# Deliverable 2.3.1: Technical report on energy Monitoring and Management tool for social housing

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# Executive Summary

Deliverable 2.3.1 requires a technical report on energy monitoring and management tool for social housing. Cork County Council are responsible for the publication of the report with support from the Icelandic Environment and Energy Agency and the Faroese Environment Agency.

Cork County Council will upgrade an existing energy monitoring tool that is used in their municipal buildings for piloting and use in theirs, Iceland's and Faroe Island's social and rural housing and buildings. The aim of this energy monitoring is to show the benefit of retrofitting housing and buildings to increase energy efficiency, reduce costs and remove greenhouse gas emissions.

The Cork County Council's energy monitoring system evolved from another EU project called E-Lighthouse (http://www.elighthouse.eu/). This project was under the Northern Periphery and Artic (NPA) Programme 2014-2020. The tool was developed by Nimbus Research Centre, Munster Technological University, on behalf of the Cork County Council.

The energy monitoring system in Cork County Council will need to be adjusted to monitor energy in real-time. Examples of new features in the system are weather data and augmented reality. The upgrade, installation and running costs of the new system can be funded through, EU Innovation Fund 2020-2030 (€40 billion), Cork County Council Annual Budget (Environment, Climate and Communications grant and subsidy from Central Government (€2,118,522(annual allocation (varied amount)).

The Icelandic Environment and Energy Agency have experience in installing heat pumps in buildings and monitoring their energy usage to show their benefits. Benefits include significant energy efficiencies leading to reduction in energy usage and costs.

The Faroese Environment Agency have also carried out similar exercises (moving from fossil fuel oil burners to heat pumps) and shared similar results.

The Cork County Council, the Icelandic Environment and Energy Agency and the Faroese Environment Agency conducted detailed discussions on their monitoring software which led to proposed upgrades of the system in Cork (regression analysis).

# 1 Introduction

Deliverable 2.3.1 of the Hybes Joint Action Plan requires a technical report on energy monitoring and management tool for social housing. This report is due in period 6 (01st August 2025 to 31st January 2026) of the Hybes project programme. Cork County Council are the partner responsible for the preparation of this report and the Icelandic Environment and Energy Agency and the Faroese Environment Agency are the supporting partners.

An innovative energy monitoring tool needs to be developed for use in social housing and rural housing and buildings in Cork, Iceland and the Faroe Islands. The energy monitoring tool stems from another municipal building energy monitoring tool that was developed in the E-lighthouse EU project (http://www.elighthouse.eu/). The E-lighthouse project was co-financed by the European Regional Development Fund (ERDF) and the Northern Periphery and Artic (NPA) Programme 2014-2020.

The energy monitoring tool will be piloted for use in social and rural housing and buildings in the three regions of Cork, Iceland and the Faroe Islands and aims to showcase the need for and benefit of retrofitting housing and buildings for energy efficiency, reduced costs and removing greenhouse gas (GHG) emissions, in the regions.

# 2 Why Required

## 2.1 Context of the Problem

In the Cork County Council Climate Action Plan, Cork County Council have committed to reduce its direct carbon emissions by 51% to 2030. This is to be achieved primarily through a reduction in GHG emissions from the Council's electricity usage, thermal heating and transport use. To achieve this target the Council needs to monitor their energy costs from plant, buildings, transport fleet, etc. to inform required changes in operations and practices. Smart meters monitor energy costs in the Council's main operational buildings, but these metres have not been installed in all the Council's housing and other buildings.

The Cork County Council's energy monitoring system derived from the E-lighthouse project. It is an energy consumption charting tool that was developed by the Nimbus Research Centre, Munster Technological University, on behalf of the Cork County Council. The system provides analysis on energy consumption by monitoring the energy and building types and specific buildings, when required. The software analyses monthly and yearly energy consumption.

Cork County Council proposes to expand the functionality of the existing energy monitoring system to support real-time monitoring of all its buildings (particularly its social housing). The new system would issue alerts and invite feedback to and from the end users of the system.

## 2.2 Cork Challenge

There is a need to improve the energy efficiency and costs of many of the Cork County Council's housing and buildings. The Council are willing to instal smart meters in all their buildings if there is an efficient way to monitor energy consumption. There is no existing system in many of the Council buildings that monitors their daily energy use other than monthly energy bills from the providers.

The Cork County Council energy monitoring system is a tested software and is live in some of the Council's buildings. A few adjustments to the system by the hosts, Nimbus Research Centre, will open it up to monitoring energy in real-time.

The system can be adjusted to include:

- Making maintenance requests
- Reporting user comfort issues
- Reporting and recording outages

The system hosts can also add data analysis features, such as weather data and augmented reality.

This project aims to see the modernised system introduced to all the social housing and buildings in the Council's administrative area. The system is also receiving strong interest from other public bodies in Iceland and the Faroe Islands.

## 2.3 Indicative Description of the Solution

The existing energy monitoring system will have to be expanded to facilitate the proposed comprehensive and real-time energy monitoring. The system enables Cork County Council and others to instal a smart meter to the existing metering network with ease. The system supports the end user behaviour and factors this into its prediction capabilities.

The energy monitoring system was developed by the Nimbus Research Centre, which is part of the engineering department in the Munster Technical University. The centre specialises in cyber-physical systems (CPS) and Internet of Things (IoT) research, innovation and learning. Nimbus Research Centre are focused on developing ICT-enabled energy management solutions such as:

- Integration of energy systems and the use of advanced building management systems (BMS) for smarter more intelligent buildings and districts.

The upgrade of the energy monitoring system will include the following adjustments:

(i) The gathering of data from deployed smart metres in real-time or adjustable sampling rates.
(ii) Communicating with smart meters in the event of an outage.
(iii) Option for the end user to provide feedback.
(iv) Analysing data and incorporating weather forecasting to predict optimal user comfort temperature.
(v) Storing, authenticating, cleansing and aggregating gathered data.
(vi) Supporting more detailed energy consumption visualisation.
(vii) Increasing awareness of energy costs, carbon footprint and reducing energy usage.

The upgraded energy monitoring system will have adjustment, installation and running costs that can be funded through the following means.

