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Analysis of total energy consumption in 100 health care homes

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SAVE AGE Project

Project Partners	Country
E-zavod - Institute for comprehensive development solutions	Slovenia
Ingema-Matia Gerontological Institute	Spain
Institute of Systems and Robotics	Portugal
W/E Consultants Sustainable Building	Netherlands
Association of Social Health Care Providers	Czech Republic
Prioriterre	France
Energy Agency for Southeast Sweden	Sweden
Steinbeis Forschungs- und Entwicklungszentren GmbH	Germany
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Centre of Research for Energy Resources and Consumption	Spain
European Association of Directors of Residential Care Homes for the Elderly	Germany
Association of Social Institutions of Slovenia	Slovenia
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1 Introduction

The Energy Performance of Buildings Directive (EPBD) which has been adopted in December 2002 and transposed into EU Member States (MS) national legislation in January 2006 has been the driver for the establishment of energy performance ratings and certification, as these are part of the EPBD implementation. The development of benchmarks to enable the comparison of the energy performance of similar buildings, across different countries, is therefore an urgent matter. Benchmarking energy efficiency is an important tool to promote the efficient use of energy in buildings.

Energy consumption benchmarks for office buildings have been already studied in several countries. These benchmarks are based on statistical analysis, of data collected through forms and includes all the type of energy consumptions used in the building. As far as it was possible to investigate, no energy benchmarks have been studied for Residential Care Homes for Elderly People (RCHEP), so far. Moreover, RCHEP lacks knowledge and awareness on energy efficiency and they are generally quite reluctant to new technologies. Their main concern is to provide the best quality care they are able to, and neglect technical energy issues. The development of cross country comparisons of energy efficiency within RCHEP will raise their awareness and drive their decisions towards energy efficiency.

Generally, establishing an energy efficiency benchmark deals with two separate phases. The first one is based on the collection of energy consumption data from field surveys and the second is based on energy consumption results from computer simulation. This report presents the methodology to develop energy performance benchmarks for RCHEP in order to compare the performance of similar institutions within the 10 European countries involved in the Save Age Project. The benchmarking indicators are based on data collected from monitoring of 10 RCHEP in 10 different Member states, such as Czech Republic, France, Germany, Greece, Italy, Netherlands, Portugal, Slovenia, Spain and Sweden. The monitoring is based on a detailed survey assessment which is based on the collection of a questionnaire filled in through interviews with the RCHEP managers, technical staff, maintenance staff, nursery, etc. There are advantages and disadvantages of this approach. The obvious benefit is that the energy consumption benchmark is more practical, because uses statistical analysis of the data collected from the survey form. However, there is a limitation of this approach. As the benchmark relies on the number of RCHEP of the sample, if the entire population is energy inefficient the result of the benchmark can be poor confident.

2 Methodology

The project started with a literature survey assessment to collect information about energy efficiency benchmarks all over the world, in similar buildings. This survey enabled the collection of data related to performance indicators for assessing energy efficiency. This data helped to establish which relevant performance indicators or measures should then be considered.

In addition there was an investigation about recent monitoring projects, in particular the Tertiary and REMODECE projects, as well as older projects like the SAVEII project DSM in Health-Care facilities, which helped us to decide what data we should collect. A detailed questionnaire was prepared with the purpose of collecting energy data as well as information about the needs and obstacles within the RCHEP. Information about recent investments in energy efficiency and available incentives within each country has also been collected with the survey form. The detailed questionnaire can be seen in Annex 1. To characterize the 10 residential care homes for elderly people in each country, the questionnaires have been filled in with an interview.

All the collected questionnaires have been stored in one database, which was created on purpose for this project. A web based platform: www.isr.uc.pt/~save age, enables each partner to feed in the database with the results from the field surveys. Each country is responsible to feed into the database with the information collected from the RCHEP.

Facility managers, management staff, etc. for each RCHEP have been interviewed in order to complete the survey form for each RCHEP for which they are responsible. The common starting point was to collect as much information as possible, such as the general information about the RCHEP (number of residents, number of beds, number of rooms, etc), construction details (type of building, location, type of terrain, etc), heating/cooling, equipment, type of lighting and collection of the energy bills in the building, amount and cost of energy use, like electricity, natural gas, biomass, etc.

The three last year's energy data were collected for each RCHEP to provide the disaggregation of energy sources used.

After the data collection, in order to make the analysis the data stored in the database was imported into an excel file and the excel statistic functions have been used to treat the data and calculate the energy performance indicators. In the future, collected data can be imported into the statistics software tool SPSS to compare the results and go further in the analysis.

2.1 Climate factors

Since there are RCHEP from countries with different climatic conditions, climate adjustment of the energy data was considered in the analysis, and therefore heating degree days have been collected. However, degree days should be handling with care. When applied to real-world buildings, common degree-day-based methods suffer from a number of problems that can easily lead to inaccurate, misleading results.

The most appropriate degree-day data should be used. However, the degree-day data freely available is unlikely to be entirely appropriate for calculations relating to any specific buildings. Ideally degree-day data should be obtained for an appropriate base temperature and covering just the hours over which the building is heated. Since it was not possible to obtain degree-day data with a suitable base temperature for all partners, but we had access to mean-air-temperature data (e.g. monthly readings of mean air temperature), the following methodology was used to obtain approximate degree-days, with a specified base temperature. The degree day value is then defined as the difference between the daily mean temperature and the defined base temperature. [5], [11].

2.1.1 How to calculate Heating Degree-Days

Heating Degree-Days (HDD), are used for calculations relative to buildings' heating requirements. Considering a base temperature (T_baseH), and the daily average temperature T_out[I] for each day I in a period of N days (typically one year). The HDD provides a measure of how many degrees, and for how long, the average outside air temperature was bellow the base temperature. It can be calculated through the following algorithm:

```
HDD = 0;
ForEach I in period N do
    If (T_out[I] < T_baseH)
        HDD = HDD + (T_baseH – T_out[I]);
    EndIf
EndFor
Return HDD;
```

Example:

*If the average outside temperature was 2 degrees bellow the base temperature for a 7 days period, there would be a total of 14 heating degree-days over that period (7 days * 2 degrees = 14 degree-days).*

2.1.2 How to calculate Cooling Degree-Days

Cooling Degree-Days (CDD), are commonly used for calculations that relate to the cooling of buildings, especially those using air conditioning. Considering a base temperature (T_baseC), and the daily average temperature T_out[I] for each day I in a period of N days (typically one year). The CDD provides a measure of how many degrees, and for how long the average outside air temperature was above the base temperature. It can be calculated through the following algorithm:

```
CDD = 0;
ForEach I in period N do
    If (T_out[I] > T_baseC)
        CDD = CDD + (T_out[I] – T_baseC);
    EndIf
EndFor
Return CDD;
```

2.1.3 Assumptions

- Base temperatures: 15° was established as the base temperature for degree-day-based calculations relating to the energy consumption of the heating system and 20°C as the base temperature for degree-day based calculation related to the energy consumption of the cooling system [www.energylens.com]. It is important to mention that the base-temperature chosen has a strong influence in the accuracy of the calculations. Remember that the figures calculated using the degree-day based methods are usually only very approximate.

- The HDD and the CDD are accumulated for a whole month;
- To calculate the heating energy consumption we should use the colder months only, let us say from January to May and from September to December;
- To calculate the cooling energy consumption we should use the warmer months only, from June to August.

2.2 Field collection of information

Field collection of data is a huge task that is very time consuming. It took a long time to collect enough data that could be useful to model the benchmark. As mentioned earlier, a detailed survey form was prepared for the interviews, and after that the partners had to fill in the database which was developed to store the huge amount of data collected.

There was not a definition of a statistical sample to be considered for the interviews, since 10 houses is not a sufficient number of samples to establish a statistical sample. Therefore there was a random selection of 10 houses in each country, located in different locations. After the selection, the houses have been contacted to participate in the project, and the reaction was quite good in all countries. For the selection of the houses, each country used its own approach. In Portugal two associations have been contacted that helped to select RCHEP in an 80 km distance from Coimbra, from sea side to inner places. In Spain, the houses were chosen by CIRCE among a selection made from LARES, National Federation of old people's home. The houses are mainly situated in Zaragoza and Teruel counties. There are also two of them which are located in the País Vasco Autonomous Community.

To collect information of the RCHEP was not always an easy task. In well organised organisations, to gather all the information to fill in the questionnaires was relatively easy, but in many sites, collecting the yearly energy consumptions for three years period was like a nightmare! Many times the information was not available, or was only partially available. Information about the costs of energy is missing from several samples, and the disaggregation of the energy consumption per month was missing in several houses, being available one value per year. Information about the area of the RCHEP is sometimes missing. However the partners tried to collect as more information as possible and the data was modelling with the best data that was possible to collect so far. It was particularly difficult to disaggregate the heating consumption from the total energy consumption, since most of the RCHEP do not have separate meters for heating purposes.

2.2.1 Development of a web-based platform

Because of the huge amount of data to be collected within Work Package 2 (WP2) in 10 different countries, it was necessary to implement a Database (DB) in order to store the collected data in an effective way. The DB was built using MySQL technology, due to its numerous advantages, like the great versatility, the reliability, fast access speed to information, and above all, because it is an open-source. It turned out that filling in the platform was not as easy as it was foreseen and expected, but the partners succeed in filling in the data base after several constraints.

To access/store the data in the DB, a web-based platform was built in PHP with HTML/CSS, in order to be easier for the users to manage this information, through any point, independently of the platform that they use. The only requirement is the availability of an Internet connection and a web-browser.

In order to facilitate the introduction and storage of the data collected in the field with the interviews in the web-based platform, the web-platform was developed according to the survey form, following exactly the same structure. The survey form can be found in Annex 1. An advantage of such a Data base is that, data can be stored online or can be collected with the survey form and be stored later.

2.2.2 Database (DB)

The DB was designed to store all the collected data from the SAVE AGE interviews, as well as to store data from future survey campaigns, as long as the same type of information is collected. This DB is hosted in the ISR-UC web-server, and can be accessible for all users by free. However, only the partners of the project can store information in the DB, for which a password is needed. General users can have access to the stored information but they need to register first. The BD also offers the possibility to produce short reports with a simplified energy diagnosis for each sample in the database.

The Save-Age DB is contained in one file: “save_age.mwb”, which was created using the MySQLWorkBench program. This file contains 53 tables, each one containing a data subset. With this kind of structure, it is possible to have no limit in the size of the DB, and for example, it is easy to add new questions to the DB (and the survey form). Above all, with this kind of structure and using MySQL, it is possible to have fast response, while searching the DB, in a way to simplify the import/export of the data. As already mentioned, 53 tables compose the DB, each one containing a subset of data that are linked together using specific fields. Most of these tables contain information about the technologies of some kind of equipment, or the list of the countries of the project partners, the type of materials, etc. The other tables are directly related to store the data from the survey form, but need the information of the other tables previously mentioned. The list of Tables in the DB is as follows:

- Country: list of all the countries involved in the project;
- Entity: list of all the entities involved in the project;
- User: list of all the users from each entity, that can access the data;
- Questionnaire: contains the general data from the survey questionnaire;
- Company_Institution_Type: contains the list of the type of companies or institutions;
- Residents: contains the information about the residents and house keepers from each questionnaire;
- Energy_Contract: contains the information about the energy contract from each questionnaire;
- Equipment: contains the information about the equipment (end use, type and characterization) from each questionnaire.
- Temperature_Humidity: contains the information about the temperature and humidity from each institution;
- Characterization: contains the information about the characterization of the building (in particular: type of building, type of terrain, type of insulation, vegetation outside, type of windows, type of widows frame, type of windows glaze, type of doors, blinders/shadows, elevators/escalators, etc.) from each questionnaire;
- HVAC_Specification: contains the information about the HVAC (type, technology and characterization) from each questionnaire;

- Lighting: contains the information about the lighting (type, control type, location and characterization) from each questionnaire;
- Energy_Source: contains the information about the energy sources (type of energy consumption, monthly energy consumption and renewable energy sources) from each questionnaire;
- Question_Answer: contains the information about the questions and the answers from each questionnaire;

With this structure, we have the possibility to continue storing data along the years to come, to have a better idea of the evolution of the energy efficiency of the RCHEP, and in a possible future work, to have access to the data and possibility to use this data to make comparisons and future analysis.

2.3 Platform interface

2.3.1 Front-End

The platform was developed using PHP with HTML/CSS and JAVASCRIPT, in order to be easier for the project partners and future users to have access to the data. Using a web-based platform has the advantage that there is no need to install any software in the computers. The only requirement is to have an Internet connection with a web-browser. This way the data is available through any internet point. Figure 1 shows the front-end of the platform.

The main advantage of using these Internet programming languages is the fact they are of open-source character. The second reason is because these programming languages are commonly used in the web, with excellent performance when compared with the other available programming languages.

In order to make it easier to work with JAVASCRIPT, two different frameworks have been used: the jQuery Framework, commonly used for the user interface and the HightCharts Framework, commonly used to draw graphics.

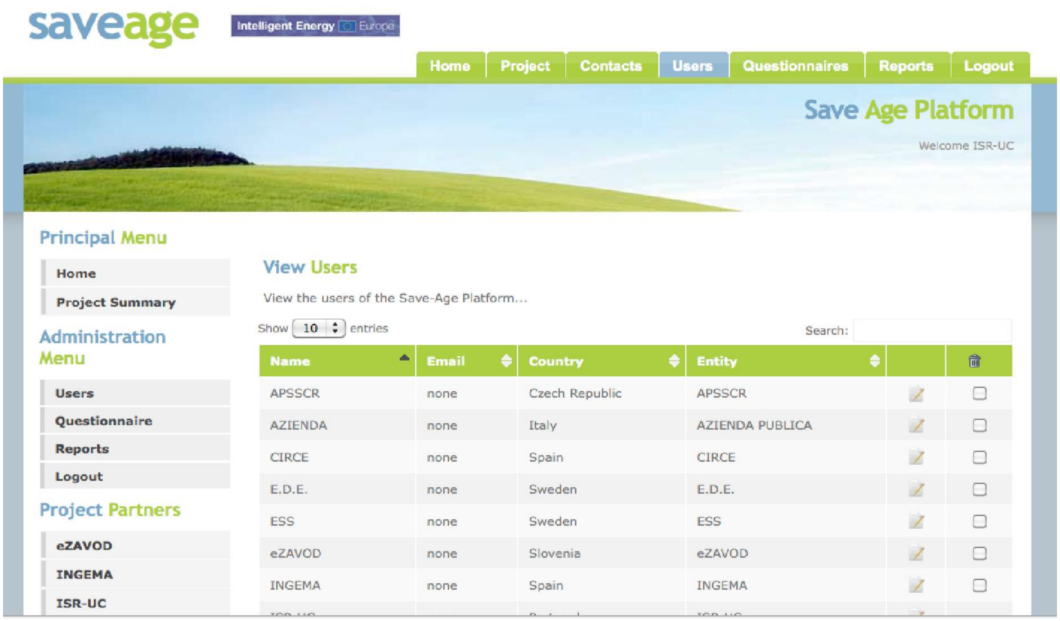


Figure 1 - Front-End of the platform.

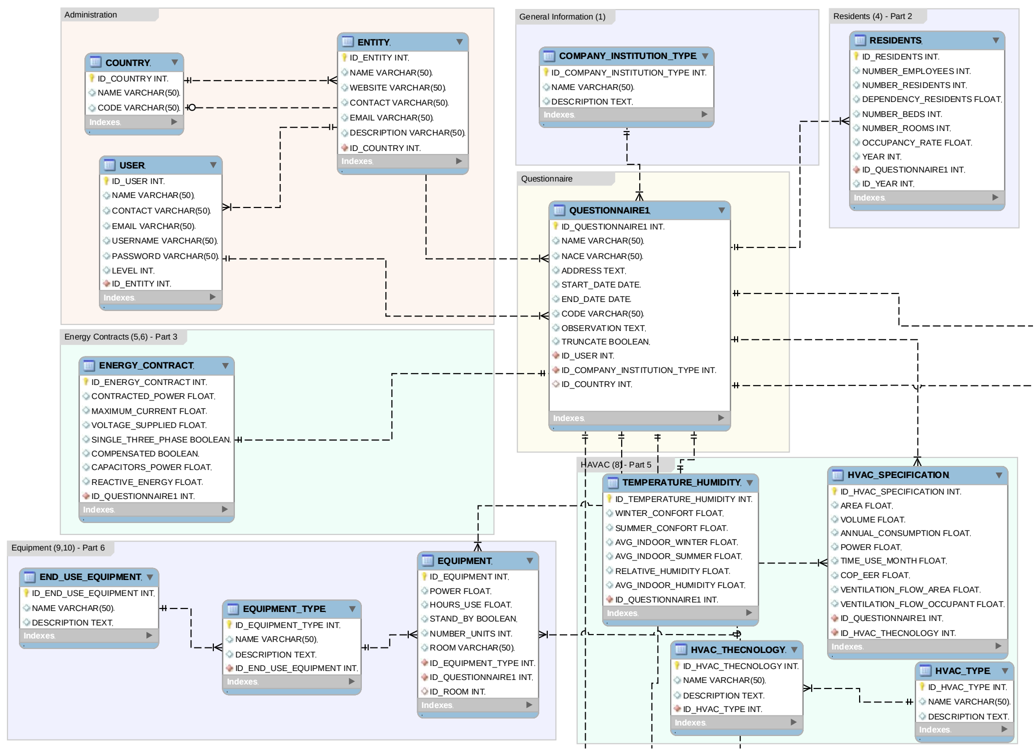
2.3.2 Using the web-based platform

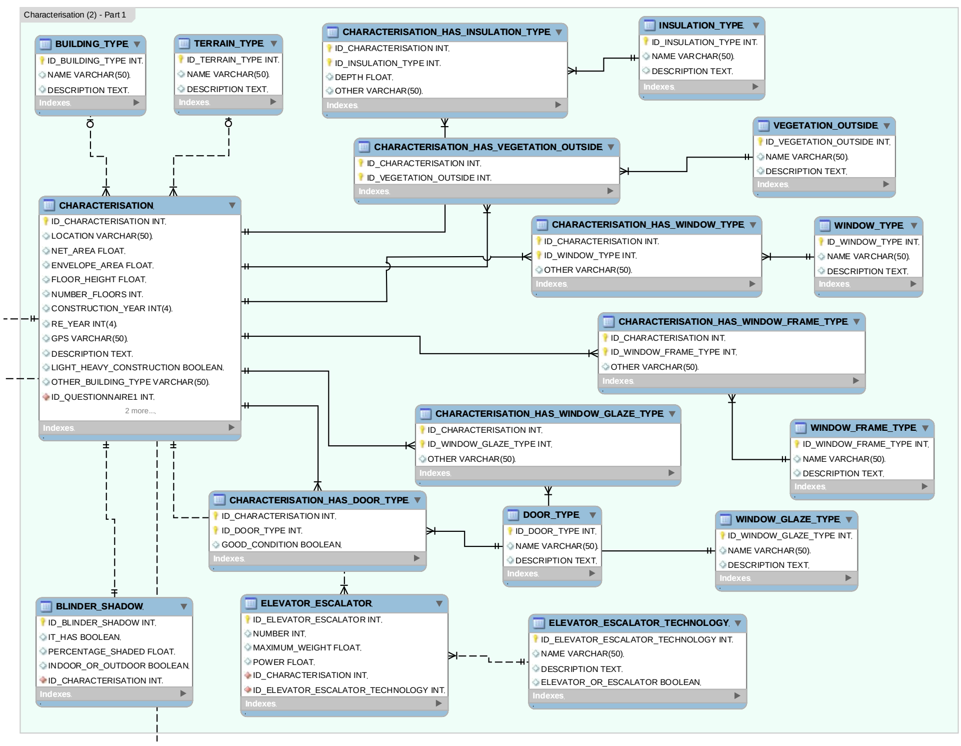
In order to access the data stored in the DB, there are two different kinds of users: the project partners and people outside the Save Age project. Project partners can modify the data in the DB, while the questionnaire form is not truncate. After truncating the questionnaire form only the administrator, ISR-UC, can edit and modify the DB.

