HEAT PUMP STATISTICS: A KEY TO HEAT PUMP RECOGNITION

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Abstract: There is a large need for reliable statistics for heat pumps. These data are necessary for publications such as those published by the IEA, and also in order to estimate the amount of energy savings and GHG emissions abatement. They should include number of heat pumps installed per year, but also details such as heat pump sizes, Seasonal Performance Factors (SPF), runtimes, lifetimes, and costs, for each heat pump type and country.

We here discuss available heat pump data. We show that heat pump statistics collection needs to be improved. Suggestions for a future statistics collection and evaluation methodology is presented, taking into account data collection, classification, and quality. Since the Heat Pump Programme is unique in that it has a global coverage, it is well suited to play a decisive role in this process. The goal is to show the potential of heat pumping technologies for the future energy system.

Key Words: heat pumps, collection of statistics, quality of statistics, energy savings, greenhouse gases emissions abatement

1 INTRODUCTION

The need for reliable statistics for heat pumps is evident. It is necessary as input to publications such as the IEA Energy Technology Perspective and the IEA “Technology Roadmap for Energy Efficiency in Buildings – Heating and Cooling” (“Roadmap”; to be published in 2011).. It is also needed to provide information to national statistics, which may form the basis for, for example, policy decisions regarding incentive programmes. Further, it is necessary in order to estimate the amount of renewable energy, energy savings, and GHG emission abatement due to heat pumps. It is also important that the statistics are correct so that any subsidies or incentive programmes can be correctly evaluated.

Indeed, specific sales and other information is needed, i.e., stating not only number of heat pumps installed per year, but also specifying data (such as installed capacity, SPF, runtime, lifetime/stock, cost, etc), so that the energy properties mentioned above would be possible to calculate, or at least estimate.

The publicly available statistics do not cover all of these aspects. For instance, JRAIA (JRAIA 2011) does not disclose installed capacity, nor any of the other non-sales numbers data mentioned. On the other hand, AHRI (AHRI 2011) and EHPA (EHPA 2011) record and report installed capacity, to some extent. Combined with SPF, runtimes, etc, obtained or estimated from work together with Eurostat (Eurostat 2010) and the SEPEMO-Build project (SEPEMO-Build 2011), the amount of renewable energy may be estimated.

However, there are certain significant information gaps. These can be divided into two groups.

The first one concerns information regarding number of sold units, such as for
- air conditioning applications. Data for this area is mainly available through trade associations, and not open to non-member companies. Another problem is how to judge reversible heat pumps, since the runtimes in heating and cooling mode, respectively, need to be estimated
- air/air heat pumps are often sold to customers at Do-it-yourself stores, and are thus not recorded in ordinary national reports
- large heat pumps, sold/installed by other companies than those normally reporting national statistics.

The second group concerns performance and related issues, such as
- Coefficient Of Performance, (COP), Seasonal Performance Factor (SPF),
- annual heat pump runtimes, and
- stock/lifetimes.

In this paper, we will present available heat pump data, collected through the IEA Heat Pump Programme, as well as national statistics, using Sweden as an example. From the data, conclusions are drawn, e.g., regarding classification of heat pumps, as well as the quality of data. Suggestions for a future statistics collection and evaluation methodology will be presented, taking into account data collection, classification, and quality.

2 METHODOLOGY

A background for this article is the statistics described in the Introduction. In the following, this is compared to the statistics collected for the Heat Pump Programme, which has been done at two recent occasions, for the Member Country Report and for the IEA “Technology Roadmap for Energy Efficiency in Buildings – Heating and Cooling” (“Roadmap”; to be published in 2011). Finally, available national heat pump statistics are discussed, using Sweden as an example.

2.1 Data Collected By The Heat Pump Programme

2.1.1 Data for Member Country Report

During 2009, an extensive survey was performed among the member countries of the Heat Pump Programme. The survey was intended to cover all types of heat pumps, with detailed questions regarding sales, capacity, costs, etc.

