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# Tapping the Potential for Energy Storage in Community Energy Initiatives

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*Driven by environmental concerns resulting from global warming, interest in renewable energy has grown in recent times. Similarly, improved efficiency and reliability in energy technologies have played a significant role in facilitating their adaptation at various scales. Of these technologies, energy storage has been suggested to have potentially far-reaching benefits including: more effective utilisation of renewable sources, better integration into smart energy systems and the improvement of grid reliability. In a community energy setting, energy storage can be used to stow away energy generated during low demand periods. This energy can then be accessed by community members at a lower cost during periods when there is higher demand and when energy is more likely to be expensive to buy. In this paper, the authors review the potential benefits of integrating energy storage into community energy initiatives based on the experiences of a community energy company set up in the Meadows in Nottingham, UK. In addition, the barriers they experienced when trying to maximise on these benefits including inefficient government policy and regulations, high capital cost and a lack of replicable business models, are highlighted. The results from t this case study review indicate that the introduction of energy storage can facilitate the future-proofing of community energy infrastructure with increased community and grid efficiencies as well as improve community resilience to changes in energy provision, particularly with regard to finances and infrastructure.*

*Keywords: energy storage, community energy, renewable energy, energy efficiency.*

## 1. INTRODUCTION

The use of renewable energy has seen steady growth the world over and has now become a mainstream source of energy (REN21, 2016). In addition to the growing demand for energy, the advancement of renewables has been propagated by several factors including: environmental concerns, competitive pricing of renewable energy technologies, policy changes, growing access to financing and the need to improve energy security (IEA, 2016, REN21, 2016). The primary renewable energy sources in the European Union (EU) are generated from solar energy, biomass and waste, geothermal energy, hydropower and wind energy (Department for Business Energy & Industrial Strategy, 2016b, Eurostat, 2016). In 2014, these and other renewable energy sources were found to contribute to 25.4% of all energy production in the EU (Eurostat, 2016). Renewables are expected to continue to play a major role in promoting a more competitive, secure and sustainable energy system with new EU targets focussing on meeting a 27% target share of renewable energy consumption by the year 2030 (European Commission, 2017a, European Commission, 2017c). Despite the decision to leave the EU (Prime Minister's Office, 2017), based on national objectives set by the UK's Climate Change Act and other international decarbonisation targets, it is anticipated that the UK will continue to be supportive of local renewable energy generation and consumption (Department of Energy and Climate Change, 2010, Committee on Climate Change, 2016, United Nations, 2017). Recently, the UK's power generation achieved its first ever coal-free day (Brown, 2017) and has reached a new record on the amount of solar power generated: 24.3% of the UK's total generation due a sunny day in May 2017 (BBC Business News, 2017).

Energy storage consists of systems that use a range of technologies to capture and store various forms of energy for use at a later time (Huggins, 2010). These technologies are classified according to the form of energy they store including: mechanical, electrochemical (batteries), chemical, high temperature thermal and electromagnetic energy storage (Renewable Energy Association, 2016). The main benefits of energy storage include: integration of renewables into the energy mix, improved energy security by the optimisation of supply and demand, enhanced system stability during power outages and a reduction in fossil fuel usage, among others (European Commission, 2013, Carbon Trust, 2016, Regen SW, 2016, European Commission, 2017b). Unlike older forms of energy storage such as coal and oil, new forms of energy storage are geared towards reducing overreliance on fossil fuels to support the achievement of global, regional and national low-carbon targets. In the growing landscape of the renewable energy revolution, energy storage has come to be deemed as one of the more innovative game changers that will help in achieving a smarter and more flexible energy system (Lusby et al., Whittingham, 2012, European Commission, 2013). In agreement with this, the UK government has termed energy storage as one of the eight great technologies of the future that would help propel future growth (Science & Technology Facilities Council, 2012, Department for Business Innovation & Skills, 2013). Even so, due to delayed uptake of this technology, the UK is yet to see the full potential of energy storage achieved by global leaders such as China, Japan, US, Spain and Germany (Energy Storage Forum, 2017).