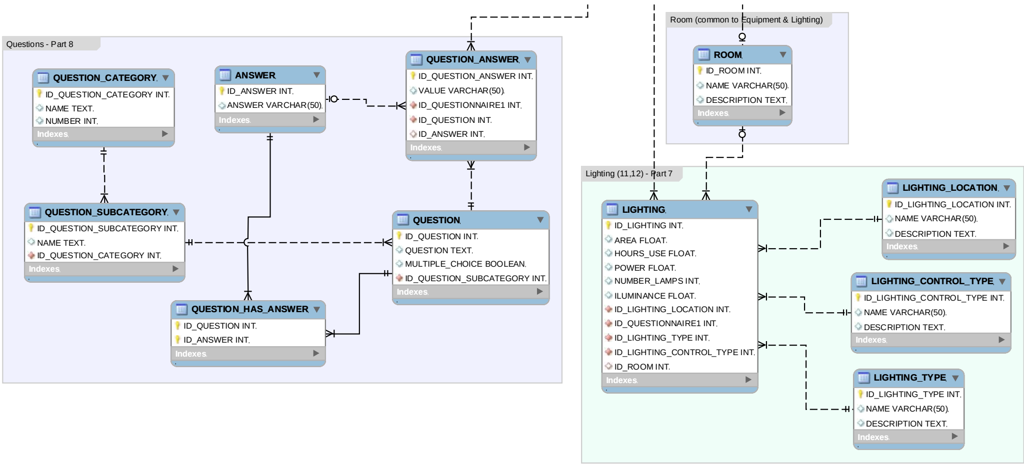
In order to keep control of the DB and to avoid inconsistencies in the data, there is a "SupraAdmin" user, who belongs to ISR-UC. This user has full access to the DB, in order to manipulate the data from the DB, even when the questionnaire form was already truncated by the partners. He has permission to edit the questionnaires, and add, modify and delete any fields. The rest of the users – project partners – are able to add, edit and modify the data stored in the DB while the questionnaire is not truncate.

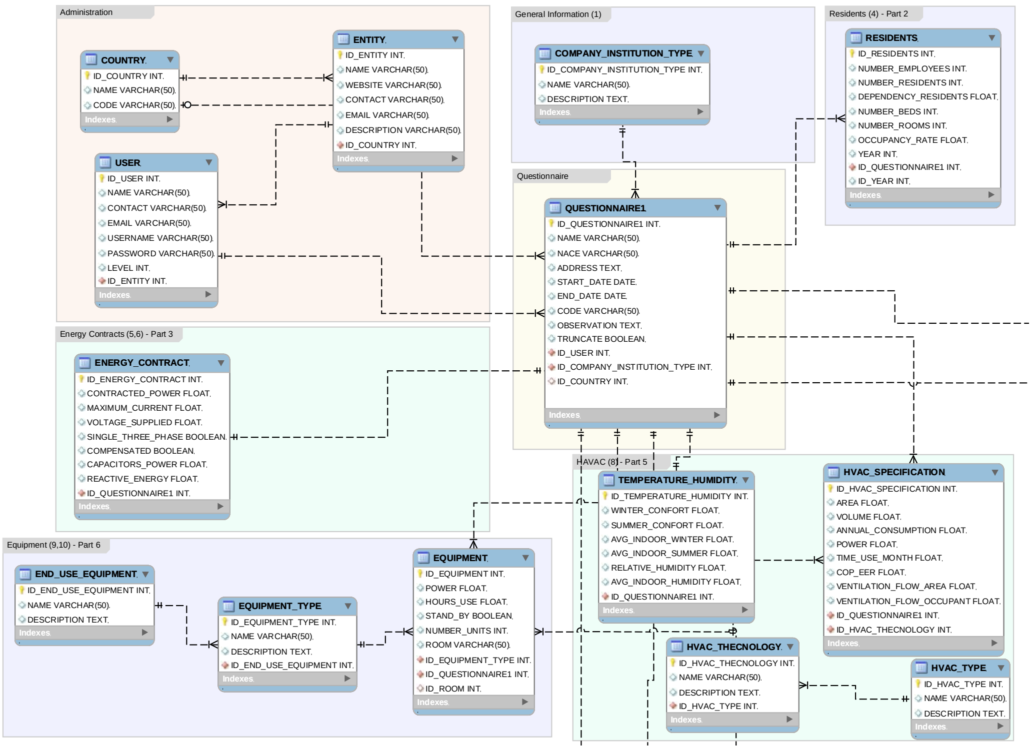
The users who have no filiations with the project, represent the second group of users. These users can only have access to the collected data.

2.3.3 Database Diagram









3 Building Characteristics

Most of the RCHEP in the sample are heavy construction type, meaning they are built with concrete, bricks, tiles, iron etc. Light constructions structures were only found in SI, one house in Sweden and two in France. Almost all RCHEP have a garden and or trees surrounded.

There is clearly a concern about the type of windows used in the RCHEP in all countries. Management staff is clearly consciousness about the impacts of the windows in the heating consumption. The vast majority of the houses have double glazed windows. The type of windows frame varies from wood, iron, PVC and aluminium, but the majority is of aluminium type with thermal cut. In southern countries, such as PT, SP, GR, IT and FR it is common to find shadows and or blinders in the windows and doors. The doors are in a bad condition in many houses. In respect to wall insulation, the situation is a bit different.

Generally speaking, older buildings are not insulated. In some countries, like FR, GR insulation of RCHEP is very common, while in Italy there is only one RCHEP with insulation. In NL, SI PT, SE, DE and SP about half of the houses have insulation while in CZ, the country with the higher number of HDD, only four RCHEP have insulation.

Among the recent retrofits carried out most actions were related to changing windows, installing solar panels, increasing the installations to increase the capacity of the house to admit more elderly and renovate the kitchen, either because it was too old or because it needed to produce more meals.

In the following sections there is a presentation of specific data for each country involved in the study.

3.1 CZ

All the RCHEP in CZ sample are of the type multi storey building, with several floors.The type of construction is heavy. All RCHEP have a small garden and or small trees around, which do not shade the building. The average net area per building is around 2000m2. Five RCHEP were built before 2000, but all those were renovated in the last decade. The remaining RCHEP were built after 2010. Surprisingly, only four houses have some insulation (one has rock wool and three have polystyrene), three of which were built after 2010, and the other was retrofitted in 2010. There are only two RCHEP that use other window frame type than wood: in particular aluminium frame with thermal cut. Almost all windows have double glaze type, but there are still two houses with single glazed windows. Four RCHEP have blinders or shadows in indoor. All but one RCHEP have wooden doors, which are in a good condition.

Considering the technology of the elevators, all but one have hydraulic elevators installed, in a number of 1, 2, 3 or 4, being the average 3 elevators per RCHEP.

All RCHEP have a small garden or small trees surounded.

3.2 FR

All the RCHEP in FR sample are of the type multi storey building, with several floors, but 4 houses have only one floor. The type of construction is heavy in 8 houses and light in two houses. Eight of the RCHEP have a small garden and or small trees around, which do not shade the building. The average net area per building ranges between 1800 and 8000m2. All but two were built between 1975 and 2000, being one built in 1928 and another in 2010. All but one are insulated with fiber glass. Half RCHEP have installed wooden frame windows and the remaining have aluminium and PVC frame windows, mostly of the type casement windows. All have double glazed and some even have low emissivity glass. All houses have blinders or shadows in outdoors. Although the windows do not seem to raise concerns in terms of energy efficiency, the situation with the doors is quite different. Eight RCHEP have wooden doors. Only two wooden doors are on good condition, the remainig doors are on poor condition.

Considering the technology of the elevators the prevalent technology is geared lift elevators. All but one house have at least one geared lift. Two houses with one floor mentioned to have a lift!

Only one RCHEP do not have a garden or trees surounded.

3.3 DE

All the RCHEP in DE sample are of the type multi storey building, with several floors (3 to 9 floors). The type of construction is heavy in all the RCHEP. Eight RCHEP have garden and trees and two RCHEP have small and large trees. There is a large variation for the average net area per building, ranging from 1783m2 to 24625m2. the average net area is about 7800m2. The buildings have been built between 1928 and 1988, but there are two buildings that are very old, buit in 1896 and 1400(??). Most of the buildings have been renovated during the last decade. Four RCHEP do not have insulation installed, however one of these buildings has very large walls. There is a mix in the type of frame window type available, from wooden frame to aluminium type and PVC. The windows are of the type casement and hopper. All but one house have double glaze windows, and many have blinders ar shadows, mostly in outdoors. Only two RCHEP do not have any blinders installed.

The doors also seem to be in a good condition. They can be wood doors and or aluminium, PVC and steel, and are in a good condition, even with insulation in same cases.

Considering the technology of the elevators there are hydraulic, geared and gearless elevators installed. The most common are hydarulic and geared (16 and 17 respectively), however three RCHEP have gearless elevators installed.

3.4 GR

All the RCHEP in GR sample are of the type multi storey building, with some floors (1, 2 or 3 floors). The type of construction is heavy in all the RCHEP. There is a significant variation for the average net area per building, ranging from 220m2 to 5500m2. The buildings have been built between 1953 and 2009. There are not very old buildings, what can justify the fact that all but two have double wall with insulationt. Only three buildings have not been renovated recently. Two have been built in the last decade. The vast majority of windows are aluminium without thermal cut and PVC windows. Only one RCHEP has wood frame windows The windows are of the type horizontal sliding, casement and hopper. Three houses have single glazed windows, and all have blinders in a percentage ranging from 60% of to 100%: seven houses have outdoors blinders while 3 have indoors blinders. The percentage of windows with blinders is lower in the houses with indoors blinders.

The doors are all made of wood and are all in a good condition.

Considering the technology of the elevators there are only hydraulic elevators installed. The smaller RCHEP do not have any lift. The average number of elevators per house is one.

Seven RCHEP have garden and among those four also have small trees. The three remaining have small and large trees.

3.5 IT

All RCHEP in Italy sample are of the type multi storey building, with several floors. The type of construction is heavy in all houses. Eight of the RCHEP have a small garden, one has no garden at all and two have large trees. The average net area per building ranges between 1500m2 and 18.270m2. The building stock is quite old, but one RCHEP was built in 2009. There are 4 buildings from the last centuries, and the 5 remaining were built between 1966 and 1999. Only two houses have insulation installed. Four RCHEP have installed aluminium frame windows with thermal cut and the remaining are wooden made. Most windows are of the type casement and there are also some, few, hopper windows. The presence of blinders is not common, and four houses mentioned to have only part (30-50%) of the windows with blinders. All but one house have double glazed windows. The doors are usually made of wood, but aluminium and PVC doors are also common. They are generally in a good condition, however in two RCHEP, the doors are in a bad condition. Considering the technology the prevalence is for hydraulic elevators, although there are two gearless and one geared lift. The number of lifts per house is one or two per house. One house, wich is much bigger than the others, has 9 hydraulic lifts.

All RCHEP but one have a garden and two also have large trees. Only one do not have any surounded vegetation.

3.6 NL

All the RCHEP in the Netherlands sample are of the type multi storey building, with several floors (1 to 14 floors). The type of construction is heavy in all the RCHEP. There is a large variation for the average net area per building, ranging from 1100m2 to 24119m2. The average net area is about 10968m2. The buildings are relatively recent and have been built between 1964 and 2004. All buildings, except two have been retrofitted. Four RCHEP do not have insulation installed, but have double walls with air cavity.

There is a mix in the type of frame window type used, such as wooden frame, aluminium type and PVC. The windows are of the type casement, hopper, and fixed panel. All have double glaze windows, two houses have special low emmissivity glazing, and all have blinders or shadows mostly in outdoors, in the vast majority of windows (beteewn 75% and 100%). There is only one house with indoor blinders or shadows.

The doors also seem to be in a good condition. They are mostly in aluminium and PVC, and all but one are in a good condition.

Considering the technology of the elevators all are geared, and all houses but one have two or more elevators.

All RCHEP have garden and or trees.

3.7 PT

All but two RCHEP in PT sample are of the type multi storey building, with 1, 2, 3 or 6 floors. The type of construction is heavy in all the RCHEP. The average net area per building, is 2405m2, ranging from 570m2 to 5170m2. The buildings have been built between 1970 and 2008. Only two buildings are not insulated, but do have double wall with air cavity. Only two buildings have not been renovated recently. Besides some aesthetic aspects, the renovations were related to increasing the installations, installing solar thermal and changing the windows. The vast majority of windows are aluminium with thermal cut and PVC windows. No wood frame windows were found. The windows are of the type horizontal sliding, with the exception of two houses where they are casement and hopper. Three houses have single glazed windows, and all have blinders in a percentage reaching 100% in most cases, intalled in the outdoors.

The doors can be made of wood and aluminium, and are all in a good condition.

Considering the elevators all but one have one or two elevators of the type hydraulic or geared. The RCHEP with one floor only, do not have any elevator. Only one RCHEP do not have any garden or trees surrounded.

3.8 SI

Eight RCHEP in Slovenia sample are of the type multi storey building, with several floors (1 to 8 floors). All the buildings are heavy construction. There is not a large variation of the average net area per building, ranging from 4397m2 to 8936m2. The average net area is about 6426,8m2. Eight buildings have been built between 1970 and 2003. One building is quite old, from 1578 and another was built in 1940. All buildings, except three have been already retrofitted. Four RCHEP do not have any insulation installed, and there is no reference about the existence of double walls in those buildings. The other 6 buidings have fiber glass, styrofoam , mineral wood or polystyrene as insulation material.

Most of the windows are of the type aluminium with thermal cut or PVC, but two houses have wooden frame windows. All RCHEP but one have double glazed windows. All the windows are of the type casement and hopper. Only a small percentage of windows (between 10 and 40%) have blinders or shadows either indoor and outdoors.

The doors are mostly made of aluminium and wood, and all but one are in a good condition.

Considering the technology of the elevators only two houses have geared lifts installed. All the others have hydarulic elevators. On average there are 3 elevators per house.

All RCHEP have garden and or trees and are located in the city center, in most of the cases.

3.9 SE

All the RCHEP in Swedish sample except two are of the type multi storey building, but on average buildings have less floors than the other contries. The type of construction is heavy in all buildings except one. All houses have either a garden or trees. There is a large variation for the average net area per building, ranging from 2061m2 to 7961m2. The average net area is about 4636,6m2. The buildings have been built between 1930 and 2008. Six RCHEP have been renovated in the nineties. According to the available information four buildings have insulation. The type of frame windows is wooden frame. The most common type of windows is casement, but fixed panel and vertical sliding windows are also available. All houses have double glaze windows, and there are two houses with triple glazed windows. This is the only country where we could fiind triple glazed windows. All the houses have a large percentage of windows and doors shaded, in the indoor. The doors also seem to be in a good condition. They can be wood doors or aluminium, and are in a good condition, even with insulation in same cases.

Considering the technology of the elevators there are hydraulic, geared and gearless elevators installed.

3.10 SP

All but two RCHEP in Spanish sample are of the type multi storey building, with several floors. Only one house has only one floor. The type of construction is heavy in 9 houses and light in one house. Eight of the RCHEP have a small garden and or small trees around. The average net area per building ranges between 1250 and 10.000m2. All but three buildings were built after 1975, being one built in 1850, another built in 1883 and another in 1900. All houses have double walls, 5 with air cavity and 5 with insulation. There is no reference to the type of insulation material used. Eight RCHEP have installed aluminium frame windows either with thermal cut (3) and without thermal cut (5). There are also 2 wooden frame windows. mostly of the type casement windows. Five houses with Aluminium frame windows have double glazed and the remaining have single glazed. Concerning the existence of blinders or shadows, around 80% of windows do have them installed in the outdoors. There are potential for improvement of the window type. All but one door are wooden made in a good condition.

