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# Renewable energy scenarios: Exploring technology, acceptance and climate – Options at the community-scale

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ABSTRACT

Community-based renewable energy could play a key role in the transition to a low carbon society. This paper argues that given the right environmental and societal conditions, communities in the UK could source a high percentage of their electricity supply from a mixture of localised renewable electricity technologies. Here we use exploratory scenarios to assess demand and renewable electricity supply-side options at the community-scale for a location in Cumbria, UK. Three scenarios are presented, using narratives of how local demand and renewable electricity supply could be constructed under either existing or modified environmental and societal conditions. The three scenarios explored were 'Current State of Play', 'Low Carbon Adjusted Society' and 'Reluctant Scenario'.



## 1. Introduction

Approaches that will increase the supply of renewable energy and reduce demand are needed in response to the UK's goal of reducing carbon emissions by 2050 (Climate Change Act, 2008) and in response to the European Union's (EU) renewable energy target of 20% by 2020 (DECC, 2009). The UK has a lower target of 15% renewable energy by 2020, however is making slow progress having achieved 7% in 2014 (DUKES, 2015; Renewable Energy Strategy, 2009). Furthermore, the UK aims to generate 30–40% of its electricity from renewable sources but to date has only achieved ~18% (DUKES, 2015). Significant changes will need to be made in the UK's approach to energy if these targets are to be met.

Although a centralised large-scale approach to energy currently dominates, there is emerging interest in distributed small-scale renewable energy, particularly where communities are involved in the ownership or management of local developments. Interest has been fuelled by the perceived benefits that locally-led developments can play in increasing local acceptance of renewable technologies and in altering energy behaviours by providing real-time information to inform energy use decisions (CSE, 2007; Heiskanen, Johnson, Robinson, Vadovics, & Saastamoinen, 2010; Warren & McFadyen, 2010). The concept of generating and using locally-owned energy is gaining popularity with residents in the UK, with the number of energy schemes labelled as 'community-based' rising to over 1000 in 2012 (Hargreaves, Hielscher, Seyfang, & Smith, 2012). This is partly due to concerns over increasing fuel prices, with consumers wanting to become more independent from large energy providers and having more control over where their energy comes from (Butler, Parkhill, & Pidgeon, 2012; Gormally, Pooley, Whyatt, & Timmis, 2013; Watson et al., 2008). The UK coalition government declared support for community-based activities, releasing it's first 'Community Energy Strategy' recognising the 'advantages that community-based action offers energy and climate change policy' (DECC, 2014, p.3).

Given the perceived relevance community energy could have in promoting low carbon technologies and reducing local demand, this paper examines the technical, societal and environmental aspects of local schemes by exploring the potential contributions of renewable supply and demand-side options for a case study community, using a set of exploratory scenarios. This paper argues that given the right societal and environmental conditions, communities in the UK could become significant producers of electricity. As shown on The Isle of Eigg (Yadoo, Gormally, & Cruickshank, 2011), it is possible for a small community to generate almost all electricity needs through community-based renewables when this is the only option available. Supply-side options used on Eigg involve combining a mix of renewable resources which have different

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seasonal and weather dependencies. By combining a mix of hydro-power, wind-power and solar photovoltaics (PV), together with 24 h battery storage and back-up diesel generators, they have managed to overcome some of the issues associated with the variability of renewable generation. This is coupled with demand-side measures including a household cap of 5 KW (all households are provided with OWL energy meters) and by asking residents to voluntarily reduce demand in times of low renewable electricity generation. Here we consider whether this concept of balancing supply and demand locally through utilising local renewable resources translates to on-grid rural communities on the UK mainland.

This paper presents the final phase of an interdisciplinary, mixed methods research project that has examined community-based renewable energy in Cumbria, UK. The first phase combined quantitative methods (spatial analysis and calculated energy outputs) with secondary data in order to assess annual renewable resource potential at the regional scale and identify areas with sufficient local resources to support a portfolio of renewable energy technologies (Gormally, Whyatt, Timmis, & Pooley, 2012). The second phase involved using quantitative and qualitative methods to assess residents' attitudes to renewable energy, in three Cumbrian communities. Themes included attitudes towards localised ownership of renewable energy, involvement in local energy schemes and preference towards different renewable technologies (Gormally et al., 2013). The communities were chosen using the results of the spatial analysis conducted in the initial phase, which identified them as having high resource potential for a portfolio of renewable technologies. Subsequently, one of the three communities was chosen as the focus for developing community-level energy scenarios in this final phase of the overall study.

