seai SUSTAINABLE ENERGY AUTHORITY OF IRELAND

Note accompanying “Understanding the Viability of Replacing Gas Fuel Sources in Communal Heating Systems with a Shallow Geothermal Energy Source”

A synopsis of the main findings and insights.

November 2023

Sustainable Energy Authority of Ireland

SEAI is Ireland’s national energy authority investing in, and delivering, appropriate, effective and sustainable solutions to help Ireland’s transition to a clean energy future. We work with the public, businesses, communities and the Government to achieve this, through expertise, funding, educational programmes, policy advice, research and the development of new technologies.

SEAI is funded by the Government of Ireland through the Department of the Environment, Climate and Communications.

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Introduction

In 2022 SEAI commissioned Ricardo Energy & Environment to conduct a study into the 'Viability of Replacing Gas Fuel Sources in Communal Heating Systems with a Shallow Geothermal Energy Source'. This note synopsises the main findings and SEAI's recommendations and comments on the foot of those insights.

Background

In a communal heating system, water is heated at a central location, generally by a large gas boiler, and distributed to households via insulated pipes that are buried beneath the ground. Typically, heat is transferred into the homes by a heat interface unit (a system that contains metering, pumps and control valves) and used to heat the emitters (typically radiators or underfloor heating) and domestic hot water (this can be instantaneous or via a storage cylinder). This drawn down heat is metered and consumers are charged for this heat, rather than the gas consumed at the central location. This compares to consumers with an individual gas boiler paying for the gas they consume. There are approximately 150 communal heating systems in Ireland, serving approximately 11,000 households.

The energy crisis of 2021 brought certain challenges for consumers of communal heating systems into focus. Relative to homeowners with individual heating systems, communal heating systems users experienced three very particular challenges.

a) Gas used in a communal heat system is charged at a commercial rather than domestic rate. The heating system operator pays the commercial rate for gas, and charges households for the heat they consume, based on that rate. In 2021 commercial gas rates rose faster and higher than domestic rates, meaning a higher heat price for consumers.
b) In Ireland, the pricing of utilities such as electricity, gas and heat is not regulated. The heating sector is not yet regulated to the same extent as other utilities, meaning consumers of heat have not had similar protections e.g. pricing transparency, technical standards or complaints mechanisms. However, the District Heating Steering Group Report approved by Government in July contains a range of recommendations to set the future policy direction for development of district heating, including the development of an appropriate regulatory and legal framework for the sector.
c) The upfront costs to decarbonise a communal heating system are significant. However, the contractual arrangement between the owners' management company and the network operators means that there may be no sinking fund, investment plan or replacement strategy for undertaking energy efficiency upgrades or replacing the boiler.

The aims of the study were to understand how a typical communal heating system operates in Ireland, assess options to retrofit low carbon heat sources including indicative costs and make recommendations for both existing and future heat networks in Ireland. The National Heat Study (2022) identified the significant potential of shallow geothermal energy to provide stable, secure, low carbon renewable heat, and this was the primary scenario assessed.

Case Study Location

Carlinn Hall is an estate of 178 homes in Dundalk with a gas fired communal heating network. Constructed over three phases, it was originally part of a wider Dundalk 2020 Project, in which district heating would be deployed in the wider area. The vision was to connect this scheme with other large heat users in the area, such as the local hotel, college and hospital. Being part of a wider district heating network, with a variety of heat users and suppliers would likely have offered higher system efficiency and stability to the consumer. The economic crisis of 2008 meant that the wider Dundalk district heating network was not progressed.

Methodology

The consultants followed three steps:

1. Using data and simulation models, they developed an understanding of the operation and challenges of a typical communal heating system. They compared the volume of gas consumed versus the heat sold to determine the overall network efficiency. By analysing water temperature at the energy centre, and around the circuit through each home and back to the energy centre they identified opportunities for network improvements.
2. Using models of the current system and analysing heat demand through the year, they tested whether any low carbon alternatives for the current gas boiler could be successfully integrated into the network.
3. They used a techno-economic model to determine the different operating costs and heat sale prices for retrofitting three low carbon technologies over a 25-year period.

Main findings

The study made five key findings in relation to the:

1. Efficiency of the network
2. Potential low-carbon alternatives
3. Modelled upfront and operating costs
4. Considerations (pros and cons) of each alternative
5. High price of electricity relative to gas acting as a barrier to heat decarbonisation projects.

Each low carbon alternative has its own considerations and each communal heat network across Ireland will have its own site-specific bespoke solution.