Energy storage offers a range of benefits in various forms to different stakeholders - including community energy groups (Parra et al., 2017). In this paper, 'community energy' refers to initiatives focussed on the collective action of purchasing, managing and generating energy (Department of Energy and Climate Change, 2015a). Generally, community energy groups are defined by their emphasis on local-led management of energy generation and supply for the benefit of local communities (Good Energy, 2016, Kiamba et al., 2017). In the UK, community energy groups have been touted as a possible solution towards tackling energy-related issues from a local needs-based perspective and with wider national implications (Department for Energy and Climate Change, 2015, Ministry of Business Energy and Tourism, 2015). For community energy initiatives, the integration of energy storage into the local energy system promises potential benefits in energy resilience and security, increased affordability, a reduction in fuel poverty and the creation of economic opportunities (Seyfang and Haxeltine, 2012, The Smart Energy Special Interest Group, 2013, Rodrigues et al., 2016, Parra et al., 2017). Spurred on by successes overseas, energy stakeholders from local communities, government and industry are all keen to trial the deployment of newer energy storage systems across the UK (Carbon Trust, 2016, Regen SW, 2016, Renewable Energy Association, 2016). Advances in technology, falling costs in energy equipment, and the combined use with information technologies has opened up the possibilities for smarter energy storage solutions and new community energy business models that can harness its potential (Regen SW, 2016).

## 2. ENERGY STORAGE IN THE UK

The UK's energy market is currently facing a number of significant challenges in the quest towards a smart and flexible energy system including: affordability, demanding international, regional and national decarbonisation targets, energy security of supply, evolving energy networks due to growth of distributed rather than centralised networks, and ageing infrastructure (Barrett et al., 2010, Bird & Bird, 2016, Department for Business Energy & Industrial Strategy, 2016b). Despite these challenges, the supply and demand of renewable energy in the UK continues to show an upward trend. For instance, recent figures indicate that almost a quarter of the UK's power supply is attributed to renewable energy sources (Department for Business Energy & Industrial Strategy, 2016b, p.155). According to various sources, energy storage systems and technologies offer significant potential for supporting renewable energy and the UK's energy system at large (Department for Business Innovation & Skills, 2013, Department of Energy and Climate Change, 2015a, Department of Energy and Climate Change, 2015b, Regen SW, 2016, Renewable Energy Association, 2016). Key stakeholders in the energy industry agree that energy storage has the potential to enable a smarter grid, reduce energy emissions and cut down on energy costs (Department for Energy and Climate Change, 2015, Paliamentary Office of Science & Technology, 2015, Regen SW, 2016, Renewable Energy Association, 2016). All considered, it is fair to say that energy storage will play a fundamental role in creating a more efficient energy system in the UK.

There are a variety of potential benefits that may be attributed to the integration of energy storage across the energy system (Figure 1). In the development of smart grids, energy storage can permit surplus energy generated at peak times to be stored for later use thereby increasing efficiency; enable the integration of distributed and renewable generation thereby increasing decarbonisation; and provide a fast response to power fluctuations with networks thereby improving energy security (Department for Energy and Climate Change, 2015, Wynn and Schlissel, 2017). Where energy storage is used in combination with renewable energy generation it can provide the opportunity to decentralise energy generation and stabilise a fluctuating energy supply (The Smart Energy Special Interest Group, 2013). Where community-level grids are concerned, as is the case with the case study highlighted in this paper, storage can help balance out the independent running of a micro-grid and also allow for connection to the national grid (Department for Energy and Climate Change, 2015, Bird & Bird, 2016). The use of energy storage can also bring about economic benefits for end-users. For example, consumers can store electrical energy in batteries for use when it is required and when electricity from the national grid is more expensive thereby delivering cost savings for themselves (Department for Energy and Climate Change, 2015, Regen SW, 2016). At the larger nationwide network level, energy storage could be used to diminish or delay the need to repair, replace or upgrade network infrastructure thereby making significant cost savings (Department for Energy and Climate Change, 2015). In the larger scope of things, with appropriate support, innovations resulting for the development of energy storage and its technologies can enable UK businesses to be at the forefront of the energy storage revolution and reap benefits from its integration and continued uptake (Bird & Bird, 2016).

