Evaluation of Renewable and Zero Direct Emissions Heating Systems in Affordable Housing Projects (Phase 2)

Final Report

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Executive summary

- Seven of eight stakeholders had previous experience with ZDEH, with ASHPs a default option for many off-grid locations. Motivations to install the ZDEH system included off-grid locations, upcoming NBHS regulations and fuel poverty concerns.

- All stakeholders had experienced at least one challenge during the implementation of a ZDEH system, however commissioning appeared to be a smoother process. The largest two challenges are related to the supply chain and geographical location of the project, which often go hand-in-hand. Cost, grid constraints, and billing and metering were also challenges experienced.

- Seven of eight stakeholders were happy with the performance of the ZDEH system and only required general maintenance, which was expected. Overall tenant satisfaction, quantified by surveys and number of complaints, is deemed to be high by housing providers.

- Monitoring of zero direct emissions heating (ZDEH) systems is rarely conducted by affordable housing providers. Only three of the participating projects were able to provide real-world heat demand or cost data, for a handful of homes within their developments. Many stakeholders had not considered monitoring and would be less likely to do so unless it became a requirement.

- Real data on the actual performance of ZDEH systems is very limited both in this project and more widely in industry. When compared to estimated annual energy consumption in an average gas-heated home and against averaged gas tariffs (using data from BEIS and the Energy Saving Trust), data from operational ASHPs are found to be less expensive, or equivalent to gas to run. The exception being for larger homes (4+ beds) which are difficult to correlate against the averaged data.

- A knowledge hub is welcomed by the housing sector and many existing organisations are interested in supporting, hosting and collaborating on such a resource. The hub needs to be well defined, funded, dynamic, and deliver real data and insights to pertinent housing sector topics (that can’t be found elsewhere) to be useful and attract high engagement.

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1. Introduction

1.1. Context

A major challenge that must be addressed to meet Scotland's target of net zero greenhouse gas emissions by 2045 is the decarbonisation of heat in buildings. The incoming New Build Heat Standard (NBHS) will prohibit the use of direct emissions heating systems in new buildings, both domestic and non-domestic, from 2024. The changes to domestic building standards under the incoming NBHS will affect many stakeholders within the new build housing sector, including private developers, Councils and Registered Social Landlords (RSLs).

A non-direct emission heating system, i.e., a zero direct emission heating system (ZDEH), is one which produces zero direct greenhouse gas emissions (at the point of use) under normal operating conditions. The standard is technology neutral, but examples of technologies included in this scope are direct electric systems, air source heat pumps (ASHPs), ground source heat pumps (GSHPs), water source heat pumps (WSHPs), and district heat networks (DHNs). Currently, DHNs that provide heat from gas and other fossil fuels are understood to meet the ZDEH classification, as they do not emit greenhouse gases at point of use, and the emissions from the heat source for a DHN will be considered in separate regulations.

1.2. Research aims

The Scottish Government has appointed Locogen to deliver the second phase of the evaluation of renewable and zero direct emissions heating systems in Scottish affordable housing projects. The first phase of this work was conducted by Locogen in 2021 and helped to formulate the goals of Phase 2. The goals of this second phase of the evaluation are:

- To collect actual (as opposed to estimated) performance data from Affordable Housing projects with zero direct emissions heating systems, including technology performance; operational costs; and occupant satisfaction.
- To advise on the creation of a knowledge-sharing hub where information and best practice guidance can be accessed by stakeholders in the Scottish housing sector, to help them achieve compliance with the NBHS.
- To develop case studies of exemplar zero direct emissions heating in Scottish housing projects, providing insight on system performance, tenant experiences and network constraints.

2. Methodology

2.1. Overview

The scope of our research and this report consists of three Work Packages (WPs), as summarised in the overview diagram in Figure 1, which was devised by the Scottish Government. The detailed methodology for the three work packages is detailed in Section 2.2 and the rest of this report summarises our findings.

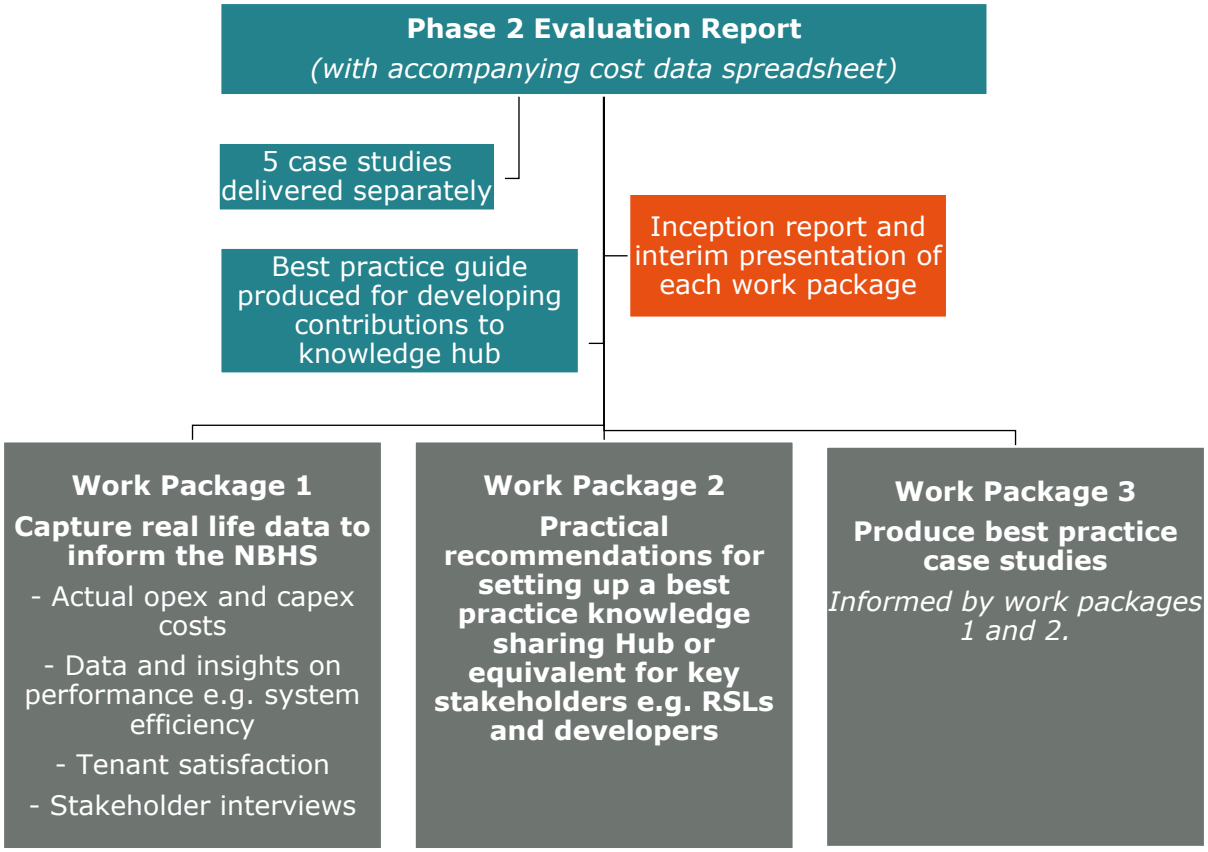

Figure 1: Overview of project scope

2.2. Detailed methodology

2.2.1. Work Package 1: ZDEH data and insight from affordable housing providers

- Develop a framework to structure and capture quantitative data from housing providers. Create a standardised template that can be distributed to housing providers for them to be able to populate with required ZDEH data.
- Collect, where available, numerical data relating to actual running costs, heat demands, capital costs, and performance from affordable housing projects with zero direct emissions heating systems.
- Collate, analyse and report on quantitative data from housing providers outlining key findings and trends.
- Design a discussion guide to ascertain qualitative insight from housing providers including rationale for technology choice, route to

implementation, challenges faced, perceived performance and tenant experience of ZDEH.
- Interview affordable housing project teams to collect qualitative insights on occupant satisfaction and the in-situ performance of zero direct emissions heating systems.
- Collate, analyse and report on qualitative insight from housing providers outlining key findings and trends.

2.2.2. Work Package 2: Knowledge sharing hub

- Discuss and define the scope, ownership and ambitions of the 'best practice knowledge sharing hub' with the Scottish Government.
- Carry out secondary research to identify the long list of existing resources, organisations, associations, best practice guidance and 'knowledge hubs' that are already available to the Scottish housing sector.
- Conduct stakeholder interviews to investigate what existing resources are used to acquire and share knowledge relating to heat in new build homes, and to understand the benefits, opportunities and challenges associated with developing a hub.
- Collate the findings from the primary and secondary research and analyse the gaps in existing resources. Assess the challenges and barriers for housing providers to engage in a hub and the risks associated with developing a hub.
- Develop practical recommendations for a knowledge hub, its required purpose and knowledge/information needed. Outline whether this should be developed from an existing resource or create a new hub.
- Create a best practice guide for contributions to the hub, to encourage quality and consistency.

