

REACHING THE KYOTO TARGETS BY A WIDE INTRODUCTION OF GROUND SOURCE HEAT PUMPS

PART II: APPLYING THE METHODOLOGY ON AVAILABLE STATISTICS IN THE EUROPEAN UNION

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Abstract: The energy required for heating in the EU has been estimated at 40% of total energy demand. A shift of this segment to include a considerable share of RES requires a major change of energy policies on all levels. In order to reach full acceptance of the positive contribution of this technology towards the reduction of energy demand and related emissions the effect of a widespread use of heat pumps on national energy balances has to be calculated. Such an approach requires a comprehensive yet detailed statistical base in order to convince politicians and other relevant stakeholders.

This paper discusses the availability of required data and applies the methodology from Part I to ground source heat pumps as sub-set of heat pump technology. As a result, ground source heat pumps can contribute considerably to the Kyoto targets, lead to savings in the use of primary energy and increase the share of renewables used in the EU-25 states.

Key Words: *heat pumps, scenario, energy statistics, RES production, GHG savings, climate protection, energy savings, EUROSTAT*

1 INTRODUCTION

Heat pump technology has seen a tremendous boost over the last three years. Not only is there a strong market development in central Europe, but also increasing recognition on the different political agendas. The latest and maybe most important step is the acknowledgement of heat pumps as contributor to reach the EU's energy savings and climate protection goals by including it in the proposed Directive on the use of renewable energy sources. This directive is a follow up to the decision of EU head of states on a new energy policy as taken at their spring council meeting (march 8th to 9th, 2007) [Council of the European Union 2007]. It was published by the commission on Jan. 23rd, 2008 [COM 2008].

In order to be able to estimate the contribution potential based on existing statistics, a methodology was developed in part I of this paper. The use of this methodology for real calculations requires knowledge on several parameters influencing the total heating energy demand for the building and the resulting emissions. Most of this information is not currently available, particularly not with a similar level of detail for all EU-27 countries.

This paper focuses on available data sources, the selection of an appropriate data set and the application of the methodology thereon. It will show which data is available at all and where existing data can be made useful by educated judgment. For the application of the method, the three scenarios suggested in part I of this paper are used. Their impact on the energy future of five countries with specific characteristics will be calculated to show the impact of heat pump use under different environmental conditions. Lastly the methodology will be applied to the EU-25 region to put the individual examples in perspective.

In conclusion, issues arising from a lack of data will be presented and recommendations on possible improvements of statistics will be outlined.

2 HEAT PUMPS AND RELATED DATA IN STATISTICS

Data on the number of heat pumps sold is predominantly collected from the national heat pump associations. While the European Heat Pump Association aggregates these data to a EU statistic, its coverage and methodological rigor is still limited. Different from the US, where the provision of sales data on (ground source) heat pumps is mandatory, such data is rarely collected and available in the energy statistics of all EU member states. In addition the approach to collect this data is not unified throughout Europe, data quality can be considered poor [cf. Nowacki / Weltin 2008 for a description on data collection methods in Sweden].

2.1 Heat pumps in European (and international) energy statistics

The joint statistics manual from the International Energy Agency (IEA), the Organization for Economic Co-operation and development (OECD) and the European statistics office (EUROSTAT) describes heat from air, water and ground as primary energy that is made useful by heat pump technology. Heat from heat pumps is **secondary energy** which is "... produced by transforming electricity to heat in electric boilers or heat pumps." (OECD/IEA 2005, p 39) This wording ignores that the predominant share of energy produced by heat pump not electricity but renewable energy from air, shallow ground and water. In contradiction to recent market developments the authors of the manual still seem to consider heat pumps rarely used, with a contribution to energy supply too small to account for [ibid, p. 47].

However a general approach towards the inclusion of heat from heat pumps exist (Figure 1): New heat will be included in the section on heat production. The electricity portion is counted towards a transformation process (which has is not yet published separately). The total output of the heat pump is counted as heat production (cf. ibid, p. 139).

