Community and Renewable Energy Scheme Project Development Toolkit Community Micro-grid/ Private Wire Network Module

Community Energy Scotland

LOCAL ENERGY SCOTLAND

Introduction

This document has been produced by Community Energy Scotland (CES) on behalf of Local Energy Scotland (LES) and the Scottish Government with support from the Community and Renewable Energy Scheme (CARES) Infrastructure and Innovation Fund (IIF).[1] The document aims to provide a resource of practical advice for community groups and other stakeholders involved in the development or operation of micro-grid projects in Scotland.

Much of the current published information on micro-grids focuses on the technical and regulatory aspects. While these are very important, from a project development point of view other essential and complex factors such as procurement, finance, energy supply arrangements, grid connection agreements, community engagement and land agreements must be considered and this guide is designed to provide a complimentary and practical accompaniment to a guidance document produced by Highlands and Island Enterprise (HIE) and the Scottish Government in 2016.[2] In recent years LES and CES have supported many community groups in Scotland with the scoping, development and operation of micro-grid projects and there is now a wealth of experience relating to these factors within the Scottish community energy sector.

This gained experience forms the foundation of this resource, which brings together learning from ten micro-grid projects in Scotland to make it more accessible to other communities, as well as other interested stakeholders who support community groups. It is hoped that the 'Toolkit' of information will help in the early identification of suitable project opportunities, as well as potential barriers, hopefully reducing duplication of effort and helping to manage communities' expectations when considering the micro-grid approach.

Toolkit Structure: How to Use This Document

This CARES toolkit is intended to be used as a reference by community groups of all kinds, including communities and community based businesses. The Toolkit is presented in a step-by-step format, with a focus on providing an overview of the project development process and showing how it differs from standalone generation projects. Within this step by step approach, we have presented relevant learning gained from our interviews and visits with community organisations and groups either developing, or operating micro-grids around Scotland. The project cycle used as the structure of the Toolkit is shown in Figure 1.

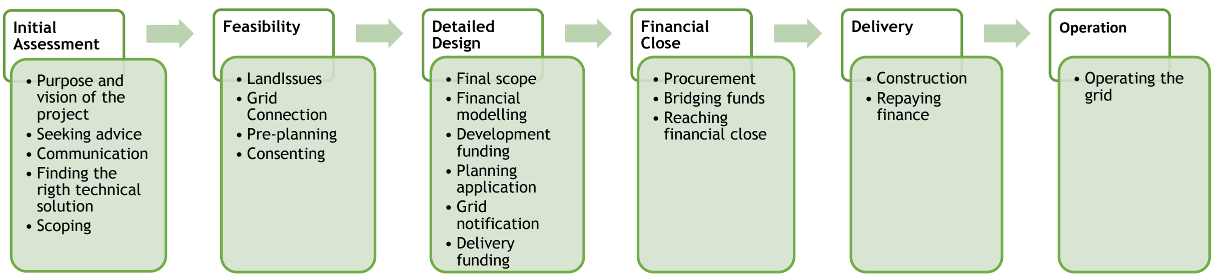

Figure 1: Micro-grid Project Process Diagram: The Structure of the Toolkit

[1] http://www.localenergyscotland.org/funding-resources/funding/applying-to-cares/infrastructure-and-innovation-fund/
[2] Xero Energy Produced an overview and detailed technical and regulatory reference guide for Micro-grids on behalf of Highlands and Islands Enterprise (HIE) and Scottish Government in 2016. See: http://www.hie.co.uk/community-support/community-energy/policy-support.html

As a step by step approach, the Toolkit follows the typical journey of a project from the very initial assessment, to detailed design and financial close, and finally to delivery, commissioning and operation. It is hoped that this format will be beneficial as those using the resource will be able to 'jump in' to the Toolkit at a point relevant to the development of their particular project.

Introduction to Micro-grids

What is a micro-grid?

Electricity Grids

An electricity grid is an electrical power system consisting of electricity generation and demand (points of consumption or electrical 'loads') interconnected by wiring, and infrastructure that helps to control it and keep it running safely. Any electricity grid serves the basic purpose of delivering electricity from the point of generation to the point of demand and consumption. Large national electricity grids, such as the UK National Grid here in Scotland, consist of various different components outlined in Figure 2, which include:

- Generating stations (power stations) that produce electric power. These are often located near fuel sources, or away from urban centres (points of demand and consumption) to reduce adverse environmental impacts.
- Transmission network infrastructure that carries electricity from the point of generation to areas of demand. This is comprised of high voltage wiring and cabling sufficient to efficiently transmit large amounts of electrical power over long distances, and transformers to reduce the voltage when it reaches areas of demand.
- Distribution network infrastructure that carries electricity from an interface with the transmission network, to the point of consumption. This consists of lower voltage wiring and cabling, with transformers to convert electricity to the required voltage for consumption – giving us the 230 volt[3] supply we're all used to in our homes.

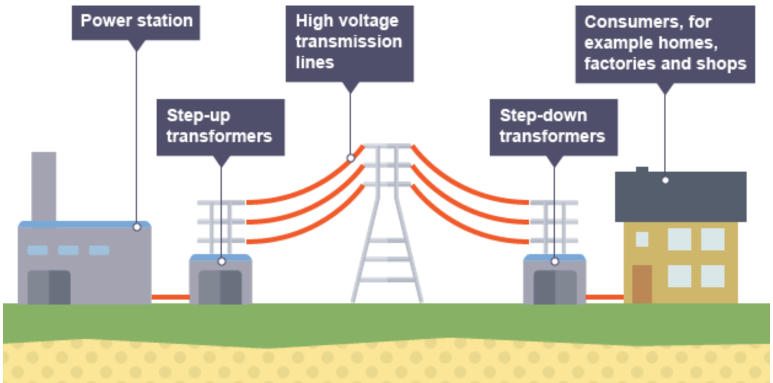

Figure 2: Basic Structure of a Large Electricity Grid such as the National Grid in the UK[4]

[3] Technically it is 230V after EU harmonisation although in reality it is still 240 on the ground (and 240 lies within the 230V allowable range).
[4] Image source: http://www.bbc.co.uk/education/guides/zbsdmp3/revision/5

Consumers of the electricity generated, transmitted and distributed through large national grids include householders and various types of organisations, including large scale industrial operations. At the point of grid connection, or the boundary between the wiring on a premises and the distribution network, consumers can also export their own generation back into the grid. An example of this would be households generating electricity with an installed solar photovoltaic (PV) system, and exporting the electricity generated. At these grid connection points the quantity of electricity imported (consumed) or exported is usually metered for purposes of managing the grid, and producing accurate billing for consumers.

The traditional model of operating a national electricity grid involves large scale electricity generation that happens at a significant distance away from points of demand and consumption. This 'centralised' approach to electricity generation is changing due to the increased development and installation of smaller scale generation, often from renewable sources (such as solar PV on households), at locations closer to point of demand and consumption. This 'decentralised' or 'distributed' approach involves the installation of electricity generation at the distribution network point of a large grid, much closer to the point of electrical demand.

Micro-grids

In the literature, there is no general definition of a micro-grid. However, just like other electrical grids, a micro-grid is an electrical power delivery system that consists of electricity generation and distribution to points of demand and consumption. It can also incorporate energy storage. The main difference between a large electricity grid and a micro-grid is that the electricity generation is decentralised and happens closer to the point of demand and consumption, usually at the equivalent distribution network level of a larger national grid. This means that no high voltage transmission of electricity over long distances is required.

A micro-grid is essentially a different type of distribution network that supplies a smaller number of local electrical loads with nearby generation through interconnected low voltage wiring and associated infrastructure. Micro-grids also incorporate control systems in order to safely and efficiently manage the local supply, distribution, and demand of electricity. This can be summarised by describing micro-grids as local power networks that use distributed energy resources and manage local energy supply and demand.[5]

An outline of a micro-grid's structure and components is shown in Figure 3. The fundamental components of a micro-grid include:

- Distributed Electricity Generation
  This can be from renewable and/or non-renewable sources. The generation can also be classified as controllable or non-controllable depending on whether it is an electricity supply that can be switched on or off. Examples of controllable generation include diesel generators or micro-hydro systems, whereas solar PV is a good example of non controllable generation that is only producing electricity when adequate sun is available.

