

Analysis of the space heating and cooling market in Europe

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Overview

Purpose of this paper is to provide a state of the art analysis of the space heating and cooling market in Europe. Data regarding energy demand for space heating, space cooling and domestic hot water preparation have been collected and critically analysed. Space heating and cooling demand data of the EU-15 member states have been evaluated following a bottom-up approach and compared with top-down acquired data. Results show that the energy demand for space cooling purposes of the EU-27 is significantly underestimated by top-down values. Furthermore, the EU-15 space cooling demand potential strongly exceeds the space heating demand. The ratio between potential and actual energy demand for space cooling is 6:1, while it is almost saturated for space heating.

1. Introduction

The overall EU-27 primary energy consumption accounts for approximately 1800 [Mtoe/a] (2010) (1). Most part of Europe's energy use is given by different kinds of H&C (heating and cooling) applications (~900 [Mtoe/a], followed by electric and transportation uses with nearly 360 and 540 [Mtoe/a] respectively (2), (3), (4), (5). The building sector accounts for 720 [Mtoe/a] (6). Around 450 [Mtoe/a] of this is for space H&C usage within European households (7).

Especially concerning space cooling purposes, cooled floor area is growing, leading to an air-conditioned residential

plus service area of almost 2 [Bn. m²] only in EU-15 2012 (8), (9), (10), (11).

Figure 1 shows the increase of cooled floor area in EU-15 since 1990 and indicates future developments in this sector:

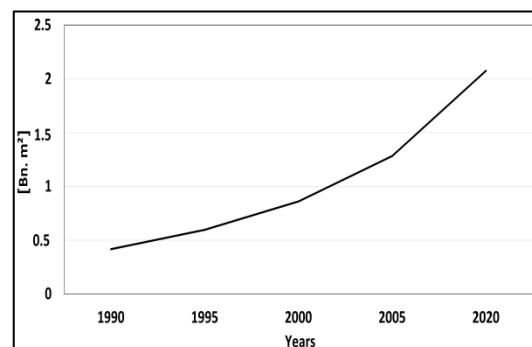


Figure 1: Trend of cooled floor area since 1990 with outlook until 2020 (EU-15) (8), (12)

Figure 2 shows the growth of CACs and RACs (central air-conditioners and room air-conditioners) installed within the EU-15 since 1990:

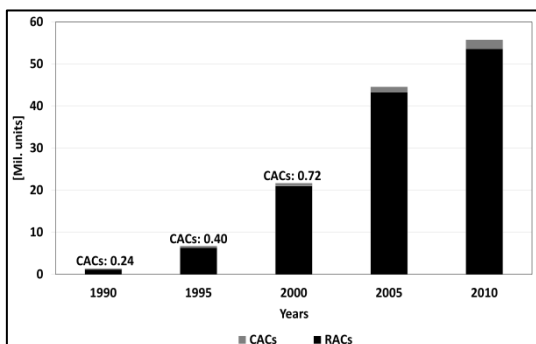


Figure 2: Amount of installed CACs and RACs per year (1990-2010, EU-15) (Amount of CACs for 1990-2000 are indicated over respective columns) (8), (12), (13), (14)

As it is registered in Figure 2, air-conditioning equipment installations also indicate a constant growth of space cooling applications. The installed quantity of CACs and RACs in the EU-15 increased by more than 50 times from 1990 to 2010. RACs account for approximately 96% of the reproduced units' amount in present Figure 2 (8), (12), (13), (14).

2. Methods

Energy demand data for space heating, cooling and DHW (domestic hot water) preparation were collected from scientific literature, expressed in [kWh/m² a]. The data were divided per country (EU-15), and then subdivided into residential and service sectors.

The space H&C demands charts (in [TWh/a]) shown in the "Results" section were obtained by multiplying average

space heating or space cooling demands per country in [kWh/m² a] by respective heated or cooled areas. DHW preparation demands ([TWh/a]) were obtained by multiplying the average DHW preparation demand per country in [kWh/m² a] by respective total residential and/or service areas.