2.1.2 Data for IEA Roadmap

As an input to several publications by the IEA (“Roadmap”, “Building Sector Book”), data was collected from regional coordinators (Asia, America, Europe) during 2010. Data reported, split by heat pump types, included unit sales numbers, typical unit sizes, and available installed stock.

2.2 National Example: Sweden

In order to obtain a national perspective, heat pump statistics for Sweden have been used. Sources for this are EHPA (EHPA 2011), nationally collected statistics (SCB 2011, STEM 2011), and interviews.

3 RESULTS AND DISCUSSION

3.1 Data Collected By The Heat Pump Programme

3.1.1 Data for Member Country Report

The answers to the questionnaires sent out to the HPP member states have been summarized. In doing this, it became clear that there were challenges connected to the data. One of these challenges concerns the classification of heat pump types, which differs considerably between regions and countries. Thus, comparisons between countries, etc., are very hard to make unless a general nomenclature explaining the differences in heat pump types is developed. Connected to this is the need to find the right compromise between degree of detail and overview/simplicity, i.e., the degree of aggregation, or "lumping together" of heat pump categories used. Thus, the sales data were originally reported as belonging to a large number of heat pump types. However, when certain assumptions were made regarding the similarity of these types, the data became more coherent. Some information can then be displayed graphically, for instance regarding equipment cost and SPF values. This has been done in Figures 1 and 2. Note that these diagrams have been made by applying the assumptions mentioned above, and cannot be fully trusted.

