GREBE

Generating Renewable Energy Business Enterprise

Northern Periphery and Arctic Programme 2014–2020

Linking Renewable Energy Technology & Resources in the NPA region

Report identifying technologies which can be transferred from areas of best practice to areas where renewable energy uptake is low

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February 2017

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The GREBE Project

What is GREBE?

GREBE (Generating Renewable Energy Business Enterprise) is a €1.77m, 3-year (2015-2018) transnational project to support the renewable energy sector. It is co-funded by the EU's Northern Periphery & Arctic (NPA) Programme. It focuses on the challenges of peripheral and arctic regions as places for doing business, and helps develop renewable energy business opportunities in areas with extreme conditions.

The project partnership includes the eight partners from six countries, Western Development Commission (Ireland), Action Renewables (Northern Ireland), Fermanagh & Omagh District Council (Northern Ireland), Environmental Research Institute (Scotland), LUKE (Finland), Karelia University of Applied Sciences (Finland), Narvik Science Park (Norway) and Innovation Center Iceland (Iceland).

Why is GREBE happening?

Renewable Energy entrepreneurs working in the NPA area face challenges including a lack of critical mass, dispersed settlements, poor accessibility, vulnerability to climate change effects and limited networking opportunities.

GREBE will equip SMEs and start-ups with the skills and confidence to overcome these challenges and use place based natural assets for RE to best sustainable effect. The renewable energy sector contributes to sustainable regional and rural development and has potential for growth.

What does GREBE do?

GREBE supports renewable energy start-ups and SMEs:

- To grow their business, to provide local jobs, and meet energy demands of local communities.
- By supporting diversification of the technological capacity of SMEs and start-ups so that they can exploit the natural conditions of their locations.
- By providing RE tailored, expert guidance and mentoring to give SMEs and start-ups the knowledge and expertise to grow and expand their businesses.
- By providing a platform for transnational sharing of knowledge to demonstrate the full potential of the RE sector by showcasing innovations on RE technology and strengthening accessibility to expertise and business support available locally and in other NPA regions.
- To connect with other renewable energy businesses to develop new opportunities locally, regionally and transnationally through the Virtual Energy Ideas Hub.
- By conducting research on the processes operating in the sector to improve understanding of the sector's needs and make the case for public policy to support the sector.

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Linking Renewable Energy Technology and Resources in NPA Partner Regions (Work Package 5)

The NPA area is undoubtedly rich in many renewable energy resources. However the form and extent of these resources vary considerably throughout the region. While these differences may be clear at national levels they also exist at more local levels as well and, as a result, areas within the NPA region will have very different technological requirements for the effective utilisation of renewable energy resources. Activity 5.1, Identification of Key Technologies has three main objectives:

1. Identify key areas (i.e. sectors, industries and geographic areas) where energy requirements are being met by non-renewable resources, or where emerging businesses require new energy sources and are considering fossil fuel based energy systems.
2. Identification of relevant renewable technologies and renewable integration enabling technologies (e.g. storage and heat pumps); this should take into account market penetration and risk.
3. Include a geographical relevance of identified technologies. This will be based on Technology Readiness Levels (TRLs) varying from 7 (tested and demonstration) to 9 (proven in an operational environment).

The main aim of this report is to inform the other activities in Work Package 5. This report will lay the foundation for linking the appropriate renewable energy (RE) technology to the specific locality and resources in the NPA Region. The findings of this report were attained through careful analysis of the feedback provided by the GREBE partners:

- Western Development Commission (Ireland)
- Action Renewables (Northern Ireland)
- Fermanagh and Omagh District Council (Northern Ireland)
- Environmental Research Institute (Scotland)
- Natural Resources Institute (Finland)
- Karelia University of Applied Sciences (Finland)
- Narvik Science Park (Norway)
- Innovation Center Iceland (Iceland)

This report will inform activity 5.2, the assembly of case studies of exemplar technology solutions, accompanied by videos showcasing the renewable energy technologies in question. The present report aims to identify key areas and technologies with the potential to generate new business models in areas where renewable energy is less developed and to establish transferability of renewable energy technologies from areas of best practice to areas where RE uptake is low. In order to ensure the appropriate level of coverage across all relevant technologies and key areas, partners provided feedback for their specific region regarding:

(1) Areas where non-renewable resources are meeting energy requirements, or where emerging businesses require new energy sources and are considering fossil fuel based energy systems and

(2) Relevant RE technologies and renewable integration enabling technologies relevant to the region, including the corresponding risk and market penetration levels.

The completion of these objectives will assist us to define the parameters, technologies, areas and demand, incorporated in the final deliverable of Work Package 5 – the Renewable Energy Resource assessment (RERA) Toolkit.

1. Identification of key areas

To identify key areas (i.e. sectors, industries and geographic areas), GREBE partners, across the northern periphery of Europe categorised areas where non-renewable resources are meeting the energy demand, or where emerging businesses require new energy sources and are considering fossil fuel based energy systems. The project partners provided an interesting and broad selection of different energy users. There is a noticeable ascending order of the three key areas with identification of seven geographic areas, eight sectors, and nine industries. In some cases, the same use (e.g. tourism), has been perceived differently. In one case, tourism is identified as a sector, while in another case, it is perceived as an industry. The terms industry and sector are often used interchangeably; however, they do have different meanings to some extent. The difference relates to their scope. A sector refers to a large, general segment of the economy. The sector then can be subsequently broken down into further segments (industries) with more defined grouping, where similar companies have similar business activities. Given this distinction, some alterations are made to the classifications presented in the summary of feedback (Table 1.1 below). For example, tourism is placed in the sector column, whilst cruise ships, as a segment of tourism, are considered to fall into the industry category.

Geographic	Sector	Industry
Island areas	Tourism	Cruise ships
Off-grid areas	Heating outside District Heating (DH) networks	District heating
Municipalities	Community initiatives	Farming
Agricultural	Education	Aquaculture
Arctic environments	Health / caring	Bakeries
Rural areas	Sport & leisure facilities/events	Data storage centres
Small towns	Technology/financial services	Distilleries
	Transport/public transport	Fisheries
		Engineering and manufacturing

Table 1.1. Key areas where non-renewable resources are being utilised

As anticipated, there are recurrent key areas in the feedback from the partners across the NPA region. Islands are mentioned by Ireland, Iceland, Norway and Scotland, as geographic areas where there is a heavy use of non-renewable resource because in most cases they are off-grid. Due to transportation issues and the lack of economies of scale, these grids typically rely highly on polluting diesel generators. However, the same three partners point out to islands as being areas with excellent RE opportunities. Islands are only one example of an overlooked opportunity for RE integration. The commonalities across the feedback from all partners, substantiates the fact that despite the geographical differences, the NPA region is facing similar challenges, which can be best overcome and realised by transnational cooperation. In order to identify further commonalities between partners, a review of the individual partner feedback for different regions is undertaken.

2. Input from Partners

Effective input is a critical constituent for the successful outcome of the report. All of our partners provided detailed and comprehensive input with regard to key areas in their regions, where the energy demand is met by non-renewable resources. What follows is a graphic representation and summary, individually for each partner, of the key *geographic*, *sector* and *industries* areas, identified as ones where non-renewable resources are meeting energy requirements and with potential to be replaced by RE resources.


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Geographic areas

- **Rural** - Finland is a sparsely populated country with rural characteristics and most rural areas tend to be outside those served by district heating networks, which results in use of non-renewable resources. Finland covers an area of 390,903 km² of which 95% is rural, total population is 5.4million – of which 30% live in rural areas. The Rural Policy Programme 2014–2020 aims at decentralised production and use of renewable energy in rural areas.
- **Urban** - Finnish feedback put emphasis on the urban environment where municipalities and the related area of district heating networks, are identified as important target for replacing non-renewable resource (oil-burners). Whilst urban areas were not identified as priority areas by other partners, it is true that those are areas which can be applicable to all regions.