2.2.3. Work Package 3: Case studies

- Review existing case studies of heat in new build housing to help develop a case study template to cover the scope of the required case studies.
- Identify 5 suitable projects and develop case studies on each of these to form the initial contribution to the hub.
- Conduct stakeholder interviews to gather information to populate the case studies and to understand the appetite for and desired content of the case studies.

3. WP1 – ZDEH data and insight from affordable housing providers

3.1. Housing project overview

Table 1 below lists the housing projects by Affordable Housing providers participating in this evaluation. The 'Data status' column indicates the development stage and whether numerical data was available to share. Representatives from these organisations, as well as representatives from Eildon Housing Association and Ayrshire Housing, were interviewed to gather qualitative insight on ZDEH. Twelve further projects were part of the initial scope of WP1 but were unable to participate for various reasons (including lack of staff resource, having heating systems with direct emissions, and/or not yet being occupied as of April 2022).

Project name	Location	Organisation	ZDEH	Data status
Sheridan Place	Aberdeenshire	Aberdeenshire Council	ASHP	No data available
Dunecht	Aberdeenshire	Osprey Housing	ASHP	Partial data available
Kirkton O'Neill Phase 1	Aberdeenshire		ASHP	
Marykirk	Aberdeenshire		ASHP	
Sauchen	Aberdeenshire		ASHP	
St Cyrus	Aberdeenshire		ASHP	
Dunbeg Phase 3	Argyll & Bute	Link Group	ASHP	No data available for April 2022
Customs House	Aberdeen	Hillcrest Housing Association	Direct Electric	Partial data (site demand) available for heat network projects
Blackford	Perth & Kinross		Direct Electric	
Brown Constable Street	Perth & Kinross		Heat network	
Wharton Square	Edinburgh		Heat network	
Sailmaker	Edinburgh		Heat network	
London Road	Edinburgh		Heat network	
Mackenzie Avenue	Western Isles	Hebridean Housing Partnership	ASHP	Partial data available
Sgeir Ghlais	Western Isles		ASHP	
Cnoc A Runaire	Western Isles		ASHP	
Cnoc Na Monadh	Western Isles		ASHP	
Winfield Close	Western Isles		ASHP	
An Glib	Western Isles		ASHP	
Trosaraidh	Western Isles		ASHP	
Suisnish Place	Highland	Lochalsh and Skye Housing Association	ASHP	Partial (electricity only) data available

Table 1: Summary of projects participating in the evaluation

3.2. Insights from stakeholder interviews

3.2.1. Overview

We interviewed 8 housing associations and local authorities who have installed ZDEH systems into more than 200 new domestic homes (under the Affordable Housing Supply Programme), on their experiences and views of:

- ZDEH technology choice and suitability
- Challenges in implementing and commissioning ZDEH
- In-situ performance of ZDEH
- Occupant experiences of ZDEH
- Approaches to monitoring

As outlined in Table 1 above, the technologies represented in the following analysis include Air Source Heat Pumps (ASHPs), direct electric heating systems, and heat networks. Given the limited number of interviews the insight below is presented graphically to disseminate the findings easily, however the data is not deemed statistically relevant and so numerical references are not included.

3.2.2. Technology choice and suitability

As outlined in Figure 2, all stakeholders (apart from one) had existing and often long-standing experience of using certain ZDEH systems, which also fed into their selection process. There were a mix of key drivers to select a technology, but often this was due to gas not being available, a desire to align with incoming building regulations, or to mitigate fuel poverty. Despite the concerns over fuel poverty, often the tenants were not explicitly considered in the technology choice upfront in the design process.

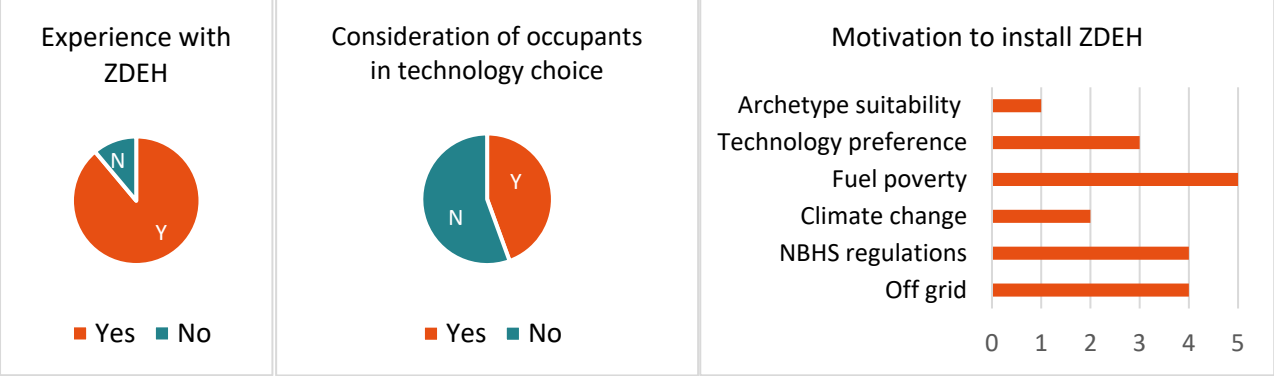

Figure 2: Qualitative stakeholder opinions on experience and drivers to install ZDEH systems.

ASHPs are the default option for several organisations in locations which are not connected to the gas grid, as they are cheaper to operate than coal/oil/LPG boilers and stakeholders had as much as 10 years' experience in developing new build housing with ASHPs. Despite being the most well used technology across the project, there was disagreement across interviews on the suitability of ASHPs across different housing types. Whilst all advised they were suitable for houses, some indicated that these were not suitable in flats, whilst others

advised that they have or would install shared and/or individual ASHP systems in flats.

"Air source heat pumps are now our default choice, even where gas is an option."

Heat networks were chosen for several projects by one housing association as they were deemed the most cost-effective solution for flats. Direct electric systems were also deemed to be cost effective options for flats with low heat demands. However, there was a lack of consensus around the suitability of direct electric heating systems across stakeholder interviews, due to the trade-off between high operational costs and low capital costs.

All stakeholders considered other and multiple technologies in the design process before selecting their preferred technology, and provided the following reasons for rejecting certain ZDEH technologies:

- Ground source heat pumps: More expensive and complex to install than ASHPs.
- Direct electric systems: Expensive for tenants to operate.
- Heat networks: Centralised issues affect all properties on the network and no choice in heat bills for tenants.

All stakeholders advised that they would specify the same ZDEH technology in future developments, either because the technology was tried and tested, or because there were perceived to be limited alternative options that would be cost-effective or align with incoming building regulations.

3.2.3. Challenges in implementing and commissioning ZDEH

Implementation Challenges

All stakeholders had experienced at least one challenge during the implementation of a ZDEH system. Figure 3 provides a summary of the types of challenges stakeholders faced. The largest two challenges often go hand-in-hand and are related to the supply chain availability and the geographical location of the project.

In terms of the supply chain a key issue was the availability of contractors in the local area, including installers, maintenance companies and specialist refrigerant contractors. Getting contractors to travel to remote regions was difficult and one stakeholder found that local contractors were not included on procurement frameworks. Other supply chain issues raised included getting spare parts and products, as well as the quality of contractors available (i.e., a contractor not installing the systems correctly).

As well as being an issue for supply chains, the location of the project also impacted the technology choice, with a few stakeholders in coastal regions needing specific ASHP models that have suitable protection against corrosion from the salinity of the air, limiting the number of available options. Capital costs are also heightened in remote locations, especially when local contractors are not available.

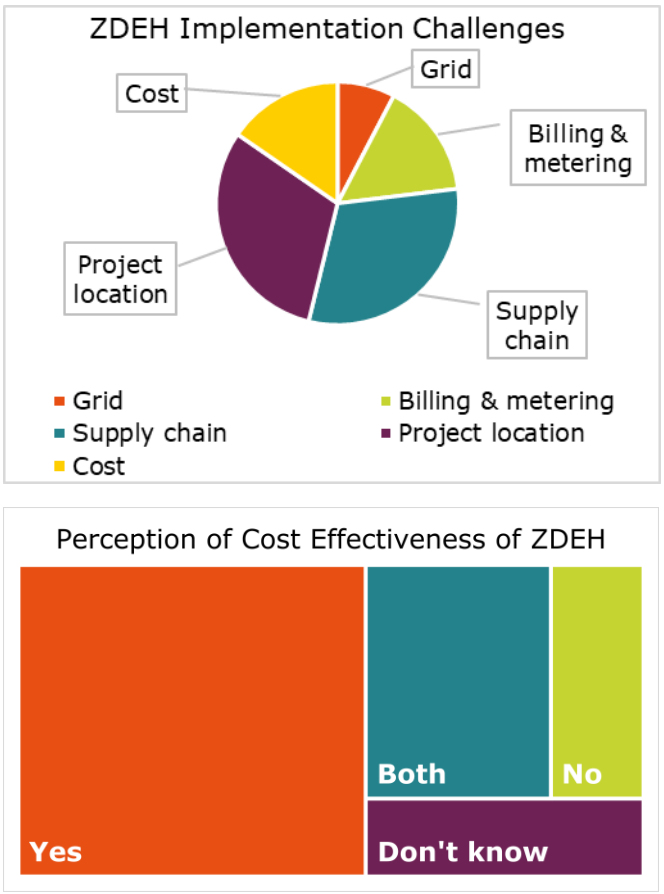

Figure 3: Qualitative stakeholder opinions on ZDEH implementation challenges and whether they deem ZDEH to be cost effective.

