GETTING THE MOST FROM COMMUNITY GENERATION - AN ECONOMIC AND TECHNICAL MODEL TO CONTROL SMALL SCALE RENEWABLE COMMUNITY GENERATION AND CREATE A LOCAL ENERGY ECONOMY

Mary GILLIE and Jen CARTER
EA Technology – UK
Mary.gillie@eatechnology.com

Roy ALEXANDER
University of Chester - UK
r.alexander@chester.ac.uk

Garry CHARNOCK
Ashton Hayes Parish Council - UK
gcharnock@rsk.co.uk

ABSTRACT
This paper describes work to develop a groundbreaking economic and technical model to match small scale generation and demand in a small community and create a local energy economy. This involves the use of unlicensed supply and a new type of Community Organisation for Renewable Energy (CORE). The work takes the village of Ashton Hayes (which is aiming to become carbon neutral) as a case study. By monitoring the LV feeders and individual buildings over several months, the team is building up a picture of the load profile in parts of the village. Likewise, surveys of buildings and the renewable energy resources provide an estimate of the renewable generation possible in the local area. The work identifies a mix of renewable energy that has a high probability of generating during times of high demand. A structure for the community to create a local energy economy and negotiate with licensed energy suppliers is developed. The results are used to develop a generic framework that could be used by other communities.

In order to implement the framework, new half-hourly metering technology is required. In addition, novel technology for automatic demand side management will help match generation and demand.

Not only will the concept allow better use of local generation, but will also increase consumers’ awareness of their energy usage and how to manage it responsibly.

INTRODUCTION
There is growing interest in locally owned renewable energy schemes. Up to now, schemes have been in the form of community ownership of part of a wind farm or other renewable generation developments. The energy is sold to a licensed supplier and the proceeds used to fund energy efficiency measures. This project investigates ways in which a community can own generation and use the energy directly, rather than sell it to a licensed supplier, via a new type of Community Organisation for Renewable Energy (CORE). This engenders community cohesion, local responsibility for energy use and encourages demand side management. The project investigates the economic and technology issues in developing such a framework. It uses Ashton Hayes (a village in the UK aiming to become carbon neutral) as a case study and concentrates on generation at LV.

DEMAND AND GENERATION MATCHING
In order to use as much energy as possible locally, a mix of generation that has a high probability of generating at the same time as the demand for energy is high is needed. This will always be an approximation as most renewable generators are not controllable and people’s patterns of usage will change from day to day and week to week.

Demand for power can be estimated in one of three ways:
- Measurements of people’s usage can be taken using domestic power monitoring equipment.
- Average typical profiles for homes or other buildings can be used.
- If the local distribution network operator has, and is prepared to provide, the information, data on the load flow to a feeder where the generation will be connected gives the overall profile.

The typical profiles are averaged usage over hundreds of households. If the area considered is a cluster of a few houses, measured values of these households’ patterns of use are desirable as they could be quite different from the averaged values (Compare Figure 1 with Figure 3 and Figure 5). Likewise schools or community buildings are likely to have almost unique patterns of use which will affect the overall demand profile if there are only a few buildings.

Figure 1 Average profiles for domestic customers at different times of the year and day [1].
To assess the options for generation, typical profiles for different types of generation were normalised and then scaled depending on the resource available.

**Wind resource**

In the UK, average wind speed for each square kilometre is available at [http://www.bwea.com/noabl/](http://www.bwea.com/noabl/). However, the wind resource can vary considerably within one square kilometre. The output from a wind turbine can vary greatly from day to day (Figure 2). In the case of Ashton Hayes, typical outputs were used as a first estimate. For a more accurate assessment of wind resources an anemometer mast has been erected.

![Wind Power Output](image1)

**Figure 2 Normalised Output from a wind turbine on different days demonstrating the variability in output.**

**Solar resource**

The output from photovoltaics is more predictable (they don’t operate in the dark!). The maximum output will be in midsummer and the minimum in mid winter. In the case of Ashton Hayes, estimates from nearby weather stations were used as a first estimate but a pyranometer has been erected for more accurate measurements.

Subtracting the half-hourly outputs of different combinations and sizes of generator from demand, a combination that has a high probability of supplying the base load and some of the peak demand was found. For Ashton Hayes, the load profile for one feeder was provided by the local Distribution Network Operator (DNO). Residents also used monitors in individual homes. This information could also have been used to build up a demand profile for the feeder as a whole.

There will be times when the generation is producing more than is needed by the local load. There is a balance to be struck between supplying as much of the load as much of the time as possible and exporting large amounts of power to the rest of the network. The combination of generators is restricted by the physical space to install it. The cost of different types and makes of generators and the capacity factor should also be taken into account.