Sectors

- **Heating outside DH networks** - Finnish feedback highlights that there is a large number of oil-heated estates located outside the DH networks. They often use light fuel oil for the heating and have challenges in finding cost-efficient RE options (especially when oil price are low). This category includes both industrial SMEs and public housing associations. At present about 50% of all buildings are part of the DH network, but gradually more and more detached houses are joining the DH network as well. District heating is energy efficient, and many of the DH plants use renewable biomass, and at present 37% of all DH energy is produced with biomass.
- **Sport & leisure facilities/events** - They create seasonal energy demand peaks; e.g. in skiing resorts (ice tracks, snowing of the skiing tracks/hills); heating of the playing fields. These situations also create opportunities of integrating heating and cooling (e.g. ice halls, swimming halls, playfields) which could be suited to low carbon technologies such as heat pumps. Additionally, how the seasonal variations in demand match the seasonal variations in RE generation will be explored in activity 5.3.

Industries

- **Bakeries** - They use oil-boilers that heat thermo-oil circulating in bakery ovens. For instance, a bakery located in Nurmes/Lieksa uses 300,000 litres of oil annually. A RE technology option has not yet been found to replace this.
- **Farms** - They have high energy consumption, but also available biomass raw materials for RE. Anaerobic Digestion (AD) technology has not yet been feasible without additional market for biogas (especially biogas for transport).
- **District heating** - Heavy fuel oil is used in satellite heating plants for peak-loads in winter time; and mainlyl use peat in large combined heat and power (CHP) plants (coal is also used in Southern Finland).


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Geographic areas

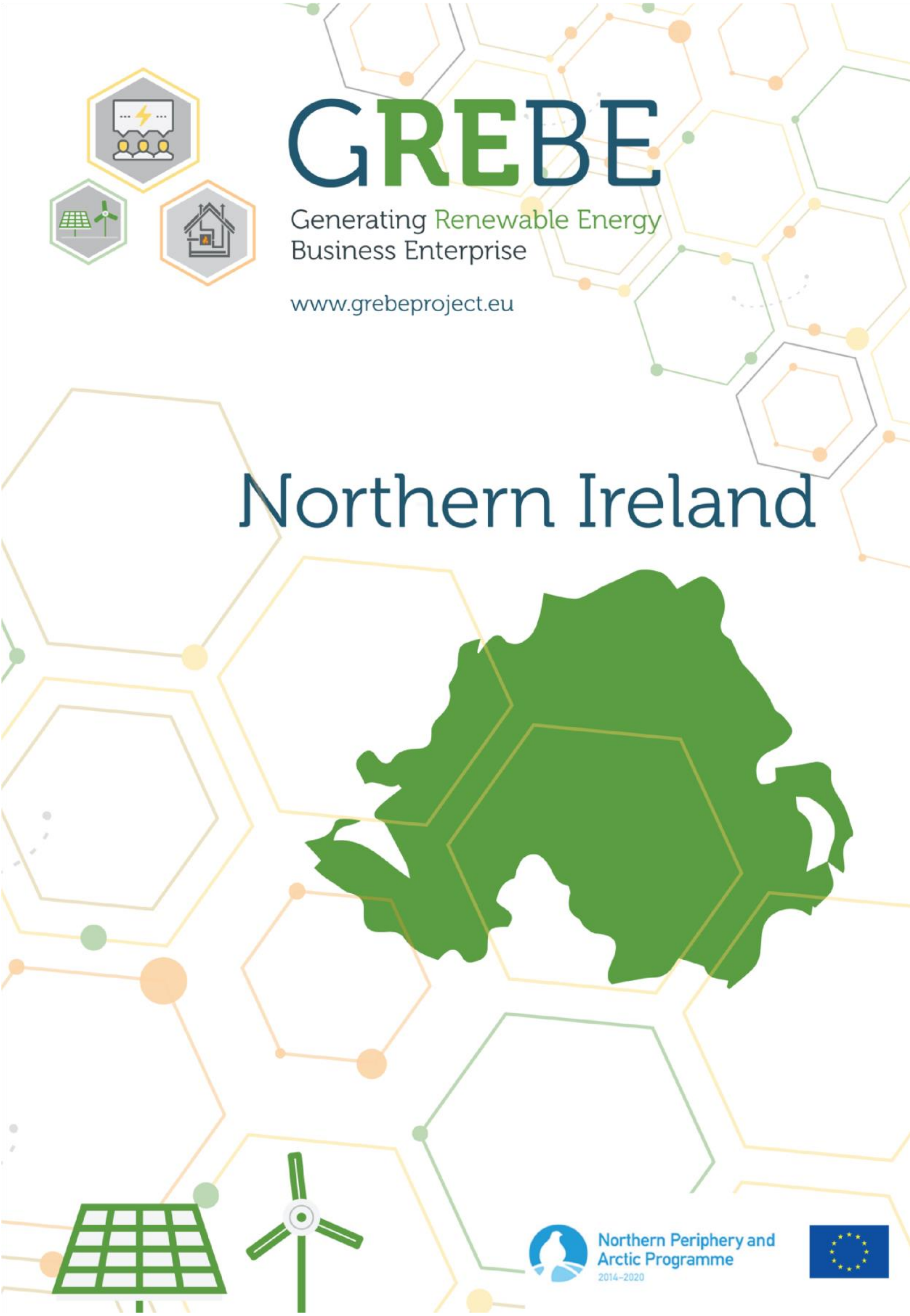
- **Small towns** - Power systems in small towns cannot provide RE to the cruise ships and fishing boats. Consideration should be given to the options of using powerful batteries to store the excess of RE generated electricity, which could be additionally used as standby power supply.
- **Islands areas** - Isolated, off-grid communities with limited access to backup energy,often rely on diesel generators as the only source of electricity, and in many cases, the fuel is delivered by helicopter. The Grímsey and Flatey island are apt examples, where replacing these costly, fossil fuelbased systems with renewable technologies, requires development of new energy storage solutions. Consideration is given to wind, tidal, heat pumps, bio diesel and hydrogen storage. Potential experiences from other partner regions, such as Scotland, maybe able to help inform how these diesel generators can be displaced.

Sectors

- **Technical services (power lines)**- There is a need for development of better technical solutions for power lines due to adverse weather conditions, wind and ice. The power lines in Westfjords are rather unstable because of weather conditions and reserve power stations operate on diesel. This situation is causing discomfort and difficulties for inhabitants and inccurs extra cost for the power companies.
- **Tourism** - Servicing cruise ships with renewable energy. It seems there is political will in Iceland to eliminate this source of carbon emissions and thus it is likely for solutions to be achieved here prior to other partner regions.

Industries

- **Cruise ships** - They have to run their own diesel generators instead of harvesing renewable energy from the harbours.
- **Fisheries** -Small fishing boats use diesel. Diesel oil is imported to Iceland. It is possible to use RE electricity instead of diesel, by charging the boats overnight, for example by plug-in hybrid solutions. It is suggested plug-in and hybrid solutions could potentially overcome this and these are likely to have some cross over with transport issues raised by the Norwegian partners. Given fishing is a major industry in many of the partner regions, renewable solutions in Iceland could potentially be very useful to transfer across all regions.
- **Wind turbines** - Development of windmills so they can operate in difficult weather conditions as ice, cold and strong winds. There is a need for small and low maintenance windmills to supply energy to all kind of equipment in remote locations for example in weather stations, communication systems, environmental monitoring, seismograph and avalanche monitoring.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Geographic areas

- **Rural areas -** Majority of the land space in Northern Ireland is agricultural land and one third of the population lives in these rural areas. The most recent Northern Ireland Housing Executive House Conditions Survey from 2011 highlighted that fuel poverty affected 50% of households living in isolated rural areas in Northern Ireland.The key point relating to Northern Irelands renewable energy potential is that it is mainly located in rural areas. Challenges remain over how the planning system deals with applications relating to renewable energy sources. There are also concerns in relation to both the levels of investment available for development of renewable sources, whether the market price for renewable production makes it a viable economic option and of the real need for investment in and enhancement of the rural electricity grid. Scotland is an apt example for well developed policies and funding mechanism in regards to RE.

