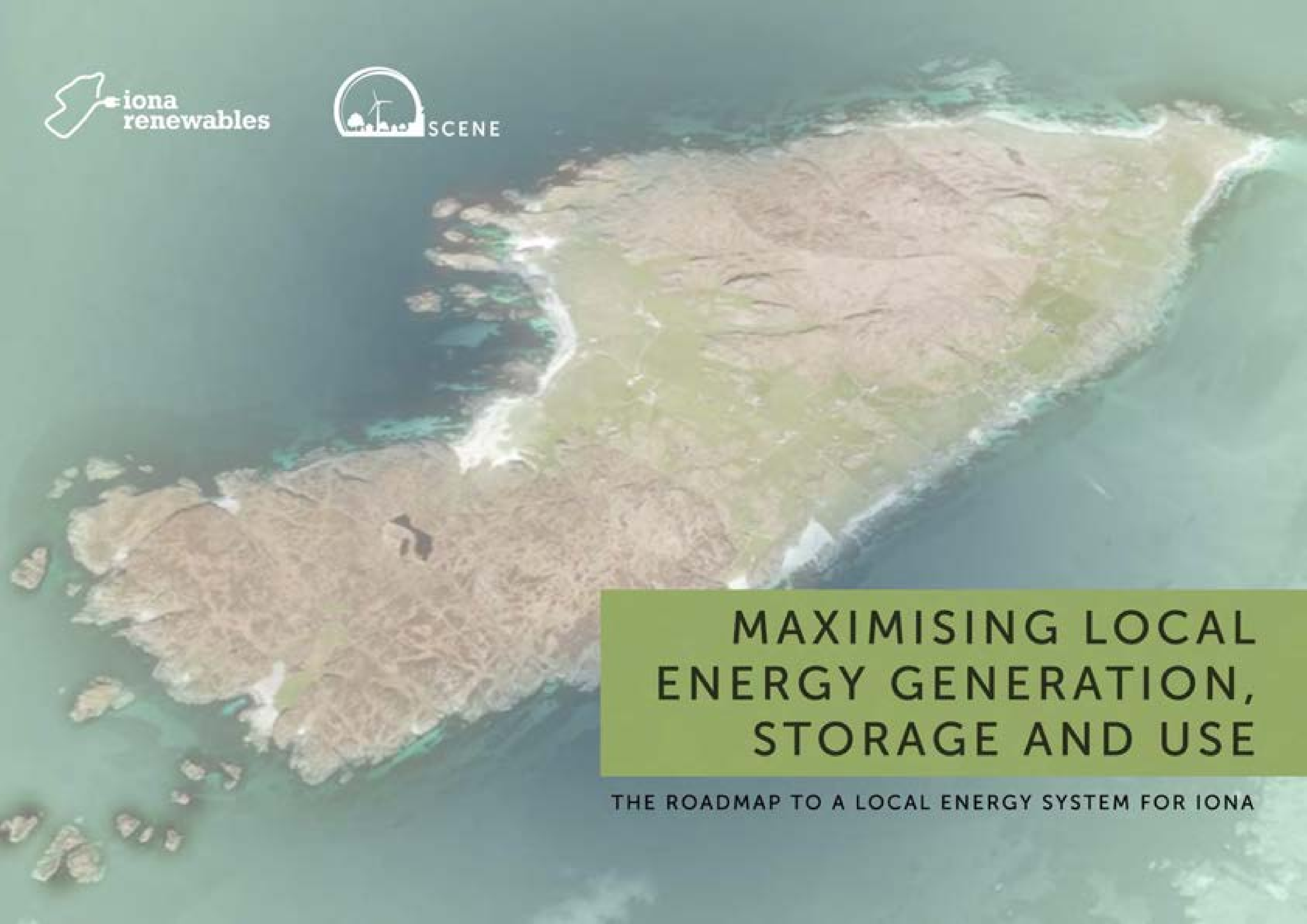

iona renewables

SCENE

MAXIMISING LOCAL ENERGY GENERATION, STORAGE AND USE

THE ROADMAP TO A LOCAL ENERGY SYSTEM FOR IONA

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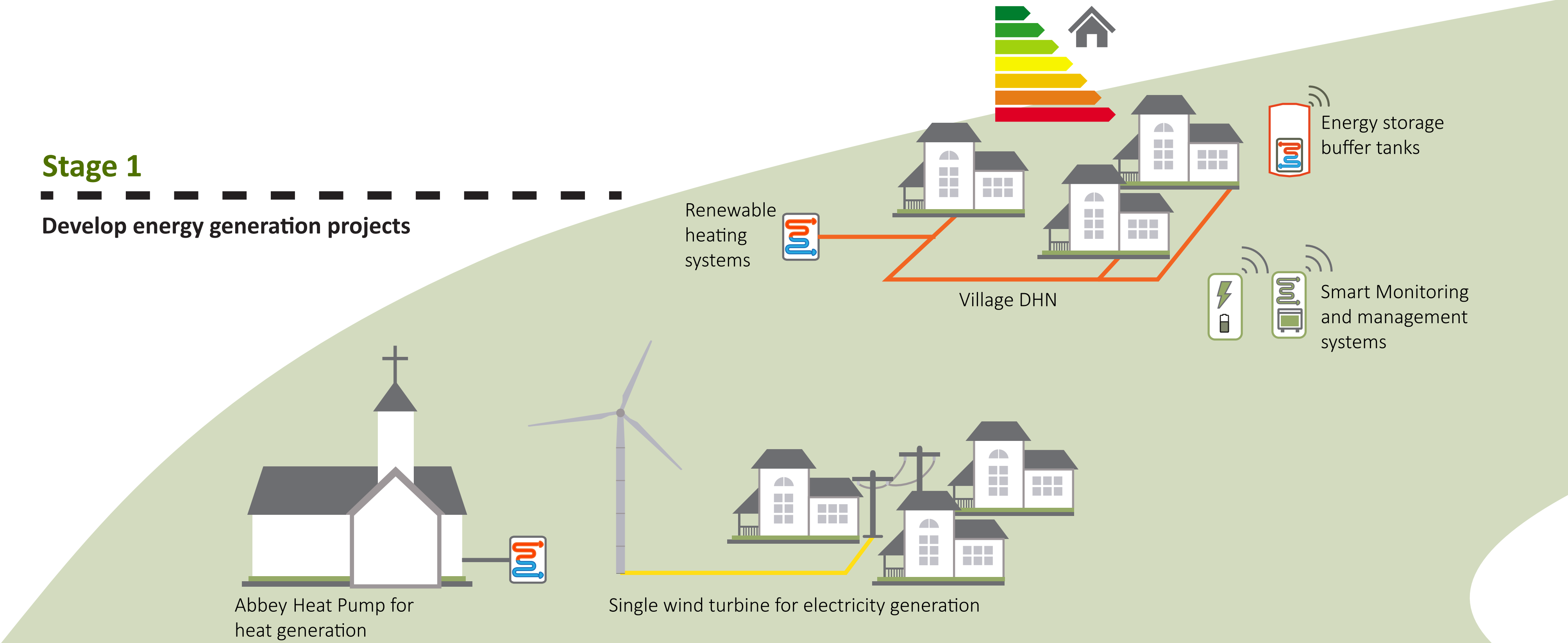

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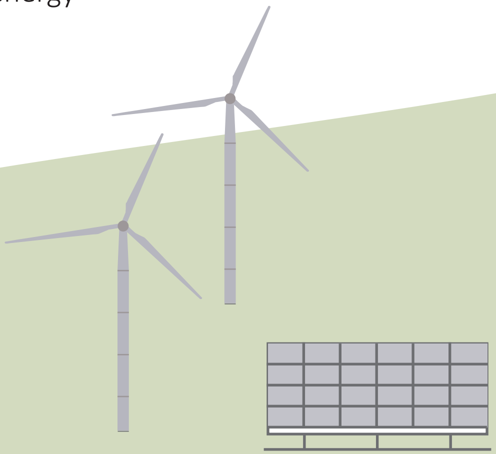

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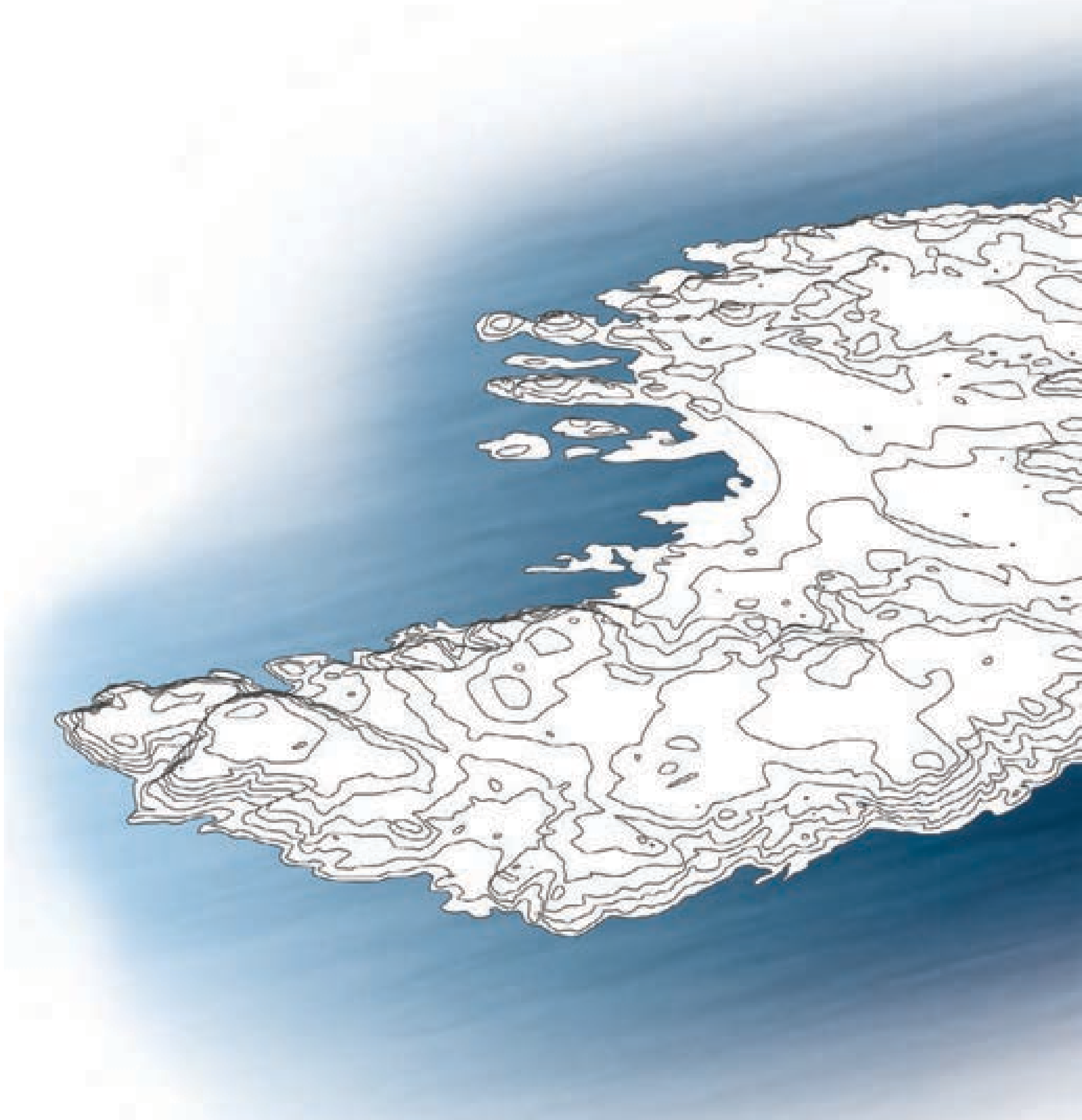


INTRODUCTION

DEVELOPMENT OF THE ROADMAP

Scene Connect Ltd. was appointed by Iona Renewables to work with the community to develop a Roadmap to maximise local renewable energy generation, storage and use on Iona.

The scope of the collaboration has been wide ranging, reviewing all viable renewable energy generation technologies, energy storage, and demand management - and working to deliver high impact first phase developments with community ownership and operation.

The energy masterplan is a community-led scheme, with engagement an essential part of the project. The goal of working towards generating, storing and using 100% of the island's energy from renewable sources is ambitious. The roadmap takes an evidence based approach in identifying and phasing opportunities, with focus on a deliverable and scaleable first phase for implementation.

iona renewables

Iona Renewables ("IR") is a community organisation, formed as a sub-group of the Community Council to investigate opportunities to take greater control of energy on Iona – to increase local ownership, and to decrease carbon emissions.

IR is integrally part of the island community, with deep and extensive relationships. It originated within Iona Community Council and is therefore part of the statutory representative structure of the whole island. The steering group comprises representatives from Local Energy Scotland ("LES"), Historic Environment Scotland ("HES"), Iona Community ("IC") and National Trust for Scotland ("NTS").

IR is in the process of being constituted as a Scottish Charitable Incorporated Organisation ("SCIO") with environmental protection and community development as its charitable purposes. IR is responsible for developing opportunities and managing delivery of these up to the stage of investment: ownership and operation of energy supply will be undertaken by trading subsidiaries, with operational surpluses gifted to the parent charity.

SCENE

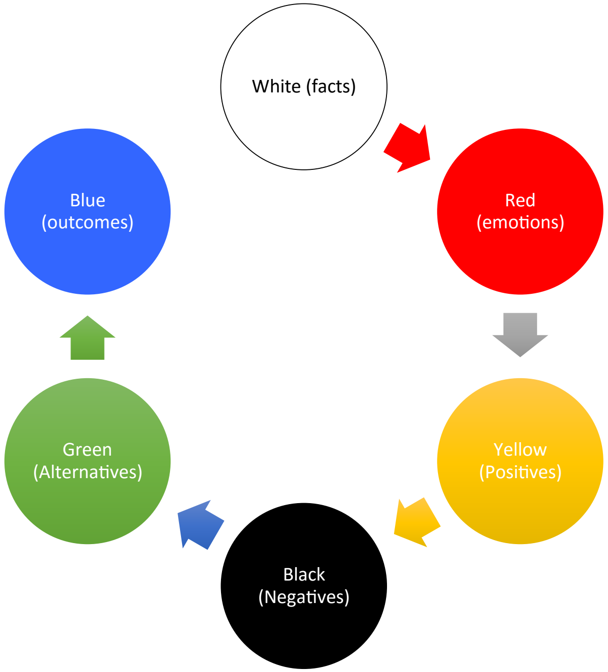
Scene is a social enterprise focused on strengthening communities through consultancy, research and development of ICT products. The organisation works across the renewable energy and energy access sectors.

Founded in Edinburgh in 2011, they have built a reputation as one of Scotland's foremost community energy organisations, and have an emerging standing as action researchers and product developers in energy access.

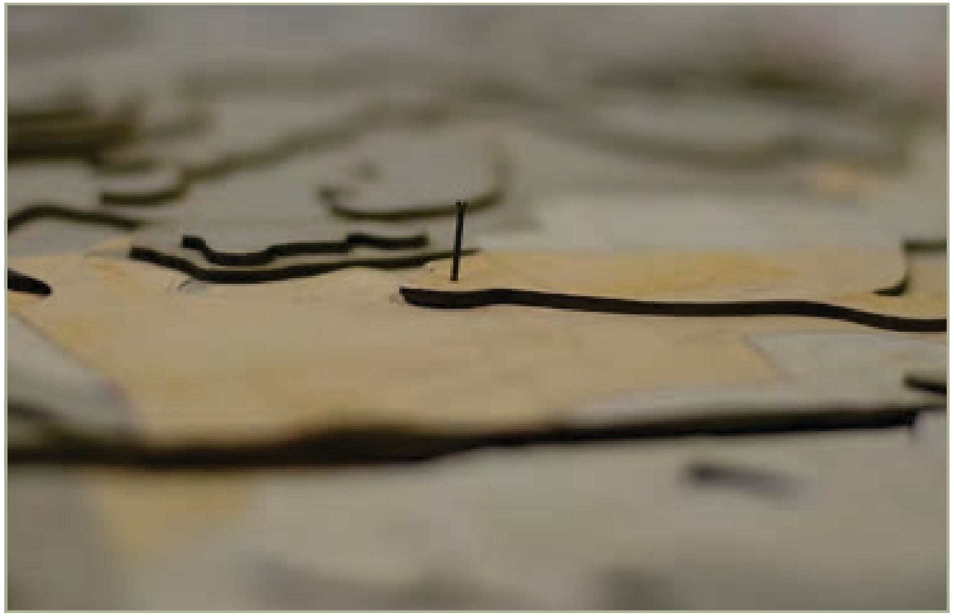
Scene is represented in Edinburgh, London and India - with projects ongoing in countries around the world.