In Ashton Hayes, a survey of the area identified that there is an area suitable for 2 or 3 wind turbines each with a capacity of 20kW or under. There is roof space on the school, Women’s Institute Hall and church suitable for installing photovoltaics. There is also the potential for an 18kWe electricity-led CHP unit providing heat for the school, run off biodiesel. This would require an underground seasonal heat store. In the summer, heat could be stored underground and then, in the winter, heating is provided by both the CHP unit and heat pumped out from the heat store.

Three times of year were selected to look at the likely generation output and demand and profiles for weekdays and weekends were used. As the output from wind turbines varies considerably, two different profiles were used for each time of year. Different combinations of generators were selected to find a mix that minimised import and export to the rest of the network.

![Generation and Load Profile -February Sunday](image2)

**Figure 3 Load profile of one feeder in February in Ashton Hayes with a mix of generation.**

Figure 3 to Figure 5 show there are some times when the generation is greater than the load and vice versa. During these times, demand side management could be used to switch on or off loads that can be scheduled. Examples of suitable devices are dishwashers, washing machines and bread makers.

![Generation and Load Profile - July Sunday](image3)

**Figure 4 Load profile of one feeder in July in Ashton Hayes with a mix of generation.**
FINDING A FOCUS

Although generators can be distributed around a number of different sites, it may be appropriate to focus on a particular building and the area around it. For example, a school and surrounding fields, or a church and village hall. In the case of Ashton Hayes the school is a prime site. Community buildings give a greater number of people a direct stake in the project.

At the same time, it is often appropriate to improve the energy efficiency of buildings or carry out other alterations. This can provide access to additional funding and reduce installation costs. For example, costs for scaffolding can be shared.

ADVANTAGES OF COMMUNITY ACTION

There are a number of benefits for installing generation on a community scale over individual installations, such as cost saving in buying in bulk and in co-ordinated installation. By connecting a number of generators at the same time, the connections can be co-ordinated and the costs of design and installation can be reduced. In addition, alternative connection designs such as one inverter connection for a number of generators can also reduce costs. This is emphasised in [2]. Community organisations also have access to certain sources of funding that are unavailable to the individual.

For the DNO, the community approach means that it only has to negotiate with one party and can co-ordinate the connection of a cluster of generators. This could include minimising the number of points of connection and inverters used. Attempting to balance load and generation at a local level should also reduce peak demand and reduce losses in the network. It also makes it easier for the DNO to negotiate more active control of the generation. By working with a community, a DNO can start to develop techniques for active network management at low voltage. Whilst one installation will make little difference to the operation of the distribution network, as the numbers increase they could have a substantial impact on the operation and control, particularly if clusters develop.

OWNERSHIP OF GENERATION

Under UK supply rules, a customer can only receive supply from one unlicensed supplier. Therefore, the model recommends that the CORE own the generation on behalf of the community, so all the power is supplied by one unlicensed supplier (which owns multiple generators).

However, it is important that the generation is sited in the most appropriate location, which may be on the premises of individual householders or on the land occupied by community buildings, such as a school or village hall. The landowners would therefore play host to the CORE’s assets as part of a contractual arrangement.

LOCAL ENERGY ECONOMY

In order to use power locally, it is necessary to know when the power is generated and when local users are using power. This requires half-hourly metering for domestic users. When demand and generation operate at the same time, the cost of the power should be lower. When demand is higher than generation, additional power must be bought from a licensed supplier. Likewise if there is an excess of power generated it is sold to a licensed supplier. The use of half-hourly metering demonstrates if demand is matching generation. The differential in price between locally generated power and power supplied by a licensed supplier should encourage customers to try to match their demand to the generation (i.e. demand side management).

How the benefits of the reduced cost of locally generated power are divided can be decided by the CORE. For example, establishments such as a school may receive more of a benefit because they serve a large number of people within a community.

Customers within the area will pay the CORE for the power they have used from the local generation. It is envisaged that the CORE will also negotiate with a licensed supplier to sell any excess power generated and buy the additional power required. Customers will therefore receive one bill from the CORE; for locally generated power and power supplied by a licensed supplier.

Customers can be aided to use demand side management with automatic demand management devices. There are a number for technologies being developed but the basic components required are:

- A switch to turn an electrical appliance on or off (or possibly reduce the load).
- A communication medium to signal to the switch.
- Measurement of the demand and generation to determine when to switch loads on or off. If all the generation and
load is on one feeder, this measurement could be a measurement of power flow, switching on load if there is export and switching off loads if there is import.

At a more sophisticated level a switch could be programmed so that an appliance must run at some point within a set period. If it has not been automatically switched on remotely by a set time, it will start to run anyway.

CONCLUSIONS

The paper examines a new structure for communities to own and manage small scale generation and create a local energy economy. This has benefits for the community as it is a lower cost option than an individual approach, via co-ordinated installation and connection, bulk purchase and access to funding. The DNO gains from negotiating with only one party and being able to co-ordinate connections. There is the possibility for peak lopping, reducing network losses and developing active networks at LV. By attempting to match generation and demand, communities can maximise the amount of generation used locally and reduce the peak load on the network.

REFERENCES


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