Analysis of the thermal heating and cooling market in Europe

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Overview

Aim of this paper is to provide an overview regarding the doctoral project describing topic, methods, data base structure, preliminary results and conclusions. The core of this analysis is the thermal heating and cooling market in Europe, starting from a top down approach concerning already existing data. After deep preliminary investigations in the residential sector of EU 15 countries, the average energy demand for heating and cooling appliances results to be 143 and 33 kWh/m²a respectively. In the whole EU 15 area the air conditioning demand shows a fairly steady rise. Main reasons for that are higher comfort standards requested by the European population. In contrast to that Europe´s residential heating demand is characterised by a constant decrease over the past two decades. This has been mainly possible through refurbishment activities in the EU 15 building stock. Significant differences concerning heating and cooling energy demand between EU 15 members have been registered. Those are mainly the result of climate, habits and economic situation influence.

1. Methods

1.1 State of the art

In the following section an overview of a possible approach for the state of the art elaboration will be given. After the definition of the data base structure (further explained in chapter 2), a top down approach will follow in order to gather the requested data. The ESTIF (European Solar Thermal Industry Association) study reports a value of 4,640 TWh (1) for the total energy heating and cooling demand of the EU (European Union) 27 in 2006. Based on data from European Communities 2008, EU energy and transport in figures - Statistical Pocket book 2007/2008 - the cooling demand is hereby estimated of being 1.9% leading to 88 TWh (2). Within the RHC (Renewable Heating & Cooling) platform as well a calculation starting from the EECCAC (Energy Efficiency and Certification of Central Air Conditioners) study has been done extrapolating the data from EU 15 to EU 27 and it leads to a value of 90 TWh (3).

These studies include the results of several EU projects, e.g. EcoHeatCool, which have been used as starting point and reference source (4).

As actual source the single National Action Plans for Renewable Energy – based on the EU directive 2009/28/CE have been used (5) (6). These had to be delivered by June 30th 2010 and include data of the overall heating and cooling demand in 2005 on a national level. Further possible sources are listed in chapter 1.2. The top down approach can be combined with a bottom up approach in order to gather all necessary data: The Top down approach starts from European statistical data, national action plans and further statistics and projects; On the other hand, the bottom up approach starts from the specific data regarding one technology or one industry sector, analysing then these specific data (e.g. from industry associations or technology interest groups). The technology mix will be described in detail by using, where possible, measured field test results as the base for performance figures (e.g. for heat pumps in transforming electricity in useful heat and cold). Here as well EU research projects, technology platforms as associations will be used as data source.

For the technology and market development the trends of the last years, possible technical improvements, price changes, legislations and R&D (Research and Development) developments will be considered.

According to the EU 20-20-20 targets until 2020 a reduction in European Union greenhouse gas emissions of at least 20% below 1990 levels is foreseen (7). Furthermore regarding the EC (European Commission) this reduction should go till 80-95% by 2050 (8). Hence, the question is how can this target be broken down to the heat and cooling sector?

In all activities it is regarded as fundamental importance to keep an absolute transparency where the data are taken from, if they have been elaborated, on which base and why specific assumptions are taken if necessary. All these information's will be included in the technical report describing the database content and elaboration.

1.2 Data collection – top down

The data are gathered on two levels. The first level refers to technology employed and the second to energy-economic performance of the systems. The first will be a comprehensive overview of current available technologies for cooling and heating in the different residential and economic sectors; the second will provide the basic figures to analyse the data.

Most of the data collection work is based on former projects like the IEE (Intelligent Energy Europe) projects as for example SO-PRO, FOREST, Solarge, CombiSol and Enerbuild. Some more are the FP6 projects Rococo and Polysmart and International Energy Agency projects in the programs such

as: IEA (International Energy Agency) SHC – Solar Heating and Cooling programme, IEA ECBCS – Energy conservation in buildings and community systems program, IEA HP – Heat Pump program, IEA DHC/CHP - District heating and cooling including CHP (Combined Heat and Power) and IEA Bioenergy.

Projects of these programs give information on the technologies employed for heating and cooling, but they also give utilization and market figures useful for the present analysis. With regard to the residential, office and services in general, heating, cooling and domestic hot water needs are analysed. Concerning the industrial applications, again heating, cooling and domestic hot water needs are elaborated. Moreover, quantity and quality (temperature) of the process heat needed and wasted will be taken to a closer look. Two or three categories of temperatures ranges will be defined (low temperature < 100°C, medium temperature 100 < T < 250 °C and high temperatures > 250°C).