- Distribution System

[5] Lilienthal, P., 2012. Island micro-grids: The first smart grids. Presented at the World Renewable Energy Forum, WREF 2012, Including World Renewable Energy Congress XII and Colorado Renewable Energy Society (CRES) Annual Conference, Colorado, pp. 1623–1628.

This is the network of wires, cables and/or transformers and other equipment that distribute electricity from generation sources to points of demand. The distribution system can be Alternating Current (AC) and/or Direct Current (DC). AC technology is typically used in larger grid networks, as it enables large voltage changes using transformers that allow the efficient transmission of electricity over long distances. In a micro-grid, generators often produce electricity in DC, and the need for high voltage transmission over large distances is not often required, so DC distribution systems may be appropriate depending on the type of demand.

- Energy Storage
  A micro-grid can optionally have energy storage connected to it. Energy storage can help balance non-controllable generation (e.g. solar PV) and electricity demand, by allowing electrical energy to be stored or discharged for use at a time when required. Additionally it can also provide initial energy requirements for when a micro-grid connects or disconnects from the larger national grid. Storage can take the form of batteries; fuel (such as hydrogen); electrical storage such as super-capacitors; mechanical storage such as pumped hydro, fly wheels and air compression; or thermal storage such as storage heaters.

- Electricity Demand (Loads)
  These are the electrical loads connected to the distribution system that consume the electrical power transmitted to them. They are usually different types of premises whose internal wirings are connected to the distribution system via meters, and sometimes switches, in order to accurately measure and control consumption. The loads can be domestic residences, commercial and industrial premises, community buildings, hospitals, schools, or any other location requiring supply.

  On a micro-grid loads are controllable; meaning that in order to match generation and demand, loads can be switched off and on. However, depending on the perceived and/or agreed importance of different loads on the grid, contracts and agreements may be made between operators and consumers to ensure that supply to critical loads are maintained, and arrange the parameters within which non-critical loads may be switched to help with micro-grid management.

- Control and Management System
  This is the information system that manages and controls the generation, loads, storage and grid connection autonomously, governed by rules programmed into it. The rules used will depend on a specific micro-grid architecture, structure and purpose. A control and management system is usually comprised of a main central control system; controllers and switches for generation, loads and storage; and a data network to communicate signals and implement actions.

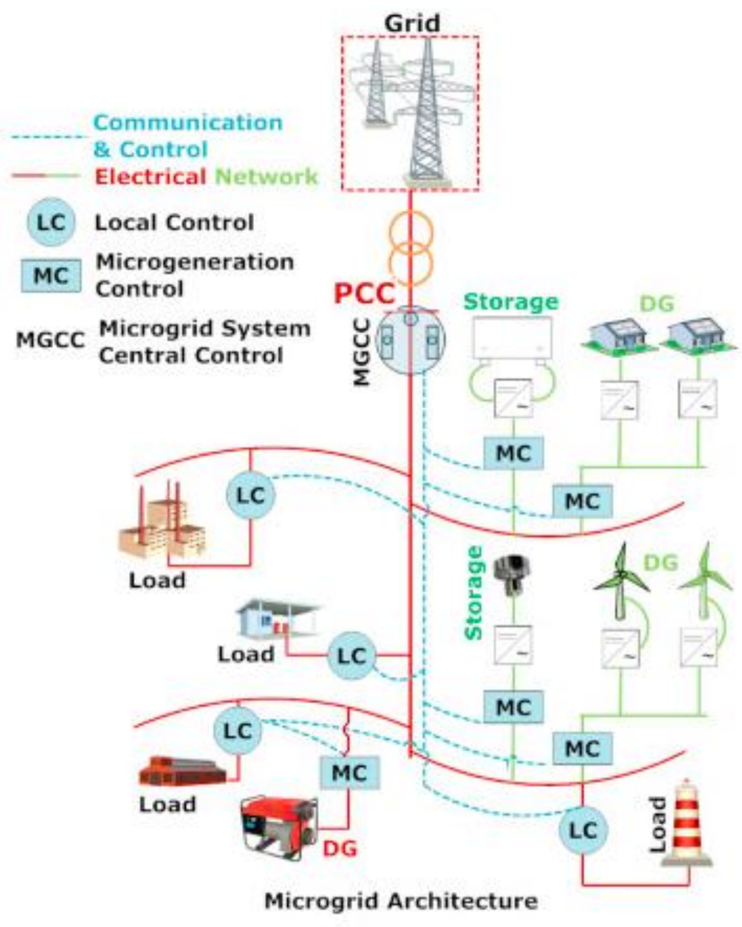

Figure 3: Micro-grid Outline.[6] DG Refers to Distributed Generation, and PCC to 'Point of Common Coupling' - This is described in the Grid Connection Section Below

Islanded or Grid Connected

There are three general types of micro-grid:

- "True" micro-grids
- Private wire networks (PWN)
- Islanded or autonomous grids

In much of the literature, a true micro-grid is one that can operate both connected to a larger grid, and isolated from it – or 'islanded'. For micro-grids that operate this way in the UK there is a 'Point of Common Coupling' (PCC – see Figure 3) that interfaces the micro-grid with the distribution network of the national grid. The PCC is the ownership boundary of the network that consists of electrical switching and protection equipment for completing electrical connections and disconnections, metering to measure import and any export of electricity, and often main control and communication equipment to manage the grid.

In some situations, a micro-grid will be permanently connected to the larger national grid, without the ability to disconnect from it and run autonomously. In the UK one form of this is a 'Private Wire Network' (PWN), which may incorporate privately owned wires, generation, and

[6] Mariam, L., Basu, M., Conlon, M.F., 2016. Micro-grid: Architecture, policy and future trends. Renew. Sustain. Energy Rev. 64, 477–489. doi:10.1016/j.rser.2016.06.037

demand, but will not be able to run in island mode. Although they have a PCC, it is primarily an ownership and metering boundary with protection switches, as opposed to switchgear and synchronisation equipment required for regularly connecting or isolating from main grid supply. PWNs are often the least complex to install due to the lack of requirement for complete autonomous control of the system and can be used to overcome local grid issues such as constraint or curtailment. However, they tend to be most cost-effective when operating over small areas, as larger distances between demand points require longer and often larger cables if a higher voltage is required for efficient distribution. Although PWNs aren't deemed as true micro-grids, they are very relevant for the community energy sector in the Scotland, with lots of them already in operation.

Some micro-grids operate in isolation permanently disconnected from a larger grid. This is often referred to as an 'islanded' grid or autonomous system. Islanded micro-grids are particularly relevant for rural electrification projects in developing nations as they represent a viable solution when communities are faced with prohibitive costs of grid extension and connection. Examples of islanded micro-grids in Scotland include Knoydart, Fair Isle and the Isles of Eigg, Rum and Muck, that are not connected to the distribution network of the UK National Grid. Although islanded systems are not deemed true micro-grids, as they cannot operate in both autonomous and grid connected scenarios, they include most of the same elements. With relevant information from their development and operation, and much to learn from it, references to islanded systems have been included in this toolkit.

Types of Uses and Scale

Due to their incorporation of generation closer to the point of demand, micro-grids are designed to power small areas. A definition of exactly how small the area or system should be does not exist, but as a guide, it should be in direct proportion to the scale of the distributed generation and demand connected to it. In the UK this is often limited to distribution of less than 1MW for domestic use, as according to regulations[7], above this threshold a micro-grid operator will have to become a licensed Independent Distribution Network Operator (IDNO)[8]. Limits under the same regulation for license exemption for non-domestic generation and supply are 10MW and 5MW respectively. The small areas that micro-grids can supply range from typical housing estates, isolated rural communities, to mixed suburban environments, academic or public premises such as universities or schools, to commercial areas or industrial estates.