Sectors

- **Public transport** - In the public transport sector the majority of travel methods are private vehicles (vans/cars) at 67%. While only 2% of workers use the NI Rail network; and 13% using buses. Renewables could potentially be introduced through more car charging ports for electric vehicles and possibly a more eco-friendly bus/ train network.
- **Tourism** - There is a significant part of NI economy, with the aim to double its contribution by 2020. As an upcoming and emerging sector it is important to support its energy requirements with RE. Tourism was the subject of other projects in the Northern Periphery Programme and is important to the economic and social sustainability of many communities. It has many aspects where renewables could be adopted to displace fossil fuels.
- **Technology / financial services** - Belfast is ranked as one the most attractive cities for foreign direct investment in the UK. Attracted by skilled workers and government subsidies, creating a good renewable energy supply to make this sector sustainable would encourage it further. Whilst this an interesting sector to include many centres for this within partner countries fall outside the NPA and will therefore not be applicable in most instances.

Industries

- **Agriculture / farming** - Farming is a large proportion of the economy in NI and so it is important to encourage renewables in this area.
- **Engineering, manufacturing of machinery / equipment** - This is a large part of the Northern Ireland economy, with a significant percentage of the population employed in this sector, the largest being Bombardier Aerospace employing 5400 people in and around Belfast.


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Geographic areas

- **Rural areas -** Most of the WDC region is very rural and there is very little natural gas available except in some towns. This means most rural homes and businesses are heated using oil (predominantly), LPG, or using soil fossil fuels (coal and peat). Consequently, there is a huge potential market for RE heating in the region but it has been slow to develop and difficult to establish. If 10% of homes were heated using wood or bioenergy this would be a very significant increase in the market and would require the development of many new businesses. Opportunities also exist for other technologies. Within rural areas the use of fossil fuels was seen as a major element to consider, showing a lot of commonality with Finland. This is likely to be an issue for most rural areas in the NPA as the least polluting fossil fuel for heating (gas) is unlikely to be tenable due to the cost of installing the necessary gas networks.
- **Island areas** - As with Scotland, these are often off-grid and rely highly on polluting diesel generators but are also in areas with excellent RE opportunities.

Sectors

- **Education**- Schools have an on-going demand for heat between September and May and most schools are not on the natural gas grid and are heated using oil; thus, there is a significant opportunity for these to switch to RE. There is significant variation in the types of schools in the region from small rural primarly schools to large secondary schools. Understandably many schools are risk averse in relation to changing heating technologies, and have little expertise as well as little money for investment. However there are opportunities for ESCO arrangements and for businesses to develop with a specific focus on the education sector using multiple technologies. Education has the dual benefit of the immediate displacement of non-renewable generation it will help inform and involve future generations with the benefits of renewable energy.
- **Health/caring** - Nursing homes, other residential care centres and day care centres all have significant heat demands and are usually reliant on oil. There are very significant opportunities for businesses to supply heat to these users under ESCO contracts which reduce the risk and knowledge requirement for the purchaser. However this market has been slow to develop perhaps though lack of finances for such businesses and also a lack of expertise in these types of heating systems. However there is significant potential if the difficulties can be addressed.

Industries

- **Distilleries** - As for Scotland, this is a growing industry (albeit much less developed than in Scotland). Many new distilleries are being established, and as they are very often completely new businesses being established on greenfield sites there is an opportunity to install and use renewable energies from the start. Renewable solutions to this industry should be highly transferable between Ireland and Scotland due to the similar climates of the regions.


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Geographic areas

- **Island areas** - Norway has some small islands that are off-grid and rely highly on polluting diesel generators. The islands has excellent renewable energy opportunities in the summertime but not in the wintertime. With a combination with hydrogen solutions, this problem could be solved by developing off-grid RE- systems.
- **Renewable energy export** - Norway has committed to export renewable energy to EU, through the Green Battery Strategy. This means that the EU challenges Norway to produce more renewable energy to replace non-renewable energy alternatives in EU.

Sectors

- **Transportation** - Norways large emission reduction will be made in the transport sector – which calls for the introduction of hydrogen. This means roll out of hydrogen infrastructure and fuel stations for car, trucks and maritime sector (boats, supply ships, ferrys and so on).
- **Maritime sector** - Batteries can and should be more widely used at sea. Different types of vessels have significant variations in the propulsion system, operational profile and which operations they perform, so even if there are already several vessels with battery systems on board – there is a need for projects that defines a standard solution.

Industries

- **Smelting industry** - Tizir Titanum in Tyssedal will use new environmental technology at their smelting plant to achieve a greener industrial production process. Tizirs project is to change their production process to be greener – which will include a water cooled copper-ceramic roof and a system for controlled heat balance in the melting furnace. The smelting plant industry, both nationally and internationally, could benefit from the results from this project, especially with regard to liquid cooling of copper-ceramic roofs. If more players start using this technology in the long term, this could generate substantial energy efficiency gains and reduced CO_2 emissions


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Geographic areas

- **Rural areas -** A large part of Scotland is rural with very low population densities. A household is defined as being in fuel poverty if it would be required to spend more than 10% of its income (incl. Housing Benefit or Income Support for Mortgage Interest) on all household fuel use. 'Extreme fuel poverty' is defined as a household having to spend more than 20% of its income on fuel. The proportion of households in remote rural Scotland which are classed as extreme 'fuel poor' is more than double that of the proportion in the rest of Scotland (22% compared to 9%). Almost 66% of households in remote rural Scotland are classed as 'fuel poor', while nearly half of households in accessible rural Scotland are in fuel poverty. Local RE options may help to tackle both the fuel poverty and economic one.
- **Island areas** - Like rural areas, islands typify the isolated nature of large tracts of the NPA and the associated challenges which come with this. Traditionally an isolated location has resulted in a higher carbon footprint due to diesel generators and similar highly polluting technologies relied upon to provide energy. Islands can present good opportunities for innovative low carbon solutions. Despite these opportunities, the island communities face higher fuel costs and often have harder-to-treat housing and more extreme weather conditions. The lack of interconnection with mainland electricity networks acts as a barrier for renewable developments when competing for market support with projects across mainland. While an island wind project could capture some of Europe's best wind resources providing benefits up to £725 million for Island economies from 2015 to 2040, the projects face unique costs that obstruct deployment under existing support mechanisms

Sectors

- **Transport** - Transport is estimated to account for 25% of Scotlands total energy use. The ratio of energy used to transport people and goods on the roads is about 60:40 respectively. Only 3.9% of transport were renewable options in 2015 with a target of 11% by 2020. Low carbon transport continues to grow but needs better integration into everyday life.
- **Domestic** - The consumption of heat accounts for 53% of the energy consumed by Scotlands homes and businesses. Scotlands heating requirement is even more marked at domestic level. Almost 90% of the energy requirement for Scotlands homes is for space and water heating. Addressing this demand represents a key challenge for the future in balancing the needs of consumers with a lower carbon secure energy system. Scotlands heating requirements are supplied predominantly from natural gas at present. In 2015, an estimated 79% of homes used natural gas as their primary heating fuel.
- **Community initiatives** - The community initiatives sector was included in this report due to strong government policy and support in this area, which has led to the development of many community renewable projects. It is hoped dissemination of these success stories will inspire other communities in Scotland to take advantage of these supports. Whilst community initiatives could be applicable across the whole of the NPA, it is likely that some degree of support will be necessary within partner regions to initiate the same level of uptake that has been seen in Scotland.

Industries

- **Distilleries** - This is growing industry in Scotland and the Scotch Whisky industry body has set an internal target of 20% of the energy use in the sector to come from renewable sources by 2020 http://www.scotch-whisky.org.uk/media/41152/guide_for_distillers.pdf
- **Aquaculture** - Aquaculture is an increasingly important industry in Scotland. Renewables could displace the traditional fossil fuel derived electricity used in applications like onsite processing, and pumping and aeration.