In contrast, potential space H&C demands per country were obtained by multiplying average space heating or cooling demands per country in [kWh/m² a] by total residential and/or service areas (not just the heated and/or cooled areas).

Space H&C averages referring to the entire EU-15, with the unit of [kWh/m² a] are obtained by weighting the average of single countries energy demand by respective heated or cooled areas. In the charts concerning DHW preparation, the average is weighted by the total residential or service areas.

Averages referring to the entire EU-15, with the unit of [kwh/inhabitant a] are obtained by calculating the average of energy demand values for the respective EU member countries. The following figure and data with the unit of [kwh/inhabitant a] indicate consumption habits of inhabitants in the different EU-15 countries. E.g. Like shown in Figure 4, Luxembourg shows the highest value of space heating and DHW preparation in [kwh/inhabitant a]. One reason for the indicated consumption are low energy prices for space heating applications in Luxembourg compared to other EU counties (15).

Not all collected data were used. Data not included in the range of the average \pm the standard deviation have been excluded from the respective data pool. Data for space heating, space cooling and DHW preparation show significant differences from source to source. Hence, the standard deviation of collected data per country are reported in form of bars over the columns in Figure 3 and 5-8. The percentages above, indicate the respective coefficient of variation. Finally, the numbers straight over the columns in Figure 3 and 5 show the amount of data utilized to form each column.

3. Results

3.1 Space heating and DHW preparation demand

Figure 3 visualizes the relationship between space heating and DHW preparation demand in the residential sector of the EU-15 nations with a unit of [kWh/m² a]:

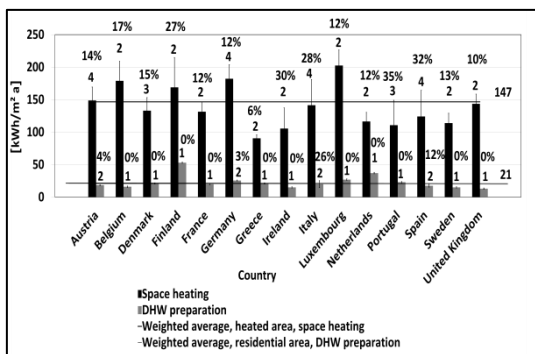


Figure 3: Space heating and DHW preparation demand per country for the residential sector in [kWh/m² a] (EU-15) (16), (17), (18), (19), (21), (22), (23), (24)

As shown in Figure 3, the average demand for space heating and DHW preparation purposes in the residential sector is about 150 and 20 [kWh/m² a] respectively. This results in a proportion of about 7:1.

The total energy demand for space heating in the residential sector of the EU-15 is around 1860 [TWh/a]. In comparison, the energy demand for DHW preparation of the same sector is about 330 [TWh/a] giving a ratio of approximately 6:1.

If residential consumption habits of different EU-15 citizens are compared regarding space heating and DHW preparation use, an even wider discrepancy emerges. See Figure 4:

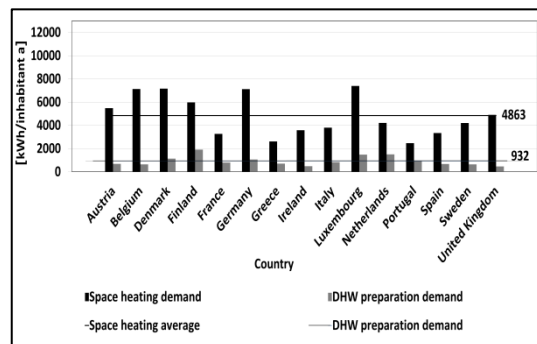


Figure 4: Space heating and DHW preparation demand per country for the residential sector in [kWh/inhabitant a] (EU-15) (16), (17), (18), (19), (20), (21), (22), (23), (24)

The average value regarding energy demand for space heating in the residential sector is approximately 4800 [kWh/inhabitant a]. If this number is compared with the average value of energy demand for DHW preparation in

the residential sector (~930 [kwh/inhabitant a]), the number for space heating results to be more than five times higher than for DHW preparation.