Since forming, Scene's core mandate has been to address the gap between energy generation and citizens. We set out to reduce the size of this gap, by helping non-specialists develop their own renewable energy solutions. We now work across a broader range of sectors, but to the same ends - to bring power and capability closer to home.

COMMUNITY ENGAGEMENT



Iona Renewables' partnership with Scene has resulted in a community engagement process which has been promoted as a model of good practice by funders. Components include use of leafleting, social media and cross-island email campaigns to engage, inform and mobilise all residents & second home-owners and businesses; community consultations with exceptional levels of attendance and participation; and working with the school to build capacity and momentum amongst the island's children. The engagement process is central to the overall project in building a coherent bottom-up community-led vision. The approach is based on using the technical expertise of the project team to provide information that enables the community to make informed decisions on priorities, builds consensus on the way forward and clarifies a community mandate to explore specific options.



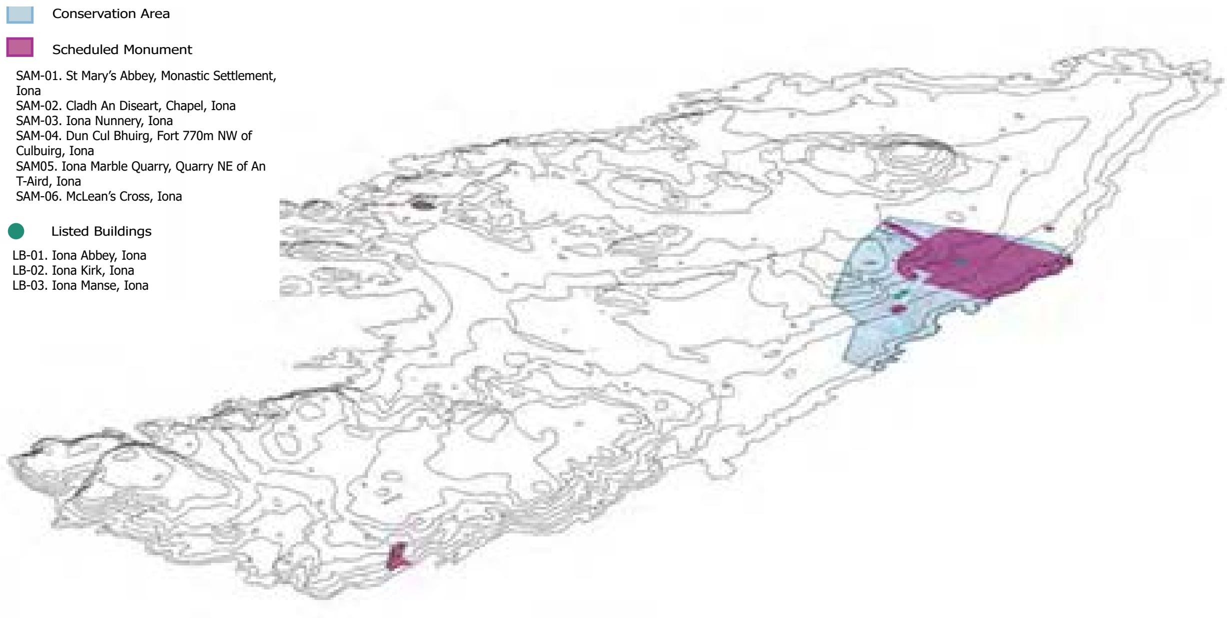
Ongoing dedicated community consultation events which have taken place so far comprise:

- First public meeting at Village Hall, May 2016, with over 1/3 of island residents participating. Strong support for investigating reinstatement of heat pump at Iona Abbey – proactively brought up as an idea by the community – which was the catalyst for the Village Heat project.
- Second community consultation event, October 2016 – again approximately 1/3 of residents and high level of engagement and discussion. Principles and components of the local energy masterplan for the island were discussed in a 'consultation café' format, combining presentation boards and round table discussion on various proposals, including discussion of Village Heat project. Event facilitated by Scene and supported by Home Energy Scotland.
- Third community consultation event, April 2017 – same high levels of attendance and high quality of discussion. Strong support for the overall roadmap and each of the high-impact first phases.

The whole community has been involved, including interactive engagement with pupils at Iona Primary School, to encourage and catalyse energy efficiency measures and carbon saving behaviour in their homes – with first session held in May 2016, and follow up event scheduled for the end May 2017.

Each development opportunity identified as a high-impact, first phase for delivery, has emerged out of this bottom-up process and has very strong community support. The principle of generating income for community benefit is also strongly supported.

BASELINE



CULTURAL HERITAGE

The island of Iona is uniquely important in terms of its cultural heritage due to its association with St. Columba. There are a number of nationally important assets on Iona, protected through Scheduled Monument and Category A Listing designations, and the Village is designated as a conservation area.

Cultural heritage is important in relation to the visitor experience, and the local economy - but it also needs to be considered in the context of the cultural heritage asset and the way in which it relates to its setting, which may not relate to locations with regular visitor access. The heritage needs to be considered in its own right. Effects can be direct, or indirect.

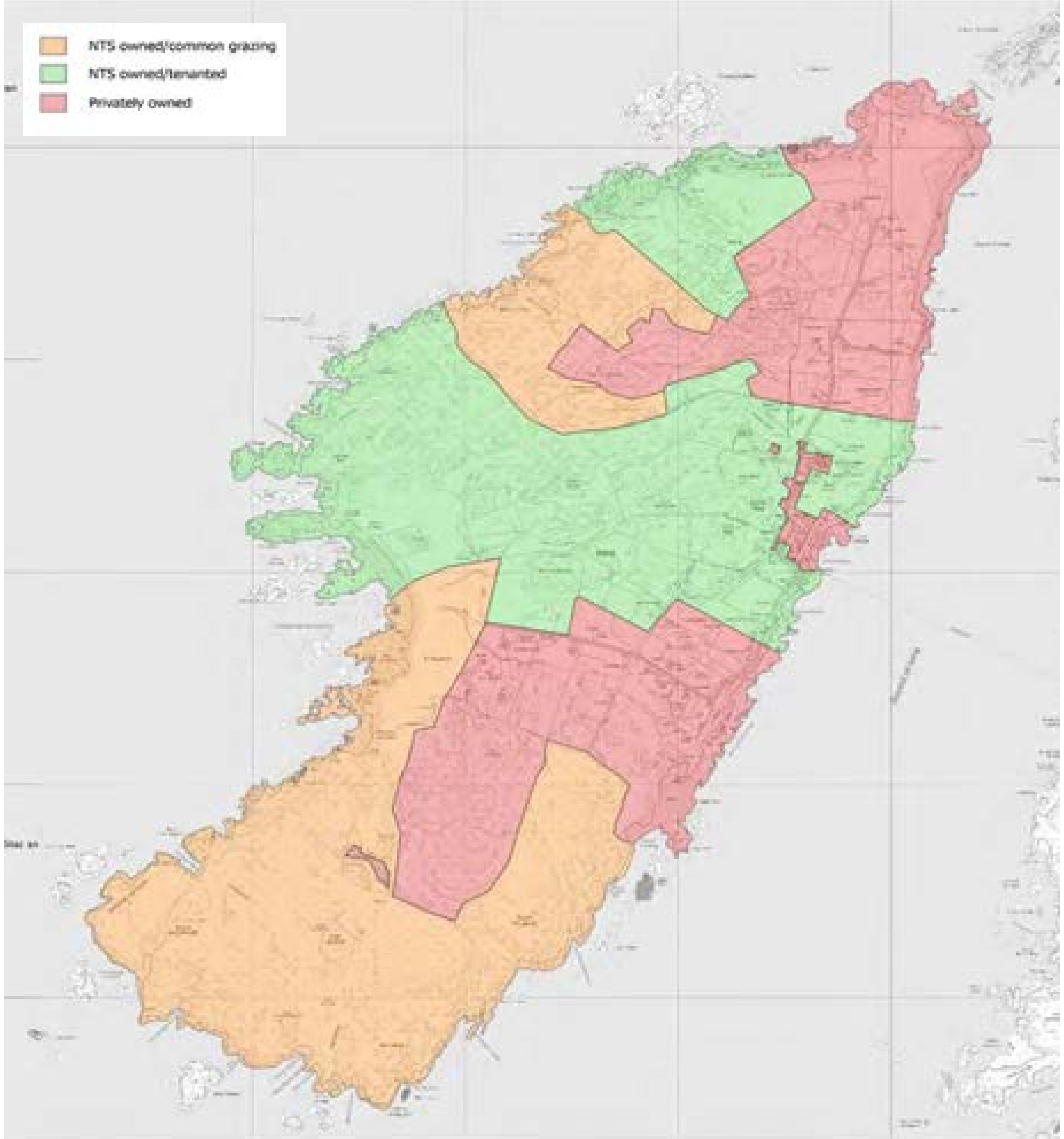
Direct effects may arise in relation to ground disturbance associated with the construction and operation of development or ancillary infrastructure. The greater the area of ground disturbance, the higher the potential for direct effects to arise. There is also the potential to uncover previously undiscovered heritage during any construction works. While it may be possible to locate (or re-locate) new development to avoid direct effects, this may cause delay or expense. Indirect effects relate to setting, and are best assessed by a cultural heritage professional.

NATURAL HERITAGE

The natural heritage of Iona is sensitive to development and site specific survey is likely to be required to accompany any planning application, to consider potential impact on designated areas or protected species. An area around Baile Mor is designated as 'Semi-Natural Woodland Inventory'. This is a national designation, which is non-statutory, and does not necessarily relate to existing woodland, but to the presence of woodland on historical mapping. There are also a number of sites which are designated as Local Nature Conservation Sites (LNCS).

The sea around Iona forms part of a candidate Special Area of Conservation (Inner Hebrides and the Minches) and Marine Protected Area proposal (Sea of the Inner Hebrides). This is an extensive area, extending from the western edge of Mull in the east to the eastern edge of the Outer Hebrides, identified for the presence of Harbour Porpoise.

Beyond the designated areas, there is the need to minimise adverse effects on individual species and habitats. Initial consultation indicates that the main species of sensitivity are likely to be birds – there are sightings of a number of Birds of Conservation Concern (BoCC 4) Red list species (Starling, Thrush, Twite, Herring gull, Skylark, Lapwing, Corncrake) and Amber list species (Snipe, Oyster catcher, Dunnock). Some of these, as well as Peregrines, are also identified in Argyll & Bute's most recent Local Biodiversity Action Plan (2010 – 2015).



LAND OWNERSHIP

A landowner agreement will be necessary not only for the footprint of any development, but also for construction and operational access. The contract with the landowner may be subject to a rental agreement or one-off payment. The time and cost required to secure the agreement should be factored into the development programme.

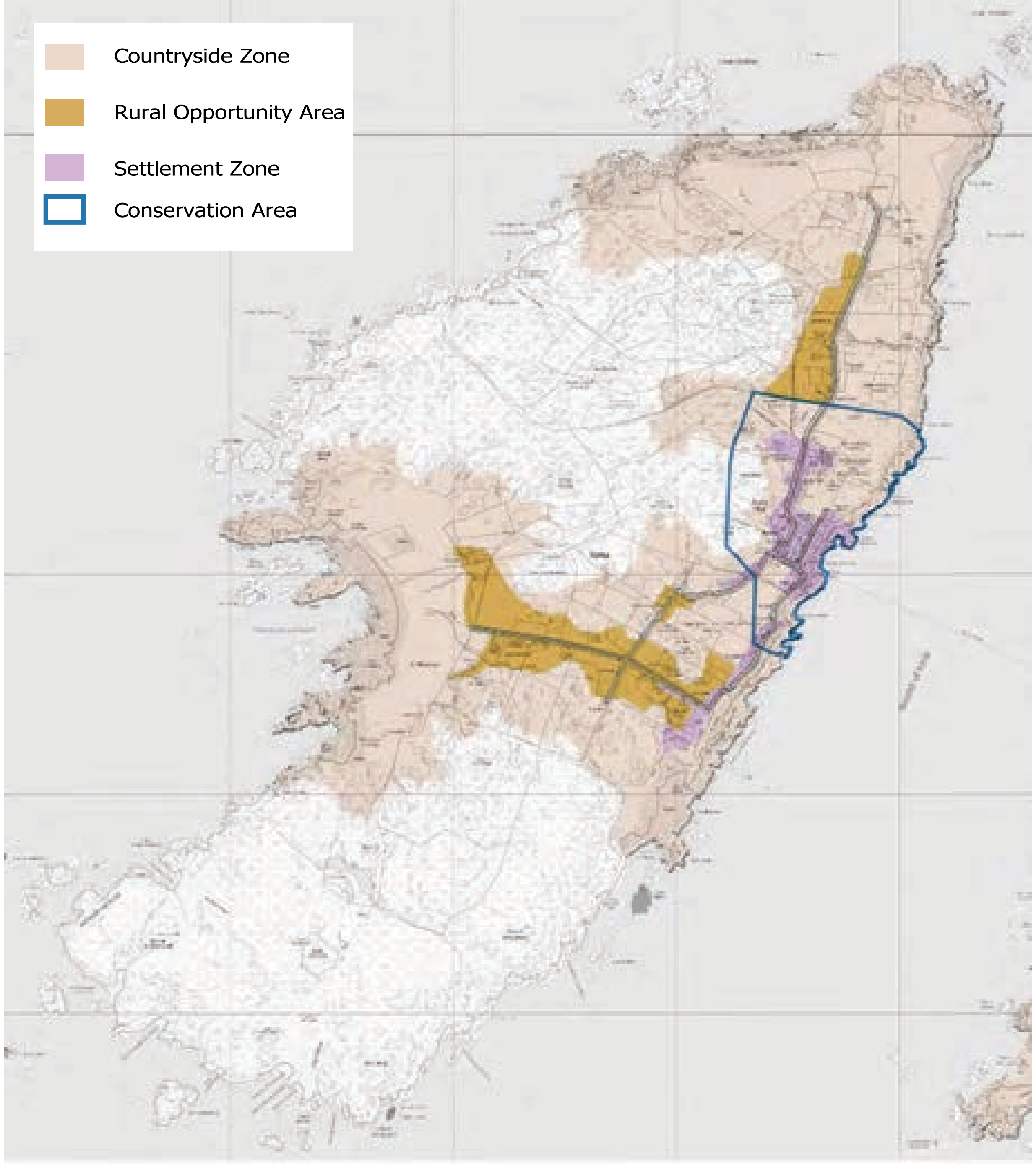
While utility companies have statutory development rights, these do not currently apply for heat and power networks installed by others. Permission from all individual landowners will be required prior to development.

The main land owner on Iona is NTS. The land in its ownership is either tenanted or subject to common grazing rights. NTS ownership and type of tenancy need to be factored in to the timescales and approvals for securing landowner agreements for development.

Discussions have taken place with NTS' Estates Department in relation to the process for securing option agreements / wayleaves. This process requires approval from Asset Management, senior management and finally the Board, and is a 3-4 month process. This process will need to be taken into account in project programming.

Other parts of the island are in private ownership, with a variety of different land owners. The public road network is assumed to be in Argyll & Bute Council ownership.

Iona Abbey is a Scheduled Monument owned by the Iona Cathedral Trust. Historic Environment Scotland (HES) is the Principal leaseholder, with the Iona Community (IC) as tenant. Responsibilities for the building are split or shared between HES and IC depending on use and function.



