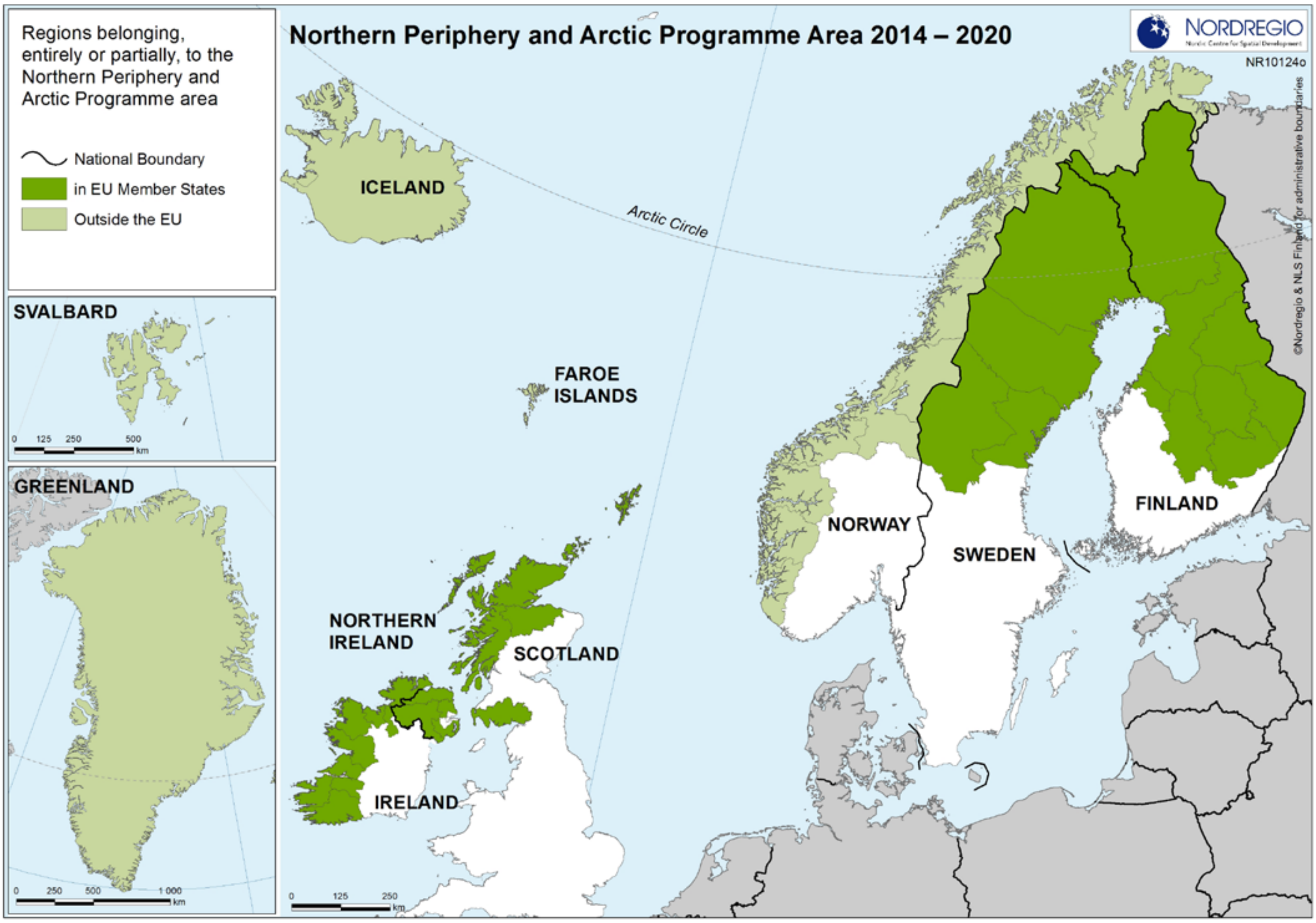
COMMUNITY GUIDE TO HOUSEHOLD COMBINED HEAT AND POWER

(H-CHP)