3.2 Space H&C energy demand

The residential energy needs for space H&C applications in the different EU-15 countries show significant differences as well. See Figure 5:

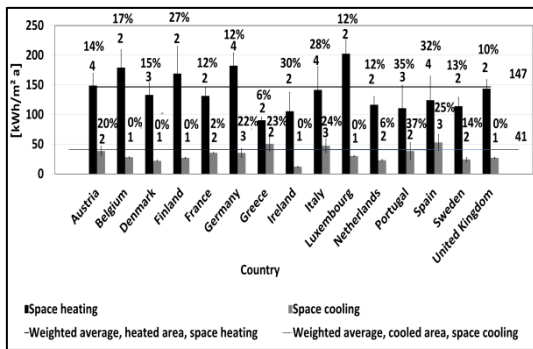


Figure 5: Space H&C demand per country for the residential sector in [kWh/m² a] (EU-15) (16), (17), (18), (19), (20), (21), (22), (23), (24), (259), (26), (27), (28), (33), (34)

Average space H&C demands of the residential sector in the EU-15 are around 150 and 40 [kWh/m² a] respectively. The resulting proportion is about 4:1.

If the space H&C demand of the residential sector is compared between different EU-15 countries with a unit of [TWh/a] an even larger proportion between these emerges: about 72:1 (around 1800 and 25 [TWh/a] for space H&C respectively).

When the consumption habits of different EU-15 citizens get compared concerning space H&C use, again a wide gap emerges.

Compared to the average value of the space heating purposes in the residential sector (about 4800 [kWh/inhabitant a]), the space cooling need is approximately 96 times lower (about 50 [kwh/inhabitant a]).

3.3 Space H&C demand potential

Following figures 6, 7 and 8 visualize the relationship between actual and potential space H&C demands in the residential and service sector of the EU-15 with the unit of [TWh/a]:

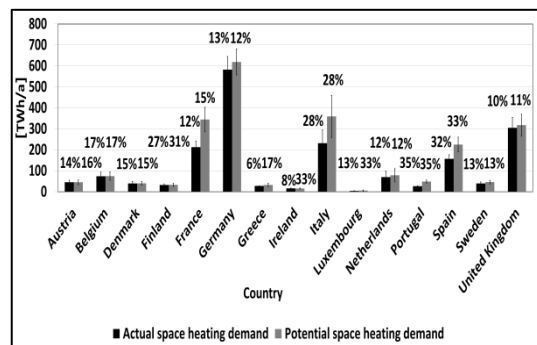


Figure 6: Actual space heating and potential space heating demand per country for the residential sector in [TWh/a] (EU-15) (16), (17), (18), (19), (20), (21), (22), (23), (24), (30), (31), (32), (33)

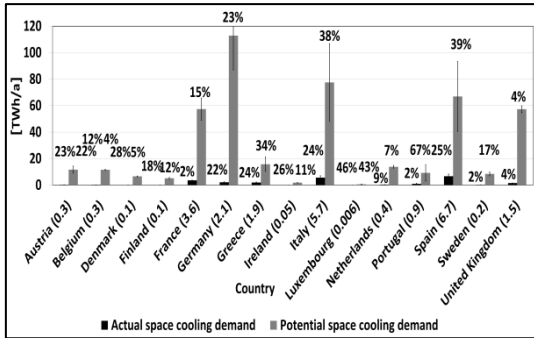


Figure 7: Space cooling and potential space cooling demand per country for the residential sector in [TWh/a] (EU-15) (Actual space cooling demands are given in brackets after countries' names) (16), (26), (27), (28), (33), (34)

By summing up the actual space heating energy demand of the residential sector, country by country (EU-15), a value of about 1860 [TWh/a] emerges. If the same calculation is applied regarding the potential space heating demand an amount of around 2280 [TWh/a] results. Hence, the difference between potential and actual heating demand of the EU-15 residential sector is approximately 420 [TWh/a].