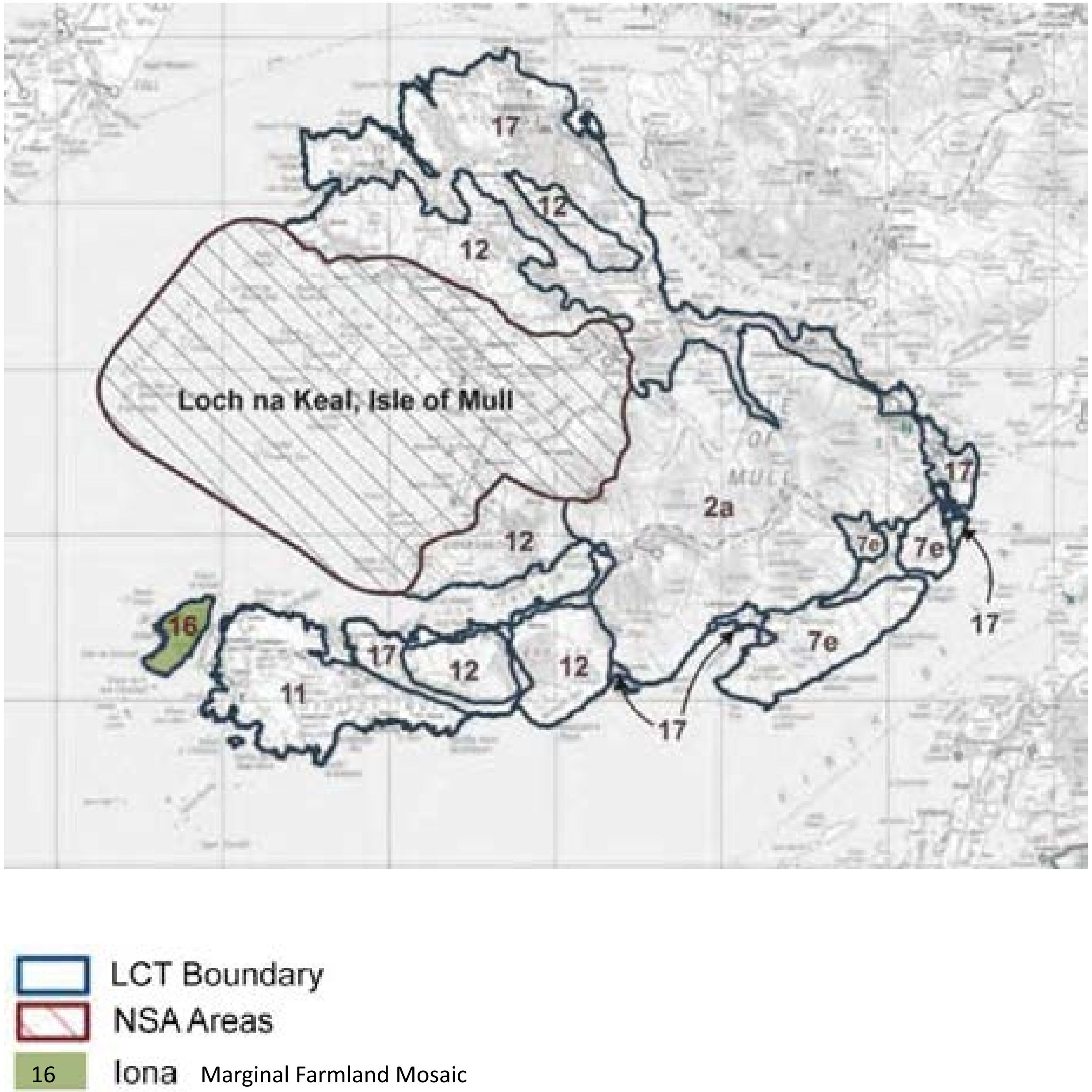
LAND USE AND AMENITY

The main land use on the island is farming, by area, with tenant farmers or common grazing rights on NTS' land.

The Local Development Plan defines the Conservation Area boundary around Iona Village, and Development Management Zones over other parts of the island. However, the policies related to these zones do not specifically apply to renewable developments.

Residential amenity is an important consideration in the siting of new development. For wind turbines, potential effects on noise, visual amenity and shadow flicker would need to be considered. For solar PV arrays, visual amenity would be relevant. Noise and visual amenity may also be considerations for biomass or heat pump proposals. Impact modelling may be required, depending on the proximity of proposed development to residential receptors.

The amenity of visitors is also relevant. As well as visitor destinations, any assessment of impact should also consider key tourist routes and viewpoints.



Basemap source: *Argyll and Bute Landscape Wind Energy Capacity Study*, 2016

LANDSCAPE CHARACTER

Within the Argyll & Bute Landscape Wind Energy Capacity Study (LWECS), the landscape character of Iona is categorised as ’16, marginal farmland mosaic’. Within this character type, the LWECS guidance on development capacity identifies opportunities for the small typology (20-35m). Specific guidance is provided later in the study on micro-siting smaller turbines to be in scale with the characteristics of the landscape. There is no specific guidance on Iona and therefore engagement has taken place with the Council’s planning department to clarify how the policy guidance would be applied:

January 2016: meeting with Senior Planning Officer to discuss planned project approach and seek preliminary steers from planning:

- This is an “exciting, incredibly worthwhile project”
- Wind is the most sensitive component being investigated but there are no absolute prohibitions
- The guiding principle is relative scale (LWECS Chapter 7) – installations should be in reasonable proportion to landscape and key buildings
- Visual impact needs to be weighed up with positive benefits for the island – see community benefit

October 2016: meeting with Senior Planning Officer and planning officials:

- Initially opposing any scale of wind development, the agreed position was that there is no in principle basis on which to refuse consideration of a single turbine
- Following internal discussion with senior colleagues and Head of Planning, a verbal steer that a suitably scaled and sited turbine could be acceptable. Site specific assessment would be critical and the decision would be determined on its own merit, taking into account the level of community support, which would be a material consideration

GRID

Initial consultation has established that while the grid capacity on Iona is adequate for the island's needs. However, there is very limited (~50kW) export capacity. Although the Roadmap strategy aims to use any electrical energy generated on Iona and not export, the Distribution Network Operator (DNO) may not allow connection to the electrical network where there are constraints. A number of different research initiatives are underway nationally to trial examples of active network management, control electronics and flexible local loads. These include:

- ACCESS (Mull)
- SMART Fintry
- Heat Smart Orkney

Preliminary engagement has commenced with the DNO to establish whether a similar approach may be possible for Iona.

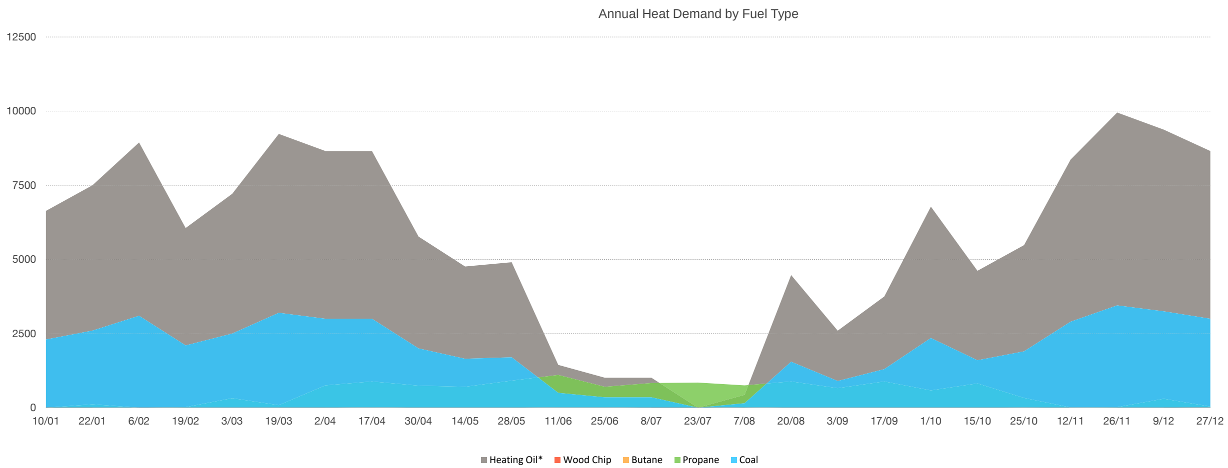
MISCELLANEOUS ISSUES

A number of miscellaneous issues may need to be taken into account when considering renewable energy development. These may include:

- Access and transportation
- Existing infrastructure and telecommunications
- Aviation
- Air quality and climate
- Health and safety

The scale of development proposed for Iona is not anticipated to impact adversely on these issues, but site specific assessment may still be required to confirm this.

ENERGY DEMAND & STORAGE



ENERGY AUDIT

An Energy Audit for the Isle of Iona was undertaken in 2015. This established annual figures by fuel type – heating oil, electricity, coal, propane, wood, butane and petrol/diesel – which were translated into MWh and CO2 equivalents. It also provided breakdowns by sector.

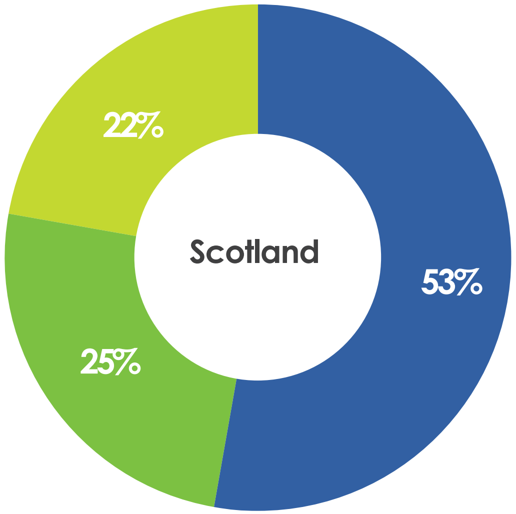
Iona's total energy consumption, including transport but excluding the ferry and staff boat figures, is 4,419MWh. Including the ferry and boat, total consumption is approximately 6,819MWh. These total figures are useful to provide an indication of overall energy use, but need to be analysed in more detail to determine how generation can be matched to demand as closely as possible.

Non-electrical heat energy (i.e. coal, gas, oil) over a calendar year (based on fortnightly deliveries) has been modelled to give an indication of energy demand profile.

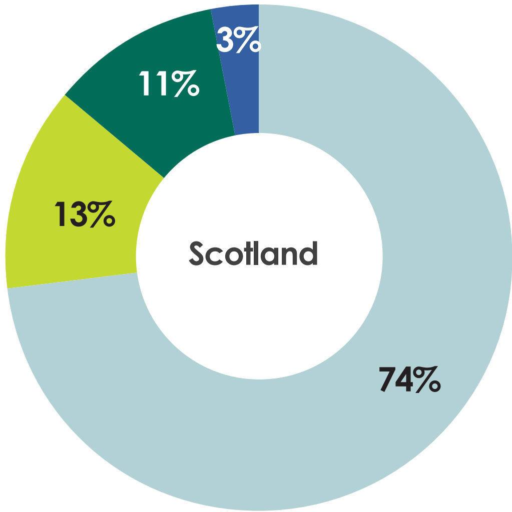
This data illustrates that heat demand in June and July is very low, which is important in getting a broad understanding of base, mid and peak load requirements.

As well as calculating the amount of energy consumed on the island, 100% of which is imported, the audit also calculated the overall annual cost to residents and businesses for their energy use, 100% of which is currently exported off the island again. The Audit indicates that an estimated £100,000 is spent annually on non-electrical heat. Electrical tariffs on the island vary widely depending on supplier and amount of energy used, but using a conservative figure of 12p/kWh (reflecting the lowest charges for large energy users on Iona), an estimated £210,000 is spent annually on electricity. At least **£310,000** is spent every year on energy supply alone.

Energy demand in Scotland



Household energy use in Scotland



Source: Scottish Energy Strategy:The future of energy in Scotland, 2017

DEMAND PROFILE MODELLING

In order to better understand the amount of generation and storage required, there is a need not only to assess the overall energy demand (as determined by the Energy Audit), but the energy demand profile. The demand profile can be considered as four-dimensional data:

- Location (i.e. where the energy is used)
- Type (i.e. electricity or heat)
- Quantity (i.e. intensity of load)
- Time (i.e. when the energy is used)

For designing the energy supply system(s), it is also necessary to understand the existing energy sources and distribution system(s).

In Scotland, heat accounts for 53% total final energy consumption (and 47% of emissions), with 25% for transport and 22% for electricity. However, this statistic is based on non-electrical heat demand, with 78% of Scottish households using mains gas as their primary heating fuel.

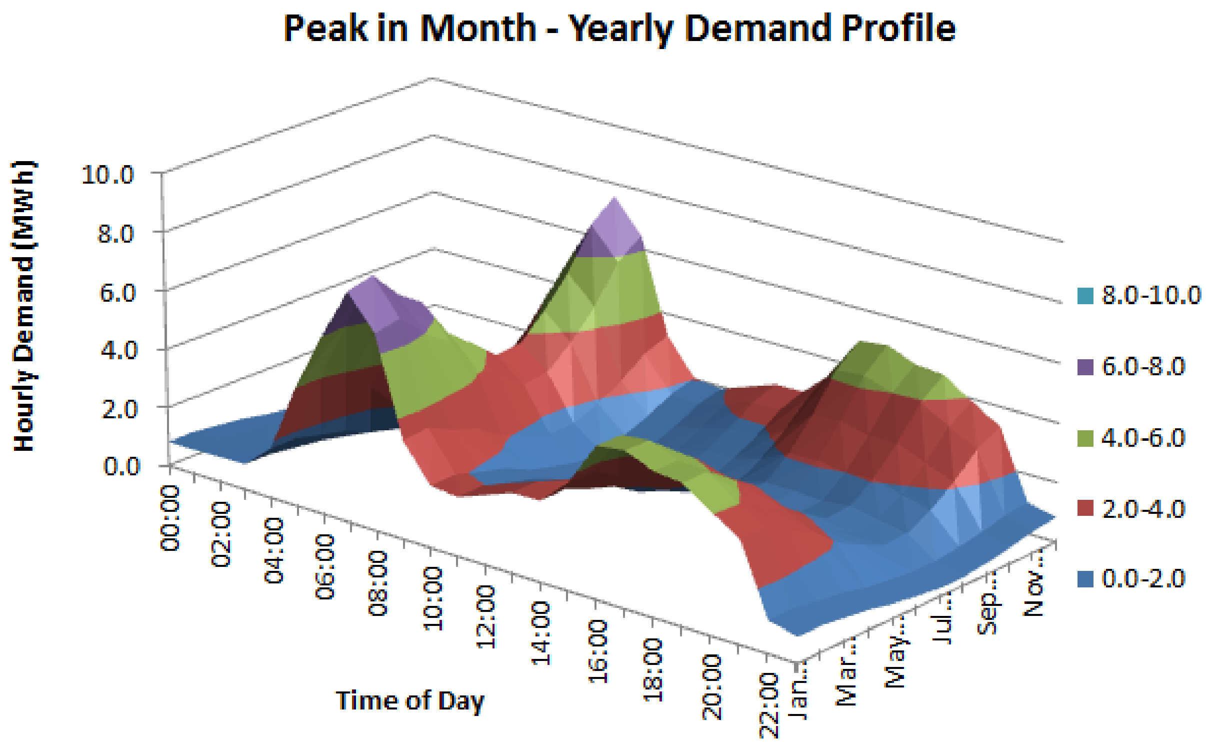
DEMAND PROFILE ON IONA

On Iona there is no mains gas, with heating provided by electricity, heating oil or solid fuels. Energy for cooking is either from electricity or bottled gas.

That makes it difficult to differentiate between how energy is used, in terms of separating out how much is used for space heating, domestic hot water (DHW), cooking, lighting and other uses. In addition, it has not been possible to get actual energy use data for a lot of buildings on the island. While data has usefully been provided by some businesses and households, there is very limited information about when that energy is used.

The only exception is Iona Abbey, which as the largest single energy user on the island has half-hourly meter data and sub-meter data for different parts of the Abbey, allowing the demand profile to be accurately modelled. However, this information relates to the current demand profile, and the Abbey has a major refurbishment planned which will include improved insulation to improve energy efficiency and a new heating system. Therefore it is necessary to model the future load when considering the design of any new building or network energy system.

