH41 data, at different scales of installed PV – tabular presentation

Installed PV capacity per household (kWp)	% Demand met by local PV	% Generation used	PV coverage of demand	% PV available for export
0.5	8%	93%	8%	7%
1.0	16%	76%	12%	24%
1.5	15%	63%	15%	37%
2.0	18%	53%	33%	47%
2.5	19%	47%	41%	53%
3.0	20%	41%	49%	59%

Figure 12 – Percentage of matched energy demand and solar generation from EH41 data, at different scales of installed PV – graphical presentation



Please see Appendix 9 for details of the above scenarios at a monthly level over the year.

6.2.2 Introduction of demand response capability

When pooling a resource like solar generation, the match between generation and demand can be improved when participants are responsive to time of use tariff and/or forecasted availability of local generation.

Although Tower Power did not include the use of a time of use tariff or forecasting of local generation, learning from the SWELL project on these elements is referred to here (with the detail of SWELL data shown in Appendix 9) to show what could be achieved. The SWELL collaborative project was led by Energy Local. This Innovate UK-supported project covered 48 properties in Oxfordshire, including 14 solar generators and six flats with electric heating and hot water. Generation and consumption data were collected for the community over the period October 2015 to February 2017, including demand from the six electrically-heated flats. These households offer example responses and consumption patterns which represent a range of heating uses. The SWELL project introduced live local control of heating and hot water circuits. The operation of the circuits was linked to availability of local solar power and time of use tariff. This would represent an approximate replacement for the Total Heat Total Control (THTC) heating control which is used by legacy electric heating systems in Scotland. Approaches could include deployment of intelligent heaters; local control of heating and hot water circuits using contactor with in-home radio communication; and contactor associated with the meter. All of these approaches would require work to be undertaken by a Part P qualified electrician.

The numerical findings from the electrically-heated flats in the SWELL project are presented in Appendix 9, to provide an indication of additional benefits which could be realised from matching demand to tariff and forecast local generation in a Tower Power project. With the relevant controls installed, this would also open up the opportunity to participate in supplier-led balancing or to help deliver distribution network operator or system operator (demand-side) services.

Scaling of the generation resource and matched heating demand

Analysis of match between solar generation and controlled demand was made in the SWELL project. The projected annual benefit to householders from solar was analysed as simple a function of their share of solar generating capacity. There was a sweet-spot for local value with a shared capacity of approximately 1kWp per household. Larger installed capacities will give an incrementally larger benefit but at the cost of an increasing proportion of the additional generation not being used locally, particularly during the summer.

With a reduced reliance on the feed-in tariff as the main source of income for a generator, there may be opportunity to optimise the orientation of solar panels to improve the match to times of greater demand. East- and West-facing panels would offer an improved overlap with morning and evening demand. Project time constraints have meant that this optimisation has not been considered in the modelling here.

6.3 What have we learnt from the analysis of Tower Power results?

Figure 12 below shows where there are likely to be financial benefits from implementation of a Tower Power model, for energy suppliers and for customers in relation to the four areas.

(NB please see detail for each item in this table in the narrative sections 6.3.1 – 9 below the table)

Figure 13 Potential financial benefits from implementation of a Tower Power model

Item of saving which contributes to:	Aggregated demand	Renewable energy matching	Manual DSR	Automatic DSR
1. Cheaper customer acquisition / Stickier customers	✓	✓		
2. Reducing set-aside budget for imbalance costs	✓	✓	✓	✓
3. Better forecasting of small scale generation and customer demand	✓	✓		✓
4. Increased ability to hedge, reduced TUoS costs and avoid peak power costs	✓	✓	✓	✓
5. 'Handling fee' where demand and generation match well and there is little or no power sold		✓		
6. Reduced costs for supplier and customer from matching renewable generation with demand		✓		
7. Time of use Tariff encourages shifting to off peak times and reduce TUoS			✓	✓
8. Avoidance of spill on to the spot market at times of negative prices		✓	✓	✓
9. Small change in BSUoS as few kWh use the services but much of the charges are not volumetric.		✓		

6.3.1 Benefits to the customers from aggregation per se /tariff discussions with Our Power

One element the Tower Power model aims to assess is whether aggregating a large number of domestic customers through an energy club, with members all buying electricity from the same supplier, provides enough savings to enable an improved tariff to be offered by the energy supplier.

The savings possible are likely to be shared between a supplier and its customers. How this is split is allocated would though need to be explored by a supplier and is likely to change over time. This section indicates where these savings may be achieved and the outcomes of discussions with Our Power, in relation to these points.

Aggregating customers together into small groups helps to co-ordinate behaviour to achieve benefits within the electricity market. Even so, the benefits will only be accrued once there are sufficient 'clubs' of customers to have significant impact on the demand curve for which a supplier has to buy electricity. Our Power indicated that for many of the benefits listed in the sections below, an absolute minimum aggregate number of customers would need to be at least 2000.

Note the benefits listed below are relevant to customers whether or not they are prepayment meter consumers. However, the Tower Power project has brought the participation of prepayment customers in such benefits a step closer with the metering and communications module proof of concept.