By summing up the actual space cooling energy demand of the residential sector, country by country (EU-15), a value of about 25 [TWh/a] emerges. If the same calculation is applied regarding the potential space cooling demand an amount of around 455 [TWh/a] results. Hence, the difference between potential and actual heating demand of the EU-15 residential sector is approximately 430 [TWh/a].

Therefore, if the difference between actual and potential energy demand is compared for space H&C in the

residential sector, the result for space cooling is higher than for space heating by approximately 10 [TWh/a]. About the ratio, it is ~1:1 for the space heating and significantly higher for the space cooling sector (~1:18).

If the same calculation is applied at the EU-15 service sector a significantly larger discrepancy between actual and potential energy demand for space H&C emerges. Regarding space heating in the service sector it has been assumed that the whole EU-15 service area is heated. Therefore no difference between actual and potential energy demand for space heating in this sector is given. In contrast, the discrepancy between actual and potential energy demand for space cooling in the EU-15 sector results to be huge. See Figure 8:

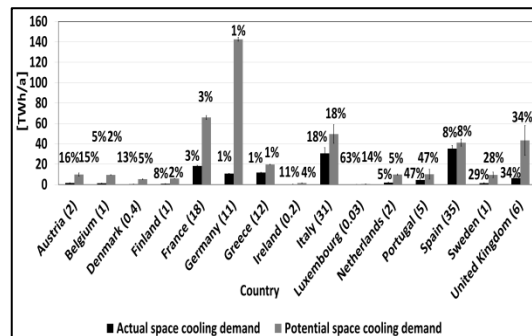


Figure 8: Space cooling and potential space cooling demand per country for the service sector in [TWh/a] (EU-15) (Actual space cooling demands are given in brackets after the countries' names) (8), (12), (25), (26), (27), (28)

By summing up the actual space cooling energy demand of the service sector, country by country (EU-15), a value of about 125 [TWh/a] emerges. If the same calculation is applied regarding the

potential space cooling demand an amount of around 424 [TWh/a] emerges. Hence, the difference between potential and actual cooling demand of the EU-15 service sector is approximately 300 [TWh/a].

Therefore, if the difference between actual and potential energy demand is compared for space H&C in the service sector, the result for space cooling is higher than for space heating by approximately 300 [TWh/a]. About the ratio, it is 1:1 for the space heating and significantly higher for the space cooling sector (~1:3.5).

Consequently, if the difference between actual and potential energy demand is compared for space H&C in the residential and service sector, the result for space cooling is higher than for space heating by approximately 310 [TWh/a].

Furthermore, the ratio between potential and actual energy demand for space cooling emerges to be 6:1 (455+424 [TWh/a] potential space cooling demand/125+25 [TWh/a] actual space cooling demand).

If the total energy demand for space heating, space cooling and DHW preparation is related, the highest position is kept by space heating with more than 2500, followed by DHW preparation with around 400 and space cooling with about 150 [TWh/a]. However of these, space cooling needs show the highest energy demand potential.

3.4 EU energy sources utilization for space H&C and DHW preparation

Attention now turns to the use of resources for space heating (inclusive DHW preparation) and cooling in the EU-27 and EU-15.

Each EU-27 citizen consumes for space heating plus DHW preparation purposes in the residential sector about 265 litres gas, 110 litres oil, 0.7 kg lignite and other combustibles every year for a total of ~3930 [TWh/a]. These ~3930 [TWh/a] are equal to about 340 [Mtoe/a] and account for around 19% of the 1800 [Mtoe/a] overall EU-27 primary energy consumption mentioned in the "Introduction" section. For the same sector and purposes, EU-15 citizens consume every year around 201 litres gas, 83 litres oil, and other resources for a total of ~2380 [TWh/a].

