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Topical Article

Early-stage Guidance on Heat Pump Retrofit for Non-Domestic Buildings: Interim Results from HPT Annex 60

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This article outlines early-stage guidance from HPT Annex 60 on retrofitting heat pump systems in non-domestic buildings. It presents an interactive tool designed to assist decision-makers by filtering over 25 possible configurations based on building constraints and priorities. The tool also connects users to case studies and system descriptions, supporting informed decisions amidst sparse data and evolving market conditions.

Introduction

We all know that we need to decarbonize the heating in all our buildings, most of which have already been built. This is as true for nondomestic buildings as it is for dwellings, yet they have received less attention in terms of policy measures or technical guidance, despite typically accounting for around one-third of national heating energy. Existing non-domestic buildings pose different problems to dwellings but also offer additional opportunities.

The aim of Annex 60, "Retrofitting Heat Pump Systems in Large Non-domestic Buildings" [1] is to provide early-stage guidance to building owners and their advisors on the types of heat pump retrofit that best suit the circumstances of their buildings and their cost and carbon reduction priorities. This will be provided by an interactive tool that first filters the 25 or so different possible system configurations to match constraints identified by the tool user and selects a short-list suggested as being worth investigating in detail. The shortlist will be linked to a database of case studies that illustrate existing retrofits that most closely match the circumstances of the tool user. It is intended to make this accessible on the Technology Collaboration Programme website, where it can be updated as new information becomes available.

With policies to phase out fossil fuel heating becoming more widespread, consideration of retrofitting a heat pump system is likely to be triggered either by an existing boiler (or other heat generator) approaching the end of its life, by a heating system needing to be replaced for similar reasons, or by the substantial refurbishment of a building perhaps for a change in use. If the average life of a boiler is about 15 years, the annual replacement rate is about 7% of the installed stock (perhaps slightly fewer if there is an incentive for life extension). Based on typical reported lifetimes, major changes to systems might occur at about half this rate. These rates are significantly higher than the estimates of the order of 1% per year for deep energy renovation. In most cases, the heat distribution system will be in good order, and systems that retain it will tend to be favoured.

Interim results

The first stage of the Annex was a literature review. This revealed that there was hardly any published guidance on retrofitting heat pumps to non-domestic buildings, though that is now starting to change [2,3,4,5,6]. There are also very few statistics on existing markets, probably because the markets are still in the very early stages of development. In the UK, for example, annual sales of heat pumps into non-domestic buildings are probably about 2000 units per year, of which about 2/3 are believed to be in existing buildings – an even smaller market penetration rate than for dwellings. They appear to be predominantly installed in two niche markets: public buildings (where financial incentives exist for a limited number of buildings) and in a specific part of the office market, where major refurbishment can be justified by expected rental increases - these "class A offices" typically require very good energy performance and sustainability ratings that favour the use of heat pumps.

The Annex has collectively collected over 100 case studies, but these vary considerably in the amount of information that is available. The term "case studies" is used in the Annex to serve several functions: to provide reassurance to tool users that others have successfully carried out retrofits in circumstances similar to their own; to provide a degree of insight into the costs and performances of systems; and to provide detailed insight into the performance of a few example installations. Most of the current case studies satisfy the first of purposes, but few have much information about actual performance. The number of "deep dive" studies is small.

The most common market sectors in the case study collection are offices, schools, and "arts. leisure, community, and religion" but this is probably not representative of the market: in particular, the retail, hospitality (hotels), and health sectors may be under-represented. It is likely that the distributions will be different in different countries. Figure 1 shows the distribution of system types in the case studies. In the absence of statistics, this is not necessarily representative of the market mix. By far, the most common system is air-to-water, of which a significant (and possibly under-reported) proportion are either bivalent systems or systems with heat pumps that can produce flow temperatures close to those that would be supplied from an oil or gas boiler. These have the obvious advantage of reducing or eliminating the need to replace heat emitters, which is a potentially expensive and disruptive action that interferes with the activities carried out in the building. Bivalent systems provide some reassurance to building owners who have concerns about being completely dependent on the heat pump system: they also appear to offer good carbon savings relative to capital cost. This is, however, contingent on their being designed and operated in a way that restricts the use of fossil fuel to "top-up" operations. We do not have sufficient data to reliably map system types against building sectors.