Having a higher rate of 'sticky customers' and lower cost of acquisition of customers is key to Our Power (and other energy suppliers).

On average a customer costs £30-50 to recruit - or about 2 years' profit. If Tower Power clubs recruit customers this would provide a saving for the supplier. The aim is for the majority of TP club members to stay in a club for at least 5 years on average such that these are more profitable and less risky customers for the supplier.

Our Power confirmed that they want customers to stay with them as long as possible as this helps to reduce their hedging risks and spreads the initial acquisition cost over a greater period. The range of costs for recruiting a customer range from a switching site - which costs~ £27 per fuel to gain the customers, and which is at the higher end of the scale - going downward from there, with the best customers gained through word of mouth. There are also administration costs of switching and administration of prepayment with a legacy meter also having initial set-up costs.

If a Tower Power club recruits a customer this would be at the lowest end of the scale, equivalent of word of mouth or possibly lower given switching could be planned and managed in tranches. Furthermore, the customers would be recruited on the basis of Tower Power and its trusted local ethos and not on a promotional low tariff and therefore would be less likely to switch away rapidly.

6.3.2 Reducing the amount set aside for imbalance costs

The cost of imbalance (i.e. fees paid when a supplier has bought too much or insufficient power) is a small proportion of the wholesale costs of electricity (~3%) and at present the market is fairly benign. However, if a supplier is significantly out of balance during a period of high imbalance charges this can have a serious impact on both profitability and cash-flow for the supplier. They must put aside credit for this purpose. Our Power indicated that this was not a problem for them but other suppliers have indicated that this ties up operating cash that could otherwise be used for development.

To give an idea of the difference in scale of the days with a high risk from imbalance, the variation in wholesale electricity prices offers a guide. Whilst normally in the range £10-50/MWh, imbalance charged have reached as high as £1,529/MWh (on 8th November 2016). System buy prices (when a supplier has bought insufficient power) or system sell prices (when a supplier has bought too much power) also fluctuate. Wholesale prices are in the order of £20-60/MWh. In contrast:

- There are over 200 settlement periods when system sell prices (SSP) and system buy prices (SBP) were negative. In these periods, a supplier would lose money from generation spilled to SVA if their demand customers did not use it (e.g. solar on a hot summer day)
- The highest recent SSP/SBP was £717/MWh on the 1st of March 2018.
- There are 44 settlement periods when the SSP/SBP was £500 or more.

For a supplier with 50,000 customers using 1.5kWh during a peak time which is 3% out of balance, they would incur a charge of £1,125 per half hour of this scale of imbalance, when system buy prices are around £500/MWh.

6.3.3 Improved forecasting and prediction of renewable energy supply and customer demand

As projects such as these would track energy generation data from small generators and customer demand for a large number of customers, then over time this would produce significant data sets on generation and on matching this to energy demand and how customers respond in such a model. This would help an energy supplier in improving their prediction models and hence reduce risk and cost.

6.3.4 Increased ability to hedge, reduce TUoS costs and avoid peak power costs

Flattening of the load curve can be done by encouraging moving energy use from times of peak demand to times of low demand. If this can be done at scale this would increase:

- The ability for a supplier to use hedge position
- Reduce transmission use of system (TUoS) charges
- Avoid peak power import costs

The savings from any one of these would not be individually large, at 1-3% of the bill. However, together, they could make an impact. Note that these are means to encourage behaviour that allows the electricity system to run more efficiently, rather than avoiding costs.

To get the most out of matching of load to generation in a Tower Power Club it requires forecasting of small scale generation. Unfortunately, it is not normally cost effective for a supplier to pay for this type of small scale forecast. An aggregation of clubs could though provide a supplier with a cost forecast of small scale generation in an area to enable them to buy power more accurately for the day ahead and avoid spilling into Supplier Volume Allocation (SVA). This may become more important on sunny days when the spot price could be negative.

Half-hourly monitoring of demand in groups, where demographics are known and behaviour influenced, can also give insight for demand forecasting. Our Power quoted an error of 10% in forecasting. To date with solar, Energy Local's forecasts have been more accurate than this. Also, there are now good wind forecasting tools that could be used at a small scale. Energy Local is still working on hydro that varies considerably depending on the nature of the river or catchment.

The cost of forecasting must always be less than the potential imbalance costs, for there to be value to the supplier. Given that the forecast information is needed to display to club participants, this Tower Power club service could be a very low cost way to provide forecasting to the supplier. Likewise, the algorithms that Energy Local has developed to forecast demand will be generated for the club and therefore could offer a more cost-effective way to improve forecasting.

6.3.5 Potential for a no risk 'handling fee' for instances where the demand and generation match well and there is little or no power sold by the supplier.

If demand and generation match closely then it would be reasonable for a supplier to charge a handling fee. This is only possible with aggregation. This has the advantage that has market risks associated with it. As the supply industry is low margin and high risk, this is an attractive income. Our Power highlighted that how this is charged (e.g. part of the standing charge or separately) would have to be thought through carefully to avoid the situation where a customer can refuse to pay without voiding their supply contract. Overall this should be cheaper for the customer.

