BRAMPTON 2 ZERO

Supporting document for the feasibility study for a Community Energy Scheme

TOWARDS A CARBON-FREE BRAMPTON

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1. A background to Brampton 2 Zero

Brampton 2 Zero (B2Z) is a Community Interest Company which was set up to practically implement sustainable solutions for local energy production/home retrofit, biodiversity, and education. B2Z was started in 2022 with the aim of helping Brampton achieve net carbon zero as a town.

This report will focus on the community energy scheme and will complement a feasibility report created by an environmental consultancy, Scene.

Community energy schemes have grown in popularity in recent years because they give more control to a community over their own energy; they save money for a community since renewable energy is often utilised; they improve the resilience of a community to climate change related events that are likely to occur such as rolling blackouts; they facilitate a move towards renewable energy such as solar PVs and wind power.

1. The Community Centre

Brampton Community Centre is a multi-purpose centre available for residents and groups to hire out. They host dancing lessons, community events, and have a café within the centre. It supports the wellbeing and resilience of locals while strengthening community engagement and socialising opportunities. There is also office space for hire and spaces for arts, crafts, and woodworking.

2. Aims of the Community Energy Scheme

The aim of the community energy scheme is for the Community Centre to be one of the key sites for Solar PV panels installation. Solar panels can be installed onto the roof of 'The Hut', seen in Figure 1. Figure 2 shows a view of the Community Centre from above. The planned location of the new EV charging points and parking spaces are shown circled in orange. The plan is to install two parking spaces, ready to house the EVs as part of a car club for Brampton. The plan is to also install solar PV panels onto the roof of the Community Centre itself, shown circled in green in Figure 2. Since the roof is not suitable for solar panels, discussions with an architecture firm are taking place regarding a separate structure which can be added to the roof to position solar panels. If solar panels still cannot be added, solar car ports are an option for the site to add extra available charge for the EVs.

Figure 1 The 'Hut' at Brampton Community Centre

3. The car club

3.1. Aims of the car club

The main aim of the car club scheme is to provide residents in Brampton with a reliable mode of transport without having to purchase a household car. This will reduce household costs since insurance, road tax, and purchasing a vehicle can be avoided. Furthermore, the car club vehicles will be electric with solar powered charging points, contributing to net carbon zero transportation.

3.2. Working example of the car club – Exeter's Co Cars

A working example of a car club like the one planned in Brampton is in Exeter with the company 'Co Cars' [1], there are 50 electric and low emission vehicles available for hire 24/7 where you pay by the hour plus mileage. A yearly individual or