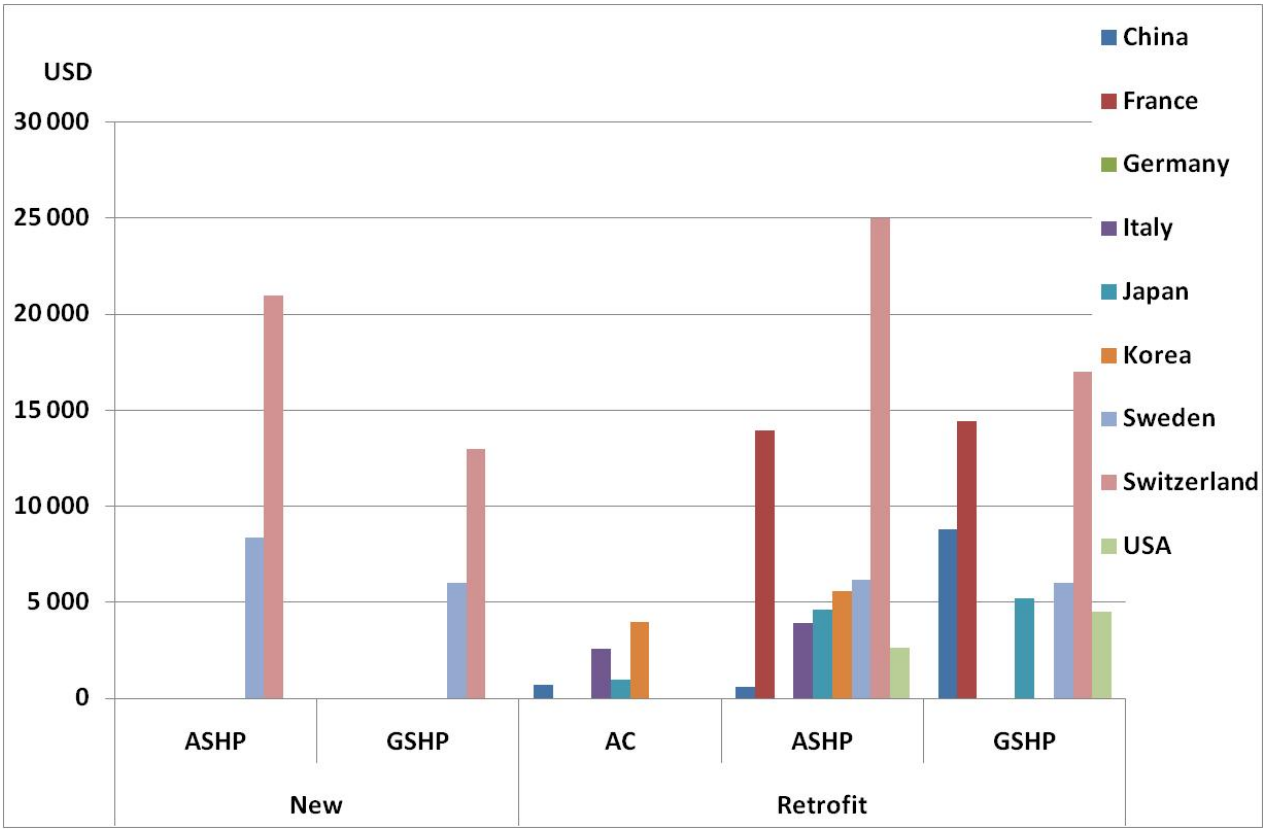


Figure 1. Unit cost. Single family dwelling, average, data as of 2008.
Note: certain assumptions have been made.