Northern Periphery and Arctic Programme
2014–2020

EUROPEAN UNION
Investing in your future
European Regional Development Fund

www.h-chp.eu



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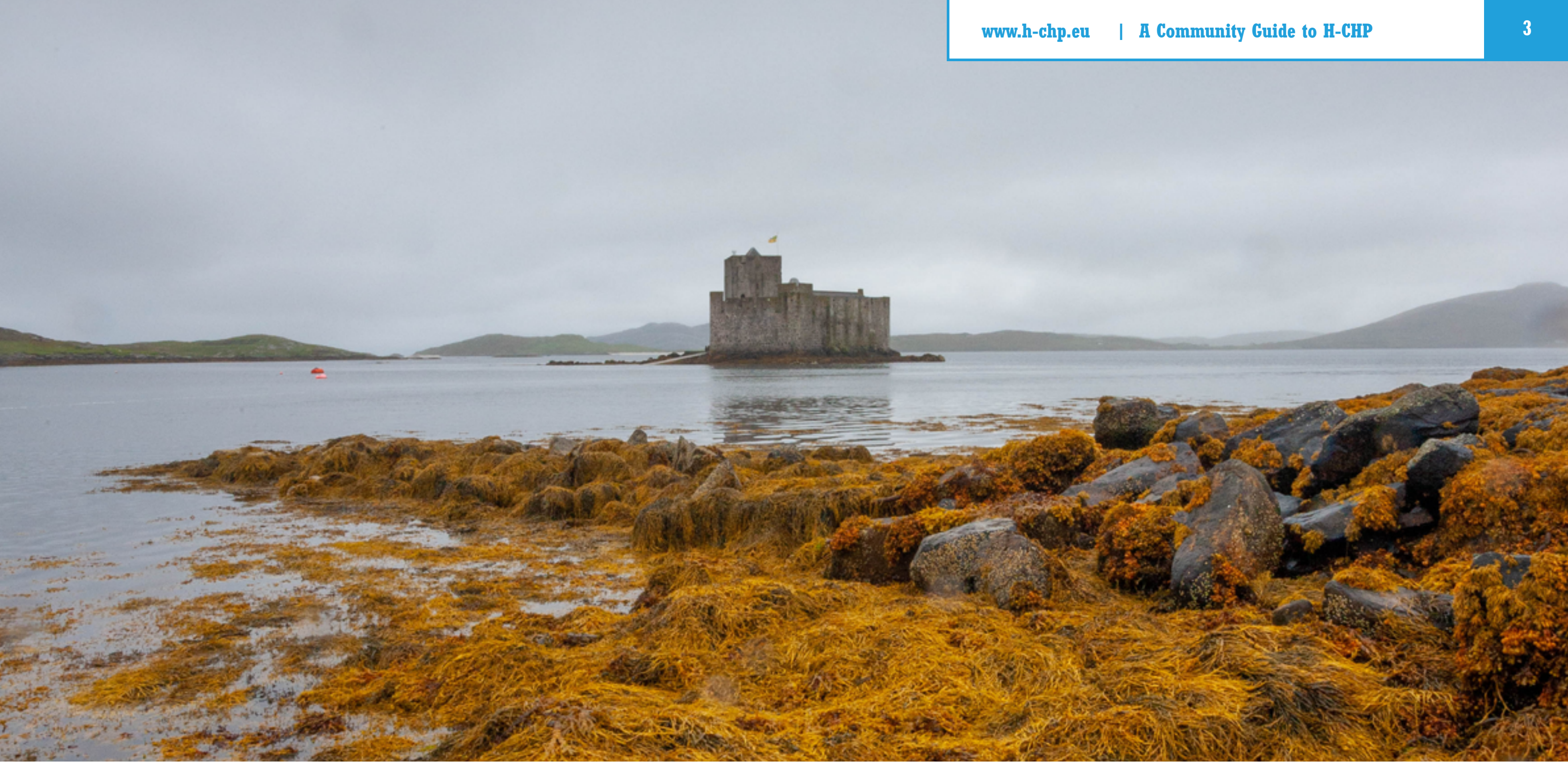

1. Introduction to the H-CHP Project

The H-CHP project aims to potentially increase energy efficiency and accelerate the adoption of renewable and sustainable energy solutions in any region. There is a specific focus on individual rural households with low population density and low accessibility to affordable energy. Domestic dwelling in sparsely populated areas is subject to unpredictable power interruptions. The proposed solution aims to:

- guarantee electricity during peak heat demand periods;
- place less strain on grids;
- reduce demand spikes;
- smooth the generation profile from power stations.