Billing and metering were a challenge for the DHN projects, where stakeholders did not know how to bill tenants' heat. Other challenges included stakeholders having limited input into the specification of systems in design and build contracts and being unsure if systems had been correctly sized for heat and hot water demands.

"Placing ASHP external units can be challenging, you want to avoid the front of properties and bedrooms, and you also need to minimise pipe length and satisfy planners."

Despite the challenges to implementation the majority of stakeholders perceived the ZDEH systems to be cost effective, if the property is designed correctly (i.e. has a low heat demand) and the heating system is operated and managed correctly.

Commissioning Challenges

The majority of projects did not experience issues during commissioning. One stakeholder mentioned that ASHPs had not been programmed correctly, but this was quickly identified and rectified. The other snagging issue was due to the wrong thermostats (hardwired rather than moveable wireless ones) being installed, but this was also rectified quickly.

Generally, post-completion support from manufacturers or developers is available but has not been required. One stakeholder had been aware that this

was available for an ASHP project, but it had not been offered or requested after commissioning.

Whilst not specified for projects in this evaluation, thermal storage was referenced by three stakeholders, who were aware of projects where these had been badly commissioned and led to expensive bills for tenants. One stakeholder mentioned that this had later been rectified in the project they were aware of.

3.2.4. In-situ performance

System performance

As outlined in Figure 4, all stakeholders except one were happy with the performance of the ZDEH system. All stakeholders from projects with ASHP systems indicated that they were generally happy with the performance of the systems. One stakeholder indicated this was not always the case previously, and they now only install heat pumps from three manufacturers which have proven to work well. Another also indicated that system performance varies significantly between ASHP manufacturers.

"We've been installing heat pumps for over ten years. We have around 280 of the same type and only one external unit has failed to date."

Direct electric systems were noted to be disappointing (to both the landlord and tenants) as they were more expensive to operate than expected. Overall stakeholders had low awareness of the operating efficiency of the systems compared to expectations (and accordingly, limited awareness of heat bills compared to pre-occupancy estimates, except via tenant feedback).

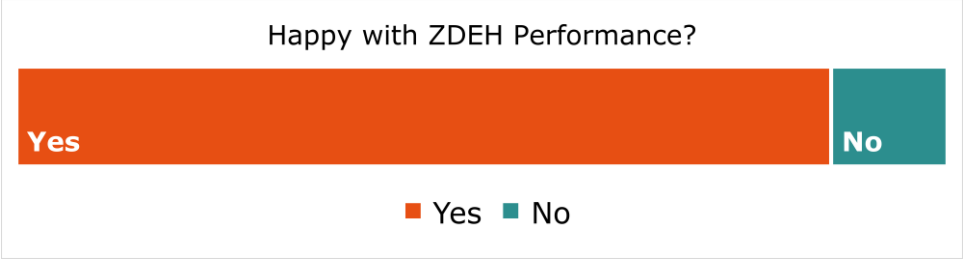

Figure 4: Qualitative stakeholder perception on the ZDEH system performance.

Maintenance requirements

Most stakeholders from projects with ASHP and direct electric systems advised that no maintenance had been required other than planned annual services. There is a split between maintenance being conducted in-house or by external contractors. The former is more prevalent in larger organisations, and less common for heat networks.

One stakeholder advised that following issues with ASHP refrigerants, it was very difficult to find specialist contractors in the Highlands who could address these problems. This illustrates the issues that remote and rural locations face compared to urban areas that tend to have more contractors (as established in

Phase 1), although conversely, one stakeholder indicated that this was not an issue in the Western Isles.

"It's a 200-mile round trip for a refrigerant engineer to reach us, which means callouts are really expensive."

It was also evident from two stakeholders that past, negative experiences with ASHPs from certain manufacturers guided them to choose heat pump models that they deemed to be of higher quality. In both cases, one particular ASHP model is now their favoured option for all new builds, as it is deemed to require less maintenance compared to other models, and has a reliable supply chain for spare parts, should these be required.

3.2.5. Occupant experiences

Handover

All organisations interviewed provided a home manual for new tenants, which includes instructions on how to operate their heating systems. The level of detail in these manuals appears to be widely variable. Four stakeholders indicated that they share YouTube videos with tenants to further explain how to work their heating systems. Some also provided advice on what electricity tariffs to select, whilst others left this to the discretion of their tenants.

Three stakeholders indicated that if requested, maintenance teams would visit homes to demonstrate how the systems work. Where this was offered, it was utilised, as tenants requested support to familiarise themselves with ASHP systems. Figure 5 illustrates the support stakeholders provide at handover and post-handover, as well as early advice on energy tariffs.

"We get our tenants to do a demonstration to us at the end of our introductory visits, to show us they can control their ASHPs."

Controls

Across the projects in the WP1 scope, all ASHP heating systems are controlled by centralised thermostats and Thermostatic Radiator Valves (TRVs). For the heat networks, controls are via a heat interface unit and were noted to be easy to use from anecdotal tenant feedback. There was a split among the ASHP projects (and evidentially within one housing provider) on how to advise tenants on controls. Two stakeholders advised that they set up the ASHPs to recommended programmes and urged tenants not to interfere with these without energy advisers' support. However, two stakeholders indicated that they encourage their tenants to program their ASHPs to a temperature routine that matches their occupancy patterns. It was noted that with the latter approach, some tenants were very nervous to do this as they worried (unnecessarily) that deviating from the default settings would negatively impact their electricity bills.

Three stakeholders indicated that their projects housed some tenants with disabilities or assisted living requirements. Only one indicated that these tenants required additional support or measures to operate their heating systems: in wheelchair-accessible homes TRVs were located at the top, rather

than at the bottom of, the radiators. They added that they would usually specify low-surface temperature radiators, but that the lower output temperatures of ASHPs bypass this requirement.

General feedback

"95% of our tenants are completely satisfied with their heat pumps."

"100% of our tenants said their heat pumps kept their homes warm on a cold winter's day."

Tenant feedback is most commonly collected through surveys conducted after the first year of occupancy. These surveys cover all aspects of the home and tend to ask very few questions about heating systems. Therefore, feedback on comfort levels and system control tends to be collected anecdotally only (i.e., via complaints and/or requests for support). Across the projects represented in the interviews, overall satisfaction was deemed to be high, particularly for ASHPs. However, one project had experienced very mixed responses to ASHPs, with one tenant advising that they were the worst thing about their home.

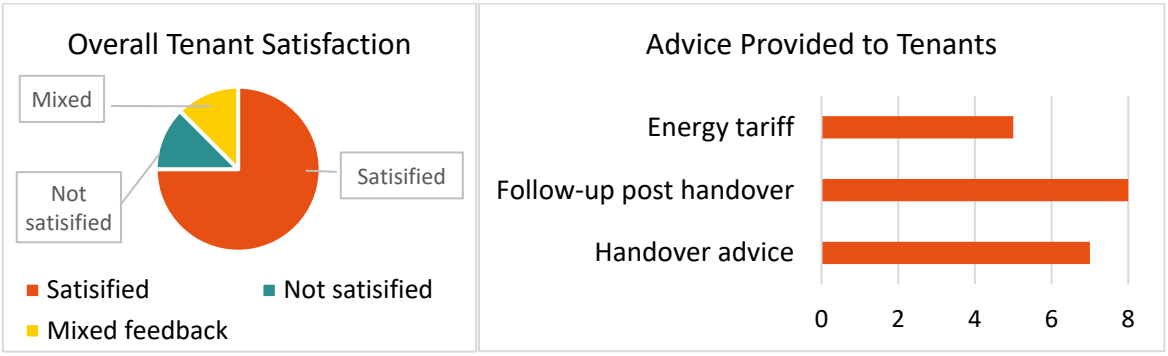

Figure 5: Qualitative stakeholder perception on tenant satisfaction (informed by tenant surveys) [left], and the amount and type of advice given to tenants [right].

"There were several requests for help in the first year but there have been none in the last five years."