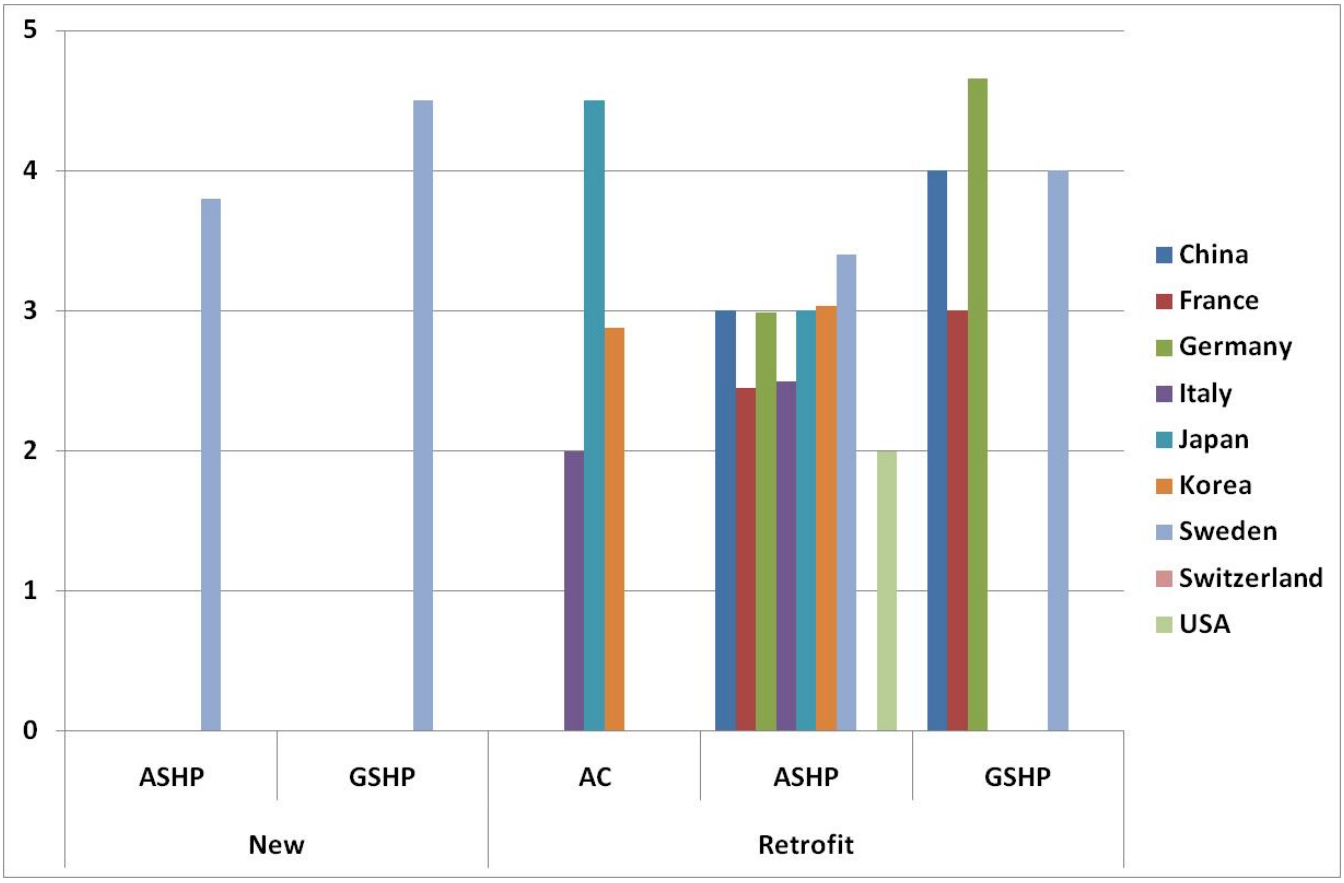


Figure 2. SPF values. Single family dwelling, average, data as of 2008.
Note: certain assumptions have been made.

Another main challenge is the quality/reliability of data, especially regarding properties such as SPF. E.g., are stated values `"typical" or "best case" for a certain heat pump type in a certain country? What definition of SPF was used? Are the stated data taken from an independent scientific field or laboratory study, or are they obtained from manufacturers?

In addition to these challenges, it is clear that the data do not contain all the information needed/required for the data treatment indicated in the Introduction section (above).

3.1.2 Data for IEA Roadmap

The data reported by the Heat Pump Programme to be used for publications by the IEA is shown in Tables 1-3.

Table 1. Heat pump sales and other data for Asia

Asia									
Type	Current stock (number of units)	Economic life time	Sales	Sales	Sales	Sales	Sales	Installed unit capacity, average	Space heating (H), space cooling (C), or both (H/C)
		(years)	2005	2006	2007	2008	2009	(kW)	
Heating only HP (excl. Exh. air HP)									
Exhaust air HP									
Tap water HP (DHW)	2 000 000	15	194 419	322 979	398 981	494 904	491 834	5,0	H
Reversible HP									
RAC	400 000 000	15	35 659 000	39 672 000	41 925 000	44 640 000	43 653 000	2,5	H/C
PAC	46 185 000	15	3 699 000	3 920 000	4 150 000	4 225 000	3 783 000	15,0	H/C
Reciprocating,Screw,Scroll	1 140 000	15	86 500	95 150	104 665	115 131	123 857	81,0	H/C
Centrifugal	45 000	15	3 356	3 692	4 061	4 467	4 591	1 860,0	H/C

Table 2. Heat pump sales and other data for Europe

Europe									
Type	Current stock (number of units)	Economic life time	Sales	Sales	Sales	Sales	Sales	Installed unit capacity, average	Space heating (H), space cooling (C), or both (H/C)
		(years)	2005	2006	2007	2008	2009	(kW)	
Heating only HP (excl. Exh. air HP)	1 400 000	18	111 930	187 288	193 366	308 000	266 130	12,0	H
Exhaust air HP	265 000	18	18 157	20 815	21 221	19 491	16 303	2,5	H
Tap water HP (DHW)	165 000	18	11 158	14 467	11 618	25 754	21 653	2,5	H
Reversible HP	1 625 000	15	108 149	147 877	166 551	223 147	206 533	6,0	H/C
RAC	82 250 000	15	5 492 000	5 907 000	7 278 000	5 438 000	4 384 000	2,5	C
PAC	10 025 000	15	666 000	744 000	859 000	681 000	556 000	15,0	C
Reciprocating,Screw,Scroll									
Centrifugal									