The purpose of the project is to promote the uptake of Combined Heating and Power systems (CHP) in the region using solid renewable biomass and gasification methods that will be appropriate for remote households.

The Northern Periphery Area has abundant natural fuel resources but is subject to a harsher climate than the rest of Europe and this results in the need for increased domestic energy. Attempts to exploit natural energy resources for households have been mixed, and as a consequence, there is significant fuel poverty in the region.

A key component is the high cost of electricity. It has been estimated that, compared to the fuel energy content, a high portion of generated electrical energy can be lost in production and transmission lines before reaching the end user – primarily as heat loss.

The principle of CHP is to use some of the heat in the home to generate electricity; this is intrinsically highly efficient. The project will analyse the energy needs of remote households in the region. The available fuel is mainly solid which is unsuitable for existing gas CHP.

We proposed a new affordable solution that uses local renewable solid biofuel in a small-scale micro CHP system. The advantage of this approach is that all fuel used is carbon neutral, transport costs are minimal, and there are reduced CO_2 emissions. This helps with carbon legislation compliance, reduced transmission losses from the grid, and the electricity-to-heat production ratio is a good match for the colder parts of Europe.

This type of system will demonstrate the energy efficient use of locally sourced, renewable bioenergy in family homes, especially in remote and sparsely populated regions.

Up to now high capital costs have been a barrier to widespread adoption of household CHP and this project has examined the factors that can make such systems affordable.

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2. The purpose of the Community Guide

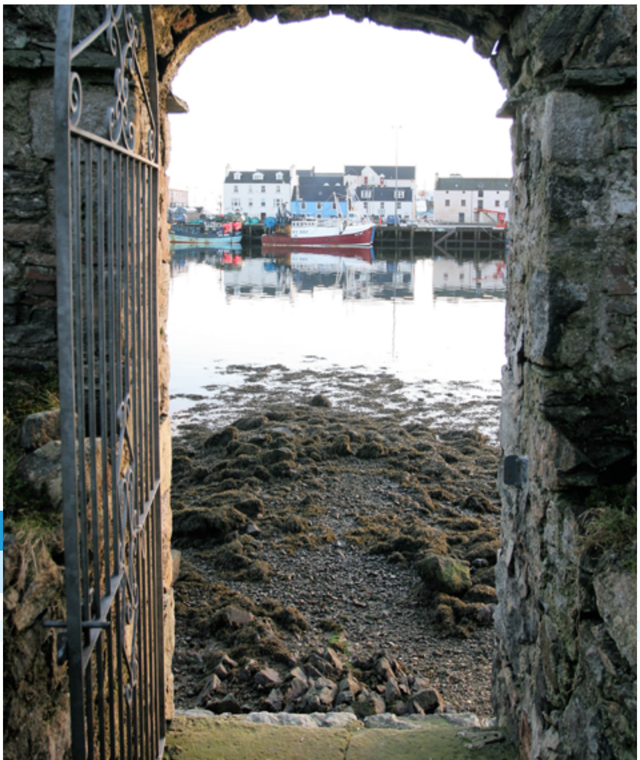
The purpose of this guide is to give an overview of our project and examples of small-scale combined heat and power for those who are interested in developing their own capacity and interest in CHP at an individual or community level.