6.3.6 Benefits of Matching Renewable Generation

The ability to match load to generation facilitates many of the benefits described above. Furthermore, when combine with a local market model such as the Tower Power model there is a direct benefit of a saving. As Our Power did not provide an illustrative tariff we cannot say exactly what this would be in this situation but we estimate the benefit would be of ~1-7p/kWh (depending on the generation and supplier tariff). For example, if the supply tariff is 14p/kWh and the renewable energy match tariff is 7p/kwh, the saving is 7p. At night if the supply tariff is 8p/kWh the saving will be 1p/kWh.

Also, participants can adapt their behaviour to facilitate benefits from load smoothing and matching described above. Measures that are easy to achieve are using delayed start on wet appliances, charging batteries, bulk cooking or using slow cookers and planning chores where possible at night or when there is generation.

The main customer benefits from demand-side response (DSR) come from the variation in wholesale electricity prices and the possibility of avoiding expensive times of day and maximising on the cheaper times.

6.3.7 Time of Use Tariff to shift load profile to off peak times

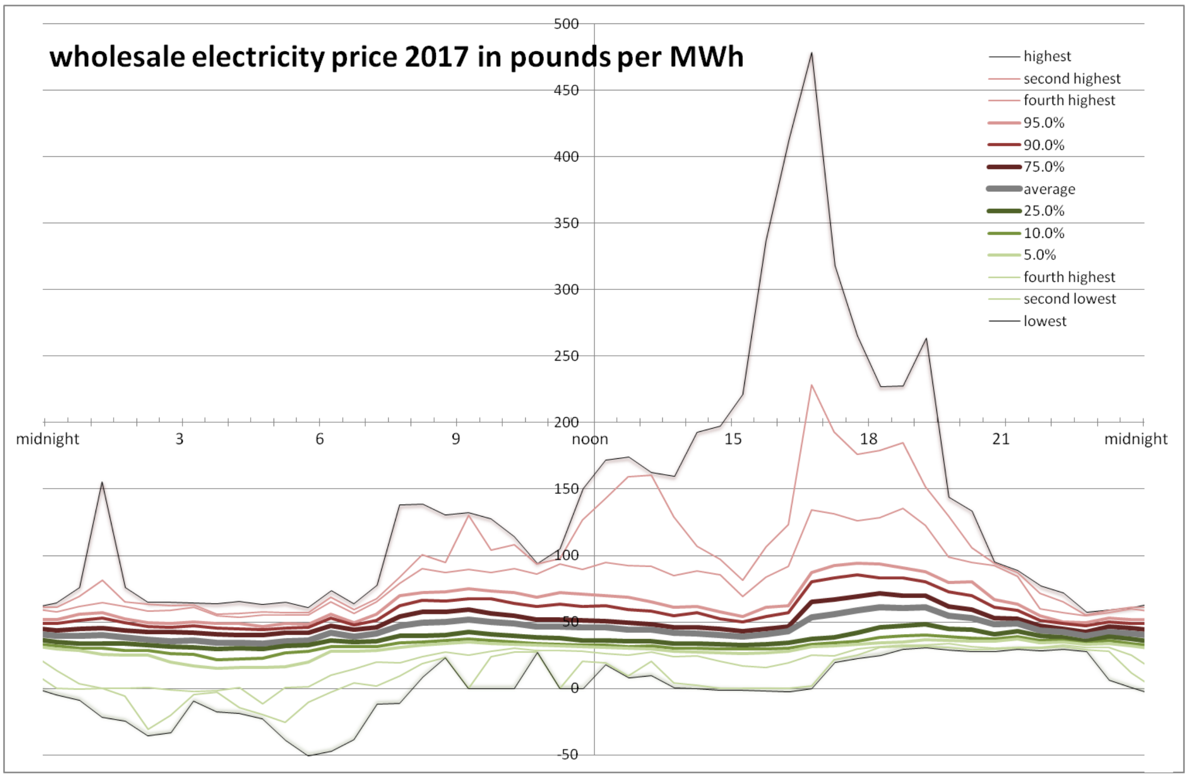
With education and engagement of customers in a Tower Power club, on time of use tariffs, customers could be encouraged to shift their load away from peak times, which reduces TUoS charges for the supplier.

6.3.8 Avoidance of spill onto the spot market

Most energy suppliers will buy the bulk of their power needs by hedging and will achieve a flat price across the day as a result. Even where their predictions for energy needs are good however, they will need to buy a small percentage of power on the spot price market where prices vary across the day. Where their predictions are poor, they will need to buy a higher percentage on this very variable market.