Considering the technology of the elevators all are of geared lift type. All but one house have at least one geared lift. One house with one floor mentioned to have three lifts.

Only two RCHEP do not have a garden or trees surounded.

4 Energy sources and main loads

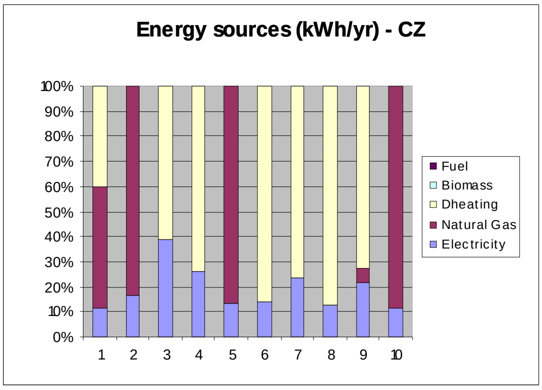
With some exceptions, most of the RCHEP provided three continuous years of energy consumption data, from the more recent four years period, from 2007 to 2010. There are five different energy sources, namely electricity, natural gas, district heating, biomass and fuel. To facilitate the analysis and enable cross country comparisons, different energy sources have been converted into a common unit, kWh. The conversion rates used to convert different sources of energy into kWh is presented in Table 1.

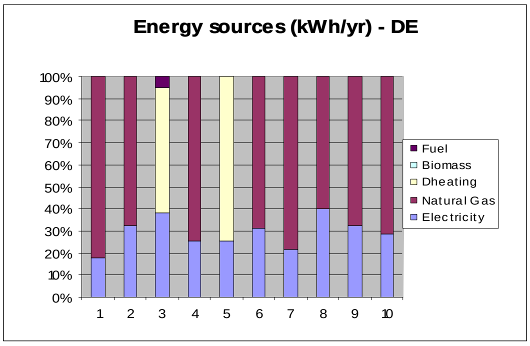
Table 1: Energy conversion rates

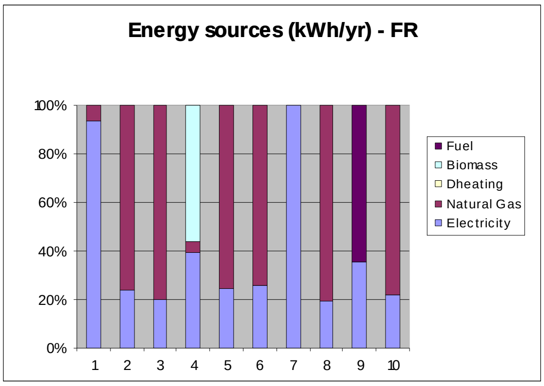
	kWh
1 ton Propane Gas	12874
1 ton Oil	10530
1 ton Biomass	4071
1000m3 NG	11800

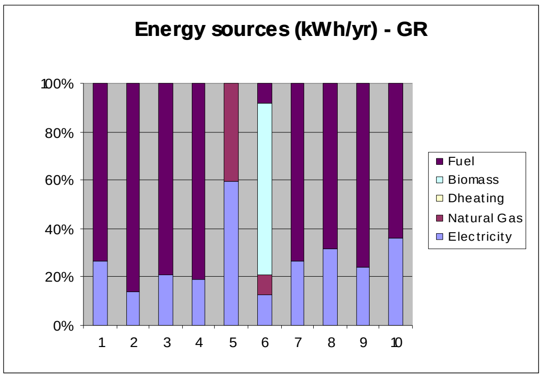
(Source: Transgás – Standard conversion factors)

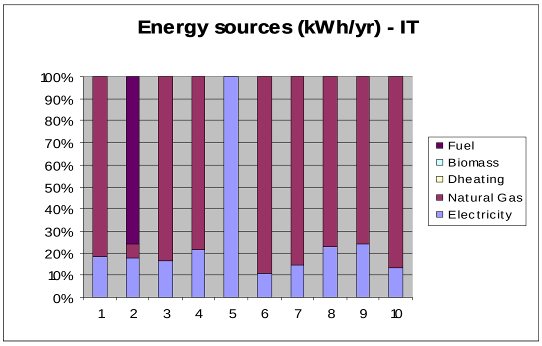
Based on the monthly information for the three years period, it was possible to calculate the average yearly energy consumption. The share of type of energy used in each country is presented below, for each RCHEP:

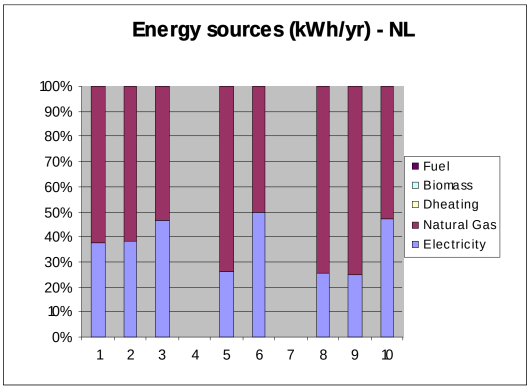


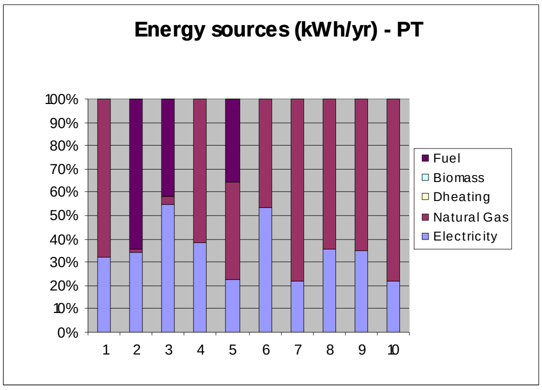


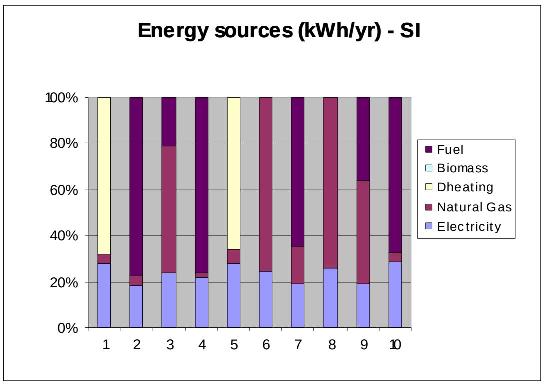


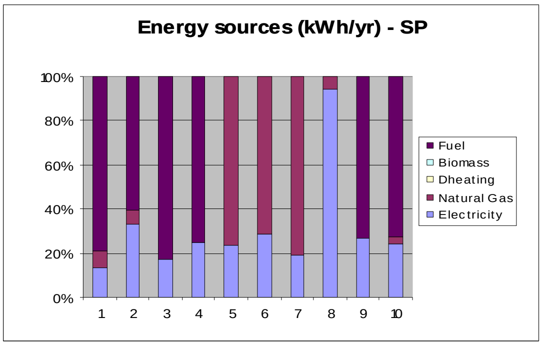


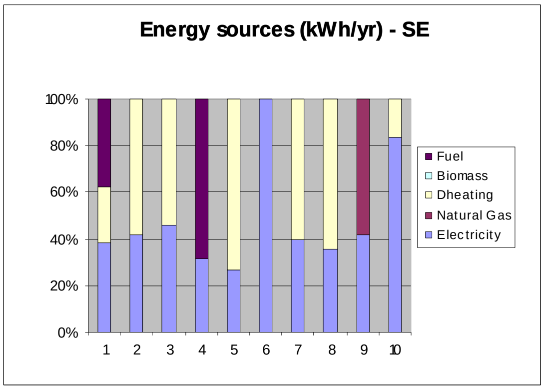












As it can be seen, electricity is not the main energy source in any country. Fuel, natural gas and district heating are the main energy sources in terms of percentage of use. This can be explained since natural gas, fuel and district heating is often used for heating purposes in all the RCHEP.

District heating is quite common in CZ and Sweden, but it can also be find in DE, SI and SE. In GR, SI and SP fuel is used quite often for heating purposes and hot water, while in the Netherlands only natural gas is used for heating, either space and hot water heating. In Italy and Portugal natural gas is the most common energy source for heating purposes, but fuel can also be found. Biomass was only found in two RCHEP, one in France and another in Greece.

4.1 Space Heating

Heating was found to be one of the major energy consumers in RCHEP. All RCHEP have central heating systems installed, of different types and running on different energy sources. The set point temperature, in winter, can range from 15°C in Italy to 26°C in Greece. The control is usually made centrally, by the staff of the RCHEP. However in some installations individual control of air temperature is possible in some divisions.

Next Table shows the type of energy used for space heating in the different countries.

Table 2: Energy Sources used for space heating

	Electricity	Natural Gas	District heating	Biomass	Fuel
CZ		X	X		
DE		X	X		
FR		X		X	
GR	X	X		X	X
IT	X	X			X
NL		X			
PT	X	X			X
SI		X	X		X
SP	X	X			X
SE	X	X	X		X

In order to estimate the space heating consumption performance indicators EUIheating (kWhheating/m2/year) and EUIheating (kWhheating/resident/year) – session 6 - and since most RCHEP do not have a separate meter to measure heating consumption, there was a need to disaggregate the space heating consumption from the general energy meters. The methodology for this disaggregation was to consider a yearly load curve for each type of energy, which was based on the collected information, and disaggregate the baseline and the heating consumption, for the energy sources used for heating. The baseline was given by the average consumption in the summer months, June, July and August.

Figure 2 compares the total energy consumption with the space heating energy consumption, which was estimated.

As it can be seen, space heating consumption has a strong influence in the total energy consumption. In countries such as SP, IT, GR, FR and CZ the space heating consumption represents more than 50% of the total energy use. In DE, NL, PT, SE, and SI the space heating consumption share about 40-45% of the total energy consumption. This information suggests that DE, NL, SE and SI, with typically much colder winters, have better insulated buildings, but other factors than insulation may of course influence the heating consumption, such as the set point temperatures, the type of controls, the habits, etc. Nevertheless, information about buildings insulation has been collected and it shows that insulation is more often used in FR and GR. In the other countries insulation exists in around half of the RCHEP in the sample. This can be however, evidence of untruthful or lack of information collected from field.

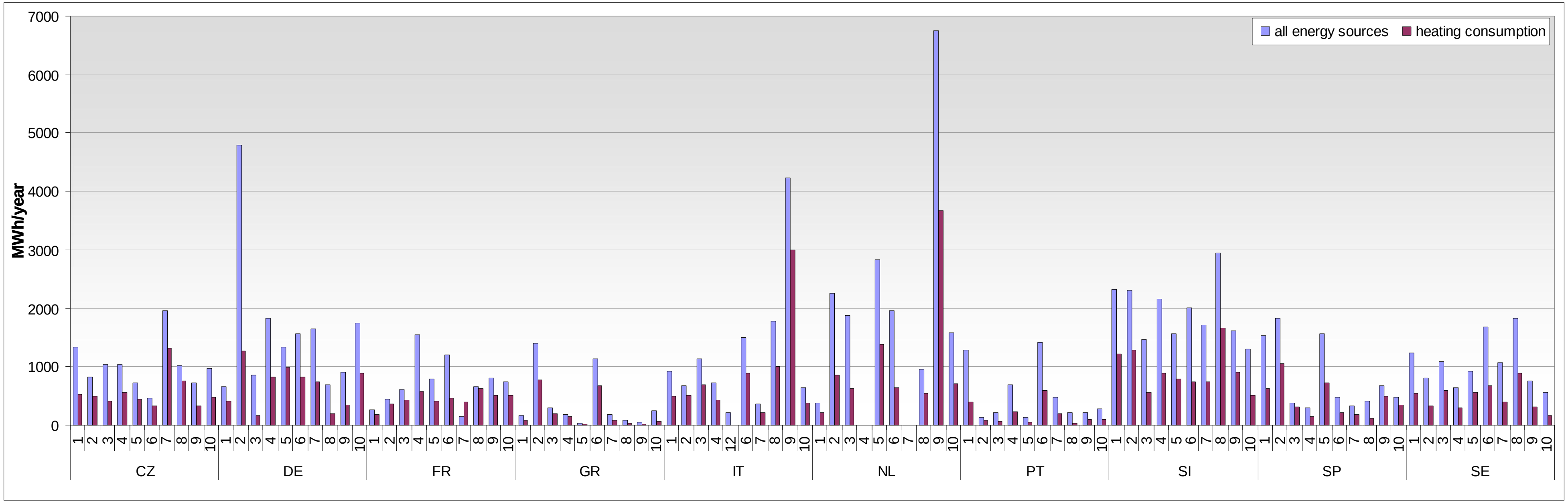


Figure 2: Average yearly energy consumption and heating consumption in each RCHEP

The numbers for space heating should be taken with care, since they are estimates which assume no heating in June, July and August, and it was considered that in winter the same amount of energy is used for hot water heating as in summer, what in principle is not the case.

4.2 Air conditioning

Air conditioning is not common in all countries. Only the southern countries, Germany and Slovenia declared the existence of air conditioning units in the RCHEP. The energy source is electricity in all cases. While in Italy, Greece and Spain air conditioning is quite common, in Portugal only two RCHEP have air conditioning systems installed.

The type of units used are split units, central air conditioning, single packaged central air, ductless air conditioning and also some portable units which have been found in Greece. Usually, it is not the whole building that is air conditioned. In GR it is common that the whole building has air conditioning. In most RCHEP air conditioning exists only in the common areas like living rooms, refectory, etc.

Requirements for minimum ventilation rates are common in all countries than in Czech Republic, where ventilation demands and demands on individual factors of inner building climate are not available. However, legislation imposing indoor comfort temperatures and relative humidity requirements are available in some countries, like for example Portugal, Spain, Sweden, and Greece.

Table 3 contains information about temperatures and humidity, both theoretical comfort values and real average values declared by the interviewees. The variance between the comfort temperature and the real temperature is usually low in GR, Czech Republic, Spain and Sweden, and can reach more significance in Sl and Italy. For Portugal and the Netherlands there was not enough data to conclude.

Table 3: Range of comfort relative humidity and real humidity, and range of theoretical comfort temperature and real temperature in winter and summer, within the 10 RCHEP in 10 Countries indoors

	Comfort relative humidity	Average indoor relative humidity	Winter		Summer	
CZ			Comfort temperature	Indoor temperature	Comfort temperature	Indoor temperature
	40%-55%	40%-60%	**22-24**	20-23	**22-23**	19-24
	5-15% variation in relation to the comfort relative humidity		1-3 °C variation in relation to the comfort winter temperature		1-3 °C variation in relation to the comfort summer temperature	
DE	na	na	22°C-25°C	na	21°C-25°C	na
FR	na	na	20°C-24 °C	na	25°C	na
GR	45%	na	23°C-25°C	23°C-26°C	25°C-29°C	26°C-30°C
			Variation between comfort and real temperature: 1°		The comfort T in all RCHEP is always below the real T (variation 1-2°)	
IT	50%		20°C	15°C-18°C	22°C-25°C	20°C-28°C
			Maximum variation between comfort and real temperature is 5°		Maximum variation between comfort and real temperature is 4°	
SI	50%	20-60%	22°C-23°C	21,5°C-23°C	22°C-25°C	24°C-28°C
			Maximum variation between comfort and real ranges between 1° and 1,5°		Real temperature usually above the comfort, between 1° and 6 °	
SP	50-60	20-55	21°C-23°C	23°C-24°C	25°C-26°C	24°C-28°C
	Maximum variation 30%		Maximum variation between the comfort and real 3° (real always above the comfort)		Maximum variation 2° (real always below the comfort)	
SE			20°C-23°C	20°C-23°C		
			Maximum variation between the comfort and the real 1°			

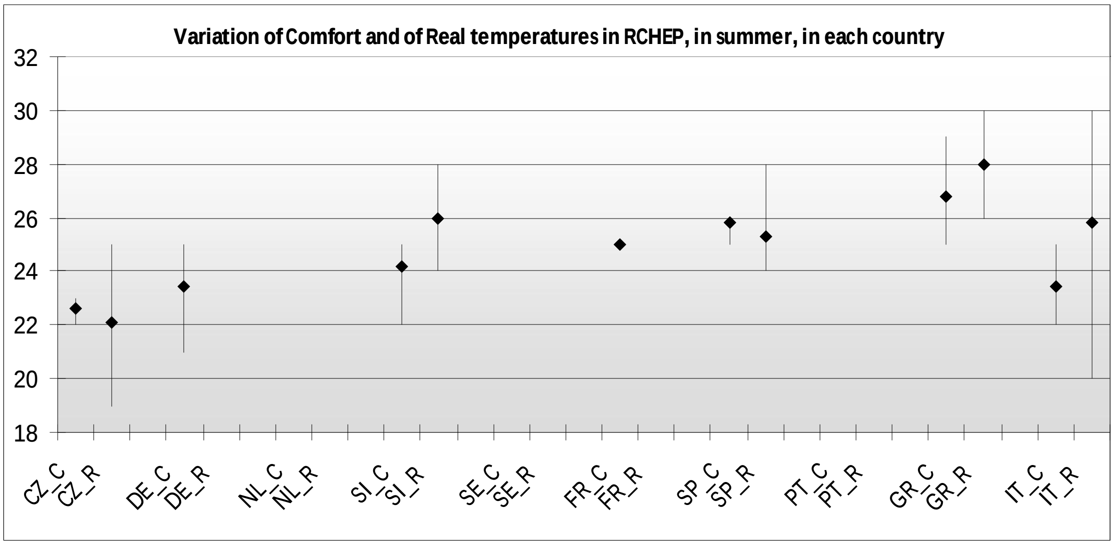


Figure 3: Summer Comfort and Real Temperature ranges within each country, and average values

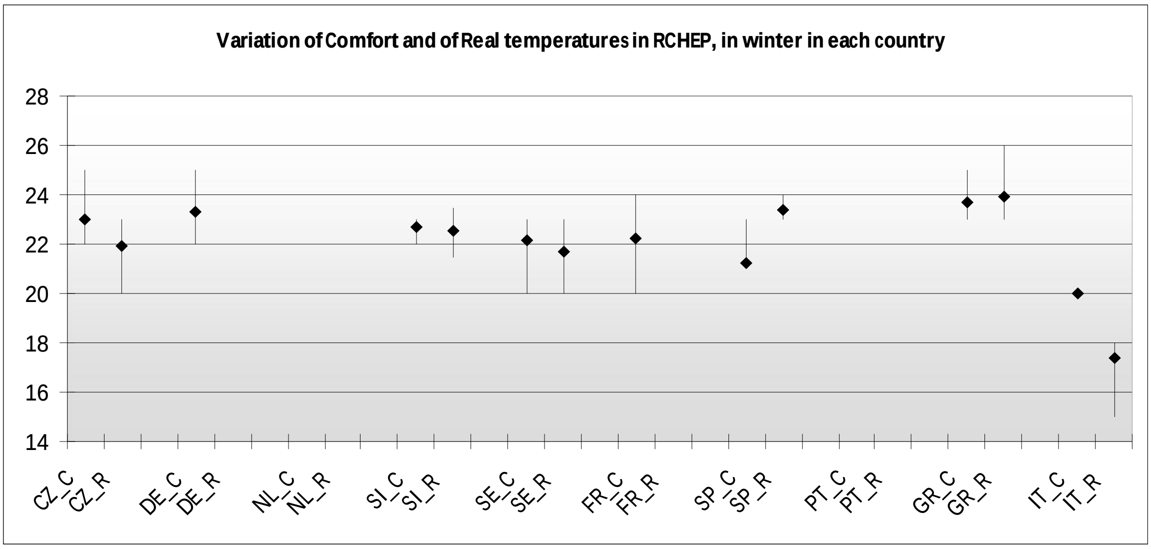


Figure 4: Winter Comfort and Real Temperature ranges within each country, and average value

From the available information, it is possible to mention that Italy is the country where there is a larger variation between the comfort temperature and the real temperature, both in summer and in winter. In winter the comfort temperature is above the real temperature and in summer the comfort temperature is below the real temperature. This information, in association with the amount of energy used in Italy for heating, gives the indication that some action is needed in Italy concerning space conditioning.