To improve the data available, the project team worked with Home Energy Scotland and Resource Efficient Scotland to undertake building surveys on energy performance in homes and businesses, as part of the service these organisations provide. With the owners' permission, this information has been shared to provide more accurate indication of existing annual energy consumption, and opportunities for reducing that consumption.



DEMAND PROFILE PRINCIPLES

There is still some uncertainty in our understanding of the energy use on the island - particularly in relation to when the energy is used - making it harder to model accurately how to meet that demand.

However, there are some principles which can be applied at this preliminary stage in understanding the demand profile:

- More energy will be used for space heating than any other use, and the use of electricity and heating oil as the main fuels are expensive. Space heating relates closely to seasonal variations in temperatures, although the high number of visitors to Iona over summer months distorts a standard seasonal profile
- Iona is an area which is eligible for Home Energy Efficiency Programme Scotland (HEEPS) Area Based Scheme, offering opportunities for Home Energy Checks and access to grant and loan funding to improve the thermal efficiency of homes
- Thermal storage is currently, and for the short to medium term at least, cheaper than electrical storage. This can take the form of hot water (domestic boilers or central thermal storage), ceramic bricks (as used in storage heaters) or chemical (heat batteries, such as that being prototyped by Scottish Company Sunamp)

These principles – particularly when combined with the electrical grid capacity constraints which affect Iona - support an approach which focuses strongly on local renewable heat generation and supply.

The potential for two heat supply developments, focusing on the areas of highest heat density – one connecting to the Abbey in a standalone system, and the other a network system for the Village – were developed into a defined works package and secured funding from Scottish Government's Infrastructure and Innovation Fund.

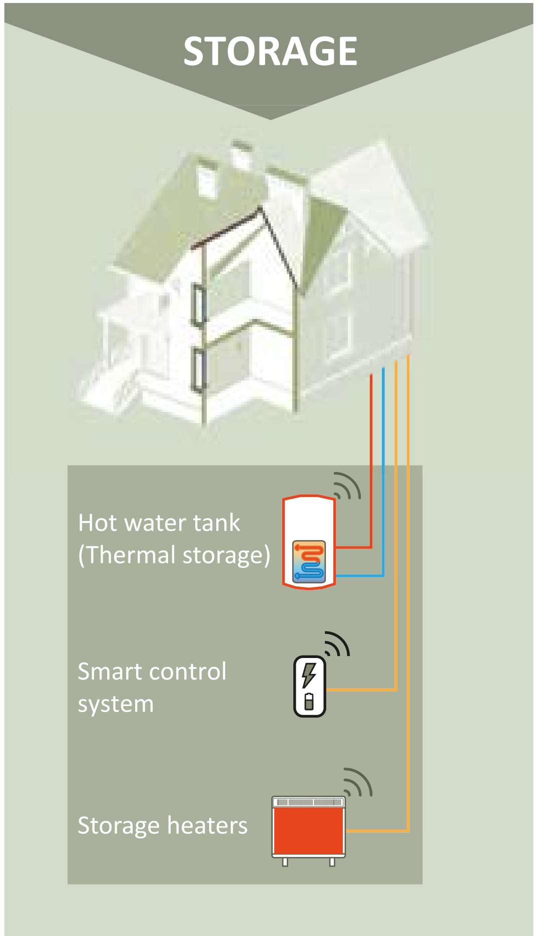
DEMAND MANAGEMENT

One of the ways in which generation (particularly intermittent generation, such as that from wind) can better match demand profile is through demand management. For instance, integrating smart control systems (both hardware and software) can provide some flexibility in managing the demand profile so it more closely matches that of the generation.

One system, used in the Access project, is that developed by V-Charge. Their product provides flexible thermal charging (storage heaters and water tanks). Their normal market is the public sector, where their installations are funded by National Grid based on the grid balancing services they can provide through allowing flexible charging of hundreds of electrically heated properties (such as tower blocks) which are connected through an ethernet spine. This system assists with demand management and provides cost-savings to consumers, reducing fuel poverty.

The V-charge technology can communicate with individual generating equipment (such as the Garmony Hydro) to maximise direct supply. A similar approach could be adopted to provide active network management and open up direct supply opportunities for generation on Iona. The advantage of this approach is it makes use of existing thermal storage within people's homes.

There are other innovative systems under development. Given the pace of development in this sector, it is recommended that the most relevant and appropriate technologies are identified at the time of deployment.



ENERGY STORAGE

Energy storage can help balance supply and demand and maximise the use of renewable generation.

While battery storage is still relatively expensive, it is currently on a steep downward trajectory, similar to that for solar PV panels over the last 5 years, as interest and demand massively increases for both mobile and stationary applications.

There are also advances in thermal storage, with the ability for ICTs to model generation, demand and other factors (such as energy costs or weather) to optimise when to draw energy – either for heating hot water in buffer tanks, or for charging the bricks in storage heaters.

There are emerging opportunities for seasonal thermal energy storage (STES), either at the community scale for district heat networks (very large buffer tanks or underground storage), or even regionally, with the potential to use disused mines. The STES can act as an energy 'dump', providing a discharge point for renewable generation when the grid capacity is constrained. Collectively, individual buffer tanks or storage heaters can also provide some system flexibility, through the integration of smart systems into a local energy system.

Three main options have been identified as appropriate storage solutions for the Iona Renewables strategy :

- Electrical storage, in the form of batteries
- Heat storage for homes with electric heating, through combining storage heaters with a smart management system, such as V-Charge, as used in the Mull ACCESS project (in combination with the Garmony Hydro scheme)
- Heat storage for homes with wet heating systems (i.e. radiators), using hot water (buffer) tanks with electric thermostats and a smart management system, or using the heat batteries from Sunamp or equivalent

The potential to develop STES should be investigated – not only for its application for the DHN, but also for its capacity to unlock electrical generating capacity. If a single large store is not feasible, then consideration should be given to using smart control systems to virtually link individual thermal storage within buildings.

Although using different technologies, the different systems could be integrated to provide a single overall solution. They can also be controllled to enable energy storage from different generating sources. The limitation is that storage at the domestic scale will typically only provide up to one day's worth of storage, or perhaps slightly more than that if individual systems are integrated.

NATURAL RESOURCES

WIND RESOURCE

Wind data over a two year period (approximately) has been generously shared by Tiree Community Development Trust to enable energy yield modelling.

This data comes from the anemometer on the community turbine at Tiree, measured at hub height (44m above ground level). The 10 minute data shows wind speed, direction and operating hours taken from the anemometer. This has inbuilt calculations to adjust the data to account for the blades passing it so does not give the exact wind speed at the site. As the data has only been recorded at a single height, it is not possible to calculate the shear factor (the factor by which wind speed varies by height above ground level) and this needs to be assumed in order to calculate a reasonable wind speed for the hub height of the candidate turbine models. There are also some gaps in the data, and as the modelling requires a complete set of values, the zero values have been replaced with averages. It is also important to note that there may be some difference in the wind resource from Tiree to Iona, which cannot be accurately adjusted for.

While there is therefore some uncertainty with the wind data, it nevertheless provides a good indication of likely energy yield. What it indicates is that Iona has an excellent wind resource, averaging >9m/s.

WIND - CANDIDATE TURBINES

Two different candidate turbines were modelled. These were selected to reflect planning constraints balanced against energy yield. Both are Class 1 machines, designed for high wind environments.

Norvento nED 100

Rated Capacity - 100kW

Hub Height - 24.5m

Rotor Diameter - 22.0m

Height to Tip - 35.5m

Theoretical Generating Capacity

490 MWh

Harbon HWT60

Rated Capacity - 60kW

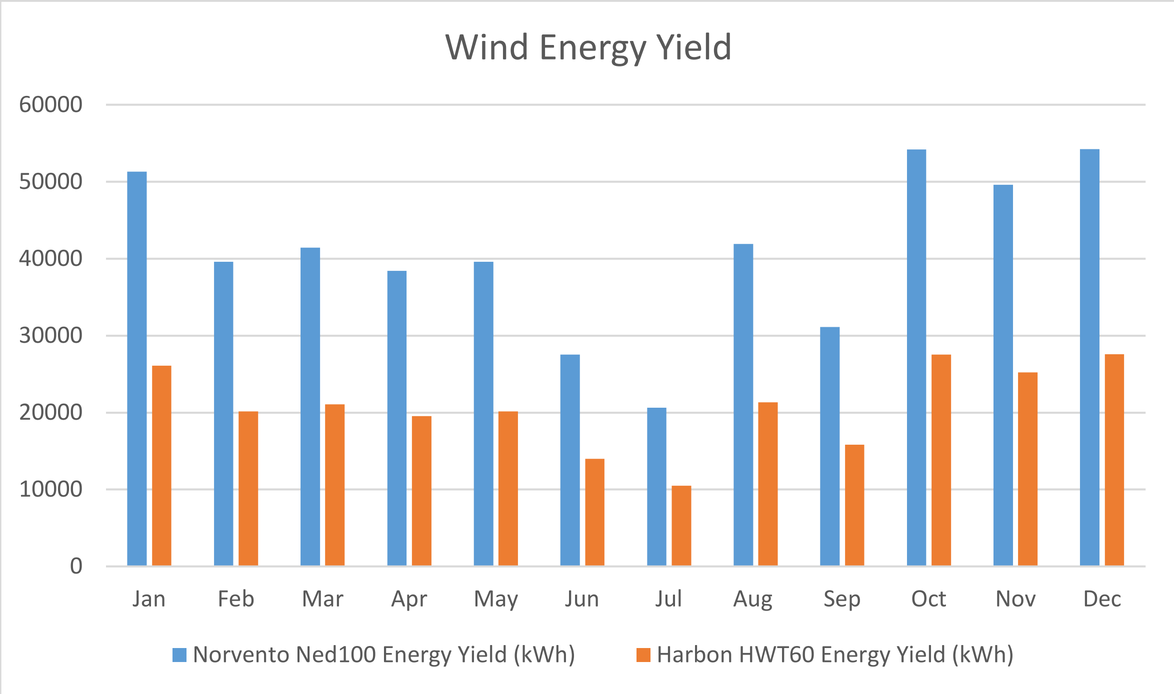
Hub Height - 18.6m

Rotor Diameter - 16.0m

Height to Tip - 24.6m

Theoretical Generating Capacity

249 MWh



WIND - ENERGY YIELD

Based on both technical (grid) and planning constraints, modelling at this stage has been limited to a single turbine. However, the longer term strategy to maximise local energy generation, storage and use means that consideration has been given to future-proofing, to accommodate the potential, at a later date, for further two turbines in the locations proposed.

The overall energy requirements modelled suggest that ~300 to ~350kW of installed wind capacity could, in combination with other technologies, storage and demand reduction measures, be sufficient for Iona.

WIND - POTENTIAL LOCATIONS

Two locations have been identified and assessed, both in terms of planning risk and financial modelling. These are:

- Traigh Mhor
- Loch Staoineig

Budget costs for connection at the alternative locations have been obtained from SSE. The cost difference between the different locations is substantial. Traigh Mhor is significantly less expensive compared to the other locations considered due to the reduced connection distance to a location without the need for grid upgrade.

Conversely, in terms of planning risk:

- Traigh Mhor is located south of the main areas of tourist and cultural interest, but has relatively open visibility
- Loch Staoineig is a predominantly visually discrete location, and is considered lowest risk in terms of securing planning consent

WIND - FINANCIAL MODELLING

Different feed-in-tariffs are available for wind turbines relative to generating capacity. On the understanding that the export constraint is currently limited to 50kW, but planned upgrades to the transmission network in 2021-22 may lift that export limit, two different options have been modelled:

- Applying a generation constraint for a five year period, and thereafter maximising generation capacity
- Applying a generation constraint for a twenty year period

The low level of feed-in-tariffs, together with the high connection costs, mean that a number of the options considered are not viable on the basis of grid-export only. This constraints, combined with the central focus of the project to develop a local energy system for Iona, led to opportunities being investigated into creating a direct supply connection to buildings on the island and generating revenue directly.

Eight scenarios have been modelled for each turbine option, using the CARES financial model, varying with different levels of 'direct supply' of wind energy generation to local consumers, and also varying by the length of time that a constrained connection would apply to the project.

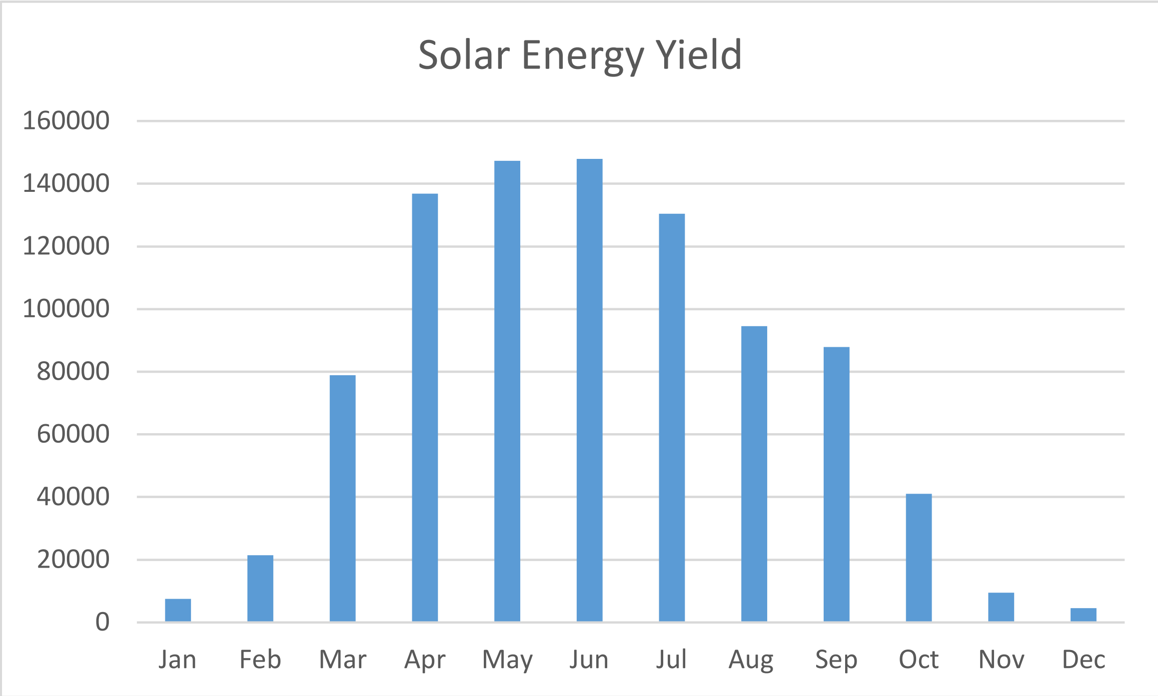
Due to the high capacity factor for wind and the potential to provide a revenue stream which can maximise benefits through direct supply, development of a wind turbine should be prioritised at an early stage in the Roadmap.

Design	Energy Yield (MWh)	Project Cost (approx.)*	Project IRR	Profit over project lifetime *	25% Direct Supply[t]		50% Direct Supply[t]		75% Direct Supply[t]	
					IRR	Profit	IRR	Profit	IRR	Profit
Output constrained to 50kW for first 5 years of operation, then unconstrained										
100kW (Norvento)										
Loch Staoineig	302 rising to 506	**£560k**	3.8%	-	5.5%	**£138k**	7.0%	**£307k**	8.2%	**£476k**
Traigh Mhor		**£430k**	6.2%	**£161k**	7.9%	**£330k**	9.4%	**£499k**	10.7	**£668k**
60kW (Harbon)										
Loch Staoineig	233 rising to 269	**£450k**	0.6%	-	2.3%	-	3.6%	-	4.8%	**£27k**
Traigh Mhor		**£330k**	3.5%	-	5.2%	**£44k**	6.6%	**£131k**	7.7%	**£218k**
Output constrained to 50kW for lifetime of project										
100kW (Norvento)										
Loch Staoineig	302	**£560k**	3.7%	-	4.9%	**£35k**	5.9%	**£136k**	6.9%	**£237k**
Traigh Mhor		**£430k**	6.3%	**£126k**	7.5%	**£227k**	8.5%	**£328k**	9.5%	**£429k**
60kW (Harbon)										
Loch Staoineig	233	**£450k**	3.9%	-	5%	**£34k**	5.9%	**£109k**	6.8%	**£269k**
Traigh Mhor		**£330k**	7.3%	**£150k**	8.4%	**£225k**	9.3%	**£301k**	10.1	**£440k**

* Based upon <50kW FiT of 8.06p, and 50-100kW FiT of 3.95p. The 50-100kW banding has been oversubscribed since the new FiT rules took effect in February 2016, meaning it is reducing by 10% every quarter (emergency degression) in addition to the planned quarterly reductions. The <50kW banding is not oversubscribed and is therefore reducing at a more gradual rate.

