HANDIHEAT WORK PACKAGE REPORT T01

Identifying Drivers

Summary

Handiheat is funded by Priority Axis 3 of the Northern Periphery and Arctic Programme. Handiheat focuses on energy performance in rural housing and public infrastructure challenges in peripheral and arctic regions. The overall objective of Handiheat is to develop a set of resources; implementation toolkits, decision making guides and a roadmap for the rural community housing sector. Pilots provide visible proof and an enduring guide to what can be achieved. The project focuses on energy networks for rural communities such as housing, both social and private, which are subject to fuel inequity/poverty and reliant on imported fossil fuels for energy. Sustainable solutions will protect rural communities from energy price fluctuations and improve the social wellbeing and quality of living throughout NPA regions.

Much of the energy legislation in the NPA region is focused on topics relevant for the larger population centres. Rural and remote areas are often confronted by different challenges when compared to those experienced in cities. This work package provides the groundwork for later stages of the project by, firstly reviewing and presenting several successful energy initiatives that worked for different rural areas in the NPA region (deliverable T 1.1.1). Secondly, it is discussed how the different initiatives came into being and what could be learned from that (deliverable T1.2.1). Thirdly, a fuel mix report was prepared for understanding based on which energy sources homes are being heated in the NPA region (T 1.3.1). Lastly, this work package concludes by presenting examples for underutilized energy resources from each of the regions to map a way forward for a more sustainable future (T 1.4.1).

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Evidencing Excellence (T 1.1.1) and Gap Analysis (T 1.2.1)

Summary

Energy related legislation in each Northern Periphery and Arctic Programme (NPA) region primarily addresses densely populated areas and does not sufficiently address fuel inequity in rural and sparsely populated areas. However, there are many examples of social, economic and environmental innovation successes at a local level. The objective of this Workpackage (WP) is to evidence excellence in NPA regions as follows: It will assess the drivers for these solutions to regional problems (RQ1) and identify working models which have successfully addressed rural energy inequity (RQ2) but have not been legislative/policy driven (RQ3). This will result in learning, to develop new solutions to fuel inequity in other regions. The focus will be on community energy models but learning from non-energy related models may identify innovation opportunities or supply chain partners. Community enterprises are instrumental in developing these local models. A number of successful networks and initiatives will be explored and shared across the NPA regions. Regional models, best practices and regulations will be investigated and presented; they provide the existing context through which energy solutions are applied. Consideration will be given to skills gaps, potential differences and barriers to adopting models across the region, for example differences in industry regulations. Each partner region has knowledge of potential regional resources which may provide energy sources i.e. fishing industry residues in Iceland, biogas or curtailed wind energy in UK and Ireland, and biogas and energy from woody biomass in Finland.

Introduction (T 1.1.1)

Remote arctic regions have in common that they often exist isolated from centralized energy networks (Boute 2016). In the past, the power of most sparsely populated, remote areas has primarily been supplied using fossil fuels and diesel generators (Elistratov & Kudryasheva 2018). Areas where this practice continues, include the Asiatic part of Russia's northern region and parts of Alaska where remote settlements continue to rely heavily on fossil energy sources (Pilyasov 2016). However, in recent years there has been a push for arctic communities to move from fossil fuel generated energy towards more sustainable solutions. The motivation for arctic communities to move away from fossil fuels is not only to do with the global effort in the fight against climate change but is also motivated by considerations about access and availability of fossil fuels and related challenges (Mortensen, Hansen & Shestakov 2017).

Examples exist of policy makers recognizing the need to change the electricity supply of remote regions to mitigate climate change, provide better energy security, and support self-reliance. Such regions include the Northwest territories in the Canadian Arctic, Northern Norway, Greenland and Iceland (Jakobsen 2016, Mallett & Cherniak 2018). There is a wide array of practical initiatives in the arctic region seeking to explore new opportunities for energy generation. This includes meteorological stations that have been installed in the rural arctic for recording wind speed for assessing the feasibility of future wind power plants or test facilities for photovoltaics. Other examples include Iceland's deep drilling projects seeking to increase the utility of geothermal power in rural areas.

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Countries such as Iceland and Greenland have succeeded in fundamentally transforming their national energy mix towards an almost exclusive use of sustainable energy. Iceland derives 85% of its total energy supply from domestically produced renewable energy sources (e.g. 65% geothermal and 20% hydro) making it the country with the largest share of renewable energy worldwide. Greenland is a close second deriving 70% of its total energy supply from domestically produced hydropower. Both countries have a legacy of national projects targeted at reducing the reliance on fossil fuels spanning at least half a century.

Due to Greenland's hydroelectricity development program and decades of focused investment most of Greenland's rural villages such as Sissimiut and Nuuk have transitioned to using hydropower. This resulted in 70% of Greenland's domestic energy production being made up of hydropower provided by small scale plants distributed all over the country. However, a drawback of this strategy are the astronomical investment costs associated with the construction of new, small scale hydropower plants (Jakobsen 2016). Against this background Greenland has started exploring alternatives for furthering sustainability in energy production such as photovoltaics and wind power (ibid.).

Taken together, there appears to be an increasing effort by governments and individuals throughout the arctic region to move away from fossil energy sources. This project can be positioned in line with earlier work in this area and seeks to understand how non-governmental initiatives can contribute to further reduce fossil resource consumption in remote arctic regions. The idea of the research covered in this work package is to identify how local initiatives undertaken by individuals contribute to further curbing reliance of fossil energy. To do so we identify four "vignettes from practice" from each of the Nordic rural areas, namely Iceland, Finland, Shetland, Northern Ireland and the Republic of Ireland. These vignettes are meant to illustrate some innovative approaches to renewable energy utilization in the Artic region. Based on these cases we will answer the first research question (RQ1): *What are the drivers behind these local initiatives and how do they contribute to solve regional problems*? Moreover, based on a discussion of the initiatives we will approach the second research question which is: *Are there working models which have successfully addressed rural energy inequity?* In addition, we will answer the third research question, namely: *Which of these have been local grassroot initiatives with individuals taking the lead rather than their governments?*

To answer these research questions, we collected data from all project partners illustrating innovative energy practices in their respective region. Data stems from documents as well as observations and interviews. To make sense of what drove the innovative practices we apply the diffusion of innovations (DOI) theory. Based on the discussion we found that dissimilar innovative energy practices had been focused in the different regions. Our findings indicate that learning across the different contexts might benefit each region and further strengthen efforts to curb fossil fuel consumption. Each partner region has knowledge of regional resources which provide energy sources i.e. fishing industry residues in Iceland, biogas or tidal wave energy in the UK and Ireland.

This report is set out as follows: First we present the methodology for the paper, then we present the findings which are the individual vignettes followed by a discussion of the results. Last, we present our conclusions and answer the research questions asked in this report.

Theoretical lens

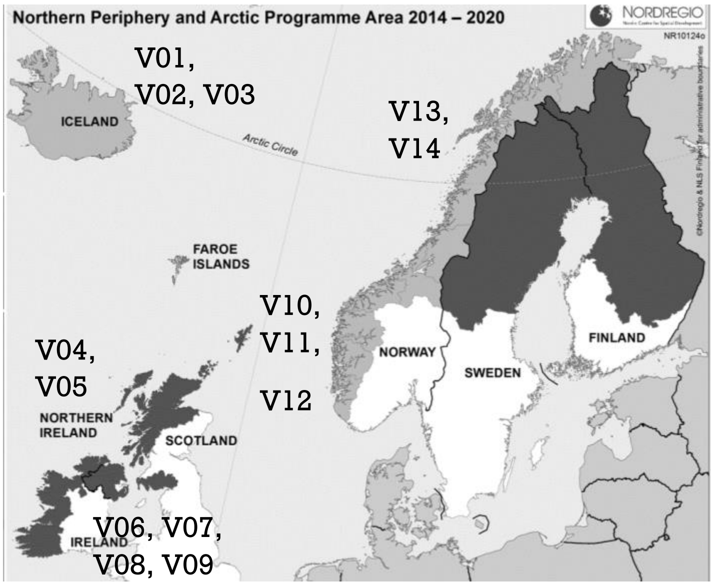
In this study we deploy the diffusion of innovations (DOI) theory as an analytical lens to understand the drivers behind the local initiatives and their adoption of innovative energy solutions. DOI theory was first advanced by Everett Rogers in his 1962 seminal book titled Diffusion of Innovations. Rogers, an agricultural scientist at the Iowa State University, found that the spread of new innovations in social groups followed a distinct pattern. He focussed his research on innovations such as hybrid seed corn, driver training in schools, and antibiotic drug prescriptions by medical doctors (Rogers, 2004). Rogers defined innovations as "ideas, practices or objects that are perceived as new by an individual or unit of adoption" (Rogers, 2003 p. 35). Rogers defined the term diffusion to mean "the process through which an innovation is communicated through certain channels over time among the members of a social system" (Rogers, 2003, p.23).

Rogers argued that the diffusion of an innovation depends on the extent to which members of a social system find the innovation important. Moreover, he observed that there were varying degrees of "willingness" to work and adopt an innovation. It is in this context that he suggested that individuals exist along a spectrum from technological "innovators" to "laggards", largely depending on their socio-economic status. Members of each category have different attitudes toward an innovation. These categories are: (1) Innovators - who are venturesome, educated individuals having multiple information sources; (2) early adopters – who are popular, educated, social leaders; (3) early majority – deliberate individuals having many informal social contacts; and (4) late majority – sceptical and traditional individuals having lower socio-economic status; and last (5) laggards – individuals whose neighbours and friends are the main source of information and who have a strong fear of debt (Rogers, 1995). In this report, we apply DOI to discuss the nature of the individuals driving energy innovation in the NPA region.

Methodology

The research strategy chosen to guide the research in this inquiry is the case study approach. There are several reasons for why the case study approach was deemed a good fit for this study. First, case studies afford the investigation of "sticky, practice-based problems where the experiences of the actors are important and the context of the action is critical" (Benbasat, Goldstein, and Mead., 1987, p. 370). Second, the research questions asked in this paper are exploratory and the case study method is perceived as well suited for studying these types of questions (Walsham 1995; Yin 2009). Further, a multiple case study design was chosen to allow the comparison of environmental initiatives across the different countries participating in this study. Case identification was done based on a snowball or chain strategy (Patton 2002). A snowball or chain approach "identifies cases of interest from people who know people who know people who know what cases are information rich, that is, good examples for study" (ibid. p. 243). The informants or "people who know" chosen to assist sample selection in this study are the representatives from the project partners all of whom have a background from working with sustainable energy in their respective regions. These people have in-depth knowledge of sustainability initiatives undertaken in their respective regions. The cases (from here on referred to as vignettes) were selected based on a "deviant" sampling strategy (Miles and Huberman 1994).

Vignettes:



(V01) Geothermal - district heating
(V02) Hydro – district heating
(V03) Lava, fish residue, sea water – central heating
(V04) Housing refurbishment
(V05) Anerobic digestion
(V06) Empowering Rural Communities
(V07) LED lighting project
(V08) Dairy processing evaporator
(V09) Better Energy Program
(V10) Carbon Management
(V11) Tidal turbines
(V12) Waste burning -District heating
(V13) Energy certificates residential
(V14) Biogas farms

Fig.1 Overview of the vignettes from the NPA region (modified © Nordregio and NLS Finland)

All vignettes were deviant in that they can be viewed as extreme cases for innovative sustainability initiatives from the regions. Some of them are recent, others were outstanding at their time. These vignettes include cases of sustainable projects which have been completed and include larger policies and initiatives initiated for achieving sustainable practice. Data were collected by circulating semi structured questionnaires comprising a mixture of closed and open-ended questions for accommodating a large range of responses. These questionnaires allowed for qualitative and quantitative information to be collected. The responses were then taken as a starting point for writing up the vignettes from each of the regions as presented in the findings part, which is up next. An overview of the vignettes presented in this study, mapped to their location in the NPA region is presented in figure 1.

Findings: Vignettes from practice

In this part of the report we present a total of twenty examples or "vignettes" from practice exemplifying innovative energy practices in the regions. In each of the vignettes special emphasis is given to uncovering who or what was driving these initiatives. The idea is to assess the non-legislative drivers, programs and initiatives in each NPA region. This includes the work of organizations operating as trusts or charities whose objectives are improving communities and wider society. There are 'grassroot' initiatives that exist in the absence of governmental support mechanisms. The chapter opens by presenting Icelandic practice followed by those of the other areas namely Northern Ireland, the Republic of Ireland, Shetland and Finland. This chapter presents the vignettes whereas the next chapter provides an overarching discussion of the cases seeking to provide answers to the research questions.

Iceland

Vignette 1: Geothermal district heating

Today nine out of ten households in Iceland are heated with geothermal energy (Björnsson and Barðadóttir 2006). This is done by direct utilization of water stemming from hot springs which is being channeled through hot water pipes to central heating units for residential buildings (ibid.). Icelanders have long understood the value of geothermal energy for swimming pools, however its utilization on a large scale for residential heating did not begin before the 1930s (ibid.). It was further accelerated during the oil price shocks in the 1970s. Iceland's geothermal areas with their naturally occurring high and low temperature areas are shown in figure 2 below. As can be seen, hot temperature fields can be found mostly along the seismic zone where the North American and the European tectonic plates meet. More often than not, harvesting and distributing hot water for domestic heating has been organized by grassroots initiatives. Examples for this include farmers like Stefán B. Jónsson from Mosfellssveit who begun heating his farm with hot water in 1908 or Erlendur Gunnarsson from Borgarfjordur who began using geothermal heat for warming his house in 1911 (Þórðarson and Jónasson 2007). Often these initiatives were started up by residents interested in joining forces for supplying their homes with hot water. This resulted in the emergence of several small, community owned energy companies in Iceland. Even todays large national heat utility companies, like Reykjavik Energy which supplies hot water to 66% of homes in Iceland, was initially a grass roots initiative (ibid.). The first large hot-water heating projects in Iceland were initiated in the 1930s in the immediate aftermath of the First World War (ibid.). Many of the early innovators in these projects were farmers.

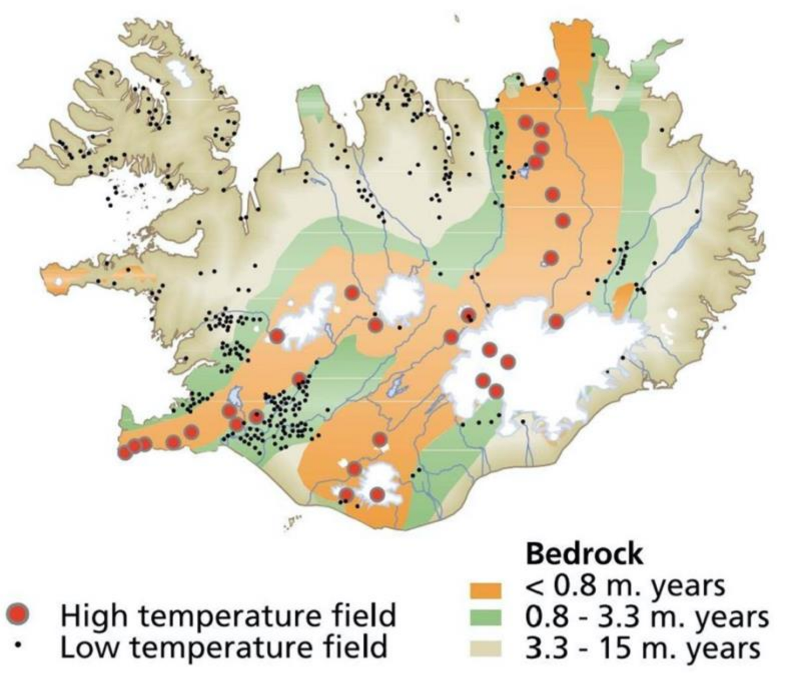


Fig. 2 High and low temperature geothermal areas in Iceland (modified from Björnsson and Barðadóttir 2006, fig.2, p.10)

Due to the war, prices for imported coal and oil rose markedly making many households struggle financially. Driven by the experienced shortages and related high prices many Icelanders looked to geothermal heating as a feasible alternative to fossil energy sources (Þórðarson and Jónasson 2007). The maybe most prominent example for this early development was the Laugardalur project in the Reykjavik area (ibid.). At the time Laugardalur was in the outskirts of Reykjavik and the inhabitants of the area linked up to the local hot springs seeing great economic benefits from the cost-effective geothermal heat (ibid.). Similar large-scale geothermal initiatives took place at the time of World War II and during the oil price shocks of the nineteen seventies (ibid.). Thus, the main driver for Icelanders to move from fossil fuel based heating to geothermal heating appears to be related to the availability and price of fossil energy rather than environmental considerations. Moreover, most projects, especially those initiated during and after the wars have been driven by grassroots initiatives. A side effect of moving away from coal and oil, was that Iceland experienced a large drop in air pollution (Gunnlaugsson 2004). This translated into a substantial decline of respiratory illnesses experienced by Icelanders (ibid). Today, hot water has become widely used with district heating networks having been installed even in remote rural areas. Today, with about 700 MW thermal, Reykjavik possesses the largest municipal geothermal district heating network anywhere in the world (ibid). Examples of rural district heating networks in Iceland are among others in Svarfaðardalur in North Iceland and Bláskógabyggð in South Iceland (ibid.).