At the same time information on the state of the art of the European buildings, market (residential, hotels, offices, services and industry) in different European countries will be assessed. Legislation, age, number, average sizes and characteristics as the thermal energy demand will be retrieved. The UIPI (International Union of Property owners), which can be considered as a major source of data in this field will be contacted (9).

The data relating to the buildings/loads will be organized in matrices depending on the typology (residential, office, hotel) and on the constructive features as the sizes of the entire building and of the internal substructures, the age and the thermal energy consumption/demand. For each typology, the number of buildings is suitable for the installation of hybrid cooling/heating plant employing solar driven systems during the refurbishment or the initial construction phase will be estimated.

The actual state of the art and the trends (of the market and of the needs) in the last 20 years will be analysed: the trends will be used to define scenarios.

1.3 Current status – bottom up

At the current status analysis the focus will be on the bottom up approach. The last named type of analysis works on a micro level, resulting to be more precise and hence having a higher validity (10). As a first step of the market analysis it is important to give a clear picture of the actual market situation.

Regarding the thermal heating market a huge amount of data are available. In contrast to that, concerning the thermal cooling a real lack of data exists.

In order to determine the thermal cooling market as a first step, the enterprises (producers, sellers, resellers), which do business regarding thermal cooling within the EU, have to be identified. In a second step from those enterprises data concerning the amount of thermal cooling units sold per year has to be

acquired. The cooling potential of those units has to be clarified as well. In a third step, through the information gathered from the identified firms and literature available how many thermal cooling units are operative within the EU at the moment and which cooling potential they have, has to be understood. Hence, taking in consideration the average operation hours per year of the thermal cooling units, an indicative energy demand concerning thermal cooling can be obtained.

Further, the following tools will be used to clarify the actual market situation:

1.3.1 Porter´s five forces analysis

The Porter´s five forces analysis is a tool to analyse a market by considering mainly five competitive forces: threat of new entrance, bargaining power of costumers, threat of substitute or services, bargaining power of suppliers and the industry jockeying for position among current competitors (11).

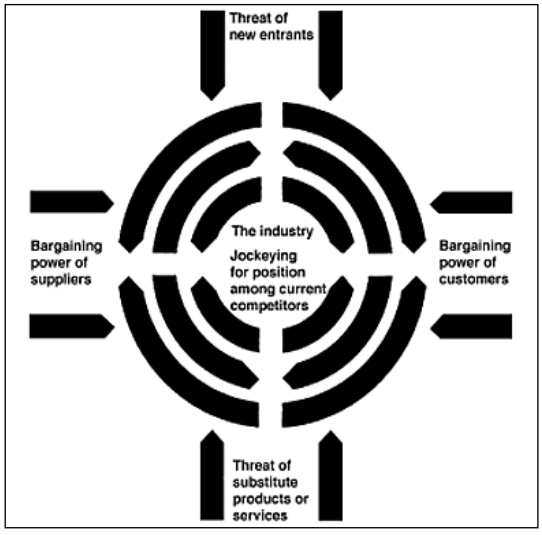

Figure 1: Forces governing competition in an industry (11)

Conducting a Porter´s five forces analysis, requires first to brainstorm all factors which are relevant for the product market situation. Then these forces have to be set against all other factors in the diagram above. Next, the key factors have to be highlighted on a diagram. The size and scale of the force on the diagram have to be summarized. Relevant signs, e.g. “+” and “-“, are recommended to be used to represent forces in favour or against the analysed commodity.

After having defined favourable and unfavourable forces of the product´s performance and attractiveness, it is important to clarify the impacts of the forces.

Trough analysing how each force affects a product and determining the direction and strength of each force, the position of a good within a market can be understood (11).

1.3.2 SWOT analysis

The SWOT analysis is a process of looking for inside and outside strengths, weaknesses, opportunities and threats of a market to define it. The single points of the four main topics (strengths, weaknesses, opportunities and threats) are than set against each other to determine an output (12).

INTERNAL	STRENGHTS	WEAKNESSES
EXTERNAL	OPPORTUNITIES	THREATS

Figure 2: SWOT matrix

The single points set against each other are marked with a scale going from 1 to 10, depending on their importance.

Following this procedure a SWOT anayisis permits to measure a business unit within a market (12).