** The funding strategy used sees the funding required for the project capital costs is raised through community shares, offering shareholders a return of 4.5% per annum over a 20 year term. Therefore, the project would look to give a return to individual investors and also create a community fund. The 'Profit' shown in the summary table would flow to the community fund. The funding strategy the project utilises has a major effect on the project profits; therefore these numbers must be treated as indicative only until a preferred funding strategy is understood to be viable.

The additional cost of creating a direct supply connection is £1,000 per house, based on discussions with V-Charge. The 25% direct supply scenario has assumed 20 connections, the 50% scenario has assumed 40 connections, and the 75% scenario has assumed 60 connections.



SOLAR RESOURCE

Energy yield modelling has been undertaken to assess the output from a ground mounted solar PV installation. The output at a particular location can be estimated with a strong degree of accuracy from solar irradiance mapping. All that is required are the co-ordinates for the specific location, performance data from candidate manufacturers, and calculations can be made using specialist industry software. Calculations have been carried out on the software package PV*Sol®, using an optimised system layout to avoid over shading, oriented to south, and assumed to be in a relatively flat area.

To provide an indication of energy yield, a nominal installation size of 1MW was modelled. This would have a minimum development footprint (to take into account panels, spacing and ancilliaries) of ~1.8 hectares (ha.). The Annual Generation output from 1MW is calculated as 907,831 kWh/year.

There is no capacity within the electrical grid on Iona to accommodate a solar installation of this generating capacity. Further analysis of the local grid network on Iona as well as further engagement with SSE is therefore necessary to identify preferred locations which minimise the requirements for local network upgrades (and therefore connection costs) to enable direct supply. This option may be most effective through multiple locations, rather than a single larger solar array. In relation to the overall energy profile for Iona, it is worth noting that the solar energy yield has a close correlation to visitors, with more visitors coming in the summer months when the days are longer and weather is better.

Due to lower capacity factors compared to wind, opportunities for Solar PV should initially focus on rooftops for direct supply, with the potential for a solar farm at a later stage once grid management is in place to complement the generation profile of wind.

HEAT PUMPS

Heat Pumps are devices which can provide heating (or cooling). A heat pump uses some external power to transfer energy from the heat source to the heat sink – the ratio of energy used to energy output is termed the co-efficient of performance (COP). While heat pumps use external power, the energy source can be renewable, and they are also deemed to be 'renewable' in situations where significantly more energy is generated than consumed - typically at least 3 times more.

They work most efficiently where the heating system can work at lower temperatures, such as when integrated with energy efficiency measures. The COP increases as the temperature difference decreases between the heat source and the destination, which means a heat pump could be less efficient when outside temperatures are lower - which is often when there is a greater need for internal space heating.

The ground and large bodies of water are natural stores of thermal energy, and therefore are more consistent temperature sources than the air, but require a larger interface (in the form of a pipe network) to extract the heat, and can be more expensive to install. Ground source, air source and water source are all being considered, in different locations, for Iona.

The heating system is also an important consideration. Some heat pumps require some form of 'wet' heating system to transfer the heat, in the form of radiators or underfloor heating. Domestic hot water and conventional heating radiators generally require high water temperatures – an equivalent ambient temperature can be achieved through lower temperatures by improving the insulation and/or by upgrading the heating system.

AIR SOURCE HEAT PUMPS

Air source heat pumps extract heat from outside air, in one of two ways:

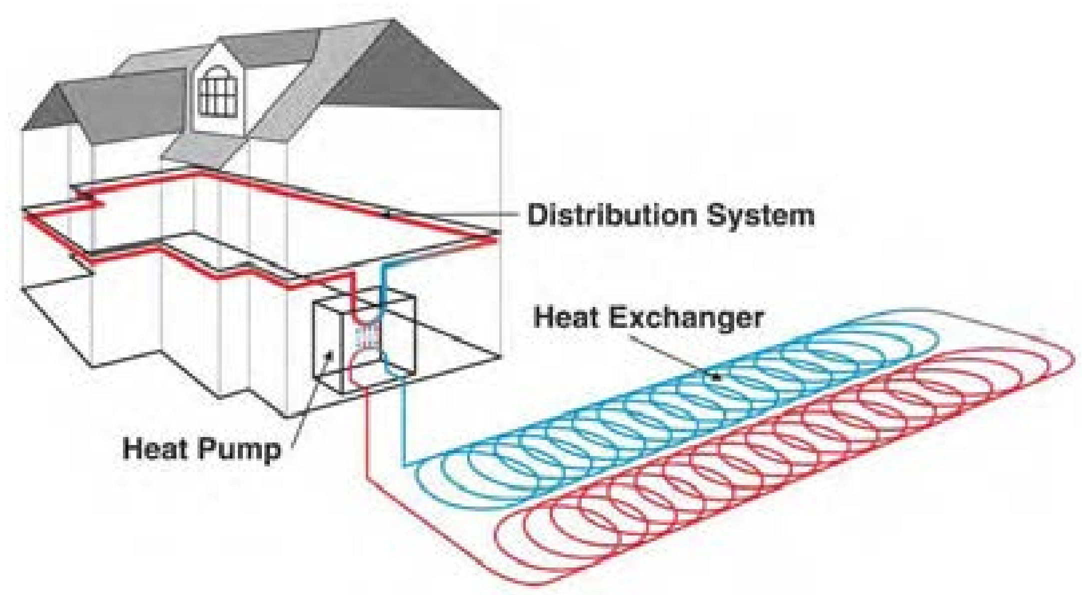
- Air–air heat pump (transfers heat to inside air);
- Air–water heat pump (transfers heat to a heating circuit and a tank of domestic hot water).

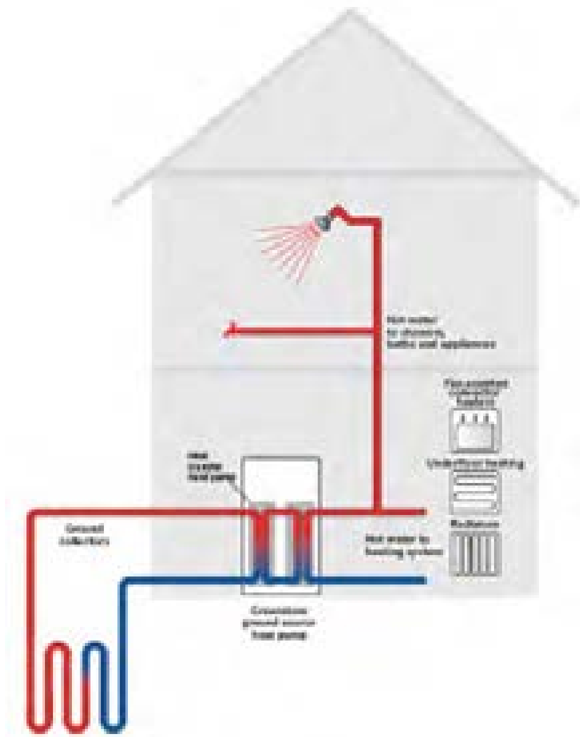
Air-air heat pumps, that extract heat from outside air and transfer this heat to inside air, are the most common type of heat pumps and the cheapest.

Air-water heat pumps are similar to air-air heat pumps, but they transfer the extracted heat into a water heating circuit, floor heating being the most efficient, and they can also transfer heat into a domestic hot water tank.

Air source heat pumps are relatively easy and inexpensive to install and have therefore historically been the most widely used heat pump type. However, they suffer limitations due to their use of the outside air as a heat source. The higher temperature differential during periods of extreme cold leads to declining efficiency.

There are a number of air source heat pumps operating on Iona, and it is therefore a familiar and trusted technology. However, the fine sand and salt air from the marine environment surrounding Iona will reduce the typical operational life and increase maintenance requirements.





GROUND SOURCE HEAT PUMPS

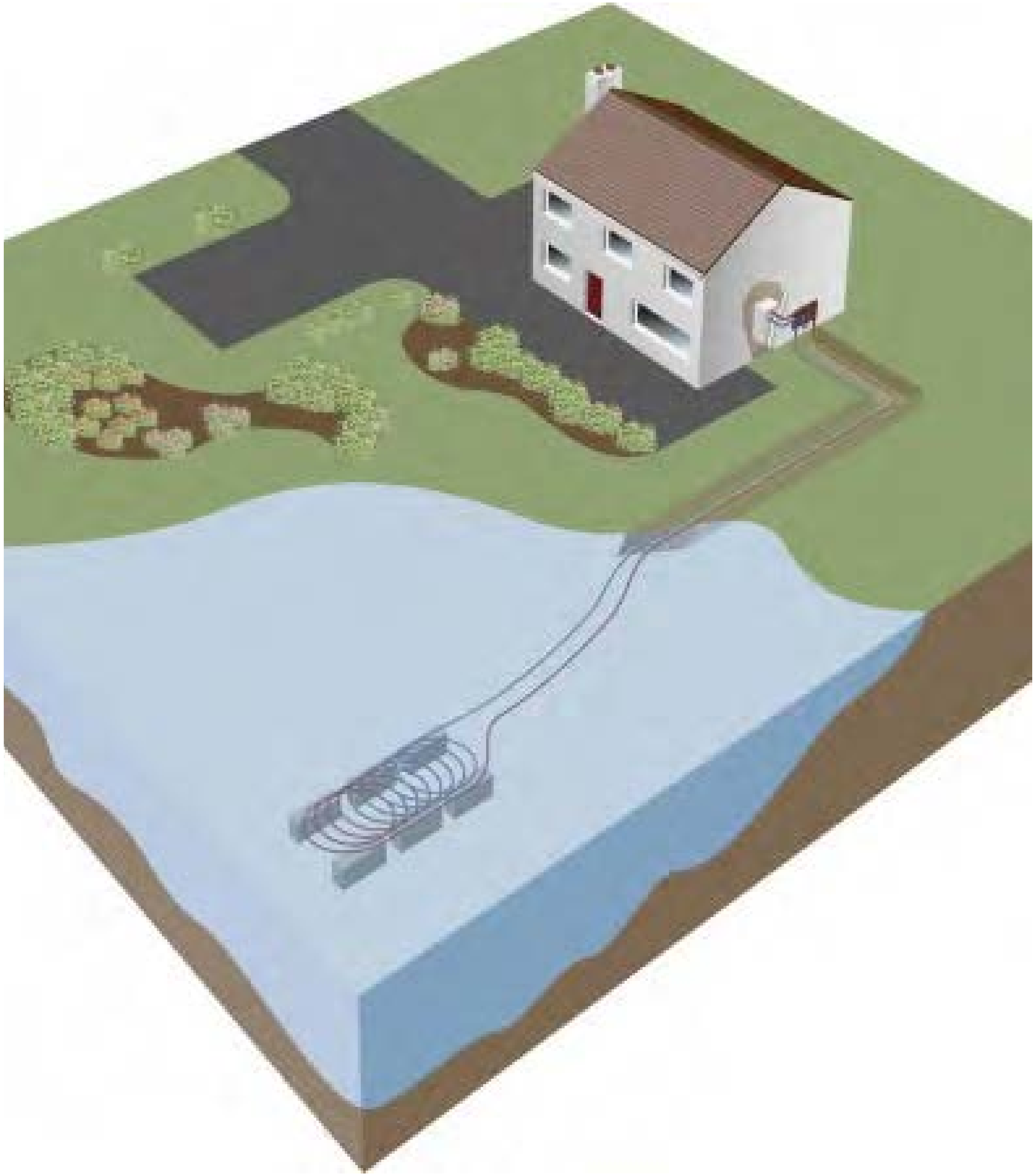
There are a variety of different ways in which a ground source heat pump can operate, but all systems operate through using a heat exchanger in contact with the ground to extract or dissipate heat. Heat is transferred from the ground into pipework, typically high density polyethylene pipe, containing a mixture of water and anti-freeze. Systems can be installed horizontally or vertically – while vertical systems are more efficient, they are also substantially more expensive.

Horizontal ground source heat pumps require a large area of ground disturbance for their installation. There are two reasons this may be prohibitive on Iona:

- The bedrock close to or at the surface could significantly increase installation costs and timescales
- The potential for cultural heritage artefacts could increase the risk for securing planning consent, and/or increase the cost and timescales for installation

Drill costs for a vertical GSHP are likely to be prohibitively expensive if procured separately for individual systems, but may be affordable for shared systems, for large heating loads, or if multiple individual systems are procured together. This reflects the high mobilisation costs for getting a drill rig to such a remote location.

WATER SOURCE HEAT PUMPS



Closed loop water source heat pumps can use the same principle of heat exchange as ground source heat pumps, through the use of pipework to exchange heat between the fluids in the pipework and the surrounding water. The heat exchange process is very efficient due to the flow of water around the pipework. Closed loop systems may be advantageous where poor or corrosive water quality precludes an open loop system or where the heat load is small.

Open loop heat pumps take water directly from the water source and extract the heat through a heat exchanger. Open loop systems need to return the water at sufficient separation distance from the intake to avoid thermal breakthrough. Since the water chemistry is not controlled, the appliance may need to be protected from corrosion by using different metals in the heat exchanger and pump.

Sedimentation may also foul the system and require periodic cleaning. If the water contains high levels of salt, minerals, iron bacteria or hydrogen sulphide, a closed loop system is usually preferable.

IONA ABBEY HEAT PUMP

Historically, there was a marine source heat pump (MSHP) in operation for Iona Abbey. This was an open loop system, which was installed over 1983 and 1984.

The heat pump unit used sea water as its heat source and apparently, worked very well and heated the building adequately and cost effectively. The system suffered from sediment in the water destroying pumps as well as lack of system back-up and frequency and cost of unplanned maintenance works. After approximately a decade, the system was abandoned and replaced by night storage water tanks.

The night storage tanks do not, however, satisfactorily address the heating issues for the Abbey. Due to space constraints within the plant room, the available storage capacity is a fraction (estimated at around 10%) of what is required. Consequently, the building tenants face the choice of either paying high energy costs to top-up the system on the daytime electricity tariff, or heat the building to levels which do not provide desired comfort levels.

The existence of a previous MSHP for Iona Abbey is both an opportunity and a constraint.