*EU Innovation Fund 2020-2030*

The EU Innovation Fund is worth €40 billion and focuses on the achievement of a net-zero continent through innovative technologies. The Innovation Fund provides funding in a flexible and simple process. It is distributed to successful applicants through calls for proposals and competitive bidding. The fund supports up to 60% grants in regular proposals and 100% in competitive bids. The Innovation Fund can be combined with


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other public subsidies. The innovation fund is interested in highly innovative technologies that can make significant emissions reductions.

*Cork County Council Funding*

In the Cork County Council Budget 2025, €2,118,522 income has been secured from Central Government as a grant and subsidy for Environment, Climate and Communications. A case will be made to use some of this funding for upgrading the energy monitoring system and the associated adjustment, installation and running costs. This will be reviewed / pursued after every annual council budget is announced.

*Anticipated Results of the Project*

There are several factors that will be used to measure the benefit of the new system. These include:

(i) The number of smart meters in the existing system and how many need to be added.
(ii) How much energy will be saved on an hourly, daily, weekly, monthly and annual basis.
(iii) The number of buildings reporting to the existing system and how many will be added.
(iv) The number of domestic heating issues that are reported and resolved when the end user results are registered.
(v) The number of building issues that are resolved when using the predictive maintenance features of the system.
(vi) Compiling and assessing end user satisfaction.
(vii) Recording end user participation in the education features of the system.

*Measuring the Projects Outputs and Outcomes*

The outputs and outcomes of the project will be measured in the following manners:

(i) Smart meter reports and dataset volume records on an hourly, daily, weekly, monthly and annual basis.
(ii) End user interactions with the system.
(iii) Alerts raised by the system.
(iv) Asset energy savings on an hourly, daily, weekly, monthly and annual basis.
(v) Other metrics and key performance indicators are likely to evolve as the new system develops and / or if building energy requirements change.

*The projects transferability and development*

The existing system has been developed to be versatile and multi-faceted to deal with emerging energy needs in the Council's administrative area. It has been successfully trailed and is transferable to other public sector bodies for their own use.

The system is robust, and its adaptability is limitless. The main barrier to the successful installation and running of the software in other public bodies is their commitment to it. Any concerns raised can be dealt with by the host, Nimbus Research Centre, and reference to the system's only existing demonstrator, the Cork County Council.

# 3 Transnational Learning

## 3.1 Iceland Case Study – Housing/Building Monitoring Solution

The Icelandic Environment and Energy Agency are interested in applying the new energy monitoring system after it have been modified and trailed in the Cork County Council social housing and buildings. The aim would be to test the software in some rural residential properties initially with the aim of extending this throughout the subject district and country, in time.

The Icelandic Environment and Energy Agency have experience in energy efficiency improvements in buildings through installing energy efficient equipment and monitoring and recording the resulting efficiencies.

An example of energy efficient projects was between the Icelandic Environment and Energy Agency and the Norðurþing Municipal Council.

In October 2021 the Icelandic Environment and Energy Agency and the Norðurþing Municipal Council signed an agreement to assess and install heat pumps to electrically heat a few agricultural buildings, in Tjörnes, and the Norðurþing Municipal Council community centre, in Raufarhöfn. The project included assessing each farm building (13 in total) and deciding, through site visits and thorough assessments, what heat pump is most suitable for each building (i.e. water-to water, air-to-water or air-to air).

The heat pump suitability assessment involved analysing recorded electricity consumption information for each building over a five-year period. The size of the building and its condition and weather data from the Icelandic Meteorological Office were also determining factors.

When the most suitable heat pump for each building was selected, the equipment and contractors were procured and tendered. The successful equipment and contractor (Nibe) were project managed, by the Icelandic Environment and Energy Agency, from installation, inspection and commissioning of each system. The heat pumps were geothermal Nibe S1255-12 kW, Nibe S1255-6 kW and exhaust air Nibe F750.

When the heat pumps were installed and functioning, the Icelandic Environment and Energy Agency monitored their performance remotely via an internet programme for a period of twelve months. Operational data based on various aspects of the unit's performance was collected.

The type of information stored was their electricity consumption, their heat production for space heating and domestic hot water heating. There was a significant variation in results between farm building heat pumps.

Heat production for space heating was 458 Watt-hour per square meter ($Wh/m^2$) per day or 167 kilowatt-hours per square meter ($kWh/m^2$) per year (see figure 1).