Vignette 2: Electric district central heating

As can be seen in figure 2 not all regions in Iceland have access to high temperature geothermal fields. Suffering from much of the same problems as other Icelanders, related to high oil and coal prices, these regions needed to find different solutions for curbing their reliance on fossil energy. Consequently, several towns in Iceland not having access to geothermal resources have set up district heating systems operated with a dispatchable electricity. The electricity for the district heating systems is for most parts produced and supplied by hydro power plants. Figure 2 shows a map of the hydro power plants in Iceland. When one overlays figure 1 and 2 it becomes obvious how Icelanders use hydroelectric energy in areas where geothermal energy is not available. The green dots in the map in figure 3 signify major plants whereas the white dots indicate small scale hydro power developments. Many of the small-scale hydropower developments are community developments that have been set up in grassroots initiatives. in this case also, the early innovators were farmers.

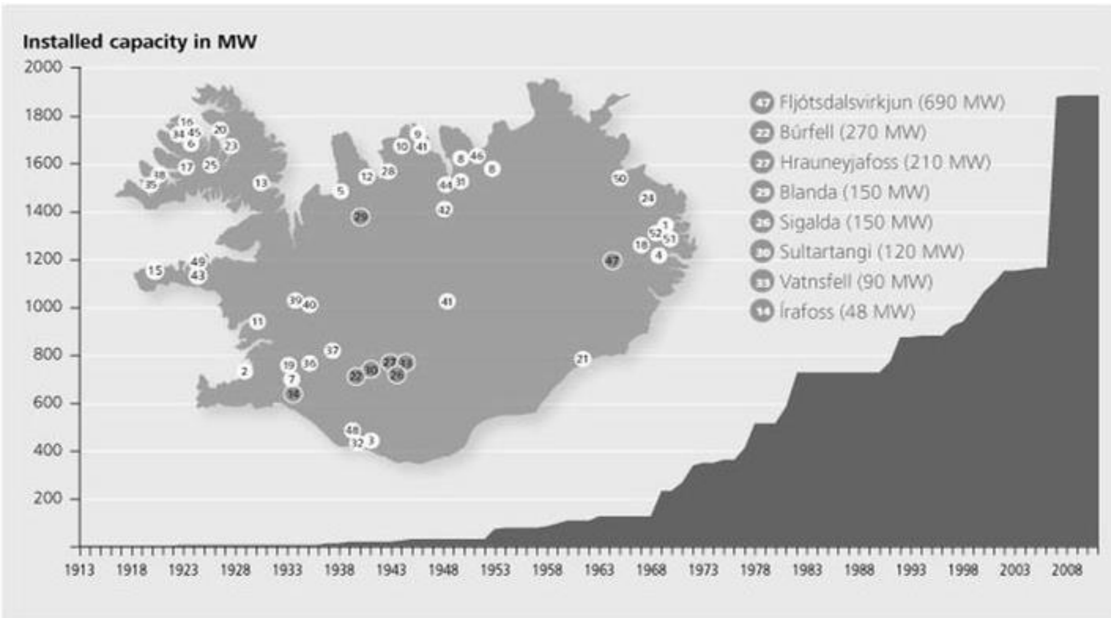
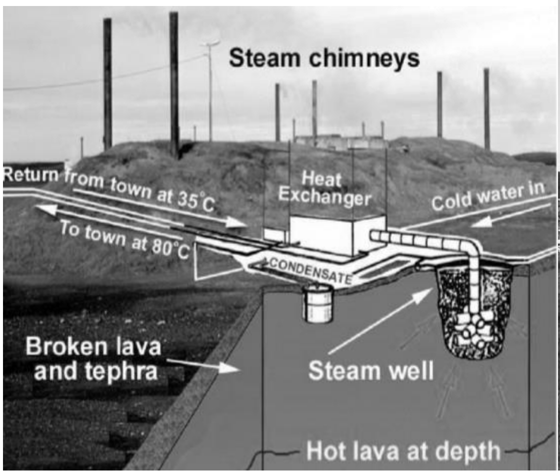


Fig. 3 Hydro Power Plants and Installed hydropower capacity in Iceland (modified from Orkustofnun 2020)

The district heating systems are backed up by diesel generators. These generators are used in case of low water flow into the hydro power reservoirs. Thus, these central district heating systems can be viewed as sustainable at most times but in case of years with low water flow into hydro power reservoirs or transmission difficulties their demand can be dispatched to secure delivery of power to priority demand users. This arrangement increases the overall efficiency of electricity production in Iceland. Due to its remote location, Iceland´s power grid is insulated from those of other countries which entails that surplus energy cannot be exported. Thus, consumers in rural Iceland even in areas without geothermal hot fields benefit from relatively affordable "green" energy. Moreover, replicating the success of the geothermal initiatives, many of the central heating networks have been initiated locally by grassroots initiatives. Such district heating systems are currently operated in Seyðisfjörður, Höfn, Bolungarvík, Flateyri, Ísafjörður, Patreksfjörður, Neskaupstaður and Reyðarfjörður (Orkustofnun 2019).

Vignette 3: Lava, fish and sea water heating

The island of Heimaey in Vestmannaeyjar is the largest populated island off the south coast of Iceland. Heimaey is sometimes referred to as the Pompei of the North, since a large volcano erupted in 1973, destroying half of the houses on the island. Unlike other parts of Iceland, the people on the island of Heimaey have neither access to geothermal hot fields nor is there an option to harness hydro power. In the immediate aftermath of the eruption there was an effort on the island to cool down the lava with sea water to stop it from advancing. It is in this context that the islanders recognized that they could use the lava as an energy source for heating their homes (Björnsson 1980). The islanders, together with scientists and engineers, developed a solutiona solution (ibid.). They installed a heat exchanger extracting thermal energy from the cooling of the lava (Jóhannesson et al. 2016). The steam from the water used for cooling was being utilized to generate about 5 MW of energy (ibid.). The principle of the steam gathering system is presented in figure 4. In addition to making use of the lava, the Heimaey residents had a second innovative idea which was to also use waste heat from their local fish processing plant as a heat source for district heating (ibid.)



a) Principle of the lava heat exchanger [modified from Jóhannesson et al. 2016]

b) Heimaey island, where the lava stopped [photo credit Thomas Quine CC-BY-SA-2.0]

Fig. 4 Principle of the steam gathering system lava heat exchanger

However, since the population on the island continued to grow, the islanders decided to test yet another innovative idea and started a new project namely setting up a sea water heat pump to supply the islands district central heating system with electricity (McLaughlin 2020). The 10 MW heat pump system uses four 2,5 MW screw compressor heat pumps and is designed to provide hot water for 4300 people (ibid.). The system is designed for sea water use and draws from novel technology provided by Danish and Finnish suppliers (ibid.). The heat pumps have a coefficient of performance (COP) of roughly three which compares favorably to other heat sources. The project is expected to provide the inhabitants of the island with 77°C hot water which in turn will be distributed to the households (ibid.). The developers are confident that this system will break even after a relatively short period of time. According to Ívar Atlason, the regional manager of the energy company HS Veitur there will be a swift return on investment: "We were talking about 8-10 years [for return on investment], but if the electricity price is higher than we expect, then the payback will be 6-7 years. It all depends on the price of the electricity," (Interview with the Danish district heating network in 2019 as cited by McLaughlin 2020). The drivers behind all aforementioned central heating systems was the local community.

Northern Ireland

Vignette 4: Northern Ireland Housing Executive

The roots of the Northern Ireland Housing Executive (the 'Housing Executive') can be traced back to the 1970s when its function was to support people who had lost their homes as a result of civil unrest during the period of huge political turbulence during the 1960s (NIHE 2020). The Housing Executive was formed by government to provide the nation with affordable social housing. Since its inception this social landlord has contributed to the construction of more than 90,000 new homes across Northern Ireland and as NI's largest social housing landlord it continues to manage a stock of circa 86,000 (ibid.). The Housing Executive is a major player when it comes to transforming the national building stock in meeting Northern Ireland's ambitious sustainable energy targets. It is in this context that the Housing Executive has worked with district heating projects, solar photovoltaic schemes and the energetic refurbishment of their housing stock (ibid.). The Housing Executive continues to work with partners in local government, councils and housing associations to deliver new-build accommodation of excellent, modern standard, however there is still some way to go as two thirds of Housing Executive stock do not yet meet current standards for insulation and heat loss.

The Housing Executive upgrades its building stock gradually on an annual basis. In accordance with that they replaced 3,061 boilers, worth £1.9 million, undertook 3,684 heating conversions worth £16.2 million, installed 2,133 double glazing windows, worth £3.7 million and in association with local district councils across Northern Ireland, administered energy efficiency projects under the Affordable Warmth Scheme in association with local councils (HECA 2017/18). This initiative led by the Department for Communities is to the value of £17 million (ibid.). Moreover, 27 community 'Oil Buying Clubs´ have been established by the Housing Executive to coordinate and collaborate the purchase of fossil fuels for householders at a more affordable cost (NIHE 2017/18). Members of the Oil Buying Clubs can buy as little as 200 litres of oil and when club member orders are put together, the Club can get a better price with the savings passed on to everyone (ibid.). The more people that take part in the club the greater the savings. The Housing Executive takes care of aspects of the oil delivery, from liaising with the supplier to ensuring the member receives their oil as well as providing monthly advice on costs and the best time to buy heating oil.

Additionally, £7 million was spent in the local NI economy on energy schemes designed for households to implement energy saving measures in their homes as part of the Northern Ireland Sustainable Energy Program (NISEP) which provides help to install energy saving measures in homes and commercial premises throughout Northern Ireland (Energy Saving Trust 2020). Measures range from the installation of whole house energy and individual solutions for householders such as the installation of energy-efficient boilers, heating controls, LED lighting, loft and cavity wall insulation (ibid.). The NISEP funding administered annually by the Energy Saving Trust is generated from a levy paid by all electricity customers across Northern Ireland (ibid.). Taken together, Northern Ireland invests heavily in measures designed to improve the energy efficiency of households led by government initiatives.

Vignette 5: Anaerobic digestion

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One example of an innovative green energy initiative from Northern Ireland is the new anaerobic digestion facility at “Granville Ecopark (GECO)” in Dungannon, Co. Tyrone (GECO 2020). The plant received an £3.75m grant from the UK government which it began in 2012 (ibid.). Its capacity is 90.000 tons (per annum commercial, residential and industrial food waste) (ibid.). Anaerobic digestion is a process or technology where electrical energy and heat are produced based on the decomposition of biodegradable waste. The most important input for the process in Dungannon is food waste from private household consumption (ibid.). There is no shortage of such waste as researchers found that about one third of all food produced for human consumption is being wasted, totalling annually 1.3 billion tons (Gustavsson et al. 2011). The anaerobic digestion facility in Dunagannon is designed to reduce the volume of the waste while at the same time generating 4.8 MW of renewable electrical energy (GECO 2020). Other biodegradable materials used in the anaerobic digestor include garden, industrial and agricultural waste (ibid.). A schematic depiction of the digester can be found in Figure 5 (ibid.).

The Dungannon plant is the first, largest commercial and industrial AD facility in Northern Ireland operated by B9 Energy Group (B9EG 2020). As can be seen in figure 5, Granville Ecopark is a so-called combined heat and power (CHP) facility simultaneously producing useable heat and electricity (ibid.). Modern CHP facilities can turn a cubic meter of waste into 2kWh of electricity and 2.5kWh of heat (ibid.). As can be seen in figure 5, the Dungannon facility turns biodegradable plant and animal material (biomass) into biogas (methane and CO2) and a semi-solid material namely digestate saturated with microorganisms. The digestion occurs in sealed tanks where anaerobic digestors, deprived of oxygen natural microorganisms digest the biodegradable material. This process then releases heat as methane. Although this technology is not new, the facility in Dungannon is the first and largest of its kind in Northern Ireland and up to September 2017 the plant has diverted 130.000 to of food waste from landfill (GECO 2020).

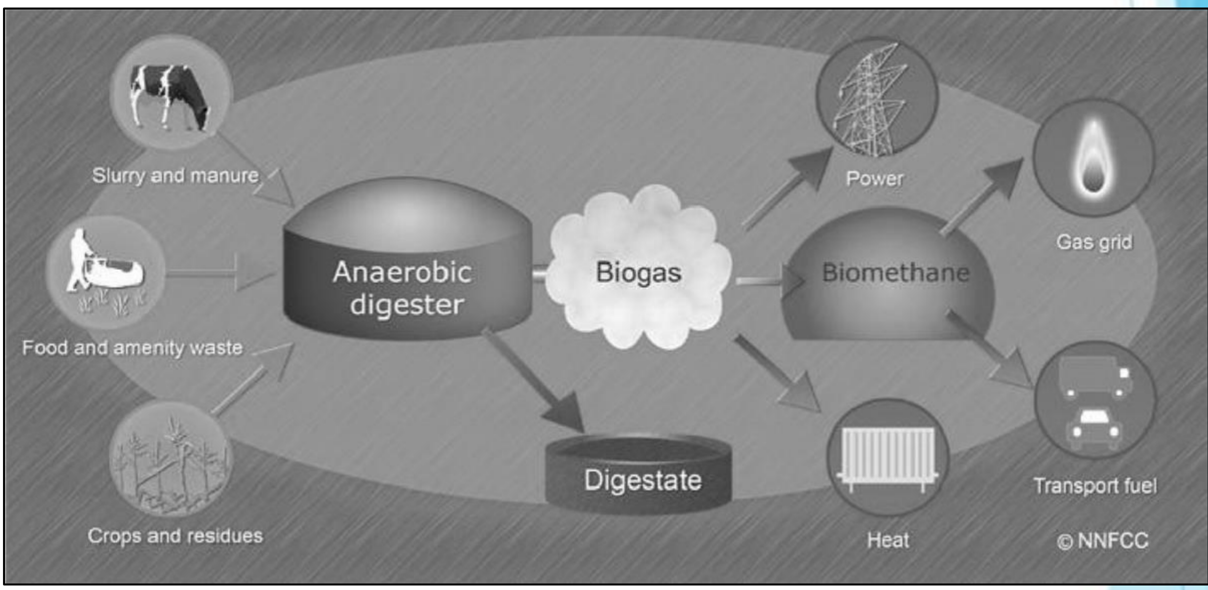

Fig. 5 The AD process showing the different types of biomass (adopted Cave 2013 ©NNFCC)

The plant has a capacity to produce 64,000 MWh per annum, which is equivalent power for 13,900 homes in Northern Ireland (UK average power consumption is 4,600 kWh per annum) (ibid.). This has been a project led by industry in conjunction with government grants. The plant has become the first AD plant in the UK to achieve certification under the recently launched AD Certification Scheme (ADCS), an industry-led initiative that recognizes good operational, environmental, and health and safety performance at AD plants (ibid.).