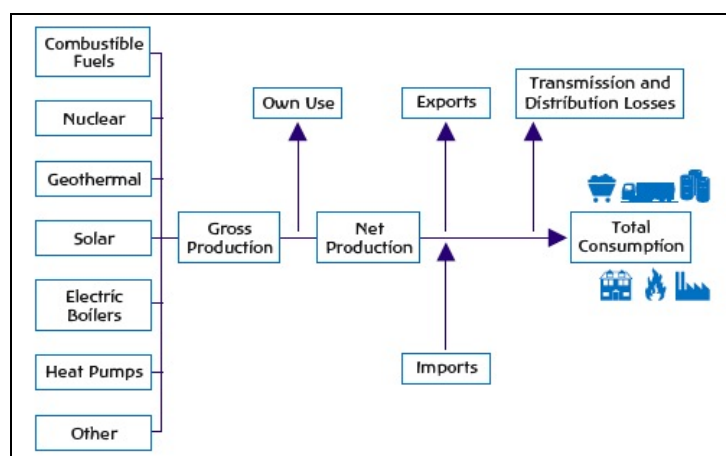


Figure 1: Simplified Flow Chart For Heat (OECD/IEA 2005, p. 43)

Without further explanation, such heat from heat pumps is currently "... only where the heat is sold to third parties (i.e. in cases where production occurs in the Transformation Sector)." [COM (2006) 850 final]. A recent revision of this document has left this paragraph untouched. In consequence the ever increasing share of heat coming from the direct application of heat pumps in buildings remains – for the moment – unaccounted for.

However due to the targets set by the energy package and the energy action plan as well as due to the proposed RES-directive, the contribution potential of the heating sector is

acknowledged and the monitoring of this new field of energy production becomes necessary. This issue is currently addressed by the Therra project which - supported by the Intelligent Energy Europe Program of the Commission - intends to develop and to disseminate a methodology for monitoring the total amount of renewable heat produced from all renewable energy sources in the EU [Therra 2008].

Within Eurostat, a permanent working group on renewable statistics has been established. This group has the goal to evaluate statistical needs from recent developments on the political level, to develop universal methodologies for data collection (particularly of heat pumps), to evaluate data quality for renewables in the Member States and to develop an action plan to improve the situation [Roubanis 2007]

2.2 Building and energy demand data in the European energy statistics

Similar to the lack of data for the number of heat pumps, there is a lack of precise data on the building stock, its energy demand and the energy source used for heating. The most comprehensive document available is the "Housing statistics in the European Union 2004" [Boverket 2005]. While a version for 2005/2006 exists, this volume – for most data sets – does not provide new data. The document is a compilation of the national buildings ministers housing statistics. However its use for the purpose of this paper is limited: While a table on "Dwellings completed by types of building" exists, it only allows for a distinction into one/two family houses and multi family dwellings, but does not provide more precise data on the energy demand of the buildings. A rough overview on the dominant heating source for the EU-25 countries is available [Pye/Thistlethwaite/Adams 2004], but precise and complementary data on energy sources used in the building stock and in new buildings is lacking.

Such information could be gathered as part of the national implementation of the Energy Performance for Buildings Directive (EPBD), where an energy certificate is required for all newly established buildings and renovated buildings that are sold or rented. Such a certificate "should describe the actual energy-performance situation of the building" [EC 2002, recital 16]. As the EPBD will have to be implemented in all countries, more detailed information on the energy demand for new and rented buildings will be available.

2.3 The PRIMES data set

The PRIMES model [Capros 2005] is widely used for energy related studies. It was developed and is maintained by a team at the National Technical University of Athens, lead by Prof. Dr. P. Capros. The model is the result of work accomplished under different EU research programs. It attempts to create a realistic picture of the development of the European energy demand including technology development trends as well as market-related and policy influence. As it is a general-purpose model, it is designed and has been used for a multitude of analysis' on the EU and national levels.