Figure 1 – Heat pump heat production for space heating results

| Appendix 1 | | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **Average outside temperature** | 8,5 | 11,9 | 12,5 | 8,1 | 3,3 | 0,8 | -0,4 | -0,1 | -2,2 | 1,2 | 2,9 | 4,6 | 7,7 | 8,9 | |
| **Heat production(kWh/d):** | **Jún** | **Júl** | **Ágú** | **Sep** | **Okt** | **Nóv** | **Des** | **jan** | **feb** | **mars** | **apríl** | **maí** | **júní** | **júl** | **Average (kWh/dag)** |
| Bær 1 | | | 17,3 | 19,8 | 33,2 | 39,5 | 40,1 | 41,0 | 37,6 | 33,4 | 25,3 | 25,5 | 16,5 | 14,7 | 28,7 |
| Bær 2 | | | 31,3 | 32,3 | 41,4 | 82,0 | 76,8 | 81,9 | 80,7 | 64,3 | 48,2 | 40,2 | 31,7 | 29,7 | 53,4 |
| Bær 3 | | | | 37,9 | 61,1 | 74,7 | 97,2 | 89,1 | 86,8 | 63,9 | 55,7 | 51,4 | 34,0 | 24,7 | 61,5 |
| Bær 4 | | | 21,7 | 53,5 | 77,7 | 100,1 | 106,0 | 111,2 | 117,4 | 89,7 | 64,3 | 50,7 | 36,1 | 38,9 | 72,3 |
| Bær 5 | | | | | 81,5 | 93,3 | 97,4 | 95,0 | 94,7 | 71,8 | 61,0 | 58,3 | 46,6 | 37,3 | 73,7 |
| Bær 6 | 37,1 | 15,9 | 25,2 | 64,5 | 92,7 | 117,1 | 120,9 | 131,6 | 133,4 | 103,6 | 83,6 | 64,6 | 54,5 | 48,5 | 78,1 |
| Bær 7 | | 14,4 | 26,1 | 67,7 | 130,5 | 136,9 | 144,7 | 150,4 | 162,9 | 133,5 | 104,6 | 91,4 | 88,6 | 93,8 | 103,5 |
| Bær 8 | 43,8 | 37,2 | 39,9 | 92,9 | 111,2 | 136,3 | 137,5 | 148,1 | 148,9 | 121,7 | 92,9 | 78,1 | 59,8 | 61,2 | 93,5 |
| Bær 9 | | | 32,7 | 83,5 | 120,6 | 142,0 | 151,7 | 155,9 | 159,2 | 126,8 | 93,8 | 88,0 | 65,2 | 72,9 | 107,7 |
| **Heat production - Wh/m2/dag** | | | | | | | | | | | | | | | |
| | **jún** | **júl** | **ágú** | **sep** | **okt** | **nóv** | **des** | **jan** | **feb** | **mar** | **apr** | **maí** | **júní** | **júlí** | |
| Bær 1 | | | 146 | 168 | 281 | 335 | 340 | 347 | 319 | 283 | 214 | 217 | 140 | 125 | |
| Bær 2 | | | 217 | 224 | 287 | 569 | 534 | 569 | 560 | 447 | 334 | 279 | 220 | 206 | |
| Bær 3 | | | | 198 | 320 | 391 | 509 | 466 | 455 | 335 | 291 | 269 | 178 | 129 | |
| Bær 4 | | | 134 | 330 | 480 | 618 | 654 | 686 | 724 | 554 | 397 | 313 | 223 | 240 | |
| Bær 5 | | | | | 642 | 735 | 767 | 748 | 746 | 565 | 481 | 459 | 367 | 294 | |
| Bær 6 | 193 | 83 | 131 | 336 | 483 | 610 | 630 | 686 | 695 | 540 | 435 | 337 | 284 | 253 | |
| Bær 7 | | 96 | 174 | 451 | 870 | 913 | 965 | 1002 | 1086 | 890 | 697 | 609 | 590 | 625 | |
| Bær 8 | 207 | 176 | 188 | 438 | 525 | 643 | 648 | 699 | 702 | 574 | 438 | 368 | 282 | 289 | |


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| | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Bær 9 | | | 168 | 428 | 619 | 728 | 778 | 799 | 816 | 650 | 481 | 451 | 334 | 374 |
| **Meðaltal:** | | **118** | **166** | **322** | **501** | **616** | **647** | **667** | **678** | **537** | **419** | **367** | **291** | **282** |
| **Heat demand per square meter, annual average:** | | | **458 Wh/m2/day** | | | | | | | | | | | |

Energy production for domestic hot water at 10 farms was 7.7 kWh per day. The lowest energy consumption was 2.8 kWh per day and the highest energy consumption was 11.4 kWh per day.

Figure 2 – Heat pump energy production for domestic hot water at 10 Farms

**Appendix 2**

| **Heated coldwater, kWst/dag** | **Jún** | **Júl** | **Ágú** | **Sep** | **Okt** | **Nóv** | **Des** | **Jan** | **feb** | **mars** | **apríl** | **maí** | **jún** | **júl** | **Average (kWst/d)** | **STD** |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Bær 1 | | | 2,5 | 2,2 | 2,2 | 2,5 | 3,4 | 2,9 | 3,3 | 3,9 | 3,2 | 3,2 | 2,4 | 1,6 | 2,8 | 0,6 |
| Bær 2 | | | 2,1 | 2,2 | 3,7 | 4,7 | 6,3 | 4,6 | 5,1 | 6,7 | 5,7 | 5,4 | 5,4 | 4,6 | 4,7 | 1,5 |
| Bær 3 | | | | | | | | | 3,9 | 3,5 | 3,6 | 3,7 | 3,5 | 3,4 | 3,6 | 0,2 |
| Bær 4 | | | 7,4 | 9,3 | 7,8 | 7,4 | 8,7 | 9,5 | 9,4 | 9,3 | 9,1 | 9,1 | 9,5 | 9,3 | 8,8 | 0,8 |
| Bær 5 | | | | | 10,4 | 10,4 | 10,6 | 10,6 | 11,8 | 9,4 | 7,8 | 7,8 | 15,7 | 1,7 | 9,6 | 3,6 |
| Bær 6 | 14,5 | 11,4 | 12,9 | 15,0 | 14,9 | 15,1 | 16,9 | 17,6 | 19,2 | | 3,4 | 2,6 | 2,6 | 2,1 | 11,4 | 6,4 |
| Bær 7 | | | 5,7 | 5,7 | 5,4 | 5,2 | 5,8 | 5,3 | 5,6 | 6,2 | 6,3 | 5,6 | 6,3 | 6,6 | 5,8 | 0,4 |
| Bær 8 | | 4,4 | 4,2 | 3,7 | 3,5 | 2,5 | 3,3 | 2,3 | 3,1 | 3,4 | 3,4 | 2,6 | 2,6 | 2,1 | 3,2 | 0,7 |
| Bær 9 | 10,4 | 11,6 | 10,5 | 10,1 | 10,8 | 10,2 | 11,5 | 10,3 | 9,2 | 9,1 | 9,1 | 9,1 | 9,5 | 9,3 | 10,1 | 0,9 |
| Bær 10 | | | 6,9 | 5,4 | 5,4 | 5,2 | 7,4 | 6,0 | -9,9 | 21,4 | 7,7 | 5,8 | 6,1 | 7,3 | 6,2 | 6,7 |
| **Average(kWh/dag):** | | | **7,9** | **8,2** | **8,3** | **8,0** | **9,2** | **8,8** | **6,9** | **9,8** | **6,7** | **6,1** | **7,5** | **5,5** | **7,7** | **1,3** |
| **STD (kWh/dag):** | | | **3,8** | **4,5** | **4,2** | **4,2** | **4,3** | **4,8** | **7,5** | **5,6** | **2,4** | **2,5** | **4,2** | **3,1** | **4,2** | **1,4** |

The Seasonal Coefficient of Performance (SCOP) indicates the heat pump's annual saving. The average SCOP of the installed heat pumps on 8 farms was 4.2. Therefore, the SCOP saving of moving from storage heating to heat pumps in the 8 farms averaged at 76%.