Figure 14 below shows the variation of prices across the day in the wholesale energy market. These are the prices that a supplier is exposed to if they have not bought enough power in advance (hedged). Normally only a small percent of power is bought on this open wholesale energy market. The cost of one megawatt-hour of electricity varies from less than -£50 to almost £500 on this market. Although these extreme prices are very rare and the majority of prices fall within a very narrow band of about £30–70, suppliers want to reduce the risk of being exposed to them even if they only have to buy a small per cent of their power on this market. This illustrates why avoiding consumption during the evening peak (16:00–21:00) makes sense and scheduling consumption in the hours before dawn reduces cost and risk.

Figure 14 Half Hourly electricity price variation across the day in the wholesale energy market



6.3.9 Benefits of DSR

DSR can either be in the form of customer controlled or automatically controlled DSR. In the case of customer controlled DSR (manual DSR) this allows a customer to more easily achieve the benefits of local balancing and arrangements such as within a Tower Power club. This means they are more likely to maximise the benefits possible locally. From a supplier's point of view, customer controlled DSR may not give them a guaranteed response when they need it, though over time consumer controlled DSR is likely to be fairly consistent and predictable by the supplier.

Automated DSR (not controlled by the customer) has the advantage of a more likely and known response and enables supplier participation in providing ancillary services and fast reaction load shedding. These services also require reliable communications to the homes but do provide another income stream.

6.3.10 Summary - Energy Supplier's readiness

Discussions with Our Power on all the above points helped Our Power, CES and EL understand potential benefits from the Tower Power model for the supplier, particularly in relation to their needs in dealing with the electricity market. Our Power gained a view of the potential for them in facilitating local electricity markets. Electricity supply companies have very tight margins which leaves very little room for manoeuvre to develop innovative business models whilst building their market share. Market share helps reduce overhead costs and therefore more mature suppliers could engage more easily.

Our Power indicated, following our discussions on the above, that though they are not ready at this stage to develop a new tariff on this model, they are interested to continue to share information and could possibly develop a tariff next year. They have a particular interest in relation to opportunities for customer acquisition and data management costs.

6.4 A Basis for a business case

6.4.1 Background on business case related work within Tower Power project

The business case for a Tower Power model comprises a number of elements that are made possible via customer aggregation, matching demand to shared renewable energy generation and load shifting to cheaper times of day or through demand side response/flexibility.

Please see Appendix 10 for details of the originally proposed business model framework for Tower Power at the start of the project. This shows the variables that would need to be investigated (e.g. minimum number of households that would need to be involved to make the business case add up; minimum tariff that would need to be secured from club members, etc.) and areas of costs and revenues envisaged in the original Tower Power energy club. The following assumptions have been made for this framework: that the CoSerCo has a tax exempt legal status (e.g. is a registered charity); that the CoSerCo and all other players are VAT registered.

As explained in this report, the project had to be significantly scaled back and the full concept was not demonstrated or investigated due to the various regulatory and technical barriers encountered. Instead we used the alternative business model of an Energy Local club in the final agreed scope of the project for December 2017 – March 2018. The demonstration energy club that was set up during February and March 2018, based on this EL model, generated one month's data from four members.

Running the club during February and March 2018 successfully proved the technical concept developed: the communications software with prepayment functionality, the remote access to the data and the updating of credit, and the remote DSR control communications. Due to the brief data collection period and the limited number of participants in the test, it did not generate sufficient data for analysing the financial possibilities of this type of energy club. This detailed financial analysis needs to be carried out in a future demonstration project, with the appropriate type of housing and heating equipment as well as local renewable generation, over a period of at least a year and with a much larger number of club members.

However, Appendix 11 models an example of Tower Power running with the alternative Energy Local club model. This model has values entered into many of the elements of the business case as an example of what a Tower Power energy club might cost and might save for participants in practice. However, due to the limited nature of the demonstration in 2018, the majority of the values applied are estimates – some based on experience from running the equipment test and working with service agencies (such as Energy Assets, ePOWER and OEM) during the proof of concept test, but many based on past experience of running Energy Local projects elsewhere and also generally accepted values (e.g. average energy use per year).

For the tariff we have used a mean value between what Tempus Energy (the Energy Supplier who was involved at the start of Tower Power) originally offered to the Tower Power club and the prevailing tariff at Our Power which the trial participants paid, which is £0.14/kWh.

Also as DSR was not part of the live trial (and we have therefore not generated data) and there is no established data on electrically heated flats, or domestic DSR market with DSR values identified, we have not included DSR values in the model in either Appendices 10 or 11. In future, demonstrating the DSR elements would be likely to improve the business model of a Tower Power club.

Usefully however, the project has identified the key elements of costs and savings which a full live trial would need to track, with learning from the project built into this, and has set up a more relevant business model which could be used for accurately measuring and assessing the savings which would result from a Tower Power club model.