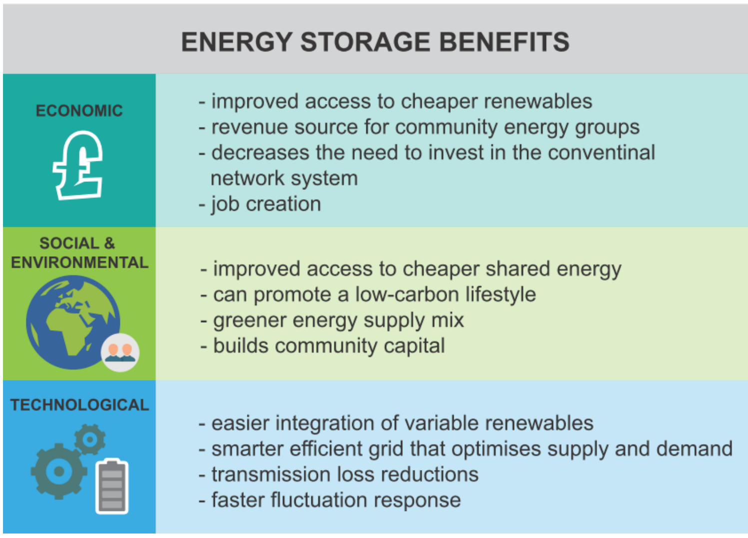


*Figure 1: Selected potential benefits of energy storage.*

In as much as there are identified benefits to the integration of energy storage at various scales in the UK, there are also hindrances that need to be addressed to allow storage to reach its full potential. The main issues include: a lack of adequate policy and regulation guidance for energy storage, poor understating of storage systems and their performance, and the lack of replicable feasible business cases (Department for Energy and Climate Change, 2015, New Power, 2016, Regen SW, 2016, SCENe, 2017). For a long time, the UK's energy market has been modelled around a traditional centralised power generation system (Huggins, 2010, Wynn and Schlissel, 2017). As a result, the existing policy and regulations tend to be biased against more flexible solutions such as those offered by energy storage (Department for Energy and Climate Change, 2015). Despite this uncertainty, there have been positive steps taken to come to a better resolution. For instance, the government has now teamed up with Ofgem (Office of Gas and Electricity Markets) to ensure that the regulation regime makes it easier for the penetration of energy storage systems and technologies (Department for Energy and Climate Change, 2015, Office of Gas and Electricity Markets, 2016). For many involved in the energy industry, energy storage for buildings and communities is a fairly new technology that is both complex and diverse (Renewable Energy Association, 2016). This considered, it is vital for stakeholders to learn more about what is on offer and what would best suit them. Although this is expected to take time and require investment, education of the market is deemed essential to enable those involved the opportunity to reap maximum benefits (Renewable Energy Association, 2016). Tied in with this barrier is the lack of adequate revenue support available for the research and development of energy storage, and followed up by financing for the implementation of storage technologies (New Power, 2016, Renewable Energy Association, 2016). These efforts would greatly help in defining replicable business cases that could then be implemented by other community energy groups.

Currently, the main energy challenge facing the UK is the provision of a resilient and cost-effective energy supply that meets decarbonisation targets. Newer technologies that encompass renewable sources and energy storage have been put forth as a suitable solution in liberalising the UK's energy market and partially meeting the aforementioned challenges. In this direction, community energy schemes can provide a mechanism through which communities can contribute to a reduction in carbon emissions, develop community capital and enhance their resilience through the use of smart energy networks and other infrastructure. The next section of this paper examines how a local community in Nottingham, UK is engaging with their energy future, including strategies that involve the integration of energy storage solutions for socio-economic benefits.

## 3. THE CASE STUDY BACKGROUND

The Meadows is a residential urban area that is located to the south of the Nottingham City Centre in UK. The area has a history of fuel poverty that has been worsened by economic deprivation. A household in the UK is considered to be in fuel poverty if they have fuel costs that are above the national median and if they are left with a residual income that is below the official poverty line after the paying of energy bills (Department for Business Energy & Industrial Strategy, 2016a). The three key elements that determine if a household is in fuel poverty are the household income, household energy requirements and fuel prices (Department for Business Energy & Industrial Strategy, 2016a). In 2009, a group of Meadows residents got together to try and work towards finding a local solution to fuel poverty and climate change while also using this as an opportunity to rally residents to do something for their mutual benefit. Mainly, the residents wanted to ensure that they were able to keep warm in the winter while cutting down on their rising energy costs by providing better insulation for their houses and being more energy efficient, and also by producing low-carbon energy. With support from the Meadows Partnership Trust, a local regeneration organisation that aims to bring the local community together to improve the delivery of services to residents through partnerships, Nottingham Energy Partnership, Nottingham City Council and local professionals, the residents set out to become Nottingham's first low-carbon community. This partnership led to the drawing up of a local energy plan which the residents sought to carry forward.

As part of this process, the community members were able to obtain a National Energy Action (NEA) grant that helped them commission a study into the formation of a local energy services company. This eventually led to the formation of the Meadows Ozone Energy Services (MOZES). Since its formation, MOZES has continued to play a significant role in the community. One of the main initiatives that MOZES has carried out in partnership with British Gas has been the installation of nearly 65 PV installations, mainly in houses, schools and other community buildings. In addition, with support from Scottish Power, MOZES has facilitated interest-free green loans for vulnerable Meadows households to allow residents to implement energy efficiency solutions such as the provision of insulation or the installation of solar PV panels. MOZES and NEP have also involved a professional energy advisor who has worked to educate residents on how to be more energy efficient and who has visited residents to give them an assessment of their individual properties. This has been useful in helping residents overcome barriers and inform them of the benefits of renewable energy use and other energy efficiency matters. In addition to providing this valuable awareness, MOZES organises regular energy workshops for the community as part of their community engagement strategy. As part of this outreach, awareness campaigns have been carried out in local schools to engage the local children on energy efficiency matters. Since the setting up of MOZES, there have been a number of volunteer and paid opportunities offered to community members that have not only provided employment but have also helped in getting more residents to get involved in local energy matters.