Although air conditioning loads are not still very important in all countries, air conditioning is increasing fast in all sectors. Elderly people can suffer severe health trouble with very hot summers, and the need for air conditioning is becoming more and more important in RCHEP, especially in southern countries. The higher indoor temperatures occur in Greece, but the maximum variation between the comfort temperature and the real temperatures occur in Italy. Greece and Spain do not have a significant variation between the comfort temperature and the set point temperature, what suggests that air conditioning is effective in those countries.

In this study it turned out impossible to disaggregate cooling energy consumption form the total electricity consumption and therefore cooling performance indicators have not been considered for analysis. Nevertheless information on cooling degree days has been record because it could be useful for future analysis.

4.3 Lighting System

There is a great diversity of lighting types installed. While incandescent lamps are being phased out from most RCHEP gradually, especially in Italy, Czech Republic, and Spain, where they are rarely used, in Greece they are still quite common. The RCHEP mentioned recent retrofits in terms of lighting, especially the replacement of incandescent lamps with CFLs, and the replacement of magnetic ballasts with electronic ones. In Greece and Spain it was possible to find LED lamps in outdoors. In Greece one RCHEP also have LED in the bedrooms.

Fluorescent lamps are widely used in corridors, offices, kitchens, dining rooms, living rooms, sitting rooms, drawing rooms, toilets, halls, gymnasium, etc. However in several countries such as, Germany, Greece, Spain, and Italy electromagnetic ballasts are still being used with fluorescent lamps quite often. In bedrooms fluorescent lamps are used as well as CFLs and sometimes incandescent lamps, which are often used in the bed-side table lamps. Halogen lamps are not frequently used but in Germany they could be found in bedrooms, halls and in outdoors.

In outdoors the type of lamps more often used are sodium lamps, CFLs and fluorescent with electromagnetic ballasts. In Italy halogen lamps are also common in outdoor.

Concerning the lighting controls, there is a large potential for improvements. Movement sensors or motion detectors can be only found in corridors in few countries (DE, SE and NL), and they are not used in bathrooms or toilets. Programmable dimmers, which adjust light output with the available daylight, were rarely found in indoors. In outdoors, twilight switches, time switches and motion sensors are frequently used in all countries.

The situation in each country is summarized below:

- CZ: Fluorescent lamps with electronic ballasts with simple switch and CFLs, in indoor. Sodium lamps with twilight or simple switch in outdoor.

- DE: Fluorescent lamps with electromagnetic ballasts, in corridors, kitchen, ware rooms, with simple switch; Incandescent and CFLs in the bedrooms with simple switch, halogen lamps in halls and corridors, motion detectors are used in corridors. Sodium lamps, halogen, CFLs and fluorescent in outdoors, with twilight switch, time switch and also motion detectors.

- GR: Incandescent lamps are still widely used in bedrooms, toilets and outdoor. Here, halogen lamps are also common. The only controls found were time switches in outdoor. CFLs are mostly used in kitchens, corridors and also in bedrooms.

- It: very common fluorescent lamps with electronic ballasts in all type of divisions, but magnetic ballasts are still found. Controls are only being used in outdoor, such as twilight and time switches. In outdoor, halogen lamps are the most common, but CFLs and fluorescent can also be found.

- NL: Information on lighting is available for few RCHEP and only few fields were completed. Fluorescent lamps are the most common type in offices, corridors and rooms. Time switches are used in corridors in two RCHEP.

- SI: The most common type of lighting is fluorescent with electronic ballasts, which are present in bedrooms, offices, kitchens, toilets and dining rooms. However incandescent lamps are still used in some houses. No controls are used in the indoor lighting, but in outdoors, twilight switches and time switches are used in all the RCHEP. The type of lighting used outdoors is sodium lamps, halogen, incandescent and fluorescent with electronic ballasts.

- SP: CFLs are very common in bedrooms and corridors. In living rooms and dining rooms, tubular fluorescent with electromagnetic ballasts are the most common lamps, but CFLs can also be found. In corridors CFLs are more widely used without any controls. In outdoors there are fluorescent, sodium, mercury and LED lamps. In some cases dimmer control is used twilight and time switch was also found.

- SE: Information is available for three RCHEP only. Incandescent lamps are used in bedrooms, fluorescent lamps and CFLs are used in dining and living rooms, and CFLs are also used in corridors. Both in corridors and in dining rooms there are motion detectors installed. In outdoors CFLs are used together with twilight switch.

There is no information available for France and Portugal. Table 4 summarizes the lighting situation in the different countries.

Table 4: Type of lighting and type of controls used in the different countries, indoors and outdoors

	Indoors							Outdoors						
	Incandescent	Halogen	Fluorescent		CFLs	Controls		Sodium	Fluorescent	Incandescent halogen	CFLs	Controls		
			Electronic	Electromagnetic		time switch	Motion detectors					Time switch	twilight	dimmer
CZ			X		X			X				X	X	
DE	X	X		X	X		X (corridors)	X	X	X	X	X	X	
FR														
GR	X	X			x (few)							X		
IT			X	X					x	X	x	X	X	
NL			X	X		X (corridors)								
PT														
SI	X		X					X	X	X		X	X	
SP *				X	X			X	X			X	X	X
SE	X				X		X (corridors and dining rooms)				X		X	

*In Spain some LED lamps were found in outdoors.

4.4 Hot water

With the collected data it was not possible to estimate the hot water energy consumption, because the same source of energy is used for several purposes, like heating, hot water and cooking. Table 5 shows the type of energy that is used to produce hot water in the different countries. In relation to the type of technology used, both heaters and boilers are used, either with gas, electricity or fuel.

Solar panels are present in very few houses, but at least one house in each country has solar panels. In GR and PT solar panels are more common, and 6 and 3 houses have solar panels, respectively. In relation to PV, there is only one RCHEP in FR which has a 33kW power photovoltaic system installed.

Table 5: Energy sources used for hot water

	Electricity	Natural Gas	District heating	Biomass	Fuel	Solar thermal	PV
CZ	X	X				X	
DE		X				X	
FR	X	X				X	X
GR					X	X	
IT		X				X	
NL		X				X	
PT	X	X			X	X	
SI	X	X			X	X	
SP	X	X			X	X	
SE							

SE did not deliver any information related to hot water production.

5 Average energy prices

In what concerns the average energy price per kWh, the following pictures show average prices per kWh of consumption. These prices should be seen as indicative, since they are based on the information collected with the survey, and as it can be seen a lot of information is missing. The zero values in the graphs mean there was no data to estimate the price/kWh. (See following Figures)

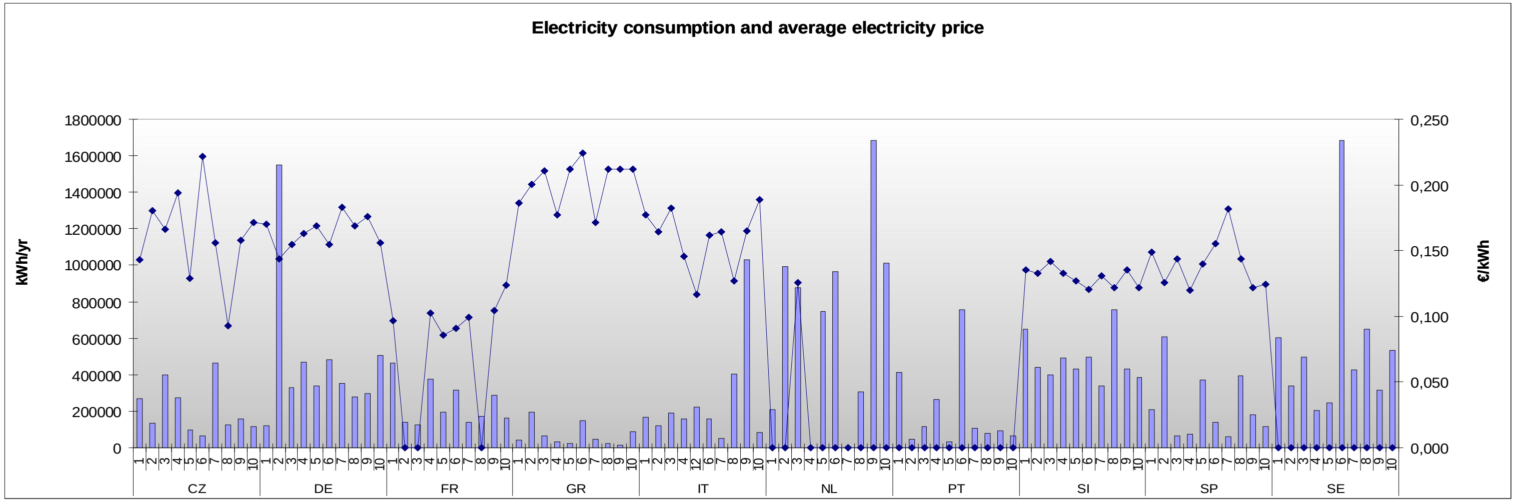


Figure 5: Average electricity price in each RCHEP

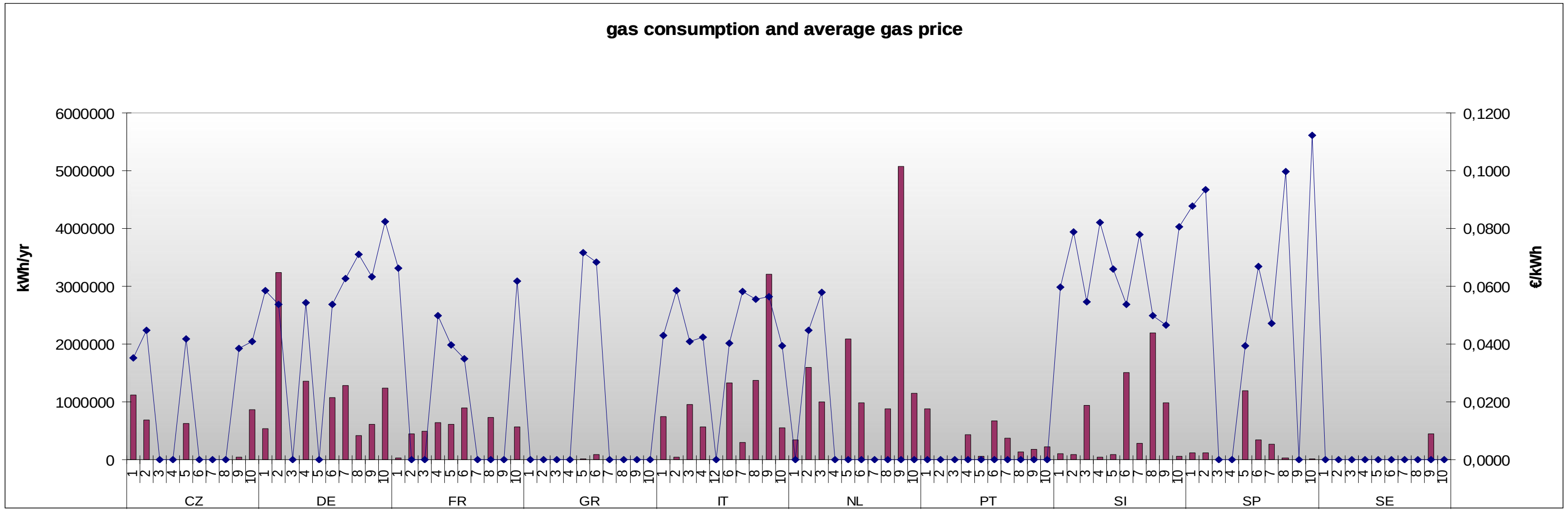


Figure 6: Average gas price in each RCHEP (zero values mean there was no gas costs available)