Why are micro-grids important?

Communities

A beneficial feature of a micro-grid is flexibility. It can act as a stand-alone source of electricity for remote communities such as Knoydart, or it can be connected to a central power system, selling and buying electricity as needed.

Additionally, the setup of a micro-grid may also be a solution for community groups who are struggling to export all of their renewable generation to the main grid due to curtailment. This

[7] The Electricity (Class Exemptions from the Requirement for a Licence) Order 2001. See: http://www.legislation.gov.uk/uksi/2001/3270/schedule/3/made
[8] IDNOs are licensed and regulated by Ofgem. See: https://www.ofgem.gov.uk/electricity/distribution-networks/connections-and-competition/independent-distribution-network-operators

is when the local distribution network grid capacity is only sufficient to allow export of a limited amount of electrical power, leaving valuable wasted generation that could be used elsewhere. Micro-grids can help with this by allowing community groups to use the wasted capacity for local demand, either via direct supply or via storage where fluctuating generation is present.

Using energy locally is also financially beneficial as it will offset expensive purchase costs of electricity from the grid, while providing revenue for the community operator. This is becoming more important now as Feed in Tariff (FiT) rates are degressing[9] and grid export of electricity becomes less financially attractive. Local income streams for energy sales are also often more financially attractive than the sale of electricity export to the National Grid.

Other benefits include the way that renewable electricity can be directly linked to local demand in a way that reduces the demand for fossil fuels. This also creates system benefits through local balancing and greater electrical efficiency. An example of this is the reduction in losses due to transmission. Micro-grids can also allow for new local commercial arrangements, and can help to retain more of the value of production in the local economy.

The Micro-grid Project Journey

Initial Assessment – is it worthwhile?

Purpose and Vision

There are numerous reasons for why installing a micro-grid can be of benefit to a community. For a community group the provision of local generation and supply of energy is a means to an end, in that the cost reductions, revenue generated, or energy services provided by a micro-grid project can ultimately enable beneficial development activity to happen within community. Additionally, the drivers for some members of community groups will also be to reduce environmental impact.

Installing a micro-grid is a complex, often costly process and it is therefore important when embarking on such a project to establish why you want a micro-grid and what you want it to achieve. Having a clear purpose and a vision for your project will help to ensure that the micro-grid you develop is suitable for your community's needs, will serve as a communication tool to explain the project to partners and stakeholders, can serve as a benchmark against which development decisions can be made and last, but not least, can provide the motivation needed to persevere when difficult obstacles arise.

To develop an overarching purpose and vision, you need to begin by determining why you think a micro-grid would be of value to your community. This will involve establishing the drivers of community group's members for developing the project, agreeing desired outcomes enabled by the development, and then forming clear objectives for the delivery of the project. Guidance on how to form a community group and consult to develop a vision for a project is given in the separate Establishing a Community Group Module of the CARES Toolkit.

[9] Degression is the process by which subsidy tariffs such as the FiT, reduce progressively over time.

Seeking Advice

The development and operation of a micro-grid is a complex undertaking. There are many community groups, at varying stages of project development throughout Scotland and around the world, who have experience developing and operating micro-grids. It is therefore worth seeking the knowledge and expertise of others to help you to navigate the various stages of the process. Depending on the aspect of the project under consideration, there are numerous bodies and resources that offer relevant advice and information:

Other communities that have already developed micro-grid projects

Speaking to somebody who has been through the process in a similar position to yourself can allow you to benefit from their experience of successes and avoiding their mistakes. This toolkit provides some detailed case studies, and a summary of the different micro-grid projects in development/operation in Scotland in Table 1.

Intermediaries

Intermediary organisations such as Highlands and Islands Enterprise (HIE) and Local Energy Scotland (LES), have dedicated teams working to support community energy developments. Charities, such as Community Energy Scotland (CES), may also be able to offer you advice and support on various aspects of your micro-grid project or arrange knowledge transfers between community groups. The Development Trusts Association Scotland (DTAS) can help with governance, setting up community organisations and funding, and Community Land Scotland have many members with experience in energy projects that may be relevant.

Online resources

There are lots of online resources for community groups relating to the development of energy projects, of which much is relevant for different stages of micro-grid development. This includes the CARES Toolkit modules. HIE and the Scottish Government have also developed a technical guide to developing micro-grids that provides a comprehensive overview of the technical, regulatory and licensing requirements for micro-grid projects.

Communications

Effective communication with all of those involved or affected by the project is key to the success of any community development. Early consultation with community members and stakeholders is essential to identifying why such a project is needed, and establish what issues need addressing. Informing stakeholders about how this project will affect them and what you will need from them from the outset can help the project to progress smoothly.

When determining whether a micro-grid project is viable, it will also be important to establish what level of local demand is interested in connecting to a micro-grid, and what level of tariff they would be willing to pay for electricity. This is to gauge the potential electrical load, and also model the financial viability of the system.

Methods of communication include:

- Stakeholder interviews
- Surveys of residents, business owners, community groups, property owners and other interested parties
- Public consultation workshops
- Social media channels

Finding the right Technical Solution

Finding the right technical solution that meets the objectives of the established purpose and vision for a project is essential. As detailed in the section ‘Introduction to Micro-grids’, there are three main types of micro-grid:

- “True” micro-grids
- Private wire networks (PWN)
- Islanded or autonomous grids

Deciding on which will be most appropriate for your project will depend on various factors. At the very minimum these should include:

- Local distribution grid availability and strength
- Geographical area to be covered by the micro-grid
- The capacity of electrical loads to be connected and their demand profiles
- Existing network infrastructure to be utilised
- The capacity and generation profiles of existing or proposed renewable and non-renewable energy generation
- Initial financial viability

Initial Scoping

Technical factors will also need to be assessed financially and against the agreed project objectives to ensure that a suitable solution is selected to pursue. It may be the case that there are several options available that look technically viable for the project, in which case they can be taken forward for more detailed investigation and financial assessment.

Pre-Feasibility Study

Due to the complexity involved with any micro-grid development, at this stage most community groups commission a pre-feasibility study to establish appropriate options for the proposed micro-grid design and assess initial viability. Pre-feasibility studies will include:

- A detailed summary of technical possibilities, including all of the detail outlined in the ‘Finding the right technical solution’ section. This should also include a physical survey of site and existing infrastructure
- Details of initial discussions with potential project partners who may benefit from local electricity supply
- Details of licenses or license exemptions required for generation, distribution and supply activities
- Details of initial contact with the Distribution Network Operator (DNO), to get an idea of their appetite for the proposal, and likely connection requirements and costs

- An overview of perceived planning and environmental consenting issues
- An outline of other estimated capital and operational costs for the system to within 10%-30% accuracy of actual cost
- Initial high level financial viability appraisal
- Recommendations on the viability of a micro-grid system and the technical configuration of the recommended proposals

The ability to commission a pre-feasibility study will be dependent on the availability of funds and as such it is worth identifying how these funds will be secured. Guidance on sources of finance is given in the separate Sources of Finance Module of the CARES Toolkit.

Energy Tariffs and Savings

The viability of the project will completely depend on whether the tariff you can charge to potential consumers of electricity on the micro-grid will be enough to cover operational costs, and represent cost savings for customers at a level attractive enough for them to sign up. This means that a market assessment of potential customers needs to be established.

It is very important to establish dialogue with potential customers to get an idea of what this tariff level might be. This can then be fed into the initial financial assessment alongside energy market tariffs.

Pre-Feasibility: Applecross

A pre-feasibility study was commissioned by the community at Applecross to explore options for a micro-grid supplying electricity from the local 90kW community hydro turbine., however, it can only export 50kW to the grid due to a constrained national grid connection. As such Applecross have been looking into ways in which the currently unused 40kW could be supplied and used locally instead of being exported.

The study looked into different sources of demand including a shower block for a local campsite, domestic electricity and heat supply to eight nearby residences owned and run by Applecross Housing Association, and heat and hot water supply for a nearby hotel currently running on oil. The recommended configuration was a PWN to supply the loads already described, and Applecross are currently developing a business plan and seeking funds to take the project forward.