As MOZES has been working in the Meadows for some years, they have developed a good rapport with community members, established a good range of contacts and managed to get a good rate of attendance at their planned activities. Stemming from its memorandum ambitions, MOZES is keen support research into innovation in sustainable energy for the benefit of its community. As a result, it has contributed to several social and energy related research projects. More recently, the Meadows was selected to be one of the main demonstrator sites for a major EU funded Horizon Research and Innovation programme project entitled Storage-Enabled Sustainable Energy for Buildings and Communities (SENSIBLE). SENSIBLE is a project that aims to explore the technical, social and economic aspects of the micro-generation of electricity and heat in conjunction with different types of energy storage. The overall objective of SENSIBLE is to develop, demonstrate and evaluate a storage enabled energy supply for buildings and communities, combining local renewable energy generation and energy-market participation. Project SENSIBLE has two other demonstrator sites in Évora in Portugal and Nuremberg in Germany. The Meadows was found to be particularly suitable as it has a significant amount of solar PV installations, varied housing types and tenures – the majority of the housing stock in the Meadows consists of large areas of social housing, and a core of traditional Victorian terrace houses (Nottingham City Council, 2010), a favourable local grid configuration and more importantly, backing from the local community through MOZES.

The prime objective of Project SENSIBLE in the Nottingham Demonstrator is to show that the integration and use of energy storage within the community could reduce energy costs and bring about other socio-economic benefits for local consumers. This will involve showing that the control of energy storage for a community rather than for an individual consumer can help increase the amount of PV generation that can be installed within a localised area. Further, Project SENSIBLE would like to demonstrate that energy storage can be used to improve the quality of electrical power within a local area. Finally, Project SENSIBLE aims to show evidence that could potentially challenge restricting policy and attitudes towards the use of energy storage at distribution level. It is noted that laboratory work carried out by researchers at the University of Nottingham (UoN) will carry out testing that emulates energy and power profiles for a range of loads (houses and other buildings) and generation (solar and wind sources) to refine community energy storage management strategies before they are deployed at the Meadows site. Following their involvement in Project SENSIBLE through MOZES, up to 40 volunteer households stand to receive energy storage equipment including batteries that will help them to manage their energy generation and storage as a means to reducing their energy bills. As part of this process, participants will also be advised of the opportunity to switch energy tariffs to a cheaper option which, when combined with the benefits of energy storage, could decrease their energy bills further.

Essentially, two energy storage systems will be available for deployment in the Meadows as part of Project SENSIBLE (Figure 2). The first type is an energy storage system that converts solar PV energy into thermal energy and can divert excess energy to keep it within the selected household. The second electric energy storage system diverts energy within the home and levels out peaks in energy use. In addition, by using community batteries, it should be possible for energy generators within the Meadows community to share surplus energy with other community members. Under this proposed scheme, the 'sellers' i.e. those with excess energy to share will be able to get higher prices for their energy as opposed to if they had sold the energy off to the national grid. Similarly, those community members buying the energy would be able to purchase it at a costs lower than those offered by 'big energy companies'. When it comes selling energy to each other outside of the traditional power company and end-user model over public wiring, existing regulatory frameworks are very prohibitive (Renewable Energy Association, 2016). Consequently, explorations undertaken by Project SENSIBLE will be carried out in a laboratory setting or via simulations as opposed to on-site. Nevertheless, it is anticipated that the findings of this study will still work towards informing the general discussion in anticipation of overdue policy and regulatory shifts.