Figure 3 - COP calculations based on energy metering readings from the heat pump at 8 farms in Tjörnes

**Appendix 3**

**COP calculations based on energy metering readings from the heat pump at Tjörnes**

Ár: 2022

| | | jan | feb | mar | apr | maí | jún | júl |
|---|---|---|---|---|---|---|---|---|
| Average outside temerature every mont at | | -0,1 | -2,2 | 1,2 | 2,9 | 4,6 | 7,7 | 8,9 |
| | Used kWh: | 340 | 278 | 273 | 185 | 199 | 114 | 94 |
| Farm 1 | Produced, kWh: | 1358 | 1134 | 1149 | 855 | 891 | 562 | 498 |
| | COP: | 3,99 | 4,08 | 4,21 | 4,62 | 4,48 | 4,93 | 5,30 |
| | Used kWh: | 893 | 499 | 553 | 418 | 297 | 220 | 199 |
| Farm 2 | Produced, kWh: | 2670 | 2150 | 2193 | 1627 | 1411 | 1105 | 1034 |
| | COP: | 2,99 | 4,31 | 3,97 | 3,89 | 4,75 | 5,02 | 5,20 |
| | Used kWh: | 1094 | 957 | 775 | 567 | 439 | 294 | 245 |
| Farm 3 | Produced, kWh: | 3283 | 3371 | 2979 | 2286 | 1841 | 1374 | 1236 |
| | COP: | 3,00 | 3,52 | 3,84 | 4,03 | 4,19 | 4,67 | 5,04 |
| | Used kWh: | 1195 | 782 | 722 | 490 | 394 | 277 | 306 |
| Farm 4 | Produced, kWh: | 3586 | 3170 | 2960 | 2107 | 1740 | 1272 | 1440 |
| | COP: | 3,00 | 4,05 | 4,10 | 4,30 | 4,42 | 4,59 | 4,71 |
| | Used kWh: | 1104 | 341 | 548 | 444 | 437 | 373 | 279 |
| Farm 5 | Produced, kWh: | 3311 | 1402 | 2500 | 2060 | 2051 | 1808 | 1434 |
| | COP: | 3,00 | 4,11 | 4,56 | 4,64 | 4,69 | 4,85 | 5,14 |
| | Used kWh: | | | 924 | 725 | 595 | 509 | 417 |
| Farm 6 | Produced, kWh: | | | 3796 | 3091 | 2586 | 2218 | 1911 |
| | COP: | | | 4,11 | 4,26 | 4,35 | 4,36 | 4,58 |
| | Used kWh: | 1574 | 982 | 1157 | 855 | 722 | 609 | 634 |
| Farm 7 | Produced, kWh: | 4722 | 4636 | 4189 | 3241 | 2912 | 2760 | 2727 |
| **Average outside temperature Mánárbakka (ºC):** | | | | | | | | |
| | COP: | 3,00 | 4,72 | 3,62 | 3,79 | 4,03 | 4,53 | 4,30 |
| | | | | | | | | |
| | Used kWh: | 1261 | 996 | 1013 | 740 | 675 | 468 | 489 |

| | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| Bær 8 | Produced, kWh: | 4879 | 3783 | 4928 | 3064 | 2818 | 2145 | 2271 |
| | COP: | 3,87 | 3,80 | 4,86 | 4,14 | 4,17 | 4,58 | 4,64 |
| | | | | | | | | |
| | **COP-average:** | **3,26** | **4,08** | **4,16** | **4,21** | **4,39** | **4,69** | **4,86** |

Users who purchase 30,000 kWh per year at a rate of 10 Icelandic Króna (0.07 euro (approximately)) (including VAT), save 230,000 Icelandic Króna (1,619.66 euro (approx.)).

The above examples would suggest that the Icelandic Environment and Energy Agency are equipped to introduce the energy monitoring system for buildings and social housing in operation in the Cork County Council administrative area.

The Icelandic Environment and Energy Agency and the Cork County Council also completed detailed comparisons of their energy monitoring software, and this has led to proposed upgrades of the software in Cork (regression analysis).

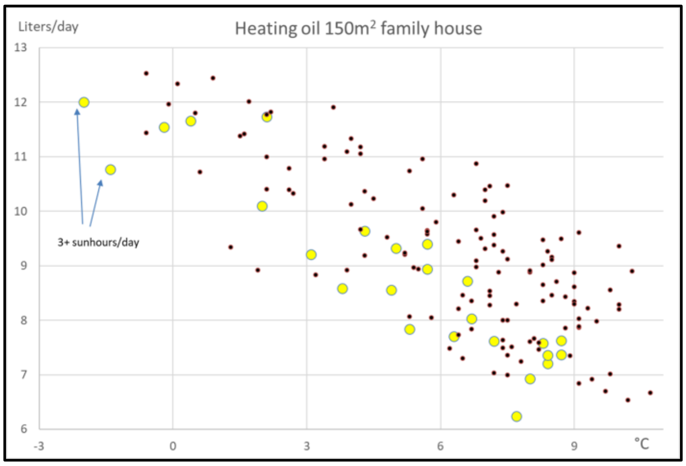
## 3.2 Faroe Islands Case Study – Housing/Building Monitoring Solution

The Faroe Islands are located at 62° north latitude with a semi cold climate where space heating is required throughout the year. For hundreds of years peat and coal were the main energy for heating and cooking. From around 1950 and onwards oil became the main energy source for space heating. With the desire to avoid fossil fuel space heating came into focus as one of the main oil users.

A project initiated on the island of Nólsoy in 2006 included detailed monitoring of the quantity of oil used for heating. This was firstly done by connecting electrical hour meters to oil burners in selected buildings that added up the time the oil burner was running. By comparing the oil used and the oil burner running time measurements were achieved on oil/hour and oil/day. Later more detailed loggers where introduced which registered start and stop of the oil burner and later again the system was improved further by connecting it to the internet using Arduino equipment.