If the space heating plus DHW preparation consumption for the service sector of the EU-27 is considered, another ~1080 [TWh/a] have to be added. For the service sector and same kind of applications the EU-15 registers a value of ~930 [TWh/a].

In total, every EU-27 citizen consumes about 325 litres gas, 150 litres oil and 1 kg lignite for space heating plus DHW preparation production. In the same sectors, the EU-15 citizens consume every year around 310 litres gas and 120 litres oil for the same type of purposes.

In total, the EU-27 energy consumption for space heating plus DHW preparation reaches a value of ~5010 [TWh/a] for the residential plus service sector (1), (27), (35), (40).

Figure 9 visualizes the EU energy sources utilization for space heating and DHW preparation:

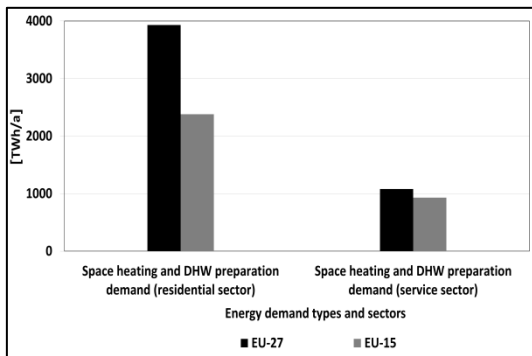


Figure 9: Space heating and DHW preparation demand for the residential and service sector (EU-27, EU-15) (1), (12), (16), (25), (26), (27), (35), (36), (40)

Concerning space cooling applications, the most used type of energy is electricity (36). For EU-15 space cooling applications in the service sector a total of about 50 [TWh/a] are consumed.

If the energy consumption for space heating plus DHW preparation is compared with this of space cooling in the EU-15 service sector, a relation of 19:1 emerges. In total space heating plus DHW preparation shows a proportion to space cooling in the EU-15 of around 1:84 (16), (26), (27), (28), (33), (34), (37).

In contrast to that, the EC (European Commission) 2009 indicates an electricity consumption for air-conditioning in the EU-27 residential and service sector of 17 and about 22 [TWh/a] respectively (38). Hence, the difference regarding space cooling consumption for the EU-27 residential plus service sector underlies the authors bottom-up approach result concerning EU-15 (~60 [TWh/a]) for around 20 [TWh/a].

4. Conclusions

European space cooling consumption indications given by the EC and the bottom-up approach described in the present paper show a significant discrepancy of at least 20 [TWh/a]. These 20 [TWh/a] are about half of the total energy use named by the EC (~39 [TWh/a]) for space cooling purposes within EU-27 member countries (38).

It has to be stressed, that the mentioned EC indications concerning space cooling regards all EU-27 countries, while the relative exceeding value obtained by the bottom approach refers to the EU-15 solely. It has to be underlined, that total EU-27 member nations account for around 100 mil. inhabitants more than the EU-15 (39). Moreover, the energy demand for space cooling applications is not negligible for these countries that joined the EU from 2004 until 2007 (40).

Energy use for air-conditioning accounts for an important part of European domestic electricity consumption and is especially significant for the service

sector. In the EU-15, energy demand for office space cooling applications exceeds these of dwellings for more than five times.

In particular, energy demand potential for space cooling applications excels these for space heating by an outstanding value of more than 300 [TWh/a] in the EU-15 nations, which is equal to more than double of the actual energy request for space cooling applications in the same sector.

Energy required for air-conditioning is rising significantly in Europe. Over the past two decades the cooled floor area as well as sales volume of space cooling equipment has significantly increased.

Therefore, it has been decided to analyse more in detail the space H&C demand in Europe by taking in consideration different building typologies. The focus lies on space cooling demand. It has to be understood how the cooling market will develop next years in Europe.

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