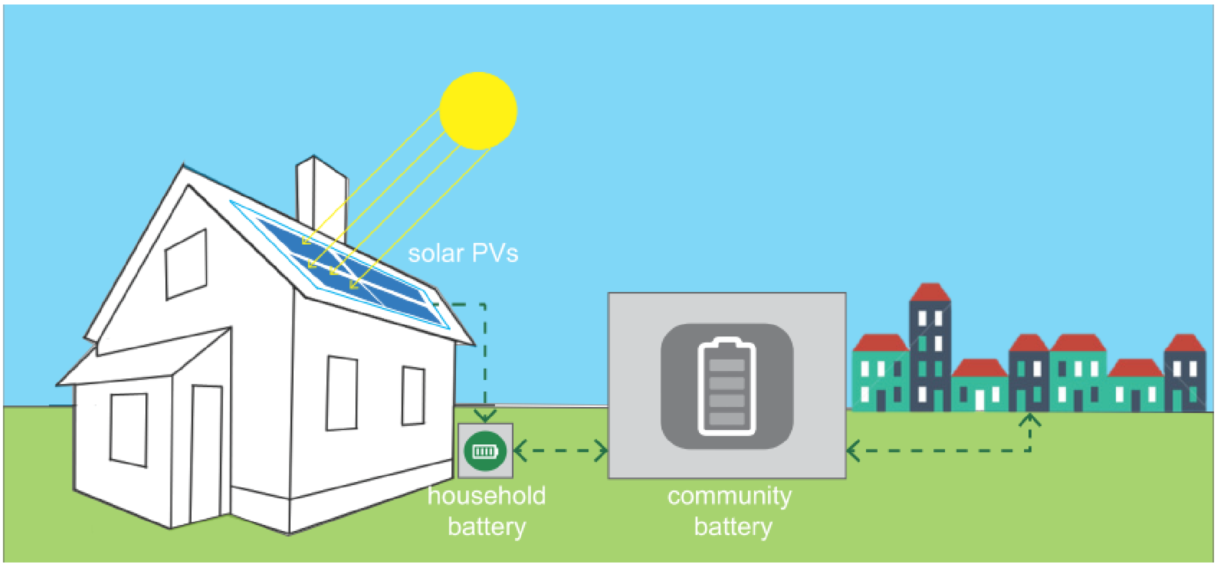


*Figure 2: Community energy in the Meadows.*

## 4. RESULTS AND DISCUSSION

Project SENSIBLE has run from January 2015 and is expected to be completed at the end of June 2018. Generally, the simplest application for energy storage is for domestic scenarios where a stand-alone battery is connected to onsite renewable generation such as solar PV. In isolation from the national grid network, this model can deliver savings by time-shifting energy use to avoid times of higher pricing. On the slightly larger scale, an energy storage system comprised of an aggregate of domestic and larger community owned batteries can allow for greater control of energy availability in the community and even allow for the transfer of energy amongst community member at lower rates (Department of Energy and Climate Change, 2014, Department of Energy and Climate Change, 2015a, Department of Energy and Climate Change, 2015b, Regen SW, 2016). Both these energy storage types will be examined during the course of Project SENSIBLE in laboratory and on-site scenarios. In the Nottingham Demonstrator, energy storage equipment is planned for installation in existing houses with PV installations and a school with a large array of PV installations. Already, two initial installations have been deployed to two properties in the Meadows for approval by the regional distribution network operator (DNO) before the rest of the installations are fully set up.

Moving away from a traditionally centralised energy network, the newer energy network in the UK is anticipated to have higher levels of localised renewable energy generation and supply that could provide opportunities for new business models (The Smart Energy Special Interest Group, 2013, Department for Energy and Climate Change, 2015, SCENe, 2017). In the Meadows, the community via MOZES and SENSIBLE is developing a local micro-grid that could potentially be linked to the national grid network. As the development of smart grids in the UK is at a relatively early stage, the piloting being carried out in the Meadows and other similar projects helps in the testing of energy storage technologies and their business models. Currently, the information available on practical and replicable business cases when energy storage is integrated is scarce. Although community initiatives such as MOZES offers potential benefits for the local community and the local network operator, they also serve as case studies for others and can assist in driving more communities to invest in similar enterprises for local and inevitable national benefits. Already the successes of MOZES in enabling the Meadows community to take charge of their energy future has been noted and encouraged (Clark and Chadwick, 2011). More recently, the current energy storage research being undertaken in the Meadows has been used to inform the frameworks of other local community energy initiatives. For instance, in another UoN affiliated energy project entitled Project SCENe (Sustainable Community Energy Networks), those involved are seeking to accelerate the adoption of Community Energy Systems in a new housing development in the Trent Basin site in Nottingham. The test bed site will be used to bring together technical knowledge, implementation and installation of renewable heat and electricity technologies as well as energy storage at community-level scale.

