Section 01a – Understanding of the sector in the UK and internationally

Policy context

Heat pumping technology is well-established in the refrigeration and air-conditioning markets but far less common for heating-only applications in buildings or industry. The need to phase out the use of fossil fuels has created an international focus on heat pumps as an important, favoured option to achieve this. The IEA 2017 ETP [1] identified heat pumps as a critical enabler needing ten-fold increase in deployment and the Sustainable Development Scenario in the 2020 version of the ETP shows them becoming dominant form of heating. [2] In its "Net zero emission by 2050 roadmap" [3,] it recommends that 50% of heating should be by heat pumps by 2045, meeting over 50% of all building heating needs, and will have an important role in decarbonising industry. UK decarbonisation and energy policy has a similar focus with a target of 600,000 heat pump sales annually by 2028, [4] supported by a number of policies including the phase-out of gas boilers, the Boiler Upgrade Scheme and changes to the Building Regulations that are expected to make heat pumps the primary heating technology for new homes [5]. While the immediate challenges relate to deployment, there is potential for international cooperation at all technology readiness levels and the HPT TCP has – and has previously had – projects ranging from fundamental research on new heat pumping technologies to near-market deployment barriers issues. [6]

Opportunities and challenges by market sector

(This section is based on a mixture of public documents and informal interactions with the industry. The focus is on the UK and similar markets. A list of references is attached separately.)

The market for heating systems in buildings can be subdivided into sectors in several ways, but the most useful distinctions are between new and existing buildings; and between dwellings (and buildings of similar size) and larger nondomestic buildings (itself a heterogenous sector: multiple-dwelling buildings straddle the boundary). Some of the deployment challenges – notably initial and running costs - apply to all sectors, but others vary by sector. Currently, total sales are around 70,000 per year, rising rapidly, with the largest sector being existing owner-occupied dwellings. Sales of larger systems into non-domestic buildings are fewer but showing a double-digit growth rate. [7]

Existing dwellings

The existing dwellings sector has the greatest carbon saving potential, but also faces the greatest challenges and has been the main focus of policy actions. It predominantly consists of single-family dwellings, of different ages and designs, heated by systems based on radiators and a gas boiler. [8] Monobloc air-source heat units have become the most common heat pump solution for this sector. The current generation of suitably sized heat pumps cannot provide output temperatures equal to those provided by gas boilers. As a result, modification to radiators (typically by replacing single-panel radiators by double panel ones) may be required, incurring extra cost and disruption. These modifications are not always be necessary, but whether this is not easy to determine. Generous "rule of thumb" sizing of boiler/radiator systems is thought to be common (the performance and cost of these is robust to a degree of oversizing, and the risk of later rectification is removed); or the building may have been insulated while retaining the original radiators. In addition, peak supply temperatures are only required at "switch-on" and can be reduced by the use of controls that automatically extend the "preheat" period. It has been estimated that around 17% of systems may not need radiator upgrading and perhaps another 10% or so being satisfactory if basic insulation was installed [9] . It would be surprising if heat manufacturers were not addressing the temperature problem – higher temperature products are already available for some nondomestic applications – though there only occasional hints that this is taking place. The provision of domestic hot water presents is another challenge, as many householders have removed hot water cylinders and

installed combination boilers that can provide instantaneous hot water. This approach to water heating requires a power output of around 25 to 30 kW which is well above the peak space heating demand or the usual electricity connection to dwellings. The availability of a suitable electricity supply can also be a significant constraint on large-scale take-up: distribution cables and transformers to groups of dwellings are sized for on the basis of the highly diversified peak of perhaps 1-2kW per dwelling. Heat pumps operation is more synchronised and therefore less diversified, so this sizing is no longer satisfactory. Most heat pump manufacturers are offshoots of air conditioning manufacturers who have limited experience of selling and installing heating systems to consumers. Sales in the existing dwelling sector are growing, but the market is still at the "early adopter" stage, with relatively expensive individual sales being made by a thinly scattered supply chain of small installation businesses. The performance of the heat pumps themselves is generally satisfactory but the measured overall efficiency of UK systems is more variable than in countries such as Germany, despite the existence of the MCS certification scheme for installers [10] . The Heat Pump Association has recognised the value of upskilling the established gas system installer population by developing accredited conversion courses. [11] Some new businesses that are now entering the market have more sophisticated and commercial strategies focussing on easy-to-install properties concentrated in well-defined locations. [12]

Existing non-domestic buildings

The non-domestic sector contains most of the heat pumps that provide heating in UK buildings, in the form of reversible room air conditioners. It has far fewer fossil fuelled hearing systems than the domestic sector, but they are much larger and the aggregate potential for carbon abatement is high. Some of the challenges for heat pump installation are less severe than in the dwelling sector. The larger scale (and sometimes complexity) of non-domestic heating systems means that they are often designed by professional engineering teams. Decisions are subject to more formal financial appraisal than in dwellings (though that can be a mixed blessing). A significant proportion of buildings have air conditioning systems, with the consequence that many system designers have technical expertise that is relevant to heat pumps. In this sector heating systems may be replaced as part of a building refurbishment programme which encourages an integrated approach to building and system modifications. The sector contains many types and sizes of buildings and a large range of possible heat pump system configurations, including the somewhat overlooked options for heat pump water heaters [13] . Many of these are relatively unfamiliar to designers but guidance to this complex landscape is increasingly available through CIBSE Application Manual AM17 and HPT Annex 60. [14, 15]