1.3.3 PEST analysis

This tool refers to the political, economic, social and technological aspects of the environment that can affect the competiveness of commodities (13). See Figure 3:

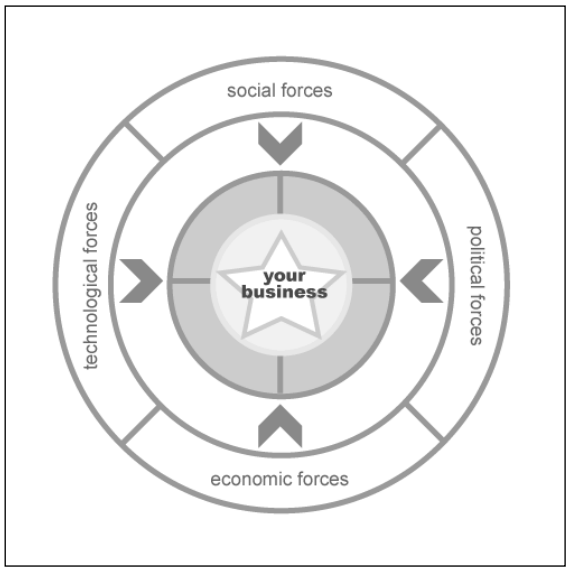

Figure 3: The four main forces within a PEST analysis (13)

The PEST Analysis is also a useful tool to analyse a business and, in particular, understanding market growth or decline (13).

A PEST analysis consists mainly of the following steps: First, relevant factors which fit to the political, economic, social and technological aspects of the environment are brainstormed. After that the information which belong to these factors has to be identified. It is very important to describe the single factors by their meaning. So, in a third step, conclusions can be drawn using this information. The conclusions obtained shall be tested against the reality experienced (14).

1.4 Trend analysis

For the trend analysis a tree model is going to be implemented in order to describe possible scenarios of the future thermal heating and cooling market. In this case a tree model will be elaborated in order to describe possible scenarios depending on which happenings occur (15). Possible examples of important happenings in this case are e.g. subvention decision by governments or significant technical evolutions. The results of the tree model are key outputs to quantify the future of the analysed market. An example of a multi-period scenario tree is given in Figure 4:

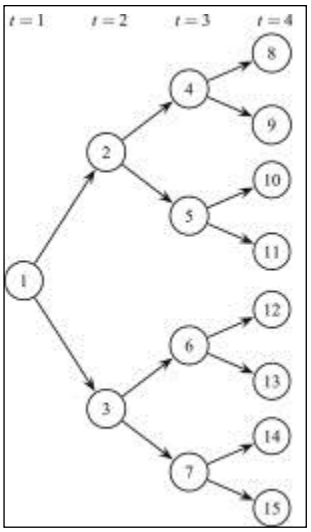

Figure 4: A multi-period scenario tree (16)

1.5 Potential market

To determine the potential market it's important to use the lowest number of estimations in order to guarantee the validity of the result. The output of the potential market analysis depends significantly from the results of the PEST analysis giving indications about a future market growth or decline (17).

What can be done to indicate a potential thermal heating and cooling market in the European residential sector before having an output of the PEST analysis is to multiply the gathered data about heating and cooling per country in kWh/m²a by the total amount of living units within the EU. The same procedure can be done for all other sectors (e.g. service, industry) as well.

2. Database and Models

The database is serving as the basis for the analysis of current status and the development of scenarios.

The database will be structured in order to define in detail the categories related to the sectors (residential, service, industry) and subsectors (e.g. offices), energy consumption, energy demand, geographical resolution and details as well as climatic conditions. The characteristics to be considered for the description of the end-use technologies will be described in detail. Also a precise description of the key technologies characteristics will be provided for improving energy efficiency and CO2 emissions reduction. Furthermore, it has to be explaining how the structure of the database (including energy flows and processes from final to useful energy) will be graphically illustrated (e.g. by means of energy flow maps).
The database on heating and cooling demand has to be populated with data for the reference year gathered in order to allow the calculation of a detailed energy balance from primary energy supply to final energy for heating and cooling demand per sector and country both with and without energy correction and the production cost for each sector and demand service.

The database has to be described in detail in order that the data sources and the methodology used harmonize as well as any calculation procedures and assumptions can be applied.

A detailed energy balance for each reference year, both for heating and cooling and per sector and country has to be established.

The calculation of production costs and the graphical structure of the database including energy flows and processes have to be presented.

A collection of maps illustrating the data for the single EU members country by country has to be realized.