As part of SENSIBLE research into the social and economic benefits of energy storage, an initial survey involving communities from the Nottingham and Évora sites was conducted in 2015. In Nottingham, this survey involved approximately 60 volunteer residents from the Meadows who had signed up to take part in Project SENSIBLE during an initial community engagement event. For each household, one representative was asked to take part by filling out the distributed questionnaires. In addition to identifying the property characterisations of the volunteer properties, the main aims of the survey were to examine participant awareness of energy efficiency in homes, attitudes towards climate change, participant views to community energy initiatives and energy storage and participant preferences regarding their involvement in Project SENSIBLE. The participants have been very supportive of the process with up to 81% of the volunteer households returning responses to the questionnaire. The results of this survey are referred to in the subsequent parts of this paper. A follow up to this initial survey is planned for late 2017 where feedback will be sought from participants following the installation and running of the storage equipment for a suitable amount of time. Community engagement is an integral part of Project SENSIBLE's strategy and is considered to be cumulative in nature. Initially, the engagement process involved gauging the level of support for the project by the community and recruiting interested participants. With support from MOZES, further engagement has been used to help prioritise local needs, manage expectations and strengthen the research relationship with community members. At the close of the project, a detailed feedback process on the entire project is planned, the results of which will be presented to the community.

Capital cost has been identified as a significant hindrance to the roll-out of energy storage technology deployment in the UK. According to the Renewable Energy Association (2016), whereas there have been a few research and development funding sources for the development of the energy storage market, even scarcer backing sources are available for investors to fund storage projects which then reduces the chance of deployment. In this case, the involvement of Meadows community members in Project SENSIBLE via MOZES has benefitted them a chance to integrate energy storage equipment in their properties at zero monetary cost to themselves. It is unlikely that these households would have had the chance to do the same on their own at current market prices. In fact, results of the aforementioned socio-economic survey indicated that only 50% of the households would consider implementing energy efficiency technologies such as energy storage if they cost more than £500. It has been determined that, at current market prices, payback periods for the domestic installation of storage equipment are estimated to be more than 15 to 20 years (Regen SW, 2016, p.30). Nonetheless, based on current global trends, it has been forecast that energy storage cost could decrease by 70% in the next 15 years (World Energy Council, 2016, p.5). Also, recent findings indicate that as costs of energy storage decrease and revenue sources linked to their integration become more discernible, more investment funding will become available thereby enabling the shift towards energy storage in the UK to gain momentum (TLT and Clean Energy Pipeline, 2017). It is anticipated that this decrease in cost will go a long way in making storage technology accessible to individuals and communities. In the meantime, it is expected that deployment of energy storage at community level where unit price falls as system size increases as is being trialled in conjunction with MOZES in the Meadows, provides the opportunity for economics of scale to be realised.

The growth of many community energy initiatives in the UK has largely been dependent on access to the Feed-in Tariffs (FITs) scheme (Community Energy England, 2016). However, the FITs scheme has now been cut down significantly by the UK government, bringing with it uncertainty for many involved in community energy initiatives. Previously, the FITs scheme provided a guaranteed revenue stream for generators of small scale renewable energy where they would sell unused energy to energy companies at a price fixed by the government. In essence, FITs would enable community energy companies to support themselves without the need to depend on grants or other types of investment. To grapple with the loss of this revenue stream, community energy groups across the country have been forced to seek suitable alternatives (Community Energy England, 2016). Closer home, having been too late to capitalise on the scheme for majority of its PVs, MOZES has been dependant on the FITS scheme for just 11 PVs. Following the termination of the scheme, various companies involved in the installation of solar PVs in households across the Meadows community have ceased this operation to re-evaluate its economic viability. Similar impact has been felt across the UK where project finance for solar fell by 78% in 2016 compared to 2015 levels (TLT and Clean Energy Pipeline, 2017, p.14). As a means of seeking more revenue, MOZES has decided to explore the benefits of energy storage via the SENSIBLE pilot where the idea of keeping the energy generated in individual homes and other community buildings for use in the local community will be trialled.

Essentially, where energy is generated by solar PVs during the day is not consumed, it is saved for use at a later time or for sharing with fellow community members. With appropriate support, it is anticipated that this format will work towards enabling Meadows residents to benefit from local green energy generation, transmission and distribution in a cost effective manner.