With regard to the residential sector it distinguishes five categories of dwelling, further split-up into four energy use types and allows for the integration of auxiliary heating systems. Among the fuel sources it includes low enthalpy geothermal energy to be used by heat pumps, however there is no transparency on the details of these categories, particularly on the assumptions made for energy demand and heating systems employed. Still we chose this data set, as it includes all European countries and distinguishes energy demand for heating and cooling by type of fuel used (Table 1).

Table 1: Final energy demand from households, EU-25. Adjustments made for cooking and electricity used for heat pumps (Source: PRIMES baseline)

TWh	2005	share	2020	share
Final energy demand for heating (excl. cooking)	2.860,76	100,00%	3.083,85	100,00%
solid fuels	67,67	2,37%	13,95	0,45%
liquid fuels	577,13	20,17%	527,25	17,10%
gas fuels	1.415,47	49,48%	1.721,91	55,84%
biomass	310,24	10,84%	275,49	8,93%
solar thermal and other RES	12,37	0,43%	32,71	1,06%
steam	217,35	7,60%	236,45	7,67%
electricity	260,53	9,11%	276,09	8,95%
electricity (HP)	0,00	0,00%	0,00	0,00%

It must be noted however, that this approach most likely lays ground to a certain margin of error for:

1. no transparency on the underlying model exist,
2. it is unclear which share of the annual change (in the model it is always an increase) in energy demand originates from new houses and which share originates from the replacement of old systems,
3. it does not take into consideration that households in multi-family buildings require less energy than those in one/two family houses.

Even though the results will not provide the initially appreciated precision, they will produce a valid general tendency and will allow for the comparison of the impact of heat pump use in different countries.

2.2 The methodology – revisited

In part one of this paper the system boundaries were drawn to illustrate the flow of energy to the final user and to illustrate the impact of heating systems on the environment. In order to apply the formulas for Greenhouse gas emissions (GHG), Final and primary energy use, and Renewable energy production to aggregated data, information on the respective energy demand for buildings, on the environmental impact of different energy sources, on conversion efficiency and on energy input required to provide final energy should be available at a sufficient level of detail. Ideally, statistics would provide the following type of data:

1. A split of **building stock** according to
 - a. energy demand (E_{building})
 - b. energy source used for heating (index s)
 - c. auxiliary energy source used (share of total energy demand; index a)
 - d. number of buildings per class (x)
2. the **average conversion efficiency** of different heating systems (η)
3. **environmental impact** (GHG emission per unit of final energy demand, eimp)

2.2.1 Data on building stock and energy use

Each class to (1) could then have indicators with the following values:

- a. demand classes (index q). For the calculation of the **energy demand of each building class**, an average would have to be taken.
- b. energy sources for heating (oil, gas, district heating, direct electricity, electricity for heat pumps, biomass): index s
- c. auxiliary energy source (solar thermal for hot water, solar thermal for hot water and heating support, electricity for hot water, electricity for hot water and heating support): index a

A fourth indicator (index c) would indicate the energy demand per country. The total energy demand for all houses in a geographic area would then be calculated as:

$$E_c^{building} = \sum_{q=1}^5 \sum_{s=1}^6 \sum_{a=1}^4 ((E_{q,s} \cdot x_{q,s}) - (E_{q,s,a} \cdot x_{q,s,a})) \quad (\text{TWh}) \quad (1)$$

q= energy demand

s= energy source

a= auxiliary source

x= number of buildings per category, energy source and with auxiliary source

This demand will be aggregated on the EU level to

$$E_{EU-25}^{building} = \sum_{c=1}^{25} E_c^{building} \quad (\text{TWh}) \quad (2)$$

c=country

The **final energy** demand is derived from this value as

$$E^{final} = \sum_{s=1}^6 \left(\frac{E_s^{building}}{\eta_s} \right) \quad (\text{TWh}) \quad (3)$$

aggregated to the EU-25 area:

$$E_{EU-25}^{final} = \sum_{c=1}^{25} (E_c^{final}) \quad (\text{TWh}) \quad (4)$$