Ireland

Vignette 6: Clar ICH Empowering Rural Communities

Clár ICH was established in 2000 as an Approved Housing Association delivering housing related services to older people and people with disabilities in Claremorris, Co. Mayo. Services included building social and sheltered housing schemes and delivering social services such as befriending services and the Care and Repair Programme. In 2006 Clar ICH was selected as a delivery pilot by Sustainable energy authority of Ireland (SEAI) to target fuel poor households. SEAI believed that community-based organizations like Clar ICH were best positioned to identify and target fuel poor households in the region due to their partnership networks and community engagement work. Clar ICH recruited local individuals through labor market schemes such as the Community Services Programme and Rural Social Scheme and trained them in certified energy retrofitting programmes. Clar ICH commenced the delivery of the Better Energy Warmer Scheme in 2006 targeting fuel poor homes and delivering attic and cavity wall insulation measures in local homes. Such programmes stimulated the local rural economy by creating employment opportunities for those far removed from mainstream labor market opportunities, stimulating the local supply chain as material were purchased locally as well as increasing the skill base and knowledge in energy efficiency in the locality.

The Communities Energy Grant is Ireland's national retrofitting initiative aimed at upgrading stock and facilities to high standards of energy efficiency and renewable energy usage, thereby reducing fossil fuel usage, energy costs and greenhouse emissions. As part of this initiative Clar ICH delivered the Better Energy Communities Programme across Ireland whilst creating Sustainable Energy Communities. By bringing together groups of buildings under the same retrofit programme, Clar ICH facilitates community wide energy improvement projects more efficiently and cost effectively than might otherwise be possible. The Communities Energy Grant is designed to engage all members of SEAIs Sustainable Energy Community (SEC) network who wish to participate in delivery of energy efficiency works, as well as those Project Coordinators who have previously participated in SEAI Community Energy Grant Projects.

The ambitions of this Communities Energy Grant are to build on the success of the previous Communities Energy Grant scheme to support delivery of large-scale projects through the support of the project coordinators to deliver larger and more technically challenging schemes. Community skills are developed to manage capital projects and empower communities to lead small to medium scale projects in their own communities like Claremorris. Under the energy efficiency obligation scheme, energy suppliers must support energy efficiency projects in businesses and homes across Ireland. Partnership with a Participating Energy Supplier (PES) is promoted under the scheme. Clar ICH have collaborated with Energia, Enprova as well as Bord Na Mona in the delivery of energy retrofitting projects.

The Sustainable Energy Community (SECI) is an initiative made up of 300 communities in the Republic of Ireland who are interrested in community energy (SEAI 2020). The aim of the network is to encourage and support a national movement in every part of the country. To do so, they aim to be energy-efficient, use renewable energy and consider smart energy solutions. An SEC can include a range of different energy users in the community such as homes, sports clubs, community centres, churches and businesses. In this way, an SEC connects sustainable energy, local economic development and public wellbeing. The SEC Network is designed to enable communities to manage and save energy across all sectors. Being a member of the Network enables SECs to engage and learn from project site visits, seminars, events, and case studies. To join the Network the first step is to establish a group of energy users to participate in the SEC. As part of the Network, the SEAI will help communities to identify and put in place sustainable energy initiatives over a 3 year period.

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The SEC will then be eligible to apply for dedicated funding from the SEAI. To provide an example for the activities conducted by SEC we include some facts listed as achievements in the SEAI´s annual statement from 2018: "ten million € committed to over 50 research and innovation projects; 21.350 home energy upgrades supported including 5.710 energy poor homes; 2.000 grants for new electric vehicles; 266 small medium enterprises and farms received a total of €1 million for lighting and efficiency upgrades; € 13.5 million invested in 69 projects in major public sector collaborations with the Office of public works and the department of education and skills; 17 major statistical and policy analysis reports published; 300 sustainable energy community network members representing over 10.000 citizens; and 58.000 students engaged with the SEAI schools program (SEAI-Annual-Report 2018, p.6). The aforementioned track record of the SEAI appears impressive and this initiative can be considered to be a fundamental driver for change towards more sustainability in the rural areas of Ireland.

(a) LED fittings in multi-story car par
[photo credit Dublin Airport Authority ©]

b) LED fittings in surface car park
[photo credit Dublin Airport Authority ©]

Fig.6 Examples of the LED lighting installed at Dublin airport

Vignette 7: Dublin Airport carpark lighting project

Dublin airport has committed itself to fulfilling ambitious sustainability goals by 2020, they are determined to become carbon neutral. This led to the decision to work on reducing the energy consumption of the lighting at the airport's car park. The lighting alone makes up 70% of the car parks energy consumption. According to the airports website, upgrading the lighting control system and using LED lightbulbs would bring down the airports total energy consumption by approximately 3,750,000 kWh. The airport applied for funding with Ireland's sustainable energy authority and once granted they went ahead to install 690 new energy efficient LED lighting fittings. Of these LED lights 304 are installed in the multi-story carpark (figure 6a) and 386 in the surface carparks (Figure 6b). Moreover, the new light fittings are linked up to a central control system allowing for controlling each of the lights individually. Taken together, upgrading the lighting at the car park contributes significantly to curbing the overall energy consumption of the airport.

Vignette 8: Dairy farming

There appears to be a collaborative effort by farmers all over Ireland seeking to innovate and reduce their carbon footprints. One such example is the farmer cooperative in the town of Tipperary that received the national 2019 SEAI energy award for their efforts (Tipperary-coop 2020). The Tipperary cooperative is farmer owned and they decided to collectively reduce their energy consumption throughout raw material production and processing of their dairy products. The annual milk intake of their plant is about 280 million liters and, according to their web presence, it can process up-to one million liters a day. The milk is then further processed into butter (12.678 to in 2017), cheese (7.427 to in 2017) and powders (15.302 to in 2017) (ibid.). The cooperative aims for all its farmers and the factory to commit to sustainable production based on a "certified sustainable dairy scheme" by 2021 thereby becoming a national leader in energy efficiency. The farms part of the coop and the processing factory have now worked on achieving this for several years. This is mainly done by replacing dated, energy intensive machinery by newer, less polluting solutions. These projects received from grants provided by the SEAI covering parts of the initial investment. It is in this context, that the farmers have invested in technology such as next gen vacuum milk pumps consuming a fraction of energy compared to their dated counterparts. However, the largest part of the energy savings stems from moving away from heavy fuel oil towards natural gas in the main production plant. This was achieved in parts by building a new evaporator facility for Tipperary Coop (ibid.).

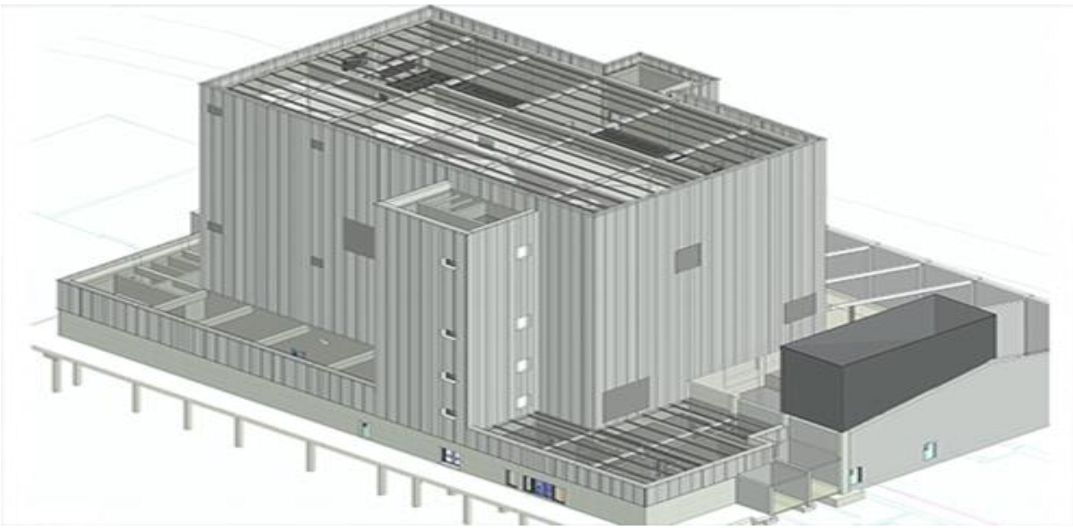

Fig. 7 Perspective view of the digital construction model of the new Tipperary evaporator plant (source https://www.johnpaul.ie current 08/05/2020 ©John Paul Construction)

In the dairy processing industry evaporators are used to extract water from milk through steam heating. Evaporation is one of the most energy intensive processes in dairy production. A construction drawing of the new 30 m tall, €5.3m evaporation plant can be found in figure 7. Taken together, the projects have led to a 20% reduction in carbon emissions which equates to taking about 3000 cars off the road. Finally, it is worth noting that the usage of fresh water in the process was reduced by 5% (source: https://www.tipperary-coop.ie/about-us/environment/ current 08/05/2020). The driver for this initiative appears to stem from a collection of local farmers in conjunction with a national support program for sustainable projects.

Vignette 9: Better Energy Program

Clár ICH is an Approved Voluntary Housing Association and manages the Lawn Social Housing Scheme on behalf of Clár IRD. The Lawn Social Housing Scheme consists of twenty-five units of accommodation and a communal facility and was constructed in 2000 with grant assistance under the Capital Assistance Scheme from The Department of Environment. In 2014 The Lawn Social Housing Scheme participated in the Mayo Area Community Project promoted by Clár ICH and funded by the Better Energy Communities (BEC) program funded by SEAI. The focus of BEC 2014 was on funding a comprehensive suite of projects which deliver energy savings to vulnerable homeowners and communities, through projects which encourage a partnership approach and are cost effective. The existing heating system comprised of inefficient electrical storage heaters that proved difficult for elderly residents to use as heat production was not instantaneous. Due to the poor fabric insulation of the unit's heat loss was also an issue leading to high electrical costs to fuel poor residents. In 2014 Clár ICH embarked on an ambitious project to connect The Lawn Social Housing Scheme to the new main gas line passing through the town of Claremorris. The Lawn Social Housing Scheme was to be the first scheme to be connected to the gas line and was a demonstration project to the locality.

Funding for the project was sourced through the Better Energy Communities program administered by Sustainable Energy Authority, Clár ICH as well as a Participating Energy Supplier (PES) who purchased the energy credits from the scheme and thus investing into the cost of retrofitting. Due to the economy of scales involved with the retrofit, Clár ICH was able to negotiate with gas suppliers and obtain a competitive rate from gas suppliers for residents.

The 25 homes in the Lawn Social Housing Scheme received the following measures: Cavity wall insulation; roof insulation; replacement of electric storage heaters and connection to the main gas line to high efficiency gas boiler with fully integrated heating controls upgrade with remote access; Installation of energy efficient light bulbs. The housing development is shown in figure 8.

Fig. 8 Lawn social housing scheme (photo credit Alma Gallagher, Clar ICH)

Shetland

Vignette 10: Shetland Council

The Shetland islands are not connected to the UK power grid and continue to produce most of their energy from burning fossil fuels. However, there are attempts being made to reduce the islands reliance on fossil fuels. The Shetland Islands council and especially its recently appointed carbon management team work on finding strategies for reducing the islands dependence on fossil fuels. The team's present activities include monitoring of the council energy consumption, implementation of energy saving measures, and the dissemination of knowledge about energy saving. The team is not only supported by the island council, but also receives funding from the Scottish funding council and the European Commission. In an effort to fundamentally reduce the use of fossil energy, the team developed a daring strategy to innovate the energy supply of the islands. Setting up wind farms on the islands proved a controversial topic for islanders and large initiatives have been stalled in recent years. The main reason for this appears to be the missing transmission link to the mainland allowing for energy to be sold to the UK grid. Moreover, there appears to be concern about the considerable amount of days with little wind in wintertime, which would need to be compensated for.

Finding a workable solution appears difficult and the carbon management team suggested a “radical” strategy to address these challenges. The team suggested a range of substantial changes. First, they suggest capturing the excess electricity produced by the wind turbines during windy days by producing hydrogen. This hydrogen is then to be stored and used for heating, fueling vehicles, and a ferry. Moreover, the team suggests increasing the number of electric cars on the island. This would create a circular power network allowing for significantly curbing the carbon emissions of the islands. However, while the ideas are formulated the carbon team still continues realizing them. Figure 9 shows the Hydrogen production life cycle as proposed in the Shetland Islands most recent carbon management plan.

Vignette 11: Tidal turbines

Addressing some of the challenges identified in the carbon management strategy, the tidal power plant has been started up on the island of Yell in the Shetland Islands (Bevington 2015). One of these projects, receiving wide attention, is the new tidal wave plant in the Bluemull sound (ibid.). This plant consists of altogether three 100kW subsea turbines installed at 30m below sea level. The turbines produce power only during tidal flow but not in slack tides. However, the advantage of tidal power plants over other energy sources like solar and wind power, is that tides can be accurately forecasted.

The machines are in principle identical to wind turbines and the electricity is transmitted onshore via 1 km subsea cable. The first Nova M100 turbine was deployed at the site in March 2016 with the second deployed in August 2016, whilst a third turbine was added to the array in early 2017 making it the first offshore tidal array in the world to deliver electricity to the grid. There are plans to extend the number of installed turbines from 3 to 6 under the EnFAIT project. EnFAIT began in July 2017 and will run until June 2022 as part of a competitive contract awarded by the European Union’s Horizon 2020 research and innovation program.

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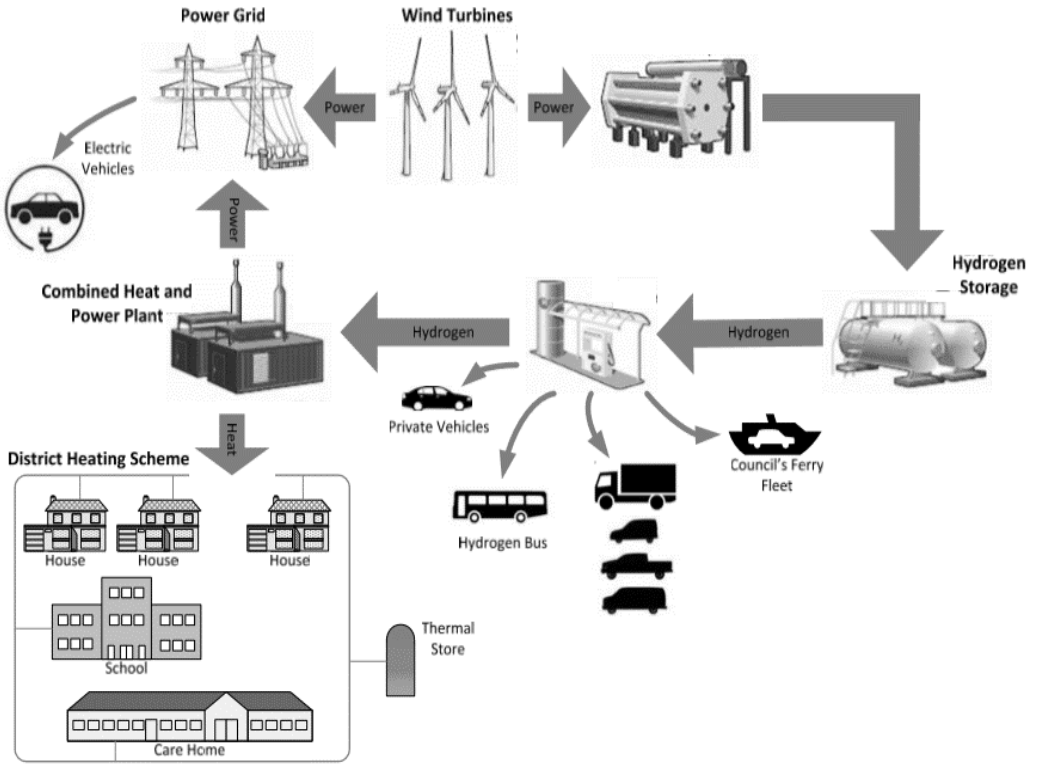

Fig. 9 Hydrogen production life cycle (adapted p.46 Shetland Islands Council - Carbon Management Strategy – Carbon Management Plan 2015-2020)

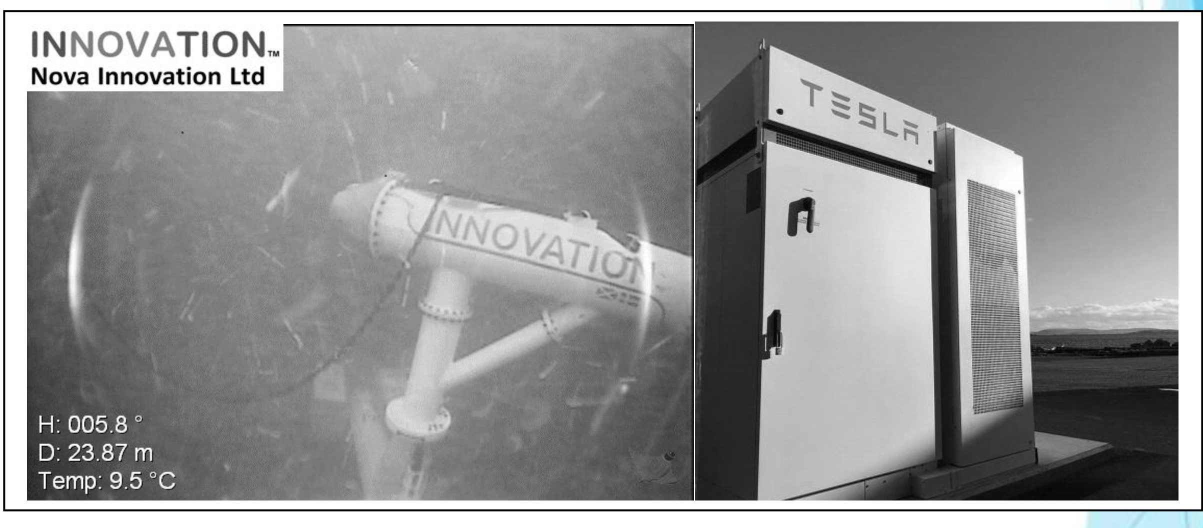

Fig. 10 Tidal turbine (left) and Tesla batteries for baseload generation (right) [© Nova Innovation]

Maybe the biggest downside of producing energy based on tidal power is that there exist significant downtimes making it challenging to provide a stable flow of electricity to the grid. In this project, this challenge was solved by installing a so called "tesla powerpack" which in essence is a large battery pack allowing for energy to be stored. This part of the project was supported by the Scottish Government's Low

Carbon Infrastructure Transition Program. This project has relied heavily on public subsidies, nonetheless it represents the first offshore tidal array in the world to deliver electricity to the grid.