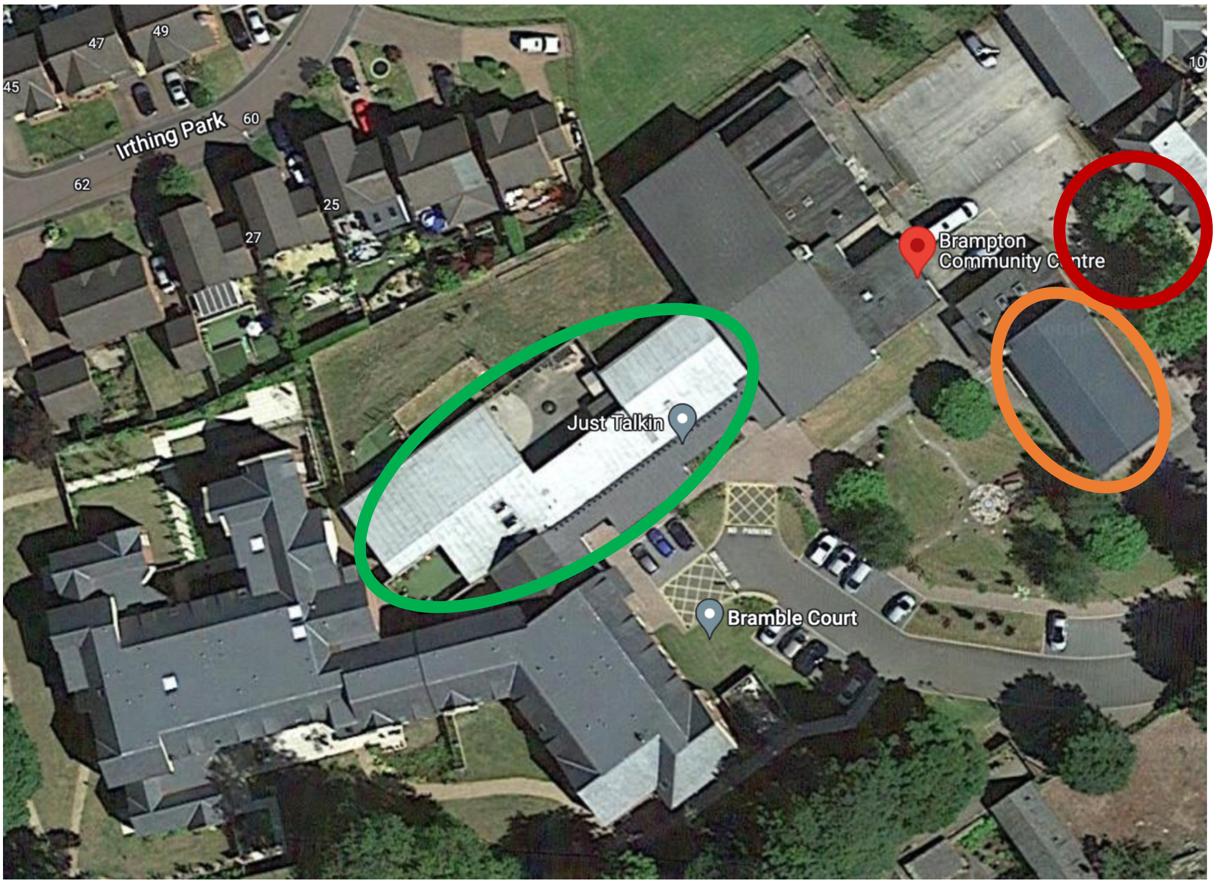

Figure 2 Bird's eye view of Brampton Community Centre. 'The Hut' is circled in orange, the location for the EV charging points is circled in red.

household membership can be purchased, a ‘small’ electric car hire costs £5.75 per hour and mileage is charged at 4p per mile. This company proves a car club can be sustainable in itself while reducing the need for many residents to own a car.

4. Powering the Community Centre

The community centre itself will also be powered by the solar PVs. The total energy usage of non-domestic properties including the Community Centre in Brampton can be seen in Figure 3. The aim is to "power down before powering up", reducing power consumption of the community centre as much as possible through schemes such as replacing the lights in the centre with LEDs. Then the remaining power plus that required by two EV charging points will be covered by the solar PVs with battery. The data seen in Figure 3 includes both buildings of the Community Centre.