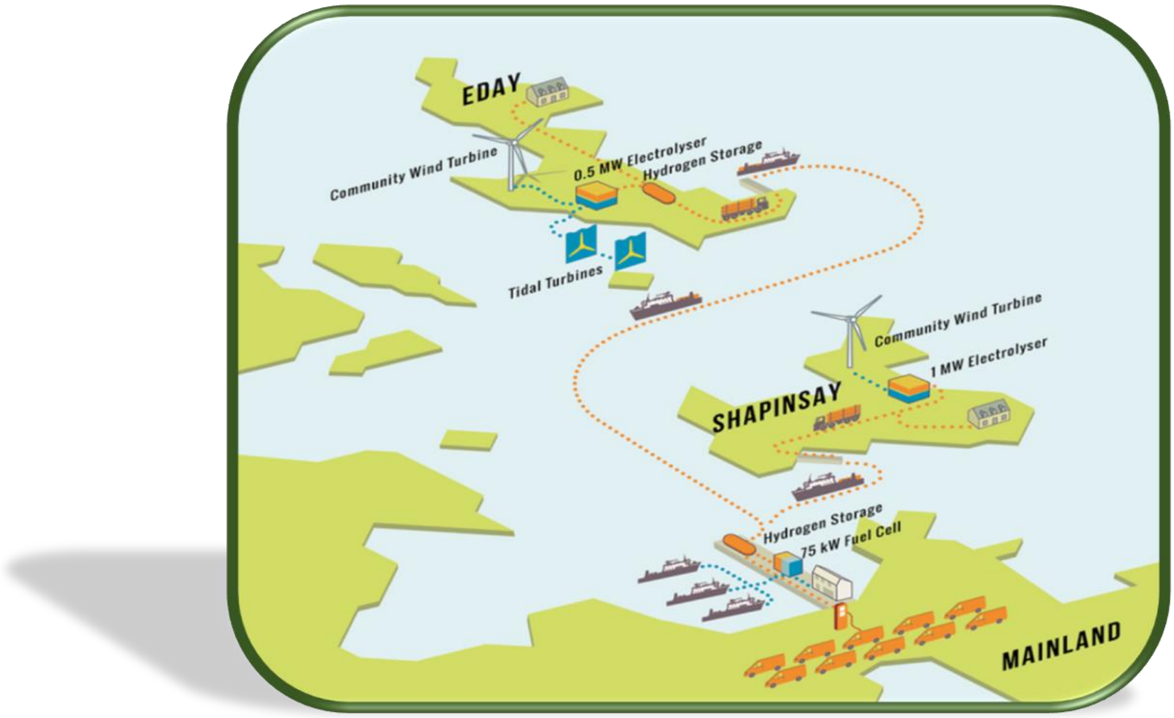
3. Preliminary Findings on Transferable Solutions (Geographic, Sectors and Industries) in Partner Regions

Geographic areas

Islands are repeatedly mentioned, by Republic of Ireland, Iceland, Norway and Scotland, as areas where non-renewable sources are used predominantly. However, simultaneously they are identified as potential key areas, where non-renewable resources are meeting the energy demand, demonstrating the potential to be replaced by renewable energy resources. Islands are seen as a promising target for increased uptake of RE technologies and innovative low carbon solutions.

The drive behind a transition from fossil fuels to renewable energy resources does not need to be motivated by the threat of climate change or renewables themselves. The case maybe, as it was in Iceland's transition, that the country/location cannot tolerate oil price fluctuations, continuously arising due to a number of crises distressing the world energy markets. Renewables can offer a stable and economically feasible domestic energy resource for the isolated location of many islands across the NPA region. Effects such as price, assembly efficiency, resource obtainability and politics play a significant role. Nevertheless, the main driver for RE technologies uptake is energy costs and energy security. However, in order for there to be a higher uptake of renewable energy technologies, unity and consistency of government policies regarding renewable energy is essential.

The government support in both Scotland and Iceland has a substantial part of the renewable energy development in the island areas, provision that may not be fully developed in Ireland but a transferrable solution/advice for both Ireland and Norway. Many of Scotlands island communities are already successfully demonstrating complex energy solutions and can be used as best practice example, which could certainly be transferred to Iceland, Ireland and Norway. Energy innovation on the islands in Scotland is driven by their isolation from mainland energy and supply networks, and the availability of some of the most powerful renewable energy resources in Europe. An apt example of that is the island of Orkney.



- **Orkney** is home to what was the UKs first smart grid, allowing renewable energy generation to be linked to Orkneys distribution network at a significantly lower cost than conventional network connection. Orkneys 'Surf and Turf' and 'BIG HIT' projects exhibit a fully cohesive energy model where hydrogen is created using excess electricity from tidal and onshore wind turbines, storing it in a fuel cell, and using to provide low carbon heat, power and transport. The projects will assist the community through providing employment and training, as well as, reduced harbour electricity costs and increased revenue.

  - ✓ **The smart grid idea** - Active Network Management (ANM), was born in 2004 out of the necessity to design another solution to Orkneys grid capacity limitations and as a result of the high cost of conventional grid reinforcement. The new and innovative ANM approach was developed to make better use of the existing network by controlling generator output, in real time, to match the available network capacity. In 2013 there was over 77MW of renewable energy generation connected to the grid, over 40% was managed by the ANM system, with 103% of Orkneys demand met by it. Consequently, Orkney became a net exporter of electricity, delivering over £4m of benefit to the local economy. After the achievement in Orkney, the system has been replicated in other grid constrained areas, including Shetland, the Western Isles and the Isle of Wight. Thus, this presents one best practice example which can be replicated in partner regions where they are facing similar constraints.

  - ✓ **Lithium ion battery (2MW)** – installed in 2013 at Kirkwall Power Station and integrated into the existing energy storage system within Orkneys ANM network. This was yet another ground breaking trial, designed to test the feasibility of large scale batteries for electricity storage. Batteries are always a good choice when it comes to dealing with intermittent power generation (wind turbines in Orkney). The battery, combined with the ANM system in Orkney, where the operator can store the energy when is not needed and use it when demand is higher, is an excellent replicable solution. Batteries are an easily transferable best practice example across the partner regions.

- ✓ **Surf 'n' Turf** - The grid connection in Orkney was not large enough and when there was over-production of electricity and the battery had reached its capacity, a curtailment of the production was compulsory. Both Edays wind turbine and EMECs tidal turbines are susceptible to curtailment because of the non-firm grid connection. Surf 'n' Turf is a collaborative, novel project between Community Energy Scotland, Eday Renewable Energy Ltd, EMEC, Orkney Islands Council and ITM Power, to use the surplus power from tidal and wind turbines to produce compressed hydrogen. The hydrogen is compressed by EMECs electrolyser. It is then stored and transported to Kirkwall for off-site use, where a specially designed fuel cell will convert the hydrogen to electrical power for buildings and berthed ferries at the harbour. Solutions including hydrogen can be transferred from partners with higher uptake (Scotland & Norway) to the other partner regions where uptake is lower or technology is not developed.

- ✓ **BIG HIT** - Orkney has been chosen for the development of a new European pilot project: 'Building Innovative Green Hydrogen systems in an Isolated Territory' (BIG HIT). The Surf 'n' Turf project laid the foundation for communities and energy technology partners to tender for the funding. The BIG HIT project has a €5m budget prepared for investment in hydrogen, as a fuel for transport and heating.

- ✓ **Lesson learnt** - The Orkney Islands is an apt example of how isolation from mainland energy and supply networks can trigger innovative, cost effective, renewable solutions. Furthermore, Orkney is a great illustration of the snowballing effect associated with RE initiatives. Starting only with a community owned wind turbine, as a result of geographical constraints and insecurity of energy supply, turning into a pioneer of dealing with a green energy surplus and attracting millions of investment.

- ➢ **The Isle of Eigg** is another example of a small island, located off the west coast of Scotland. The island is not connected to the mainland electricity grid and relied on heavily polluting diesel generators. Each individual was dependent upon producing their own electricity, mainly using costly and inefficient generators. At present, the island has switched to a 100% renewable electricity supply. Eigg Electric, which is a community owned company, provides the electricity. The repairs and servicing is the responsibility of a trained maintenance team of island residents. The generation capacity consists of three hydroelectric generators, one of 100kW and two smaller 5kW and 6kW installations; four 6kW wind turbines; and a 50kW photovoltaic array.

- ✓ **Mix and balance** - The capacity of the scheme is about 184kW but not all the renewable energy resources produce the maximum output they are capable of. The selection of three different renewable energy resources and technologies allows for a balance where the output of the readily available resources is maximised in order to ensure energy demand is met.

- ✓ **Security of supply** - This is guaranteed by a lead-acid battery bank, capable of supplying power for a day allowing optimisation of the supply – demand curve. As part of the control strategy on the island, two 70kW diesel generators support the system acting as a reserve for emergencies.