Key technologies for improvements in energy efficiency and CO2 emissions and their technical and economic characterization will be presented.

Data, information sources and the methodology used has to be accurately

described. What´s more the database has to be designed in order to allow a dynamic update of data in future.

An important point regarding the acquisition and elaboration of data are the spatial and geo-referenced data. The visualization of spatial data in maps, but also the further analysis of data with GIS (Geographic Information Systems) systems (combining e.g. climatic information, economic information and population density) can give the decisive added value compared to a mere database related evaluation and presentation.

3. Results

As the elaboration of this PhD-Thesis has been proceed since just a few months, by now only preliminary results can be shown.

The PhD-Project has two main fields of investigation, one technical and one economical. Results will be shown in two separated parts. In the chapter conclusion a connection between them will be created.

3.1 Preliminary results of the technical analysis

Especially as a first approach the EU 15 countries have been taken into consideration.

First an investigation regarding the heating and cooling demand of the EU 15 countries (residential sector) has been taken place. Data have been collected in kWh/m²a. After preliminary investigations the momentary results can be summarized as follows:

The largest part of energy consumption in the European households is represented by the sector of heating and cooling (18). The average energy demand of the EU 15 countries for heating purposes in the residential sector is around 143 kWh/m²a. In contrast, energy demand for cooling application leads to about 33 kWh/m²a. Hence, comparing the average energy demand for heating and cooling in EU 15 (kWh/m²a) a relation of about 1 to 4 emerges. See Figure 5:

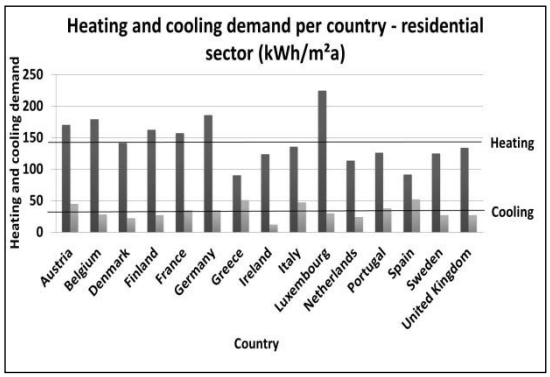

Figure 5: Heating and cooling demand per country (EU 15) - residential sector (kWh/m²a)

In particular, cooling demands in EU 15 households have been increasing significantly over the past two decades. The most important reasons for that are higher comfort and living standard, especially in Middle Europe. The fast growth over the past 20 years in the EU is another relevant reason of the increasing total cooling demand (19).

In contrast to that, looking at different data, published within the past 10 – 20 years, a decrease for all EU 15

countries in the residential sector is recognizable.

In residential buildings, retrofitted wall and roof insulation offer the greatest opportunities to save energy (20).

Figure 6 shows the growth of cooled floor space in some EU 15 countries during the last two decades and forecasts future development in this sector.

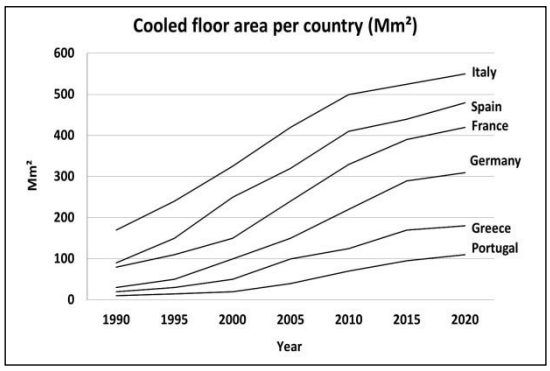

Figure 6: Cooled floor space per country in some EU 15 countries with forecasts (21)

Furthermore, having collected data of the heated floor area per country (Mm²) in the residential sector and having acquired the actual heating demand in the same sector (kWh/m²a) the quantity of the total heating demand of the households in all EU 15 countries (TWh/a) has been determined as reported in Figure 7. This reports, furthermore, the distribution of heating demand (residential sector) in the EU 15 member states.