Vignette 12: Waste burning district heating

The Lerwick district heating scheme commenced operation in November 1998 using backup oil fired boilers. In November 1999 the 7 MW Energy Recovery plate (ERP) plant run by Shetland Islands Council became operational, leaving the boiler plant as standby and to meet peak loads. A 15 MWh hot water thermal storage tank was constructed in 2006 at the Peak þload Boiler Station. This helped to significantly reduce the use of the peak load boilers by storing up heat at night and using it at peak times when the demand exceeds the available output of the waste to energy plant.

The Plant burns over 23,000 tons of waste per year and generates 7MW of thermal power to heat the district heating schemes infrastructure. The Energy Recovery Plant burns unrecyclable domestic and commercial waste from Shetland and Orkney which would otherwise be sent to landfill. The hot water produced is pumped to the Peak Load Boiler Station and thermal storage tank before being distributed around the town of Lerwick. The thermal energy is distributed around Lerwick through a 30km network of underground, insulated pipes into properties through a heat exchanger meeting all heating and hot water needs while providing a clean, green, sustainable source of heating and hot water.

The hot water created from un-recyclable waste then heats approximately 1230 domestic properties, commercial and public buildings around Lerwick including schools, care homes, the leisure center and the Gilbert Bain Hospital. The ERP and district heating scheme celebrated its 20th year of operation in 2018 and typically delivers around 50GWh of thermal energy that otherwise would have been provided by conventional hydrocarbon means. Emissions from the Plant's 46-meter-high stack are continuously monitored to ensure compliance with the legislation and the Stringent emissions legislation is enforced on the incineration of waste.

Finland

Vignette 13: District heating and energy certificates

Similar to many countries in Europe, Finland has devised national legislation focusing on the eco-efficiency and reduction of energy consumption in buildings. Not only does constructing a building require a substantial amount of natural resources, but buildings also consume a significant amount of energy throughout their life cycles. The goal of this legislation is to curb the adverse environmental impacts by supporting technologies enabling low energy, passive, zero energy, energy neutral and energy positive buildings. It is in this context that Finland has introduced a mandatory energy certification system. Nowadays, sellers and landlords must provide a certificate providing an overview of the building's energy performance before any sales or rental agreement can go ahead. Exempt from this rule are buildings that have been built prior to 1980. Through this legislation and the certification system, a building's energy performance has become an integral part of a building's value.

In addition, Finland has a long tradition of applying district heating systems for heating homes for reducing the energy consumption of individual housing units. In recent years, there has been a development towards moving away from fossil fuels used in district heating. The idea is to replace fossil fuels by increasing the use of wood-based materials. How important wood-based biomass, from forestry and the wood-industry, has become for power and heat generation is illustrated by recent figures provided by the Natural Resources Institute Finland (Luke). Finnish heating and power plants consumed a total of 20.5 million solid cubic meters (39.4 terawatt-hours) of solid wood fuels in 2019, being 2% more than in the previous year and more than ever before (LUKE 2020).

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District heating solutions have become a viable concept for smaller towns and communities, too. And consequently, there is increasing application of district heating at the municipal level (e.g. case Eno Energy cooperative). Nonetheless, district heating continues to be more widely used in larger towns and for public buildings (with exceptions also for private house heating). For now, in rural private housing, electric heating and/or electric heat pumps continue to be the most common way of heating in Finland. In addition, wood heating systems, fireplaces, stoves and boilers are common in rural areas - often also a combination of electric- and wood-based heating. A case for a rural community using wood-based materials for district heating can be found in the Joensuu, North-Karelia namely the Eno Energy Cooperative.

Vignette 14: Biogas farms

There are a range of Finnish farmers who have been early adopters and innovators of biogas technology. In the project region ten farms produce biogas based on the anaerobic digestion of manure and grass silage. The farms use the biogas to generate both heat and electricity. The heat is used for heating barns housing livestock as well as farmhouses. A pioneer in the region is technician and dairy farmer Erkki Kalmari who constructed a biogas plant on his farm in Laukaa, Central Finland, in the late 90´s. Beyond providing energy and heat for their own operations, the Kalmari farm provides heating for a neighboring farm as well. Moreover, Kalmari founded a consultancy company called Metener which designs and constructs wet and dry fermentation plants, upgrades existing plants, and provides other biogas related services. The company is engaged in research together with the Technical Research Centre of Finland (VTT) and the Natural Resources Institute Finland (Luke). Kalmari has realized biogas projects in Finland, Estonia, the UK, Australia and Mexico.

Another prominent example for a biogas initiative in Finland lies in Kitee municipality, namely the BioKymppi Ltd waste treatment plant. The plant processes different types of biodegradable waste. The BioKymppi biogas plant can be viewed as an early predecessor of facilities like the Northern Irish Granville Ecopark facility in Dungannon (vignette 5). The BioKymppi plant produces biogas from organic substrates. They produce methane which is turned into heat and power. The plant consists of three combined heat and power (CHP) plants each producing 160kWh. Part of the biogas is conducted to Kiteen Lämpö Ltd and used for district heating.

A third example for biogas production exists in south Finland close to the town of Hyvinkää where three farms cooperate for producing biogas. The term “agroecological symbiosis” has been coined by scholars at the University of Helsinki to refer to this new collaborative approach taken by bioenergy producers. The idea is to form a system where food is produced and consumed in a resilient way while at the same time producing biogas. In the case of Hyvinkää, the biogas plant is located at one of the farms and is owned and operated by the regional utility provider Nivos Energia Ltd. Most of the gas is upgraded and used as traffic gas, but part of it is also used for heating the farmhouses. A promising heating solution for rural areas are the emerging biogas plants located at farms. These plants cogenerate heat and electricity based on biodegradable waste materials from agricultural activity. Naturally, the sustainability of such solutions depends on which materials are being used as input to the process.

Gap analysis (T 1.2.1)

At the outset of this report we asked three research questions, and, in this part, we provide an answer to each of them. The first question was: *What are the drivers behind these local initiatives and how do they contribute to solve regional problems*? In table 1 we provide an overview of our findings for each of the vignettes. The key drivers for each of the initiatives and the problems solved by these initiatives are presented in the table, too.

What became evident is that in addition to environmental concerns, fossil fuel prizes constitute a key driver for sustainable development. To illustrate this claim, all of the Icelandic initiatives (vignette 1-3) were initiated out of economic considerations rather than environmental concern. The geothermal projects, presented in vignette one, were all carried out in the aftermath of substantial fuel and coal prize escalations. Projects were initiated immediately after the world wars and the oil price shocks in the 1970s respectively. While these projects led to a substantially improved air quality in Iceland´s capital area, this was more of a side-effect rather than the intention of the initiatives. Moreover, the knowledge base about climate change was not yet well developed when the Icelandic initiatives took place. Two of the Icelandic vignettes, namely 1 and 3, were clearly driven by innovative individuals and citizen initiatives rather than by their government. The early geothermal projects in Iceland were started up by farmers. Arguably the hydro power projects, presented in vignette 2, required a concerted national effort and they likely would not have succeeded without substantial governmental support.

The initiatives undertaken in Northern Ireland, Ireland, and Shetland are more recent when compared to the Icelandic and some of the Finnish ones. This means that commitments to sustainable development in these countries had a stronger role in project initiation. Consequently, these projects were not only conceived based on economic consideration but also based on larger more general concerns about the environment. Moreover, most of the projects (vignettes 4-11) benefited from funding from either regional, national, or European sources focused on curbing carbon emissions. In addition, it is likely that high oil prices between 2006 and 2016 contributed to making the projects starting up during this time viable. The vignettes show that projects have been started "bottom-up" by individuals, through "top-down" initiatives by government or through a mixture of the two. Maybe unsurprisingly, it seems to be the case that individual farmers play a key role when it comes to starting up sustainable projects in rural areas. This seems to have been the case in Iceland, Northern Ireland, Ireland and Finland.

Especially when a technology is not yet well established, farmers prove vital for innovation since they are willing to take substantial risks by investing in emerging technologies. The maybe most poignant examples for this, are vignettes one and twelve, this is where Icelandic farmers started on their own accord to tap geothermal fields for heating their houses or where Finish farmers began developing technology for biogas plants. Another example is the Tipperary Coop in Ireland where a group of farmers collaborated to make their operations more sustainable. Thus, it can be reasonably claimed that individual "champions" are crucial for establishing new sustainable solutions in rural areas. However, once a technology is established, it seems to be important for governments to support rural areas in their efforts to roll out the new solution to a wider area. Examples for government initiatives actively contributing to spreading new sustainable solutions are the efforts by the Housing Executive (vignette 4), the sustainable energy communities' network (vignette 6), or the Shetland Island Carbon Management (vignette 9).

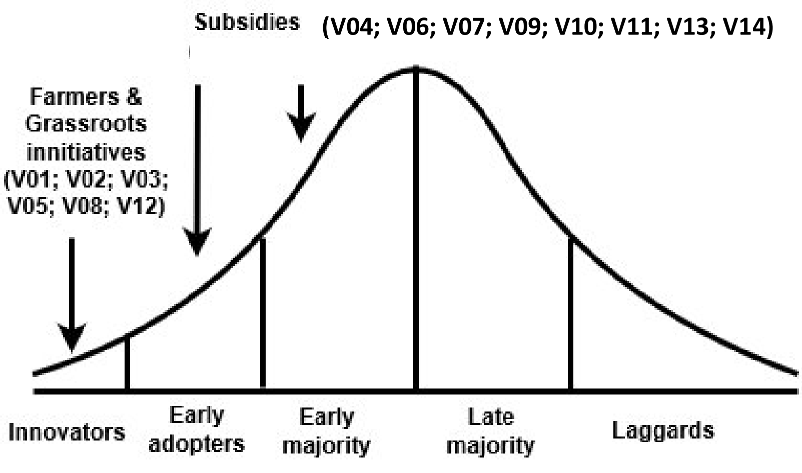

Fig. 11 Diffusion of Innovation in NPA (modified Rogers 1962)

Applying a diffusion of innovations DOI lens to the findings, it can be argued that for rural areas, farmers are often the innovators. Maybe counterintuitively some farmers appear to be the venturesome, educated individuals having multiple information sources driving change and technological innovation in the NPA area. Moreover, it would appear from our findings that once early innovators have demonstrated the viability of innovations, governmental subsidies are important to activate popular social leaders (e.g early adopters) and the early majority. Figure 11 depicts how rural areas diffuse innovation and move away from fossil energy sources.

The second research question was: Are there working models which have successfully addressed rural energy inequity? The answer to this question is yes, there are successful examples for initiatives contributing to solving energy inequity, indeed all of them contributed towards this goal in their own right. The maybe most intriguing example for a successful initiative is the Finnish initiative of creating "agroecological symbiosis" projects. This idea entails several farms bundling their resources to collaboratively develop sustainable solutions for heating and power generation.

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Iceland

Vignette	Driver(s)	Regional Problem(s) solved
(V01) Geothermal central heating	• Fossil and coal prize • High temperature geothermal fields • "Grassroots" innovators	• Removal of coal stoves and diesel generators in Reykjavik, remote villages, and farms • Less cases of respiratory illnesses
(V02) Electric district central heating	• Fossil and coal prize • Hydropower and backup generators • "Grassroots" innovators	• Removal of coal stoves and diesel generators in remote villages
(V03) Lava, fish and sea water central heating	• Fossil and coal prize • Lava, fish processing, and sea water • "Grassroots" innovators	• Power and heat for 4.300 homes

Northern Ireland

Vignette	Driver(s)	Problem(s) solved
(V04) Housing Executive	• Climate change concerns • Fossil fuel prize • Grant schemes • "Top-down" governmental initiative	• Reduction in energy consumption in thousands of social housing units
(V05) Anaerobic digestion	• Climate change concerns • Fossil fuel prize • Grant schemes • Use of biodegradable waste • "Grassroots" corporate innovators	• Power and heat for 13.900 homes

Republic of Ireland

Vignette	Driver(s)	Problem(s) solved
(V06) Sustainable Energy Communities Network	• Climate change concerns • 300 networked communities • Initiated by national government • Top-down and bottom-up	• Completed thousands of small-scale projects • 21.350 home energy upgrades in 2018
(V07) Dublin Airport carpark lighting project	• Climate change concerns • New LED lighting • Government grant • "Grassroots" corporate innovators	• Reduced energy consumption by approximately 3,750,000 kWh
(V08) Dairy farming	• Climate change concerns • Fossil fuel prize • Grant schemes • "Grassroots" initiative local farmers	• 20% reduction in carbon emissions from evaporator plant
(V09) Better Energy Program	• Climate change concerns • Fossil fuel prize	• Reduction of energy consumption in 25 homes

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Shetland

Vignette	**Driver(s)**	**Problem(s) solved**
(V10) Shetland Council – Carbon management	• Climate change concerns • Government and European Union funding	• Developed the hydrogen production lifecycle strategy • Carried out several sustainable projects on public property
(V11) Tidal turbines	• Climate change concerns • EU project and national funding • Wave and tidal resources	• Provide power for 30 homes, a port, and a freezing facility
(V12) Waste burning district heating	• Reduce amount of unrecyclable waste • Provide heating • Reduction of fossil fuel consumption	• Plant burns over 23,000 tons of waste per year • Generates 7MW of thermal power

Finland

Vignette	**Driver(s)**	**Problem(s) solved**
(V13) District heating and energy certification	• Climate change and economical concerns • Governmental initiative	• Energy efficiency has become an integral part of a buildings value • District heating established in most large towns
(V14) Biogas farms	• Fossil fuel prize • Use of biodegradable waste • "Grassroots" corporate innovators • Research and practice collaboration	• Farms collaborate to produce heat and power • New concept of agroecological symbiosis • Start-ups selling biogas services and products

Table 1. Evidencing excellence from the NPA region

The third and last research question needing answering was: Which of these [initiatives] have been local grassroot initiatives with individuals taking the lead rather than their governments? Vignettes 1, 5, 7, 8, 10 & 12 are examples for initiatives where individuals took the lead rather than their governments. Our work is naturally not without its limitations and while we claim to have provided an initial understanding of how successful networks and initiatives have been created in the NPA area, our account is incomplete as there may be more examples falling beyond the scope of this study.