For current information see:
http://www.applecrosshydro.scot/

Other Costs

Additional costs to investigate and factor into the business plan include:

- Estimates of insurances. This will include public liability and a policy for the hardware installed. It may also include loss of income insurance to cover revenue losses should the system fail for any reason. Employers liability will also be required if the community organisation will employ staff to undertake administration and/or customer service for the system

- Operational costs for the organisation running and operating the system and the energy supply company including staff, premises, IT, etc.
- Maintenance
- Costs of designing and coordinating procurement
- Administration costs for planning and environmental consenting
- Legal costs for securing options on land or way leaves
- Ongoing communication and media costs. If reaching out to potential energy consumers, the community organisation will need to engage with them. Estimates of ongoing costs may therefore need to be included for branding, websites, promotional activity and social media
- Project management costs. All community groups we spoke to highlighted this as the area they wish they had considered and budgeted more for at the outset. Projects are organisationally, technically and financially complex, and involve many stakeholders. Most stated that 20% of total costs should be included for project management

Breakpoint 1: Is There a Reason to Proceed?

At this point, with initial assessment steps complete, you should have an idea of the viability of your proposed micro-grid. Taking the project forward from here will involve significant time investment, and as such you must ensure the following criteria are fulfilled before proceeding:

- The community is aligned and agreed on the purpose and objectives of the project
- There is adequate existing or proposed generation that will be sufficient for matched demand
- There are sufficient loads and associated demand that are of adequate scale and consumption profile to match connected generation, and willing to connect to the micro-grid for local electricity supply, at a tariff level suitable for its ongoing operation
- The initial feasibility assessment indicates the options for development are financially viable enough to proceed to gather further detail
- The initial feasibility assessment indicates the options for development are aligned with project purpose and objectives
- The DNO has indicated that they are supportive of recommended proposals
- There are no perceived show stopping or consenting issues

Feasibility – Evaluating the Project

If the initial scoping has deemed recommended options for micro-grid development worthy of further investigation, the next step is to evaluate the various regulatory and legal challenges in more detail to ensure that the project stands the best chance of proceeding. These key challenges include:

- Land Issues
- Grid Connection
- Pre-Planning and Consenting

Most of the detail gained from the initial scoping phase will be sufficient as the basis for engagement throughout these next steps.

Land Issues

A micro-grid will potentially cover a large geographical area on which lots of electrical hardware will need to be installed or housed. This will include generation plant itself; cabling that may be overhead or underground; transformers that can be pole or ground mounted; and switchgear, protection, metering and other equipment at the PCC. Additionally, access will also be required for installation works and ongoing maintenance. In this sense the main difference in securing a site for a micro-grid project is the scale of the land, and thus potential different number of owners, involved.

It may be that the micro-grid is being proposed on community owned land, such as in Knoydart, in which case there issues present may be greatly eased. However, if there is a mixture of owners for different plots then consultation with them will be required to secure required title or access.

With a proposed site selected for a micro-grid project, it is essential to establish land requirements, identify ownership/title in order to establish contact, and initially assess potential for required purchase, community buy out, or arranging required wayleaves or deeds of servitude.[10]

Legal agreements will need to be drawn up with landowners and payments made to them. Their legal fees will usually be included in this. This is best handled through a solicitor who has experience in dealing with community energy projects. Guidance on the process for securing a required site is available through the Securing a Site Module of the CARES Toolkit.

Land Issues - Eday

In Eday, the Surf 'n' Turf project is using a small micro-grid to overcome grid curtailment of the installed 900kW wind turbine. This is being achieved with the generation of hydrogen from an electrolyser connected to the turbine via a PWN. When curtailed, the wind turbine will supply the electrolyser to create hydrogen, which will then be repurposed back into electricity at Kirkwall pier. The project involves Eday Renewable Energy Ltd, Community Energy Scotland (CES), and the European Marine Energy Centre (EMEC).

The project is still under development but has undergone delays related to agreeing wayleaves required as part of the project. The team in Eday assured us that they would definitely recommend taking legal advice up front, in order to avoid costly delays later down the line.

For current information see:
http://www.surfnturf.org.uk/

[10] A wayleave is a right of way granted by a landowner, generally in exchange for payment. A Servitude is a specific granted right on a property, often involving access, drainage, or water supply access.

Grid Connection

If the proposed micro-grid is not islanded, it will still require a formal national grid connection to the distribution network. This requires an application that will be received and managed by the DNO who operates the distribution network in your area.

At this stage, you should have consulted with the DNO initially to discuss the proposal, understand any requirements and constraints, and get an indicative estimate of costs. However, the DNO will want full sight of the proposed micro-grid design, including generation and all components within a connection application to which it will formally respond.

The costs associated with connection are based on the work that a DNO has to undertake to satisfy its requirements to safely connect the micro-grid to the network. This includes infrastructure for network extension and reinforcement, any studies and electrical design required, and any administration costs.

The process for application will be different depending on the scale and configuration of your micro-grid. The type, scale and profile of demand and generation will differ from place to place, along with control measures, and the physical length of the micro-grid cabling. This will impact the connection required and the costs associated with it.

Speaking to community groups, the biggest issue with grid connection are the timescales involved with securing a connection, and the differential in initial estimates of costs compared to the actual costs involved. The DNO will only have visibility of an overview of the system at the initial scoping stage, so costs can vary as the scope of requirements gets firmed up. As such it is important to communicate with the DNO early and regularly, and factor in contingency estimates for the initial quoted costs.

A full guide to the grid connection process, including a useful overview of who the DNO is in your area, is available in the Grid Connection Module of the CARES Toolkit.

Grid Connection Issues - Fetlar

In spring 2016, Fetlar Developments Ltd commissioned their micro-grid that incorporates two 25kW wind turbines supplying a domestic residence, charging facilities for a community electric minibus, and heating and power for a nearby primary school. The school is fed from two large (4000L!) thermal stores for hot water, that allow the energy produced by the wind to be stored at times when not immediately required.

Fetlar Developments Ltd supplies their energy to domestic residences on a private wire under a license exemption. However, in order to become the supplier for each premises, the DNO required that each of the existing connections and associated metering needed to be terminated before any new cable sand meters could be installed. One piece of learning was that this was a lengthy process as the DNO effectively has to destroy an official metering supply point (and the Meter Point Administration Number (MPAN) associated with it) registered as required by the energy market regulations. If this is the case with your proposed micro-grid it will be worth adding in additional time in the project plan.

One benefit for Fetlar with the grid connection was that they were able to co-ordinate any excavation works with the DNO to save costs and time. As such it is worth continuingly exploring ways to reduce the duplication of work and sharing costs for activities.

For current information see:
http://www.fetlar.org/fetlar-developments-ltd

There is also a video available on the HIE website about the project:
http://www.fetlar.org/hie-video

Pre-Planning & Consenting

Developing a micro-grid in certain areas will require additional consultation and assessment as part of the planning process. This can be the case in areas with specific designations such as:

- Sites of Special Scientific Interest (SSSI)
- Regional Parks
- Local Nature Reserves
- Local Nature Conservation Sites
- Special Areas of Conservation (SAC)
- Special Areas of Community Importance (SCI)

Generally there are no major issues relating to planning applications that are distinctly unique to a micro-grid project. All of the projects consulted stated that planning generally wasn't an issue in the case of distribution infrastructure and cabling, as most of the wiring was run underground. The biggest planning and consenting issues for projects remained around the installation of renewable generation, and help with this is available in the Planning Module of the CARES Toolkit.

However, specific consultation would be required for structures to house the electrical substation and PCC. In the case that the project is also running overhead cables on telegraph poles, the planning department may require details and engagement. As is best practice, all issues should be discussed at the earliest opportunity with your local authority.