Experiences encountered during Project SENSIBLE have underlined the need for a stable policy and regulations for the community energy sector, and the definition of a replicable energy storage framework. On the one hand, the UK government has lauded the potential benefits of community energy and energy storage in meeting national and local climate-change objectives and energy security targets (Department of Energy and Climate Change, 2014, Paliamentary Office of Science & Technology, 2015). On the other hand, minimal progress has been made in dismantling the identified regulatory barriers (Bird & Bird, 2016, Community Energy England, 2016, New Power, 2016, Regen SW, 2016, Renewable Energy Association, 2016). Whereas it is appreciated that the government is keen to take a consultative approach to the matter (Department for Energy and Climate Change, 2015, Office of Gas and Electricity Markets, 2016), it is hoped that it will go ahead and set long-term policy guidelines that make it easier for the market to embrace energy storage, especially where regulations negatively affect the interaction of smaller players such as community energy groups. In the Meadows, the relationship with the DNO has been challenging. Despite early contact with them, the approval system has been especially difficult with a lack of clarity encountered from the onset preventing timely connections and leading to project delays. Additional costs for witness testing of equipment demanded by the DNO has led to extra costs of approximately £20,000 for just four installations. In hind-sight, more thought should have gone into debunking the potential problems related to the installation of storage and monitoring equipment. As the project deadlines were not built around the supply of equipment, the supply date has been pushed back many times jeopardising the ability to collect a whole year's data stream.

For a growing number of community energy schemes in the UK, the local generation of energy for local consumption is mainly derived from solar and wind energy sources and in some cases micro-hydro installations (Clark and Chadwick, 2011, The Smart Energy Special Interest Group, 2013, Community Energy England, 2016, The British Academy, 2016). Due to the variable nature of solar and wind energy output, storage can be especially useful in keeping energy for use when demand is higher and more expensive. In cases such as in the Meadows where the community has a significant number of solar PV installations, the integration of energy storage enables them to maximise the potential of a variable energy source. This option can help the community members to improve their energy security by optimising their supply and demand, thereby reducing the need for them to buy grid electricity at greater cost. It is anticipated that future energy and regulation changes (related to generation and supply permissions) will also enable residents to buy cheaper energy from each other thereby improving energy security for residents who do not have access to storage equipment. In addition, besides the need to reduce fuel poverty brought on by high energy costs, Meadows community members through MOZES remain keen to shift their energy consumption from fossil fuel sources to 'green' sources such as solar and wind energy as a means of embracing a low-carbon lifestyle. The integration of storage is deemed vital in achieving this goal as it enables a greener energy supply mix for residents.

As the name suggests, community energy groups are defined by their community-led approach. In this way, community members are able to come together and define their energy needs and explore ways of meeting them. The introduction of newer types of energy storage into community energy systems works well by providing community members with options to store locally generated 'green' energy for later use. One of the main implications of this is that energy storage can be used to improve local ownership and local management due to the economic freedom garnered from its integration. This benefit combined with the potential to 'share' stored energy further strengthens the community energy model. These potential benefits are not lost on Meadows residents who are taking part in Project SENSIBLE. In fact, 90% of the respondents of the aforementioned socio-economic study noted that they would like to see their community managing their own energy use, with a slightly greater proportion (92%) indicating that they were willing to share excess energy with the community. In addition, in alignment with their aim to be more energy efficient, majority of the respondents indicated that they believed that centralised energy storage within communities (89%) and in homes (95%) can help improve energy efficiency.

Although the concept of energy storage is not new, the development of energy storage batteries and equipment for domestic and community energy applications is at a fairly early stage (The Smart Energy Special Interest Group, 2013, Community Energy England, 2016). In view of this, it is likely that many potential end-consumers are not aware of the bulky nature and size of equipment available on the market today. Even the sleeker-looking batteries, such as the Tesla Powerwall 2 which measures at 1150mm long by 755mm wide by 155mm thick and weighs 120kgs (TESLA, 2017), are considerably large and heavy. As a result, it is important to consider their location well before their deployment. In Project SENSIBLE, as part of the community engagement strategy, interested residents were welcomed to take part in an engagement session where researchers provided life-sized models of the batteries and equipment that were to be installed in households (Figure 3). In addition, detailed surveys were carried out by contractors of the selected properties to confirm their suitability. Although a few residents dropped out due to the spatial intrusiveness of the equipment with respect to their own properties, this process gave those that proceeded adequate confidence to go ahead with full knowledge of how the equipment would impact on their specific properties. That considered, the suggested option of shared community batteries would still give those that will not get individual installation a chance to share the energy generated in the community. The benefit of shared community batteries is that instead of deploying large intrusive batteries for individual use, a larger battery system that is near to end-users can be deployed at selected community-owned sites instead, thus saving on interfering with existing properties and also saving on battery costs based on economies of scale.