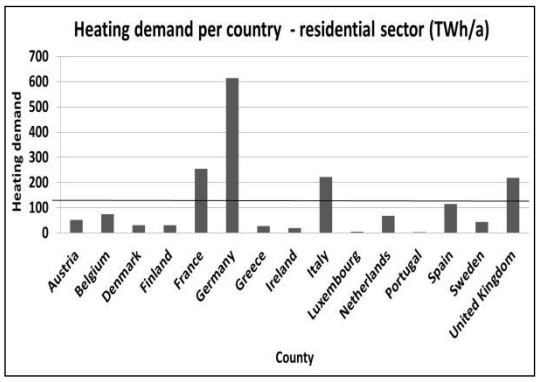

Figure 7: Heating demand per country (EU 15) – residential sector (TWh/a)

Germany shows the highest value with more than 600 TWh/a. The total heating demand (residential sector, EU 15) results in almost 1,800 TWh/a. Apparently, Germany is responsible for ca. 1/3 of the whole heating demand in the residential sector of the EU 15 member states.

France, Italy and the United Kingdom follow Germany with a demand of around 200 – 250 TWh/a. Together these four countries reach almost 3/4 of the overall demands in this sector of the EU 15 countries.

The remaining EU 15 members have just a small influence on the total final demand of this sector, because of mainly two reasons: either a low number of inhabitants (e.g. Luxembourg), relatively warm climate condition (e.g. Spain) or both. Also the economic situation of a country has an influence on that point.

What´s more the heating demand in the residential sector per country (EU 15) with the unit of kWh/inhabitant a year has been analysed.

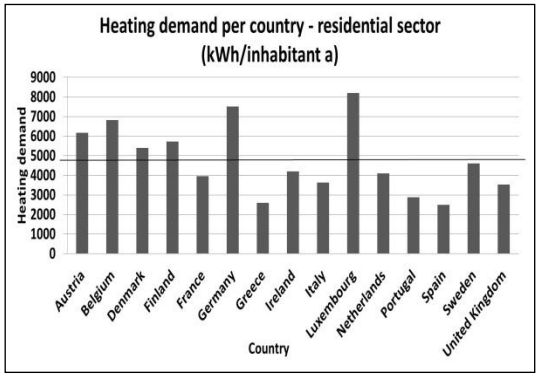

Figure 8: Heating demand per country (EU 15) – residential sector (kWh/inhabitant a)

Figure 8 mainly shows the consumption habitudes of the inhabitants in the different EU 15 countries. The highest values are given by Luxembourg, Germany and Belgium. The lowest values are given by Portugal, Spain and Greece. Again at this point the influence of the climate has to be mentioned. The economic situation of country has to be taken in consideration as well.

Besides that, other aspects can be underlined. If for example the value of France in Figure 8 gets compared with that one of Figure 5, it is recognizable that the value in kWh/inhabitant a year (Figure 8) is quite small in the ranking compared to that one in kWh/m²a (Figure 5). According to data of the Czech Ministry for Regional Development, dwellings in France have a smaller size than the EU 15 average (22). France results in having ca. 89.7 m² floor area per living unit and in contrast to that the EU 15 average per dwelling is about 93.3 m². That is one reason, why the bar of France is relatively smaller in the ranking in Figure 8 compared to that one in Figure 5.

In the following Figure 9, results obtained for DHW (Domestic Hot Water) demand regarding the EU 15 countries in kWh/m²a are shown. The values of DHW get compared to those of the heating demand. Both types of data refer to the residential sector.

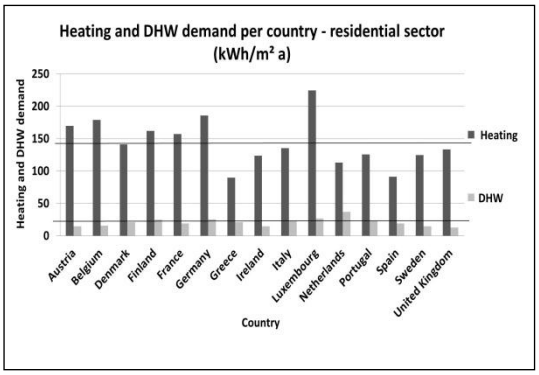

Figure 9: Heating and DHW demand per country – residential sector (kWh/m²a)

As it is visible in Figure 9, the average demand for heating and DHW purposes in the households of the EU 15 is about 143 and 23 kWh/m²a respectively. This results in a proportion of about 1 to 6. In this case Netherlands is an exception, where the proportion between heating and DHW in the residential sector is around 1 to 3.

Also Netherlands shows a high value for energy demand regarding DHW production compared to the other EU 15 countries. In this case low energy prices are one of the reasons for such a high number (23).