1) Efficiency first

The efficiency of the network (how much heat is being delivered to consumers relative to the gas consumed) should be addressed first, before low carbon alternatives are considered. A well performing heat network would typically have efficiencies of 70-80% (100 units of gas would yield 70-80 units of useful heat). Currently, the efficiency of the network in Carlinn Hall is considerably lower at 52% (100 units of gas only yields only 52 units of useful heat). This is in part due to the low density of housing on the estate, meaning hot water has to travel farther around the network, incurring more losses than would be considered optimum.

The consultants recommended three significant improvements:

- Upgrade the controls and metering on the network
- Investigate pipework, manholes, heat-interface units and domestic hot water systems in more detail
- Develop a strategy for maintenance of the individual heat interface units.

The expectation would be that any efficiency upgrades would lead to lower costs of operating the network relative to the November 2022 baseline.

2) Three low carbon alternatives can be used in this heat network, with CO_2 savings of up to 77%.

The consultants assessed three low carbon alternative heat sources to replace the existing gas boiler: a ground source heat pump, air source heat pump or a biomass boiler. They could deliver up to 77% CO_2 savings compared to the current system. A commercial grade 350kW heat pump or biomass boiler could provide sufficient heat for approximately 80% of the year. For the remaining 20% of the year thermal storage and a gas backup boiler would provide the additional heat. The associated costs and non-financial considerations of each technology are outlined in the following sections.

3) Upfront, operating and replacement costs were modelled over a 25-year period including potential subsidies.

A 'heat sale price' was modelled, which is a theoretical balancing over the network of both income and outgoings. It provides a consumer price for a unit of heat for the network operation to 'balance' overall. It is indicative rather than an absolute price guarantee. A sinking fund is a 'pot' of money accumulated as part of regular payments, this is set aside to pay for planned, expected expenses, such as the replacement costs for the heating system. The heat sale price that consumers were paying at the beginning of the project was 22c/kWh and this is referred to as the 'business as usual' scenario and does not include any sinking fund.

	Business as usual	Ground source heat pump	Air source heat pump	Biomass
Upfront cost to install **(€million)**	0	Up to 3.63	1.4	1.14
Upfront cost per household **(€)**	0	Up to 20,400	7,865	6,400
Potential SSRH subsidy **(€million)**	0	0.8	0.23	0.89

Table 1: The different upfront costs associated with each scenario.

As the heat pump scenarios include devices that are larger than those typically for individual homes, commercial heat pump grants may be available. SEAI's Support Scheme for Renewable Heat (SSRH) scheme offers installation grants to support investment in renewable heating systems. The grant will provide funding of up to 40% of eligible cost, to successful applicants and potential supports have been incorporated into the modelling of the heat sale price. Each scenario is summarised (Table 1) in terms of the upfront costs and the overall modelled price of heat over a twenty-five-year period, with different costs considered (Table 2).

	Business as usual	Ground source heat pump	Air source heat pump	Biomass
Price of heat only**(c/kWh)**	22	16.4	18.7	32.7
Price of heat & sinking fund**(c/kWh)**	22.8	20.1	23.1	35.2
Price of heat & sinking fund & upfront cost**(c/kWh)**	22.8	25.4	24.1	37.3
Price of heat & sinking fund & upfront cost & social cost of carbon**(c/kWh)**	28.9	26.4	25.1	100.1

Table 2: The different modelled 'heat sale price' for each scenario, when modelled over a 25-year period.

4) A balanced assessment, including a non-financial viewpoint, is required for each individual communal system when considering decarbonisation.

Each low-carbon alternative technology that could be retrofitted onto this existing network has different considerations. A balanced assessment which includes non-financial aspects that are often specific to the location is needed when considering decarbonisation of a communal system. These include financial (upfront, replacement/useful life and operating costs) but also non-financial (stability, security of supply, carbon, air pollution, noise and visual impact). Both heat pump solutions require electricity to operate whereas the biomass scenario involved burning woodchip or pellets. The coefficient of performance (COP) is a measure of the efficiency of a heat pump and is described as the ratio of how many units of heat are output relative to one unit of electricity input. A higher efficiency indicates more heat for less electricity input.

A ground source heat pump extracts heat from the ground and upgrades it with a COP of 3.5-4.0 (or an efficiency of circa 350-400%, meaning for every 100 units of electricity used one might expect to get 350-400 units of useful heat). There would be some short-term disruption arising from the installation of the borehole array (estimated up to 220 needed at depths of 150m in Carlinn Hall), however the green areas or car park can be reinstated afterwards. The infrastructure associated with shallow geothermal can be in situ for 50-100 years and requires relatively less maintenance than the air source heat pump. The replacement period for the actual heat pump device is 20 years.