Conclusion

Based on a multiple case study approach this report has presented networks, initiatives and best practice in sustainable energy projects in the NPA regions. Our analysis shows that all initiatives contributed to curbing fossil fuel consumption. The main drivers for all projects were economic and sustainability considerations. Moreover, it became evident that the early innovators leading many of the initiatives in rural areas were farmers. These individuals had a willingness to take risks, financial liquidity and contact to scientific sources (in case of the Finnish farmer in vignette 12). This is similar to what has been suggested by Rogers in his seminal work on the diffusion of innovations (Rogers 1962). Our findings also indicate that governments can accelerate the process of the innovations reaching other farmers and rural communities by financially supporting the work and by disseminating information about the innovative practice. It

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would appear, that while all the regions, in their own way, strive towards reducing fossil fuel consumption their solutions differ significantly. This has much to do with the natural resources available in the respective regions. Each partner region has knowledge of regional resources which may provide energy sources i.e. fishing industry residues in Iceland, biogas or tidal energy in UK and Ireland. This illustrates that there is a prospect for sharing expertise across regions and thereby further strengthening sustainable energy projects.

References

Benbasat, I., Goldstein, D. K., & Mead, M. (1987). The case research strategy in studies of information systems. ***Management Information Systems quarterly***, 11(3), 369-386 .

Björnsson, S. (1980). Natural heat saves millions of barrels of oil: Unique procedures developed by Icelanders - they even tap hot lava ***Atlantica and Iceland Review***, 18(1), 28-37.

Björnsson, S., & Barðadóttir, H. (2006). Geothermal development and research in Iceland. ***Orkustofnun***, Reykjavik, Iceland

Boute, A. (2016). Off-grid renewable energy in remote Arctic areas: An analysis of the Russian Far East. ***Renewable and Sustainable Energy Reviews***, ***59***, 1029-1037.

B9EG (2020). retrieved from: https://www.b9nrg.com. current 26.06.2020

Cave, S. (2013). Anaerobic Digestion across the UK and Europe. ***Nothern Ireland Assembly***.

Elistratov, V., & Kudryasheva, I. (2018, October). Methodology of wind-diesel power complexes parameters justification for decentralized supply of arctic regions. In 2018 ***International Ural Conference on Green Energy*** (UralCon) (pp. 127-132). IEEE.

Energy Saving Trust (2020) retrieved from: https://energysavingtrust.org.uk. current 25.06.2020

Bevington, P. (2015). Yell tidal turbine hits troubled waters. ***Shetland News.*** 01.10.2015

GECO (2020) retrieved from: https://www.granvilleecopark.com. current 25.06.2020

Gunnlaugsson, E. (2004, May). Geothermal district heating in Reykjavik, Iceland. ***Proceedings of the International Geothermal Days***. Zakopane, Poland

Gustavsson, J., Cederberg, C., Sonesson, U., van Otterdijk, R. & Meybeck, A. (2011). Global Food Losses and Food Waste. ***Proceedings of the International Congress "Save Food!" at Interpack***, Düsseldorf, Germany

HECA (2017/18) ***Home Energy Conservation Authority Annual Progress Report 2018***

Jakobsen, K. R. (2016). Renewable energy potential of Greenland with emphasis on wind resource assessment. PhD thesis Technical University of Denmark.

Jóhannesson, Þ., Chatenay C., Thorsteinsson H. H., Atlason Í, & Albertsson A. (2016) How policy, technology and innovation can foster geothermal district heating development - An Icelandic case study. ***European Geothermal Congress*** Strasbourg, France

LUKE (2020) retrieved from: https://stat.luke.fi/en/wood-energy-generation. Current 29.06.2020

Mallett, A., & Cherniak, D. (2018). Views from above: policy entrepreneurship and climate policy change on electricity in the Canadian Arctic***. Regional Environmental Change***, 18(5), 1323-1336.

McLaughlin C. (2019). From lava to ammonia heat pumps: an Icelandic district heating sage. ***Accelerate Europe***, 18-20.

Mortensen, L., Hansen, A. M., & Shestakov, A. (2017). How three key factors are driving and challenging implementation of renewable energy systems in remote Arctic communities. ***Polar Geography***, ***40***(3), 163-185.

NIHE (2020). Retrieved from https://www.nihe.gov.uk. current 23.06.2020

NIHE (2017/18). ***Northern Ireland Housing Executive Annual Report & Accounts For the year ended 31 March 2018.*** Northern Ireland Assembly

Orkustofnun (2019). OS-2019-T007-01: Final heat use in Iceland 2018 by district heating area.

Orkustofnun (2020). Retrieved from www.https://nea.is. current 23.06.2020

Patton, M. Q.(2002). ***Qualitative research and evaluation methods*** (3rd ed.). Thousand Oaks, CA: Sage

Pilyasov, A. N. (2016). Russia's Arctic frontier: Paradoxes of development. ***Regional Research of Russia***, 6(3), 227-239.

Rogers, E. M. (1962). ***Diffusion of innovations*** (1st ed.). New York: Free Press

Rogers, E. M. (1995). ***Diffusion of innovations*** (4th ed.). New York: Free Press

Rogers, E. M. (2003). ***Diffusion of innovations*** (5th ed.). New York: Free Press

Rogers, E. M. (2004). A prospective and retrospective look at the diffusion model. ***Journal of Health Communication***, 9(S1), 13-19.

SEAI (2020). Retrieved from www.https://seai.ie. current 25.06.2020

SEAI annual report (2018). „***Annual Report 2018 on Public Sector Energy Efficiency Performance***" Department of Communications, Climate Action & Environment, Ireland

Tipparary coop (2020). Retrieved from https://www.tipperary-coop.ie. current 08.05.2020

Walsham, G. (1995). Interpretive case studies in IS research: nature and method. ***European Journal of information systems***, ***4***(2), 74-81.

Yin, R. K. (2009). ***Case study research: Design and methods*** (4th Ed.). Thousand Oaks, CA: Sage.

Þórðarson, S. and Jónasson, Þ. (2007). Um hitaveitur á Íslandi. Norræna sagnfræðingaþingið 2007, Reykjavík, 34 bls.

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Fuel mix for domestic heating in the NPA region (T 1.3.1)

Summary

This report looks at the energy sources used for space heating across the NPA region, and how the cost of energy compares between urban and rural areas in different countries. The NPA regions includes parts of Finland, the Faroe Islands, Greenland, Iceland, Norway, Northern Ireland, Republic of Ireland, Scotland and Sweden.

The main energy sources for domestic space heating vary largely between the partner countries. Access to energy is also often quite different between regions in the same country and generally energy is more affordable in the more densely populated regions of each country.

The heating need is also very different with the heating season only spanning few months in the southern parts of Ireland up to the whole year in parts of the Nordic countries.

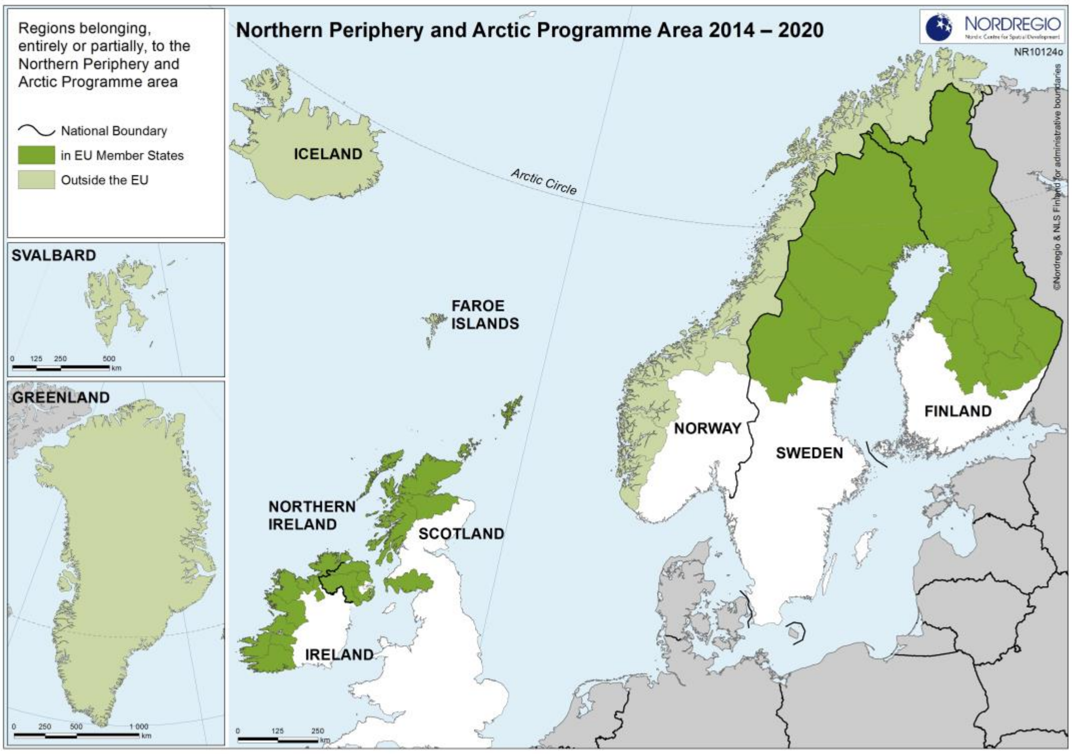

Figure 1: NPA region.
Source: www.interreg-npa.eu

Finland

Finland has the highest forest coverage of any country in Europe or 74% of its land area. Wood is also the single most utilised energy source for space heating in Finland with 28% share. About 31% of Finnish homes have access to district heating. In 2008 about 20% of Finnish homes heating demand was met with electric heating and 4% by heat pumps. In 2017 these numbers had gone up to 24% for electric heating and 11% for heat pumps. At the same time use of oil has gone down from 12% to 6%, gas and coal account for only about 0.5% of the heat demand.

District heating in Finland

In 2018 90% of the energy for the district heating networks came from fuel-based production, 16.5% from natural gas, 23.5% from coal, 1.8% from oil, 16.6% from peat, 37.2% from wood or other carbon neutral biomass and 4.4% from other fuels. The remaining 10% of the energy came from heat recovery and heat pumps.

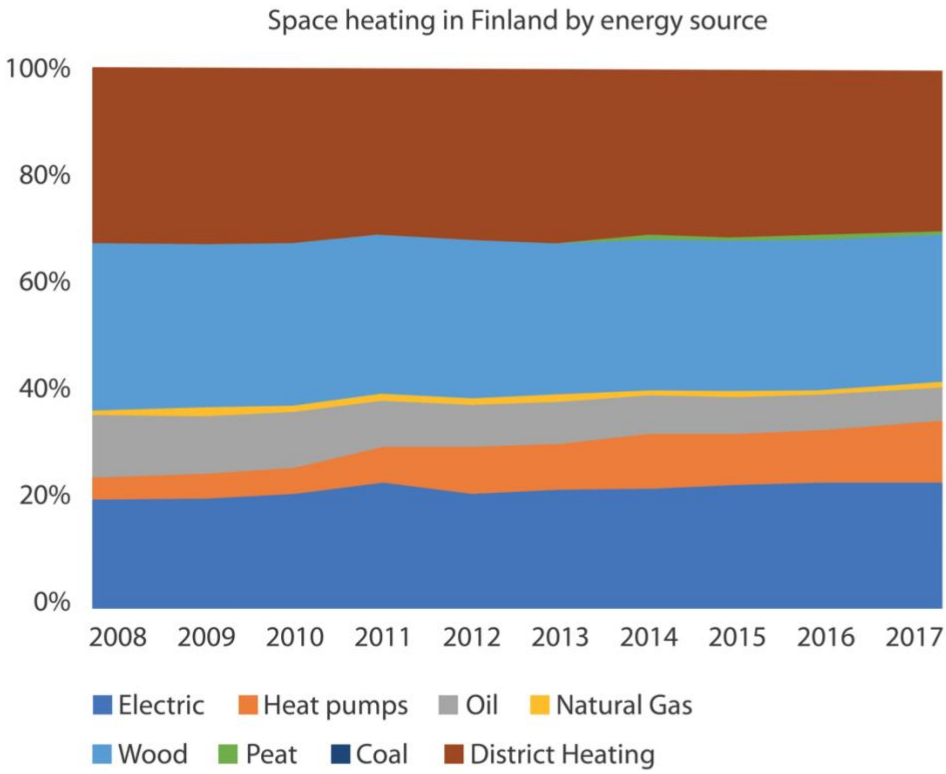

Figure 2. Source: 1) Statistics Finland, 2) Finnish Energy, “District heating in Finland 2018”

Central Finland

Central Finland is one of Finland’s 19 regions, it is about 20,000 km^2 and has a population of 275 thousand. About half of the region’s population lives in the regional capital of Jyväskylä. Most of the city’s inhabitants are provided with district heating from the Rauhalahti CHP plant, which in 2017 met 49% of the heating demand in Central Finland. In the same year about 34% of the heating demand in rural Central Finland was met with electric heating, 4% with heat pumps, 36% from oil and 28% from wood.

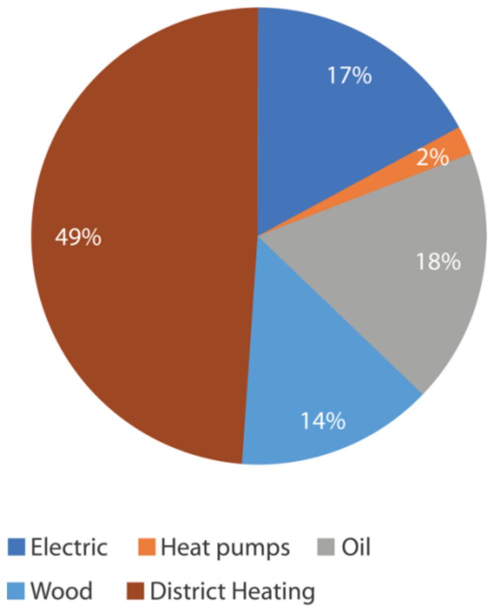

Figure 3: Energy source for space heating in central Finland.
Source: Koponen Hannu, presentation, Jyväskylä 2018

Figure 4: Rural landscape in Muurame.
Source: Tiia Monto, Wikimedia

Faroe Islands

The Faroe Islands consist of 18 major islands with a population of 52 thousand. Space heating demand in the Faroe Islands has in the past been dominantly met with oil, but in recent years the use of heat pumps has gone up significantly. In Tórshavn the Faroe Islands capital small parts of the population are connected to a district heating network that uses heat from the local waste incineration plant. In the fall of 2019 a new large scale heat pump installation was put in operation in Klaksvík. The heat pump will utilise heat from the ocean and will initially displace a demand for about 1 million litres of oil and potentially 5 million litres with future expansions. The heat pump installation will also deliver heat to customers in Klaksvík at 15-20% lower costs than the current oil fired solutions. The Faroese government has the goal of moving entirely away from the use of oil for space heating.

Figure 5: Turf-roofed house in Klaksvík", Brookie, wikimedia.
References: 1) Dansk Energi, d2016-86677-21.0, 2) Orksuskiftið, www.os.fo

Greenland

Greenland is the largest island in the world with a population of 56 thousand. Oil is still the most important energy source for space heating in the country. The use of oil has however been steadily declining in recent years and from the year 2011 to the year 2015 the share of oil usage has gone down from 75% to 68%. In the year 2015 about 23% of the space heating demand for homes in Greenland was served through district heating and about 9% used electric heating. Greenland is actively investing in hydro power production infrastructure and from the year 2004 to 2015 electricity production from hydro power more than doubled and went from being 32% of the annual electricity production to 81%.