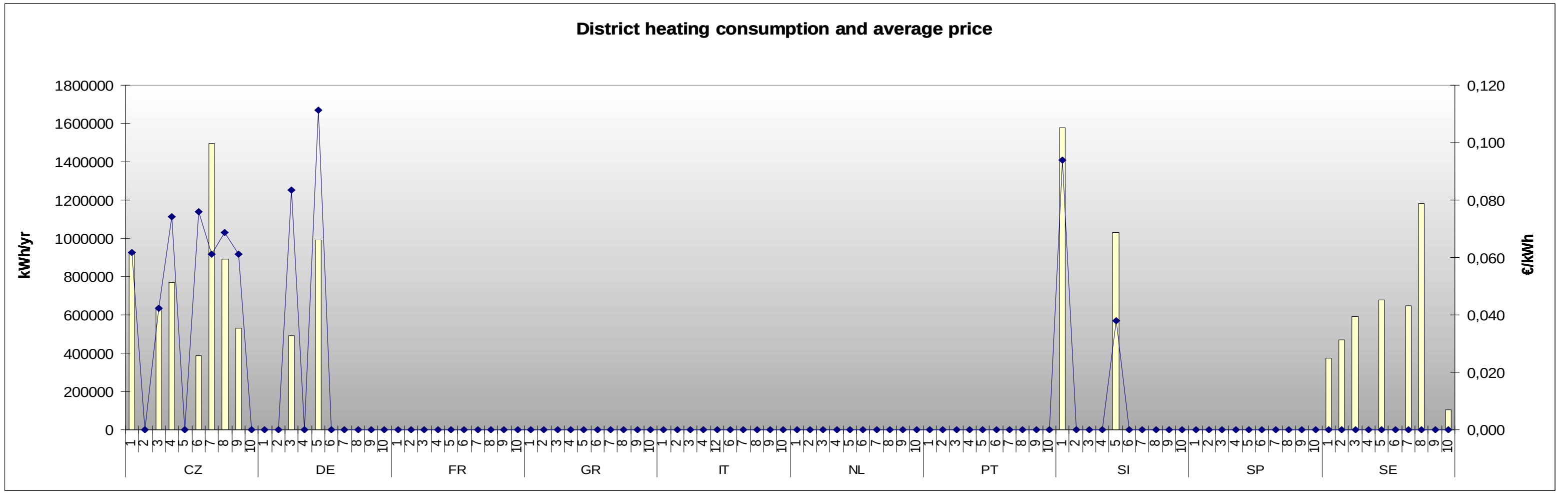


Figure 7: Average district heating price in each RCHEP

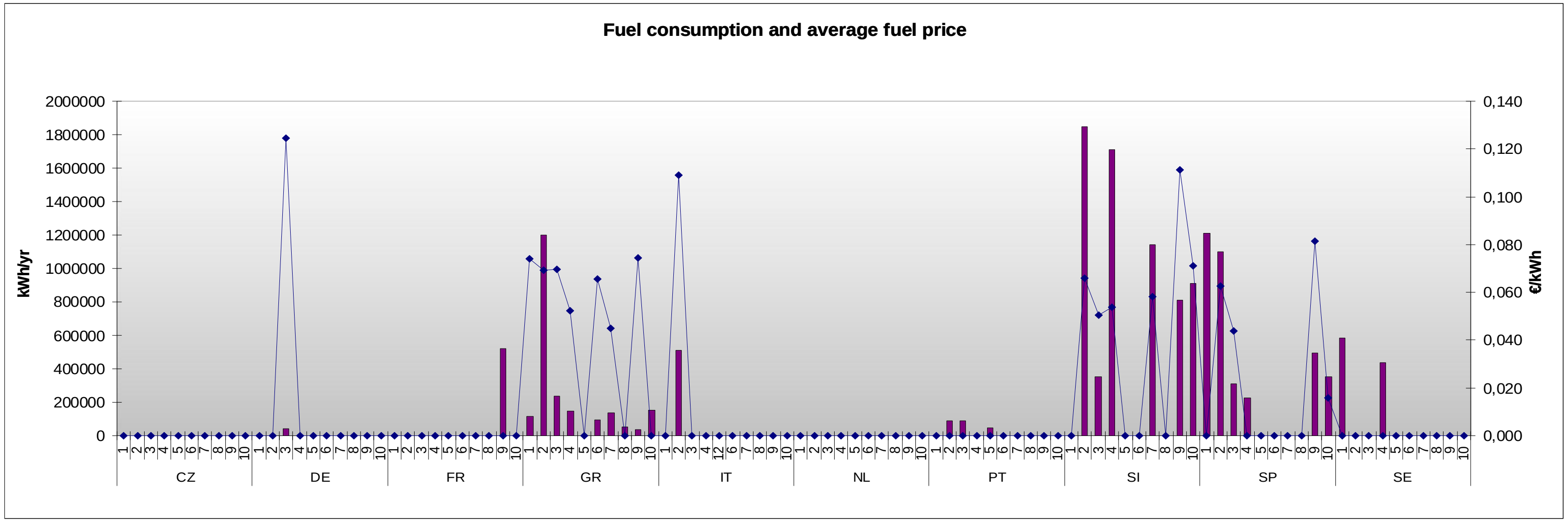


Figure 8: Average fuel price in each RCHEP

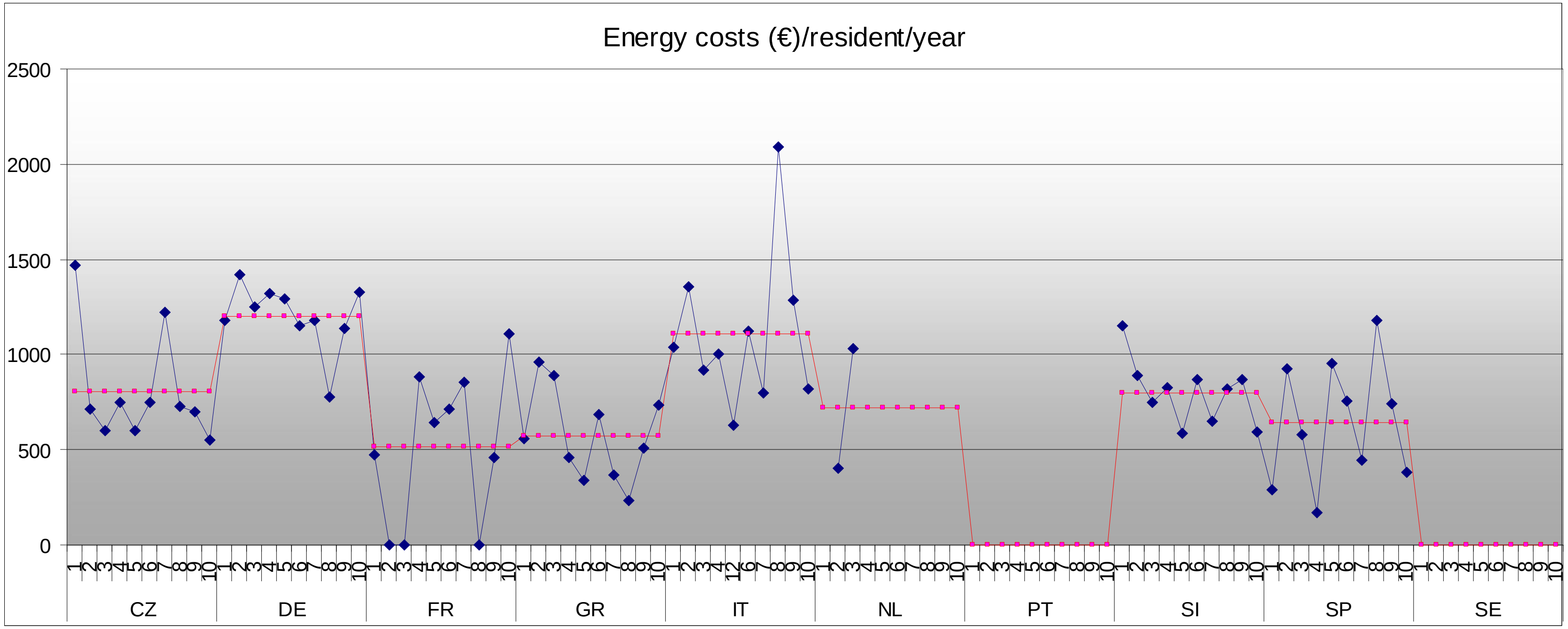


Figure 9: Total energy costs per resident , in each RCHEP (energy costs per year are based on the three years data collected for each RCHEP) and average energy costs per resident in each country

The average price per kWh is around the same order of magnitude within the country, with some exceptions. According to the data collected, electricity seems to be cheaper in France, Spain and Slovenia. Greece and Czech Republic seems to have the higher prices for electricity.

Natural gas is cheaper in France, Italy and Czech Republic than in SP, SI and DE. There is no information on gas prices in PT, and many RCHEP gas prices in NL are missing.

Prices for district heating in SE are not available. CZ presents the lowest prices, however there is not significant price differences in the few countries where district heating was used.

The average fuel prices are about the same order of magnitude in all countries, but very few samples are available. The zero values presented in the graphs where there is energy consumption represent lack of data on fuel costs.

Concerning the average energy costs per resident, all sources together, it seems that CZ, FR and GR are the countries with the lower prices (Figure 9).

6 Energy Efficiency Benchmark

Energy benchmarking is an assessment approach in which energy-related metrics measured or estimated at one building are compared to those from other buildings and/or specific performance targets. These metrics can be specified at the level of the building, a functional area within a building or specific systems or operations. Benchmarks can be derived from distributions of metrics values obtained from buildings that have a similar functionality or characteristics. Consequently, improvements in benchmarking methods can have a large impact on the energy use within the building. Benchmarking energy efficiency is an important tool to promote the efficient use of energy in RCHEP.

Benchmarking Energy indicators should be developed to compare the energy performance of the buildings. These indicators should be relevant and meaningful for the use of the building. First we developed energy-efficient indicators before conducting the benchmark. These indicators should enable the comparison of different RCHEP as more accurately as possible. This is accomplished by using indicators that are normalized, like the Energy Use Intensity (EUI). The Energy Use

Intensity is the average annual energy consumption normalized by net plan area of the building, and it is typically expressed in kWh/m2/year.

This methodology of simple floor area normalized EUI can be developed using a multivariate linear-regression model approach to correlate EUI with factors that may influence the energy consumption of a building, such as HDD, number of residents, number of employees and year of construction. If the data is nonlinear, this approach may not fit very well the data and other more complex ways of data fitting might be necessary for a credible energy-consumption performance rating.

6.1 Data treatment

When collected data exhibits significant variability and visual inspection of data suggests a relationship between y and x, the more appropriate strategy is to derive an approximating function that fits the shape or general trend of the data, without necessarily matching each individual point. A linear regression can be used to characterize the trend of the data.

One way to determine the best line through the points is the least squares regression. The simplest example of a least-squares approximation is fitting a straight line to a set of paired observations (x_1, y_1), (x_2, y_2), ... (x_n, y_n). The mathematical equation for such line is:

$$y = a_0 + a_1 x + e$$

Where a_0 and a_1 are coefficients representing respectively the intercept and the slope and e is the error or residual between the model and the observations (real values) and can be represented by:

$$e = y - a_0 - a_1 x$$

e is the discrepancy between the true value of y and the approximate value a_0+a_1x, predicted by the linear equation.

The best fit is the line minimizing the sum of errors in-between the trend line and the data points.

After the data collection, there is a need to treat and process this data in order to establish the energy consumption benchmarks in terms of the Energy Use Intensity (EUI). The energy use intensity is the average energy consumption per square meter per year (kWh/m2/yr).

The benchmarking model makes use of the "best-fitted" regression model to calculate the predicted EUI. The EUI can then be expressed based on a set of explanatory variables: X1...Xn. The linear multivariate regression is performed using the Excel software tool.

6.2 Performance Indicators

The performance indicators calculated for the benchmark are used as an energy performance rating system to compare different buildings with the same functional use.

Table 6 shows the Key Performance Indicators (KPIs) selected to be used to compare the performance of the RCHEP. The following Energy Use Intensity performance indicators were considered: kWh/m2/yr, kWh/res/yr, $kWh_{heating}$/m2/yr and $kWh_{heating}$/res/yr.

Table 6 - Key Performance Indicators (KPIs)

Key Performance Indicator	Source of Energy	Units	Data Required	Comments
Energy Use Intensity (EUI1)	All sources (electricity+gas+oil+ biomass, district heating, etc.).	kWh/m2/yr	Annual energy consumption; Net area of the building	Provides information about the total energy consumption of the building.
EUI2	All sources (electricity+gas+oil+biomass, district heating, etc.).	kWh/ residents/ yr	Annual energy consumption; Number of residents	Provides information about the total energy consumption per resident.
EUI3	All sources of energy used for heating	kWh heating/m2 /yr	Heating energy consumption; net area of the building	Provides information about the heating consumption per square meters.
EUI4	All sources of energy used for heating	kWh heating/ residents/ yr	Heating energy consumption; Number of residents	Provides information about the heating consumption per resident.

6.3 Selection of EUI and explanatory variables

The EUI (kWh/m2/year and kWh/residents/year) are chosen as the dependent variables in the multiple regression models. Some factors that may affect the EUI, which we are going to consider, are climate (degree days), number of residents, number of employees and age of the building and year of retrofit. But there are other more qualitative factors which may also affect the EUI such as occupant's behavior, level of environmental awareness of user's maintenance practices, energy end-use system factors, etc. but these factors were not modeled since they are difficult to quantify or evaluate.

In this study six explanatory variables are being considered in the multiple regression models. These factors are presented in the following Table:

Table 7: Explanatory variables considered in the model

Explanatory variable	Variable name
X1	HDD
X2	Net area (m2)
X3	Year of construction
X4	Number of residents
X5	Number of employees
X6	Year retrofit

A random selected sample of 10 RCHEP in each country was surveyed to develop a data-base for energy-efficiency benchmarking. In principle, a sample size of 100 is sufficient to provide a statistically significant model. However, due to missing of important data in some countries, and in some RCHEP, there was the elimination of 8 samples due to missing data for those houses, and the final number of houses considered in the analysis is 92 samples.

6.3.1 The regression model

If we assume that the typical distribution of energy consumption is affected by the selected explanatory variables, including HDD, net area, year of construction, number of residents and number of employees, year of retrofit, (X1...X6), the multiple regression model for the RCHEP (kWh/m2/yr) is given by:

$$EUI = \beta_0 + (\beta_1 * x_1) + ... + (\beta_8 * x_8) + u = \beta_0 + \sum_{i=1}^{8} \beta_i \left(\frac{x_i - \bar{x}_i}{S_i} \right) + u$$

Where base levels (normal standards) are used as references that reflect the "normal/mean" operating conditions. [3]. Multiple regression models fit the input data to models, where Y (kWh/m2/yr and kWh/resident/yr) is a continuous measured variable. The data analysis has been carried out using Microsoft Excel. The input data used for the benchmarks and the estimated benchmarks are presented below.

After modeling the data, an analysis of the influence of the explanatory variables in the indicators showed that the explanatory variable Year of retrofit does not have influence on the benchmark, and therefore was neglected. Therefore only the explanatory variables X1...X5 were considered to the final modeling of the data.

6.4 EUI1 (kWh all sources/m2/yr)

Table 8 summarizes the statistics of the survey results for EUI1. Due to the presence of some outliers, the total number of houses considered was 86. The Table presents the minimum and maximum values, the average and the standard deviation of EUI1 and the explanatory variables under evaluation. The linear coefficient generated by the model and the sensitivity of the model to a given variable (the product of the standard deviation of that variable by the linear coefficient generated by the model) is also presented in the Table 8.

Table 8: Summary of statistics of survey results of EUI1

	N	**Min**	**Max**	**Mean**	**SD**	**βi**	**Sensitivity to the model**
EUI1(kWh/m2/yr)	86	46	551	252	106		
X1 (HDD)	86	432	2775	1975	740	0,0329	24,35
X2 (Net area, m2)	86	220	18270	4278	2994	-0,0386	**-115,84**
X3 (Year of Construction)	86	1400	2010	1957	102	-0,0721	-7,32
X4 (Number of residents)	86	11	273	91	61	0,88732	54,43
X5 (Number of employees)	86	3	340	62	54	1,23484	66,12

As it can be seen the standard deviation is significant for all the explanatory variables. This is an indicator of large variability in the data sample.

The model for EUI1 is:

EUI1=335,81+0,0329*X1-0,0386*X2-0,07209*X3+0,88732*X4+1,23484*X5, with an R^2=0,4.

R^2 is the coefficient of determination. It gives a normalized indication, ranging from 0 until 1, of the error from the model to the sampled data. If it is 1, there is a perfect correlation to the sample. Anyway, it is worth noting that with the heterogeneous data of the current sample, no model would provide a perfect fit.

Figure 10 shows a frequency chart to depict the distribution of the RCHEP according to their net area. The histogram does not approach a bell-shaped curve.

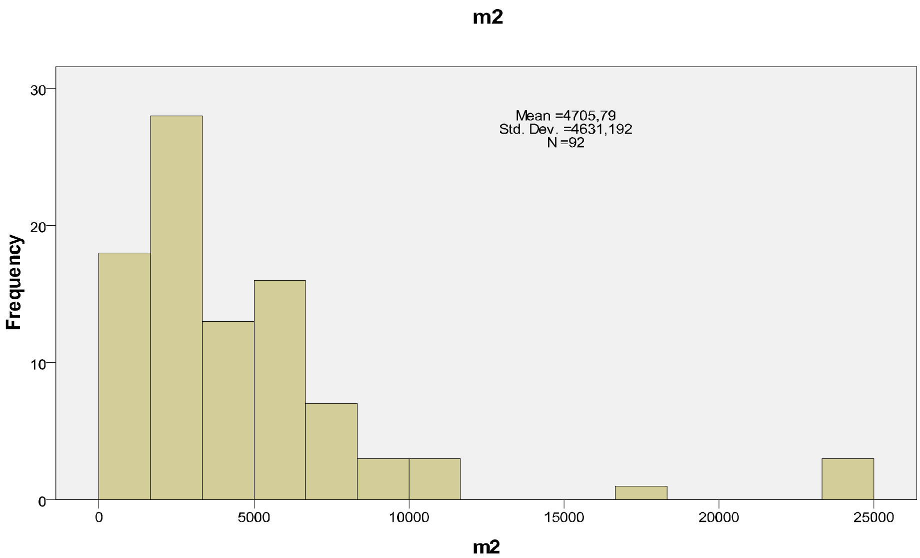


Figure 10: RCHEP distribution according to the net area of the buildings

Figure 10 shows the distribution of RCHEP per net area. Most RCHEP are below 5.000m2, but the sample contains five outliers with areas above 15000m2. The frequency of RCHEP with more than 3.000m2 decrease as area increases.

Houses with areas above 10.000m2 and with a relatively small number of residents were not properly modelled by the benchmark for the EUI_kWh/m2/yr indicator. This happened because the study includes only five houses above that area and the regression coefficient reduces too much the magnitude of the performance indicator that might result in unreasonable expected values, as happened with the cases of DE2, NL2, NL9, and SP9. These cases have been treated as outliers.

Table 9, shows the input data used to model the benchmark which indicator is kWh/m2/yr, indicator EUI1.