Other statutory consultees include Scottish Environmental Protection Agency (SEPA) and Scottish National Heritage (SNH), who may have requirements depending on the type of infrastructure and hardware to be installed and operated. Again contacting such bodies early on can help you to determine what their requirements are and what actions are required on your part to meet them. Working with regulatory bodies can also allow for early identification and avoidance of potential issues.

Consenting Issues – Bright Green Hydrogen in Levenmouth

Bright Green Hydrogen is developing an innovative micro-grid in Levenmouth, Fife. Electricity is generated by a 750kW wind turbine and 160kW of solar PV on a PWN. Any excess wind energy is used by three electrolysers to create and store hydrogen, which can be repurposed back into electricity via a fuel cell, or used as fuel for a fleet of hydrogen vehicles owned by Fife Council.

Due to the nature of technological advancements that are making micro-grid projects possible, they are at the forefront of innovation including new technologies that regulatory bodies may be still establishing procedures for. Hydrogen production, storage and transportation on this scale is such an innovation that it has required consenting input from SEPA. The Bright Green Hydrogen (BGH) Project engaged with SEPA early on to establish consents required. At this stage they were asked only about groundwater release (water run-off), with no mention of hydrogen. This information was provided and BGH assumed that they were environmentally compliant. However, following construction and delivery of the project, in Oct 2016 SEPA contacted BGH informing them that they may require a permit to produce and store hydrogen under the Pollution Prevention Control Act 2014. This would come at a cost to the project of £10,000 for the permit fee alone, with additional cost associated with data collection in year one, and £2,000 for annual renewals.

At a stage of the project where construction is complete and the micro-grid is almost operational, this has been a huge concern for BGH. At present they are challenging the permit requirement, but their advice for potential developers is to do your own homework when it comes to consenting and don't just rely on the statutory authority to issue your obligations and requirements. Otherwise this risk can also be managed by making sure that a thorough assessment from regulatory authorities is undertaken at the outset.

For current information see:
http://brightgreenhydrogen.org.uk/

Breakpoint 2 – Can the Challenges be Overcome?

At this stage an assessment of the potential regulatory and legal challenges is required to understand whether the micro-grid project is worth taking forward. If the following criteria are fulfilled then the project can move forward:

- The land and access requirements for the site are feasible and affordable to secure
- There is clear potential to achieve an adequate and affordable grid connection (the The Commercial Business Models module of the CARES Toolkit provides some insight into this).
- There is potential to achieve the required planning and environmental consents for the proposed micro-grid development.
- Local residents are aware and broadly supportive of the development.

Detailed Design & Developing the Project

Deciding on Final Scope & Detailed Feasibility

At this stage the technical scope of the project needs to be firmed up and fixed. The initial scoping and evaluation will have provided clear options available to take forward, and the next step is to explore these in further detail and select one configuration to proceed with.

This will require a detailed feasibility study from a professional electrical engineering organisation. It will involve similar work to the pre-feasibility study, but in much greater depth and leading to recommendation of a fixed proposition. A good study should contain:

- An appropriate, fully costed technical design for the micro-grid ready to be developed. This should include detailed analysis and modelling of generation (energy capture), demand profiles, and control systems to manage the system
- Outline of grid connection procedures for the proposed micro-grid
- Financial model with viability assessment. This should look at the financial viability, but also assess the proposal against the purpose, vision and objectives of the micro-grid that will ultimately determine its success
- Recommended ownership structure for the project
- A detailed schedule of works for project development with accurate quotations from suppliers and contractors
- Identification of suppliers and contractors who can undertake the work
- Detailed budget plans for project development, delivery, and operation
- Details of operation and maintenance requirements

This may be be an expensive piece of work and may require financing to complete. Making sure that you have a good contractor with significant experience is essential to ensure that the design is robust and ready to take forward. Most projects we spoke to arranged a tendering process to secure a contractor for this work, issuing a specification of what was required to be delivered and inviting bids.

Contractor Issues - Eday

In Eday, the Surf 'n' Turf project is using a small micro-grid to overcome grid curtailment of the installed 900kW wind turbine. This is being achieved with the generation of hydrogen from an electrolyser connected to the turbine via a PWN. When curtailed, the wind turbine will supply the electrolyser to create hydrogen, which will then be repurposed back into electricity at Kirkwall pier. The project involves Eday Renewable Energy Ltd (ERE), Community Energy Scotland (CES), and the European Marine Energy Centre (EMEC).

The basis and rationale for the project was grid curtailment. Even after ERE had run a good tendering process for the appointment of contractors to carry out the detailed technical design and feasibility for the wind turbine connection, they ran into issues around the level of grid curtailment agreed with the DNO. The connection agreement was signed on advice from the contractor who had handled discussions with the DNO, assuming a certain level of curtailment. When energised the system was in fact curtailed at four times the assumed level, which put the whole business plan at risk.

The source of the problem was identified afterwards to be poor data that had been used in the design. However, the configuration and business plan had to be reconfigured to make the system viable once more, and eventually resulted in the 'n' Surf 'n' Turf project. This wasn't picked up by the due diligence carried out by funders and the team state that it would've been difficult to avoid this happening. However, the learning they offer is to make sure that you have contractual recourse with suppliers, and ensure that they have the appropriate insurance to protect against such liabilities.

For current developments see:
http://www.surfnturf.org.uk/

Securing Development Funding

Funding will now need to be secured to take the project forward through the next stages of development. Detail and help with types of funding and sources available are provided in the Project Finance Module of the CARES Toolkit.

Planning Application

At this stage you will need to design and submit your planning application, and applications for any environmental permits. Depending on initial consultations with SEPA and your Local Authority's planning department, and the complexities present within the project, these may require the input of consultants to prepare and submit. Help with planning is available in the Planning Module of the CARES Toolkit.

Finance for the project is unlikely to be secured until all required consents are in place, so it is important that required applications are submitted at this point in the project process.

Grid Notification

With the detailed technical design and financial viability established, a formal application for the required grid connection can now be made. The application required will depend on the connection type. More information on the detail and process is available in the Grid Connection Module, and Commercial Business Development Module of the CARES Toolkit.

For all micro-grid projects we spoke to, the grid connection application process had been undertaken by commissioned and contracted electrical engineers who had developed the detailed technical design and undertaken the detailed feasibility study.

When the DNO has assessed the application and undertaken required investigations, a connection offer will be made that outlines the conditions and costs for connections. This should be assessed and queries fully discussed with the DNO before giving them notification of acceptance of the offer.

Identify Funding for Delivery

Once the project has been confirmed as a viable financial proposition, the next step is to identify how it will be funded. Micro-grids are significant undertakings and will require a large capital investment. This may make traditional community share offers difficult to achieve to fully fund a project. However, there are many options for funding and finance and detail on project financing, including types and sources of funding is available in the Project Finance Module of the CARES Toolkit.

It should be noted that different funding sources will have different due diligence requirements and priorities for allocation of their funding. Great care should be taken to discuss these through with potential funders to understand them fully and factor them into the project plan. Additionally it is essential to make sure that any funding doesn't compromise the overall purpose, vision and objectives of the project. If it does, the community should be consulted on the details in order to make a decision.

A good example of the requirements of funders can be found on Eday, where the project is part financed by a private bank who must commission due diligence studies. The project will not receive any learning from the studies and in total they are expected to cost the project in the region of £10,000.

Full Financial Modelling

Using the detailed feasibility work, a full business plan can be developed for the selected configuration and proposal for the micro-grid. This will provide a summary of all of the detail gained throughout the process to date, and include a full detailed financial model, with projections for the micro-grid's financial operation.

The financial model will compare the cost of setting up, financing and operating the micro-grid with the projected income from the system, which may include savings in existing energy costs. Funders will have different requirements in terms of financial modelling, however, the most common method of calculating the financial performance is by way of a cash flow analysis that looks at the long term costs and income. Some projects that we spoke to, such as the West Harris Trust, contracted out the development of this model in order to make sure it was robust, and provide an added independent assessment that would help with any due diligence required. Whether you outsource this work will largely depend on the experience that you have within the project team, and how stringent you perceive identified funding to be with due diligence requirements.