An air source heat pump scenario extracts heat from the air and upgrades it with an efficiency of circa 280% (280 units of useful heat for 100 units of electricity used). There may be some noise from the heat pump that could be mitigated by locating it away from nearby homes and using a buffer. The replacement period for an air source heat pump is 15 years.

A biomass scenario involves burning wood pellets (sourced, contracted and delivered regularly to the energy centre) in a boiler to heat water centrally. The primary advantage of this scenario is the relatively low upfront cost to install, however the primary disadvantage is the high operating cost and security of supply. When considering the social cost of carbon and the associated air pollution locally in a suburban environment, the biomass scenario has the highest heat sale price. This scenario would also require the most upkeep and general maintenance of the energy centre.

5) Heat decarbonisation projects via electrified means will struggle economically with the current pricing of electricity relative to gas.

At the time of the study, electricity was 2.8 times more expensive than gas and as electricity is the main input into the two heat pump solutions, it has a big impact on the operating costs. If this ratio was to fall to 2.0-2.4, then this study found that the modelled heat sale price could be largely in line with the current heat sale prices. This highlights the financial barriers posed by the high cost of electricity to any electrified heat solution.

As Ireland moves to reduce its dependency on fossil fuels, there will be more and more demands from different sectors to be electrified. Investments to the grid infrastructure will be paid for by the state, therefore there is a benefit to the taxpayer from a system-wide perspective to consider ground source heat pumps in more situations due to their inherently higher coefficient of performance. Despite their upfront cost, a GSHP system could result in lower electrical demands than an equivalent ASHP system due to the higher COP. This may have local implications on the magnitude of grid re-enforcements required.

This points to a national heat decarbonisation perspective that may be in contrast to the local or homeowner one.

Considerations and comments for stakeholders

Key Recommendations from the report and from further SEAI insights are summarised below. They are presented for the Case Study homeowners and operators, communal heating networks more generally and furthermore for policymakers.

Short Term Efficiency First → **Medium Term** Planning to decarbonise → **Long term** A low carbon communal heating system

1) Case Study homeowners and operator (Carlinn Hall)

Short Term - Efficiency First

- Undertake control upgrades and monitor to ensure optimised scheme performance.
- Isolate and remove the non-operational CHP unit.
- Run monthly performance checks on the HIUs.
- Monitor network performance regularly, aim to increase the difference in temperature between the water leaving the energy centre and returning (delta- T) and reduce system flow temperatures where possible.
- Explore in home service arrangements for heat interface units' maintenance.

Medium Term - Planning to decarbonise

- Prepare sinking fund or strategy for replacement as boiler approaches end-of-life.
- Ensure any future updates to the Support Scheme for Renewable Heat are recorded and integrated into the techno-economic model (TEM) supplied with this report, similarly any new data (e.g. test boreholes) or information arising from efficiency upgrades.
- Determine if air quality concerns would rule out a biomass fuelled solution.
- Ensure wider-Dundalk heat strategies i.e., design of any future heat networks in the local area, possibility of using electricity from the nearby DKIT wind turbine, any cooling demands, are assessed and incorporated.

Long term - Low carbon alternative

- Discuss options with installers and designers leading to a design and contract with an installer.
- Install the chosen low-carbon alternative and associated monitoring and controls.
- Monitor performance and seek to improve, critical over the first few years of operation.

2) Other Communal Heat Networks

- Undertake similar studies to assess current network performance and potential efficiency improvements, particularly where networks operate at lower efficiencies and increasing fuel costs are passed through.
- Improve the networks' efficiency first, then assess the viability of other low carbon alternatives, using the framework approach outlined in this report. Consider any wider heat network development in the area.
- Ensure an adequate sinking fund is maintained for communal heating schemes. Carry out regular reviews of this sinking fund and the available funding mechanisms to support the capital investment needed to deliver future decarbonisation measures.

3) Policymakers

- Supports for upfront and operating costs and for efficiency upgrades to existing heat networks.
- Consider extending the reduced VAT rate on domestic gas (9%) to commercial gas purchased to sell heat for domestic consumers.
- Extend contractual period beyond three years as specified in the MUD Act 2011.
- Establish linear heat density as a key feasibility metric in a standalone heat network.
- Continue developing a strong regulatory framework for heat networks.

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