Energy poverty – or fuel poverty – whereby citizens have difficulty in paying for heating and powering their home is a growing concern in the EU. Combined heat and power is one way of reducing energy costs, as heat produces power thus lowering costs. There are also environmental reasons for considering CHP, as emissions are lowered through co-production of heat and power. For community groups who are considering a local heat and energy efficiency strategy for their communities, CHP may prove a valuable concept for reducing emissions and reducing energy poverty at the same time. A further benefit is for those communities which are off gas grid, or indeed those with a home or community facility in this situation. This is particularly so for those who currently use oil to heat their homes and have weak grid infrastructure locally. CHP, and in particular household level or H-CHP (otherwise known as micro-CHP) will be beneficial.

We set out the basic principles of CHP and H-CHP below. We also give some examples of H-CHP and small-scale CHP which can be used in a community context. Our brief was to explore those which are powered from renewable sources, i.e. wood or organic waste. We briefly touch upon other types, fuel cell for example, however the main emphasis of this report is to explore technologies which can be fuelled from renewable sources. For the purposes of our project, we include fuel from organic waste. This is principally because in the Northern Periphery and Arctic Area of the EU, Finland and Sweden have vast forestry areas and easy sourcing of wood logs and pellets. However, in the Islands of Scotland and Iceland, for example, there are few sources whilst the ability to source organic waste is relatively simple.

Therefore, our community guide also demonstrates briefly gasification from organic waste, a work package stream of our partner the University of Iceland, led by Professor Rúnar Unnþórsson. Further details of this equipment, and all the others explored and developed within this project can be found in our Toolkit, a copy of which and all other information about our project can be found at

www.h-chp.eu



3. What is household or micro CHP?

Let us start with a basic question, what is a Micro-CHP unit?

In general, CHP (which stands for Combined Heat and Power) is a technology which allows the production of heat and electricity at the same time, using a process called cogeneration.

Why is this better than what communities use now?

It is because cogeneration is a more efficient use of fuel where otherwise-wasted heat from electricity generation is put to some productive use. In fact, a CHP unit (whatever size) uses some of the heat it produces to make electricity, thus not wasting it and optimizing the whole process.

CHP PLANTS HAVE AN EFFICIENCY OF AROUND **80/90%** COMPARED TO AN AVERAGE OF 30/40% OF CLASSIC METHODS

Another fact is that CHP plants have an efficiency around the values of 80/90% which, compared to an average 30/40% of classic methods of electricity production, makes clear the convenience of this technology.

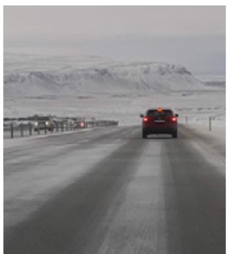
It comes naturally, then, that CHP installations are typically located where there is both the need of heat and electricity.

While classical CHP units can be very big and bulky (especially for industrial applications), Micro-CHP units, as the name would suggest, are instead in similar in shape and size to a standard domestic boiler and can also be wall hung or put standing on the floor.

The main difference to a standard boiler, as the previous paragraphs explain is that they can produce electricity while they are heating water.

Micro-CHP units help in making the most of any fuel used. This is because, as stated, they also operate with the normally wasted heat, thus reducing the need to burn additional fuel. In this way, harmful emissions due to the energy generation process are also overall reduced.

Regarding fuel, Micro-CHP units can use natural gas, LPG or similar, oil, or also alternative means such as biomass (wooden pellets, wood chips, etc.) or biogas. In the case of the last two fuels, Micro-CHP systems can essentially be considered carbon-neutral, further helping the environment.



4. Types of H-CHP and micro systems

Micro-CHP installations can come in different main formats.

1. The first one includes an internal combustion engine with a heat recovery unit, with simple water as the fluid that will help in transferring the heat. The water itself can be heated up to create steam or just normal hot water, and then transported to the desired location, while electricity is provided by a generator connected to the engine.

2. The second format includes instead a steam boiler unit with an associated steam turbine. The boiler heats the fluid, which is again simple water, that after being evaporated into steam it will go through the turbine allows the generation of electricity and the steam or hot water are ready to be moved where necessary. This type of CHP is being explored by the H-CHP project and a prototype wood fired version has been developed.