Detail and help with financial modelling is provided in the Project Finance Module of the CARES Toolkit.

To develop the financial model you will need to have an idea of income and costs relating to energy tariffs. For Private Wire Networks and True Micro-grids, related tariffs will include:

- Tariffs agreed for export of generated electricity to the main grid
- Tariffs from the sale of electricity to micro-grid connected consumers.
- Tariffs for the purchase of electricity from the grid in order to supply connected customers when generation or storage connected to the micro-grid is unavailable.

For Islanded Grids, the main tariff will be that charged to micro-grid customers, although the costs of diesel if incorporating a backup generator will also need to be considered.

Export Tariffs

Tariffs for export are usually agreed as part of a Power Purchase Agreement (PPAs) arranged with PPA providers as part of the renewable generation set up. If eligible for subsidies, the export will also attract income via a Feed in Tariff (FiT) payment, or the sale of Renewable Obligation Certificates (ROCs).

Tariffs for Micro-grid Customers

Tariffs from the sale of electricity on the micro-grid are to be agreed with consumers of the electricity, and different tariffs can be arranged with different consumer based on the scale of consumption, and the time profile of when they consume.

For most projects, to make the proposition attractive it is essential that this tariff is cheaper than what consumers would pay connected to the main grid. Operating as non-profits, most communities offer a tariff that simply covers the costs associated with the project. However, others have had to negotiate different levels of tariffs to attract various different consumers connected to the same micro-grid. Funders will want to have confidence in these tariffs being agreed as they are crucial to the financial viability of the project. As such it is important to get signed letters of support or intent, or draft PPAs between you and your customers when you have negotiated a workable tariff.

One piece of learning from projects we spoke to is that the appetite and willingness of customers can change when it gets to the stage of formalising the PPA. This is an issue as the whole financial model can change (and potentially become unviable) based on this. There is not much that a project can retrospectively do to mitigate this risk, aside from carrying out prolonged re-negotiations. However, all projects highlighted that the best way to manage it was to keep constant communication open with all stakeholders and potential customers.

Tariffs for Electricity Import from Grid

For a PWN or true micro-grid, at any time when electricity is not available from generation or associated energy storage, you will need to purchase energy from the grid to ensure a continuous supply for consumers on the micro-grid. As such you will need to negotiate another PPA with a supply utility. This can be done directly or via a contracted third party broker, which is often attractive as the energy market is difficult to understand and you are usually locked into a price for either one or two year contractual agreements. However, some community groups such as Findhorn do this in house; although they appreciate that it represents one of the biggest financial risks to ongoing operation. When contracts are re-negotiated the prices offered can vary wildly due to the market, and this can have a huge impact on the operation of the micro-grid.

With all relevant projects we spoke to it was clear that importing electricity is an expensive cost that eats into the income generated from the project, and any agreements should be scrutinised carefully to make sure that the estimated grid energy requirement, and cost of it is respectively conservative and workable. This can be helped by ensuring that the technical design will minimise the need for grid import as much as possible.

Financial Modelling & Energy Costs:
Machrihanish Airbase Community Company

The Machrihanish Airbase Community Company (MACC) purchased an existing Ministry of Defence (MoD) airbase on the Kintyre peninsula with its own high voltage distribution network, for £1 in 2012. The site has been re-generated as a business park with the aim of driving socio-economic growth in the area. They set up a trading subsidiary organisation to manage the commercial growth of the site with spaces to let or hire for permanent business operations and one off events.

Installed by the MoD in 1991, the distribution network is exempt from regulation by Ofgem, and MACC own and manages the entire electrical infrastructure on the airbase, which includes metering, 25 transformers and 12km of underground cables. The distribution network was taken on with the intention of converting to a micro-grid by installing 1MW of solar generation (which would be grid curtailed to 50kW) to match perceived demand. The solar is still under development and the network currently supplies 35 electrical loads (businesses) with varying demand profiles by purchasing electricity from the grid. At this stage it is at around 25% demand capacity.

Due to the current low capacity, and lack of current local generation, the network is being run at high cost, and as a result, fluctuations in the cost of energy purchased from the grid have a dramatic effect on the viability of operation.

At contract break points the team at MACC are currently agreeing PPAs in house, but accept that this is a complex and difficult process with limited internal expertise. The team and board of MACC have tried using independent brokers, but still consider this one of the biggest financial risks of the projects operation..

For current developments see:
http://www.machrihanish.org/charity.php

Breakpoint 3 – Confirm Consents, Planning and Grid Connection

At this point of the project the following should be in place in order to proceed:

- Organisational entities to own and operate micro-grid infrastructure
- Planning consent
- Any environmental consents and permits
- Grid connection offer
- Confirmation of technical design and financial viability
- Letters of support and/or intent from proposed consumers of energy on the micro-grid at a tariff level supporting financial viability
- A good idea of funding options to take forward

Financial Close

Procurement

With the project coming to the end of the design and planning phase, procuring services and equipment is now required. Best practice for this process is to seek competitive tenders that should now be developed and issued. However, depending on the scale of the project, some projects have appointed locally known and trusted suppliers for various services. Help and guidance on procurement is available in the Procurement Module of the CARES Toolkit.

When putting projects out to tender, it is important to be as specific as possible as to what is required in the project specification. If it is not explicitly asked for, then it cannot be anticipated by those seeking to win the bid and will likely not be delivered. Much of the specification for the design of the various components of the system will have been delivered as part of the detailed design and feasibility work already carried out. Procurement is often carried out with commissioned support by technical consultants to ensure that the specification is fit for purpose.

Projects that we spoke to indicated that the key learning for procurement is that it is worth taking as much time as possible to develop accurate specifications. Some indicated that the tenders should also potentially include provisional contracts to help minimise the risk that you are exposed to and avoid any potential misunderstandings of what is required to be delivered. Including contracts with the initial tenders implies that those bidding for the tenders have accepted the terms of the contract as part of their submission.

The different equipment and services required may include:

- Project management services
- Final electrical design and installation, including procurement of all associated equipment. This may involve different contractors for installation of generation and storage hardware, the distribution network and infrastructure, and metering.
- Final design and installation of the micro-grid management and control system
- Civil contractors
- Required legal services
- Energy brokering
- Operation and maintenance services

The procurement of these services can be phased due to the critical path of their delivery and requirements. For example, it would be beneficial to procure project management support up front (if being contracted out), so that the contractor can lead with procurement and delivery for the rest of the project. Similarly the operation and maintenance contracts are likely not to need formally procuring until the end of the construction phase.

All projects indicated that it is essential to make sure that all contractors have appropriate insurances associated with their activities to manage risks associated with the work they will undertake.

Reaching Financial Close

It should now be possible to secure your chosen finance. You will need to satisfy the finance providers' process of due diligence and provide more detailed analysis of estimated system performance. This information should have been gathered already getting to this point in the process.

More detail on financing project is available in the Project Finance Module of the CARES Toolkit.

Delivering the Project

Construction

Once all of the permissions and agreements are in place, you can reach financial close and installation can commence to construct and commission the hardware for generation (if not existing), storage (if included), the electrical distribution infrastructure, the control system, and finally the grid connection.

It is essential that construction is overseen by an appropriately qualified person or organisation to ensure that the design is realised as intended, within budget and on time. This is most likely to be provided by the project management support already procured. At Levenmouth BHG were keen to stress that the project management is the essential component to a project's success, and it is important to find a supplier/person with the appropriate technical acumen and experience, as well as project management experience.

Construction should not only include hardware and software installation, but also the development and delivery of required tools and operating procedures associated with the ongoing operation of the micro-grid. This will involve a risk assessment and technical manual, but also information and procedures for:

- Submitting required data for receipt of subsidies
- Metering, invoicing and collecting payment from customers
- Providing customer service and engagement (communication strategy)
- Drawing up final PPA contracts for customers.