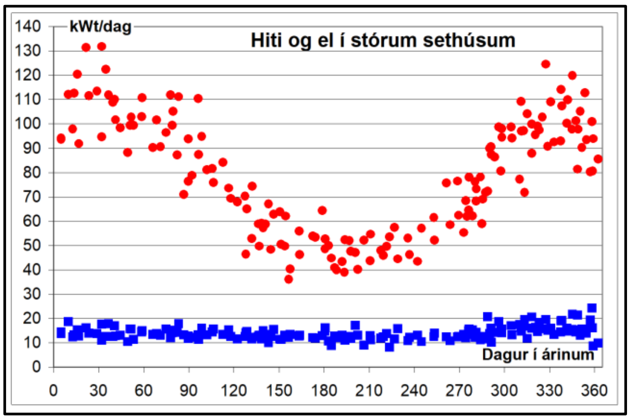
From this monitoring program results as the figure shown below were achieved. The use of oil/day in an average family house is plotted against outdoor temperature and sun hours from a local weather station. The oil used is inversely proportional to the outdoor temperature. Also, days with a few sun hours require less oil.

Figure 4 – Monitoring results from the Arduino programme on oil usage in Nólsoy




The heating requirement in kWh/day can be calculated from the oil/day data using 10 kWh/L oil and 82% efficiency in the oil burner. When plotting this for a whole year the figure below is achieved. The required heating energy during the winter is more than double compared to the summer period.

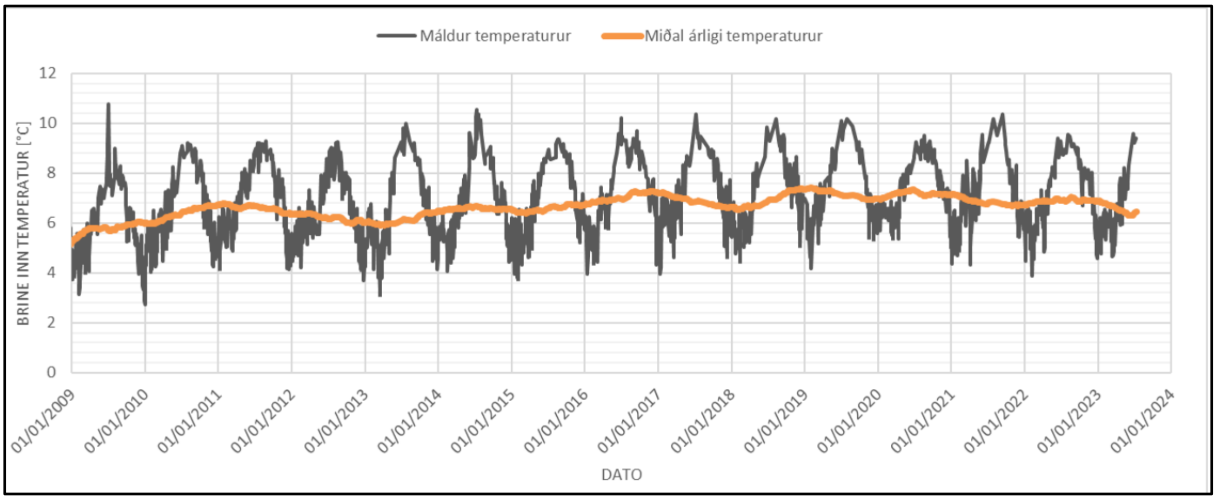
Figure 5 – Annual oil heating results in Nólsoy




From around 2005 heat pumps started to replace oil burners. With the rapid increase in oil prices in 2007-2008 air/water heat pumps became very popular. At the same time the Faroese Environment Agency started investigations into ground source heat pump systems. As there were no experience in the Faroe Islands on ground source boreholing, Swedish expertise was hired to drill the first holes and to make test on hole heat capacity by testing rock type, thermal response test, etc. Five test systems were prepared using boreholes around 200m depth. For these heating systems a detailed monitoring program was developed.  The energy from the borehole was measured using Kamstrup (Denmark) energy meters that measure the water (brine) flow and the input and output temperature.  Similar energy meters were used to measure the heat energy that was delivered from the heat pump to the building.

Meters were also installed to measure the electrical power used by the heat pump and also outdoor and indoor temperature sensors were installed.  All data were collected via mobile datalink in a database created and maintained by Kamstrup and sent to the Agency upon request.  Data collections started in October 2008.  As the ground source heat energy systems were new to the area many questions arose.  One main question was if the ground source hole would cool down when heat was extracted.  This can be made visible from the data collected.  In the figure below the temperature of the water coming up from the bore hole is plotted over the past 15 years.  The temperature is around 4-6°C during winter, when the heat pump uses most energy from the ground, but increases again up to 9-10°C during the summer period.  It is expected that the large amount of water in the ground adds heat to the borehole every summer.

Figure 6 – Water temperature in the heat pump bore hole over a 15 year period in Nólsoy




Another question was on the efficiency of different heat pump systems. Similar monitoring systems that were used for ground source heat pumps were also installed on several air/water systems.  From the data the COP (Coefficient of Performance) factor was calculated simply by dividing the energy delivered to the building by the electricity used by the heat pump.  When comparing it was obvious that ground source heat pumps had a higher COP compared to air/water heat pumps.  One possible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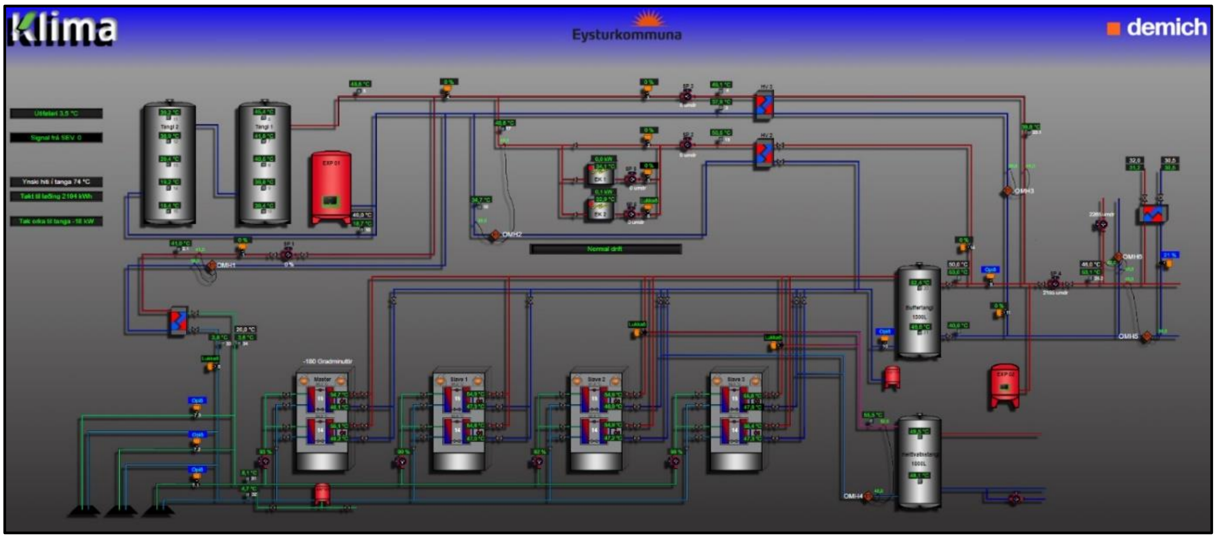
explanation is that air/water heat pumps need defrosting. General figures from the data collections can be summarised in a COP for air/water heat pump of 3-3.6 and for ground source heat pumps of 3.7-4.3. The lower COP is in buildings using radiators which require more than 50°C input and the higher COP is for buildings using floor heating which require input as low as 30°C. These data are used in an energy calculator at https://www.orka.fo/roknarin/ (English version available) where customers can estimate the energy efficiency and cost for heat pump systems compared to oil burners.