New buildings

Systems for new buildings can avoid or minimise many of the technical challenges facing installations in existing buildings, where there is much more design flexibility. The market penetration of heat pumps is already higher but, as the potential market for annual sales is much smaller than for existing buildings, the number of sales to the new and existing building sectors have been comparable. In nondomestic building that have both heating and cooling demands, ground source systems – sometimes using "energy piles" – are already a relatively common design solution as they reduce the need for cooling towers and provide a degree of inter-seasonal heat storage in the ground. [16] The market penetration of heat pump systems is likely to increase substantially following the introduction of the newly revised building regulations. Systems in new buildings may combine heat pumps with other renewable technologies in ways that are relatively untried and there is a need to carefully monitor and report on early experiences in order to prevent the spread of attractive looking but, in practice, problematic approaches.

Section 01b – Developing research tasks and leading working groups

Experience

Throughout most my career I have been involved in collaborative projects and working groups including international and national standards committees and working groups, national and international collaborative research projects, government and inter-government advisory groups, and interdepartmental working groups. A reference list is appended. [REDACTED]

Between 2000 and 2010, when UK interest in heat pumps was much lower than it is today, [REDACTED]

Beyond the UK, and in the wider framework of building energy efficiency, from 1999 until recently [REDACTED]

[REDACTED]

Suggestions for Annexes

The TCP already has Annexes that address issues at all technology readiness levels. Although there are several annexes relating to deployment issues (including in the somewhat overlooked industrial market), there remain some deployment-related gaps, typically on the fringes of the traditional scope of a TCP. My suggestions are:

1. *Higher temperature domestic heat pumps*. Evaluation of the options and market-readiness of higher-temperature domestic heat pumps. Technically, heat pumps that provide supply temperatures compatible with those used with gas boilers are possible. I am not aware of any significant manufacturers who admit to this but, from my experience working in applied research in the gas industry, it would be surprising if they did not have development projects. A logical response would be to first gain experience from the emerging products for use in larger buildings, where extra cost and complexity is less of a barrier, the technical knowledge of installers and operators is likely to be greater and the opportunities to respond to teething troubles more manageable than in the more challenging dwelling market. The benefits would be much easier access to the existing building retrofit market.

2. *Integrated provision heat pumps into hot water services*. The provision of a heat pump-based hot water service is challenging in existing dwellings, partly because of the higher temperatures required, especially for legionella control, and because of space limitations for hot water storage. Water heating systems combining heat pumps with solar thermal (or PV "spilled electricity") energy exist (and have often been simulated) but there does not appear to be any consolidated review of the costs, benefits, and optimal design features of such systems, especially for larger, non-domestic systems. This could draw on the results of a previous Annex on heat pump water heater performance.

3. *Decentralised heating systems using heat pumps*. In the UK, heat pump systems in dwellings (in particular) are commonly characterised as being a development of the whole-house, radiator-based systems with which UK consumers have become accustomed over the last half-century. Although consumers tend to have strongly rooted perceptions, other system configurations have been available in the past, features from which may be rationally more appropriate to their needs. These could, for example, be room-based systems – perhaps centrally controlled – with mixtures of small heat pumps (perhaps with ventilation heat reclaim or providing cooling to a "safe space" during heat waves) , and direct or semi-storage heaters.

Section 2 Links with community in the technology area

[REDACTED]

[REDACTED]

R*elevant committee and working group membership and chairmanships*

[REDACTED]

Section 3 Knowledge transfer plan

My knowledge transfer plan retains the existing framework and procedures, [REDACTED]

A network of knowledge transfer links is a central component of all TCPs. Many of these links are common to all TCPs, but those that include market-ready technologies have a specific need to exchange knowledge with the designers, installers and operators of products and systems that are entering the market. This requires additional knowledge exchanges addressed to these audiences, focussing on issues of particular relevance including feedback from early installations and a general sharing of experience. Several TCP annexes address these issues; their results are made publicly available and are communicated to the UK heat pump industry through the National Team, in particular through the annual seminar/workshop which typically attract 60 to 100 delegates (more when online) and attract favourable comments; and by regular mail-outs to the 300plus National Team contact list. These activities should continue but although the national team contact list is large and includes representatives from all sectors of the industry it cannot reach all the target audience. As the TCP is relatively unknown to practitioners, practical information is best delivered through the trade and professional bodies who have more direct links with them and can provide a more focussed and familiar source of information. The UK has always encouraged informal participation in annexes from industry bodies alongside the formal academic participants. This should be continued and, if possible, strengthened. Unlike some other countries, the UK does not have a national energy agency that can provide a focus for this type of activity, and it is an important part the role of the alternate delegate. If appointed, I would continue to encourage such participation through my links with the trade and professional bodies, the industry-wide Heat Pump Liaison Group and by one-to-one contacts. [REDACTED] This knowledge exchange would be strengthened by a wider general visibility of annex outcomes, ideally focussing on industry concerns. This could be achieved by, for example, producing press releases and short articles for the trade press that focus on the potential implications for the heat pump market, inter-country comparisons and UK contributions to the work. This activity would require specialist support from professional press officers who are familiar with the target (or similar) audiences.