Whilst support is required initially, this has tended to reduce significantly after the first year of occupancy. ZDEH, particularly ASHPs, evidently require an adjustment period where tenants are used to conventional (fossil fuel) systems. For example, tenants of one project were nervous that the ASHP was supposed to run all the time, whilst tenants of another project were surprised that their clothes would not dry on the radiators, due to lower operating temperatures.

Tenants of a development with direct electric heating indicated that this was too expensive and also difficult to operate. For heat networks, a common issue that tenants noted was that they were not able to choose their heating supplier. The heat networks were billed via a third party, which tenants felt provided bad customer service. However, satisfaction with bills and heat delivery was noted to be high.

3.2.6. Monitoring

Four of the organisations interviewed had conducted monitoring of the ZDEH systems for the following purposes:

- Billing some of its heat networks (but uses floor area benchmarking to estimate heat consumption in other).
- Monitoring energy demands across whole housing stock to investigate ASHP performance, among other factors.
- Monitoring heat demand to decide if maintenance is required.
- One stakeholder collected data manually from homes' heat meters specifically for this study.

The other stakeholders indicated that they have not conducted monitoring because the option of doing so had not been considered and they would likely only do so if pushed to by the Scottish Government or by new regulations.

3.3. Analysis of numerical data

3.3.1. Overview

Four of the affordable housing provides participating in the evaluation were able to provide (some of) the numerical data requested. A summary of this is provided in Table 2 below.

The data provided by Hillcrest Homes represents annual gas consumption for the whole heat network for four developments, rather than the consumption of individual units, which is not known to the housing association as it is metered and billed by a third party. As such, this data is not presented as it does not align with the aim of this evaluation, and limited insight can be drawn without significant assumptions regarding network losses.

Organisation	Location	Technology	Type of data
Osprey Housing	Aberdeenshire	ASHP	One year of annual electricity consumption from ASHP for 13 homes
Hebridean Housing Partnership	Western Isles	ASHP	Estimated annual heat demand, one year of annual electricity consumption from ASHP for 7 homes
Hillcrest Homes	Edinburgh	Heat network	One year of total annual demand and costs for 4 heat networks
Lochalsh and Skye Housing Association	Highland	ASHP	One year of annual electricity consumption (whole household – not just heating) for 24 homes

Table 2: Summary of numerical data provided

As only two organisations provided data in the same format, only these two datasets, representing 20 homes, can be compared on a like for like basis. The other dataset is therefore analysed independently. In order to suggest if these datasets represent affordable energy bills, standard tariffs from Energy Saving Trust have been applied to compare them financially to the UK Government's mean domestic energy consumption statistics. Given the low volume of the data collected, the analysis should not be taken as representative of the Scottish context.

3.3.2. Additional real-world data sources

As demonstrated above, only four of the housing associations participating in the evaluation were able to share real-world data. To expand the dataset, we contacted the following 30 organisations to request any data they might have:

- 4 Scottish universities which research energy in new homes.
- 5 manufacturers of ZDEH technologies.
- 10 companies that provide home energy monitoring solutions.
- 5 affordable housing developers (councils and RSLs).
- 4 private housing developers.
- 2 electricity distribution network operators.

Of the above organisations, only one was aware of any real-world data relating to heat in new builds. This is for two Welsh developments of 49 homes, with ground source heat pumps. This data was requested for this evaluation but was not made available within the required time. Additional conversations with industry representatives for WP2 were also used to source additional data. However, numerous individuals confirmed that there is a distinct lack of real-world data on ZDEH in new build homes in the public domain.

A report by Changeworks and Delta-EE for ClimateXChange, 'Heat pump use in Scotland: an evidence review' [1], provides an overview of the heat pump monitoring projects conducted up to the publication of the report in August 2021. Of the 12 projects named in their report, 8 were conducted in homes, including a monitoring project by the Hebridean Housing Partnership, who are participating in this evaluation. Of the other data sets, none were deemed relevant to this work, as they either focused on retrofitted installations, a single building and/or hybrid heat pumps, or were over ten years old and therefore not representative of current building standards.

3.3.3. Analysis of data provided

Lochalsh and Skye Housing Association (LSHA) collected total electricity demand figures for 2020 from Suisnish Place, a development of 24 homes. The values provided represent 20 of these homes and are presented graphically in Figure 6 and tabulated in Table 3. Annual electricity costs have been

[1] Climate XChange, 2021

presented, based on the Energy Saving Trust's standard electricity tariff in the UK as of April 2022[2].

Figure 6 illustrates that broadly, electricity consumption at Suisnish Place increases with the number of beds (a proxy for occupancy). The tabulated *average annual electricity consumption per bed* values suggest that this relationship is linear, with the exception of the bungalow unit. A likely explanation for this unit type yielding an above average electricity consumption per bed, is that bungalows will have the highest percentage of building envelope compared to other the unit types, resulting in greater heat load (and therefore a higher electricity demand to drive a heat pump). However, this is heavily caveated by the small size of the data set.

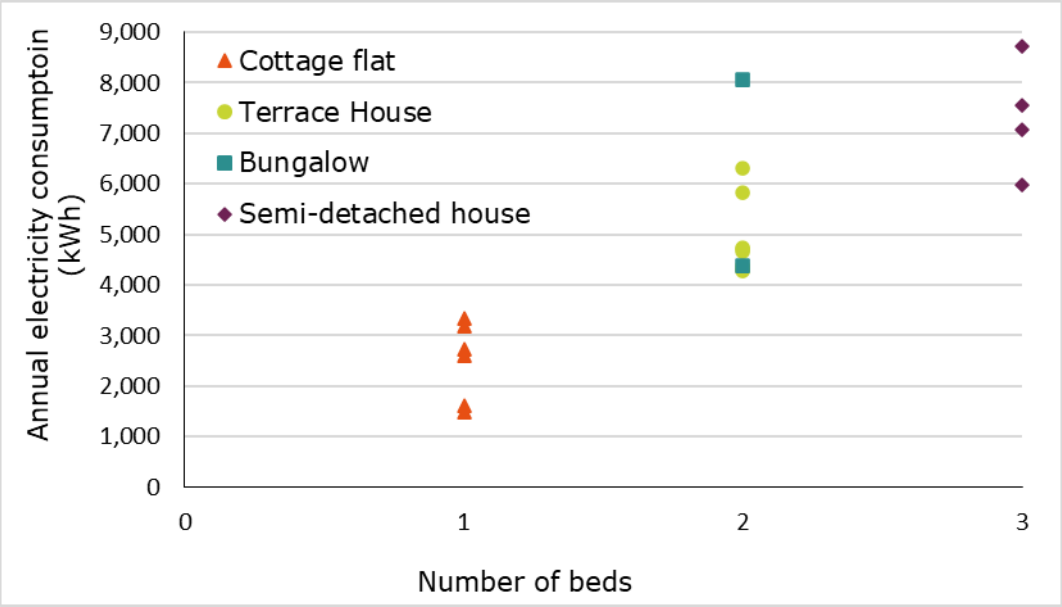

Figure 6: Annual electricity consumption for LSHA development with ASHPs

The UK Government's mean annual energy consumption levels for homes are 13,600 kWh for gas and 3,600 kWh for electricity[3]. Assuming a gas boiler efficiency of 90% and a gas price of 7.4p/kWh (based on Energy Saving Trust data), this equates to a mean annual gas spend of £906 and a total energy spend of £1,925, excluding standing charges (which are also excluded from our analysis). This suggests that the 1- and 2-bed homes at Suisnish Place are cheaper to run on average compared to the mean UK home. The 3 bed units are, on average, £151 more expensive to run, however caution should be taken comparing 'real data' with estimated and inferred data on mean energy consumption and electricity costs. Moreover, the extent to which this is due to heat being provided from a heat pump is impossible to determine, as factors such as occupancy patterns, occupant comfort preferences and local climate (among others) influence energy consumption.

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[2] Energy Saving Trust, 2022

[3] BEIS, 2020

Unit Type	Cottage flat	Terrace House	Bungalow	Semi-detached House
Number of units	8	8	2	6
Number of beds	1	2	2	3
Range in electricity consumption (kWh/an)	1,498-3,351	4,279-4,741	4,375-8,058	5,969-8,725
Average electricity consumption (kWh/an)	2,496	4,901	6,217	7,334
Average electricity consumption per bed (kWh/an)	2,496	2,450	3,108	2,445
Average annual electricity cost @ 28.3p/kwh	£706	£1,387	£1,759	£2,076

Table 3: Analysis of electricity consumption for LSHA development with ASHPs

Hebridean Housing Partnership (HHP) and Osprey Housing (OH) provided annual heat data for 7 homes in the Western Isles, and 13 homes in Aberdeenshire, respectively. The data provided is presented in Table 4 for HHP, and in Table 5 and Table 6 for OH. In Figure 7, heat pump demand is plotted against occupancy and floor area for all 20 homes.