6.4.2 Explanation of the monetary benefit to each customer in the Energy Local club model for Tower Power – please also refer to Appendix 11

The benefit to each customer is primarily from the matching of energy usage to shared renewable energy generation. Using data from the Bethesda project, 7 electrically heated homes were modelled over a year. In the modelling no shifting of time of energy use was assumed. The following assumptions were made which explain the figures in Appendix 11:

INPUTS							
Flat tariff and standard time of use tarif		7	Customers				
No DNUoS, GNUoS, TRIAD, etc. charges							
Av. Current tariff	£0.14	/kWh				£80	Standing charge
						£0.2381	daily
Existing PPA	£0.0500	/kWh				£86.91	
				ToUT?	Yes		
ELC Import tariff	Start: hour	End:hour	Cost / kWh		Cost / kWh	£80	Standing charge
	0	6	£0.0838		£0.0838		
	6	11	£0.1468		£0.1468		
	11	16	£0.1468		£0.1468		
	16	20	£0.1568		£0.1568		
	20	24	£0.1468		£0.1468		
Match tariff	£0.07	/ kWh					

The standing charge has increased slightly but the PPA price is the same for the power not used locally. It is assumed that each household pays £7/year to cover the running costs of setting up and running the club. This gives the following benefits to the households and the generation. By varying the match prices, the benefits can be spread differently.

Note however that these are benefits for just 7 households. With more households the benefits may be spread to more homes but the demand will be smoother and more of the renewable energy generation may be matched.

OUTPUTS				
Annual total consumer bill	*Before*	*With ELC*	*Saving*	
Standing charge	£560	£560		
Import	£5,306	£4,091		
Match	0	411		
ELC levy	0	49		
Total	£5,866	£5,111	£755	13%
Generator income	Before	With ELC	Addition	% increase
Export PPA	£468	£175		
Match	0	£411		
Total	£468	£586	£118	25%
ELC levy income			£49	
Total retained benefit			£922	

Ongoing business model.

To demonstrate a business case long term, to cover the costs of setting up and maintaining such clubs, we have assumed the following figures.

Scaling from the few households' data that we have to a larger club, we have estimated the impact for a club with 100 households and 2.3kWp per household. We have then compared scenarios for a Tower Power block of 500 households to a scenario where you might get 30 clubs established (total of 3000 members). These show enough value to justify a £7 admin fee, though differing timescales for breaking even.

The initial set up costs for 30 clubs are estimated to be primarily made up of the costs of the equivalent of 0.6 of an FTE employee, and 0.2 of an FTE for 500 customers. Other set-up costs are also identified below:

No. of customers		**3000**		**500**
Legal costs	£	1,000	£	1,000
Employed Facilitator	£	26,000	£	4,333
Website & comms	£	1,500	£	1,500
Other set-up	£	1,500	£	250
total	**£**	**30,000**	**£**	**7,083**

We have also assumed one employee, working 1 day a week, will maintain the 30 clubs (3000 households) on an ongoing basis alongside volunteers: i.e. 30% of £26,000 with 20% overheads (and a proportionate amount for a Tower Power club of 500 households).
We have assumed a further amount of running costs of £500 annual costs and £50 monthly costs in addition on an ongoing basis.

We have also assumed there is a fee for access to the Energy Local Toolkit and knowledge sharing and support of £1 per household per year.

CIC income

Levy per customer per year	£7.00	

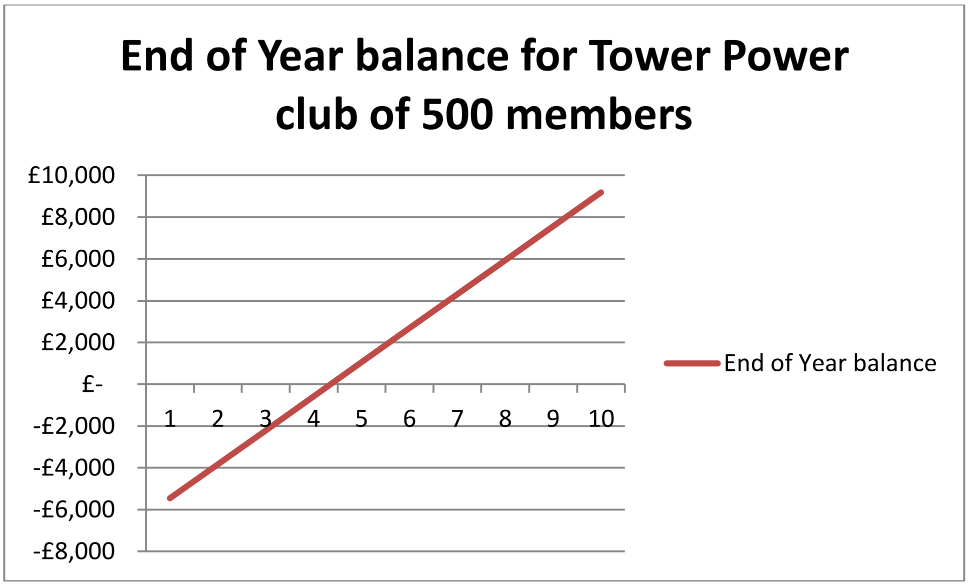
CIC running costs

Business manager salary		
FTE during build-up	0.05	
FTE ongoing	0.05	
Annual base	£26,000	
On costs	20%	
Annual CESCO admin costs	£5,000	
Monthly CESCO admin costs	£500	
Energy Local CIC membership	£1	/customer/year

Note this assumes no grants to cover the upfront costs of developing the local markets.