The principal link between the TCP (and individual annexes) and UK policy makers and their advisers is (and will presumably continue to be) via the principal delegate. The Heat Pump Centre (HPC) prepares short summaries of annexes results that are primarily intended for policy makers but are more generally useful.

The HPC is a hub for many other knowledge exchange links. In particular, it provides the main communication channel to the policy development and guidance operations of the IEA and manages formal links between participating countries and between TCPs. It supports the dissemination of information from Annexes by the organisation of final reports and webinars, produces a free quarterly magazine that is available online to anyone within a participating country, and supports the organisation of the triennial international IEA Heat Pump Conference.

Section 4 Service delivery

The service delivery plan below is based on the brief in the ITT [REDACTED] The time budget for general tasks exceeds the indicative minimum because it includes allowances for two one-off events that are likely to require extra time in individual years (in the table the effort has been averaged over all years).These are the hosting of an ExCo meeting in the UK in Autumn 2022 and a provision for possible attendance at the triennial IEA Heat Pump Conference in 2023. Expenditure on these activities would only be incurred only with the approval of the primary delegate. The allowance for the National Team marginally exceeds the guideline because experience shows this level to be necessary for what is a relatively large and active team. The figure for annex support is at the lower end of the suggested range because the principal need for support will relate to the new Annex 60 for which BEIS is separately providing the operating agent. An important new activity will be agreed informal cooperation with the EBC TCP on one of its Annexes. Several new HPT annexes of potential importance to the UK have already been discussed and attempts to enlist UK participants will continue. Support for ongoing annexes is likely to take the form of selective attendance at webinars and online meetings of annexes of relevance to the UK but where the UK is not a formal participant, and attendance at UK meetings of annexes in which UK is a participant. The budget does not include any contingency for unforeseen exceptional tasks that could create additional demands.

Table 1. Indicative Annual Resources

Type of task	Days/year	Comment
General tasks		
Participation in Executive Committee meetings (ExCo)	4	Assumes one physical and one virtual, includes some preparation and follow up
Participation in ad hoc meetings	3	Includes possible participation in TCP international conference in one year (2023)
Provide expert review and comment on relevant TCP documents	2	The Heat Pump Centre TCP produces numerous draft document for the TCP
Investigate opportunities to link up with other TCPs	2	The TCP plans to be active in this area
Preparation and research for the annual IEA reports	2	
Respond to requests for expert advice from TCP members	1	
SUBTOTAL	**14**	
Leading the UK National Team		
Routine discussions with the primary delegate	1	The NT already exists so no set-up time is required
Act as the primary liaison between the TCP and the National Team,	3	Co-ordination of participation of members of the National Team in TCP activities and dissemination of TCP information
Communication between the TCP and the National Team	2	Includes preparation and delivery of annual meeting and follow-up activities.
SUBTOTAL	**6**	There is a large and active NT which requires at least this level of support
Active participation in annex work: support for:		
Development of new Annexes	3	
UK participation in ongoing Annexes	2	
SUBTOTAL	**6**	
TOTAL	**25**	

The timing of some tasks such as ExCo meetings is fairly predictable and is fixed some time in advance, allowing time to be reserved (or other arrangements agreed with the primary delegate). It is assumed that the annual NT seminar/workshop will be held in the autumn, as has been usual: the exact date depends on the timings of other meetings such as an ExCo or UK-based Annexe meeting but is within the control of the primary and alternate delegates. Most of the work on annual reports will presumably take place towards the year-end or early in the following year. Other tasks are more or less reactive and unpredictable and often related to ExCo meetings; though the months of July, August and January are usually quiet. The illustrative timetable shown below illustrates a likely pattern of demand but can only be indicative. It is crucial to agree the activities and priorities of the alternate delegate with the primary delegate as they become clearer.

Table 2: Illustrative timetable

Indicative timetable (days per month)						
			Activity			
Month	ExCo meetings	National Team	Annex support	Annual reports	Other	**TOTAL**
April		1	1	1	1	4
May	2					2
June		1	1		2	4
July					1	1
August						0
September		1				1
October		2				2
November	2		1			3
December		1				1
January			1		1	2
February			1		2	3
March				1	1	1
Total	4	6	5	2	8	25

[REDACTED] I do not have any planned lengthy periods of unavailability.

The arrangements for general communication with the principal delegate are to be agreed, but I assume that they would be similar to existing arrangement: that is, regular on-line meetings and communications, complemented by occasional physical meetings, especially when linked to UK-based annexes or other TCP meetings. The timing of specific tasks including reports and reviews would be agreed at such meetings.