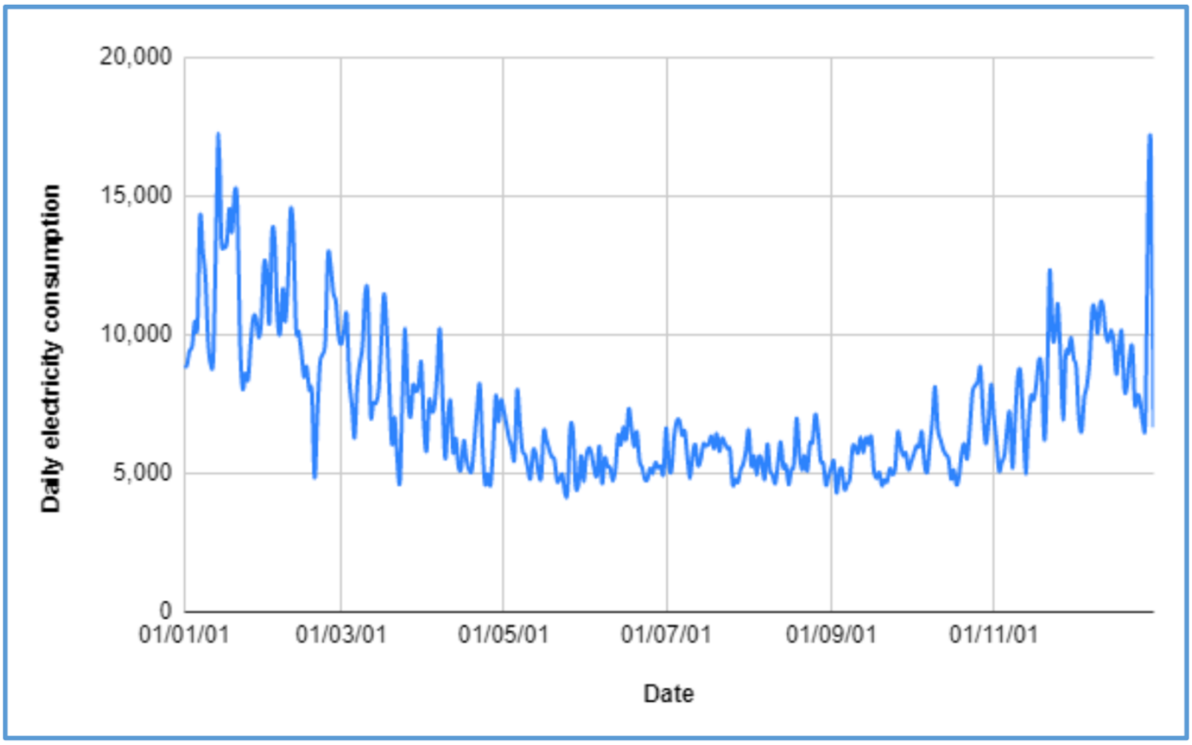

Figure 3 Annual electricity demand profile for the non-domestic properties in Brampton - taken from Scene's interim baseline report.

2. Community Energy Scheme

A community energy scheme in Brampton would give increased autonomy to residents and would enable residents to become energy "prosumers". A "prosumer" is an energy consumer who moves past being a passive consumer to being an active producer of energy [2]. Distribution systems in developed countries are reaching the end of their life cycles [2], and so this could be the perfect time to move towards community energy schemes. Since community energy is gaining popularity across the globe, careful consideration needs to be given to the physical energy network as well as the type of renewables that are used since there is no current standard setup. If a Community Battery Energy Storage System (CBESS) is required, the battery type and system should be carefully considered.

2.1. Background to Community Battery Energy Storage Systems

2.1.1. Why is a battery required?

There tends to be weak chronological coincidence between EV charging times (which would typically be during the night time at home), and the times when PVs generate power (during the day time) [3]. An energy storage system is therefore required to utilise solar power to its maximum extent. CBESSs can be one large, centralised battery within a community, or batteries can be purchased by individual households to store EV power.

2.1.2. Associated costs

The main costs associated with a CBESS are

- The initial set-up costs:
  - The cost of the battery

    - The cost of the power conversion system
- Operating and maintaining the CBESS
- Replacement costs [3]

2.1.3. Peak Shaving

One of the stresses on batteries is charging to maximum load and then discharging to minimum load over multiple cycles or in short amounts of time. Peak load shaving is a power exchange between generation units and storage devices which allows power to be stored when generated during off-peak periods and then discharged during peak load periods [4]. CBESSs can help to reduce peak loading and can regulate frequency with community micro-grids [5]. Peak shaving can therefore allow system upgrades to be deferred for years and also reduces energy losses [4]. CBESSs can also mitigate the wear from voltage rise caused by PVs [3].

2.1.4. Battery type

There are many different commercially available battery types to choose from for a CBESS. Since new batteries are constantly being researched and improved, it is important to select the most suitable battery for an individual community energy system. Some of the options are listed below however there are several other choices available.

Lithium-ion batteries

Lithium-ion batteries usually have high energy density, a long cycle life, and "environmental benignity" [6]. These are one of the most commonly used batteries for CBESSs [7] and so are likely to have the most available support systems and guidance available for community energy schemes.