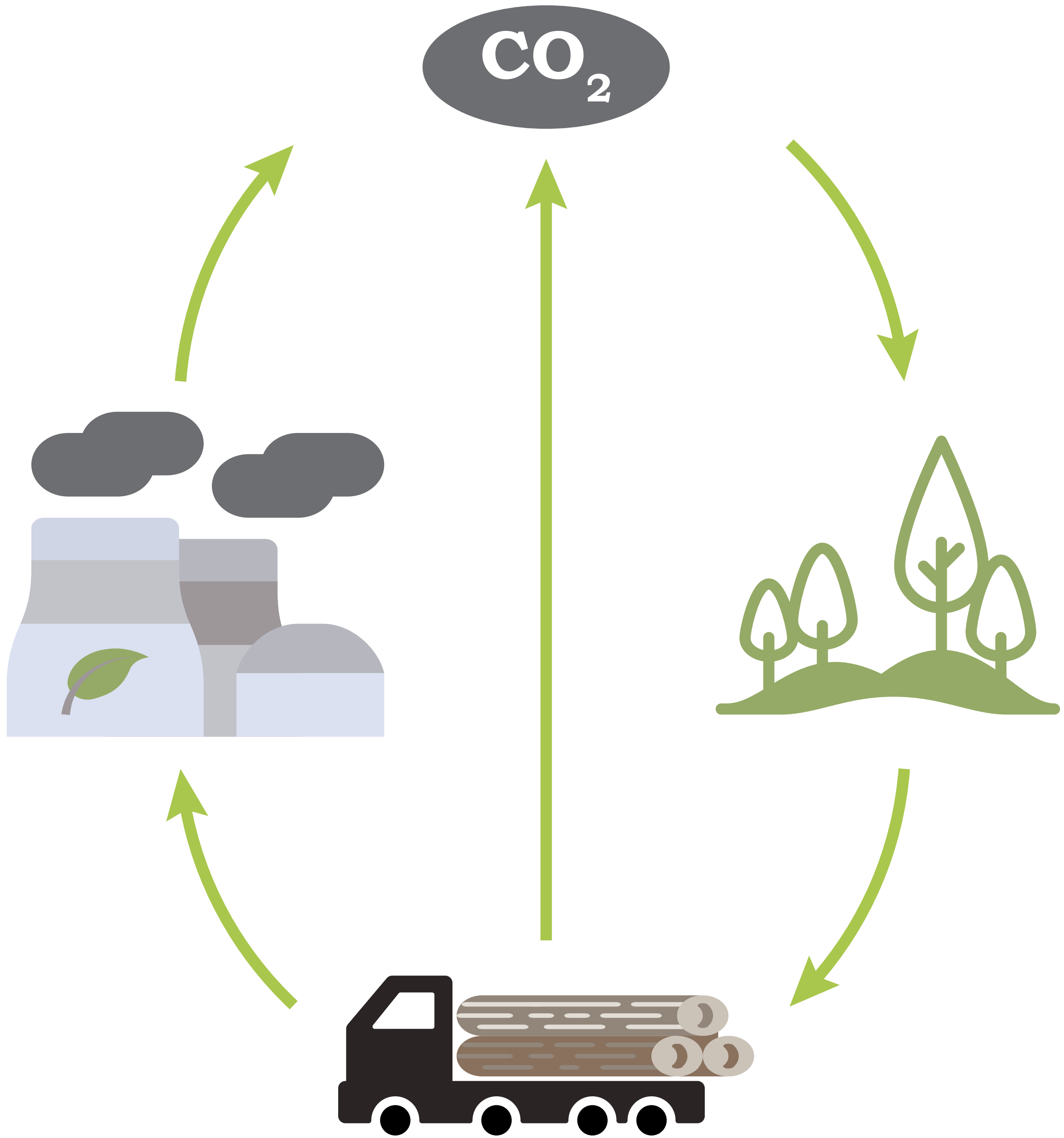
The opportunity is that there is existing infrastructure in the form of an underground heat pump room, which could be re-used and is specifically excluded from the scheduling for the Abbey. The pipework can be located along the alignment of the previous sea-water pump pipework, therefore not disturbing any area which has not already been affected by construction works although it would require Scheduled Monument consent (SMC). Initial discussions with Historic Environment Scotland indicate that in principle, the proposed approach should be able to secure the necessary Scheduled Monument and Listed Building consents.

One potential constraint is that the Iona Community (IC) had already tried and tested this technology, and experienced significant installation and operational issues. This could have increased the difficulty in providing sufficient security and confidence that a new system would be reliable. Initial discussions with Iona Community indicated that this could potentially be addressed by Iona Renewables taking on the responsibility for the supply and operation of the MSHP, with IC being an energy customer. In this scenario, IC would still need to be persuaded that the heat supply was at least as cost effective and reliable as the alternative.

A planned refurbishment of Iona Abbey represents a further opportunity, in that IC is already planning a significant refurbishment of the Abbey, which will include an upgrade to the Abbey's thermal performance and heating system, allowing the heating system to operate at a lower temperature. A planning application and building warrant for the proposals was submitted in May 2016 and secured consent. These include proposals for an Air Source Heat Pump.

The refurbishment was planned for the winter 2017-18, pending funding, and the proposals are at an advanced stage. Iona Renewables therefore sought as a priority a meeting with IC and Historic Environment Scotland (HES) to discuss the potential for the Abbey to be a heat customer, rather than proceeding with the installation of an ASHP. This meeting took place on 28th June 2016 and was very positive. As a consequence, Iona Renewables proceeded with an application for further funding from the Infrastructure and Innovation Fund (IIF) to progress this specific initiative. The funding application was supported by Letters of Commitment in Principle from both IC and HES.

Through the IIF, this opportunity has been progressed, with the intention to develop a GSHP using geothermal boreholes along the route of the historic pipework, having established this technology option is preferable to a marine-source system. This has now secured planning and Scheduled Monument consent.



BIOMASS

Biomass is organic matter which can be used as a source of energy, and can be derived from wood or other plants, and generated by different levels of processing. Ideally it should be of local provenance: biomass from a long distance away has additional embedded carbon emissions from the transportation. In addition, biomass from uncertified supply sources may not be renewable; and biomass requires energy to dry and chip or pelletise. Finally, the combustion of biomass results in carbon dioxide emissions, as well as other particulates.

There are no requirements with respect to provenance or embedded energy for the feedstock supply for biomass to be eligible for the Renewable Heat Incentive, the government's support scheme for renewable heat. This can, however, be an issue in securing local support.

There is a relationship between efficiency and cost on the one hand, and level of processing on the other, as follows:

- Split
- Chips
- Pellets

Split wood is more commonly used for domestic biomass systems, and is not likely to be the best option for Iona. Wood pellets are the most expensive option, but also provide the most efficient heating performance. There are no pelletising facilities on Mull, and this option is therefore excluded on the basis of provenance.

The initial consideration of biomass for this proposal at this stage is therefore limited to local supply, and therefore focuses on wood chips.

TIRORAN COMMUNITY FOREST

Through South West Mull and Iona Development (SWMID), the community of South West Mull and Iona own Tiroran Forest, with the purchase completed in November 2015. The funding for the purchase came through grant and loan support from various sources, with a need to generate sufficient income to repay the loan within five years. There is therefore an initial short term plan to fell and sell the first coupe of mature conifers, with a longer term forest management plan to be developed with various social, environmental and economic objectives. While the higher value wood would be sold for timber, there will be a significant resource available over the short to medium term for biomass from the 760 hectares of this community forest.

Discussions with Tilhill, the forest managers, has established an indicative volume of wood appropriate for biomass of between 1,000 and 5,000 tonnes over a 5 -10 year period. Some of the larch within the forest is diseased, and is therefore subject to restrictions, but these can be managed.

The quantities available at Tiroran would be significantly in excess of what is required to meet the island's energy needs over that 5-10 year period, and thereafter there would not be a community owned supply until replacement planting reached maturity. However, there is a substantial local supply chain and finding a market for the excess from the community woodland in the short term, and securing a local supply over the medium and long term is unlikely to be an issue, subject to identifying an appropriate partner.

WOOD CHIP - SOURCES

The energy demand on Iona is not sufficient to support a dedicated drying and chipping facility for the island, and the location is not suitable to support a commercial operation with a wider distribution network beyond the island.

The nearest existing facility is in Dervaig run by North West Mull Community Woodland Company Ltd (NWMCWC). NWMCWC is the trading arm of the Community Trust. They dry and store wood chip (and cut logs) which are suitable for larger boilers (up to larger scale domestic systems), but not necessarily smaller domestic systems. For chipping, they bring in external contractors.

While in principle NWMCWC would consider collaborating with SWMID to take responsibility for chipping, drying and storing biomass from Tiroran, they do currently have specific concerns about this supply due to the contamination from Phytophthora ramorum affecting the diseased larch, which does not currently affect trees in the north of Mull.

Proposed route
Start and End point
Tiroran Community Forest (737.50 ha)

SUPPLY, VOLUME AND COSTS

Dervaig is approximately 60 miles from Fionnphort, and therefore too far to be supplied under NWMCWC's existing arrangements (which are by tractor/trailer). New arrangements would be required, and the round trip of >120 miles is potentially significant in terms of distribution costs. Transport by boat would be prone to seasonal interruptions (when the need for fuel supply could be most critical).

Based on initial estimates of heat load, a system of ~200-300kW might be necessary to power a heat network for the Village. This is a similar scale of development to the hospital system NWMCWC provides fuel for, with volume demand of ~20m3 (i.e. one trailer delivery) ranging from one a week to every 2.5 weeks depending on the season. Therefore to provide one week's worth of back-up for Iona Village would require a 20m3 hopper. An alternative would be to substantially up-scale the storage for use by both the Village and distributed housing, reducing the number of deliveries from NWMCWC, and creating a local distribution network (e.g. quad bike and trailer for local customers).

On a collection basis, the chips are currently sold at ~£31.50 - £32 /m3. Distribution would be additional.

Due to uncertainties on reliability and proximity of supply biomass is considered appropriate on a small-scale basis, potentially to replace coal as a primary fuel on a house-by-house basis, but a secondary option for community scale energy generation options.

HYDRO RESOURCE

Hydro power options on Iona were assessed through a desktop study, reviewing water bodies and channels to assess their potential for development and generation. Additionally, the field survey inspected Loch Staoineig, located to the South of the island, which is the only water body on Iona.

Catchment	0.46 km2
Perimeter	3.4 kilometres
Head Height	7 metres

(For watercourses shown on OS mapping, up to 67 metres from head height to sea level if lower level discharge to sea is acceptable to SEPA).

Affected Reach 0.5km

The limited catchment would lead to a very low flow rate within the watercourse. This low flow rate, coupled with a low head height, would likely limit generation potential to below 10kWp (kiloWatt peak), meaning the opportunities arising from development of the site would be minimal. The length of river over which water would be removed, the 'affected reach', would be around 500m – a significant distance for a small scheme, leading to high civil engineering and piping 'penstock' costs. The nearest property (and existing electrical grid) is around 1.31km away, meaning the expense of cable routing for any generated power would outweigh the benefits of any generation scheme implemented.

No other waterbodies or channels worthy of further analysis were identified during the desktop study or inspected during the field survey.

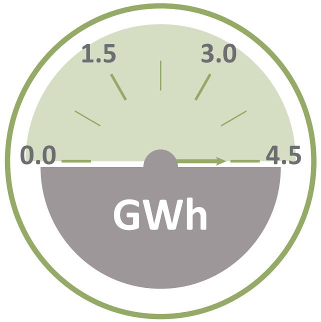
There is not considered to be a viable hydropower generating resource on Iona.

THE ROADMAP

	Demand (estimated annual total)	Supply & Storage
Senario 1		
Senario 2		
Senario 3		

Senario 1

Existing demand
(2015 audit)



Substantial local grid reinforcement for local distribution

No smart control systems

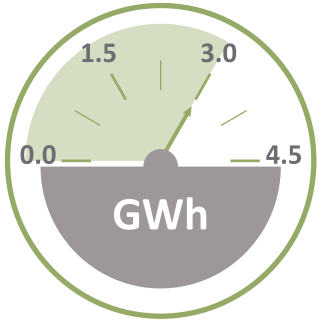
No storage

Senario 2

Energy Efficiency Measures

Reduced demand

Assume **1/3** energy saving through



Some local grid reinforcement for local distribution

Use of smart control systems to enable some demand side management

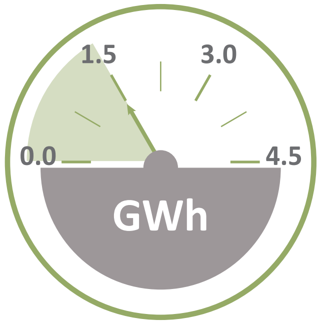
No storage

Senario 3

Integrate heat pumps with heating systems at COP of ~3*

Reduced demand

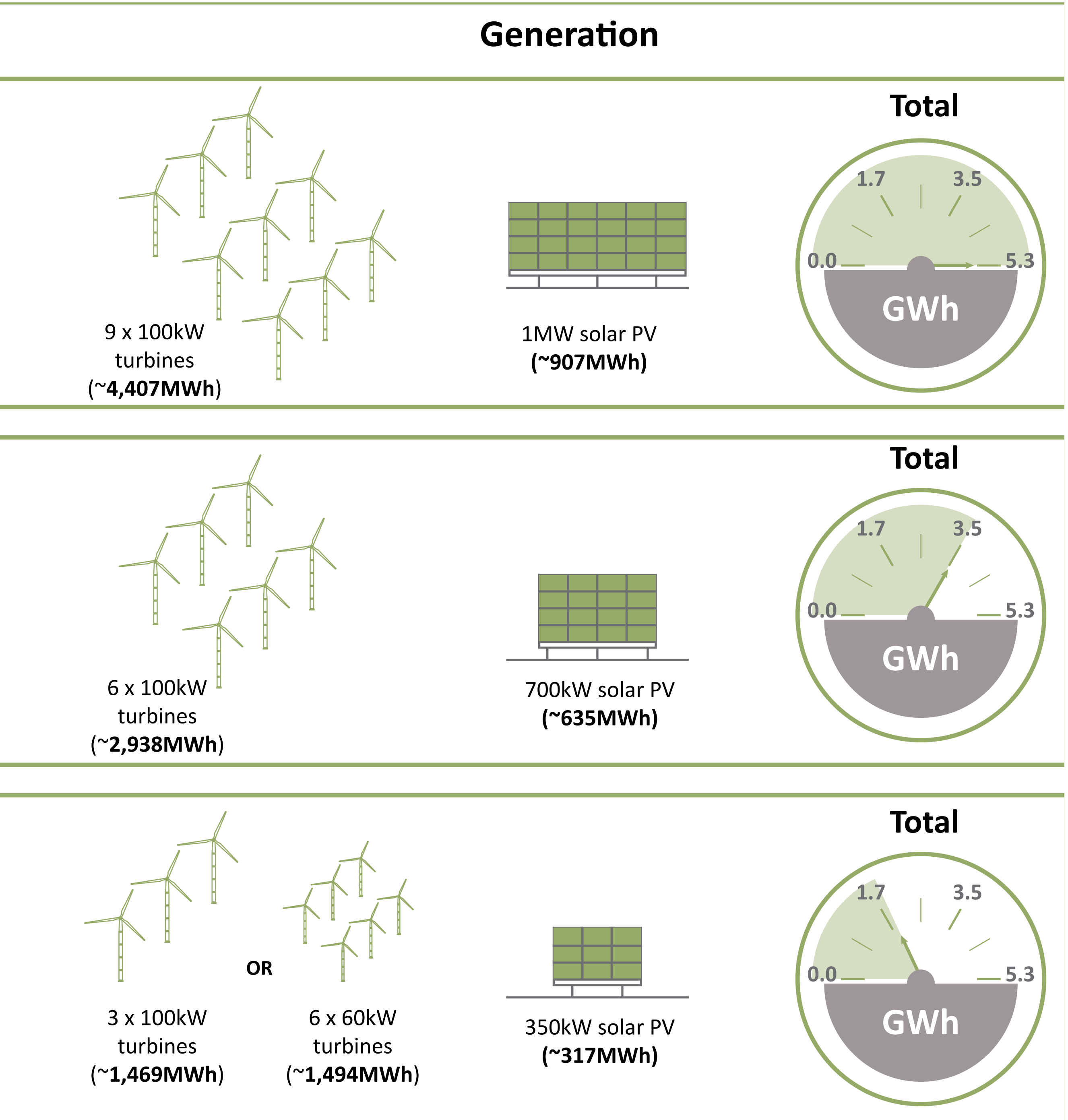
Reduce the heat energy requirement by **2/3** through



Use smart control systems and battery storage to enable some demand side management

Use smart controls on heating thermostats (water and ceramic brick) to provide some storage capacity

* Overall energy demand based on an assumed split between heat/electricity of 60/40.



DEVELOPMENT SCENARIOS

In developing appropriate development scenarios, it is necessary to understand the three ways to manage energy and the way in which these are inter-related:

- Generation – how to make the energy
- Supply and storage – how to move and store the energy, to enable it to be used when it is needed
- Demand reduction – how to reduce energy needed

Considering these within the context of Iona, the following outline scenarios are described:

1. Status quo – focusing on the level of additional generation needed to displace grid imports
2. Reduce demand and meet residual needs with new generation
3. Reduce demand, use storage to facilitate demand management and meet needs with new generation

These are illustrated in the diagram to the left.

Stage 2

Undertake energy efficiency measures and enable renewable heat supply to all buildings on the island.

Install infrastructure to enable **smart control systems** and **demand management**.