It is essential that the micro-grid is commissioned to the satisfaction and safety standards of the DNO, as well as the engineering consultants undertaking the design. This will involve commissioning and testing of all aspects including generation, the distribution network, loads, metering, storage, and the management system that controls the operation and frequency balancing of the system.

Repaying Finance

Any debt that is due for repayment should be paid back at this point. Development loans (where applicable) are set up to be repaid at Financial Close. The debt provided by funders should include provision for this repayment.

Operation of the Micro-grid

Following commissioning, a full package of information and training should be delivered as part of the handover process to take the system into operation. Any procured contracts or identified personnel taking on the operation and maintenance and contracts will need to be engaged at this stage to make sure that the handover is as smooth and comprehensive as possible. A full technical manual for the system should be provided including Standard Operating Procedures (SOPs) or Risk Assessment Method Statements (RAMS) that at a minimum the system manual should include:

- Roles and responsibilities for safe operation of the system
- Contact details and processes for communication with appropriate responsible persons
- Details of connected customers (energy users) and associated transformers
- Full technical diagrams and overviews of the various interconnected systems including generation, distribution, storage, loads, and control system.
- Contracts and policies for contractor
- Health and safety policy, requirements and procedures
- Incident reporting procedures and forms
- Procedures and schedules for operation of all systems
- Procedures and schedules for maintenance activities
- Procedures and schedules for different types of system faults
- Procedures and schedules for events relating to environmental consenting
- Document and record management policies and procedures

With the system commissioned and energised, PPAs can be finalised with customers and arrangements made for the ongoing supply of their electricity. This will include invoicing and transactional arrangements and communication details for customer services and queries. Clear communication of policies relating to system operation that customers need to be aware of will need to be communicated. This could include agreed limits of electrical capacity, contact details and procedures in the event of faults, and a clear summary of roles and responsibilities for users of the system. Agreements with customers may also include details of any arrangements for time based or system balancing based switching of connected loads that have been agreed as part of the PPA. Depending on the system and meters installed, manual metering may need to be carried out for accurate billing.

All of the operational groups indicated that it was essential to maintain open and frequent communication with users of the grid to make sure they remain engaged and almost take a stake in managing the system effectively. This is no more prevalent than in Knoydart where, as an islanded grid, any faults or issues can result in temporary losses of power quality or supply altogether. In this case the provision of training for a dedicated local maintenance team is essential.

In lots of cases the supplied users are actually part of the same community organisation, in which case the metering, reconciliation, billing, invoicing and customer care is very straight forward. This is the case with the Ardgour centre run by the Abernethy Trust, which is supplied by a 90kW hydro scheme that was installed in 2010. The PWN supplies the outdoor centre itself and four houses that are used as residences for instructors throughout the year. Everything is owned and operated by the Trust.

Case Studies

Case Study: Findhorn

Background

The Findhorn Foundation is located near Forres in Moray, and is an intentional eco community that was established in 1962. The Foundation operates the oldest community micro-grid in the UK – it was installed in 1987 alongside a 125kW wind turbine used to supply energy. As an ecovillage, the drivers for the Findhorn community to develop their micro-grid based on renewable generation were largely environmental. With the growth in the system to date, they have now become net aggregate annual exporters of electricity to the grid.

Micro-grid Type & Details

The generation now connected to the grid includes 675kW of wind power from three turbines. This was 750kW but the turbine installed in 1987 has now reached the end of its useful life and is being decommissioned. There are also various households in the community with domestic solar PV systems installed. Some are privately owned, but most are owned and operated by Findhorn Wind Power Ltd as an Energy Service Company (ESCO). There is also a completely separate district heating system supplied by various biomass boilers at different locations on the site.

In terms of demand, the Foundation supplies domestic and non-domestic customers including commercial activities such as pottery studios (with kilns), offices, printing studios, and the local cafes and restaurant. Currently the micro-grid supplies over 200 domestic residences and 30 commercial premises. The Findhorn Foundation is always expanding with new demand regularly the site proposed at the site.

The original distribution infrastructure consisted of telegraph pole mounted low voltage cabling and transformers, but these have been submerged over time for ease of maintenance, aesthetics, and to reduce risks associated with line faults.

The system is operated as a private wire network and controlled to maximise the use of produced renewable energy on site. If there is a surplus or deficit in supply from local generation, the system will automatically switch to respectively export or import electricity from the grid.

The micro-grid is operated and maintained by an in house team, but FWP and NFD have external contractors and suppliers for services when required. These relationships have been built up through years of operating the grid.

Organisational Structure & Business Model

With the original 125kW turbine, one community company called New Findhorn Direction Ltd (NFD) was set up to run and manage the generation of energy and the retail of it to consumers on the grid. It operated as a license exempt supplier of electricity for customers on the site.

The further three turbines were proposed when the Renewables Obligation scheme came into effect and the available subsidies made it more attractive to develop. They were installed and commissioned in 2006. At this stage Findhorn Wind Power Ltd (FWP) was set up to own and operate the turbines in order to maximise the subsidies available in the form of Renewable Obligation Certificates (ROCs). NFD then became the owner and operator of the micro-grid only, and effectively just the license exempt retailer of electricity to consumers at the Foundation. The benefit is that FWP can gain ROCs from exported generation, but also from the sale of the renewably generated electricity to NFD. If NFD had continued to operate generation and supply as one company, it would only be able to claim export ROCs. This is the set up currently in operation.

With installed solar PV, FWP Ltd operates as an Energy Service Company (ESCO), in that it owns the infrastructure and receives the Feed in Tariffs from their generation, and the residents hosting the system receive free electricity.

Funding

Original funding for the first turbine was raised through a community investment in the 1980s. At this stage no subsidies were available, so Findhorn lead the way to some extent in demonstrating the viability of community energy projects. At that stage the electricity generated amounted to 20% of the demand on the site.

The further three turbines and micro-grid development were funded through initial research grants from the Scottish Government, investment from funds from NFD from prior operation of the micro-grid, community development investment from Ektopia Ltd, and investment form Energy4All Group.

Key Findings & Learning

The biggest challenge facing the operation of the micro-grid is the uncertainty in the import cost of electricity. With contracts lasting one or two years (depending on which you choose), there is an ongoing battle to secure a tariff financially workable for the system. The market seems distorted as export tariffs and retail tariffs remain reasonably constant, but the import prices vary wildly. Findhorn’s import PPA is soon to be up for renewal, and they are currently facing a 35% hike in costs. They are keen to get external expertise in to aid getting a better deal, however, there are issues of cost and trust associated with this, and are unsure who to approach.

For more detail see:

http://www.ecovillagefindhorn.com/findhornecovillage/wind.php

Case Study: Bright Green Hydrogen in Methil, Levenmouth

Background

Still under development, the idea for the Bright Green Hydrogen (BGH) project was hatched in 2014 and was based around a zero carbon business park utilising an existing electrolyser that was used to power a hydrogen fuel cell as part of the previous Hydrogen Office Project. The project is a collaborative venture between BGH, Fife Council and Toshiba, and has been funded through the Local Energy Challenge Fund administered by Local Energy Scotland. The proposal is based around a micro-grid incorporating hydrogen production and storage, to supply a business park, nearby premises, and a fleet of vehicles owned and operated by BGH and Fife Council.

Micro-grid Type & Details

Electricity is generated by a 750kW wind turbine and 160kW of solar PV on a PWN that existed as part of the prior Hydrogen Office Project. This connected in parallel to a smartly controlled true micro-grid that switches supply between its main grid connection and the renewable generation available through the PWN. Any excess wind energy is used by a 250kW electrolyser, to create hydrogen. 50kg of this can be stored or it can be repurposed back into electricity via a 100kW fuel cell, to be used as fuel for a fleet of hydrogen vehicles owned by BGH and Fife Council.

In terms of demand, the project supplies three non-domestic loads on the PWN and five non domestic premises on the smartgrid. These include the business park offices, a nearby boat club, the Fife Renewables Innovation Centre (FRIC), and a nearby childcare centre and football stadium. The rationale for opting for a parallel smartgrid instead of extending the PWN was that for the scale of demand, a much larger capacity transformer for the grid connection would be required and was uneconomical. Additionally, Toshiba joined as a project partner to specifically demonstrate their smart Hydrogen to Energy Management System (H2EMS). This meant that the control required for the smartgrid was sufficient.