Other relatively common types of system are the ground source (sometimes bivalent) and the modification of air conditioning systems to provide heating. In many countries, the largest market for heat pumps is as reversible room air conditioners: these are considered to be out of scope for the Annex, but variable refrigerant flow (VRF) or water-loop systems (WLHP) are in scope. In the case study portfolio, there are similar numbers of polyvalent (4- or 6-pipe) chillers and VRF systems. VRF systems have the advantage that they can be implemented floor by floor in buildings where the duration and timing of leases for each floor varies. Case studies that only provide service hot water are shown separately, but stand-alone water heating installed alongside a separate space heating or cooling systems is not distinguished from a combined system.

Figure 1 shows 13 types of system, but the guidance tool includes twice this number, selected from over 200 theoretically possible configurations. The identification of which options look promising for a specific building depends on many factors: the priorities of and constraints facing the decision maker, the location of the building (including its climate and electricity supply), the levels and patterns of heat demand, and the level of planned system refurbishment (if any). The nature of the existing heat distribution system will often be an important factor: unless it needs to be replaced for other reasons, modifying or replacing it is an avoidable cost, and (if it is satisfactory) its design is a good proxy indication of many of the system design requirements.

The tool is intended to provide its users with early-stage guidance through this maze by using their responses to questions to filter out options that have serious constraints or do not match their priorities and concerns. This will leave a “short list” (of variable length) of options on which to focus a more detailed assessment. It will provide some generic relative guidance: for example, “Option A will usually be more expensive than option B but will abate more carbon emissions.” This is intended to allow them to have a focused discussion with their design consultants or equipment suppliers. It is likely to be useful, for example, to decision makers in smaller businesses who may be considering what would normally be a boiler for boiler replacement but are aware that regulation or sustainability concerns require them to consider a heat pump instead. These decision makers probably do not have immediate access to specialist system designers and may wish to become better-informed ahead of detailed discussions with suppliers, installers, and designers. They are probably not contemplating major building or system refurbishment, though the tool should also be useful if they are.