Table 3. Heat pump sales and other data for North America

North America									
Type	Current stock (number of units)	Economic life time	Sales	Sales	Sales	Sales	Sales	Installed unit capacity, average	Space heating (H), space cooling (C), or both (H/C)
		(years)	2005	2006	2007	2008	2009	(kW)	
Heating only HP (excl. Exh. air HP)	550 000	15	35 000	45 500	49 500	55 000	42 000	13,0	H
Exhaust air HP									
Tap water HP (DHW)									
Reversible HP	22 360 000	15	2 023 313	1 997 291	1 768 969	1 733 590	1 525 559	10,0	H/C
RAC									
PAC [US definition]	4 400 000	15	307 000	238 000	233 000	246 000	201 000	10,0	H/C
Reciprocating,Screw,Scroll									
Centrifugal									
Other AC	84 600 000	15	6 770 000	5 239 000	4 791 000	5 130 100	4 530 000	2,5	C

Although most likely more complete than those of the previous section (above), the data still have the same main problems. Thus, classification is a main issue. As an example, the definition of PAC differs between North America and the other regions. Further, the question of how to treat Air Conditioning is a significant issue, with many reversible heat pumps being run completely or to a large part in the air conditioning mode. Such units are also not always included (Europe).

3.2 National Example: Sweden

In order to illustrate the challenges, a national example will be discussed. Sweden was selected for this, since heat pumps are very established, with large annual sales numbers per capita, and the Swedish heat pump statistics are relatively well developed. Still there are problems of various kinds, as will be shown.

Figure 3 shows the sales statistics for Sweden, of heat pumps (number of units) for heating of single-family dwellings (EHPA 2011).