Using these assumptions, Appendix 11 shows that a club of 500 Tower Power members would each secure a benefit of about £100 per year (about a 13%) benefit over a standard customer, about £50 from matching with renewable energy and probably a further £50 from changing time of use. Also, as shown in figure 15 below, that a club of 500 members would breakeven from year 4 of the club (breakeven would be in year 2 for a larger group of 3000 members).

Figure 15 Breakeven point for a Tower Power club



7. Key learning points from Tower Power and how this learning might be used more widely

The project has needed to address various challenges throughout its implementation. Some of these were known or expected and others less so.

7.1 Technical

Meter related issues

The smart meter roll-out theoretically provides the data routes for a Tower Power approach to be implemented. Unfortunately, there are various technical issues with the SMETS (Smart Meter Equipment Technical Specification), both the original SMETS1 and the second version (SMETS2), neither of which have sufficient specification to enable a Tower Power model. Also, there are continuing problems with the DCC communication system that is fundamental to the SMETS2 infrastructure. Consumer Access Devices (CADs) could potentially provide the necessary access to data and the communication routes for securely crediting meters but these devices are only reaching pilot stage as we finish this project and those developed to date are not designed to be hardwired and therefore cannot be relied upon as a consumer could unplug them.

The solution that we developed used 'advanced meters' that are more capable than SMETS equipment and not constrained by the limitations of the UK Smart Meter system. Once CADs are available and the DCC is providing the data backbone adequately, it should be possible to transition the solution developed within Tower Power onto SMETS meters with linked CADs.

Energy Dashboards
The Energy Dashboard that has been developed for this project is a flexible means of providing the information households would find helpful in managing their electricity use. It is a means to show aggregated data and generation forecasts and enable the control of DSR. It is much more flexible, and can be tailored to the needs of individual communities, than a standard in-house display as provided by SMETS meters.

Energy Suppliers serving Total Heat Total Control customers
Many customers in Scotland who have electric storage heating have Total Heat Total Control (THTC) meters. Until recently the only energy suppliers who could support these customers were Scottish Power and Scottish and Southern Energy which meant that Tower Power would either need to work with one of these two energy suppliers or not include THTC customers within the project. Usefully, in 2017 Our Power became the third supplier to support these customers, however an issue still remains in terms of lack of competition for these customers and the local energy projects hoping to work with them.

Lack of Half-Hourly energy use data for electrically heated properties with prepayment meters
There appears to be no half hourly demand data available for electrically heated properties with prepayment meters in Scotland and this data is in very limited supply in England and Wales, with the main data sets coming from the tracking of small numbers of properties within innovation projects.

Energy Suppliers willing or able to innovate

Developing new Local energy systems can often rely on working together closely with an innovative energy supply company who can see the potential in your idea. It is our experience that not many of the more innovative energy supply companies currently have the resource, capacity and/or motivation necessary to develop such systems during a period of regulatory uncertainty.

7.2 Regulatory

MPAN numbers
Under an aggregated system, the Individual MPAN number could be marked as de-energised, however DNOs are concerned that this would affect how they prioritise reconnection after a fault as these connections would not be marked as live. This was a major issue for the project and took several months to find a solution that ensures all connection are marked as energised.

SMETS accreditation for advanced meters
The meters which were selected for trial in this project do not have SMETS accreditation and therefore If advanced meters are to be used in future then the regulatory position of using these rather than SMETS 2 meters needs to be clarified with BEIS and Ofgem. This is an ongoing discussion.

Permission for accessing half hourly data

Households taking part in an energy club like this must give explicit permission to a supplier to collect half hourly consumption data from participants' meters (general use of 'data' consent is not specific enough to comply with regulation).

7.3 Social

Working with innovation in communities
Innovative project such as this can put a great deal of pressure and uncertainty on community groups and finding groups with the appetite for risk that is necessary for such projects is a challenge. It is also a real challenge for the communities themselves to risk innovating when their incomes or livelihoods are fragile. The lack of certainty around the tariff that could be offered through the scheme or how it would work in practice is an example of this. In Tower Power this problem in lack of clarity about the final tariff (as a result of the withdrawal of Tempus and several changes in energy supply partner) decreased the effectiveness of the community engagement work.

The community engagement work involved in the project included a great deal of door-knocking in a diverse community. Therefore, staff had to be trained in how to deal with difficult or aggressive behaviour, how mental illness impacts on engagement, as well as that of addictions, child protection, vulnerable adult concerns and other issues that the team were likely to encounter.

The project benefitted from being connected to wider range of work being carried out by our community partner, Comas, as people were more receptive and trusting when the known entity was mentioned and cross-referral could take place between projects.

Commercial salesmen and switching brokers working in the community were hostile to the project and caused confusion, as they might have seen the Tower Power model as future competition for them.

Community engagement can be side-swiped by approaching communications in the wrong order (public announcement before showing local presence), leading to “soft politics” sabotaging community good will. It is advisable to plan announcements to take place after first step engagement, to avoid this.