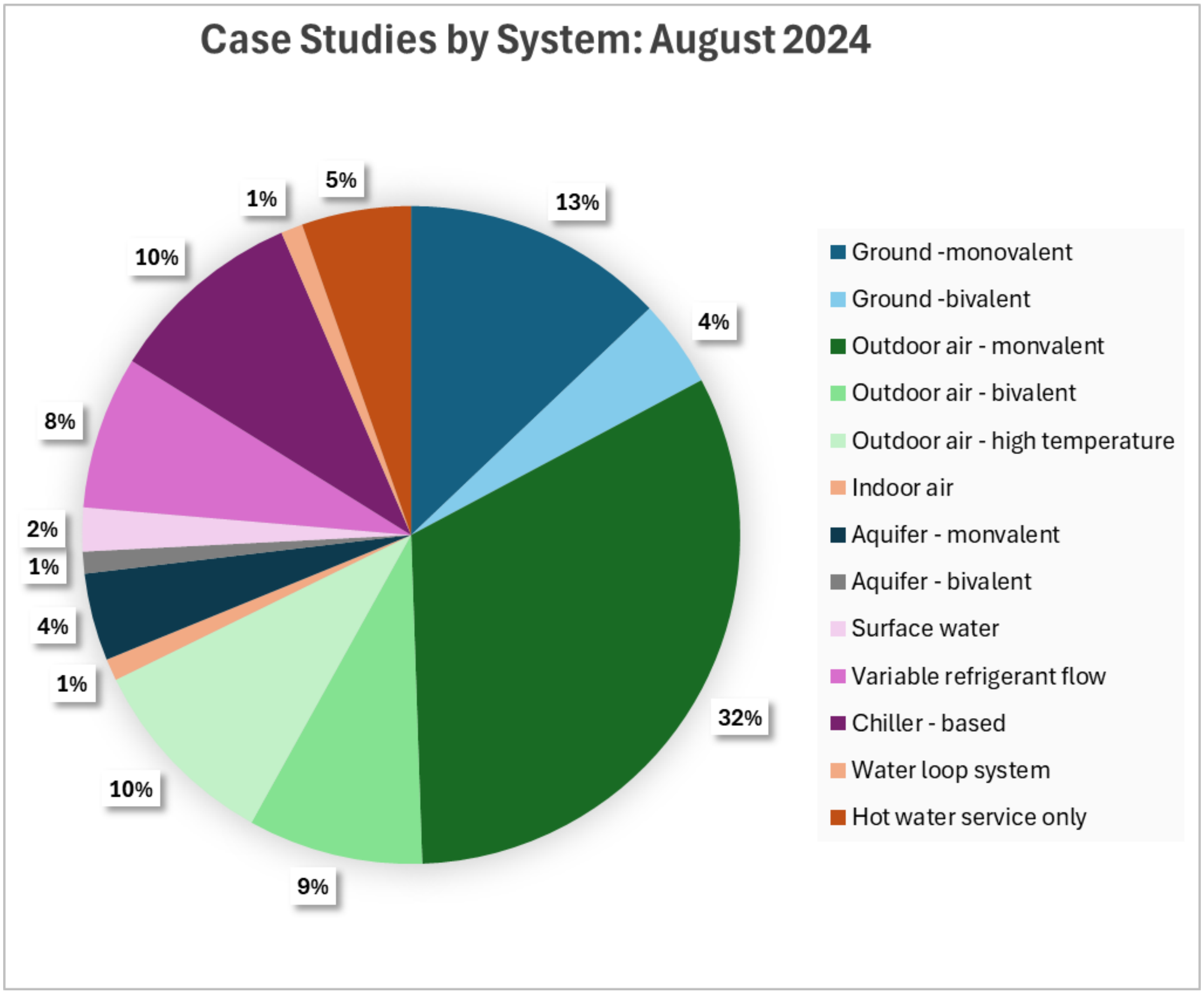

Figure 1: Distribution of system types in the case studies

The basic structure of the tool is shown in Figure 2: the logic module handles the short-listing process and links to a database of case studies and also to a set of generic descriptions of each type of system. The shortlist of suggested system options provides links to these for those systems that are suggested. If they prefer, tool users can interrogate the case study and system description databases directly, for example, before answering the questions for the guidance module.

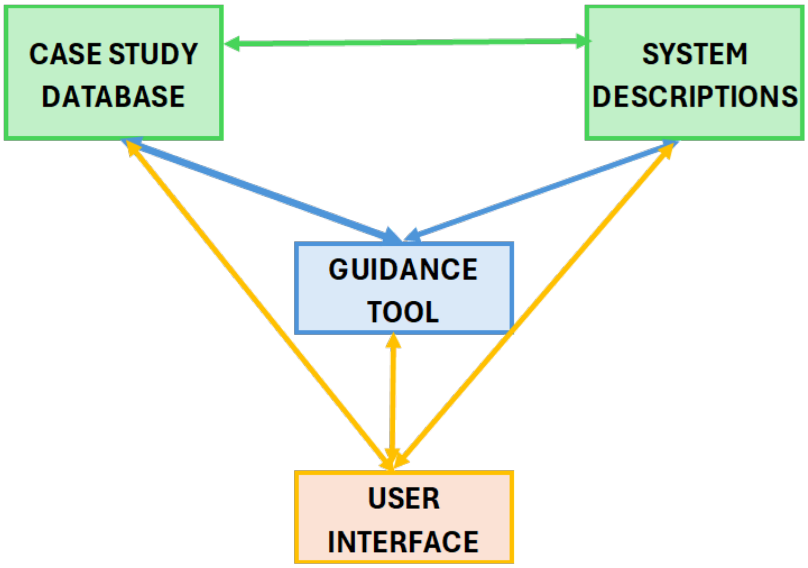

Figure 2: basic structure of the tool

Figure 3 provides an overview of the logic process: the initial long-list - currently of 27 system options - is filtered by question responses – currently 12 to 14 questions (in some cases, the response to a question leads to additional ones) to produce the shortlist. Some questions will allow a “don’t know” response, which will generate advice to either seek more information or explore the options for both “yes” and “no” responses.