Unit Type	A. Semi-detached bungalow	B. Semi-detached bungalow	C. Semi-detached bungalow	D. Semi-detached bungalow	Detached bungalow	E. Semi-detached bungalow
Number of units	1	2	1	1	1	1
Number of beds	1	2	3	3	4	6
Floor area (m^2)	53	78	88	105	133	154
Heat pump consumption (kWh/an)	1389	2589	2475	4110	5579	12372
Heat pump consumption per bed (kWh/an)	1389	1386	825	1370	1395	2062
Heat pump consumption per m^2 (kWh/m^2/ an)	26	36	28	39	42	80
Annual heating cost @ 28.3p/kwh	£393	£785	£700	£1,163	£1,579	£3,501

Table 4: Analysis of electricity consumption for HHP developments with ASHPs

From Table 4, it is clear that heat demand increases with floor area and occupancy. The values for consumption per bed and per unit floor area do not indicate that this trend is linear. This is not surprising given the small dataset, the impacts of occupant behaviour, and the fact that the homes are not all built to the same specification or in the same development (although they are all constructed to the Bronze sustainability standard and utilise the same heat pump model).

Using the Energy Saving Trust standard electricity tariff, heat pump costs for the HHP homes can be compared to the mean spend for UK homes with gas heating (£906/year). Table 4 indicates that only the smaller three-unit types are as affordable to heat as the UK average. However, the homes that are more expensive to operate are larger in floor area and number of beds (4 and 6 bed units) and this is likely not directly relevant to the mean UK consumption data, which is likely to be more representative of a 3-bed home (although the data source does not confirm this). Moreover, given the location of these homes in the Western Isles, they will more likely require more heat and therefore have higher costs than average, given that the temperature in northern Scotland is lower than in the majority of the UK.

Unit Type	**Detached bungalow**	**Semi-detached bungalow**	**Terrace bungalow**	**Detached bungalow**	**Terrace House**	**Terrace House**	**Terrace House**
Number of units	1	1	1	1	1	1	1
Number of beds	1	2	2	2	2	2	2
Floor area (m^2)	54	56.2	58	69.77	75.5	76.6	84
Heat pump consumption (kWh/an)	574	1236	557	1370	2198	2870	1993
Heat pump consumption per bed (kWh/an)	574	618	279	685	1099	1435	997
Heat pump consumption per m^2 (kWh/m^2/ an)	11	22	10	20	29	37	24
Annual heating cost @ 28.3 p/kwh	£162	£350	£158	£388	£622	£812	£564

Table 5: Analysis of electricity consumption for OH developments with ASHPs (1)

Unit Type	Terrace Bungalow	Semi-detached bungalow	Terrace House	Terrace House	Terrace House	Terrace House
Number of units	1	1	1	1	1	1
Number of beds	3	3	3	3	3	3
Floor area (m^2)	72.8	72.89	89	93.2	96.2	103.8
Heat pump consumption (kWh/an)	783	1346	1911	2257	2447	2279
Heat pump consumption per bed (kWh/an)	261	449	637	752	816	760
Heat pump consumption per m^2 (kWh/m^2/ an)	11	18	21	24	25	22
Annual heating cost @ 28.3p/kwh	£222	£381	£541	£639	£693	£645

Table 6: Analysis of electricity consumption for OH developments with ASHPs (2)

From Table 9 and Table 10, the relationships between electricity consumption and floor area or occupancy is not as clear. This can be explained by the small size of the dataset, the impacts of occupant behaviour, and the fact that the homes are not all built to the same specification, are across different developments and utilise different heat pump models. However, the two tables do indicate that regardless of the variability in demand, all of the OH homes are more affordable to heat than the UK average gas heated home (£906/year).

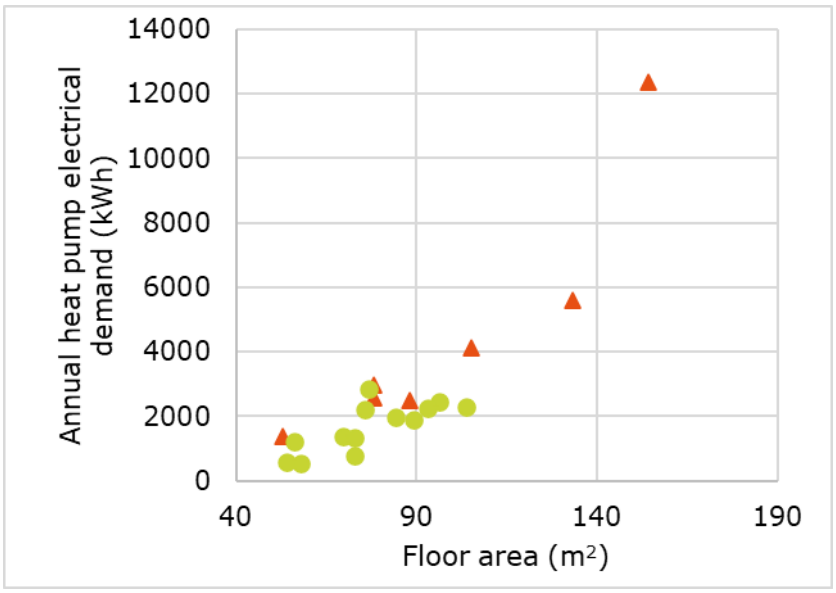

Figure 7: Annual heat pump electrical demand vs floor area (HHP homes in orange, OH homes in green)

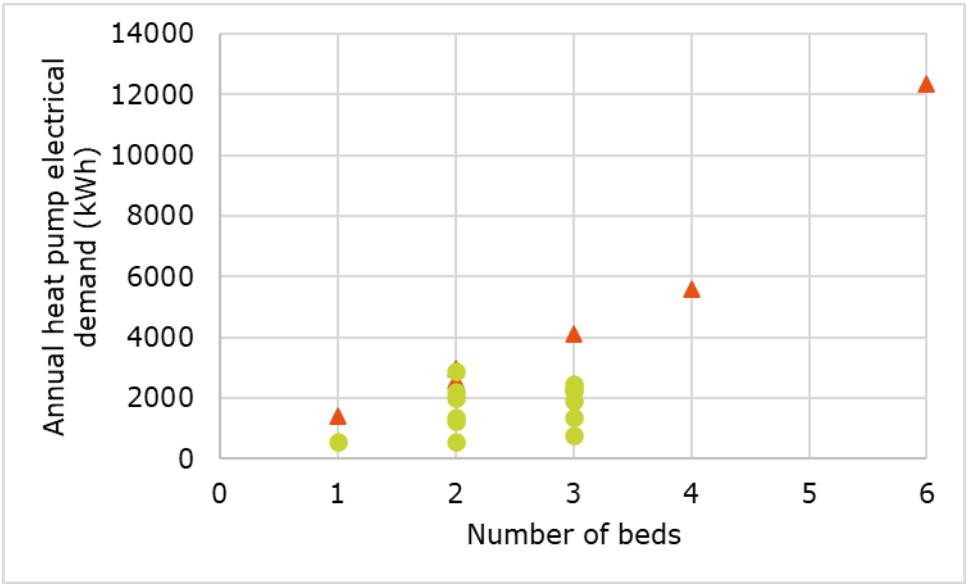

Figure 8: Annual heat pump electrical demand vs number of beds (HHP homes in orange, OH homes in green)

Figure 7 demonstrates a linear relationship between heat pump demand and floor area across the 20 homes, with HHP homes having higher heat consumption. In Figure 8, the relationship between number of beds and heat pump demand is weaker for the OH homes than the HHP homes, although it is difficult to explain these discrepancies with any certainty of accuracy.

4. WP2 - Knowledge sharing hub

4.1. Overview

4.1.1. Rationale

The Phase 1 evaluation in 2021 made the following recommendations on knowledge sharing to support the uptake of ZDEH in new affordable homes:

- Facilitate knowledge sharing between RSLs and Councils to help them save time, use more cost-effective approaches, and increase the use of low- and zero carbon generation technologies (LZCGTs) in new builds.
- Publish best practice and knowledge-sharing findings to support affordable housing providers and increase the use of LZCGTs as a default.
- Facilitate knowledge sharing and best practice between affordable housing providers and private developers to help developers get onboard with LZCGTs. Private developers were noted by several stakeholders to be behind in terms of LZCGT uptake and meeting higher sustainability standards.

These recommendations led the Scottish Government to specify the following as one of the aims for Phase 2 of the evaluation:

- Develop more detailed, practical recommendations for setting up a best practice knowledge sharing hub or equivalent for key stakeholders e.g. developers either through an existing mechanism or developing a new one.