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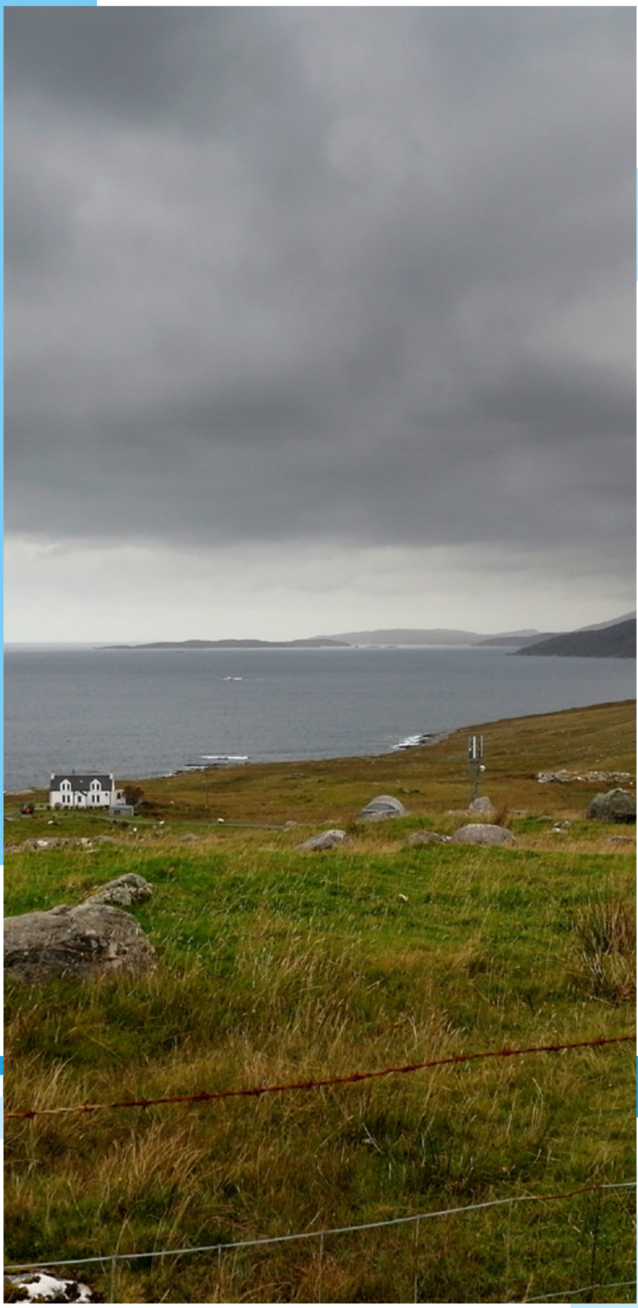
3. A third format utilizes fuel cells. They work by taking energy from the fuel used by chemical means instead of burning it (so there is no combustion involved) and they then use this energy to generate heat and electricity. This last technology is not still widely available, however. A good source of information on fuel cell CHP is the EU project ene.field. ene.field deployed more than 1,000 residential fuel cell Combined Heat and Power (micro-CHP) installations, across 10 key European countries. It represented a step change in the volume of fuel cell micro-CHP (micro FC-CHP) deployment in Europe and a meaningful step towards commercialisation of the technology.

5. How does H-CHP work?

In section 3 it was described what a Micro-CHP installation is and how it works. To give a more practical and approachable example, a Micro-CHP unit works similarly to a car engine. That is, it powers the car but at the same time it uses the waste heat produced to warm the interior of the car itself.



But, what is needed for it to reach its peak performance?

Firstly, a Micro-CHP unit has to be installed where there is the need of high and/or continuous thermal load, since, as we already stated, the energy production ratio is always in favour of thermal energy.

The location has also to need long operating hours. The longer, the better, but definitely more than 3000 to 4000 hours every year. This is because, the more a Micro-CHP unit is turned on, the more benefits it can produce for the community.