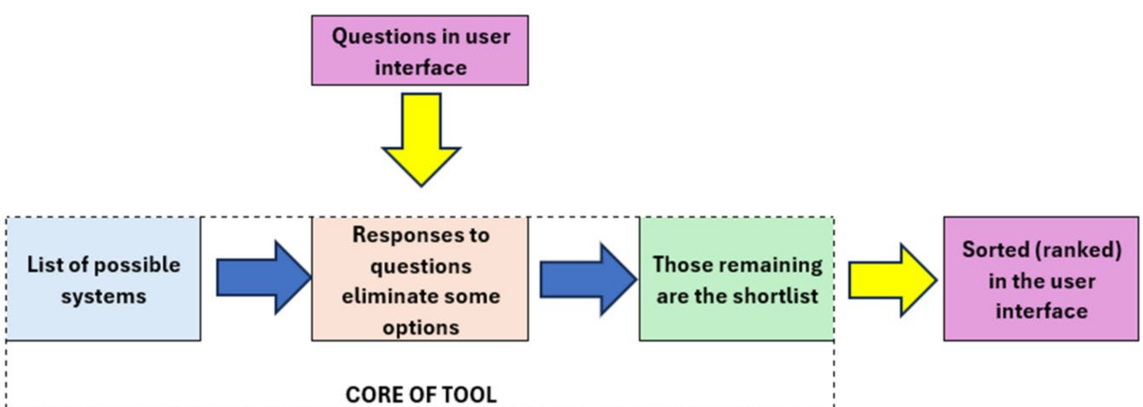

Figure 3. Overview of the logic process:

The ranking process is proving to be one of the more challenging aspects of the project because data is sparse and consistent comparison between data for different system/building combinations is difficult. Ideally, comparisons would be based on technico-economic studies of different options for the same building, but these have proved to be difficult to obtain, even anonymously.

The best means of presenting the results to tool users is also still to be agreed upon. Figure 4 shows one graphical possibility. The chart shows the relative performance of a set of systems for three metrics: capital cost (blue), carbon abatement (orange), and capital cost per unit of carbon abated (grey). The longer the bar, the better the performance. Alternatively, the tool user could be asked to prioritise their criteria.

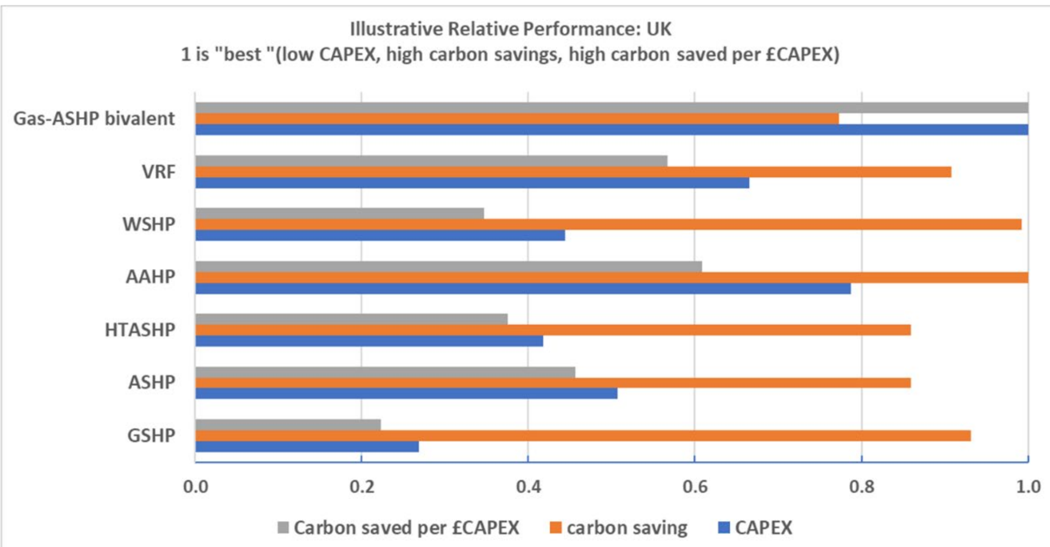

Figure 4: Relative performance of a set of systems for three metrics: capital cost (blue), carbon abatement (orange), and capital cost per unit of carbon abated (grey)

Discussion

The project has been more demanding than expected, partly because less information and experience is available than had been expected. It is hoped to extend the project for a year, but, even so, it is clear that market experience on which guidance can be based will remain in short supply. There is a longer-term need to collect and collate experience as the market develops.

Other outstanding questions include:

- How much does the guidance need to be specific to countries or regions with different energy supply systems, climates, and regulatory frameworks? Canada, for example, contains regions that differ substantially in some of these respects – making its substantial contributions to the project difficult to generalize.

- Who are the decision-makers? Small businesses may be run by a few individuals who have many other business decisions to address, but larger organizations are likely to have multilevel management hierarchies, each level of which needs to give approval.

More generally, and outside the formal scope of the project, the shortage of market information means that policymakers are poorly placed to consider policy instruments focused on the sector.

Meanwhile, the guidance tool and databases will form a framework whose value will increase as it becomes better populated and feedback from its use is used to develop its content and procedures further.

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