*Figure 3: Life-sized models of proposed equipment shown at a community engagement session in the Meadows.*

The Meadows volunteer participants have remained very cooperative and well-engaged during the course of the study. Following the early engagement sessions, 98% of those who signed up to take part in Project SENSIBLE were happy to have equipment installed in their properties. A review of why residents were eager to take part in the work carried out by Project SENSIBLE revealed that they are attuned to the potential benefits of energy storage and to a larger extent, energy efficiency. The findings of the socio-economic study revealed that the main reason participants gave for joining Project SENSIBLE was to be 'greener' (37%). The second most important reason was the potential energy savings (30%). The third most important reason given was the potential monetary savings (19%). Less important reasons included: to prepare my household for the future (7%), to get free energy storage/ batteries (5%) and for more engagement with the community (2%). As part of the continued engagement efforts, there are plans to provide a visualisation tool that will be accessible to study participants via monitors and displays. To make the tool more accessible, arrangements are underway to ensure that the tool is kept simple and useful for users. As such, the information relayed is expected to consist of understandable and relatable indicators including: real-time weather data, available energy stored from solar PV generation, and the potential monetary savings being made. It is envisioned that the provision of this data via the tool will enable participants to see the direct impact of combining renewable energy and storage in their homes. The potential success of this tool has been gauged based on the responses received from volunteer participants of the socio-economic study where a majority of 55% indicated that they would like to check for real time feedback of the monitoring equipment to enable them to make more energy efficient choices. By translating the data in a way that can be understood by the participants, it is hoped that they will feel less like energy technology spectators and more like controllers.

## 5. CONCLUSIONS

Faced by a new dawn in energy systems characterised by low-carbon sources and parity, many are looking towards the potential suitability of community-driven generation and distribution in providing a more sustainable system. Community energy groups have a useful and unique position that enables them to act as a contact for energy consumers in a local area, and helps them to engage with energy matters by harnessing local natural resources to build social capital, creating revenue to address community needs and combating fuel poverty. It is anticipated that the wide scale implementation of sustainable local energy generation will help provide greater efficiencies and cost savings to households and communities at large. The collective effect of the efforts of community energy groups are expected to help transform the UK's energy network through tackling energy issues from a local perspective and with regional and national impacts. At the same time, energy storage has been earmarked as the technology that will help propel renewable energy use to the next level as part of a smart energy system. The ability to store energy for later use fits in well with community energy initiatives that are modelled around variable energy sources. Due to the intermittent nature of micro-generation sites dependent on these variable energy sources, energy storage offers the potential to provide access to cheaper energy for use during low generation and peak demand times. Despite the high hopes for community energy and energy storage, there are still a significant number of challenges that need to be eliminated to maximise the benefits brought on by this devolved approach to energy generation and distribution.

At the moment, the main hindrances to tapping the potential for energy storage in community energy initiatives include inefficient government policy and regulations, high capital cost and a lack of replicable feasible business models. As the UK prepares to leave the EU, there is an urgent need to chart a clear framework that tackles challenges that may impede the delivery of a low-carbon energy future. The absence of clear policy and regulation as concerns community energy and energy storage has led to a delay in the achievement of the potential benefits. Currently, many of the energy policies and regulations that exist were modelled for a centralised energy system dependent on fossil fuels and which regards communities as passive consumers. As we move towards a distributed energy systems, there is a need to dismantle archaic regulatory restrictions that hamper the creation of effective community energy initiatives – the inability to sell cheaper locally generated energy to members of one's community while also connected to the national grid is one case in point. Besides offering policy and regulation guidance, to further provide guidance in the matter, government at all levels need show a high level of support for community power that focuses on renewable energy and decarbonisation. This can be showcased by engaging with community energy stakeholders and framing development agendas that provide financial or other incentives for community energy and energy storage schemes.

Slow uptake of energy storage across the country has continued to hamper the rate and scale of the investment in this technology. To help advance efforts, communities can serve as suitable test-beds for the integration of the technology and the measuring of social, economic and technological impacts. Following the reduction in government subsidies such as FITs, more community energy groups are struggling to demonstrate that community energy incentives can still develop viable income models. Confronted by the need to continue to generate income and still keen on improving energy security for residents, a local community energy group in the Meadows is now working to capitalise on the benefits of energy storage. The experience at the Meadows has shown that community energy schemes can be used to increase the resilience of energy systems by encouraging local energy generation, and can also improve access to low-carbon energy sources. Although Project SENSIBLE is still in progress, it is anticipated that long-term benefits for the community could include: an increase in community resilience (as relates to changes in energy provision from an infrastructure and financial perspective), improvement of energy grid efficiency and the future-proofing of community infrastructure, a decrease in fuel poverty and an increase in energy security by providing cheaper energy through grid forecasting. Furthermore, it is expected that the locally generated energy will minimise external grid energy purchasing, thereby reducing the community's reliance on fossil fuels in line with their low-carbon goals.

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