Figure 10 shows the ranking of the EU 15 countries between them - concerning heating and cooling demand per country in the residential sector (kWh/m²a). Following the logic given by climatic conditions this graph should follow the

given ranking: 1-15, 2-14 and so on. That means that those countries which have the highest values for heating applications should have the lowest one for cooling. But looking at Figure 10 it is not like that.

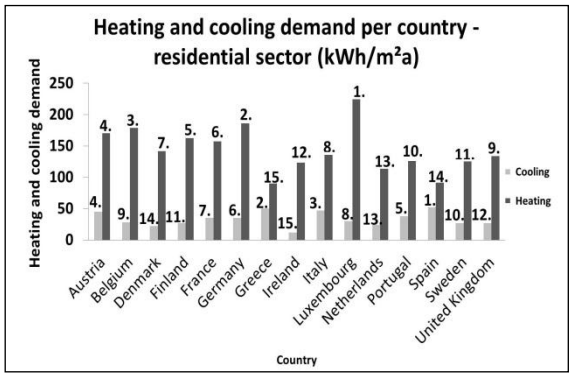

Figure 10: Heating and cooling demand per country (EU 15) – residential sector (kWh/m²a)

Reasons for that are influenced by economical and habitudinal factors.

The high energy demand values of Luxembourg whether for heating as well as cooling and DHW has been analysed. Concerning to that a high electricity consumption of the inhabitants in Luxembourg (> 16 MWh per inhabitant and year) has been detected (24). Furthermore, in Luxemburg low energy prices for heating applications have been found (25).

In the following part the results of heating + DHW and cooling loads in the residential sector of UK, France, Germany and Italy for the building stock subdivided by different construction periods are shown. Those four countries have been chosen as a first step at this kind of analysis, because they are considered to be the most representative ones in terms of building stock and heating, cooling and DHW applications within the EU. See Figure 11 to Figure 14:

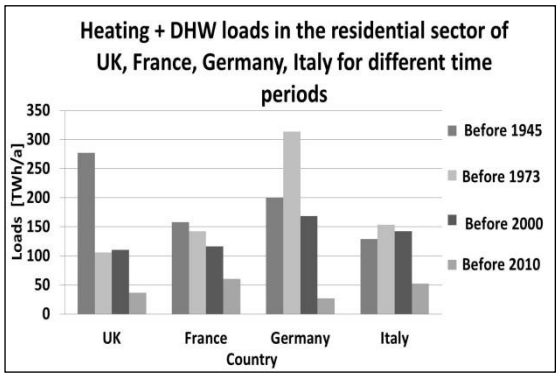

Figure 11: Heating and DHW loads in the residential sector of UK, France, Germany and Italy for different time periods (TWh/a)

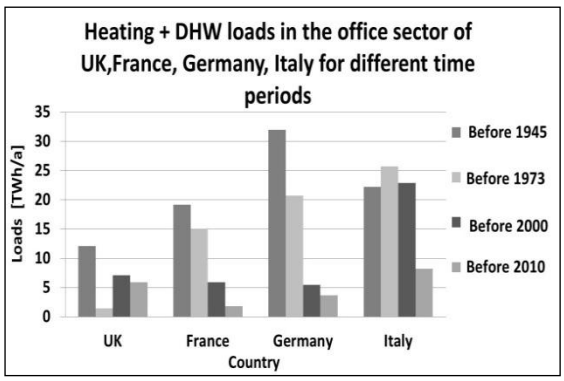

Figure 12: Heating and DHW loads in the office sector of UK, France, Germany and Italy for different time periods (TWh/a)

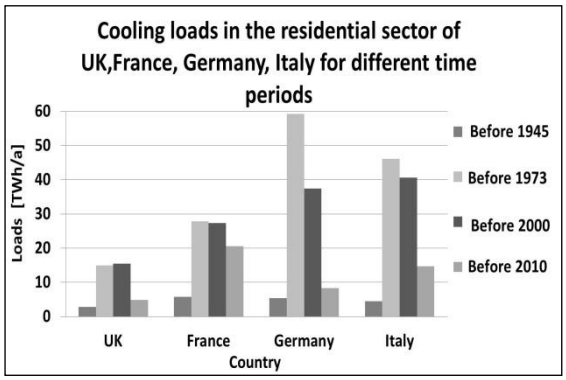

Figure 13: Cooling loads in the residential sector of UK, France, Germany and Italy for different time periods (TWh/a)