4.1.2. Consultee overview

As affordable housing providers, all eight stakeholders interviewed for WP1 were asked for their opinions on knowledge sharing in the Scottish housing sector and on a potential knowledge sharing hub. Alongside conversations with these stakeholders and the Scottish Government, the following organisations were also consulted on the potential hub:

- SSE
- Cala Homes
- The Glasgow and West of Scotland Forum of Housing Associations
- Good Homes Alliance
- Built Environment – Smarter Transformation
- The Association of Local Authority Chief Housing Officers
- Scotland's Housing Network
- Homes for Scotland
- The Scottish Federation of Housing Associations
- UK Green Building Council
- The Heating and Hotwater Industry Council

The following chapter represents the feedback gathered from these organisations.

4.2. Opportunity analysis

4.2.1. Existing resources

The resources that are currently available to stakeholders in the Scottish housing sector were assessed, with the aim of identifying available information and means of knowledge exchange relevant to the Scottish housing sector, as well as the gaps in these resources. A matrix of these resources is presented in Appendix A.

Whilst this matrix is not exhaustive, it indicates that there are numerous resources available to support the Scottish housing sector. However, none of the resources are dedicated to domestic buildings in Scotland or to ZDEH, and there are no current resources that focus entirely on heat in Scottish buildings (although one is understood to be in development). These findings have been echoed by the interviews with affordable housing stakeholders from WP1.

As such, there is an opportunity to develop a hub specifically for ZDEH in domestic new builds, that utilises existing resources, collaborates with relevant stakeholders, and creates new content directly relevant to its focus, in order to help the sector work towards meeting the 2024 NBHS.

4.2.2. Current knowledge sharing practice

During the calls with stakeholders from WP1, most advised that they currently engage with external groups to share learnings relating to heat and to keep up to date with best practice. Although, two of the eight advised that they engage with energy forums to a very limited degree, partly because they had significant experience and minimal issues with heat pumps.

Across the WP1 stakeholders and the private housebuilder consulted, meetings and forums facilitated by the following groups were referenced as platforms to discuss heat in new builds:

- Homes for Scotland
- Scotland's Housing Network
- Built Environment – Smarter Transformation
- The Scottish Federation of Housing Associations
- The Glasgow and West of Scotland Forum of Housing Associations
- Local Authority Strategic Housing Investment Plan meetings
- Regional Council-RSL housing networks (such as the Highlands and Islands Housing Associations Affordable Warmth Group)

Two stakeholders also referenced email bulletins and a further two mentioned direct relationships with local contractors and heat pump manufacturers as a means of acquiring knowledge.

Given that all stakeholders provided different answers when asked how they currently share knowledge, it is clear that not all housebuilders are accessing the same resources. Over half consulted also indicated that they have a distinct lack of time to engage with external resources. As such, a dedicated hub for ZDEH in new build housing should be clearly advertised to the whole

sector, and represent high value for the time commitment made, in order to avoid low or diminishing engagement.

4.2.3. Requirements for a knowledge sharing hub

Support for a hub

Among the affordable housing providers interviewed, all voiced support for an online knowledge hub dedicated to heat in new builds. Of the 11 industry stakeholders consulted, all but one voiced high support, with one housing network indicating that they would be much more supportive of additional face to face knowledge exchange, rather than an online resource.

Reasons provided in support of a hub, in order of frequency, include:

- To provide **evidence-based** information on the real-world costs of ZDEH in new-builds, as well as tenant experiences
- ZDEH feels very new to a lot of housebuilders
    - Concerns around the costs to install ZDEH systems, and costs to tenants are very high, particularly in urban areas where gas heating is still common in new builds
    - A hub with reliable information could tackle scaremongering in the sector, particularly relating to ASHPs
- It would be good to have a **credible, go-to source of information** on ZDEH, particularly for organisations with limited resources
- To address common questions that housebuilders have in relation to how electric heating and grid connections interact

"I absolutely support the development of a hub, the sooner the better! Housebuilders need to see examples of good practice in one place and speak directly to those who've delivered projects that others can learn from."

Stakeholders from existing networks and associations provided specific questions that they were aware their members would want a hub to address. These are listed in section 5.2, where the content of potential case studies is considered.

Concerns for a hub

Stakeholders also voiced several reservations and concerns regarding the potential knowledge hub. In order of frequency, these included:

- Housebuilders may have a distinct **lack of time to engage** with a hub
    - Many affordable housing providers are currently more concerned with decarbonising their existing stock, rather than new builds
    - The hub should be easy to access – people will be put off if they need more than one password or if they have to pay
- The information provided must be **up to date, unbiased and impartial**
- The hub should have a clear focus and a unique selling point
    - It should avoid duplicating existing information for the sake of creating a new resource

- Some housebuilders **won't want to share bad experiences** in the public domain
- Affordable and private housing developers may not wish to interact with each other

"The housebuilding sector is so busy, learning and sharing knowledge is an 'add on' that often gets dropped due to lack of resources."

The above motivations and concerns regarding the potential hub have been used to inform the recommendations on establishing and implementing a hub (Section 4.4) and what content should be delivered (below), to maximise the benefits to the sector and to reduce risks to success.

Knowledge hub content

The following suggestions for the content of the knowledge hub were provided by stakeholders:

- Summaries of how different ZDEH technologies work
- Case studies that include real-world data on system performance, across different housing types and locations
- Evidence-based recommendations of reliable contractors
- Evidence-based recommendations of ZDEH models and systems that work well
- News and funding opportunities related to ZDEH technologies
- Links to building standards and other relevant policy and regulatory documents
- Links to industry organisations and other relevant resources
- Up to date statistics from the Scottish Government concerning the uptake of ZDEH in developments that receive funding from the Affordable Housing Supply Programme.
- Consumer guides for ZDEH technologies
- DNO guidance on interactions between grid connections and electric heating
- Best practice compliance guides for meeting building regulations
- Relevant research from universities and industry bodies

As a key aim of the hub would be to support the Scottish housebuilding sector, we feel that all of the above suggestions for content merit consideration, having all been suggested by the sector and its supporters. In particular, case studies were discussed with all stakeholders, and opinions around these are summarised in Section 5.

"We think forums are the best way to share knowledge - the lack of sharing of valuable information is more prevalent than a lack of information itself."

Aside from written content, there was strong support, particularly among representatives of housing networks and associations, for the hub to facilitate various activities. The following activities were suggested:

- Forums for the sector to discuss good and bad experiences of ZDEH
- Site visits to housing developments where ZDEH systems are in place

- Q&A events with guest speakers from manufacturers, contractors and DNOs

4.3. Risks to developing and operating a knowledge hub

Through discussing the hub with stakeholders, and exploring existing resources, the risks to developing and operating a hub were identified (as listed in Table 7 below). Suggestions to mitigate each of these are presented based on insights from stakeholders and our own experience.

Name	Description	Mitigation
Funding	Whether the hub is funded externally or via memberships may impact access and engagement.	The Scottish Government could fund the set-up and management of the hub to allow free access to all.
Management	The host organisation will require the time and expertise to manage the hub on an ongoing basis for increased impact.	The Scottish Government should appoint an organisation with good links to industry and existing expertise and experience to lead the hub.
Purpose	The hub should have a clearly defined and communicated purpose based on sector needs.	Engage with the sector to identify their concerns and requirements.
Accessibility	The level of ease of access to the hub impacts willingness to engage. This applies to physical and virtual accessibility as well as accessible content.	If the hub has member-only content, there should be a maximum of one password-protected step to access this content. Online forums enable those in remote locations to access the hub and require less time commitments for all involved.
Engagement	Some stakeholders are likely to have limited time to engage with a new resource.	Engaging with existing organisations with networks in the sector is likely to lead to greater engagement.
Trust	The credibility and reputation of the hub as a resource may impact engagement.	Endorsement from existing networks (where merited) will encourage engagement.

Name	Description	Mitigation
Quality	Resources need to be high quality to be useful to the sector. Engagement may be low or diminish if the resources are not deemed to be high quality.	New content should be moderated to ensure additions are relevant, insightful, unbiased and address key sector questions. Avoid sales pitches, marketing and too much anecdotal insight.
Reputation	Some stakeholders may be nervous to contribute content that highlights challenging or unsuccessful projects if this could be deemed to impact their business.	Consider making sensitive case studies member-only content or using member-only forums to discuss negative experiences to avoid the public domain.
GDPR	Stakeholders may be unwilling or unable to contribute content due to real or perceived GDPR concerns.	Provide guidance on GDPR and that no personal information should be shared in contributions to the hub. Ensure that the hub has a strict GDPR policy.
Inconsistency	Contributions to the hub may use different assumptions or be based on particular conditions (such as electricity tariffs).	Where relevant, all assumptions and conditions should be explicitly stated and standardised as much as practically possible.
Continuity	The hub's resources should be up-to-date and in line with current regulations and best practice.	The hub should be regularly updated and reviewed so that out-of-date information is archived as necessary.
Relevance	The information presented should be relevant to all stakeholders and their respective budgets and remits.	Content should be relevant to the full range of locations, scales, ZDEH technologies and business models.
Vested interests	Private organisations that may manage or provide content to the hub may have vested interests.	Ensure potential vested interests are understood before selecting host organisation and moderate content appropriately.
Unknown unknowns	Issues not yet identified that may impact any aspect of the hub.	Continue scoping the hub and develop a detailed proposal in order to identify further risks.