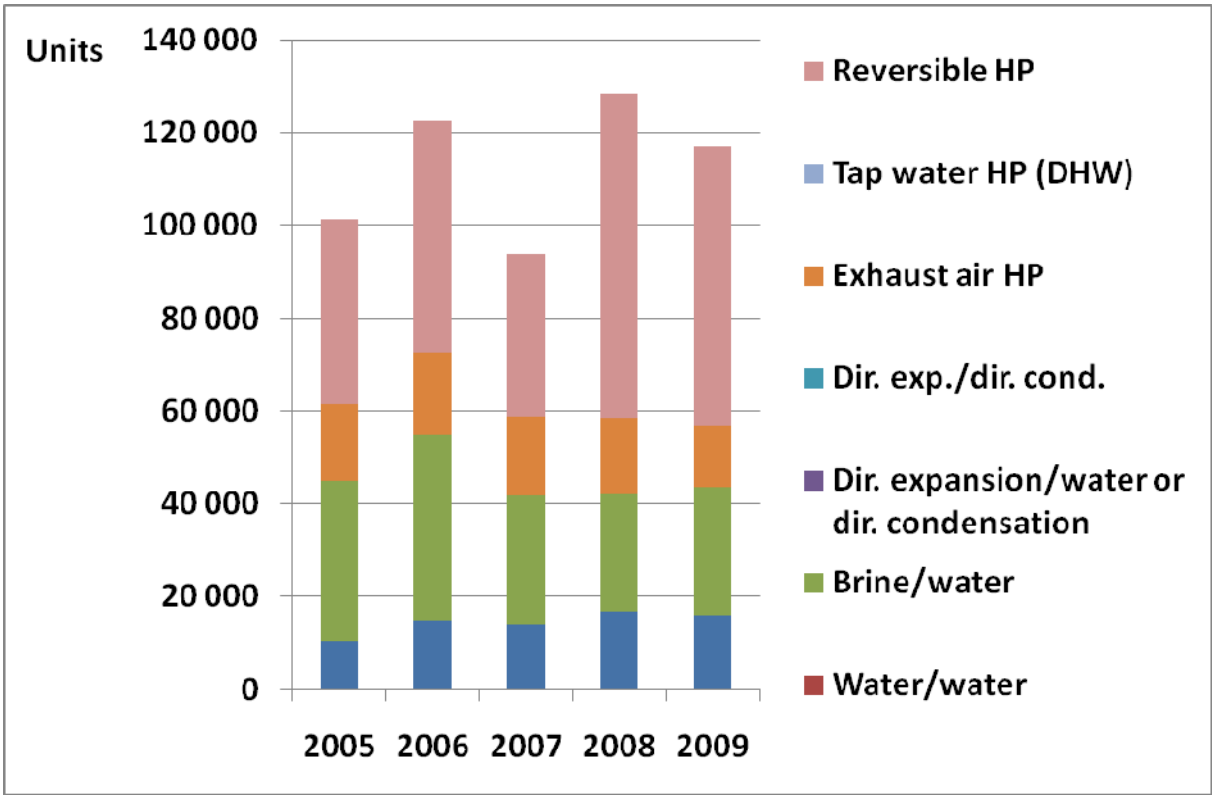


Figure 3. Heat pump sales in Sweden.

The sales numbers are large considering Sweden is a small country. Several specific factors have influenced the sales during the last few years. Most notable is the recent recession, causing a slight drop in the number of new construction houses between 2008 and 2009, which has affected the sales of exhaust air, air/air, and air/water heat pumps negatively. However, the sales of brine-water heat pumps (GSHP) have not suffered this loss. This is due to a national subsidy scheme for labour connected to renovation and extension, which has decreased the difference in up-front cost, for the home-owner, between GSHP and other heat pump types.

An ambition of the EHPA is to collect data on sold heat pump capacity (kW), so that the amount of renewable energy used can be calculated, in accordance with the RES directive (RES 2009), as suggested in the introduction. Although this is at its initial stage in most countries, the Swedish data have been relatively well recorded.

However, there are problems also with the Swedish statistics, such as air/air and large heat pumps. We will give a brief account of those problems, which are, often to a larger extent, also a problem in other countries.

Air/air reversible heat pumps are normally run only in the heating mode in Sweden. Their sales numbers are high, mainly since they provide an economically attractive way of replacing direct electric heating. However, they are often sold through do-it-yourself stores and similar channels that are not covered by the ordinary heat pump manufacturers and installers. Since it is these manufacturers/installers that provide the sales data to the national organisations (SVEP, for Sweden) the sales numbers of air/air heat pumps are not fully reliable. Calculating the renewable energy (according to the RES directive) provided during 2009 by air/air heat pumps that were installed during 2005-2009 (for input data, see EHPA 2011 p 35), we arrive at > 2.0 TWh. This is a significant number, and corresponds to nearly a third of the total renewable energy from all heat pumps (of all types) installed in Sweden during 2005-2009. Thus, any error in the estimation of the sales of these heat pumps may have a significant impact on the calculation of renewable energy delivered from heat pumps.

The applications of large heat pumps can broadly be divided into three categories: heating of multifamily dwellings and premises, district heating, and heat for industrial processes.
Heat pumps for multifamily dwellings and premises are not generally sold or installed by SVEP members, and sales statistics are thus not reported by them. In spite of this, an estimation was possible to make of these sales, pointing at a large increase of sales between 2009 and 2010 (SVEP 2011), with a 47 % increase of the market value of installations in large buildings, while this market segment was reported to be 15 % of the total turnover of the heat pump market, and growing at a fast pace. However, these data are not easily accessible from open reports, and a comparison between 2009 and 2010 cannot be made from open data. Some open data can be found in (EHPA 2011), table 6.15-2, p 84. In total, 6% of all heat pump installations during 2009 were made in multifamily houses (3%) or commercial premises (3%). Their contribution to the amount of renewable energy must be considered significant.