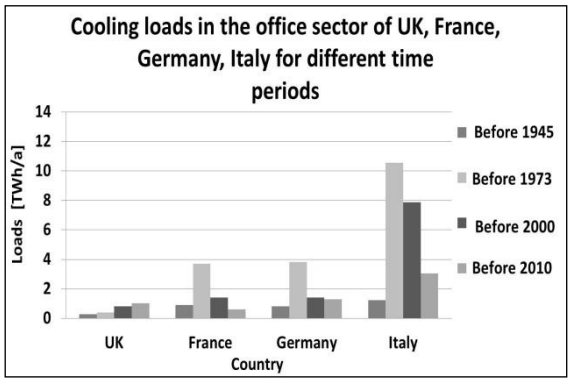

Figure 14: Cooling loads in the residential sector of UK, France, Germany and Italy for different time periods (TWh/a)

As it is visible in Figure 11 heating + DHW has the largest impact regarding energy demand in the living units of the handled countries. Cooling is becoming more and more important in the last years (mostly in the last decade). In the residential sector cooling loads are about 7 times less than heating loads and in the office sector approximately 5 times.

Concerning the cooling sector in this case it has to be focused on southern European countries like Italy and France. In Italy the energy loads for cooling in comparison to heating + DHW are about 5 times less and around 6 times in France. In Germany this value is ca. 6 and in the UK around 14 times less.

The largest part of the building stock has been built after World War II until the early 70´s. For the majority of the analysed countries (UK, France, Germany and Italy) there is a peak in constructions from 1945 – 1973. The most consuming building stock results to be the dwellings constructed during the 70´s and 80´s.

A surprising fact regarding the UK emerged. Interestingly, heating energy consumed is slightly higher by the building stock erected between 1974 - 2000 than for dwellings built between 1946 - 1973.

3.2 Preliminary results of the economic analysis

As part of the of the market analysis the R&D (research and development) funding for thermal heating and cooling within the EU have been analyzed.

This is a point, which is part of the “Opportunities” in the SWOT analysis and a factor to be taken into consideration under the sector of “Technologies” in the PEST matrix.

The FP7 (Seventh Framework Programme) has been the focus of this investigation. This funding program is financially the hugest EU programme for R&D within the time period of 2007-2013.

Officially approximately 45% of the FP7 finance for the energy sector has been dedicated to RES (Renewable Energy Sources) (26). As shown in Figure 15 until February 2012, following the EC assignment classification, this goal has been matched almost perfectly.

Bioenergy, Photovoltaic and Wind energy got the largest amount of finance in the RES sector. In order CSP (Concentrated Solar Power), RHC (Renewable Heating and Cooling), Ocean energy, Geothermal energy and Hydro energy follow. RHC is to find in the deep lower half with around 3% of the total and ca. 8% of the RES funding.

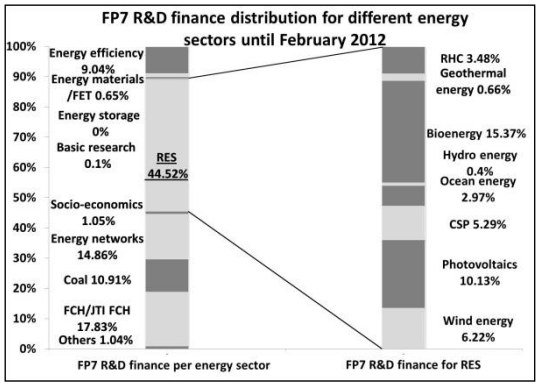

Figure 15: Seventh Framework Programme for different energy sectors (2007 – 2013) (27)

A deeper analysis on FP7 shows that about 7% of the energy finances goes to the H&C (Heating and Cooling) sector. The above mentioned 3% for RHC are a part of it.

Futhermore, in order to analyze the ecomical theory standing on the basis of the Porter´s five forces framework (the SCP - Structure-Conduct-Performance) structures and organisations of the thermal heating and cooling market in Europe were analyzed.