- ✓ **Smart management** - Demand management is used to help with the electricity system security. A maximum use limit of 5kW for any house is in place and 10kW for each business. 5kW is enough for an electric kettle and washing machine (or about 500 energy saving light bulbs).

- ✓ **Lessons learnt** - The Isle of Eigg is an apt example of the possibility of a completely stand-alone system with no external input from the mainland. Integration and incorporation of all available resources and demand management are transferable solutions, replicable across partner regions.

Sectors

Transport seems to be a recurrent sector across partner in the NPA region. Long distances and dispersed settlements increase energy use in transport. There are two promising technologies in that sector - electric vehicles (EVs) and fuel cell vehicles (FCVs). EVs use electricity directly to charge their batteries, while FCVs are powered by hydrogen. Development of these two key technologies, through entrepreneurship, is driven by the fluctuating fuel costs and the need for fuel security. However, growth in entrepreneurship in the transport sector will be dependent on removing the barriers such as high unit costs for low carbon vehicles and lack of recharging/refuelling infrastructure.

In the input provided by Northern Ireland it is highlighted that the preferred travel methods by people are private cars, accounting for 67% of the public transport sector. Only 2% use the NI Rail network and another 13% rely on buses. Transport is estimated to account for 25% of Scotlands total energy use and the Scottish Government has a 2020 target of 10% of transport fuels to be from renewables. In 2014 in Scotland, 68% use their private cars as their primary mode of transport. From the remaining 32%, 78% of all public transport journeys were made by bus and 16% by rail in 2013.

The transport sector is identified as one that heavily relies on non-renewable resources. However, it is a sector with a huge potential to be converted to renewable energy resources, especially taking into account the targets set by many governments regarding the share of renewables in the transport sector.

- **Government incentives** - EV uptake in Scotland is rapidly increasing because of government support and policies for the transport sector. There were only 25 hybrid electric vehicles and 342 electric vehicles in 2002, while in 2014 there were 9,030 and 5,082 respectively.

  - ✓ **Governments schemes** - At the end of June 2016, due to lowering the barrier of high unit costs for low carbon vehicles there were 3,570 electric cars and vans licensed in Scotland (eligible for the UK Governments plug-in car and van grant schemes), compared to 2,050 at the end of June 2015.

  - ✓ **The ChargePlace Scotland** is a growing national network of public charge points for electric vehicles (EVs) and the majority of charge points are currently free to use. The network has expanded to over 600 publicly available EV charging points, equating to over 1,200 charging bays.

  - ✓ **Rural areas** - The Highland and Islands comprises of many remote communities, which despite being at close proximity to North Sea oil fields, are paying some of the highest costs fuels because of logistics and delivery costs. Despite the traditional “range anxiety” across potential users, an increased interest in EVs is noticeable, in the northern parts of the country.

- ✓ **Costs and security** - An EV running costs are about 20% of conventional fuel cost and when charging through Scotlands Plugged-in Places network it will be free. This, coupled with alluring tax allowances and grants, lowers the high unit costs barrier. Furthermore the government agency 'Transport Scotland', supported by 'Switched on Scotland', provided a £900,000 investment in order to deliver charge points facilities at 35 mile intervals, which will lower significantly the barrier associated with lack of recharging/refuelling infrastructure.

- ✓ **Lessons learnt** – Government support is essential for a transition of the transport sector from fossil fuels to renewable resource.

➢ **Isle of Lewis** (off the northwest coast of mainland Scotland), introduced a car hire scheme which utilises electric vehicles.

- ✓ **Innovative entrepreneurship** - The car hire scheme is a perfect example of novel entrepreneurship. A joint venture between Zero Carbon Marine Ltd (operators of the Pentland Road wind farm) and E-Car Club Ltd. (who operate entirely-electric car clubs across the UK) came together to bring affordable, zero carbon transport. Ten electric vehicles will be available for the public to book for as little as an hour, or up to several days at a time at exceptionally affordable rates.

- ✓ **Renewable energy** - What makes this scheme exceptional is that the majority of electricity used to power the vehicles will be produced by the islands wind turbines, making this one of the cleanest, greenest mobility solutions across UK. These low carbon transport solutions are suitable for piloting on island locations, as they have a captive transport fleet and the problem of range is limited due to the small geographic extent that journeys cover.

- ✓ **Lessons learnt** – Innovation, entrepreneurial spirit and excess of renewable energy can transform the transport sector on islands.

➢ **The Isle of Mull** - The Mull and Iona Sustainable Transport Project (MIST) targeted to promote a more sustainable transport system and increased from three EV/Plug-in hybrids to eleven, more than doubling the project target.

- ✓ **Showcasing** - A Nissan LEAF electric car was purchased by MIST to allow islanders to appreciate the practice of driving with zero emissions combined with very low running costs. MIST also acquired a 100% electric Citroen Berlingo van, targeted specifically at island businesses to test and to borrow it free of cost, in order to promote uptake. Following MISTs successful collaboration with the Energy Savings Trust to host Electric Vehicle 'Hot spot' events on Mull, a Mitsubishi Highlander hybrid 4WD was offered as a free loan, available for islanders to try out at no cost for a period of two months.

- ✓ **Liftshare**- the Mull and Iona Lift Share page on Facebook, with the objective to match willing drivers with willing passengers to share journeys, has attracted around 452 members over a period of 7 months, frequently cooperating through the platform.

- ✓ **Lessons learnt** - Showcasing is a key element for acceptance, development and uptake of renewable energy solutions.

➢ **The BIG HIT** project in Orkney targets a demonstration of a fully cohesive model of hydrogen production, storage, transportation and utilisation for low carbon heat, power and transport.

- ✓ **Ten electric vans** - with a built-in hydrogen fuel cell range extender, provided by the Orkney Islands Council, will be deployed. A hydrogen refuelling station will be constructed.

- ✓ **Demonstration** - Fuel cells will provide users with longer range compared to their battery-powered EVs counterparts. The main aim behind the deployment is a demonstration of the potential scope of hydrogen use.

- ✓ **Lessons learnt** - There is significant potential for these projects to be replicated or scaled-up in the future. Hydrogen may have the potential to provide the lowest cost and least disruptive solution.

➢ **North Coast 500 (NC500)** - This is the new touring route, also known in the media as the Scottish version of Route 66, targets to blend the best of the Scottish Highlands. The North Coast 500 involves travelling 500 miles (804km) round the coast of the Highlands. The Highland trip showcases EVs - and impressive charging network.

- ✓ **Highlighting** - What makes the NC500 experience unique is the branding of the new tour, which highlights the opportunity to enjoy a zero emissions trip. Visitors can drive the route in fully electric/hybrid cars using the charging points along the way. There are eleven rapid charging points, which recharge batteries to 80 per cent in about thirty minutes.

- ✓ **White Car** – This is an electric car only rental company, which is one of the service providers. The company is another example of innovative entrepreneurship, where they redefined the frequently burdensome and ineffective self-drive car hire sector by enabling customers to rent the new Tesla models with simplified booking and collection process permitting customers to simply ‘arrive and drive’ all at the touch of an app.
- ✓ **Lessons learnt** – Being green is trending and more and more companies are trying to incorporate it in their businesses models. Entrepreneurship can be born out of something already established (car rental) by twisting it into another direction (exclusively electric).

Industries

Industries, unlike geographic areas and sectors, tend to be more country specific. However, there are some overlaps like farming and distilleries.

- "**The Flying Farmer**" – John McKenzie is an apt example of the possible snowball effect that can stir from RE entrepreneurship, especially when the entrepreneur is ready to share his knowledge and skills with other like-minded people and assist them.

  - ✓ **Entrepreneur** - John McKenzie used his own farm as a foundation to encourage local renewable energy production and savings by combining a variety of his experiences stemming from visiting the remote islands of Scotland. He embarked on a number of projects to promote local energy production and saving. His farm is harnessing sun, wind, and rain for energy production, resulting in Wind, Hydro (on and off grid), Solar PV, Solar Gain, Solar Thermal and Biomass RE projects, as well as an electric car.

  - ✓ **The GlenWyvis Distillery –** This will be 100% powered by green energy, where non-thermal energy is going to be used for baseload generation (lights, pumps etc.), while thermal energy will be utilized in the production process. John McKenzie has already agreed that variety of RE generation on site (11kW wind, 41kW solar array and 12kW hydroelectric turbine) used for his "Flying Farmer" business, will be available to the GlenWyvis Distillery free.