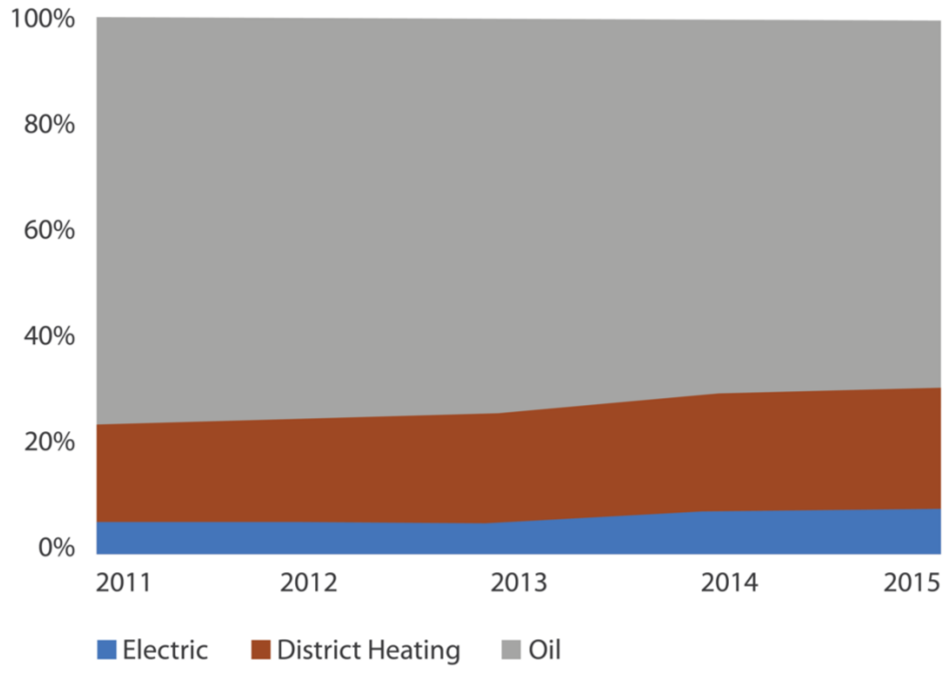

Figure 5: Space heating in Greenland by energy source.
Reference: Statistics Greenland, "Grønlands energiforbrug 2015"

Iceland

Icelanders are privileged with a vast geothermal resource and the nation has been world leading in direct use of geothermal energy for space heating and electricity production. Today geothermal energy is used as the heat source for 90% of Icelandic houses, about 9% of the heating demand is met with electricity and below 1% with oil. The geothermal resource is however, not evenly distributed across the country and currently operated reservoirs are mainly positioned on and around the tectonic plate boundary that runs through Iceland from the south-west to the north-east. In regions such as the West-fjords and East-Iceland many towns don't have access to utilizable geothermal reservoirs and therefore have to rely on electric heating.

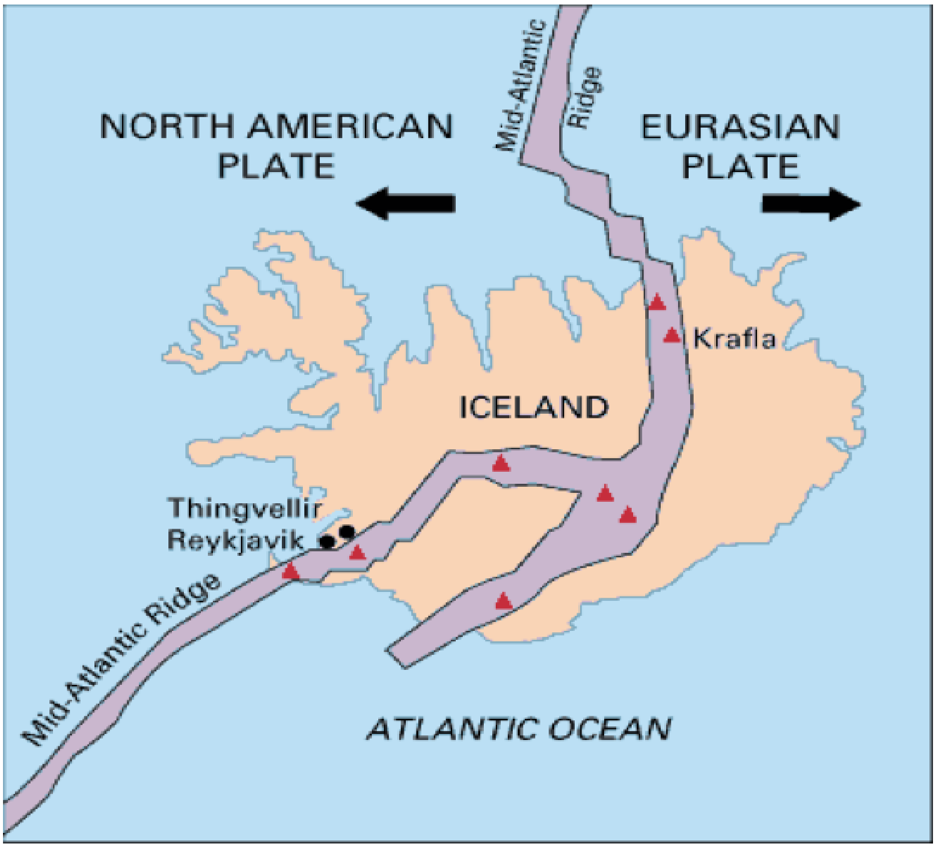

Figure 6: Tectonic plate boundary through Iceland.
Source: USGS, pubs.usgs.gov

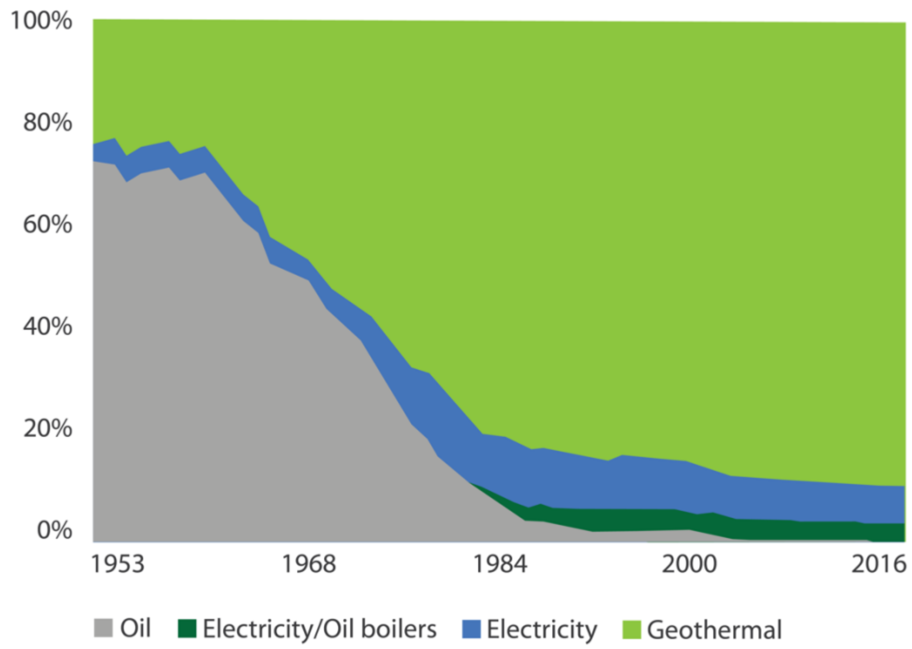

Figure 7: Space heating in Iceland by energy source.
Reference: Orkustofnun, (2018). OS-2018-T010-02

Austurland

Austurland is the eastern most region in Iceland. Even though it is among the regions lying furthest away from the most active geothermal areas about 41% of its inhabitants have access to geothermal heating. The remaining heating demand is almost entirely met with electricity, either in individual homes or through district heating grids that are operated on dispatchable electricity. In the cases when delivery of electricity has to be curtailed to the district heating network operators, oil boilers are available to step in as reserve heat source. The use of the oil boilers is however becoming a very rare event. Electricity in Iceland is entirely produced with renewable energy from either hydro power or geothermal power.

Figure 8: Geothermal extraction site close to Egilsstaðir East Iceland.
Source: J.S.G. Mýrdal (2018)

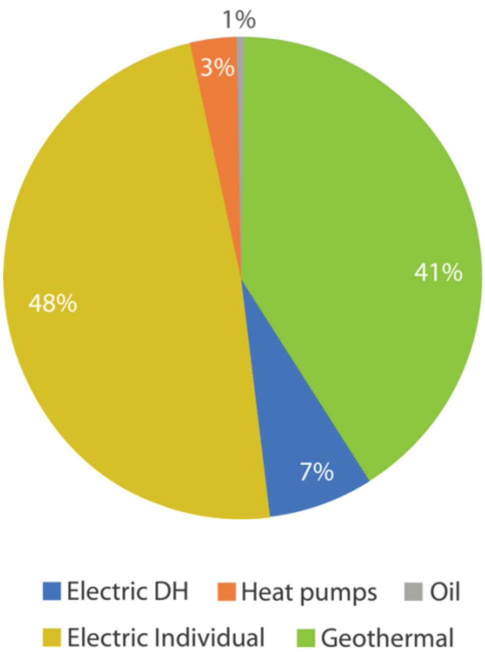

Figure 9: Space heating in Austurland by energy source.
Reference: Austurbrú (2019)

Norway

Norway is among the largest energy production countries in Europe with 32 GW of installed capacity of hydro power and an oil production of around 90 million tons per year. This makes Norway, which has population of 5.3 million, the largest producer in both of these sectors in Western Europe. Norway also has a large forest resource with 37% of its area considered to be covered in forest or wooded land. In 2012 electricity made up 80.5% of the energy consumption of Norwegian homes, oil and kerosene 3.5% and wood, coal and coke 16%. About 15-25% of this demand went to appliances but the rest has been consumed for heating. District heating reaches a small portion of the Norwegian nation compared to other Nordic countries and in 2015 about 62% of the district heating networks served industries and not homes.

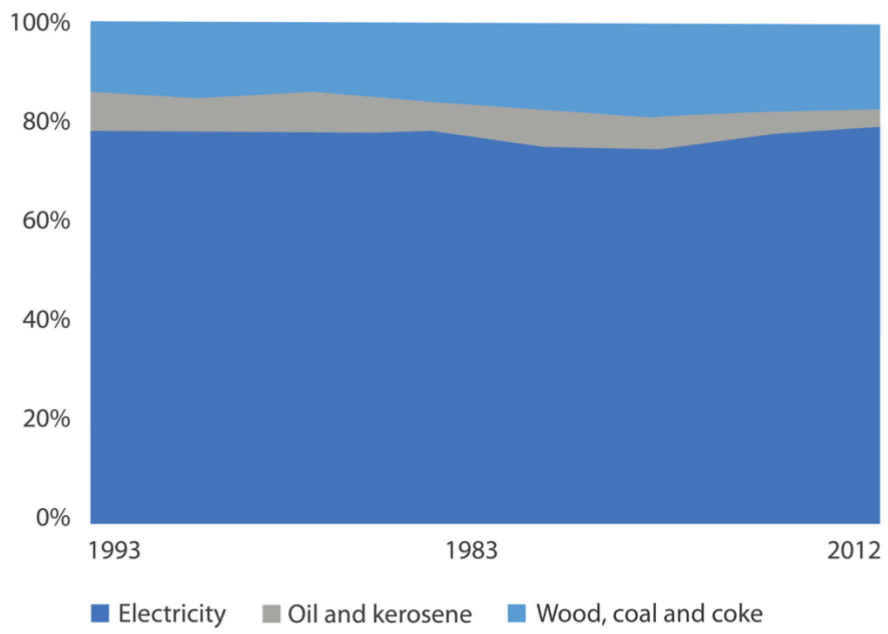

Figure 10: Household energy consumption in Norway by source.
Reference: Statistics Norway

Northern Ireland

Northern Ireland is positioned at the north-eastern part of the island of Ireland and has a population of close to 1.9 million. In Northern Ireland oil has been the most important source of energy for heating of homes with a share of 68%. The share of solid fuels has gone down over the past decade from 16% in 2006 to 8% in 2016. The consumption of solid fuels has been replaced by natural gas which in 2016 covered 24% of the heating demand. Currently natural gas is not available in the west of Northern Ireland, which means that a large portion of the Northern Irish population has limited options of heating fuel other than oil.

Figure 11: The Cuilcagh range.
Source: Carl Meehan, wikimedia commons

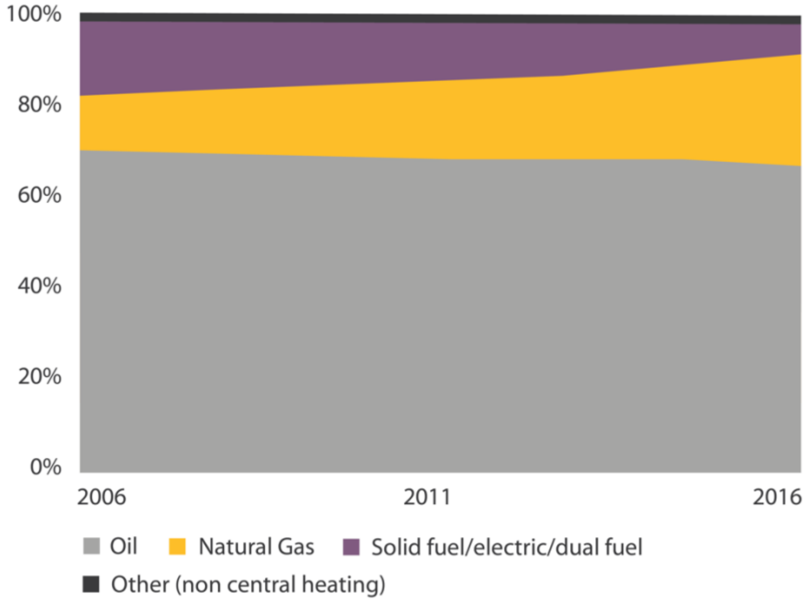

Figure 12: Space heating in Northern Ireland by energy source.
Reference: NIHE, House condition survey (2006), (2011), (2016)

Republic of Ireland

The Republic of Ireland occupies the south and west of the island of Ireland and has a population of 4.9 million. Statistics over central heating systems in Irish homes over the last 30 years show significant changes. In 1987 half of Irish homes had no central heating systems, while in 2015 that number had gone down to 6%. Those who had central heating systems in 1987 were mostly using solid fuels as a heat source, in 2015 only 5% of homes in Ireland used solid fuels for heating. The share of oil consumption grew up until 2005 and has been coming down since then. Oil and gas are still the most common heating fuels with a share of 38% and 35%, respectively.

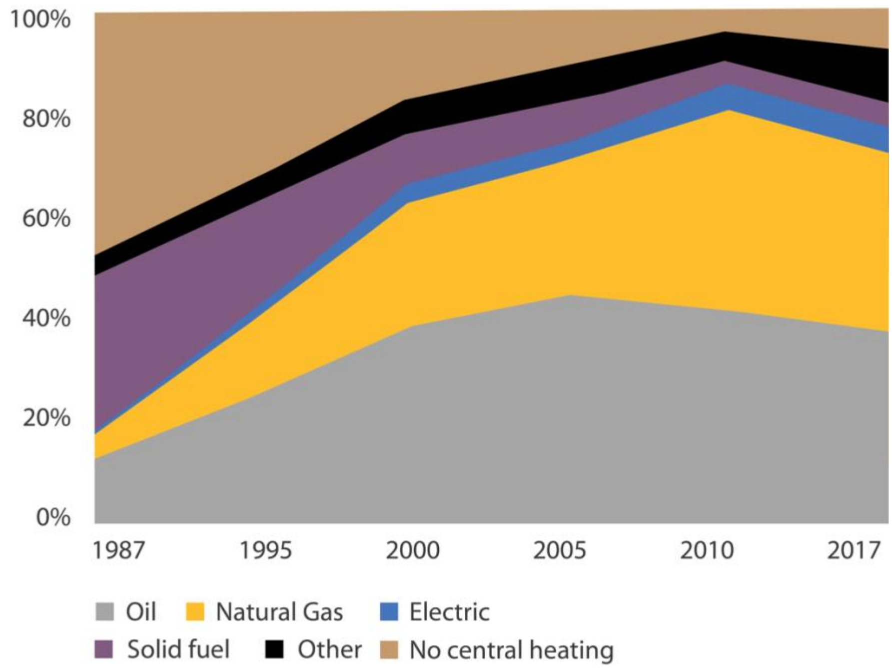

Figure 13: Central heating in Ireland by fuel type.
Reference: SEAI, Energy in the residential sector (2018)

Urban and rural Ireland

According to SEAI there is a large difference in the share of heating systems between urban and rural areas in Ireland. In urban areas over 50% of homes have gas central heating systems, over 25% use oil and over 10% use electric heating. In the rural areas about 65% of homes use gas heating systems, over 10% use peat and about 7-8% use coal as their primary heat source.