As of today, more than 20% of the 18,000 households in the Faroe Islands have converted to different kinds of heat-pumps.

The Faroese Environment Agency has been involved in a space heating system in the village of Leirvík where the municipality has invested in a ground source heat pump system to heat the local school and a nearby elderly home and replace existing oil burners. With available external funding it was decided to include large water tanks as energy storage in the system. Also, the utility company, SEV, was involved and created a special scheme with lower prices in periods when the grid was largely based on renewable energy. The reason was that after recent windfarms were included in the grid there were periods of surplus wind energy that had to be curtailed. The system in Leirvík was seen as an attempt to use surplus wind energy to avoid curtailment. The system was inaugurated in April 2023. A range of energy meters, temperature sensors, control valves etc. are connected to a Building Energy Management Systems from TREND. A screen dump from the system is seen in the figure below with four ground source heat pumps at the bottom, two water tanks in upper left, two electrical heaters in the upper middle and connection to the users to the right.

Figure 7 – Ground source heat pump system in Leirvík




Another system was developed that summarizes the data and calculates the cost of heating from the current system and visualizes the savings compared to a heating system based on oil burners.

Figure 8 – Heating cost data of the ground source heat pump system in Leirvík

Another available IT solution for Cloud based energy monitoring in buildings is called EnergyKey and is hosted by kmd.dk.  However, it is only used by the Ministry engineering office for buildings owned by the Ministry.

The above examples would suggest that the Faroese Environment Agency are equipped to introduce the energy monitoring system for buildings and social housing in operation in the Cork County Council administrative area.

The Faroese Environment Agency and the Cork County Council also completed detailed comparisons of their energy monitoring software, and this has led to proposed upgrades of the software in Cork (regression analysis).

## 3.3 How Cork is Inspired

Cork County Council are encouraged and inspired from the case studies demonstrated by the Icelandic Environment and Energy Agency and the Faroese Environment Agency on their energy saving success rates from the heat pumps they installed and monitored. The functionality of their monitoring systems has informed the proposed upgrade of the Cork software (regression analysis).

This type of approach will be applied to the energy monitoring and energy efficiency assessments of the Council's social housing and buildings. The results obtained from this monitoring will also lead to changes in the Cork County Council resident's behaviours and will justify the need to upgrade all the Council's social housing and buildings to Building Energy Rated (BER) Grade B and higher.

# 4 Procedure and Solution

## 4.1 Collaborative Monitoring

Cork County Council requires the development of the energy management software tool that will be used to monitor its social housing and buildings. This software, when upgraded and tested further, will be transferred to the Icelandic Environment and Energy Agency and the Faroese Environment Agency for similar monitoring (of their rural housing and buildings) in their regions.

# 5 Objectives

## 5.1 Mandatory Objectives

The mandatory objectives of the proposed energy management software is as follows:

1. The Intellectual Property Rights (IPR) is owned by the Cork County Council.
2. Proposed software must adhere to Cork County Council's network and security standards.
3. Proposed software must adhere to up to date General Data Protection Regulation (GDPR) rules and regulations. Note: Proposed software is to be used within the EU only.
4. Provide a software to carry out regression analysis to predict energy consumption by analysis of consumed energy against heating degree days. i.e.
   a) Heating degree days data to be 'pulled' from suitable online website - http://www.degreedays.net/, or similar
   b) Electricity consumption – To be dropped / uploaded into proposed software via an excel file and PDF file (software shall be capable of both uploads as required by the client). Software to be capable of matching the Meter Point Reference Number (MRPN) number of buildings against energy consumption.
   c) Gas consumption – as per electrical consumption above.
   d) Oil consumption – to be input manually against individual buildings.
5. Software to compare the predicted energy consumption against actual energy consumption for each building.
6. Non-conformance emails (amber & red) to be sent to a nominated email address account when a building performs poorly –
   a) Amber = 4% above predicted energy use.
   b) Red = 8% above predicted energy use.
7. Similar type buildings to be allowed to be pooled together and table/charts developed. i.e. libraries / fire stations to be compared individually.
8. New buildings to be easily added by the user in the future, as required.
9. Software is to allow for buildings to be located on Google Maps, and images of buildings to be uploaded.
10. As software is to be used by non-IT qualified staff, the software is to be user friendly. The developer is to provide a user manual and 2 days training once the software is received.

The software shall be transferable to other EU public bodies, as requested. Table 1 below outlines additional various requirements of the proposed software. The developer shall provide costs on both on-premise and cloud-based file storage.