Lastly, the **primary energy demand** is calculated based on upstream efficiency values as

$$E^{primary} = \sum_{s=1}^6 \left(\frac{E_s^{final}}{\eta_s^{up}} \right) \quad (\text{TWh}) \quad (5)$$

aggregated to the EU-25 area:

$$E_{EU-25}^{primary} = \sum_{c=1}^{25} (E_c^{primary}) \quad (\text{TWh}) \quad (6)$$

While this would be the most precise way to approach data collection, this level of detail is not available in current statistics in general and particularly not for all EU-25 countries. Some countries provide more detail on the number of houses according to classes, but very little information is available on the buildings energy demand, the type of energy source used for heating, or the existence of an auxiliary heater, particularly not when searching for this data for all EU countries.

Thus the methodology developed in part I of this paper is applied to the previously mentioned data set from the PRIMES model, as it at least distinguishes energy demand for all households by type of fuel. It also allows the comparison of the impact of the application of heat pumps across countries.

2.2.2 Data on conversion efficiency of heating technology

In order to calculate the final energy necessary to cover a buildings energy demand, efficiency values are required. The values for gross calorific value (thermal efficiency) are taken from the global emission model for integrated systems (GEMIS v4.4.2) [Öko-Institut

2008]. This model uses a total life-cycle approach to estimate the energy and material use products and processes as well as their impact on the environment. Values have been corrected by 10 percentage points for gas and six percentage points for oil, as suggested in the ecoboiler study [VHK 2007] leading to the values presented in table 2.

Table 2: Conversion efficiency of heating technology (source: Gemis, datasets as in Table 3).

		conversion efficiency η	Upstream efficiency, η^{up}
solid fuels		65%	90,91%
liquid fuels	Oil condensing boiler	85%	90,91%
gas fuels	Gas condensing boiler	92%	90,91%
biomass	Pellet boiler, wood	85%	84,62%
solar thermal and other renewables		100%	95,22%
waste		95%	90,09%
electricity	Direct electricity	100%	44,10%
electricity (use for heat pumps)	Heat pumps (SPF)	300%	44,10%

2.2.3 Data on environmental impact of energy sources

Data on the environmental impact of different energies is widely available. For consistency, the values presented in table 3 are taken from the GEMIS model.

Table 3: Emission values for different energy sources (Source Gemis)

environmental impact	GHG emissions 2020 kg/kWh	dataset used
solid fuels	0,4460	Braunkohle-Brikett-Heizung-DE-Lausitz-2000 (Endenergie)
liquid fuels	0,3065	Öl-Heizung-DE-2005 (Endenergie)
gas fuels	0,2425	Gas-Heizung-DE-2005 (Endenergie)
biomass	0,0267	Pellets: Holz-Pellet-Holzwirtsch.-Heizung-10 kW-2005 (Endenergie)
solar thermal and other renewables	0,0348	SolarKollektor-Flach-2000
steam	0,0064	Fernwärme-Heizung-DE-2000 (Gas-GuD-HKW/el-mix)
electricity	0,4280	Specific for each country and EU-25
electricity (use for heat pumps)	0,4280	Specific for each country and EU-25

These values include all energy and material input required to produce one kilowatt-hour of the respective energy; all upstream losses are included. The used datasets represent the situation in Germany, but the environmental impact of solid and liquid fuels should be similar throughout Europe. Emissions values for electricity are different for each country – the above-mentioned values apply to the EU-25 average electricity mix while for all calculations of national emissions, the values for the national electricity mix are used.

3 SCENARIOS

Three scenarios have been created to get a better understanding of different market shares for heat pumps as well as for a gradually improving average efficiency of the units (Table 4).