Lithium iron phosphate batteries

Lithium iron phosphate batteries are also fairly common as CBESSs [7]. They are highly safe and long-life, making them ideal for energy storage systems. They can meet system load demand whilst also being low-carbon, relatively economical, and reliable [8]. There is widely available academic research around these types of battery.

Sodium-nickel-chloride batteries

Several technologies can be considered mature for batteries that are dedicated to grid applications. Sodium-nickel-chloride batteries (also known as zebra batteries) and sodium-sulphur batteries are typically used for peak shaving and load shifting however both operate at higher temperatures [2].

Vanadium batteries

Vanadium batteries are relatively eco-friendly, highly efficient, have fast response times, and a long life cycle [9]. A vanadium battery is used as part of the Oxford LEO project's community energy scheme discussed in **Section 2.4**.

Second-life EV car batteries

Second-life batteries from EVs which do not satisfy the requirements for EVs still have use as CBESSs. Retired batteries usually preserve 70-80% of their original capacities, this makes them ideal in less demanding applications such as energy backup support [5]. By 2030, it is estimated that there will be 112-275 GWh second-life batteries becoming available per year globally [5].

An issue with reusing old EV batteries is the degradation that they might experience. Batteries reach a 'knee-point' within their lifetime where degradation occurs at an increased rate, for a retired battery, the remaining life will be shorter than that of a new battery, however this could be outweighed by the cost savings on the price of the battery itself [5]. These batteries are also more environmentally friendly as they are recycled.

One company which offers batteries for individual households, Powervault [10], sells a Lithium-polymer battery with a 10 year warranty and a recycled Lithium-manganese-oxide battery from electric vehicles with a 3 year warranty. The recycled battery has lower available capacities but still has a maximum capacity of 7.9 kWh.

It is necessary to consider if a recycled battery will be suitable for a project given its reduced capacity potential.

2.1.5. Battery Capacity

The capacity of a battery system for both a community energy scheme and an individual household should be considered. For a typical household, a 3.5 kW array plus an 8 kWh battery per household could be considered. This could cost around £15,000+ [7]. For the energy usage calculated by Scene for Brampton, it is thought that a 2MW battery system could be required. A similar sized system was used in Willenhall which cost £4 million [11]. Costs for these systems are likely to reduce with increased R&D and usage.

2.2. Other techniques to improve community energy schemes

2.2.1. Altering peak demand

Another way that peak shaving can be attained is by incentivising consumers to use energy at times of lower demand and providing additional charges at times of typically increased demand. For example, with the current energy crisis, the National

Grid Electricity System Operator has announced plans to incentivise customers to not use high power appliances at peak times during winter 2022 [12].

Altering peak demand is also known as ‘Load shifting’, customers can either be offered payments to reduce their electricity consumption in times of system stress, or they can be offered discounted retail rates. Load shifting can also be achieved through ‘smart’ appliances which automatically control electricity consumption [13].

A similar system could be used in Brampton to minimise the amount of power that is required from the main grid at peak times, which would ensure as much of the power from solar PVs is utilised at the time of production as possible.

2.2.2. Virtual monitoring of community energy systems (“Smart grids”)

One of the problems with community microgrids is the fluctuations in the local profile caused by intermittent renewable energy sources such as PVs [14]. Because they are weather dependent, they are subject to large variations [2]. Artificial intelligence led systems are increasingly being used to monitor and inform community energy systems in real time. In some areas, EV batteries in buses and cars can be used as energy storage during times of high solar output, these can feed into a “smart grid” and are known as “vehicle to grid (V2G)” systems. EV batteries as storage must be managed by an innovative grid model which increases capital costs and transmission capacity but significantly improves lifetime and performance of a community energy system [14].

This virtual management can contribute to peak shaving of large fluctuations from the output. Sudden load peaks of storage systems occur during real-time operation of CBESSs and are difficult to model and predict. Therefore the costs of ageing upon a system are usually underestimated in community energy [14].

A community energy system is likely to be connected to the grid as opposed to operating completely independently, a programme to manage the flow of energy can calculate the associated costs/profits depending on if power is drawn from or given to the grid and then allocate these to the houses within the community energy scheme [5]. The price difference between the purchase of power for a low price and the subsequent selling of power at times of high demand is termed 'arbitrage benefit' [4].