Village – investigate the potential for a District Heating Network (DHN), using Ground or Marine Source Heat Pump (GSHP/MSHP) and integrating a Seasonal Thermal Energy Store (STES). If this is not feasible, standalone improvements can be implemented on a building by building basis.

The implementation of energy efficiency measures can proceed independently of energy generation projects, and will improve the comfort levels and reduce the energy costs of all participating households and businesses.
The integration of smart control systems opens further opportunities for demand management and storage – and the potential to secure more competitive tariff arrangements.

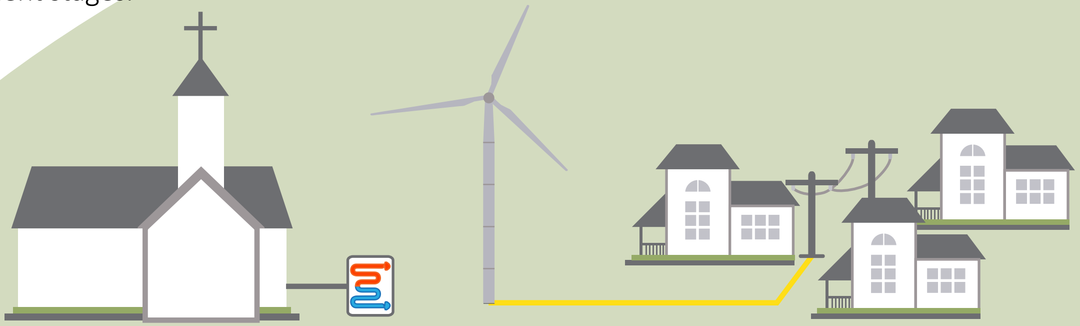
Install buffer tanks with integrated heat pumps for properties with existing wet heating systems.

Integrate monitoring and management to thermal storage to provide flexibility for charging.

Stage 1

Develop energy generation projects to maximise the exportcapacity and direct supply opportunities.

Generation developments have the greatest income potential - developing these at Stage 1 will provide revenue for subsequent stages.

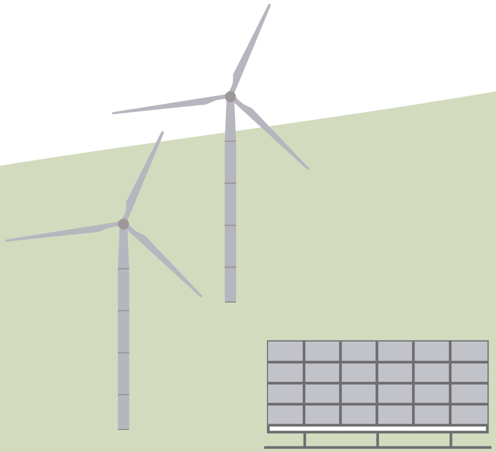


Ground Source Heat Pump for the Abbey, as the largest single energy user

Single wind turbine with 50kW export capacity to the grid network and providing direct supply to homes and businesses.

Stage 3

Develop generating capacity to meet the remainder of residual energy requirements renewably, having demonstrated the performance capacity of the local energy system to provide effective active network management.



This stage can take advantage of any further developments in generating technology, downward cost trajectory, and any changes to perception from Stage 1 of development.

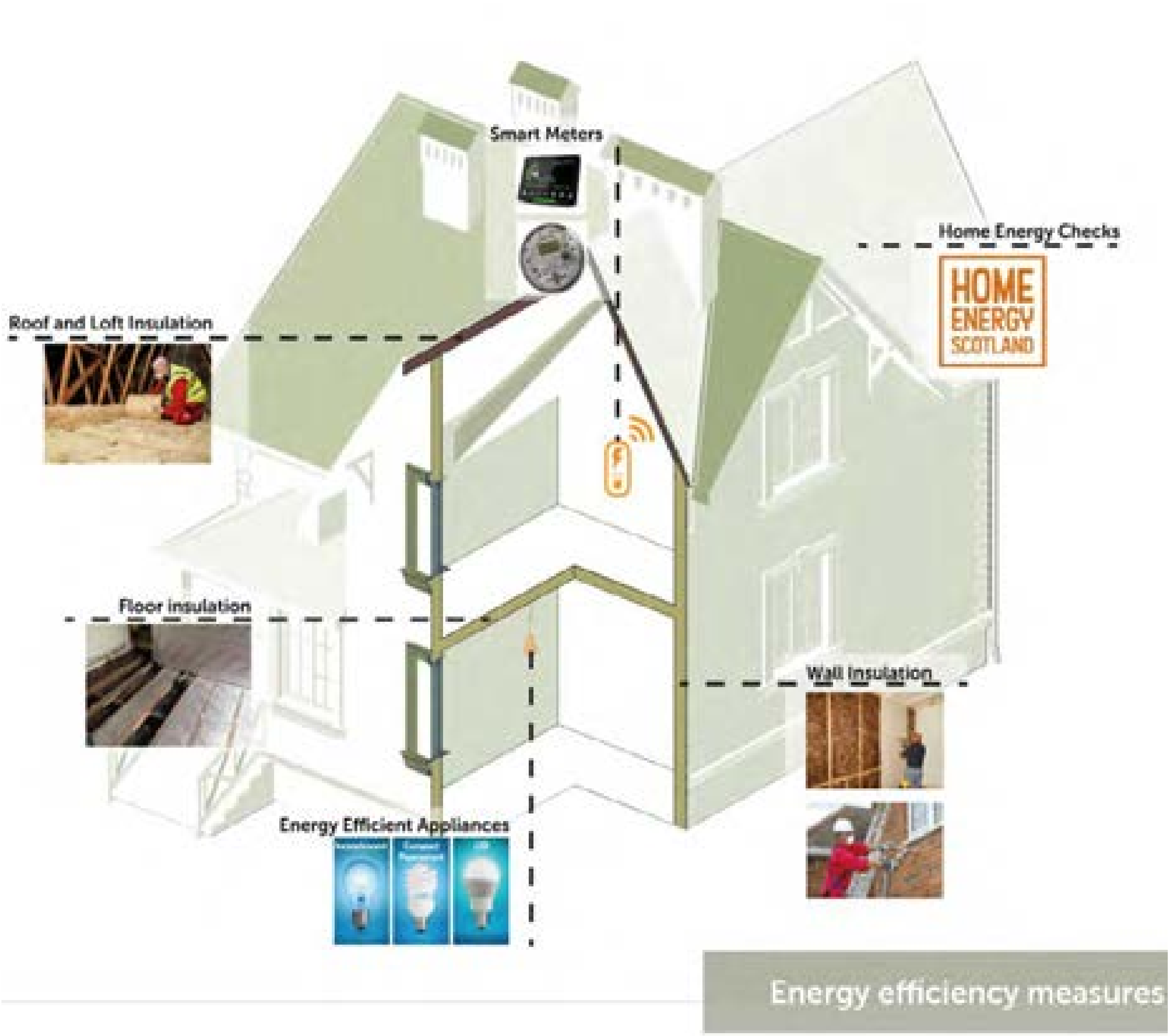
Stage 4

Deploy battery storage to provide increased flexibility for the non-heat elements of the system.

The timing for implementation of battery storage can be determined by a cost-benefit analysis and take advantage of the downward trajectory of battery costs.

There are multiple advantages of a phased approach, including, but not necessarily limited to, capacity building, experience, financing, and break points. The proposed strategy reflects the mandate from the community engagement process to provide a mosaic solution. It provides the flexibility for individuals to be involved to the extent to which they choose, albeit recognising that the more involved people are, the greater the collective benefits which can be delivered.

MOVING FORWARD



HIGH IMPACT FIRST PHASE PROJECTS

Four high-impact first-phase projects have been identified through the Roadmap:

- Lightening the Load, funded through the Climate Challenge Fund, until March 2018
- Single wind turbine, to be funded through a CARES pre-planning loan, progressing to securing grid connection offer and planning consent by December 2017
- Geothermal heat supply for Iona Abbey, to be developed as a partnership between Iona Renewables (funded through CARES pre-planning loan) and Historic Environment Scotland
- Geothermal heat supply for Iona Village, to be delivered as a Pathfinder pilot as part of Scotland's Energy Efficiency Programme (SEEP) and part funded through grant from SEEP, other energy efficiency grant and loan programmes, and Scotland's District Heating Loan Fund

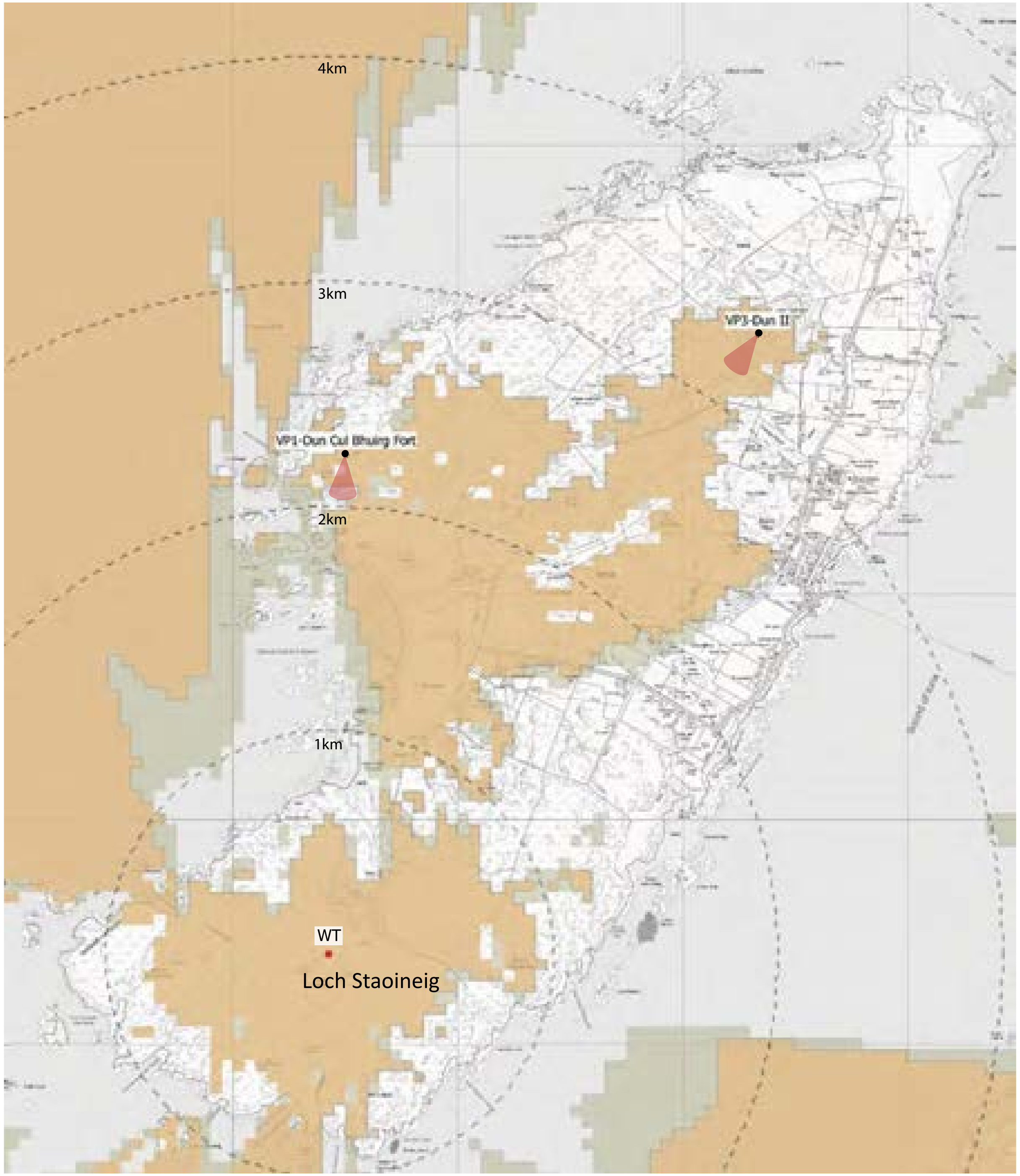
ENERGY EFFICIENCY

The **Lightening the Load** project uses CCF funding to help people who live on, work on and visit Iona to increase their carbon literacy and to understand and deliver the actions they can take in their daily lives, as individuals and as a community, to reduce their carbon footprint.

Lightening the Load also provides all possible help to encourage homeowners, tenants and businesses to implement the recommendations of survey work undertaken by Home Energy Scotland and Resource Efficient Scotland, including physical improvements to buildings which result in lower energy wastage and lower costs.

The project is funded from April 2017 until March 2018.

Climate Challenge Fund
Part of the Keep Scotland Beautiful Charity
Greener Scotland
Scottish Government
European Union
The Scottish Government
Europe & Scotland
European Regional Development Fund



WIND

Seek support through the CARES programme pre-planning loan for funding to progress a single 35m HTT (height to blade tip) wind turbine proposal.

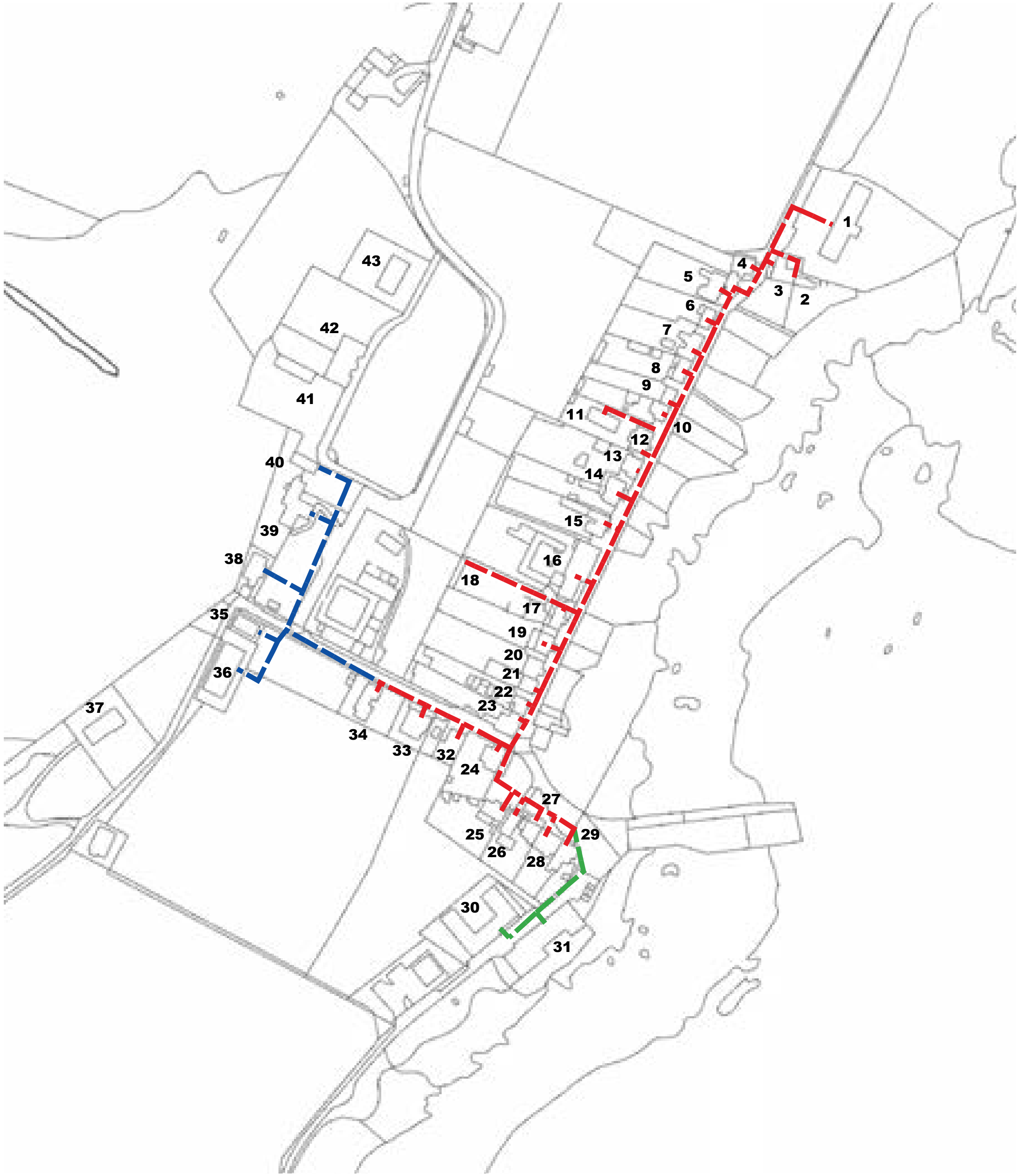
The initial focus should be to confirm, through pre-application engagement and community consultation, a preferred site from the two options:

- Traigh Mhor: much better financial returns but higher risk in terms of planning, and potentially constrained to accommodate any further development)
- A site south of Loch Staoineig: requiring direct supply to be viable, but which could be future-proofed through scaling infrastructure for future extension for up to a further two turbines (to provide a total installed capacity of 300 kW)

Initial ornithology survey work has commenced and the remainder of environmental surveys are planned over the summer to accompany a planning application in Autumn, 2017.