Table 4: Scenarios for the employment of heat pumps

		Reach out	Jackpot	Full impact
	2005	2020	2020	2020
Share of HP	0,0	0,2	0,3	1
SPF	3	4	4,2	4,2

For the different countries compared an increase in the share of RES in the electricity mix as well as in the cumulated energy content per kWh produced can be observed. Emission values are shown in Table 5.

Table 5: Development of GHG-emission (eimp) for different countries (Source: Gemis)

GHG emissions (kg CO ₂ equ/kWh)	2005	2020
EU-25	0,38	0,36
Austria (AU)	0,21	0,21
Switzerland (CH)	0,07	0,10
Germany (DE)	0,56	0,57
France (FR)	0,09	0,13
Sweden (SE)	0,07	0,16

The scenarios use the year 2005 for comparison. For each country, values for

- the total energy demand from buildings ,
- the primary energy demand,
- the final energy demand, and
- the environmental impact

were calculated. A simple business as usual-scenario (BAU) is developed assuming that no heat pumps are introduced. This scenario is based on the PRIMES data for 2020 and is based on the same values as used for the year 2005. As PRIMES presents the final energy consumption, the following formulas can be used to calculate the buildings energy demand and the final energy demand per heat source and region:

$$\text{Building energy demand: } E_{\text{building}} = E_{\text{final}} \cdot \eta_s \quad (\text{TWh}) \quad (7) \Leftrightarrow (3)$$

$$\text{Primary energy demand: } E^{\text{primary}} = \sum_{s=1}^6 \left(\frac{E_s^{\text{final}}}{\eta_s^{\text{up}}} \right) \quad (\text{TWh}) \quad \text{equal to (5)}$$

The final energy demand from PRIMES for gas and electricity is adjusted for energy used from cooking by an assumed demand of 600kWh per household and year.

$$E^{\text{final}} = E_{\text{PRIMES}}^{\text{final}} - \sum_{s=1}^2 E_s^{\text{building}} \cdot n_s \cdot 600 \quad (\text{TWh}) \quad (8)$$

s= gas, electricity

n_s = number of households heating with source s

The calculation of the environmental impact per energy source is performed based on final energy use. As values for $eimp_s$ are based on final energy used, the upstream efficiency losses (η_s^{up}) can be neglected in the formula.

$$\text{Environmental impact: } eimp = \sum_{s=1}^6 E_s^{\text{final}} \cdot ef_s \quad (\text{Mt}) \quad (9)$$

s=1 – oil, 2 – gas, 3 - district heating, 4 - direct electricity, 5 - electricity for heat pumps, 6 - biomass

Savings are calculated as a subtraction of the values from the BAU-scenario to the respective scenario with heat pumps.

For **final energy** savings:

$$\Delta E^{\text{final}} = E_{\text{PRIMES}}^{\text{final}} - E_{\text{scen}}^{\text{final}} \quad (\text{TWh}) \quad (10)$$

scen= reachout, jackpot or fullimpact

For **primary energy** savings:

$$\Delta E^{primary} = E_{PRIMES}^{primary} - E_{scen}^{primary} \quad (\text{TWh}) \quad (11)$$

For **reduced environmental impact** from the use of heat pumps in the scenarios:

$$\Delta eimp = eimp_{PRIMES} - eimp_{scen} \quad (\text{Mt}) \quad (12)$$

For RES production the formula as suggested by the Therra document is used. RES produced is the difference between electricity needed and total energy output:

$$E^{RES} = E^{building} - E^{final} \quad (\text{TWh}) \quad (13)$$

$$\Leftrightarrow E^{RES} = E^{building} \cdot \left(\frac{SPF - 1}{SPF} \right) \quad (\text{TWh}) \quad (14)$$

3.1 Business as usual

The business as usual scenario is the reference. It does not take the use of heat pumps into consideration at all. The application of formulas leads results as shown in table 6.