As a first step associations and organisations promoting thermal H&C technology in Italy have been taken in consideration. See figure 16:

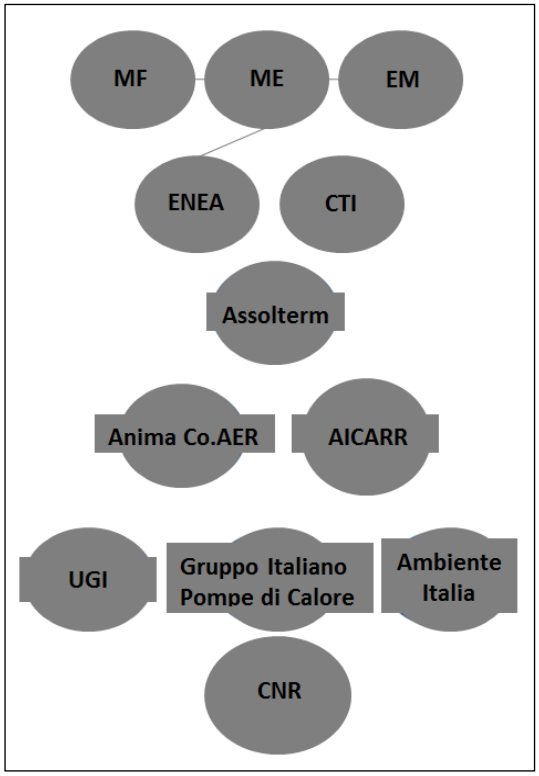

Figure 16: Associations and organisations in Italy, which deal with thermally driven H&C

At the top of the Figure 16 three ministries are present: MF (Ministry of Ecomomy and Finance), ME (Ministry of Economic Development) and the EM (Ministry of Environment). Those are mainly involved in the process of promotion opportunities and standardization activities of thermally driven H&C. The ENEA (National Agency for New Technologies, Energy and Sustainable Economic Development) provides technical advice to the Ministry of Economic Development. Next to the ENEA we find the CTI (Italian Committee for Thermal Engineering). The CTI has the task to create standards for the field of thermal engineering. Furthermore several associations are reported: The three most influential organizations are Assolterm (Italian solar thermal

association), Anima CO.AER (Italian national association for mechanical engineering) and AICARR (Italian association of air-conditioning and H&C). Less influential, but still important are the UGI (Italian geothermal union) and Ambiente Italia (Environment Italy).

At the bottom of Figure 16 we find the CNR (National research council). The CNR acts as technical advisor for the ministries at the process of creating and developing subsidies and standards for thermally driven H&C technologies.

Finally the two most important incentives within the Italian borders for the use of thermal heating and cooling have to be mentioned. These incentives are mainly two: “the tax relief of 55%”, which refers to all those interventions aimed at energy savings, including the installation of TDHPs (Thermally Driven Heating Pumps) and the “Tax deduction of 36%” from the IRPEF (i.e. personal income tax) on costs incurred for ordinary and extraordinary maintenance of the housing stock mainly with residential use.

Regarding incentives for thermal heating and cooling at EU level the European Directive 2009/28/CE and the EPBD Energy Performance of Buildings Directive have to be mentioned. The EU Directive 2009/28/CE is introducing new regulations in the sector of renewable energy and energy efficiency (6). In contrast to that, the objective of the EPBD is to activate the enormous savings potential in the European building stock and stimulate sustainable investments (28).

4. Conclusions

The conclusions presented in this section are provisional and as such to be handled with care.

Following deep preliminary investigations it emerges that Europe´s residential cooling demand is characterised by a constant increase over the past two decades. Especially affected by this energy demand rise are the EU 15 countries. Concerning EU 15 countries, the average demand for cooling appliances is about 33 kWh/m²a. Southern European countries like Spain, Greece and Italy have the highest values with 52, 51 and 47 kWh/m²a respectively. In the whole EU area the air conditioning demand show a fairly steady rise. The main reasons for that are higher comfort standards requested by the European population and inefficient cooling machinery.

Regarding heating the average energy demand in EU 15 is around 143 kWh/m²a. Middle European countries like Luxembourg, Germany and Belgium have the highest values with 225, 186 and 179 kWh/m²a respectively. Main reasons for that are old and inefficient heating applications.

If the average energy demand for heating and cooling in EU 15 (kWh/m²a) gets compared to a relation of about 1 to 4 emerges.

The Scandinavian countries presented in the EU 15 (Denmark, Sweden and Finland) show a low heating demand in the residential sector related to their climatic location. The average value of these three countries reaches about 140 kWh/m²a, what actually is lower than the EU 15 midpoint. Looking at different data, published within the past 10 – 20 years, it is recognizable that for the heating demand in the residential sector a decrease for all EU 15 countries is recognizable.

The current EU funds of R&D for H&C and RHC account for a very low percentage of finances if compared with other energy sectors.

Despite incentives and regulations to bring forward the thermal heating and cooling applications in Europe, the thermal cooling market results to be a niche market and to be rather small.

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