ICT solutions, such as the cloud-based software implemented in Oxford discussed in **Section 2.4**, could be less costly than extending or reinforcing the physical infrastructure of a micro-grid [2]. Instead of a typical 'radial' energy scheme, community energy can use active distribution networks to effectively manage energy flows and improve battery and distribution network lifetimes [2].

2.2.3. Smart hot water cylinders

Currently, hot water systems in domestic households contribute to significant energy waste since they hold their heat until required and old boiler systems heat an entire tank of water instead of just the water that is required by the household. Recent research has found that, as with shifting peak usage, hot water tanks can be heated during non-peak energy use periods and heated only to the level that will be required by a household at peak times. This can reduce the need for a battery with Solar PV as hot water tanks can effectively store the energy given suitable insulation. This can also reduce the need for expensive investment in generation and transmission infrastructure for a community energy scheme [15]. This utilises IT systems in a similar way to the 'Smart Grid' system. Hot water usage in domestic households is likely to have a periodicity, especially during weekdays. Timeseries of hot water usage from electricity data can predict and manage smart hot water systems within houses,

helping to shift the peak demand on a community energy system by shifting it within individual households [15].
Smart water cylinders could be used in Brampton as an additional effective way of storing energy created during the day by solar PVs.

2.3. Resilience to climate change

Climate change should always be considered. Community energy generated from renewable sources will help to reduce the effects of climate change. Climate change could also threaten community energy schemes, for example with extreme weather events, extreme heat, etc [2]. However, community energy schemes will increase resilience to climate change since a deregulated system provides protection from countrywide power outages.

2.4. Working example of a community energy scheme – Oxford's LEO project

An example of a community energy scheme currently being trialled is in Project LEO – Local Energy Oxfordshire. Project LEO includes many different trials within Oxfordshire to understand how to improve local electricity systems.

Energy Superhub Oxford is a community energy scheme within Project LEO. It uses a hybrid 50MW lithium-ion battery and a 2MW vanadium flow battery. An energy management system controls and optimises the charge and discharge schedule for the battery. The vanadium flow battery does not degrade in the same way as the lithium-ion battery and is therefore able to compensate for the lithium-ion battery during times of higher demand [16].

Oxford's LEO programme also uses a cloud-based software to control the amount of energy that is exported or imported by the system. The software is called "The People's Power Station 2.0". It gathers data from the solar PVs or batteries and then controls the amount of energy based on consumer usage. This, alongside the hybrid battery system, optimises the usage of the energy assets. According to the LEO project, there are several benefits to a cloud-based tool in that it will:

- "Improve the operations of the Low Carbon Hub portfolio by reading inverter data and automatically flagging any issues, allowing remote diagnosis and quicker response times.
- Empower the Low Carbon Hub to develop more flexible operations, to control the power output of energy assets and deliver flexibility services 'behind the meter' at the grid edge.
- Enable others to operate flexibly too, by helping to test the model and encourage roll out of flexible energy across Oxfordshire."

This case study could be used as a model for Brampton2Zero to learn about community energy schemes and understand which batteries work best as a CBESS and how to implement a scheme within a community.

3. Overview of the report

The completed community energy feasibility report is due from Scene in September 2022. The two reports will complement each other and will be used to inform the setup of Brampton's community energy scheme.

In this report, the background to B2Z's community energy scheme plan has been given alongside information on the amount of energy that will be required by the scheme. More information on this will be found in Scene's report. The physical requirements of a community energy scheme have also been explored. Further research on the best CBESS and "smart grid" will need to be explored, as well as research into other methods of achieving peak shaving such as smart water cylinders. Incentives mentioned in this report such as payments and bill reductions could also be considered to modify behaviours and therefore peak energy usage.

Before a community energy scheme is implemented, it is worth considering the likely population growth and energy use change in Brampton in the future. This will impact the peak energy usage. Ideally, energy demand in the community will be reduced before a community energy system is implemented. This could be achieved through retrofitting homes. Community engagement in this scheme will be crucial for its success.

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