Responses to letters and flyers in most communities is less than 5% so for schemes seeking a large response rate door knocking it the only option. It is not an easy job and requires excellent judgement and communications skills and a high level of motivation and training.

Contact rates for the project was 28% (doors opening as a percentage of doors knocked). Once contact was made, 38% responded positively to the idea of Tower Power (the average for commercial door-to-door sales is 20%). This showed that there was real interest in the community.

It is very difficult to determine annual energy usage as majority of customers do not keep bills or pay attention to annual statements. Future projects would need to identify ways of determining this early in the project and by helping communities to track this as it went along.

7.4 Economic

Warm Homes discounts (£140-£150 year) are available to vulnerable customers of large energy suppliers, creating a barrier to small suppliers who want to create cost savings for such customers.

The cost of the additional home hubs (that allow demand side management) that are required to maximise the benefits from this model, through automated matching and demand response, needs to be borne by the project or enterprise that is established as a result.

At present the DUoS charging regime does not allow for the saving from reduced use of system charging to be passed onto the customer when local demand is matched with local use. There is an ongoing discussion at a national level around charging structures.

7.5 Project Management

Being able to swiftly respond to new challenges and discoveries throughout the course of the project has been essential. Whilst monthly reporting has provided a useful check-in with project funders, several project breakpoints and in particular break-point associated periods of gaps in funding within the project has slowed work momentum and affected clarity of partnership working with external partners and efficient project delivery.

Finding the right partners to work with has been a challenge. Key concerns from community partners has been the level of uncertainty and risk involved in taking forward an innovation project. In terms of licenced suppliers not all will see the benefit of investing their own time and resources into a project that may or may not succeed, and many are unable to provide the transparency required in terms of their pricing strategies or business model to allow the economic analysis necessary to enable the business case development of new model of supply.

8. Recommendations and Next Steps

As outlined in previous sections in the report, the work done through Tower Power has done much of the ground work needed for setting up one or more Tower Power type energy club(s) which include prepayment customers. This includes producing community facing information on the model including online information that could be tailored for each club; community engagement recommendations; CoSerCo constitution; useable online member dashboard with new multi-club capabilities (so each new club would not need to develop its own new dashboard facility); and the business model framework needed for each club to test feasibility and help in deciding on levels of tariffs, size of club etc. to make it viable. Future clubs would therefore have a very useful base on which to build. The draft business case has also shown likely improved value for Tower Power participants within an Energy Local type model as in Appendix 11.

Also, a major step forward from this project has been the successful development, testing and demonstrating of the communications module capability and feasibility for the EDMI advanced meter, enabling inclusion of prepayment customers in an energy club that aggregates its demand and shares the output from a renewable energy source. Much of the software development for the communications module used in the demonstration can be taken and used in building any future CAD that would be needed for a SMETS accredited meter which might have equivalent 'smart' capability as an EDMI advanced meter has.

However, there remains a key technical issue in relation to having a fully functioning and SMETS-accredited prepayment smart meter with the data management requirements for the Tower Power model. The EDMI advanced meter, with the communications module developed to date through Tower Power, has been shown to have the technical capability of delivering a Tower Power club's requirements. However, the EDMI advanced meter has not been accredited for the SMETS rollout and the communications module has not been fully developed and accredited by DCC as a CAD to enable settlement. The current SMETS 2 meter specifications does not have the required 'smart' capabilities needed for the Tower Power type model including prepayment customers. These are factors outside of our control and which may take considerable time to be resolved by the relevant parties.

Also, we have not identified an Energy Supplier during the work of Tower Power willing to offer a relevant tariff at present, though Our Power has shown considerable interest in continuing discussions. They are particularly interested in seeing evidence of how a Tower Power model could deliver both in relation to enabling cheaper customer acquisition and providing sufficient cost savings to them (e.g. improved renewable energy generation predictions/energy use predictions). Tower Power partner organisations aim to continue to liaise with them on this. Cooperative Energy has provided a tariff to the Bethesda energy club, however this does not include prepayment customers, but they may also be a supplier to keep in touch with in relation to the Tower Power model.

The next steps needed therefore to enable delivery of a commercially viable Tower Power model are:

- Either a SMETS meter with suitable functionality and communications or for BEIS/Ofgem to allow advanced meters to be used long term.
- BEIS and Ofgem developing new regulations for the new 'smart energy system' that is evolving, allowing a group of customers to collectively buy energy as a 'single customer unit'

We would then need also to run a real demonstration club, with negotiated tariffs and renewable energy prices, to fully test the commercial viability of the Tower Power model.