Table 9: Input data to model EUI1

		HDD	m2	Yr Construct	Residents	Employees	Benchmark	kWh/m2/yr	Difference	Difference %
CZ	1	2515	2681	1899	92	42	311	496	-185	59,3%
	2	2545	1930	2002	77	52	333	426	-92	27,7%
	3	2225	1879	1985	156	90	443	551	-108	24,4%
	4	2506	2267	1998	148	71	406	460	-55	13,6%
	5	2540	1353	1913	65	38	333	540	-206	61,9%
	6	2386	1648	1995	58	26	291	275	16	-5,4%
	7	1990	5054	1893	134	92	302	388	-86	28,6%
	8	2554	2927	1975	101	64	333	347	-14	4,3%
DE	1	2231	1783	1928	44	37	286	369	-83	29,1%
	3	1957	5000	1954	78	101	259	173	87	-33,4%
	4	2063	8100	1904	114	103	181	225	-44	24,2%
	5	2665	8697	1400	129	45	156	152	4	-2,4%
	6	2063	7720	1984	115	142	239	202	38	-15,7%
	7	2470	5600	1966	123	120	316	293	23	-7,4%
	8	2377	4919	1896	98	95	292	140	152	-52,0%
	9	2377	6663	1971	80	60	159	137	23	-14,1%
	10	2377	5000	1988	136	90	309	349	-40	13,1%
	1	2639	4420	1989	100	20	222	60	162	-72,9%
FR	2	2639	3839	2001	58	43	234	114	120	-51,3%
	3	2552	4100	1993	46	25	189	150	39	-20,9%
	4	2639	5358	2010	80	80	240	289	-49	20,4%
	5	2639	3500	1975	63	13	217	228	-11	5,2%
	6	2639	3606	1994	84	82	315	334	-19	6,1%
	7	2639	3063	1992	47	3	206	46	160	-77,6%
	8	2639	3306	1994	58	38	249	198	51	-20,5%
	10	2639	2836	2000	50	33	254	259	-5	2,0%
GR	1	1053	771	1995	30	9	234	205	29	-12,4%
	2	931	5500	1960	127	51	188	253	-65	34,7%
	3	1037	936	1953	34	13	239	322	-83	34,7%
	4	1543	738	1968	30	5	249	248	1	-0,3%
	5	649	375	1995	18	5	221	104	116	-52,7%
	7	1069	1500	2008	39	20	228	123	105	-46,2%
	8	432	672	2000	22	10	212	115	97	-45,6%
	9	432	220	1990	11	4	212	228	-15	7,3%
	10	642	2974	2009	25	18	141	81	60	-42,5%
IT	1	1040	3112	1909	60	50	227	295	-68	30,1%
	2	953	2436	1930	58	39	233	278	-45	19,1%
	3	1481	3535	1400	80	70	304	324	-20	6,4%
	4	970	1650	1995	47	3	205	436	-231	112,7%
	7	975	1820	1968	33	13	201	197	4	-2,1%
	9	1507	18270	1966	273	340	198	232	-33	16,9%
	10	1083	1500	1999	46	46	267	424	-157	58,8%
NL	1	1978	3540	2001	68	68	264	108	156	-58,9%
	3	1978	7604	1973	162	162	308	246	62	-20,1%
	5	1978	11124	1964	192	194	239	254	-15	6,4%
	6	1978	10212	2004	181	180	244	192	53	-21,6%
	8	1978	5940	1968	80	55	168	162	7	-3,9%
	10	1978	9904	2000	163	144	196	160	36	-18,3%
PT	1	964	3200	1988	141	142	401	403	-2	0,6%
	3	964	570	1998	30	19	251	371	-120	47,7%
	4	796	2294	1970	111	85	335	301	34	-10,2%
	5	964	1105	1997	33	10	222	125	98	-43,9%
	6	796	5170	1997	82	76	185	275	-90	49,0%
	7	796	4000	1985	55	41	164	120	44	-26,6%
	8	1150	1013	1986	48	36	278	214	65	-23,2%
	9	796	1420	2008	45	28	237	148	88	-37,3%
	10	699	1700	2003	30	15	193	169	24	-12,6%
SI	1	2405	6953	2002	210	135	355	335	20	-5,7%
	2	2415	7056	1979	212	101	312	326	-14	4,6%
	3	2476	5469	1977	169	74	305	267	38	-12,4%
	4	2512	6375	1940	194	114	345	339	6	-1,7%
	5	2036	5450	2003	171	77	294	286	8	-2,6%
	6	2327	5934	2000	163	83	285	339	-53	18,7%
	7	1356	6410	1980	205	106	303	268	34	-11,3%
	8	2212	8936	1973	247	155	331	330	0	-0,1%
	9	2462	7288	1975	224	109	326	221	105	-32,2%
	10	2036	4397	1578	195	92	406	297	109	-26,8%
SP	1	2421	5300	1976	143	38	242	290	-49	20,1%
	2	2474	9000	1977	169	51	139	203	-64	45,7%
	3	2519	2200	1984	39	10	238	171	67	-28,1%
	4	2250	2000	1977	52	20	261	151	110	-42,2%
	5	928	7700	2008	104	62	93	203	-111	119,6%
	6	2568	2500	1985	59	24	262	194	68	-26,0%
	7	2568	1250	1979	53	20	301	261	40	-13,3%
	8	2561	4186	1850	50	29	205	100	106	-51,5%
	10	2473	1350	1883	58	26	313	360	-47	15,0%
SE	1	2775	5073	1982	45	42	180	245	-65	36,0%
	2	2775	4069	1930	58	53	247	198	48	-19,6%
	3	2775	3777	1964	41	30	212	287	-75	35,4%
	4	2775	2803	1974	30	27	236	228	9	-3,7%
	5	2775	2583	2008	27	28	240	358	-118	49,0%
	6	2775	7961	1992	83	106	180	212	-31	17,3%
	7	2775	6843	1962	49	45	120	157	-37	30,7%
	8	2775	6506	1970	50	47	136	281	-145	106,6%
	9	2775	4455	1993	46	51	215	171	44	-20,5%
	10	2775	2061	1975	21	30	261	270	-10	3,7%

It should be noted that the *difference* between the real and the estimated performance indicators should sum about zero, so the values shown in the last column of the table, can be used to identify highly performing care houses in terms of energy consumption and poorly performing ones, depending on their difference to the expected value. Those with a positive difference % are using more energy than the model estimated.

The data collected using the questionnaire in Annex 1 is assumed reliable, but no posterior verification was carried-out and some error might exist, particularly in what concerns the houses' area. These errors do not compromise significantly the benchmark obtained, since this is based on the whole data set, but might appear as outliers. RCHEP with basic (e.g., energy consumption) or too much information missing have been neglected for the model.

Figure 11 shows the real consumption per square meter, kWh/m2/yr, and the benchmark obtained through the modeling, for each RCHEP. On average, CZ, IT and SE are the countries with worst situation in terms of energy consumptions per square meter.

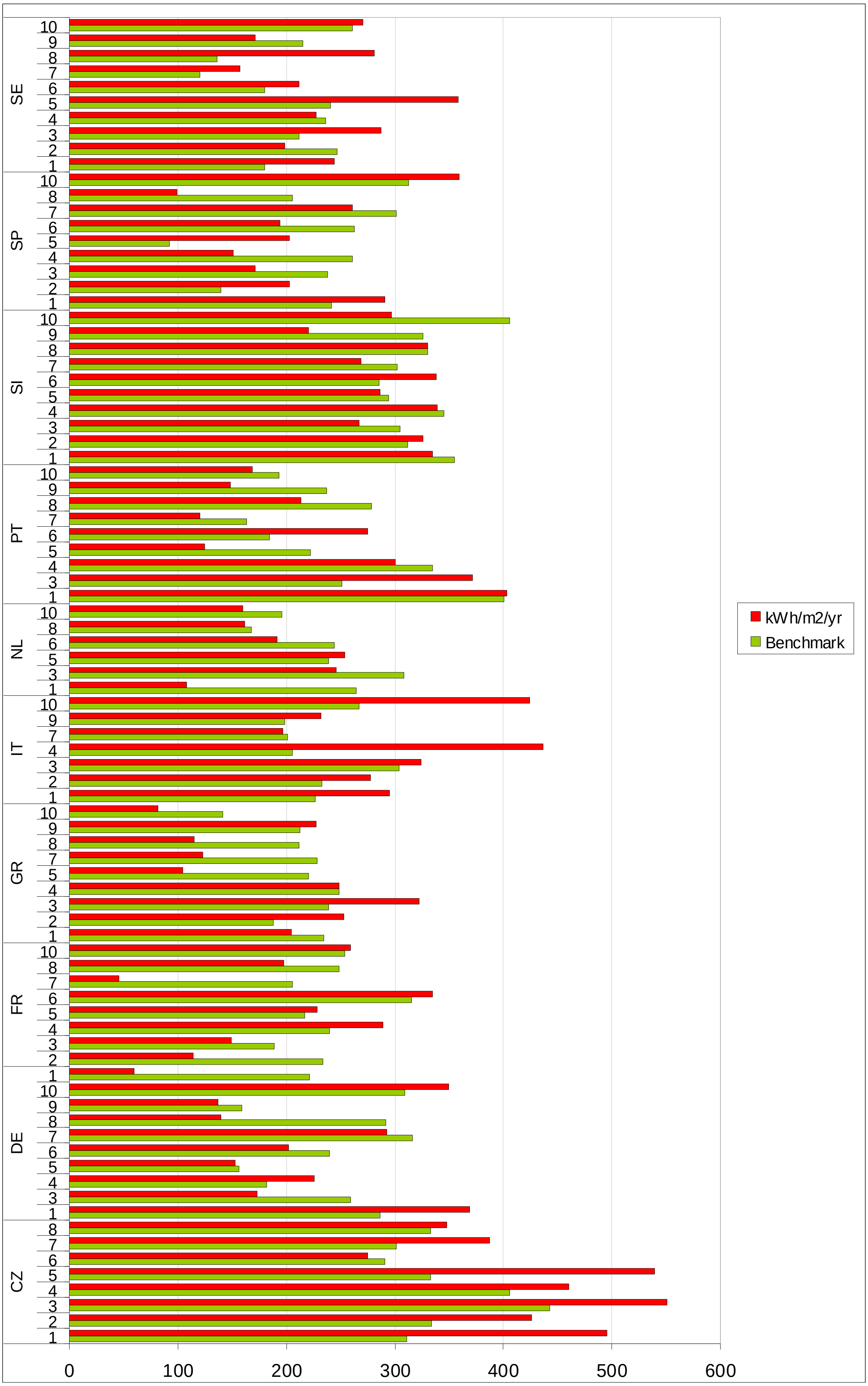


Figure 11: Real consumption per square meter, kWh/m2/yr and benchmark

In Figure 12, the indicator EUI1 (kWh/m2/year) is plotted against net area of RCHEP. Real values are presented in different colours for each country. Benchmark trend line is also plotted.

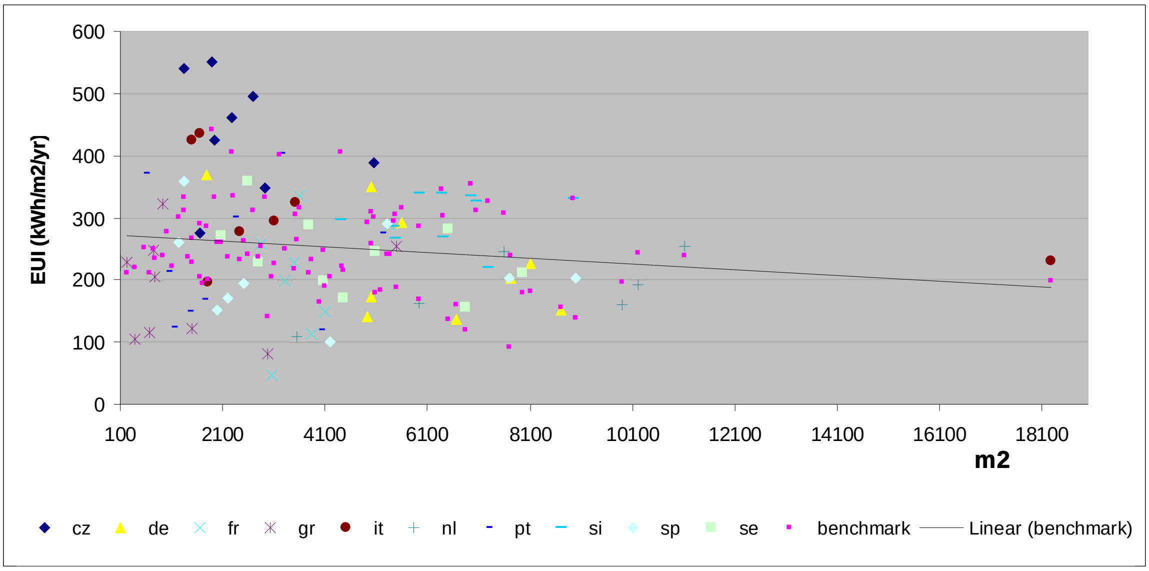


Figure 12: EUI1 (kWh all sources/m2/yr) versus m2

As expected, the energy consumption per square meter decreases as the net area of the building increases. This does not mean that larger buildings perform better; it just means that a building consumption increases less per square meter as the net area increases.

In Figures 13 and 14, the indicator EUI1 (kWh/m2/year) is plotted against number of residents and number of employees, respectively. Real values are presented in different colours for each country. Benchmark trend line is also plotted.

There is a positive correlation between the energy consumption per square meter and the number of residents and the number of employees. However this relation is not very strong as the slope is very low in both cases.

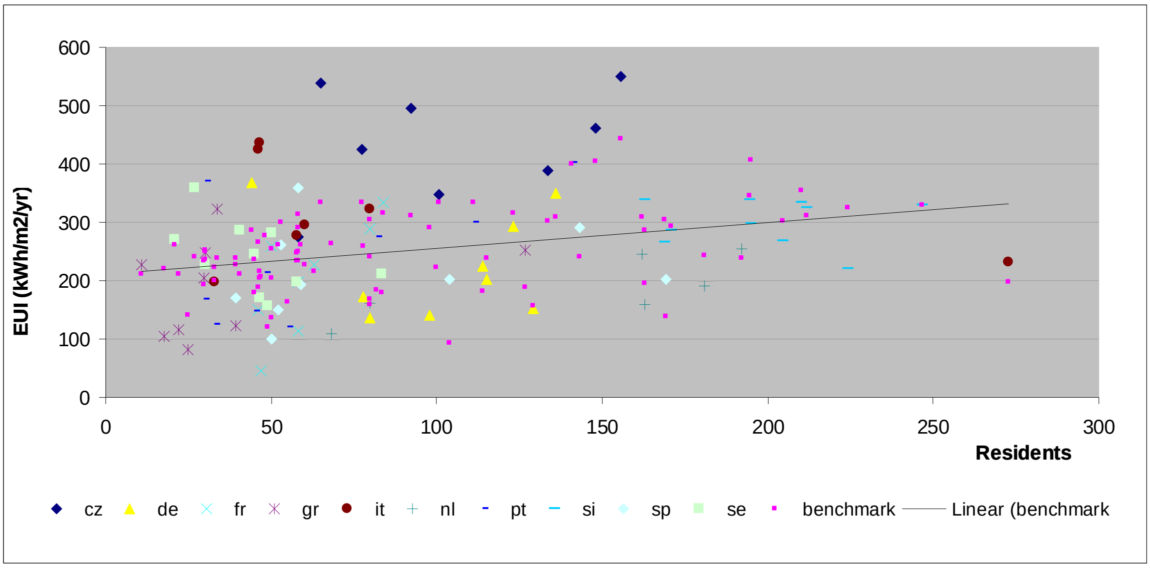


Figure 13: EUI1 (kWh all sources/m2/yr) versus residents

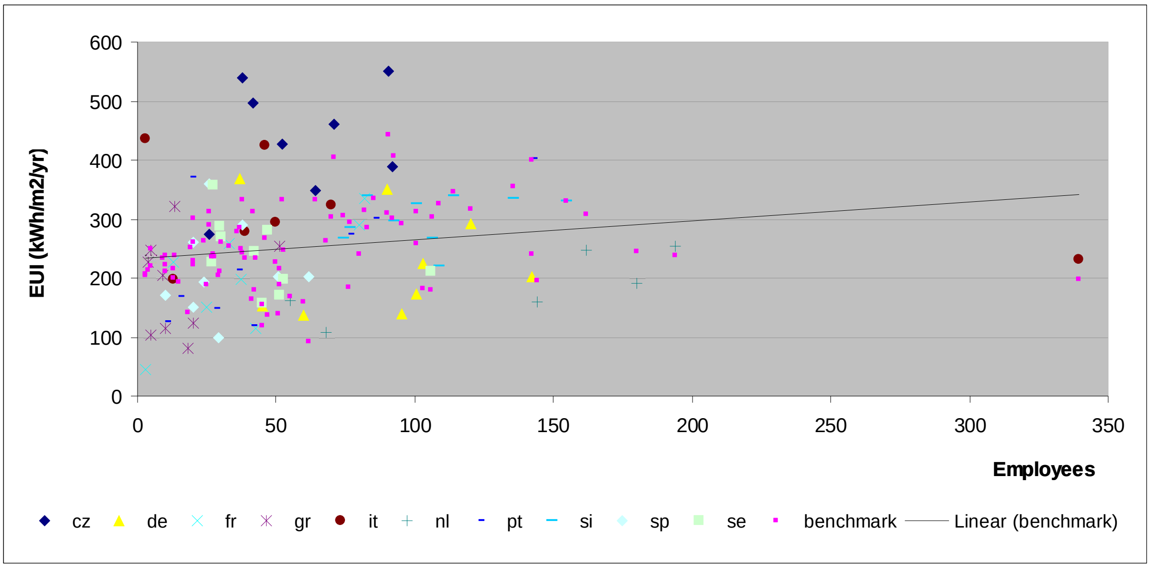


Figure 14: EUI1 (kWh all sources/m2/yr) versus employees

In Figure 15 EUI1 is plotted against HDD.

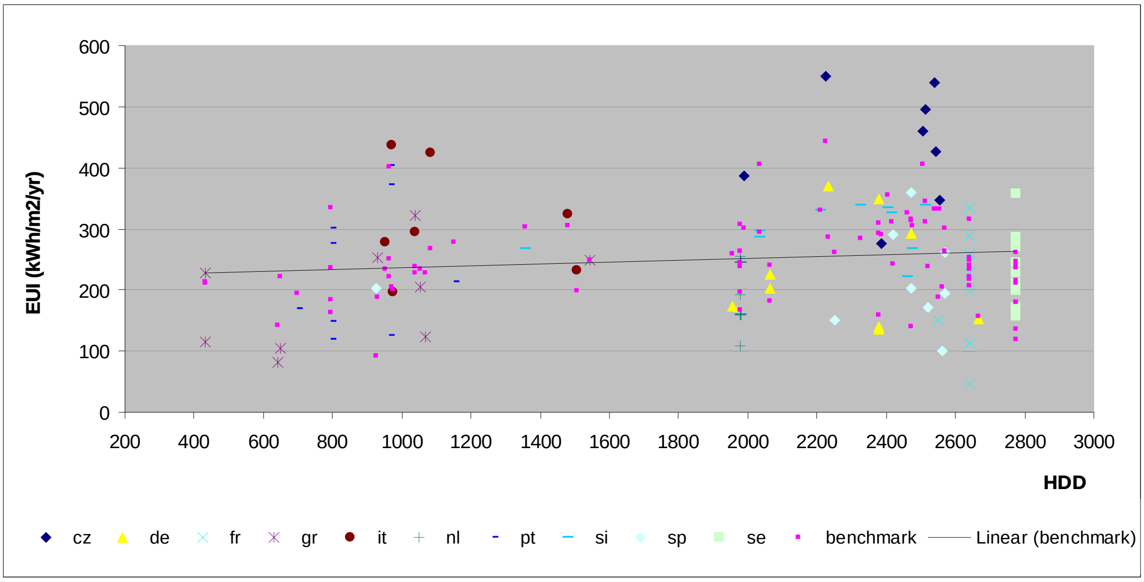


Figure 15: EUI1 (kWh all sources/m2/yr) versus HDD

There is a small positive correlation between HDD and energy consumption per square meter. There are two main range levels of HDD: small number of HDD: [500; 1500], and large number of HDD [2000; 3000]. It is possible to conclude that some RCHEP are performing better than the others, for the same order of magnitude of HDD, within the same country, and across the different countries.

Cooling Degree Days have not been analysed because it was not possible to estimate the cooling consumption. Besides the number of houses where air conditioning is available was very small.