Table 7: Summary of risks to successful hub development and operation

4.4. Routes to implementation

Broadly there are three potential pathways to developing a knowledge sharing hub. These, and their respective benefits and risks, were discussed with industry stakeholders and are summarised in the table below.

Pathway 1	**Hub developed by the Scottish Government (SG)**
Benefits	• Allows SG to have full control of scope. • Scope can be fully dedicated to heat in new builds. • Easiest way to mandate participation from RSLs and Councils.
Risks	• Internal resource within SG required. • Additional admin time for sector to engage with new hub.
Stakeholder feedback	• Several stakeholders indicated that SG backing is important for the credibility of the hub. • Conversations with SG suggested that an SG-run hub would be a static information portal, which does not meet all the requirements of the sector. • Two industry stakeholders were concerned that SG would not have the expertise to manage the hub over the long term.
Pathway 2	**Hub developed as a new, independent resource**
Benefits	• Scope can be fully dedicated to ZDEH in new build homes.
Risks	• New organisation to be developed, resourced and paid for. • Dedicated staff required. • New website to be created and maintained. • Likely to have highest development costs. • Additional admin time for sector to engage with new hub. • Encouraging engagement from sector may be difficult.
Stakeholder feedback	• Two stakeholders suggest that a new hub could be created by a consortium of existing bodies with complimentary expertise (such as skills, policy, supply chain), although one voiced that a single body should have overarching control in order to have a single point of accountability. • Good Homes Alliance offered to develop and manage the hub, having created a sustainable housing hub for

	new builds in England[4] and advised the Welsh Government[5] on developing a hub for Zero Carbon Housing.
Pathway 3	**Hub added to an existing resource**
Benefits	• Minimises admin for sector if it already engages with the resource. • Minimises requirements for human resource and web development.
Risks	• Scope may overlap with the organisation's other activities. • Not all existing resources are open to the whole of the housing sector. • SG may have limited control of content. • Existing resource could be limited by a membership fee. • Encouraging engagement from sector may be difficult.
Stakeholder feedback	• Two organisations were very supportive of this option as they felt that their members did not have time to engage with a new resource. • A further three organisations were supportive of this option if fully funded. • Built Environment – Smarter Transformation advised that they have a remit from Scottish Enterprise to develop a knowledge hub for heat in buildings (including non-domestic and existing buildings). The scope of the hub is in development as of April 2022.

Table 8: Summary of hub Development Pathways

On the basis of discussions with the Scottish Government and stakeholder feedback, Pathway 1 is understood to be the least viable of the three options. Whether Pathway 2 or Pathway 3 is selected is likely to depend on the budget that the Scottish Government has to support the hub, as creating a new organisation and website is likely to be more expensive than utilising an existing resource. Pathway 2 could be viable if the scope aligns well with the existing organisation/s and its membership, is fully funded and the hub insight is made freely available to non-members.

The feedback from Good Homes Alliance indicates that the appetite exists for a single organisation to lead on the development and management of a hub as a new resource (Pathway 2), provided that it is funded externally (most likely via government support or a paid membership model). The most suitable option

[4] Good Homes Alliance, 2022

[5] Good Homes Alliance, 2021

for Pathway 3 appears to be the hub that the Built Environment – Smarter Transformation are developing, based on stakeholder interviews and the existing resources explored in Section 4.2.1.

4.5. Recommendations for the knowledge hub

Based on the insights presented above, the following recommendations for the development and operation of the hub are suggested.

Knowledge hub creation

1. Engage with and utilise the vast expertise, experience and knowledge from existing associations and networks that already represent the interests of the housing sector. Although not specific to the scope of the prospective hub, they have relevant data and insight, access to and engagement from industry stakeholders and would contribute or advertise the new hub if relevant for them or their members.
2. A new hub or an extension to an existing organisation likely needs to be created, as existing resources do not cover the specific scope of the Scottish Government remit.
3. We recommend that the hub should be developed by an independent entity to give it enough time and resource to focus on the scope that the Scottish Government wants it to deliver. An independent entity might be best placed to deliver on the Scottish Government's objectives if they have existing experience, networks, and understanding of the domestic new build market.

Knowledge hub content

1. A hub should be dynamic in nature, with a variety of content, tools and support for the housebuilding sector to meet the New Build Heat Standard. This includes e.g. forums, events, site visits, as well as written case studies. This is to ensure maximum input and output, avoid static content and overcome reservations around sharing negative experiences in the public domain.
2. The case study library needs to be actively managed to ensure quality, relevance, dissemination of useful data and insights and answering key, up-to-date, industry questions.
3. The hub should link visitors to other useful resources, including policy, regulations, and best practice guidance. The hub managers should create content (or invite appropriate industry bodies to do so) where it cannot be found in existing, publicly available resources.

Knowledge hub implementation

1. Funding will be required to establish the hub since the remit is very specific and existing organisations are already following their own agendas with their resource. This funding could cover staffing costs to create content, moderate external content contributions, organise and advertise events, liaise with the Scottish Government, the supply chain and industry networks and other yet to be defined duties. Funding also ensures the hub content is not behind a pay wall.

2. There is an appetite for a knowledge hub and many existing organisations indicated their interest in collaborating, contributing and hosting the hub, including the UK Green Building Council, the Heating and Hotwater Industry Council, Scottish and Southern Electricity Networks, Good Homes Alliance and Built Environment – Smarter Transformation.
3. To expedite the move to net zero new builds, the hub should be established as soon as possible and run until ZDEH systems are more commonplace in new build developments.

5. WP3 – Case studies

5.1. Stakeholder opinion on case studies

5.1.1. Rationale

Across WP1 and WP2, the stakeholders were very supportive of case studies being developed as a resource for the knowledge sharing hub, with key reasons for support including:

- To guide developers on what heating systems and specifications are appropriate for different housing types and locations.
- To provide evidence of the operational costs of various ZDEH systems.
- To demonstrate the successes and challenges associated with developing and operating ZDEH systems.
- To give Council/RSL developers peace of mind that a given heating system is a good solution for tenants.
- To provide more training materials for staff.
- To help educate tenants on comfortable and cost-effective heating system operation.

5.1.2. Content

Among the stakeholders, there was a strong feeling that case studies should present unbiased, evidence-based information that is replicable for as broad as possible a range of development types, sizes and locations.

In terms of the content of case studies, stakeholders made the following suggestions:

- Examples of systems that have worked well in practice, including systems that have been designed, installed, and maintained well.
- Projects that are replicable (i.e., not innovation or grant-funded projects that cannot be achieved within typical budgets).
- The names of reliable contractors and manufacturers.
- Details of how the systems were funded.
- Actual capital and operational costs of ZDEH systems.
- Effective strategies for educating tenants on how to operate ZDEH systems.
- Positive and negative experiences, and lessons learned.
- Contact details to allow follow-up conversations with the housebuilder.

"I'd want to see how tenants were impacted, and what went well and badly. The case studies should be honest and highlight lessons learned. I don't want to feel like I'm being sold something."

"Evidence is essential - without this, a case study is just a bit of advertising and a pat on the back for the housing provider."

Whilst support for case studies was high, the following reservations were raised:

- The case studies need to be well advertised so they are not a wasted opportunity.
- Without evidence of real-world costs and post-completion experiences, the case studies may be regarded as low value.
- Supply chain conditions, the state of the art in terms of ZDEH technologies, and best practice can change very quickly, so the case study library needs to be kept up to date.

These suggestions were used to develop the case study template that Locogen used to create five case studies (Section 5.3) and to develop recommendations for future contributions to the hub's case study library.

5.2. Best practice guidance

It is important that case studies are informative, well presented and efficiently communicate relevant insights, so that they will be of high value to the Scottish housing sector. Having reviewed a wide variety of case studies on built environment projects, we created a template for the five initial case studies to draw from the best elements of these. Suggestions for layout formatting are listed in the table below.

What works well	What to avoid
• Clear layout with headings • Use of images and charts • Structured narrative points • Use of break out boxes • Use of quotations • Use of relevant data • Text broken up by other elements • Accessible font sizes	• Too much continuous text • Too many pictures • Too much use of color • Crowded layout due to lack of blank space • Sales and marketing narrative

Table 9: Suggestions for layout and formatting of case studies

Suggestions for case study content, along with the rationale for each of these, are provided in the table below. These are based on the findings from the previous work packages and are believed to help the reader determine how they could successfully implement a given ZDEH technology in a new development.