Scotland

Scotland is composed of the northernmost part of the island of Great Britain, the Western Isles, Orkney and Shetland. Scotland has a population of 5.4 million. Natural gas is the most important heating fuel in Scotland with a share of 79%, electric heating is second with a share of 12% and oil has a share of 6%. Scotland has the target of producing 11% of its non-electrical heat demand from renewable source by 2020, in the year 2017 the share of renewable sources for non-electrical heat demand was 5.9%.

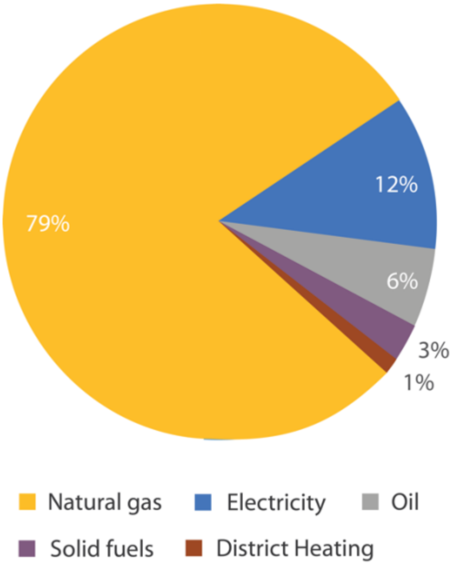

Figure 13: Central heating in Ireland by fuel type.
Reference: SEAI, Energy in the residential sector (2018)

Sweden

Sweden has the largest population out of the Nordic countries, about 10 million. Similar as Norway and Finland, Sweden has large forests that cover 57% of its land area. Sweden has large district heating infrastructure that serves about half the demand for heat from Swedish homes each year. Electricity is the second most used energy source for heat with about 20% share. Included in the electricity numbers are heat pumps, which are common in Sweden with over a million installations around the country. Biomass has a share of 18% in the heat consumption and the share of oil consumption for heating has gone down from 6% in 2007 to 1% in 2017. Biomass is also the main fuel for the district heating networks with a 62% share in 2014. Heat recycling from industry is also a significant source of energy for district heating in Sweden with a share of 7%.

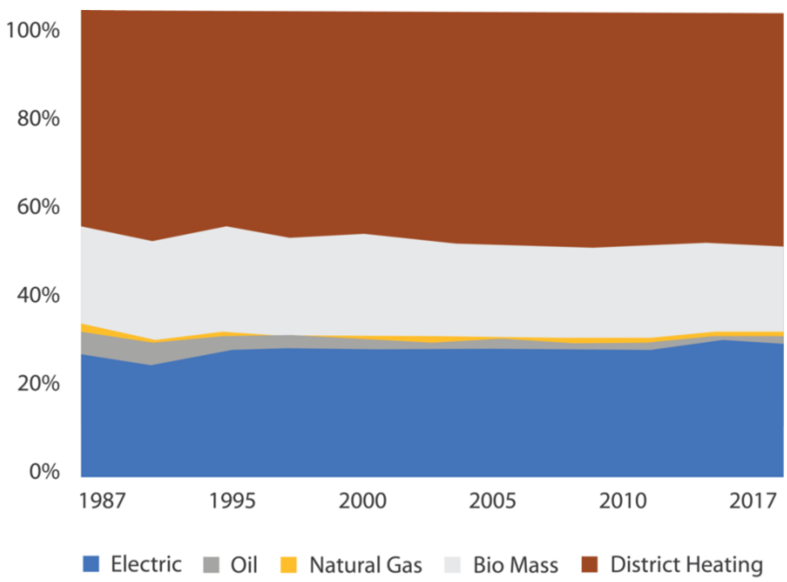

Figure 15: Space heating and hot water in Sweden by energy source.
Reference: Swedish Energy Agency and Statistics Sweden

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Underutilized energy resources (T 1.4.1)

Summary

Work package 1-4 is concerned with providing a better understanding of underutilized energy resources in the Northern Periphery and Arctic (NPA) region. Identifying opportunities to further increase the availability of reliable and clean energy in the region is a worthwhile undertaking. The NPA region has witnessed increased demands for sustainable energy due to a rise in population, with the possible exemption of Greenland, coinciding with the recent global push for decarbonizing energy production. A multiple case study method has been deemed appropriate for identifying cases of underutilized energy resources. Cases were identified based on feedback by subject matter experts for sustainable energy part of the Handiheat project. This allowed for compiling cases of underutilized energy resources from Ireland, Northern Ireland, Finland, Scotland, Sweden, Faroe Islands, and Iceland. The results are presented as vignettes and the report concludes by providing an overview of the potential for future sustainable energy development in the region. This report can be viewed as complimentary to the WP 1-1 report which established existing best practice examples for innovative and sustainable energy practices in the partner regions. WP 1-4 provides a brief outlook into the future of innovative energy practice in the region.

Findings

This chapter presents cases of underutilized energy resources as identified by the experts in the partner regions. The experts provided cases of underutilized resources in writing and below the essence of these statements is presented as "vignettes". The findings presented here are not intended to be exhaustive, rather they are intended to provide examples for where energy resources could be used more effectively. It can be claimed that the vignettes provide a starting point and ideas for regional development. Beyond just identifying cases for better energy practices, further work should seek to provide a more comprehensive account of opportunities for improving the utility of energy resources in the NPA region based on large scale investigations.

Iceland

Vignette 1: Industrial waste energy resources

East Iceland has made some progress towards reducing its dependence on fossil fuels. Examples for this trend include the regional fishing industry upgrading their fleet of dated vessels, the recent construction of the 690 MW Kárahnjúkar hydro power plant, and the recent exploitation of a new geothermal well in Eskifjörður. An opportunity for further reducing the regions dependency on fossil fuels is to utilize the industrial waste energy from the primary aluminum smelter in Reyðarfjörður. The smelter is the biggest consumer of electrical energy in the country consuming 4964 Gwh per annum. According to a recent report, it would be feasible to use 20MW of waste heat energy from the smelter to provide heating energy to the nearby village of Reyðarfjörður. Reyðarfjörður has a total demand of 5MW heat energy annually. Thus, there exists a realistic prospect for waste heat recovery in the region (Gunnarsson, 2020). This is just one example and it is conceivable that the waste energy of other primary aluminum smelters could be reused as well.

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Vignette 2: Medium enthalpy geothermal resources

Iceland has a long-standing history of using geothermal energy for producing power and heat energy. According to a recent publication of the Icelandic National Energy Authority (Sveinbjörnsson, 2016), Icelanders have been very efficient when it comes to harvesting high-energy and high-enthalpy geothermal fields for power production and low-energy fields for domestic heating. This leaves about 38 medium enthalpy geothermal systems which are largely underutilized (ibid.). It has been conservatively estimated that exploring these resources could add up to 70MW electrical energy to the national energy mix. This reflects untapped potential, and it could help especially remote regions of Iceland to achieve better energy independence from the South-west volcanic zones of the country (ibid.). Moreover, this could contribute to further decarbonizing Iceland's energy mix.

Vignette 3: Rural electricity transmission system

Disruptions in the electricity transmission system, especially in rural areas, are a major reason for concern for Icelanders. The most recent example for a major power outage followed a severe blizzard hitting the island in December 2019. This blizzard led to a blackout in large parts of Northeastern Iceland leaving several settlements without power for nearly two weeks following the incident. The main reason for the blackout was icing of power lines ultimately leading to collapsing wooden transmission towers. During the time of the power outage, backup generators operated with fossil fuels were the only remaining power source. This phenomenon has troubled Iceland for some time and while there are consistent efforts to improve transmission lines, there is a need for more concentrated efforts. Limiting power outages by improving the grid or decentralizing the power production further can help Iceland to build resilience toward natural disasters (Eliasson, 2005). Moreover, increasing the resilience of the national power grid would allow for a more consistent provision of sustainable energy to all parts of the country whereby curbing fossil fuel consumption.

Vignette 4: Tidal wave power

Iceland is presently exploring the opportunity to make greater use of tidal waves in power generation. Early feasibility studies in several places in the western fjords have established that electrical power could be generated based on tidal power (Jónsson 2009). This is especially true for Breiðafjörður where the difference between ebb and flood is around 4m (ibid). Building a tidal power plant in this fjord could produce around 80 MW of electrical power. Since the Icelandic Road Authority has plans to build a bridge across this fjord, it would become thinkable to install turbines harvesting tidal power on this future bridge (ibid.). Thus, tidal power is a feasible option for further increasing Iceland's production of sustainable energy. Moreover, the Icelandic Innovation Center has designed a prototype turbine called Valorka, well suited for harnessing the power of the tidal waves in the fjord (http://www.valorka.is/, current 03.12.2020).

Vignette 5: Small scale hydroelectrical power plants

While Iceland has made considerable strides in recent years to increase the use of hydro power, signified by the construction of the 690 MW Kárahnjúkar dam in East Iceland, there exist considerable reserves for further development. The way forward may lie within developing small scale plants on smaller rivers. A recent feasibility study exploring the prospects of developing 883 small scale power plants placed on small rivers in East Iceland concluded that it would be possible to produce an additional 1600 MW electrical power in the region (Guðmundsson et al. 2020). This represents a great opportunity further increasing Iceland's production of sustainable energy. However, there exists a need for further developing small scale hydro power solutions that can be readily installed. Considering that this study has had a limited focus on the east part of Iceland there likely exist similar potentials for further developing hydropower in other remote parts of Iceland.

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Ireland

Vignette 6: Group Water Scheme - solar power

Using solar panels to power water treatment plants in remote regions of Ireland represents an opportunity for tapping into underutilized energy resources. One early example for a pilot project of this type is the Polecat Springs Group Water Scheme (GWS) located near Elphin, County Roscommon (Irishtechnews 2020). The Polecat Springs GWS supplies water to rural properties covering 80 square kilometers stretching from Elphin Town northwards to Carrick on Shannon and from Ballinameen eastwards to the River Shannon and is operated as a community co-operative (ibid.). Installation of the new solar panels means electricity, which was previously drawn from the National Grid, will now be produced locally to power the various stages of the water treatment process (ibid.). Once installed, the solar panels will reduce energy costs by 70% and substantially cut carbon emissions of the water treatment plant (ibid.). Installing the photovoltaic system is anticipated to, in the long run, reduce the water treatment cost for the community (ibid.). The project has been backed by a Sustainable Energy Authority of Ireland through the Better Energy Communities Programme providing a grant covering 50% of costs, and the resultant energy cost savings will enable the project to pay for itself within six years (ibid.).

Vignette 7: Better Energy Communities - Community Empowerment Tool.

Underutilized energy resources exist in communities in rural areas of Ireland. While urban areas have begun embracing sustainable energy solutions, rural areas appear to have been left behind. This appears most pronounced in rural areas with many so-called fuel-poor households where socio-economic factors prevent residents from investing in new, more sustainable energy solutions. One way the Sustainable Energy Authority of Ireland has identified for addressing this problem is to identify and support fuel-poor households in rural areas (SEAI 2021). Since 2006 training programs have been run in rural areas where people can attain certificates in sustainable energy retrofitting (ibid.). One example for this is the better energy warmer scheme targeting fuel poor homes and delivering attic and cavity wall insulation measures in local homes (ibid.). Such programs stimulated the local rural economy by creating employment opportunities for those far removed from mainstream labor market opportunities, stimulating the local supply chain as material were purchased locally, as well as increasing the skill base and knowledge in energy efficiency in the locality (ibid.). Moreover, the Communities Energy Grant has been started up for sponsoring initiatives aimed at refurbishing rural homes as well as larger projects in rural areas. There is great potential for further strengthening the "better energy communities" whereby modernizing and energetically refurbishing rural homes (ibid.).

Finland

Vignette 8: Biogas

Current annual biogas utilization is around 1 TWh out of which 0,1 TWh is consumed as upgraded biomethane. It has been estimated that total potential in Finland is 16 TWh while economically and technically viable potential would be 4-5 TWh. Biogas production and upgrading enables biomethane based solutions outside gas grid. These off-grid biogas plants will form hubs for vehicle filling and combined heat and power production. Furthermore, the compressed natural gas can be transported from the hub to the site of utilization such as combination storage for heating and vehicle filling in rural areas. This proposed business model is being investigated in Handiheat Pilot 1 by Karelia University of Applied Sciences (Energiauutiset 2020).

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Vignette 9: Wood pellets

Wood pellets are a logical source of energy in forest covered areas of Eastern Finland. Eastern Finland has quite a lot of mechanical wood working industry, which provides a good amount of savings and wood dust as a by-product. This material is the best possible raw material for energy pellets for multiple reasons. The material is already dry, thus enabling the cost-effective pellet production. From the CO2 binding point of view, the raw material for pellets is not causing any new cuttings of forests. It is a by-product from the production of wood panels, houses, furniture, etc., which in turn are binding the carbon for a long time. According to the inquiries made by KUAS (Karelia University of Applied Sciences) project from a few years ago, the amount of free raw material (i.e. sold annually to different purposes and customers) from the regional wood working companies can be estimated to be ca. 5.000-6.000 tons of dry mass. This equals to appr. 23.000-28.000 MWh/a, which would cover the annual heat demand of appr. 1.000-1.400 private houses regionally. However, since its appearance to the energy sector in Finland two decades ago, the wood pellets have only achieved a marginal share as the main heating solution in separate buildings. The modern pellet heating technology offers high efficiency with minimum emissions, and even CHP production in the private house scale. The knowledge on Middle-European technology level is, however, spreading quite slowly among Finnish house owners. Therefore, it is much easier also for the companies to offer simple electricity-based solutions.

Vignette 10: Flue gas heat recovery in district heating and small-scale heating networks

Heating energy to district heating systems is produced with CHP plants and dedicated heating plants mostly utilizing renewable solid fuels. When combusting mixed renewable solid fuels we can achieve combustion efficiency of 90% quite easily. The remaining 10% is lost with flue gas flow through cleaning processes and finally exiting the chimney. It has been estimated that total heat loss through flue gases is around 4,4 TWh/a in heating plants and CHP plants connected to district heating systems. Slightly less than 1 TWh/a of the losses are being recovered already so the estimated potential is more than 3,4 TWh/a in total. The figures provided covers bigger installations and there is massive additional potential to be found from small scale heating networks as well. Potential technologies to harness the flue gas losses is to equip the boilers with wet scrubbers if possible. Wet scrubbers in combination with better temperature management of the heating network will generate considerable benefits both economically and environmentally (TEM 2020).

Vignette 11: Solar PV in apartment buildings

In Finland, all apartments in condominiums, row houses and multistorey buildings have their own contract for electricity transfer and electrical energy. Current status has been that when excess small-scale solar, wind or similar power production is fed to the grid it cannot be used later or sold to your neighbour etc., without inducing transfer fees and taxes. This has hindered the use of solar PV in apartment buildings. Finland has 90.000 condominium companies consisting of 142.000 buildings and almost 50% of the population live in these condominiums. It has been estimated that if multi-storey condominium companies would be equipped with 14 kWp and row house condominium companies with 2,8 kWp PV system, total Solar PV capacity would be 1094 MWp producing 983 GWh/a of electricity. This is more than 1% of annual electricity consumption. More conservative scenario would be to assume that every third condominium company would invest in 10 kWp solar PV system it would increase total solar PV capacity by 380 MWp. Grid connected solar PV capacity was 200 MW in 2019 so total capacity would rise by 200%. Legislation was changed at the fall of 2020 to allow the condominium companies to transfer electricity within the apartment building. This will lead to increased solar PV arrays in the future as all apartments in the building can enjoy one single PV system (Energianeuvonta 2020).