In Figure 16, the EUI1 is plotted against the year of construction.

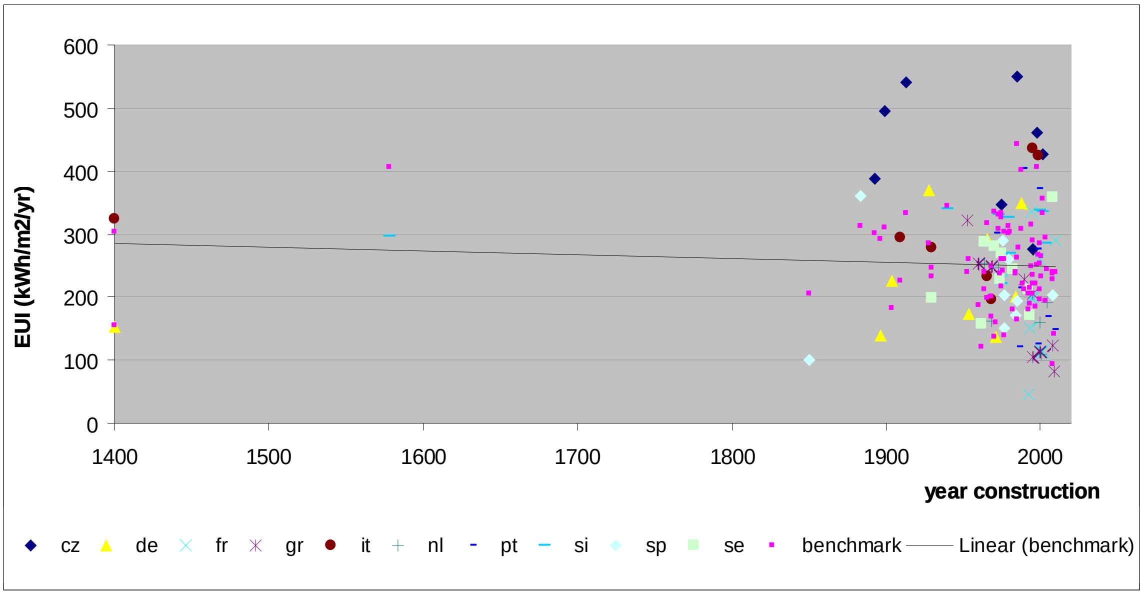


Figure 16: EUI1 (kWh all sources/m2/yr) versus year of construction

There is a small negative correlation between the year of construction and the consumption per square meter.

6.5 EUI2 (kWh/resident/yr)

Table 10 summarizes the statistics of the survey results for EUI2. It presents the minimum and maximum values, the average and the standard deviation of EUI2 and the explanatory variables under evaluation. The linear coefficient generated by the model and the sensitivity of the model to a given variable (the product of the standard deviation of that variable by the linear coefficient generated by the model) is also presented in the Table 10.

Table 10: Summary of statistics of survey results of EUI2

	N	Min	Max	Mean	SD	βi	Sensitivity
EUI2(kWh/res/yr)	86	2215	36349	11711	6319		
X1 (HDD)	86	432	2775	1975	740	3,09889	2292,87
X2 (Net area, m2)	86	220	18270	4278	2994	1,10689	3314,56
X3 (Year of Construction)	86	1400	2010	1957	102	0,10167	10,33
X4 (Number of residents)	86	11	273	91	61	-76,2216	**-4675,62**
X5 (Number of employees)	86	3	340	62	54	29,0516	1555,5

As it can be seen the standard deviation is significant for all the explanatory variables. This is an indicator of large variability in the data sample.

The model for EUI2 is:

EUI2=5812,9+3,09889*X1+1,10689*X2+0,10167*X3-76,2216*X4+29,0516*X5, with an R^2=0,37.

Figure 17 shows a frequency chart to depict the distribution of the RCHEP according to the number of residents. The histogram does not approach a bell-shaped curve and therefore we are not in face of a normal distribution.

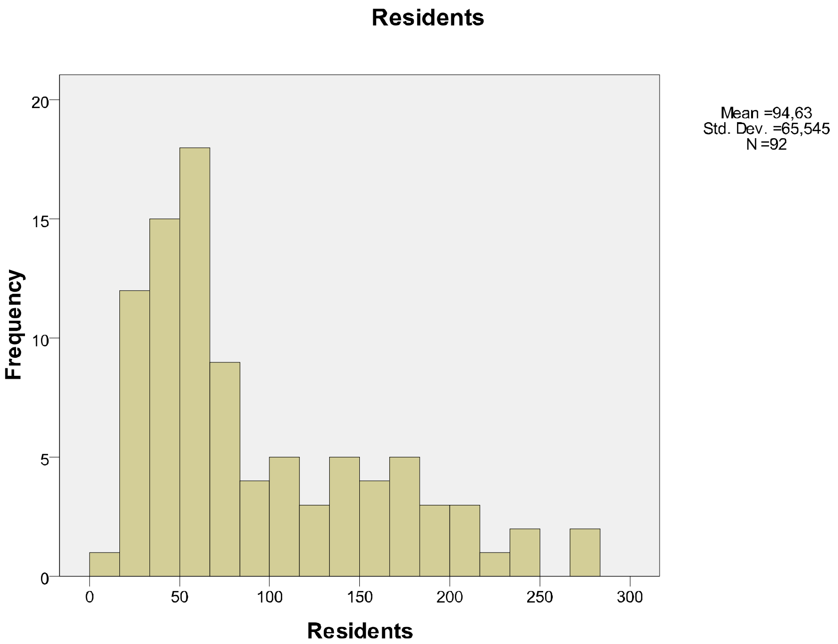


Figure 17: Histogram of number of residents

Table 11 presents the benchmark for the indicator EUI2 (kWh/resident per year). Like the indicator EUI1 (kWh/m2/yr), there are RCHEP for which the consumption per resident is much higher by several orders of magnitude. There are RCHEP performing much better that the model, and others that perform worst. In SE, the consumption per resident is generally very high, compared to the benchmark. This is due to the very large area heated per resident in the Swedish care homes. In addition the available floor area per resident is large in SW.

Table 11: Input data to model EUI2

		HDD	m2	Yr Construct	Residents	Employees	Benchmark	kWh/resident/yr	Difference	Difference %
CZ	1	2515	2681	1899	92	42	10939	14397	-3458	31,6%
	2	2545	1930	2002	77	52	11656	10628	1028	-8,8%
	3	2225	1879	1985	156	90	5750	6648	-898	15,6%
	4	2506	2267	1998	148	71	7074	7054	21	-0,3%
	5	2540	1353	1913	65	38	11516	11232	284	-2,5%
	6	2386	1648	1995	58	26	11544	7770	3774	-32,7%
	7	1990	5054	1893	134	92	10251	14658	-4407	43,0%
	8	2554	2927	1975	101	64	11365	10103	1262	-11,1%
DE	1	2231	1783	1928	44	37	12618	14958	-2340	18,5%
	3	1957	5000	1954	78	101	14590	11076	3513	-24,1%
	4	2063	8100	1904	114	103	15668	16014	-345	2,2%
	5	2665	8697	1400	129	45	15316	10280	5036	-32,9%
	6	2063	7720	1984	115	142	16313	13551	2761	-16,9%
	7	2470	5600	1966	123	120	13978	13325	653	-4,7%
	8	2377	4919	1896	98	95	14116	7031	7086	-50,2%
	9	2377	6663	1971	80	60	16400	11388	5012	-30,6%
	10	2377	5000	1988	136	90	11164	12848	-1684	15,1%
	1	2639	4420	1989	100	20	12044	2655	9389	-78,0%
FR	2	2639	3839	2001	58	43	15257	7530	7726	-50,6%
	3	2552	4100	1993	46	25	15683	13346	2337	-14,9%
	4	2639	5358	2010	80	80	16352	19365	-3013	18,4%
	5	2639	3500	1975	63	13	13641	12668	973	-7,1%
	6	2639	3606	1994	84	82	14164	14359	-195	1,4%
	7	2639	3063	1992	47	3	14088	3000	11088	-78,7%
	8	2639	3306	1994	58	38	14502	11235	3267	-22,5%
	10	2639	2836	2000	50	33	14480	14688	-208	1,4%
GR	1	1053	771	1995	30	9	8131	5329	2802	-34,5%
	2	931	5500	1960	127	51	6823	11002	-4180	61,3%
	3	1037	936	1953	34	13	8081	8957	-875	10,8%
	4	1543	738	1968	30	5	9470	6104	3365	-35,5%
	5	649	375	1995	18	5	7240	2215	5025	-69,4%
	7	1069	1500	2008	39	20	8582	4681	3901	-45,5%
	8	432	672	2000	22	10	6711	3516	3196	-47,6%
	9	432	220	1990	11	4	6900	4700	2200	-31,9%
	10	642	2974	2009	25	18	9916	9669	247	-2,5%
IT	1	1040	3112	1909	60	50	9554	15317	-5763	60,3%
	2	953	2436	1930	58	39	8397	11732	-3335	39,7%
	3	1481	3535	1400	80	70	10393	14309	-3915	37,7%
	4	970	1650	1995	47	3	7377	15433	-8055	109,2%
	7	975	1820	1968	33	13	8912	10848	-1935	21,7%
	9	1507	18270	1966	273	340	19991	15522	4468	-22,4%
	10	1083	1500	1999	46	46	8864	13824	-4960	56,0%
NL	1	1978	3540	2001	68	68	12856	5644	7212	-56,1%
	3	1978	7604	1973	162	162	12917	11554	1363	-10,6%
	5	1978	11124	1964	192	194	15456	14729	727	-4,7%
	6	1978	10212	2004	181	180	14882	10805	4077	-27,4%
	8	1978	5940	1968	80	55	14217	11999	2218	-15,6%
	10	1978	9904	2000	163	144	14893	9732	5161	-34,7%
PT	1	964	3200	1988	141	142	5956	9176	-3220	54,1%
	3	964	570	1998	30	19	7898	7058	840	-10,6%
	4	796	2294	1970	111	85	5026	6214	-1187	23,6%
	5	964	1105	1997	33	10	8000	4181	3819	-47,7%
	6	796	5170	1997	82	76	10162	17344	-7182	70,7%
	7	796	4000	1985	55	41	9906	8730	1176	-11,9%
	8	1150	1013	1986	48	36	8086	5000	3086	-38,2%
	9	796	1420	2008	45	28	7438	4685	2752	-37,0%
	10	699	1700	2003	30	15	8238	9685	-1447	17,6%
SI	1	2405	6953	2002	210	135	9092	11091	-1999	22,0%
	2	2415	7056	1979	212	101	8100	10871	-2770	34,2%
	3	2476	5469	1977	169	74	9008	8632	376	-4,2%
	4	2512	6375	1940	194	114	9351	11129	-1778	19,0%
	5	2036	5450	2003	171	77	7551	9124	-1572	20,8%
	6	2327	5934	2000	163	83	9773	12327	-2554	26,1%
	7	1356	6410	1980	205	106	4801	8406	-3605	75,1%
	8	2212	8936	1973	247	155	8450	11960	-3510	41,5%
	9	2462	7288	1975	224	109	7770	7170	600	-7,7%
	10	2036	4397	1578	195	92	4968	6704	-1736	34,9%
SP	1	2421	5300	1976	143	38	9587	10765	-1178	12,3%
	2	2474	9000	1977	169	51	12207	10790	1417	-11,6%
	3	2519	2200	1984	39	10	13550	9565	3985	-29,4%
	4	2250	2000	1977	52	20	11816	5797	6019	-50,9%
	5	928	7700	2008	104	62	11290	15046	-3756	33,3%
	6	2568	2500	1985	59	24	12939	8229	4710	-36,4%
	7	2568	1250	1979	53	20	11896	6151	5745	-48,3%
	8	2561	4186	1850	50	29	15612	8345	7267	-46,5%
	10	2473	1350	1883	58	26	11496	8372	3124	-27,2%
SE	1	2775	5073	1982	45	42	18021	27573	-9552	53,0%
	2	2775	4069	1930	58	53	16248	14005	2244	-13,8%
	3	2775	3777	1964	41	30	16556	26674	-10118	61,1%
	4	2775	2803	1974	30	27	16215	21258	-5043	31,1%
	5	2775	2583	2008	27	28	16218	34259	-18041	111,2%
	6	2775	7961	1992	83	106	20156	20212	-56	0,3%
	7	2775	6843	1962	49	45	19760	21905	-2145	10,9%
	8	2775	6506	1970	50	47	19344	36349	-17005	87,9%
	9	2775	4455	1993	46	51	17498	16452	1045	-6,0%
	10	2775	2061	1975	21	30	16167	26521	-10355	64,0%

Figure 18 shows the real consumption per resident, kWh/resident/yr, and the benchmark obtained with the model, for each RCHEP. IT, SI and SE are the countries in the worst situation in terms of energy consumptions per resident, since there are many RCHEP which energy consumption per resident is going above the benchmark estimated value.

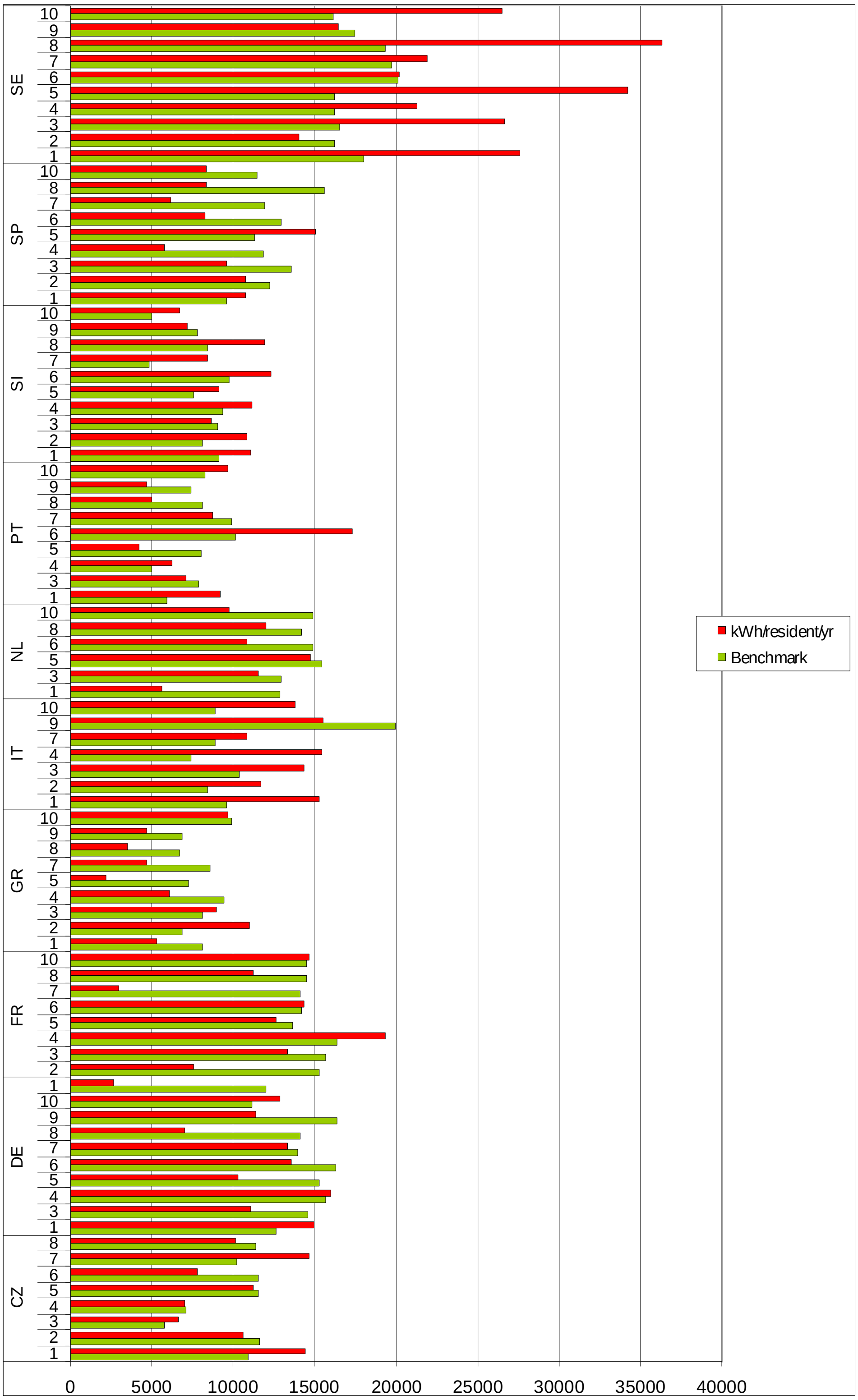


Figure 18: Real consumption per resident, KWh/resident/yr, and the benchmark

Figure 19, 20 and 21 plot the EUI2 (kWh/resident/yr) against the net area of the building, the number of residents and the number of employees, respectively. As it can be seen there is a positive correlation between the indicator and the variables.