Table 1 – Minimum software requirements

| **Requirement** | **Note** |
|---|---|
| Ability to batch upload documents - excel/PDF | Software to identify the energy consumption of each premises from MPRN or GPRN number on the bills |
| Ability to carry out regression analysis | Pull heating degree days information |
| Broadcast / Alerter function | Non conformance system as per ISO 50001 |
| Ability to target policies to specific groups of users | |
| Audit facility to monitor which policy and version a user has accepted | |
| Reporting tool, to include reports outlining staff compliance | |
| Functionality to provide follow up reminders and enforcement if necessary | |
| Workflow management | |
| Ability to manage the lifecycle of documents | |
| Ability to use the system as a general communications tool | |
| Ability to use the tool for staff awareness training | |
| Ability to include Training from external websites | |
| Compatibility with Windows 7 and 10 | |
| SharePoint integration | Current version 2007 |

# 6 Existing Process of Managing Building Efficiencies

## 6.1 Existing Process

The current method by which energy efficiency is calculated is by Consumed energy/Building Area kilowatt per hour / metre squared ($kWh/m^2$). The consumed energy is electricity plus gas / oil, etc. A generic example of the existing regression analysis and energy management tool can be provided on request.

To calculate the predicted energy consumption of a building, a regression analysis of heating degree days against energy consumed (kWh) is used. The heating degree days is downloaded from http://www.degreedays.net/. An excel sheet from this website is downloaded monthly. The weather station ID used is Cork Airport.

## 6.2 Description

The current energy monitoring system deals with bills on the following utilities and builds a record of each:

- Electricity
- Natural Gas
- Kerosene
- Smart Meters (currently kerosene)
- Water
- Waste
- Waste Characterisation

The system also generates alerts on unexpected consumption and provides statistics in top consumer (per energy type) and manages energy efficiency actions.

*The New System*

The system is being updated internally to predict energy consumption using historic consumption (per calendar year). Charts showing internal energy share and building proportional consumption will also be included.

Energy bills will be edited to show the following consumption:

a) Diesel
b) Petrol
c) Unmetered electricity
d) Renewable electricity

The system will be improved to show a new burndown graph to show projected decrease in energy consumption versus actual decreases.

Data management will be improved to remove old redundant buildings records but retaining their historic energy data.

New Metrics will be added to the system, i.e.:

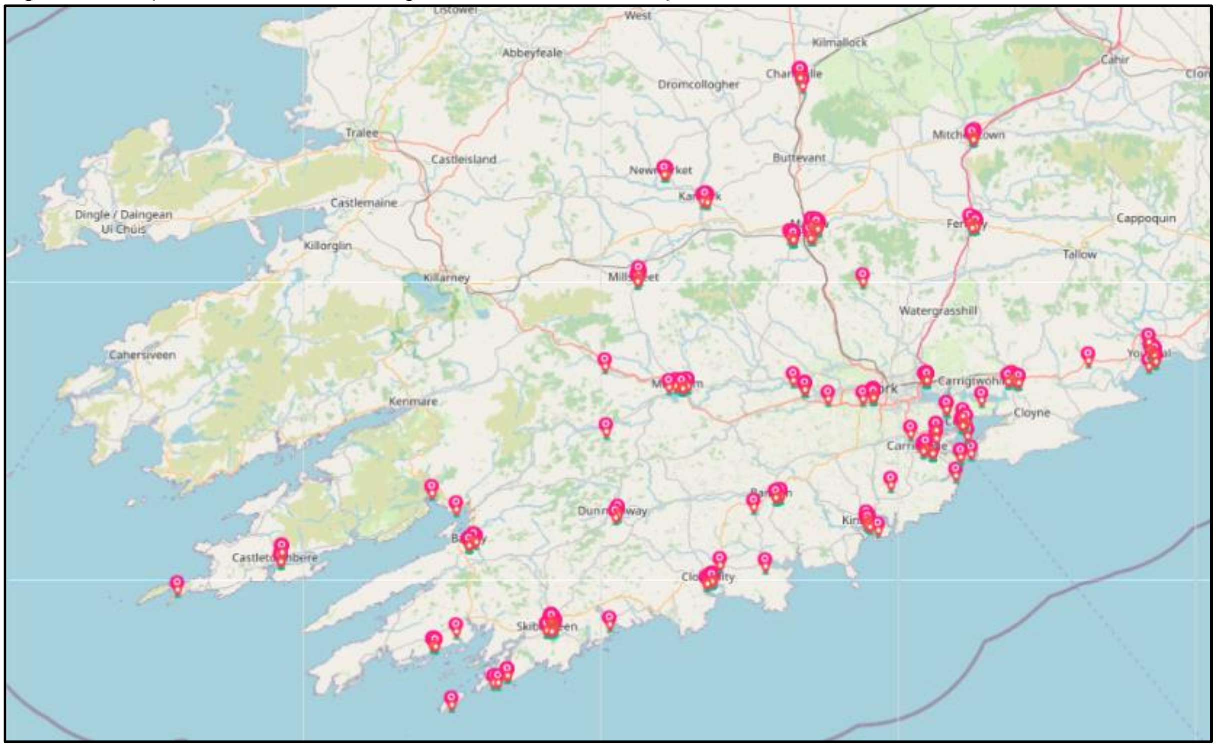
- Yearly cost per unit of heating degree day;
- Yearly energy consumed per unit of heating degree day,
- Yearly units of carbon emitted per heating degree day.

The number of days from the last meter will be added to the system.

A map of the meters will be included, to:

a) Display meters on a map with pins (with asset name and meter number);
b) Allow filtering by asset type;
c) Record meter locations using geographic co-ordinates,
d) Allow the relocation of pins on a map (if incorrect).

Figure 9 – Map of Monitored Buildings and Meters in County Cork




New graphs will be added to the system, to;

(i) Show import capacity for electricity;
(ii) Add filtering option for finding assets,
(iii) Show maximum import capacity of electricity supply limit and actual amount used (monthly and yearly) (to be based on existing energy/euro/CO2 reports.
(iv) Identify a visual graphic of asset proportional consumption. An example is as follows:
- Choose Asset Type / Directorate;
- Choose Electricity / Natural Gas / Kerosene / Liquefied Petroleum Gas;
- Choose Kilowatt-Hour / Kilograms of Carbon Dioxide / Euro,
- Apply Floor Area (yes or no).
- Apply Consumption Colour Code (yes or no), i.e.:
  - ➢ Green – below or at expected consumption;
  - ➢ Orange – higher than expected consumption,
  - ➢ Red – very high consumption.

(v) Show interval data, i.e., half-hourly electricity data.