Table 6: Business as usual scenario (2020)

Results table	EU25	AU	CH	DE	FR	SE
Building energy demand ($E^{building}$)	2.944,99	62,16	50,73	597,67	389,23	64,22
Final energy demand (E^{final})	3.083,85	68,18	53,39	638,48	413,47	66,13
Primary energy demand ($E^{primary}$)	3.613,86	77,97	67,41	597,67	389,23	64,22
Environmental impact (eimp)	700,03	12,69	14,59	597,67	389,23	64,22

3.2 Scenario Reach out

This scenario foresees that in 2020 20% of the building stock is heated by heat pumps and that heat pumps operate on average with an SPF of 4. Changes of emission factors are taken into account on a national basis as estimated in the PRIMES model. Results are displayed in table.

Table 7: Comparison of results for the reach out scenario (2020)

Results table	EU25	AU	CH	DE	FR	SE
Building energy demand	2.808,98	61,14	49,02	575,86	374,95	62,70
Final energy demand	2.607,53	57,60	45,16	539,58	349,52	56,04
Final energy savings (ΔE^{final})	476,32	10,58	8,23	98,90	63,95	10,09
Primary energy demand	3.279,08	67,10	60,06	682,24	525,59	85,09
Primary energy savings	458,76	12,33	8,26	82,96	61,33	12,96
Environmental impact	661,30	9,95	9,65	160,87	72,08	6,62
change vs. BAU	52,33	2,78	4,78	-15,04	28,82	6,56
RES produced	421,35	9,17	7,35	86,38	56,24	9,40

Emission reduction in all countries but Germany are positive. The German situation can be explained by several new coal-fired powerplants that are planned today and will result in a dirtier electricity mix. This tendency is getting worse in the other scenarios.

Total primary energy savings can be calculated in two ways. Either it is based on non-renewable primary sources only, as done in the BAU scenario, which is then compared to non-renewable primary energy used to run the heat pumps (formula (11)) or total primary energy is understood as the sum of renewable and non-renewable primary energy (15). In this case total primary energy from the use of heat pumps is nearly equal to primary energy in the BAU scenario (16). Primary energy savings are limited. Savings are then largely equivalent to the RES produced.

$$E_{total}^{primary} = E_{non-RES}^{primary} + E_{RES}^{primary} \quad \text{TWh} \quad (15)$$

$$\Delta E^{primary} = E_{BAU}^{primary} - E_{total}^{primary} \quad \text{TWh} \quad (16)$$

3.3 Scenario “Jackpot”

This scenario foresees that in 2020 30% of the building stock is heated by heat pumps and that heat pumps operate on average with an SPF of 4,2. Improvements in the electricity production have lead to reductions in emissions and in the total energy input required to produce one kilowatt-hour of electricity. Results are shown in table 8:

Table 8: Comparison of results for the Jackpot scenario (2020)

Jackpot	EU25	AU	CH	DE	FR	SE
Building energy demand	2.808,98	61,14	49,02	575,86	374,95	62,70
Final energy demand	2.359,34	52,09	40,87	488,07	316,21	50,77
Final energy savings	724,51	16,09	12,51	150,41	97,26	15,36
Primary energy demand	3.029,07	60,68	55,54	635,75	490,92	78,14
Primary energy savings	708,77	18,75	12,77	129,44	96,00	19,91
Environmental impact	636,64	9,12	8,73	163,02	67,02	6,39
change vs. BAU	76,98	3,62	5,69	-17,18	33,88	6,78
RES produced	642,05	13,97	11,20	131,63	85,70	14,33

3.4 Scenario “Full impact”

This scenario foresees that in 2020 100% of the building stock is heated by heat pumps and that heat pumps operate on average with an SPF of 4,2. Improvements in the electricity production have lead to reductions in emissions and in the total energy input required to produce one kilowatt-hour of electricity. This scenario shows **what would be possible** in terms of energy savings and emission reduction were energy demand for buildings completely covered by heat pumps. Results are given in table 9:

Table 9: Comparison of results from the full impact scenario (2020)

Full impact	EU25	AU	CH	DE	FR	SE
Building energy demand	2.808,98	61,14	49,02	575,86	374,95	62,70
Final energy demand	668,81	14,56	11,67	137,11	89,27	14,93
Final energy savings	2.415,04	53,62	41,71	501,37	324,20	51,20
Primary energy demand	1.375,27	16,93	25,74	333,73	266,92	31,68
Primary energy savings	2.362,57	62,50	42,57	431,46	319,99	66,37
Environmental impact	499,00	3,55	2,52	191,45	33,95	5,17
change vs. BAU	214,62	9,19	11,90	-45,62	66,95	8,01
RES produced	2.140,18	46,58	37,35	438,75	285,68	47,77

3.5 Do heat pumps save primary energy?

Several documents mention the fact that heat pumps or other technologies using renewable energy would save primary energy. This statement must be taken with caution. The following

definition from the IEA/OECD energy statistics manual shows that renewable energy sources are also counted as primary energy sources:

“Primary energy commodities may also be divided into fuels of fossil origin and renewable energy commodities. Fossil fuels are taken from natural resources which were formed from biomass in the geological past. By extension, the term fossil is also applied to any secondary fuel manufactured from a fossil fuel. Renewable energy commodities, apart from geothermal energy, are drawn directly or indirectly from current or recent flows of the constantly available solar and gravitational energy.” [IEA/OECD 2005, p. 19]

Consequently the use of renewable energy does not automatically lead to a decrease in primary energy usage. What is commonly understood as the “saving of primary energy” from the use of heat pumps or other technologies using renewables should precisely be named “saving of non-renewable primary energy”.

The above calculation examples show that given sufficient efficiency of energy production and high efficiency of the heating systems, even with this extended understanding primary energy is saved. To be clear: the employment of heat pumps does always save non-renewable primary energy sources and deserves support for this contribution to energy savings and emission reduction.

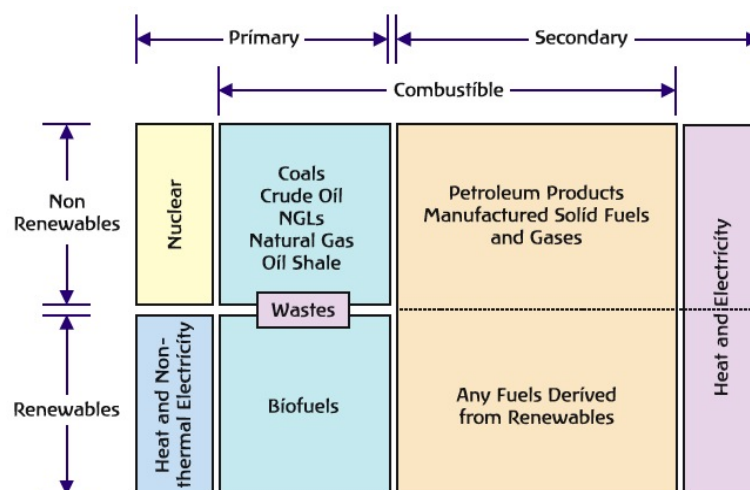


Figure 2: Overview of terminology (Source: IEA/OECD 2005, p 18)

The “Full impact”-scenario for EU-25 shall be used to illustrate this relation for the use of heat pumps (See figure 3). In this scenario heat pumps provide 100% of all energy demand for heating thus covering the demand for $E_{\text{building}} = 2\,808\text{ TWh}$.

The PRIMES baseline scenario leads to $E_{\text{PRIMES}}^{\text{primary}} = 3737,85\text{ TWh}$ vs. $E_{\text{full-impact}}^{\text{primary}} = 1375,27\text{ TWh}$. Savings of non-renewable primary energy is $2\,362\text{ TWh}$.