Access to fuels is also needed, and if the Micro-CHP unit is situated in a location with low to no access to them, then a supply chain will need to be established, and the associated costs considered. Among the various possible fuels, biomass is generally preferred because of the maximization of the environmental benefits.

6. Examples of H-CHP and small-scale CHP fired from renewable fuels explored by our project

Biogen Woodlog Gasifier

www.microgen-engine.com

For remote places using available local wood. Household size. Creates up to 1 kW of electricity and hot water to provide heating and running hot water. In the top firebox (furnace) wood logs are converted into wood gas.

The hot gas is guided into the bottom combustion chamber where it is burnt off and heats up the "hot end" of the Stirling generator. The rest of the flue gas warms up the water on the boiler.

The Microgen Woodlog BioGen Power and Heat unit is based on the successful combination of two principles: wood gasification and Microgen-free piston power generation.

We are trialling this equipment in the Outer Hebrides, Scotland as part of the H-CHP project.

All Power Labs GEK

www.allpowerlabs.com/products/gasifier-kits

The GEK Gasifier kit is a complete gas-making system: from biomass fuel feed input through syngas/air mixer output to engine.

Professor Rúnar Unnþórsson from the University of Iceland demonstrates the equipment to colleagues.

The gasifier turns 1.2 kg biomass into 3 metres cubed of gas which then produces the equivalent of 1 kWh of electricity.

Volter 40 Indoor

volter.fi

Woodchips or pellets generating electrical power of 40 kW. Enough for a small community hall, farm or school where the equipment has been working successfully.

This is being used in Scotland, Northern Ireland, Finland, Sweden and other EU states. We have worked with Volter to consider how community-based organisations might benefit from this size / type of equipment. The company is based within the Northern Periphery and Arctic area of the EU and is available to help and advise community organisations on any development ideas they may have.

7. Community engagement for H-CHP and energy efficiency projects

Energy production, use and affordability are fundamentally community issues. Can a community generate their own energy for local use? For example, in Scotland many community owned areas have become pioneers in community energy ownership through the installation of wind turbines. Even municipality owned energy from waste plants, although removed from local community ownership have an aspect of engagement through elected representatives. With CHP this may happen through community management such as housing cooperatives or tenant representative bodies. Communities often own facilities such as community halls or places of worship. Each requires energy use, and all could benefit from combined heat and power. For those community organisations who support households, perhaps in areas of low income or who manage housing could also benefit from household combined heat and power, or H-CHP.

Municipalities have responsibilities for drawing up local heat and energy efficiency strategies. H-CHP can play a role in this, particularly if areas rely on imported oil to provide a source of fuel for heating. Why not consider H-CHP as a tool to reduce emissions from fossil fuels?

We have found that the key questions to community engagement for H-CHP or small community sized CHP are:

1. Is there a weak electricity grid in our area?
2. Do we wish to reduce fossil fuel use in our area?
3. Is there a supply chain for alternative fuels such as logs or wood pellets?
4. Do we wish to reduce energy costs for residents in our area?
5. Does the use of CHP and H-CHP in our area benefit local people?
6. Is there a way of subsidising the cost of equipment & installation for local people?

If the answer is yes to 1 or more of these then H-CHP could be of benefit and it is worth exploring further.

8. Mechanisms to engage the community on H-CHP

We have found that the key methods of engaging the community around H-CHP and energy efficiency in general are:

Publicity

Engage with local media such as community newsletters, local papers, local radio stations to get your message out.

Social Media

If you have a community event or issue you wish to raise locally, use social media such as Facebook, Twitter or Instagram to get the message out. LinkedIn is often used by professionals and you may wish to engage this way also. Whichever platform you use, make sure your message is punchy, or funny but at least accurate so that people can engage.

Use Pictures

Make sure people can see the equipment and fuel source so they understand immediately what you want to do (or at least the concept!).

Leaflet Drops

If you know people are going to a market for example, hand out flyers there for your project. Or you can drop them to households locally.

Public Meetings

These can be a good way of engaging the community, but make sure you offer refreshments, a good venue, interesting speakers and a reason why people should attend. Also make sure you publicise it via the above methods!