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Northern Ireland

Vignette 12: Electrification of heating off the gas grid

Given that the Northern Ireland climate change committee aims at installing 100.000 heat pumps in public housing by 2030, substantial investments are required. There are several pilot projects underway investigating how to best undertake these improvements. At the Northern Ireland Housing Executive (NIHE), which provides public housing and helps with rent to people with low income, the heating units of about 86.000 social housing units can be retrofitted as part of the efforts. Based on pilot projects undertaken in Newry, the costs of modernizing heating systems have been estimated at £22,000 to £30,000 per housing unit. In another pilot, part of the HANDIHEAT[1] project, mini pilots have been executed across 6 dwellings, off the gas grid. All houses have £10k of energy efficiency measures where the building envelope is energetically improved, digital hot water flow meters are installed, and a low carbon heating solutions like (1) hybrid air source heat pumps with existing oil boilers, (2) hybrid oil boiler with an inset immersion to model the use of cheaper tariffs and (3) electric battery storage, with solar PV generation and using electric storage heating system are being tested. The intended outcome is to measure the household cost/savings and carbon reductions. The data analysis is being led by Ulster University. A key focus is householder attitude and satisfaction. Ulster University have also commissioned a PhD student to assess the householder expectations and experiences before, during and after the one-year evaluation. Results are expected in June 2021.

Vignette 13: Utilized wind curtailment from renewable energy for social housing

Northern Ireland and Ireland produce high levels of wind energy to the all-island power system, however when wind generation exceeds set limits, the output from wind turbines is turned down through; curtailment (system-wide, to keep the percentage of electricity generated by wind at a maximum of 65%) and; constraint (local, due to restricted network capacity). This represents an underutilized energy source which could be utilized better, for instance in social housing. In 2019, 10.7% of NI's available wind energy, with a retail value of close to £50M, was turned down (4.7% through constraints and 6% through curtailment). Total turn down for the Republic of Ireland was 6.9% (3.8% constraints and 3.1% curtailment). As well as issues of constraint and curtailment, wholesale electricity prices are low at times of high wind generation. Two NIHE projects (HANDIHEAT[1] and GIRONA[2]) currently trialing technologies, including electric heating systems with thermal and battery storage, which can make use of wind energy at times of low demand. A project, RULET3[3], is developing agile tariff options and market arrangements to provide low-cost, green electricity to NIHE tenants. Energy Cloud is a concept developed in the Republic of Ireland to make use of curtailed wind energy by providing it for free to social housing tenants. In Northern Ireland, Energy Cloud has been incorporated into RULET as a separate strand which aims to specifically address the issue of curtailment by using existing storage systems (hot water cylinders and immersion heaters) to provide load for wind energy which would otherwise be curtailed. This energy will be provided for free to social housing tenants; in particular, the project wants to prioritise households at risk of fuel poverty. Energy cloud requires no new technology other than relay switching in individual homes which can respond to an instruction from the system operator. The Republic of Ireland's new program for Government (PfG) set a target of 5 GW of new offshore wind capacity by 2030. NI has a pipeline of ca. 1

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[1] HANDIHEAT is a €2m EU Interreg project with pilots investigating low carbon heating solutions in rural housing, with NIHE as Lead Partner.
2 GIRONA is a £2.2m Innovate UK project which will investigate the business model to utilise electric batteries within social housing. NIHE is a stakeholder and partner in this project based on CXBC approval in 2017. A CXBC paper noting the additional NIHE involvement will be drafted by the end of July 2020, after initial briefing to Director of Asset Management.
3 RULET is a test pilot project led by Ulster University within their SPIRE2 EU project. RULET will investigate how householders can benefit from demand flexibility within the energy network and explore the benefit of agile tariffs to householders. This project has key energy stakeholders from across NI and NIHE have provisionally agreed to provide the housing, subject to Director's approval. (again, subject to a CXBC paper after initial briefing to the Director of Asset Management, NIHE).

GW of onshore wind projects in the planning and approval process. NI peak demand is 1.8 GW, and this extra capacity is likely to result in levels of curtailment which are substantial enough to maintain the proposed model. The UK has similar ambitions for new renewable capacity, but Northern Ireland will need to await the detail from its NI Energy Strategy which is due in late 2021. In summary, with continued ambition for more renewable generation it is envisaged there will continue to be excess energy to provide for this arrangement.

Vignette 14: Utilize electric generation and storage through householders

The GIRONA[2] project's aim is to create a revolution in the energy market, giving customers an easy, inexpensive way to incorporate smart solutions like solar panels, battery storage and decarbonization of heat and transport in their daily lives. The proposal of a smart grid will offer users the chance to have small-scale renewable technology and battery storage installed in their homes, the cost of which will be absorbed by PowerOn, UK Government funding and supported by investment from our partners (in keeping with the original proposal that Power On would design, fit, manage, and maintain the systems within NI Housing Executive (NIHE) properties, and after the research period, remove them dependent on direction from the Housing Executive). By analyzing information on their household electric profiles, we will help customers to not only understand their energy usage, but they will also be able to manage their consumption; to reduce their energy bills and potentially profit from unused capacity.

The project focuses on Coleraine, Northern Ireland, typical of many UK regions in terms of population density, energy distribution, mix of users and the effect energy constraints have on economic growth. The GIRONA project is part funded by an Innovate UK award of £2.4m under BEIS and the 'Prospering from the Energy Revolution' programme. The remainder is funded by PowerOn Technologies and Grant Electrical Systems that formed a collaboration called GIRONA Energy Limited. The consortium has considerable experience in complex projects within the energy sector. Members of the long-standing Stakeholder Group include the local electricity Distribution Network Operator (NIE Networks), the Utility Regulator, the Consumer Council for Northern Ireland, Department for the Economy, Invest NI and NI Housing Executive as noted earlier. Project Summary: Smarter management of electrical assets; cheaper, cleaner, more reliable power; access to data. Add in reduction of fuel burn, maximized use of renewables and deferred capital expenditure on the grid, and the opportunity to change a country's energy landscape emerges.

The GIRONA project: the first custom-built, micro grid of its kind, sets out to determine the extent to which network constraints can be relieved by deploying flexible, predictable renewable energy and pairing it with "behind-the-meter" storage assets. The key objectives of the project are to digitalize, decentralize, decarbonize and democratize the energy system. This will be done by deploying Energy Flexibility as a Service, which in turn makes the energy buying process more democratic – empowering and enabling users to transition from being passive consumers, to prosumers – engaged, proactive users of a system that rewards flexibility and predictability. Flexibility in the sense that demand can be increased or decreased as well as deferred or front loaded; predictability refers to GIRONA's capability to anticipate demand. The result of these facets is three-fold; an overall electricity demand that is both reduced and smoothed out; analysis of data that results in reliable forecasts for operational control and planning, but which can also be used to take advantage of the new Single Electricity Market and a measurable, predictable reduction in emissions and air pollution. By creating a system where customers are rewarded for smart solutions like solar panels and battery storage, a reduction in domestic electricity bills is forecast. Given that 27% of homes within this district are categorized as 'fuel poor', decreasing the cost of fuel by even 5%.

Vignette 15: Utilize bio-fuel for oil boilers – off the gas grid

The NI Housing Executive are investigating the possibility of using 50% Bio Fuel and/or 100% Bio Fuel as a substitute for 35 sec kerosene oil to reduce the carbon footprint of this fossil fuel. The issue is +500k homes (68%) of NI housing use oil boilers and this is an option to transiton off fossil fuel. Ultimately the ambition is to use 100% bio fuel, which is carbon free. The Housing Exceutive want to investigate the following: (a) Sustainabilty of this fuel source, and availability; (b) Long term pricing structure of bio fuel; (c) Adaptability of using bio fuel with existing oil boiler; (d) Appetite of the oil distribution industry to adapt to supplying this fuel. The Housing Executive will trial this option in the RULET project in summer 2021, pending approval.

Scotland

Vignette 16: Scottish transmission grid

With regards to the wind power, large areas of the electrical transmission and distribution networks across Scotland are facing constraints, primarily as a result of the unprecedented increase in distributed generation connections over the past decade. The following figures from the Transmission Entry Capacity (TEC), Register, The UK National Grid's database of connected generation, illustrate the scale of onshore wind on Scottish networks: 4.7 GW connected; 180 MW under construction; 2.4 GW with consents approved; 1.4 GW awaiting consents; 1.9 GW in the scoping phase of development. These figures do not include the 3.2 GW of onshore wind projects connected to the distribution networks that do not have transmission entry capacity (TEC), meaning they do not participate in the Balancing Mechanism (BM) and so are not eligible for curtailment payments. i.e., smaller renewable generation developments below transmission level. There is no specific pattern to the areas of constraint; however, those more rural areas with plenty of land for development and abundant wind resource have been more susceptible.

These areas include Ayrshire, Lothian & Borders, Dumfries & Galloway and the Highlands & Islands. Of the 145 Grid Supply Point (GSP) substations in Scotland (across both distribution network operator (DNO) areas [SSE and SP]), 89 are constrained. The DNOs are already trialling new solutions to managing network constraints through the implementation of Active Network Management (ANM) and other technologies, to provide a cost-effective connection option to generation developers and avoid or defer costly wider network reinforcements. To put this into context The UK charity REF published a brief analytic review of the extreme spike in constraint payments to Scottish wind farms during the first two months of 2020. As part of the balancing mechanism, Constraint payments happen when wind power in Scotland exceeds local demand but cannot be exported to England due to insufficient grid capacity. In the analysis conducted in 2020, it was found that in excess of £69 million was found to have been passed onto consumers at an average rate of more than £1 million a day. This is found to be four times greater than the previous most expensive January-February period in 2016. The vast majority (96%) of the January/February 2020 constraint payments went to sixty-two Scottish wind farms, twenty of which received more than £1 million in the first two months of 2020.

Sweden

Vignette 17: Pelletized magnetite ore energy in Kiruna

Turning magnetite ore into pellets is a process whereby large amounts of excess energy are produced (Davies 2016). This excess energy, occurring in mining and refining operations, is frequently left unused and thus represents an underutilized heat energy source (ibid.). It is thinkable to use this industrial waste energy for large scale district heating of homes or similar. Recognizing this there are efforts underway to use the industrial waste heat of the Kiruna iron ore mine to provide heat for the town of new Kiruna with its 23.000 inhabitants (ibid.). Estimates show that the heat would be sufficient for heating up to 90% of the town's buildings (ibid.). This project is still in its initial stages, and it remains to be seen if these ambitious aims will become a reality. Nonetheless this example shows that there are large potentials for making greater use of industrial waste energy in remote regions.

Vignette 18: Steel manufacturing excess heat radiation

During the making of steel a large amount of heat is generated. This heat can be recovered using so called Thermophotovoltaic technology (TPV) absorbing the radiation and turning it into energy (Johansson and Söderström, 2011). With Sweden`s SSAB (Strip Products and Sandvik AB) being one of the world's largest steel producers operating in remote arctic areas in northern Sweden, reclaiming energy from steel production represents an underutilized resource which could be further exploited (ibid.). Waste heat recovery could, for instance be feasible in Luleå where there exists a coking plant, a blast furnace and steelworks (ibid.). Already today some excess gases of the Luleå plant are used for production of electricity and district heating at the local power plant operated by LuleKraft AB. Beyond burning execess gas from the plant, it could be possible to use TPV to produce electricity amounting to 90-130 GWh in Luleå alone (ibid.).

Faroe Islands

Vignette 19: Wind power

The Faroe Islands have established a vision to use 100% renewable power by the year twenty-thirty (Tróndheim et al. 2021). As of 2019 the share of sustainable energy use stands at 41% (ibid.). Using modelling systems and optimization techniques a group of researchers at the University of the Faroe Islands has proposed a strategy for achieving these ambitious energy goals (ibid.). According to one of the scholars, namely professor Niclasen, who with his colleagues has done some extensive modelling of energy sources in the Faroe Islands "wind is the cheapest and most underutilized source at the moment". The idea is to produce wind energy and create a pumped hydro-storage solution allowing for the energy to be kept for 8-9 days (ibid.). The roadmap created suggests extending the use of other energy sources like solar power and tidal stream power, too. The opportunity for new hydro power projects is limited and there appears no opportunity for building new plants.

Discussion/Conclusion

This study does not claim to be exhaustive, however, the vignettes identified above indicate that underutilized sustainable energy resources exist in all the NPA regions. The resources range from industrial waste energy to improvements in transmission grids to the installation of hydro and tidal power plants. This report showcases that much can still be done to harvest reliable, sustainable energy in the NPA region.

Country	Vignette	Type of resource	Underutilized power
Iceland	01	Industrial waste energy	20MW
	02	Medium enthalpy geothermal	70MW
	03	Rural electricity transmission	na

	04	Tidal wave power	80MW
	05	Small scale hydropower plants	1600MW
Ireland	06	Group Water Scheme -solar power	na
	07	Better energy communities	na
Finland	08	Biogas	16TW
	09	Wood pallets	23000-28000MW
	10	Flue gas heat recovery	3.4TW
	11	Solar PV in apartment buildings	1094MW
Northern Ireland	12	Electrification of heating off the gas grid	na
	13	Utilize wind curtailment	na
	14	Utilize generation and storage householders	na
	15	Biofuel for oil boilers	na
Scotland	16	Scottish transmission grid	na
Sweden	17	Pelletized magnetite ore energy in Kiruna	na
	18	Steel manufacturing excess heat radiation	90-130 GWh
Faroe Islands	19	Wind power	na

Table 1. Underutilized power as identified in the NPA vignettes

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References

Energiauutiset (2020). https://www.energiauutiset.fi/uutiset/pelastaako-biokaasu.html current 27.02.2020

Energianeuvonta (2020). https://energianeuvonta.fi/wp-content/uploads/2020/05/Aurinkosa%CC%88hko%CC%88n-lainsa%CC%88a%CC%88da%CC%88nto%CC%88-taloyhtio%CC%88issa%CC%88_04052020.pdf

https://aaltodoc.aalto.fi/bitstream/handle/123456789/43236/isbn9789526089881.pdf?sequence=1&isAllowed=y current 27.02.2020

Davies, N (2016). Kiruna Sweden: A town on the move – literally, *Engineering and Technology* (2) 6

Eliasson, A. J. (2005). Natural hazards and the Icelandic power transmission grid. 7. konferenca slovenskih elektroenergetikov.

Gunnarsson, G. (2020, 20.05) Getur Austurland komist af an jardefnaeldsneytis? Austurglugginn pp 6-

Irish Tech News (2020, 06.03) Veolia help group water scheme launch solar energy project. https://www.irishtechnews.is current 28.07.2021

Johansson M. T. and Söderström M. (2011), Options for the Swedish steel industry – Energy efficiency measures and fuel conversion, *Energy*, (36) 1, pp.191-198,

Jónsson, B. M. (2010). Harnessing tidal energy in the Westfjords (Master dissertation, University center of the Westfjords).

Sveinbjörnsson B. M. (2016) *Medium Enthalpy Geothermal Systems in Iceland Thermal and Electric Potential* Report prepared for Orkustofnun/ National Energy Authority of Iceland, NEA

Guðmundsson Á., Sigurjónsson H. and S. Ó. Pálmarsson (2020) *Austurland. Kortlagning smávirkjanakosta* Report prepared for Orkustofnun/ National Energy Authority of Iceland, NEA

TEM (2020)
https://tem.fi/documents/1410877/2897650/EEDselvitys+l%C3%A4mmityksest%C3%A4_loppuraportti+2020.pdf/88a0e63b-e2b6-eef9-1b4c-8c5411a0e531/EEDselvitys+l%C3%A4mmityksest%C3%A4_loppuraportti+2020.pdf?t=1601627038073 27.02.2020

SEAI (2021) *Better Energy Communities 2021* accessed online at https://www.seai.ie/grants/community-grants/project-criteria-and-funding/ current 28.07.2021

Tróndheim, H. M., Niclasen, B. A., Nielsen, T., Da Silva, F. F., & Bak, C. L. (2021). 100% Sustainable Electricity in the Faroe Islands: Expansion Planning Through Economic Optimization. IEEE Open Access Journal of Power and Energy, 8, 23-34.

Johansson M. T. and Söderström M. (2011), Options for the Swedish steel industry – Energy efficiency measures and fuel conversion, Energy, (36) 1, pp.191-198,