In this paper we use one type of energy scenario to explore possible 'renewable futures' for our chosen case study community. Scenarios are a means of exploring alternative futures and Kowalski, Stagl, Madlener, and Omann (2009) describe three main types that are often used – forecasting scenarios (those which are a continuation of the past), normative scenarios (those which aim for milestones and assume a certain future can be created) and exploratory scenarios (those which explore a possible space for the future but do not aim to predict it). Here we use exploratory scenarios to examine electricity demand and supply at the community scale. Therefore, we do not aim to predict the future for this community, we simple aim to explore plausible and potential futures based on different assumptions of technologies, acceptance and climate.

The scenario options described in this paper are modified by both local demand and renewable supply-side conditions. Reviewing renewable supply-side options involves exploring the existing potential (current meteorological conditions) and future potential (possible future meteorological conditions) by exploring the effects of climate and extreme weather events. The impact of extreme weather events is important in terms of ensuring security of supply, especially as extreme events in the UK are predicted to become more severe and more frequent in the coming decades (Fowler & Ekström, 2009; Meehl et al., 2007). Indeed, this has raised interest among the energy-related research community with studies addressing the energy outputs and economic impact of such changes on hydro-power and wind-power (Greene, Morrissey, & Johnson, 2010; Harrison & Whittington, 2002). The UK has seen a shift in some meteorological conditions, for example, rainfall patterns are found to be changing with winter rainfall events becoming more intense and more frequent in upland areas such as Cumbria (Burt & Ferranti, 2012; Ferranti, Whyatt, & Timmis, 2009; Malby, Whyatt, Timmis, Wilby, & Orr, 2007; Osborn, Hulme, Jones, & Basnett, 2000). This could have implications for renewable technologies in the future (for instance, energy outputs from hydro-power). It is important to note that the aim of this paper is not to model future climate for this community. That is beyond the scope of this research and outside of the remit of the 'exploratory' scenario approach taken here. To help explore possible impacts of climate or changing weather patterns on renewable supply-side options, we take a simplified approach by using 'extremes' identified in the local 30-year meteorological record (for more details see section 2.1.2).

Supply-side options are additionally modified by societal acceptance which is used to define both the renewable technology options used and the scale of the chosen technology. Demand-side options use current estimates of local residential electricity demand and future estimates which explore both reduced (high awareness) and increased (low awareness) levels of residential demand. For an example of all pathway options used to construct the scenarios described in this paper, see Fig. 1.

## 2. Methodology & results

The following methodology was used to develop exploratory energy scenarios for one community in Cumbria, UK. We firstly describe the case study community followed by the methods and data used to determine local levels of electricity demand and renewable energy supply. Three exploratory scenarios are then constructed. These are 'Current State of Play', 'Low Carbon Adjusted Society' and 'Reluctant Society'. All three scenarios represent different narratives of how local demand and renewable energy supply could be constructed under either existing or modified environmental and societal conditions. Each scenario considers the demand and supply balance on temporal scales ranging from annual to monthly and daily. To contextualise the results, each scenario considers whether the community could generate sufficient renewable electricity to satisfy three different levels of local demand. Firstly, greater than 30% of the community's electricity needs; secondly 90–100% of the community's electricity needs and thirdly, in excess (>100%) of the community's electricity needs. The 30% contribution was chosen in line with the UK's overall target of >30% renewable electricity by the year 2020 (Renewable Energy Strategy, 2009), the 90–100% contribution was chosen due to its suggested feasibility given the evidence from The Isle of Eigg (Yadoo et al., 2011), and the >100% contribution was chosen to establish whether given the right conditions of environmental, societal and technology mix, the community could become a net exporter of electricity to the grid.

### 2.1. Case study community

The village of Sedgwick (Fig. 2) was chosen as the case study community to develop the energy scenarios and explore possible 'renewable futures' at the community level. It is located in the South Lakeland District of Cumbria in the North-west of England and is situated between the boundaries of the Lake District National Park and the Yorkshire Dales National Park. It has a population of 378 inhabitants (source: 2001 census; key statistics) and achieved a high response rate (61%) to the household questionnaire survey on community energy carried out in an earlier phase of this research (Gormally et al., 2013). Results of this survey indicated a high level of support for locally-led initiatives. The regional scale mapping of resource potential carried out in Gormally et al. (2012) also suggests that this community and its immediate surroundings could potentially support a number of renewable electricity developments. For example, hydro-power, wind-power, solar PV and land for bioenergy crops, specifically Miscanthus or Short Rotation Coppice (SRC).