For district heating, heat pumps were installed mainly in the 1980's and early 1990's. Data on their use is readily available (STEM 2010). The energy production from these heat pumps was steady at about 6-7 TWh/year for a number of years, but is now decreasing, since 2005. Main reasons for the decrease is the relative increase of cost for electricity (compared to other alternatives), and also the introduction of the electricity certificates, providing an incentive for electricity generated from biofuels. This makes it favourable for the district heating companies to co-generate heat and electricity from biofuels, instead of using electricity for heat pumps.

The use of heat pumps for industrial processes is not the subject of any systematic statistic collection; it is for instance not gathered by SVEP. It has been covered by an Annex of the IEA Heat Pump Programme in the 1990's (Annex 21), and a new Annex (Annex 35) has recently been initiated. As an example of recent data, one of the leading companies has installed a total of nine ammonia heat pumps, each in the range 1.0 – 1.4 MW, in four different industries (Francks Kylindustri 2011). Assuming operating times of around 8000 hrs a year, these heat pumps, delivered from one single company, together supply about 95 million kWh annually, which is similar to more than 6000 private homes.

Thus, regarding large heat pumps, the available Swedish statistics ranges from reliable (district heating) over intermediate (multifamily dwellings) to incomplete and not easily accessible (industrial heat pumps). However, it must be emphasized that these large heat pumps are important to include in the statistics, since even a few of them may provide a large annual energy contribution.

From this national example, it is clear that national statistics may be good, but is still not good enough to give the full information, as listed in the Introduction section.

3.3 Suggestions For Future Collection Of Heat Pump Statistics

We believe that the first issue that needs to be addressed is the classification of heat pumps, with the goal to agree on a ”dictionary” of heat pump types. I e., for each type of HP in any available regional list (ASHRAE, EHPA, JRAIA), find a ”translation” for the others (if relevant). In principle, this is planned to take place in the following way. The coordinator sends out a set of schematic drawings of different types of heat pumps. The regional coordinator then assigns the regional heat pump type term to each of the drawings.
As the second step, the requirements from IEA, and others (such as national organisations), need to be discussed. This includes, for instance, SPF (definition; test data) and other parameters mentioned as the “second group” in the Introduction (see above). Goal: for each of the data types that IEA requests, find a reasonable way to obtain/calculate and report the data. Take into account regional and national differences, so this can be done in all countries involved (thus, there may be differences between countries). Also, take into account improvements over time (from year to year) of the data obtained. Implicit in this second step are the issues of data collection and quality of data.

The aim of this work is that, within a few years, reliable, comparable data will be available for, first, all Heat Pump Programme member countries; and at a later stage more countries. In this way we will be able to provide data to IEA for publications, national statistics, etc. Heat pumps can then be given just credit for amount of renewable energy, energy savings, and GHG emissions abatement.

4 CONCLUSIONS

It is clear that a significant amount of heat pump statistical data is being recorded, in many countries. However, it is also clear that these statistics are not complete enough to deliver the information needed to provide reliable data requested by the IEA for its publications, or to be able to estimate the amount of renewable energy, energy savings, and GHG emissions abatement due to heat pumps. Although efforts are being made, some important pieces of information are missing, both regarding heat pump application areas (such as air/air and large heat pumps) and certain data parameters (such as runtimes, especially for reversible heat pumps, technical/economic lifetimes). This is the case also in countries where the statistical recording is relatively good. The consequence of incomplete statistics will be that the role and future potential of heat pumps will be underestimated.

The Heat Pump Programme, which has a unique position due to its global coverage, is now initiating a new way of recording heat pump statistics. Initially, we will work on developing a common classification terminology (or a “dictionary”) of heat pump types. Then, the requirements from IEA and others will be discussed, in order to reach an understanding on what data needs to be collected, and what the requirements on these data should be (quality, reporting interval, etc). The aim of this work is that, within a few years, reliable, comparable HP data will be available, for many countries. In this way, the potential of heat pumping technologies for the future energy system will be clearly shown.

5 ACKNOWLEDGEMENTS

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