Further work is also required on developing the feasibility of the direct supply. Work to date has focused on the potential to deploy the V-charge system used in the Access project / Garmony Hydro, which includes buildings on Iona, confirming viability in principle. Further work is required in relation to stakeholder engagement, assessing the potential (thermal) storage capacity, identifying the most appropriate monitoring and management system, and engaging with SSE over active network management.

The development of electrical generation, the need for direct supply, and the programme of energy efficiency, provide an excellent opportunity to also develop smart control systems for maximising demand management.



VILLAGE

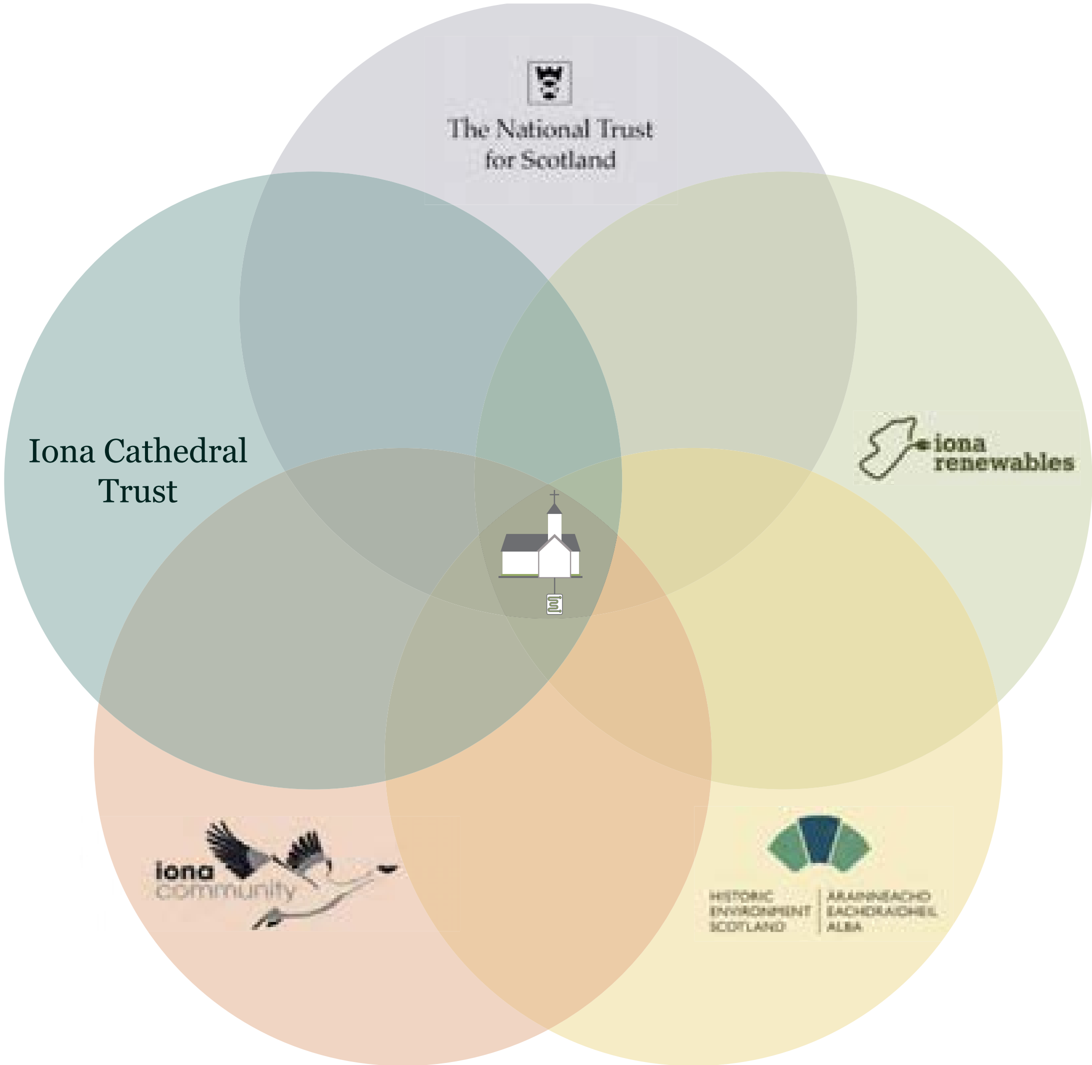
The project is to develop a community owned renewable heat supply for the existing buildings within the Conservation area of the Village of Iona, which lies on 'an island off an island' in the Inner Hebrides.

The selected heat supply option, from a series of geothermal boreholes, has been identified from review of potential technologies.

The extent of the network, and the proposed connections, have been defined through technical analysis and stakeholder engagement. 100% of building owners and tenants contacted for letters of support for the project have confirmed their support (i.e., 35 of 40 buildings, with the remainder in ownership of the Council plus 3 second homes whose owners have not yet been reached).

The network adopts a distributed system with individual heat pumps within each building, and the network from the boreholes to the heat pumps is very low temperature at an estimated 9.1°C. This dispersed approach reduces heat losses to a negligible level, and avoids costs associated with the construction of an energy centre with highly insulated pipework. An options appraisal comparing a centralised system against a distributed system was undertaken as part of the detailed feasibility into the Village network to identify the most appropriate option for this project.

The project has in parallel being submitted to Scotland's Energy Efficiency Programme Pathfinder Fund Pilot Projects 2017-18 and the Scottish District Heating Loan Fund.



ABBEY

Seek support through the CARES programme pre-planning loan for funding for the community's contribution to progress the project to procurement, building on the significant progress made through the "Heat from the Sound" IIF funded project.

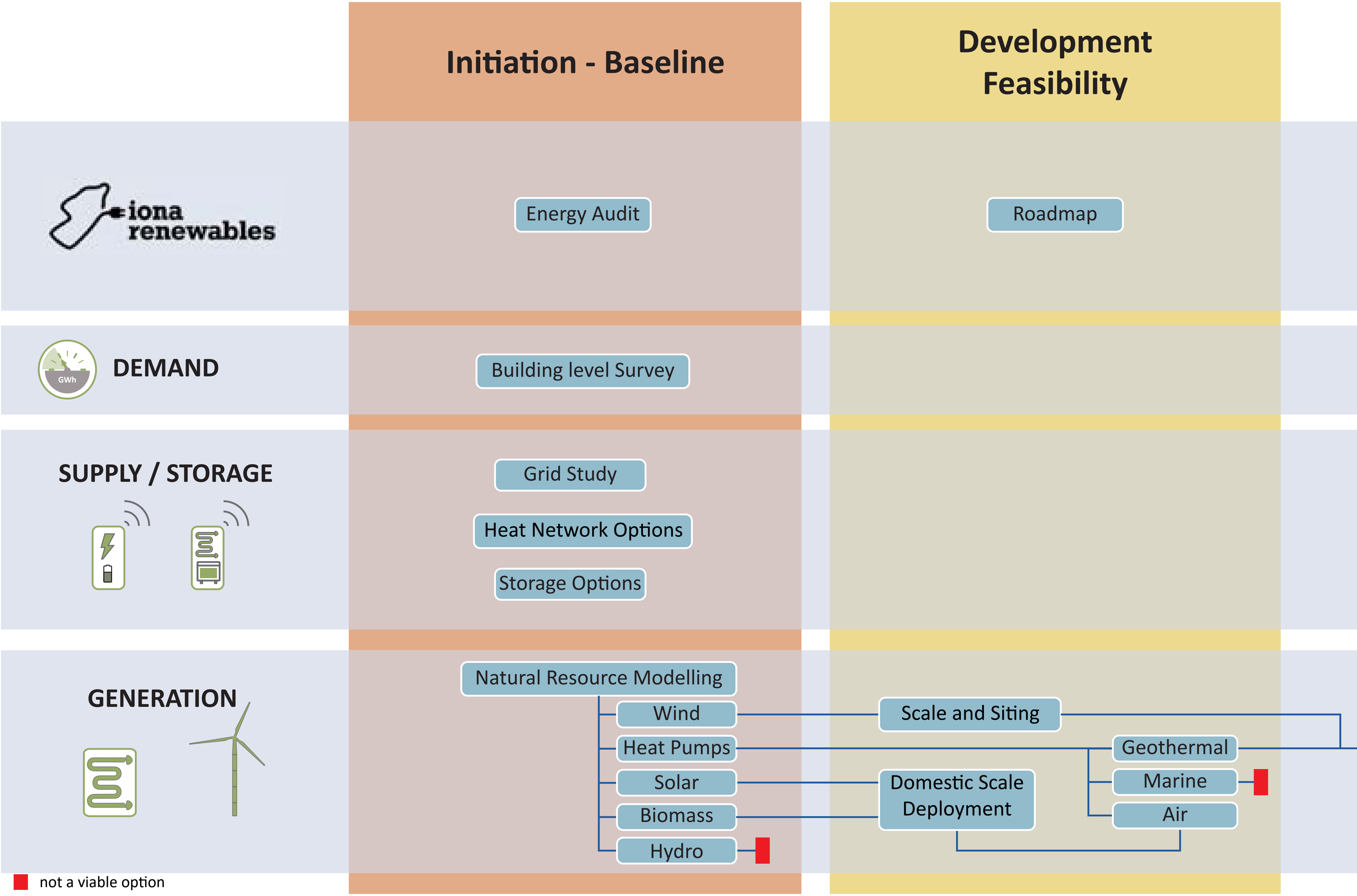
The project comprises a fully serviced heat supply from a geothermal source heat pump (GSHP) system. Our work to date has confirmed the technical, regulatory and financial feasibility of this option.

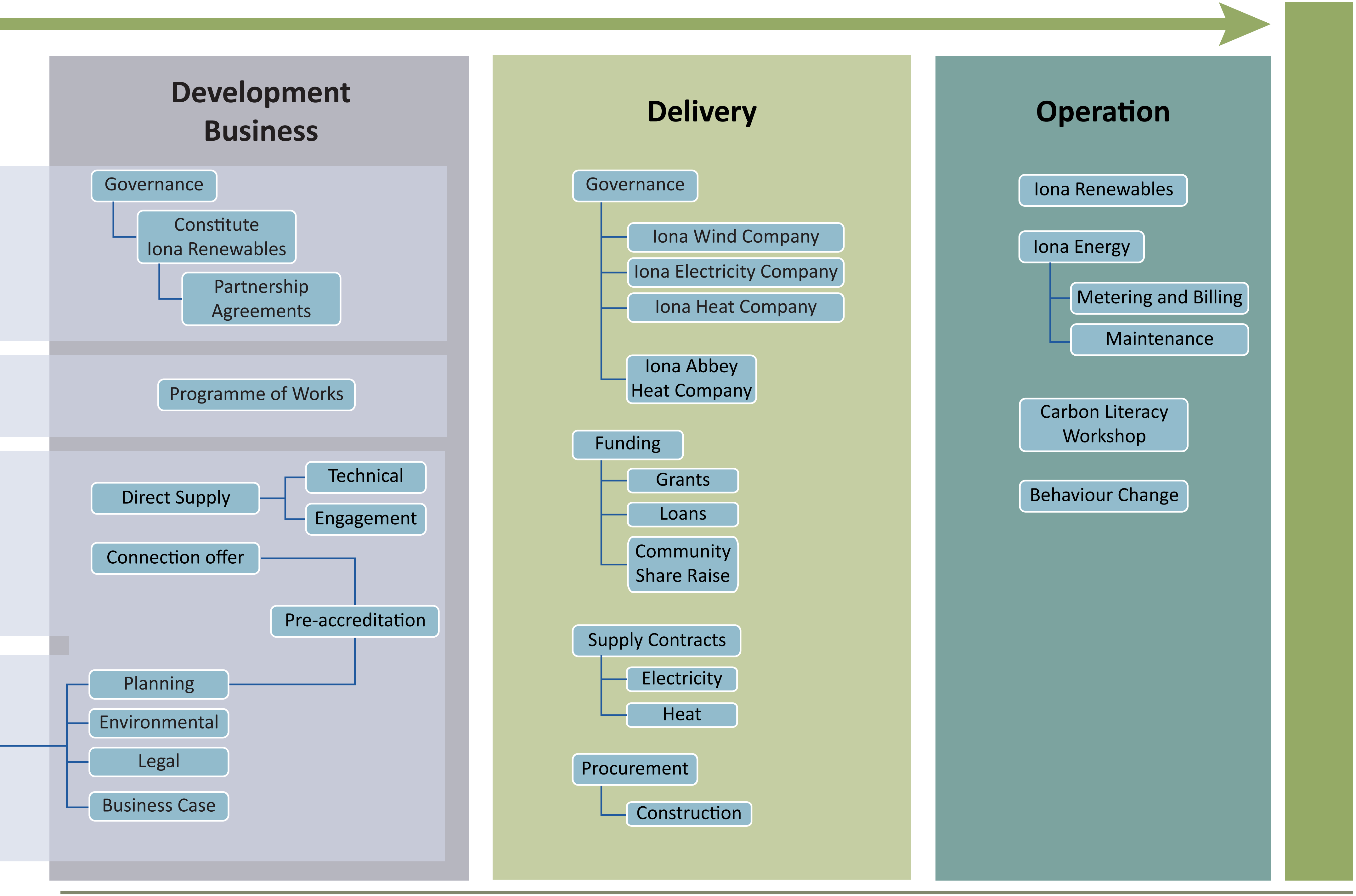
It will deliver significant benefits:

- Cheaper heat, providing savings to building tenants of over 15%
- Reduced carbon emissions, saving over 80 tonnes of carbon a year
- Increased heating performance, providing 90% of the predicted heat load for the Abbey
- Improved conservation performance, with the additional heat enabling drying out of damp masonry
- Connection with wider island initiatives

The stakeholder position for this project is complex, requiring the co-operation and collaboration of all parties. These have been brought together with increasing levels of commitment by Iona Renewables as part of its overarching role on project delivery.

Different delivery structures have been considered for the development and operation of the GSHP system. Considering the interests of each party separately, and of both parties together, for as long as both parties wish to be actively involved a joint venture model is considered to be the only appropriate delivery structure. It is the best way to ensure that the project has as great an impact as possible. For each party, a partnership approach is closely consistent with its strategic objectives.


Initiation - Baseline
Development Feasibility
iona renewables
Energy Audit
Roadmap
DEMAND
GWh
Building level Survey
SUPPLY / STORAGE
Grid Study
Heat Network Options
Storage Options
GENERATION
Natural Resource Modelling
Wind
Heat Pumps
Solar
Biomass
Hydro
Scale and Siting
Geothermal
Marine
Air
Domestic Scale Deployment
not a viable option


Development Business
Governance
Constitute Iona Renewables
Partnership Agreements
Programme of Works
Direct Supply
Technical
Engagement
Connection offer
Pre-accreditation
Planning
Environmental
Legal
Business Case
Delivery
Governance
Iona Wind Company
Iona Electricity Company
Iona Heat Company
Iona Abbey Heat Company
Funding
Grants
Loans
Community Share Raise
Supply Contracts
Electricity
Heat
Procurement
Construction
Operation
Iona Renewables
Iona Energy
Metering and Billing
Maintenance
Carbon Literacy Workshop
Behaviour Change

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