  - ✓ **Pioneering entrepreneur** - John McKenzie started his own farm and business, through the assistance and support he made to both, Dingwall Auction Marts Endurance Turbine and the Dingwall Wind Coop, culminating in the 100% community- owned and green Glen GlenWyvis distillery.

  - ✓ **Lessons learnt** - The Flying Farmer model of entrepreneurship is certainly transferable and replicable solution for partner countries.

4. Guidelines for Successful Transferability of Solutions across Partner Regions

- **Geographical isolation** can trigger innovative solutions. Islands and rural areas provide considerable opportunities to demonstrate high penetrations of variable renewables in isolated energy systems whilst maintaining security of supply.
  - ✓ **The Orkney Islands and the Isle of Eigg** models are transferrable solutions for islandic entrepreneurs. The success of their transferability is highly dependable on local empowerment and public engagement.

- **Highlighting and showcasing** every step of the development of a renewable entrepreneurial project is imperative. This ensures public participation, understanding of the process and triggers a snowballing effect.
  - ✓ **Long – term planning** for renewable energy implementation is central for the snowballing effect.

- **Government** backing through incentives, support and schemes (as it is in the case of Scotland) is important when is backed by a favourable legal and regulatory framework.
  - ✓ Government support alone is not enough, the **snowballing effect** is important for innovative entrepreneurship. A project can be triggered by issues surrounding energy insecurities/high fuel costs, grow into economic instrument (net exporter of low carbon electricity), culminating into a project attracting millions worth of investment.

- Tackling issues starting with the bigger picture (key geographic area) and filtering down (sectors, industries) is a **winning method**. If a solution is targeted first at geographical level (island/rural communities), as is the case with EV charging points, it can trigger automatically solutions to the sector sub-levels (transport/tourism) and industry (cars).
  - ✓ **The Isle of Lewis** being an apt example for when an island becomes a net exporter of low carbon electricity, the next coherent step is to start using that green energy to decarbonise the transport sector and promote tourism.

- **Lessons learnt** – Just as wind generation is a popular choice for many projects across Scotland, local conditions, availability of RE resources and demand will vary across partner regions. Correspondingly, it is essential to link all three mentioned with the right choice of technologies in order to balance the output of the readily available resources and maximised it to ensure energy demand is met (**Isle of Eigg**).

  - ✓ Geothermal and hydropower generation is popular in Iceland, combustion in Finland, wind and solar across Northern Ireland and Ireland and hydro in Norway. The differences in available resources is not important, as the transferability lessons are across areas rather than technologies.

5. Identification of relevant renewable technologies and renewable integration enabling technologies

The second objective of this report is to identify the relevant RE technologies and renewable integration enabling technologies applicable to every partner region, including the corresponding *risk* and *market penetration* levels. Every RE project encompasses a wide range of *risks* and each phase of the project must be given different considerations across the diversity of threats. However, it is imperative to note that many of the risks and threats can be significantly reduced using proven technology and techniques. Attention also must be paid to the weather conditions and especially the technology suitability to withstand those conditions. *Market penetration* consists of the commercial development of a technology so it can become widely available and used on a mass scale. Many technologies may have reached the market penetration stage in view of their technology readiness levels (TRLs 7-9 proven technology). However, they may not be able to penetrate the market because of several hindering factors as lack of economic incentive or government support. On the other hand, there are many technologies with lower TRLs that are expected to reach the market penetration point in the near future. The selection of renewable technology will be determined by the balance of energy demand in the business, the prospect of exploiting local natural resources and the existing supply network. Assessing the energy mix assists in determining which RE technology is right for the business. These matters will be discussed in depth in the Activity 5.3 Deliverable - **Renewable Energy Resource Assessment Toolkit**.

The input that we received from our partners was beneficial and ensured a good coverage of all the technologies available across the NPA region. After discussion, in addition to the traditional forms of renewable technologies, it was decided to include energy efficiency, batteries and other forms of storage. The reason behind that decision is that the above-mentioned are considered to come under the category of enabling technologies for renewables. The enabling technologies sometimes may be as important as the renewable technology itself, as seen in many of examples in the previous chapters.

What follows is a summary of the RE technologies used across the partners in the NPA region. An in-depth description and analysis of the technologies will be presented in Deliverable 5.2 – A Collection of Case Studies, accompanied by videos, along with transferable solutions across partner regions and advice notes.

The renewable energy and renewable integrating enabling technologies relevant in each of the partner regions have been analysed to include risk and market penetration levels.

The renewable energy technologies for each region are presented in a descending order, starting with the most utilized technology in the region with the highest market penetration rate and lowest attributable risk to it. This is followed by taking into consideration the market penetration and then the risk for each technology.

Overview of RE Technologies

Wind (On Shore)

- Wind turbines produce electricity by capturing the natural power of the wind to drive a generator. A variety of different scales exists and the technology is almost handled as a commodity. However, this is an intermittent resource; thus, some form of storage present is preferable.
- Simple, mature and developed technology, with about a 15 years lifespan without new investment and low maintanance costs.

Solar PV

- PV devices convert sun light directly into electrical energy. The amount of energy produced is directly dependent on the sunshine intensity.
- Mature technology with about 25 years lifespan, low maintanance costs with modular nature allowing for range of sizes, storage is preferred.

Solar Thermal

- Solar thermal systems use solar collectors to absorb energy from the sun and transfer it, using heat exchangers, to heat water.
- The technology is well established (capital costs are still relatively high) but its success depends on a number of location and orientation based factors.

Hydro

- Hydropower is the extraction of energy from falling water (from a higher to a lower altitude) passing through an energy conversion device.
- It is a highly site-specific technology, with a lifespan of about 30 years. Power is available at a fairly constant rate, subject to water resource availability.

Geothermal

- This is very site dependent as the resource needs to be near surface. Technology is mature and proven.
- It can be used for heating and power generation purposes, in principle it is an inexhaustible energy source and no problems of intermittency.

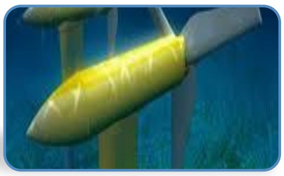
Biomass

- Biomass energy is the use of organic materials such as wood, straw and dedicated energy crops, for the generation of both heat and electricity.
- Mature technology but unlike most RE technologies, fuel needs to be sourced/purchased, unless waste material is available as a by-product from any process in the business. Thus, it is essential to ensure that a local and secure supply of biomass feedstock is available.

Wave

- Emerging, scalpable by multiplication technology, where the installation is anchored to the ground and the technology captures the energy contained in ocean waves to generate electricity.
- Simple technology as no moving parts other than the air turbine, but performance level is not high at present. Only a few installations (lack of track record), with limited suppliers and extreme conditions at sea.

Tidal

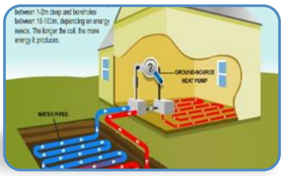


- Underwater turbines are placed in areas with high tidal movements, designed to capture the kinetic motion of ocean tides to produce electricity.
- Full-scale deployment of single turbines has been achieved, the next step is demonstration of arrays of turbine, which is underway.

Hydrogen Fuel Cell

- A fuel cell combines hydrogen and oxygen to produce electricity, heat, and water. It converts the energy produced by a chemical reaction into usable electric power.
- Large quantities of hydrogen can be stored over long periods of time, facilitating the integration of high shares of variable RE into the energy system for power and heat. This is a promising technology, the development of hydrogen generation (electrolysers) incurs costs , and R&D and retail infrastructure is challenging as well.

Ground Source Heat Pump (GSHP)



- GSHPs take low-level heat from solar energy stored in the earth and converts it to high-grade heat by using an electrically driven or gas-powered heat pump containing a heat exchanger.
- Well-established technology, as well as, sound design and installation criteria. The installation of a GSHP requires a large amount of civil engineering works and installation, best suited to new build properties.