Invite the Right People

If you need local politicians to decide on your project, invite them to such events, or invite yourself to visit them to explain why they should back it. Contact them and ask them to attend, or you wish a meeting with them personally.

9. Economic benefits to the Northern Periphery and Arctic Area of the EU

There are several economic benefits to the NPA of the EU. The level of benefits depends on existing infrastructure, geography and supply chains. Let us explore the potential of each individually.

Infrastructure

Where manufacturing capabilities exist in regions then it is possible to imagine production of H-CHP along say the Airbus model. For example, parts can be machined in regions and assembled as H-CHP systems in another. Metals can come from the regions too, such as iron ore and iron ore steel production in Sweden and Finland.

Geography

Trees. In Iceland and other areas of the NPA there are few trees. This presents a problem for sourcing fuel but a potential economic benefit in so far as a new industry in forestry and use of wood thereafter. One of the project associate partners is The Woodland Trust (Scotland), and they have been exploring the potential for planting of forestry in the region of the islands of Scotland. They have been supported financially by Point and Sandwick Trust, who have used some income from their local wind farm generated profits to pay for planting of trees by crofters in the Outer Hebrides. Viring of funds created by generation of energy to literally grow another source is particularly novel in a community context.

Find out more www.pointandsandwick.co.uk/news/croft-woodland-project

Supply Chains

H-CHP provides a wonderful opportunity for economic development through encouraging the set up of new supply chains. Production of equipment requires at least 20 layers of supply chains from metal production, specialist design and manufacturing, through components, movement of goods, assembly of parts, overall assembly of equipment, marketing and sales, deliveries, and all stages of installation (for which we cover in our Toolkit). Ancillary workforces are required to maintain and provide customer service.

Overall there is no reason to doubt that household combined heat and power can produce great economic benefits to the Northern Periphery and Arctic Area of the EU.

The Airbus model is a good one to consider, given its mass use throughout the EU and the world, and that it has been through cooperation between member state companies and supply chains that make it work. However, it is true to say that unless H-CHP is mass produced, costs remain high and using the airplane and European cooperation we may be looking at the Concorde model early on!

10. Positives and downsides of micro scale combined heat and power

The benefits of Micro-CHP are multiple. The first apparent one involves the lowering of the energy yearly costs for the customer, paired with a more affordable way to heat households.

This is possible because Micro-CHP units require less fuel compared to the normal way of producing (with, for example, oil, gas, etc.) the same amount of heating and electricity.

It also gives the passive option of making the community grid more reliable, by creating a larger number of smaller energy generation centres, which will be able to supply power when it is needed.

Also, even if it can seem against logic, by doing this there will be a decrease in air pollution, for both dangerous carbon dioxide and sulphur dioxide emissions, because of the Micro-CHP optimized energy production process.

All of this, in the long term, will be able to support a more efficient energy infrastructure, limiting any kind of distribution issues along the community grid.

To cover the Micro-CHP disadvantages, instead, we will briefly refer to the operating factors of this technology described in section 3, clarifying them.

A Micro-CHP unit has to be precisely sized (that is, its energy production has to be very similar to what is needed in the community) because the heat output is fixed and cannot be changed once the unit is installed, while electrical output can only be moderately adjusted.

To achieve this, a good energy demand analysis is recommended to be completed by the community before deciding which unit will be installed.

Furthermore, Micro-CHP installations are known for being initially financially intensive.

This is caused by the high capital costs, which include the unit itself and its installation in the chosen location. Also, because, even if the technology is already on the market, the benefits of mass production (that would lower the overall price) have not been fully reached yet, due to the low numbers of in-use Micro-CHP units.

Another important point to consider is the fuel supply chain. When and where the Micro-CHP fuel is not immediately available from nearby locations, it can add an additional cost which could offset the whole planned economic scenario.

To conclude, this technology is not suitable for every site. A Micro-CHP unit requires space to be installed properly and there is the requirement of creating (if not already present) a distribution and storage network that will be able to move the fuel as needed.

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