Recommendations:

We would recommend that:

- further investment is made in continuing to develop the very useful prepayment functionality in the communications module developed in Tower Power, to enable the full functionality for prepayment meters (i.e. to add elements such as debt management), building on the very useful software development to date in Tower Power.
- community outreach work continues, to raise awareness of the potential from the Tower Power model, with community organisations and groups of energy customers including those in areas with high fuel poverty and with prepayment customers
- learning from this project is shared with social housing providers, to raise awareness of its potential for reducing fuel poverty among their tenants
- BEIS and Ofgem consider the value of enabling groups of high density urban housing blocks or units with multiple ownership (and including those using prepayment meters) to share renewable energy generation and collectively purchase energy, as demonstrated through Tower Power, and develop systems and regulation as part of the emerging smart energy system that enable this model
- Continue to work with BEIS and Ofgem and other relevant parties to ensure that meters with suitable functionality and communications are permitted within the regulations
- Gather a bank of half hourly demand data for people with electric storage heating and on pre-payment meters, to fill the gap we identified in this type of data

Actions planned by project partners:

Community Energy Scotland is developing a programme of community capacity building with communities in Scotland, including those in urban high density housing areas. We aim to start with a pilot initiative including a small number of existing community trusts engaged in energy initiatives. Learning from Tower Power, alongside that from other related smart innovation projects such as ACCESS and Islay as well as projects such as Heat Smart Orkney, will be shared with these communities and scoping will be done to see what application this learning might have for their communities and plans. The Tower Power model could be replicated and potential established with those not on prepayment meters first, until the prepayment smart meter and CAD has been fully developed.

Community Energy Scotland plan to share this learning with City Councils in Scotland also, including Edinburgh and Glasgow, and through the Sustainable Scotland Network (SSN) which is the public sector officers' network in Scotland on sustainable development and climate change with officers involved from most of Scotland's 32 local council areas. In addition, we will share this information with social housing provider networks and groupings, such as the Wheatley Group and others, in Scotland.

Energy Local has submitted an Innovate UK application to develop the functionality of the communications module further, in a setting with a social housing provider. Whilst, if awarded, this project will not be based in Scotland, Tower Power partners will use the learning from this project to transfer the knowledge back to projects in Scotland.

Energy Local is also working with partners in London, exploring innovate means for participants to pay a credit union for their electricity up front rather than use a prepayment meter. There is scope for sister projects in Scotland to also use this model.

9. Financial Report

The budget for Tower Power has varied according to the 4 separate scope (and budget) changes throughout the course of the project. The agreed budget at the start and at the end of the project is detailed within the table below. Match funding for the project was expected to come from a combination of in-kind contributions and match funding from project partners together with a loan from the Energy Savings Trust. In practice match funding came from project partners alone with the majority coming from The City of Edinburgh Council for which Tower Power partners would like to express their thanks.

	Initial Approval June 2016	Final Approval Jan 2018
Total Project Costs	£1,348,548	£519,190
Total LECF Funding	£821,262	£347,329
Match Funding Requirement	£527,278	£171,861

As you can see the project costs have reduced considerably over the course of the project which has mainly been a result of following two factors;

- Withdrawal of solar installation element of the project
- Scaled back project scope to focus on metering issues when it was decided that roll out of project across Dumbiedykes would not be possible

The final grant awarded, match funding and spend breakdown of project costs of grant are shown below in Figures 16 and 17.

Figure 16 Tower Power project grant and match funding percentages

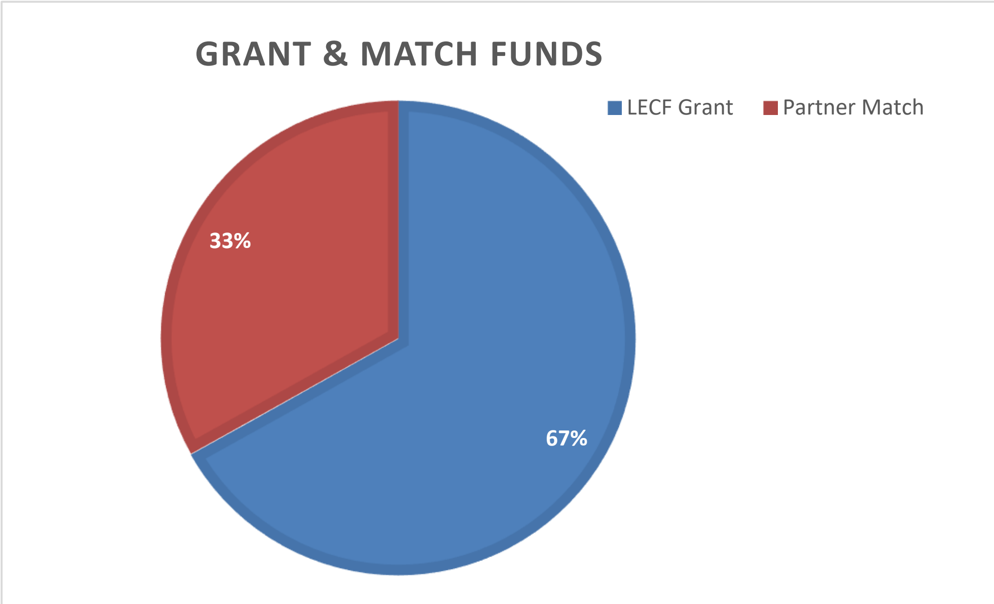


Figure 17 Details of how funds were spent