Air-Source Heat Pump (ASHP)

- ASHPs work on a similar principle to GSHPs, but source the low-level heat from the air, using an air-source collector, located outside of the building.
- ASHP involves siting an external unit and drilling holes through the building wall, additional pipework may also be required. ASHPs tend to be cheaper and easier to install than GSHPs. The performance of an ASHP varies dramatically with the external air temperature and this should be taken into account when considering the use of such a system.

Batteries

- There are many battery technologies available, such as lithium-ion, lead-acid, NiCd, Vanadium Redox-Flow, sodium-sulphur or ZEBRA
- Mature and proven technology for energy storage, stability flexibility, power flow management, and delivering power-on-demand whenever it is needed.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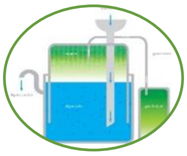
Technology	Market Penetration	Risk
 **Combustion**	**Very High** Mainly small to medium scale plants.	**Very Low** Proven technology.
 **Solar PV**	**Low** Emerging service, with proven technology.	**Intermediate** Proven technologies available but still limited demand.
 **Micro - CHP**	**Low** Howeve, public demonstrations and one private plant in North Karelia.	**Intermediate/high** Technology has reached markets but there is limited information about long-term feasibility.
 **Anaerobic Digestion**	**Low** Close to the market access and demonstration units are established.	**Intermediate/high** Technology is simple but has not penetrated the market in Finland. No information on technical/economic feasibility.
 **Hybrid energy systems**	**Low** There are public demonstrations.	**Intermediate/high** Technology has reached markets but there is limited information about long-term feasibility.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Technology	Market Penetration	Risk
 **Micro Hydro**	**High** Proven technology with high market penetration in Iceland.	**Low** Quite simple to produce, inexpensive parts and the use is mainly from electricity from the network.
 **Geothermal**	**High** Proven technolody with high market penetration in Iceland.	**Low** Proven technology and abundance of resources in Iceland.
 **Solar**	**Intermediate – high** Convenient for trailer parks and summer cottages and other retreats that do not have access to electricity.	**Intermediate – high** There is not enough sun during winter so if battery solutions were improved it would be useful during summer.
 **Hydrogen**	**Intermediate – high** The key challenge facing hydrogen production in Iceland, is the supply of cheap electricity(geothermal/hydro).	**Intermediate – high** There is abundance RE resources, (hydropower/geothermal sources), so electrolysed hydrogen is created indirectly, using electricity as an energy carrier.
 **Wind (Ice Wind)**	**Intermediate** High opportunities, but the production costs tend to be much higher than hydro/geothermal. Opportunities through better utilization of windmills & different design (cheaper for production).	**High** High probability of developing wind resources in Iceland and the risk would be mainly during production process because of the extreme weather conditions.


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Technology	Market Penetration	Risk
 Solar PV	**Very High** Very popular choice of technology in NI.	**Very low** Well established technology in NI already.
 Wind	**Very High** High market penetration, popular technology and is best situated to NI resource base.	**Very low** Already established as a viable technology in NI, although changes in government incentives may cause a decline in number of applications.
 Biomass	**Intermediate** Intermediate throughout NI due to the popular demand of the renewable heat incentive (RHI), especially in non-domestic sector. However, since February 2016 the RHI is no longer available in NI.	**Intermediate** Due to incentives (RHI) being reasonably attractive to businesses and farms, biomass may have an opportunity to create a larger market share for itself. This depends on continuation of government funding.
 Solar Thermal	**Low - Intermediate** Mainly due to the high cost of instalment, followed by weak support.	**Intermediate** Some government incentives for these, not as common as solar PV.

Wave

Very Low
Not successful in NI to date; however, small amount of R&D taking place.

High
No permanent technologies introduced yet.

Tidal

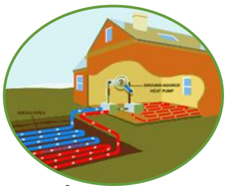
Very Low
Very low market penetration with very few installments taking place.

High
Permanent technology installed, promising results.

Air Source Heat Pumps

Very Low
The market penetration is low due to the climate in Northern Ireland.

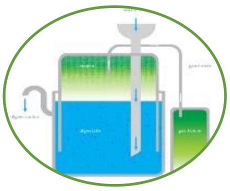
High
Not very effective in NIs climate due to cool temperatures; thus, high risk.



Ground Source Heat Pumps

Very Low
Very low market value due to the potential harm if the pump is damaged. With no funding available it is not popular choice.

High
System leakage can cause ground water to become toxic due to chemicals used in pipes (antifreeze). Also costly to install, very little government incentives.



Anaerobic Digestion

Very Low
Low due to the cost of the instalment and also very strict rules and regulations when installing. This can cause additional cost.

High
Difficult to secure planning permission, also no incentives/ grants. Lack of experience/ training for instalment and management of them.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Technology	Market Penetration	Risk
 **Wind (on shore)**	**Very High** Significant wind resource and very high market penetration.	**Low** Well established supply chain, local expertise and significant grid penetration. Reaching maximum grid capacity but with further interconnection this will increase.
 **Combustion**	**Low** Market penetration is low at present. However, there are significant opportunities.	**Intermediate** Variety of examples of unsuccessful installations. Fuel moisture content is a significant problem; thus, inherent risk.
 **Air Source Heat Pumps**	**Low** Some market penetration at domestic level and some opportunities available but it is hard to determine potential at present.	**Intermediate** Some domestic penetration; however, risk is based on lack of expertise on installation and maintainance can cause poor efficiency.
 **Ground Source Heat Pumps**	**Low** Lower market penetration than ASHPs but likely to be some increase in use.	**Intermediate** Risk occurs due to lack of market penetration. Also suggestion that damp climate might affect lifespan of equipment but this is not substantiated.

 **Micro - Hydro**	**Low** Some small scale hydro but these were mostly installed in 1960s, very little new installation.	**Intermediate** Risk is intermediate due to few new installations, and lack of expertise. The is good potential for the technology but may encounter risks related to environment and fisheries issues.
 **Solar PV**	**Low** Market pentration is low at the moment but there are some possible opportunities.	**Intermediate** Risk occurs because of the low solar potential in NW of Ireland and weak policy support. However, cost and simplicity of installation may make it attractive in the medium term.
 **Solar Thermal**	**Low** Market pentration is low at the moment but there are some possible opportunities.	**Intermediate** Risk occurs because of the low solar potential in NW of Ireland and weak policy support. However, cost and simplicity of installation may make it attractive in the medium term.
 **Batteries**	**Low** A number of demonstration installations and very significant potential given the level of wind energy and the wind resource.	**Intermediate** Early stage of technology might be a risk but significant opportunities if successful.
 **Wave**	**Very Low** Emerging technology, in the development and testing phase. Significant resource opportunity when technology reaches higher TRL.	**High** Development currently at test sites and risk occurs mainly because of the high investment costs needed for new technologies in Ireland.


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Technology	Market Penetration	Risk
 **Hydro**	**High** Proven technology and market leader in Europe.	**Low** Very low risk associated with technology because of the high TRL and high market penetration.
 **Hydrogen**	**Intermediate - High** Close to market access in Norway, demonstration units established.	**Intermediate - High** Proven technologies are available to the public but still limited demand.
 **Solar PV**	**Intermediate** It is an emerging service in Norway but with proven technology.	**Intermediate** Proven technologies available but still limited demand
 **Micro - Hydro**	**Intermediate** There are variations in the market penetration of the technology as there are periods with high prices and periods with low prices.	**Intermediate** Risk occurs due to licence cost and application procedure. Furthermore, there is lack of public funding and support.
 **Batteries**	**Low** Market penetration is low as energy storage is not essential because the RE resources in Norway are not intermittent.	**Intermediate** Early stage of technology might be a risk but significant opportunities if successful. A number of demonstration installations and very significant potential given the wind resource.