Suggestion	Rationale
Size, unit types and location of development	To provide context that will help establish the relevancy of the case study to the reader
Name of housing provider and contact details	To allow the reader to follow up with the provider if they have questions
Details of the heating system (including manufacturer), heat delivery system and in-home controls	To provide a technical overview of the heating system and its key elements
Explanation of the development process, including funding sources, justification for key decisions made, and details of any problems faced	To highlight what process was followed, what decisions were made and what challenges were faced prior to handover and how these were addressed
Explanation of handover process	To demonstrate how the handover process introduced the heating system and its controls to tenants, and any good or bad outcomes
Feedback from occupants	To provide evidence of tenant/owner perceptions of the heating system, what compliments and complaints they had and what support they required to address these
Actual annual running costs	To provide evidence of what occupants pay for their heating systems
Technical performance, including long-term efficiency, planned and unplanned maintenance requirements	To provide evidence on how the heating systems performed compared to expectations, and what issues were faced and how these were resolved
Lessons learned, including the key challenges and successes of the project	To highlight important insights from all phases of the project, so that the reader can learn from these

Table 10: Suggestions for content of case studies

From WP1 and WP2, stakeholders highlighted the following questions that they would like case studies to address:

- What are the actual capital, running and maintenance costs of ZDEH systems?
- How can air source heat pumps work for developments with flats?
- How do heat pumps impact disabled tenants?
- What are all of the ZDEH options, aside from ASHPs?

- How does billing work for district heating systems?
- Which manufacturers and contractors can we rely on?
- Do ASHPs work as well in colder locations?
- When is a 'fabric first' approach with direct electric heating more cost effective than an ASHP?

Whilst these topics represent some of the sector's current priorities and concerns, it is important to acknowledge that these will change over time, due to changes to innovations in technology and best practice, and changes to policy, regulation and the supply chain. Therefore, if the hub advertises suggested topics to guide the content of case studies, these should be reviewed (annually at a minimum) to ensure that the case studies remain relevant over time.

5.3. Case Studies

Given the strong indication from stakeholders that case studies should detail operational experiences and be supported by numerical data, we approached housing associations with operational projects, where heating cost and/or demand had been monitored for at least a year. The case studies completed are presented in a separate document and summarised in the table below.

Project	Housing provider	Technology	Occupation date	Location	No. of units
Dunbeg Phase 3	Link Group	ASHPs	2021	Argyll and Bute	300
Suisnish Place	Lochalsh and Skye Housing Association	ASHPs	2018	Highland	24
MacKenzie Avenue	Hebridean Housing Partnership	ASHPs	2020	Western Isles	7
Kirkton O'Neil Phase 1	Osprey Housing	ASHPs	2020	Aberdeenshire	50
Wharton Square	Hillcrest Housing	Heat network	2013	Edinburgh	174

Table 11: Overview of completed case studies

5.3.1. Suggested future case studies

During the process of selecting potential case studies, the following projects were identified. These are expected to make valuable contributions to the knowledge hub, on the basis that they meet the current questions of the sector, but either were not ready to be profiled at the time of writing or were surplus to the agreed WP3 scope.

Project	Housing provider	Technology	Status	Location
Granton	City of Edinburgh Council	Communal ASHP	In development	Edinburgh
The Blar	Highland Council	ASHPs, PV, Heat Batteries	In development	Highland
Tomintoul	Tomintoul and Glenlivet Development Trust	ASHPs, PV, Heat Batteries	In development	Moray
Queens Quay	West Dunbartonshire Council	District heating from River-source heat pump	Operational	West Dunbartonshire
Newbridge	Hillcrest Homes	GSHP	In development	Edinburgh
Glenrothes	Kingdom Housing Association	District heating from industrial	In development	Fife
Galashiels	Eildon Housing Association	Communal ASHP	In development	Scottish Borders

Table 12: Summary of proposed case studies

We also approached ZDEH technology manufactures directly to ascertain if they had any existing case studies on Scottish new build housing projects that could be added to the hub. No examples were found, although Kensa advised that they were working on a case study of a GSHP in April 2022, and that they would be happy for this to be included in a prospective knowledge hub. Scotland's Housing Network and the Scottish Federation of Housing Associations both indicated that they would encourage their members to submit case studies to the hub.

Appendix A. Existing Knowledge Share Resources

The following tables summarises the existing online resources available to the Scottish Housing Sector that are relevant to heating systems and/or new build construction.

Organisation	Name	Homes for Scotland	UK Green Building Council	Scotland's Housing Network	Heat Pump Association
	Type of Organisation	Association	Association	Association	Association
	Sector	Housing	Building	Housing	Heat Pump
Scope	Building Scope	Domestic	Both	Domestic	Both
	Geographical scope	Scotland	UK	Scotland	UK
Information	Performance	N	Y	Y	Y
	Tenant	N	N	Y	N
	Implementation	N	Y	N	Y
	Lessons Learnt	Y	N	Y	Y
	Policy & regs	Y	Y	N	Y
	Costs	N	N	N	N
	Innovation	Y	Y	Y	Y
	Supply chain	Y	N	N	N
How information is shared	Website	Y	Y	Y	Y
	Reports	Y	Y	Y	Y
	Meetings	Y	Y	Y	Y
	Webinars	N	Y	N	Y
	Events	Y	Y	N	Y
	Information Accessibility	Membership required	Semi-private	Publicly available	Semi-private

Table 13: Online resources for Scottish Housing sector (1 of 4)

Organisation	Name	National House Building Council	Scottish Federation of Housing Associations	Convention of Scottish Local Authorities	Built Environment – Smarter Transformation
	Type of Organisation	Association	Association	Government body	Association
	Sector	Housing	Housing	General	Building
Scope	Building Scope	Domestic	Domestic	Both	Both
	Geographical scope	UK	Scotland	Scotland	Scotland
Information	Performance	Y	N	N	Y
	Tenant	Y	Y	N	N
	Implementation	Y	N	N	Y
	Lessons Learnt	Y	N	N	Y
	Policy & regs	Y	Y	Y	Y
	Costs	N	N	N	Y
	Innovation	Y	Y	N	Y
	Supply chain	Y	N	N	Y
How information is shared	Website	Y	Y	Y	Y
	Reports	N	Y	Y	Y
	Meetings	Y	Y	Y	Y
	Webinars	Y	Y	N	Y
	Events	Y	Y	Y	Y
	Information Accessibility	Semi-private	Semi-private	Publicly available	Publicly available

Table 14: Online resources for Scottish Housing sector (2 of 4)

Organisation	Name	Zero Waste Scotland	BRE	Highlands and Islands Enterprise	Scottish Enterprise
	Type of Organisation	Association	Association	Government body	Association
	Sector	Sustainability	Building	General	General
Scope	Building Scope	Both	Building + wider scope	Building + wider scope	Other
	Geographical scope	Scotland	UK	Scotland	Scotland
Information	Performance	Y	Y	N	N
	Tenant	N	Y	N	N
	Implementation	Y	Y	Y	N
	Lessons Learnt	Y	Y	Y	Y
	Policy & regs	Y	Y	Y	Y
	Costs	Y	N	N	N
	Innovation	Y	N	N	Y
	Supply chain	Y	N	Y	N
How information is shared	Website	Y	Y	Y	Y
	Reports	Y	Y	Y	Y
	Meetings	N	N	N	N
	Webinars	Y	N	N	Y
	Events	Y	N	Y	Y
	Information Accessibility	Publicly available	Semi-private	Publicly available	Publicly available

Table 15: Online resources for Scottish Housing sector (3 of 4)

Organisation	Name	Energy Saving Trust	Energy Systems Catapult	Passivhaus Trust	Energy Action Scotland
	Type of Organisation	Organisation	Association	Association	Association
	Sector	Energy	Energy	Building	Energy
Scope	Building Scope	Building + wider scope	Building + wider scope	Both	Domestic
	Geographical scope	UK	UK	UK	Scotland
Information	Performance	Y	Y	Y	N
	Tenant	Y	N	Y	Y
	Implementation	Y	Y	Y	N
	Lessons Learnt	Y	N	Y	N
	Policy & regs	Y	Y	N	Y
	Costs	Y	N	Y	N
	Innovation	Y	Y	Y	N
	Supply chain	Y	N	N	N
How information is shared	Website	Y	Y	Y	Y
	Reports	Y	Y	Y	Y
	Meetings	Y	Y	Y	Y
	Webinars	Y	Y	Y	N
	Events	Y	Y	Y	Y
	Information Accessibility	Publicly available	Semi-private	Publicly available	Publicly available

Table 16: Online resources for Scottish Housing sector (4 of 4)

This publication is available at **www.gov.scot**

Any enquiries regarding this publication should be sent to us at

The Scottish Government
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Edinburgh
EH1 3DG

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