When calculating the same values for the approach suggested by Eurostat the Building energy demand of $2808,98\text{ TWh}$ (at SPF of 4,2) requires $668,81\text{ TWh}$ of final energy; which in turn (at a cumulated energy input per kWh_{el} of 2,06) requires $1\,375,25\text{ TWh}$ of primary energy as accounted for in current statistics and $2\,140,18\text{ TWh}$ of ambient heat.

$$E_{\text{non-renewable}}^{\text{primary}} = 1357,27\text{ TWh}$$

$$E_{\text{renewable}}^{\text{primary}} = 2140,18\text{ TWh} \text{ and}$$

$$E_{total(Eurostat)}^{primary} = 3515,45TWh$$

Compared to the primary energy demand from the PRIMES baseline, the primary energy demand according to the stated definition is reduced to 3 515 TWh (-6% compared to the PRIMES baseline). A smaller, yet positive saving of total primary energy (222 TWh) and a tremendous reduction of non-renewable primary energy (232 TWh) remain.

When comparing only the non-renewable fractions, in the full impact scenario a total of 2 362 TWh non-renewable primary energy is saved (as accounted for in Eurostat statistics (cf. Table 9, column EU-25).

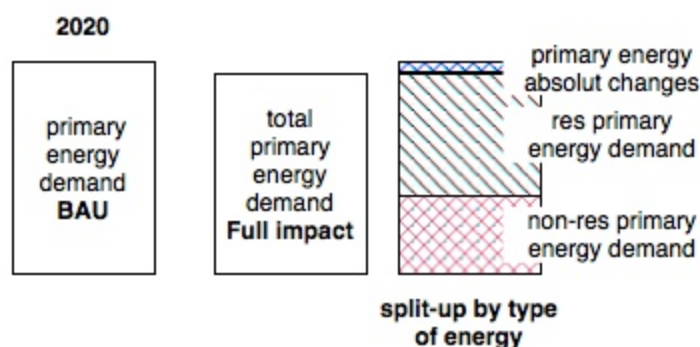


Figure 3: Relation of primary energy demand and savings in non-res and res primary energy demand

4 DISCUSSIONS OF RESULTS & OUTLOOK

The scenarios show that a **widespread implementation of heat pumps does lead to considerable savings in the demand of non-renewable primary energy** and subsequent improvements of environmental pollution from the production, transportation and use of these resources. Even in a scenario with rather moderate expectations (Reach out), which might be achieved from a continuous development of the current market, heat pumps could contribute 5% towards the reduction goal of 1 073 Mtonnes of GHG emissions (See table 10). The presented calculations confirm the assumption that in countries with low carbon intensive electricity the environmental impact of heat pumps is very small.

Table 10: GHG emission in the EU-25 vs. contribution of heat pumps to emission reduction

Million Tonnes	1990	2004	2020
GHG Emission EU-25 (excl. LULCF)	5.369 (100%)	4.986,40 (92,88%)	4.294,80 (80%)
Reduction Goal			1.073,70 (20%)
Contribution from		Reach out	52,33
		Jackpot	76,88
		Full impact	214,62

The more ambitious scenarios Jackpot and Full-Impact would result in a share of 7,1% and 20 % respectively.

These results are only a guideline. Nevertheless they stress the importance of better statistics for heat pumps. Given their contribution potential towards the targets as set in the EU energy and climate package, the contribution towards the “production” of renewable energy sources, towards final energy savings and towards GHG emission savings must be counted and included into statistics.

The market for heat pumps in Europe has reached a state where the technology can no longer be labeled as unimportant, unavailable or negligible. Heat pump technology requires adequate recognition and support. But again this requires the introduction of the contribution into statistics. Only then can support programs as foreseen by the proposed RES Directive be created, executed and monitored efficiently on a national and on a European level.

5 REFERENCES

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