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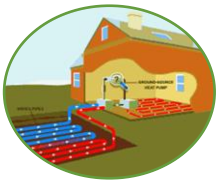
Technology	Market Penetration	Risk
 **Wind (on shore)**	**Very High** Scotland is one of the windiest countries in Europe and has an installed capacity of nearly 6GW of onshore wind; thus, very high penetration.	**Low** Good supply chain in place and large deployment in the region. Changes in government subsidy could become an issue.
 **Hydro**	**High** High market penetration as a result of high TRL with the most modern plants achieving energy conversion rates over 90%.	**Low** The risk is low as the technology is widely used in Scotland but small-scale hydro, at risk due to changes in subsidies.
 **Batteries**	**High** Batteries are widely used as energy storage solutions, especially on islands and off-grid locations. High market penetration in Scotland with variety of technologies available	**Low** Risk is low as this is mature and proven technology for energy storage, stability flexibility, power flow management, and delivering power-on-demand.
 **Air Source Heat Pumps**	**Intermediate** Some market penetration at domestic level but hard to determine the future potential. Possibilities for uptake as a result of a renewable heat incentive (RHI).	**Low** ASHPs are part of the Domestic Renewable Heat Incentive. RHI incentive is available. No planning permission needed subject to a number of conditions.
 **Ground Source Heat Pumps**	**Intermediate** Some market penetration at domestic level but hard to determine potential. Possibilities for uptake as a result of RHI.	**Low** GSHPs are part of the Domestic Renewable Heat Incentive. RHI incentive is avaialble. No planning permission needed dubject to a number of conditions.

 **Solar PV**	**Intermediate** Solar energy is playing a small part in the renewable energy mix, since Scotland doesn't have the highest rates of sunlight, thus the level of uptake is intermediate	**Intermediate** Proven technology available but limited demand. Feed in Tariffs (FiTs) are available but tariffs have been cut drastically; thus, higher risk.
 **Solar Thermal**	**Intermediate** Proven technology, approximately 22,000 installations in Scotland. However, payments are made when the technology is used to heat hot water, but not for space heating.	**Intermediate** Market has slowed down considerably since the introduction of the RHI, favouring other technologies. Thus, despite the substantial potential, the demand for technology is lower.
 **Wave**	**Low- Intermediate** In between demonstration and proven technology. Huge potential - around 10% of Europes total wave resource flows in the seas surrounding the Highlands and Islands of Scotland - up to 14 gigawatts of recoverable energy.	**High** With high capital costs, a long payback period, little design convergence and a level of engineering risk, it has been challenging to secure continuing finance for wave projects.
 **Hydrogen**	**Low -Intermediate** Still relatively new for hydrogen technology in Scotland, but exciting new projects and investment is bringing it closer to market access.	**High** Emerging technology; thus, there is perceived high risk and the issues of long term return.
 **Tidal**	**Very Low** Technology is in its infancy and numerous devices are in a prototype stage. The immediate challenge for tidal energy is to demonstrate its ability to deliver electricity at a price that is competitive with offshore wind.	**High** Risk occurs due to very high capital cost . however, a generous amount of funding is being provided for demonstration projects and hopefully it will quickly gain market access which will lower production costs.

6. Preliminary Findings on Technology Transferable Solutions in Partner Regions

Renewable energy can be available on-site (e.g. hydro), produced locally (e.g. biomass) or be complemented by renewable energy enabling technologies (e.g. batteries). Deployment of established technologies such as hydro and biomass has increased rapidly, which correspondingly has reduced cost, improved confidence in the technologies and opened up new opportunities. When calculating the costs associated with different technologies, the best approach is to look at the life-cycle cost, as renewable energy technologies often have high initial capital costs but very low operation and maintenance costs, and in many cases no significant fuel cost. Renewable energy technology deployment, market penetration, and risk, are highly dependent on the available local and regional renewable energy sources on site (wind, solar, and hydro energy) or produced locally (biomass, combustion, anaerobic digestion). The amount of resources on site determines the economic feasibility of a given choice of technology, ensures local control, security of supply and energy price stability.

Whilst many technologies are already technically mature and proven, with approximately low life cycle costs, the level of *market penetration* and *risk* across partner region attributable to them is dissimilar.

The technology used for hydropower generation is mature and proven with a comparably long lifespan of around 30 years. However, it is a highly site-specific technology that is vastly dependent on the amount of available resource, in order to be an economically feasible choice. In **Iceland**, **Norway** and **Scotland**, the *market penetration* of the technology is considerably *high* as a result of high TRL where most modern plants achieving energy conversion rates above 90%. Correspondingly the *risk* associated with the technology in those countries, is regarded as *low* or *intermediate*. However, both **Scotland** and **Norway** highlight that lack of public funding (Norway) and changes in subsidies (Scotland) elevates the risk from low to intermediate. In **Ireland**, a low *market penetration* of hydropower technology is indicated with respective *intermediate risk*. Justification for the low penetration and higher risk; however, is not attributed to lack of availability of resource (there is good potential in Ireland), rather than that, it is credited to deficiency of new installations, lack of expertise and environmental/fisheries concerns. Thus, technology development and expertise from **Iceland**, **Norway** and **Scotland** ought to be transferable.

Combustion technology too, is a mature and proven one but unlike most renewable energy technologies, fuel (local and secure supply of biomass feedstock available) needs to be sourced/purchased. **Finland** has an abundant amount of wood resources available and consequently the *market penetration* and *risk* for combustion technologies is respectively *high* and *low*. Combustion technologies using biomass in **Northern Ireland** are indicated as a technology with *intermediate* level of *market penetration* and corresponding *risk*. The justification for the level of market penetration and risk was credited to the introduction of government incentives (RHI), which are attractive to businesses and farms. However, the trend is increasingly dependent on the continuation of government support through subsidies. In **Ireland** combustion technologies have *low market penetration* but significant opportunities because of resource availability in their region. The level of *risk* is regarded as *intermediate,* as a result of unsuccessful installations, coupled with, the additional problem of fuel moisture. The level of *market penetration* and *risk* associated with combustion/biomass in **Scotland** at present is *low/intermediate*. However, there is a government desire to increase the percentage of biomass resources in the energy mix. The support through incentives (RHI) will increase

the level of market penetration and decrease the risk, in the near future. Hence, transferable solutions for **Ireland** can be derived from both **Finland** (technology development – lowering the associated risk) and **Scotland** (subsidies development – increasing the level of market penetration).

Batteries are an example of mature and proven renewable energy enabling technology for energy storage. They are a price competitive technology and available in many different variations. In **Scotland**, especially in isolated, off-grid, rural/island areas, *market penetration* of batteries is *high* as they are widely used for energy storage. The related *risk* to batteries is *low* due to the mature and proven TRL in combination with the stability, flexibility, power flow management, and power-on-demand delivery, offered by the technology. In **Norway** the *market penetration* of batteries in the region is *low*, because the most widely utilized renewable energy resources in Norway are not intermittent. Thus, energy storage is not a crucial enabling technology. The *risk* is indicated as *intermediate*, as the technology is at an early stage. However, emphasis is made on the significant wind resource potential, which will be given priority by the Norwegian government in the future energy mix. In **Ireland** *market penetration* of batteries is *low* and corresponding *risk* is *intermediate* at present, due to the early stage of development of the technology. There are a number of demonstration installations and a substantial potential, given the level of wind energy and resources. Whereas, in **Iceland** batteries have *low market penetration* and *high risk* in their region, due to the lack of infrastructure and focus on the development of other technologies, such as deep geothermal. **Scotlands** batteries provide a solution to problems arising in in isolated, off-grid, rural/island areas which can be transferred across all partners where same issues arise.

As seen in the examples above, many technologies may have reached a high market penetration and low risk in some partner countries, while in others their development/deployment may be hindered by factors such as the lack of an economic incentive or government support. An in-depth analysis of the technologies and which of them have a feasible prospect to be transferred across partner regions will be presented in Activity 5.2 – A Collection of Case Studies, accompanied by videos and advice notes.

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Project Partners

GREBE will be operated by eight partner organisations across six regions:

- WDC – Western Development Commission
- Action Renewables – the future of energy, today
- Luke – Natural Resources Institute Finland
- FPN – Forskningsparken i Narvik
- eri – environmental research institute
- Fermanagh & Omagh District Council – Comhairle Ceantair Fhear Manach agus na hÓmaí
- Innovation Center Iceland
- Karelia

About GREBE

GREBE is a €1.77m, 3-year (2015-2018) transnational project to support the renewable energy sector. It is co-funded by the EU's Northern Periphery & Arctic (NPA) Programme. It will focus on the challenges of peripheral and arctic regions as places for doing business, and help develop renewable energy business opportunities provided by extreme conditions.