An updated user manual needs to be produced to deliver further training for building and directorate managers.

Figure 10 – Natural Gas Usage and Regression in Cork

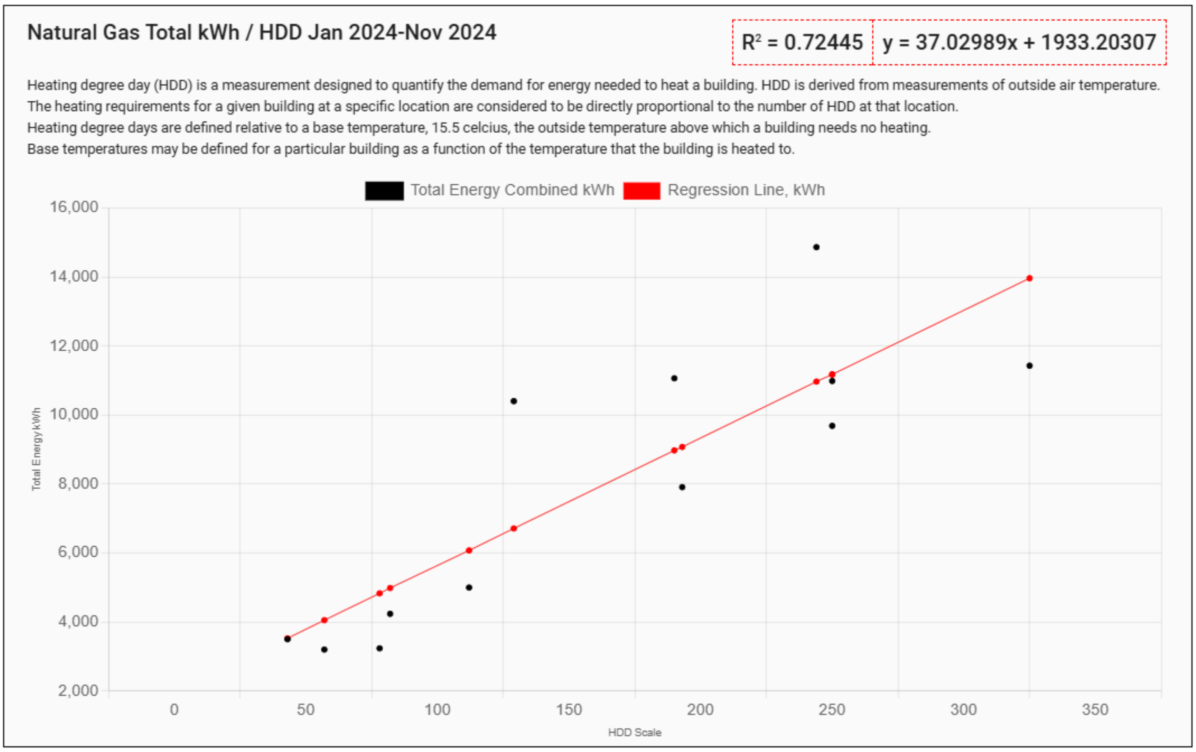
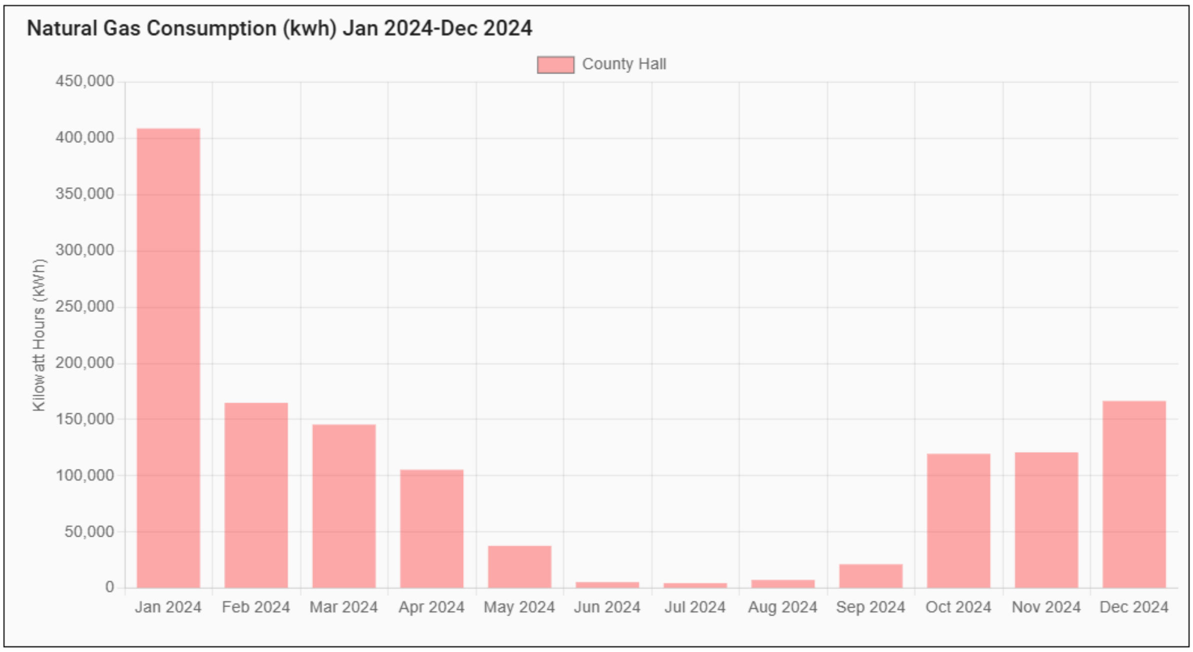



Figure 11 - Natural Gas Consumption in Cork



# 7 Conclusion

The subject energy monitoring tool is a tested software and when upgraded will support Cork County Council, the Icelandic Environment and Energy Agency and the Faroese Environment Agency achieve energy efficient buildings in their districts.

The tool will give each authority an oversight of how their buildings use energy and what interventions are needed to improve energy usage and efficiency. The tool will also lead to behaviour change of the building occupiers and will build knowledge and awareness of energy usage, efficiency and responsibility.

Proposed upgrades to the Cork software have been devised from detailed discussions and programme comparisons with Iceland and Faroe Islands.