The smartgrid works on an either/or switch between the renewable energy or main grid supply. This is managed autonomously by the Toshiba system, which is advanced enough to incorporate weather (and renewable resource) forecasts to calibrate requirements three days in advance.

The project is still under development and has been incredibly complex to deliver technically, especially working to integrate the hydrogen refuelling systems into the grid. The grid connection procedure has been difficult too because of the scale of generation, and the complexity of the configuration and smart management system. Many tests have been required in order to make sure that the system can reach the DNOs safe standards.

Organisational Structure & Business Model
The PWN, smartgrid and generation will all be owned and run by BGH Ltd. As a demonstration unit, Toshiba will maintain ownership of the smart management system for the smartgrid.

PPAs have been developed by legal contractors and will be held between BGH and energy consumers. These are yet to be finalised until the project is complete, however, they have required significant negotiation with individual commercial consumers.

BGH intends to handle the operation of the grid and manage the relationships and contracts with customers. They will do this as license exempt suppliers.

Funding
The project has been funded through the Local Energy Challenge Fund (LECF) administered by Local Energy Scotland (LES), along with partner contributions.

Key Findings & Learning
There have been many challenges for the BGH team, which encompass all aspects of project delivery. We have highlighted the key learning points below.

The first is to pay attention to the political context in which the project is happening. The project was unfortunate in that at the time the contracts were signed to install the solar PV system, the FiT rates were dropped by the government. Without any pre-accreditation completed or grandfathering, the project was left with a large financial gap in projected income.

The project has also suffered from not having one team or contractor responsible for controlling the overall design. This is essential due to the technical complexity of the project. Developments so far have happened with little bits of design responsibility for the individual parts and contractors. It is essential that someone is responsible for ensuring that all the components integrate.

Projects should not underestimate project management costs. BGH budgeted 5% of the total project costs for project management. In reality, and given the technical and political complexity, this should have been more like 20%.

Be realistic about your project timescales. The BGH project has overrun significantly, which is result of various issues along the project journey. However, overestimating time requirements and adding contingency time into the project is essential. Especially if there is technical complexity present that will require significant DNO input, and potential for complex legal agreements to be struck with commercial and public sector organisations.

For procurement, if the project is of a scale that it needs to be tendered through Public Contracts Scotland (PCS) then would advise getting a specialist to write the tender (with a contract) to ensure you get what you need.

For more detail see:

http://brightgreenhydrogen.org.uk/home/hydrogen-office-project/

Case Study: West Harris Trust - Talla na Mara Community Centre

Background

The Talla na Mara Community Centre in Horgabost, West Harris, was opened in March 2017 after five years of development. The West Harris Trust commissioned a community survey in 2012 to identify local needs. The resulting vision and purpose for the community included opportunities for employment, development of a community meeting point, nearby space for communal working and facilities, and the development of sustainable income streams.

Following a feasibility study in autumn 2012, the proposal for a community enterprise centre was put forward, that would be powered and heated from a nearby wind turbine. The site incorporates commercial space for organisations including office space and studio space for local artists. It also has a restaurant and capacity to host large events, as well as campsite hook-ups for tourists. Additionally, the site also includes six residences for a local housing association, which are all supplied electricity from the turbine.

Micro-grid Type & Details

The micro-grid is operated as a PWN interfacing with the grid via a G59 connection. Although originally designed with a 60kW turbine, design flaws in the maintenance regime for the original turbine, meant that an alternative needed to be found. As such a higher capacity turbine was selected and a 100kW machine is now installed.

The system wasn't originally going to incorporate a micro-grid, but due to the higher capacity turbine to be installed and the involvement of the housing association, a collaborative approach was taken to explore the installation of a micro-grid.

The system runs electricity to the community centre and the six housing association properties. When excess generation is present, electricity is firstly used by two thermal stores of water to eventually heat the community centre. These are two large 5000L cylinders. If there is excess capacity after this it is then exported to the grid.

Organisational Structure & Business Model

The micro-grid is owned and run by the West Harris Trust as a license exempt supplier. A trading subsidiary of the Trust called West Harris Renewables Ltd part owns the wind turbine as part of a Special Purpose Vehicle set up to fund and develop it.

The trust has PPAs drafted and agreed in principle with the tenants of the housing association properties, to which it is charging a fixed rate tariff to cover costs with a slight surplus for development and contingency.

Funding

The funding for the project was provided from various sources including the Scottish Government, The Big Lottery Fund, Comhairle nan Eilean Siar (Western Isles Council), Highlands and Islands Enterprise (HIE), The Coastal Communities Fund, The Robertson Trust, Scottish Hydro Electric Community Trust and an in kind contribution from the West Harris Trust.

Key Findings & Learning

The project has been developed with success and has encountered only minor issues given the scale and complexity of the undertaking.

This has in part been due to the clear inclusion of the community as a driver in the process of development. The socio economic benefits of the centre are clear and came from community need, so when any issues with land tenure were faced, it was straight forward to consult and arrange the agreements required.

In terms of procurement, the WHT team recommend that you should be as specific as possible with tender specifications to make sure that the required services are delivered.

One piece of learning was also around the contestable work agreed to be undertaken by the DNO. Some cabling supplied up to the meters of the residential housing was provided and installed by the DNO. However, WHT found out that they could have undertaken the work at a much cheaper cost. As such they recommend that you scrutinise the contestable work as much as possible to see if you can reduce costs.

For more detail see:

http://www.westharristrust.org/

Matrix of Community Micro-grid Projects in Scotland

Table 1: Matrix of Community Energy Micro-grid Projects in Scotland Consulted as Part of this Study

Community	Type of Micro-grid	Generation Technology	Types of Load	Includes storage?	Operational?	Website Details
Abernethy	Private Wire Network	90kW Micro Hydro	Domestic and Non-Domestic	✓	✓	http://www.abernethy.org.uk/our-centres/ardgour/
Applecross	Proposed Private Wire Network	Local generation from 90kW hydro scheme - currently constrained to 50kW.	Domestic and Non-Domestic	✗	✗	http://www.applecrosshydro.scot/
Eday	Private Wire Network	900kW wind turbine and hydrogen production	Non-Domestic	✓	✗	http://www.surfnturf.org.uk/
Fetlar	Private Wire Network	Two 25kW wind turbines	Domestic and Non-Domestic	✓	✓	http://www.fetlar.org/fetlar-developments-ltd
Findhorn	Private Wire Network	Generation comprised of three 225kW wind turbines and domestic solar PV	Domestic and Non-Domestic	✗	✓	http://www.ecovillagefindhorn.com/findhornecovillage/renewable.php

Knoydart	Islanded Grid	200kW Micro Hydro system	Domestic and Non-Domestic	✗	✓	http://www.knoydart-foundation.com/about/about-the-foundation/knoydart-renewables/
Levenmouth	Private Wire Network & True micro-grid	750kW wind turbine, 160kW of solar PV, and hydrogen production	Non-Domestic	✓	✗	http://brightgreenhydrogen.org.uk/home/levenmouth-community-energy-project-2/levenmouth-community-energy-project/
MACC	Proposed True Micro-grid	Proposed 1MW of Solar PV	Non-Domestic	✗	✓	http://www.machrihanish.org/charity.php
Vatersay	Proposed Islanded Grid	One 900kW wind turbine, currently constrained and connected to National Grid.	No micro-grid infrastructure currently. Planned loads include district heating for 22 domestic households. Potential for a school, hospital, or swimming pool depending on grid location.	✗	✗	http://www.isleofbarra.com/coimhearsachdbharraigh.htm
West Harris Trust	Private Wire Network	100kW wind turbine with thermal store to supply heat to community centre	Domestic and Non-Domestic	✓	✓	http://www.westharristrust.org/

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