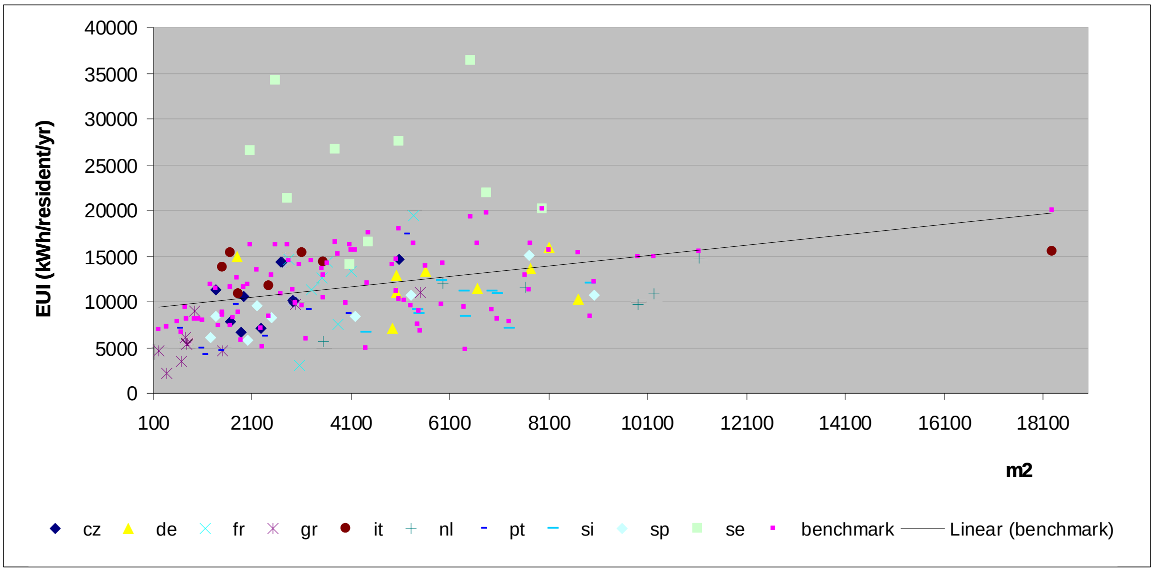


Figure 19: EUI2 (kWh/resident/yr) versus m2

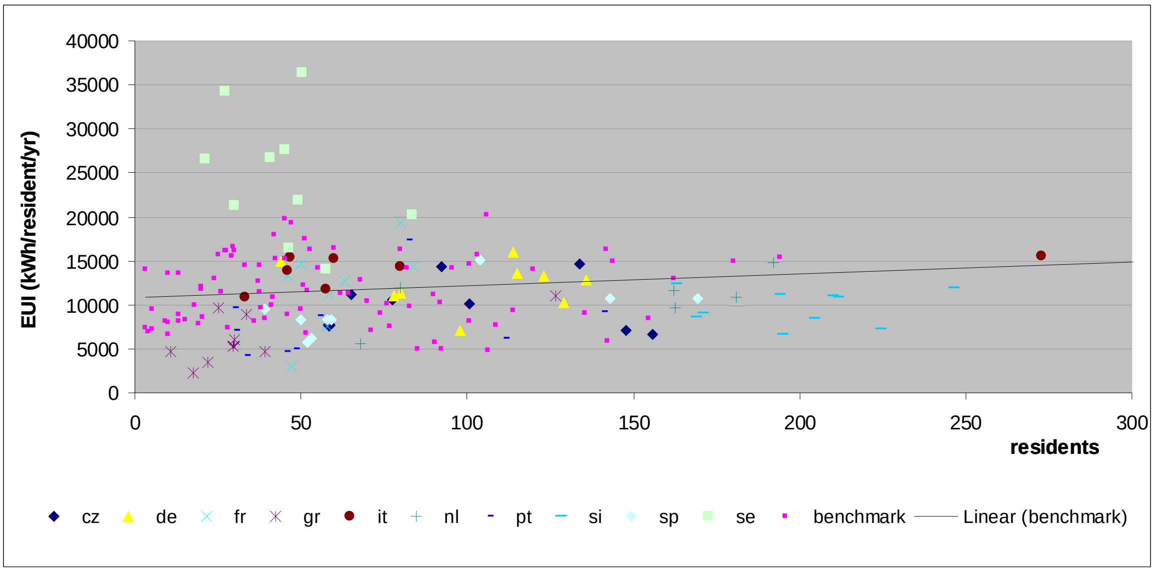


Figure 20: EUI2 (kWh/resident/yr) versus residents

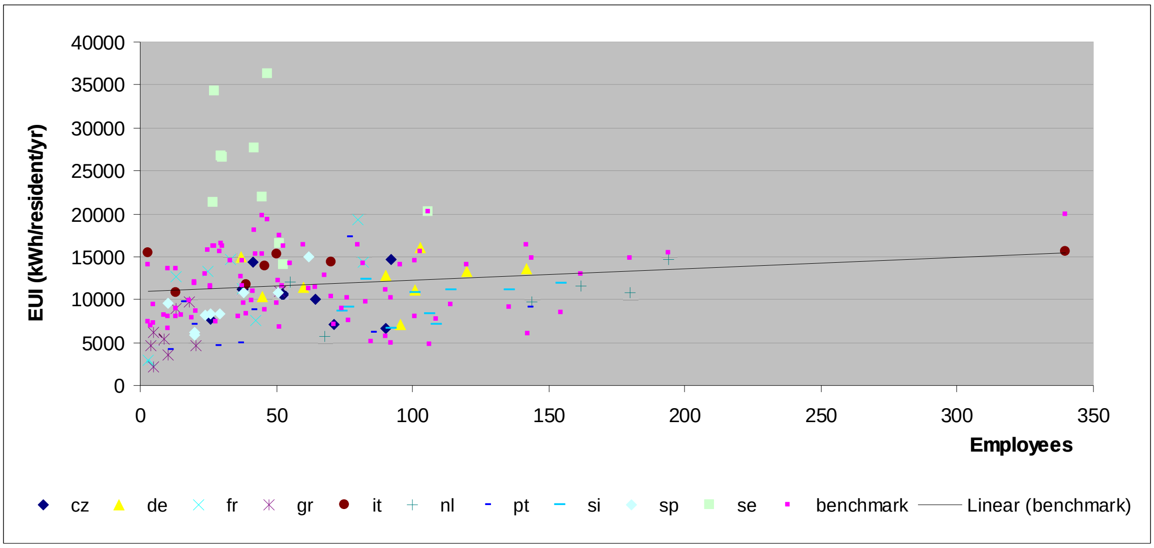


Figure 21: EUI2(kWh/resident/yr) versus employees

In Figure 22 the EUI2 is plotted against HDD.

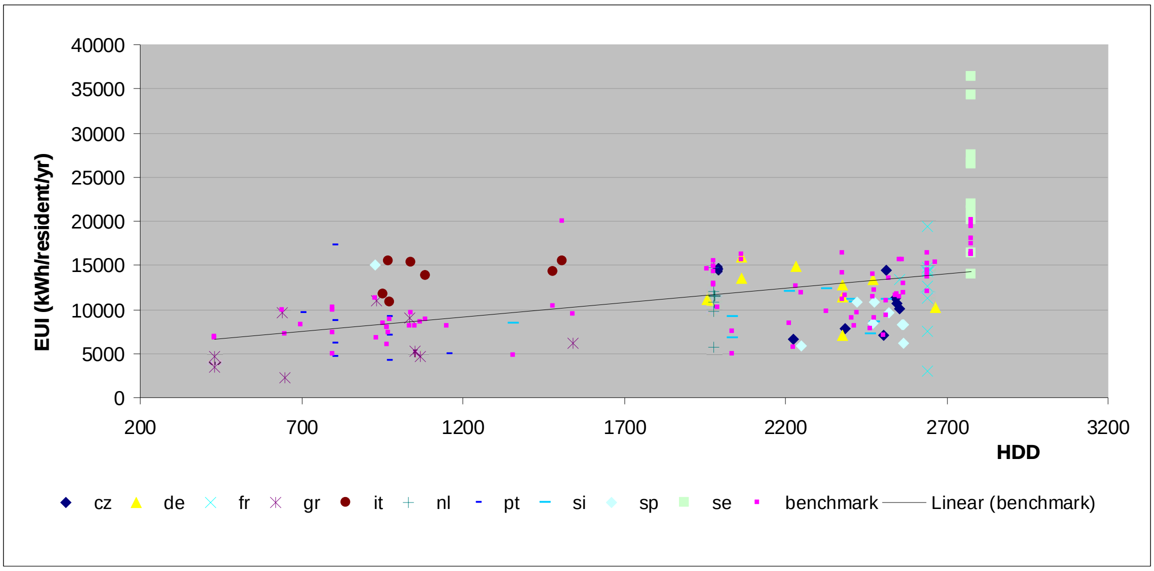


Figure 22: EUI2 (kWh/resident/yr) versus HDD

The energy consumption per resident increases with the increasing number of HDD. IT, SI and SE present consumption values per resident above the trend line, although the number o HDD in the case of Italy being small. Few RCHEP in PT also presents higher consumption than the model estimated.

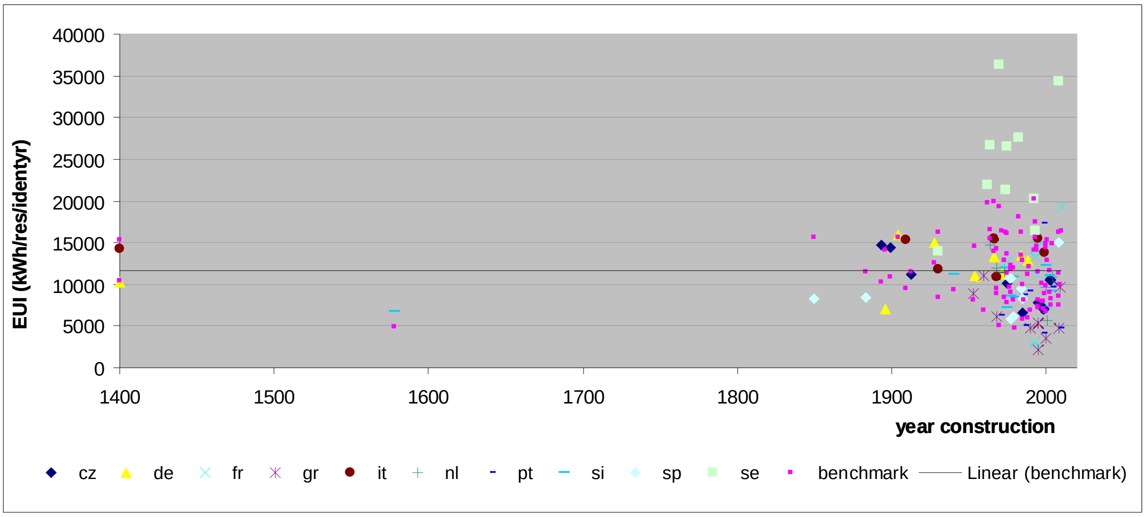


Figure 23: EUI2 (kWh /resident/yr) versus year of construction

The relation between the year of construction and the energy consumption per resident is not significant. The trend line is completely flat, without any slope, meaning there is no influence in the energy consumption per resident in relation to the year of the construction.

6.6 EUI3 (kWh heating/m2/yr)

Table 12 summarizes the statistics of the survey results for EUI3. It presents the minimum and maximum values, the average and the standard deviation of EUI3 and the explanatory variables under evaluation. The linear coefficient generated by the model and the sensitivity of the model to a given variable (the product of the standard deviation of that variable by the linear coefficient generated by the model) is also presented in the Table 12.

Table 12: Summary of statistics of survey results of EUI3

	N	Min	Max	Mean	SD	βi	Sensitivity
EUI3(kWhheating/m2/yr)	86	21	333	129	67		
X1 (HDD)	86	432	2775	1975	740	0,0255	18,81
X2 (Net area, m2)	86	220	18270	4278	2994	-0,0179	**-53,60**
X3 (Year of Construction)	86	1400	2010	1957	102	-0,0681	-6,92
X4 (Number of residents)	86	11	273	91	61	0,41938	25,76
X5 (Number of employees)	86	3	340	62	54	0,4295	23,08

As it can be seen the standard deviation is significant for all the explanatory variables. This is an indicator of large variability in the data sample.

The model for EUI3 is:

EUI3=224,3065+0,0255*X1-0,017898*X2-068099*X3+0,41938*X4+0,429465*X5,

with an R^2=0,2356.

Table 13 shows the input data to model the indicators related to the consumption of heating within the RCHEP. Heating consumption is significant for all RCHEP, representing more than 50 % of the total energy consumption.

Figure 24 shows the real heating energy consumption per square meter, kWh heating/m2/yr, and the benchmark obtained through the modeling, for each RCHEP. In IT and CZ the real heating consumption is much higher than predicted by the benchmark in many RCHEP. These are the countries in the worst situation in terms of heating energy consumptions per square meter

Table 13: Input data to model EUI3

		HDD	m2	Yr Construct	Residents	Employees	Benchmark	kWh heating/m2/yr	Difference	Difference %
CZ	1	2448	2681	1899	92	42	166	197	-31	18,9%
	2	2545	1930	2002	77	52	173	259	-85	49,4%
	3	2225	1879	1985	156	90	216	215	2	-0,7%
	4	2506	2267	1998	148	71	204	249	-44	21,7%
	5	2540	1353	1913	65	38	178	333	-155	87,1%
	6	2386	1648	1995	58	26	155	205	-49	31,6%
	7	1990	5054	1893	134	92	151	260	-108	71,7%
	8	2524	2927	1975	101	64	172	258	-86	50,2%
DE	1	2231	1783	1928	44	37	152	230	-78	51,0%
	3	1957	5000	1954	78	101	128	31	96	-75,3%
	4	2063	8100	1904	114	103	94	102	-7	7,7%
	5	2665	8697	1400	129	45	115	114	1	-0,8%
	6	2063	7720	1984	115	142	113	107	6	-5,0%
	7	2470	5600	1966	123	120	156	132	25	-15,8%
	8	2377	4919	1896	98	95	150	41	109	-72,8%
	9	2377	6663	1971	80	60	91	51	40	-43,7%
	10	2377	5000	1988	136	90	156	179	-23	15,1%
FR	1	2725	4420	1989	100	20	130	40	90	-69,5%
	2	2638	3839	2001	58	42	129	93	36	-27,7%
	3	2552	4100	1993	46	25	110	106	4	-3,7%
	4	2639	5358	2010	80	37	108	107	1	-1,1%
	5	2639	3500	1975	63	13	126	116	11	-8,3%
	6	2546	3606	1994	60	20	123	128	-5	4,5%
	7	2480	3063	1992	48	3	118	132	-13	11,1%
	8	2639	3306	1994	58	37	137	189	-52	38,2%
	10	2639	2836	2000	50	31	139	182	-43	30,9%
GR	1	1053	771	1995	30	9	118	110	8	-7,0%
	2	931	5500	1960	127	51	91	141	-50	54,4%
	3	1037	936	1953	34	13	121	203	-83	68,3%
	4	1543	738	1968	30	5	131	202	-71	53,9%
	5	649	375	1995	18	5	108	43	65	-60,6%
	7	1069	1500	2008	39	20	113	59	54	-47,9%
	8	432	672	2000	22	10	101	42	58	-57,9%
	9	432	220	1990	11	4	102	90	12	-12,2%
	10	642	2974	2009	25	18	69	21	47	-68,8%
IT	1	1040	3112	1909	60	50	112	158	-46	41,1%
	2	953	2436	1930	58	39	115	209	-95	82,8%
	3	1481	3535	1400	80	70	167	196	-29	17,2%
	4	970	1650	1995	47	3	105	259	-155	148,0%
	7	975	1820	1968	33	13	102	116	-14	13,9%
	9	1507	18270	1966	273	340	62	164	-102	163,7%
	10	1083	1500	1999	46	46	128	252	-124	96,8%
NL	1	1978	3540	2001	68	68	133	60	73	-55,0%
	3	1978	7604	1973	162	162	142	83	59	-41,7%
	5	1978	11124	1964	192	194	106	124	-19	17,5%
	6	1978	10212	2004	181	180	109	63	46	-42,0%
	8	1978	5940	1968	80	55	92	92	0	-0,1%
	10	1978	9904	2000	163	144	91	72	19	-21,0%
PT	1	964	3200	1988	141	142	176	122	54	-30,5%
	3	964	570	1998	30	19	123	128	-4	3,5%
	4	796	2294	1970	111	85	152	104	48	-31,8%
	5	964	1105	1997	33	10	111	45	67	-59,8%
	6	796	5170	1997	82	76	83	113	-30	36,2%
	7	796	4000	1985	55	41	79	49	29	-37,0%
	8	1150	1013	1986	48	36	136	28	108	-79,3%
	9	796	1420	2008	45	28	113	66	47	-41,5%
	10	699	1700	2003	30	15	94	59	36	-37,7%
SI	1	2405	6953	2002	210	135	171	175	-4	2,5%
	2	2415	7056	1979	212	101	157	182	-25	16,2%
	3	2476	5469	1977	169	74	158	103	54	-34,4%
	4	2512	6375	1940	194	114	173	139	34	-19,5%
	5	2036	5450	2003	171	77	147	144	3	-2,2%
	6	2327	5934	2000	163	83	145	124	21	-14,5%
	7	1356	6410	1980	205	106	141	117	24	-17,3%
	8	2212	8936	1973	247	155	156	187	-30	19,5%
	9	2462	7288	1975	224	109	163	124	39	-23,6%
	10	2036	4397	1578	195	92	212	117	94	-44,6%
SP	1	2421	5300	1976	143	38	133	119	14	-10,3%
	2	2474	9000	1977	169	51	84	116	-32	37,8%
	3	2519	2200	1984	39	10	135	142	-7	5,3%
	4	2250	2000	1977	52	20	142	74	67	-47,6%
	5	928	7700	2008	104	62	44	94	-50	114,5%
	6	2568	2500	1985	59	24	145	88	57	-39,0%
	7	2568	1250	1979	53	20	163	144	20	-12,0%
	8	2561	4186	1850	50	29	122	27	96	-78,1%
	10	2473	1350	1883	58	26	170	261	-91	53,3%
SE	1	2775	5073	1982	45	42	106	107	-1	1,0%
	2	2775	4069	1930	58	53	138	82	56	-40,7%
	3	2775	3777	1964	41	30	124	156	-33	26,6%
	4	2775	2803	1974	30	27	135	108	27	-19,9%
	5	2775	2583	2008	27	28	135	215	-80	58,9%
	6	2775	7961	1992	83	106	97	85	12	-12,6%
	7	2775	6843	1962	49	45	79	58	21	-26,7%
	8	2775	6506	1970	50	47	86	136	-50	57,9%
	9	2775	4455	1993	46	51	121	69	52	-43,3%
	10	2775	2061	1975	21	30	145	82	64	-43,9%

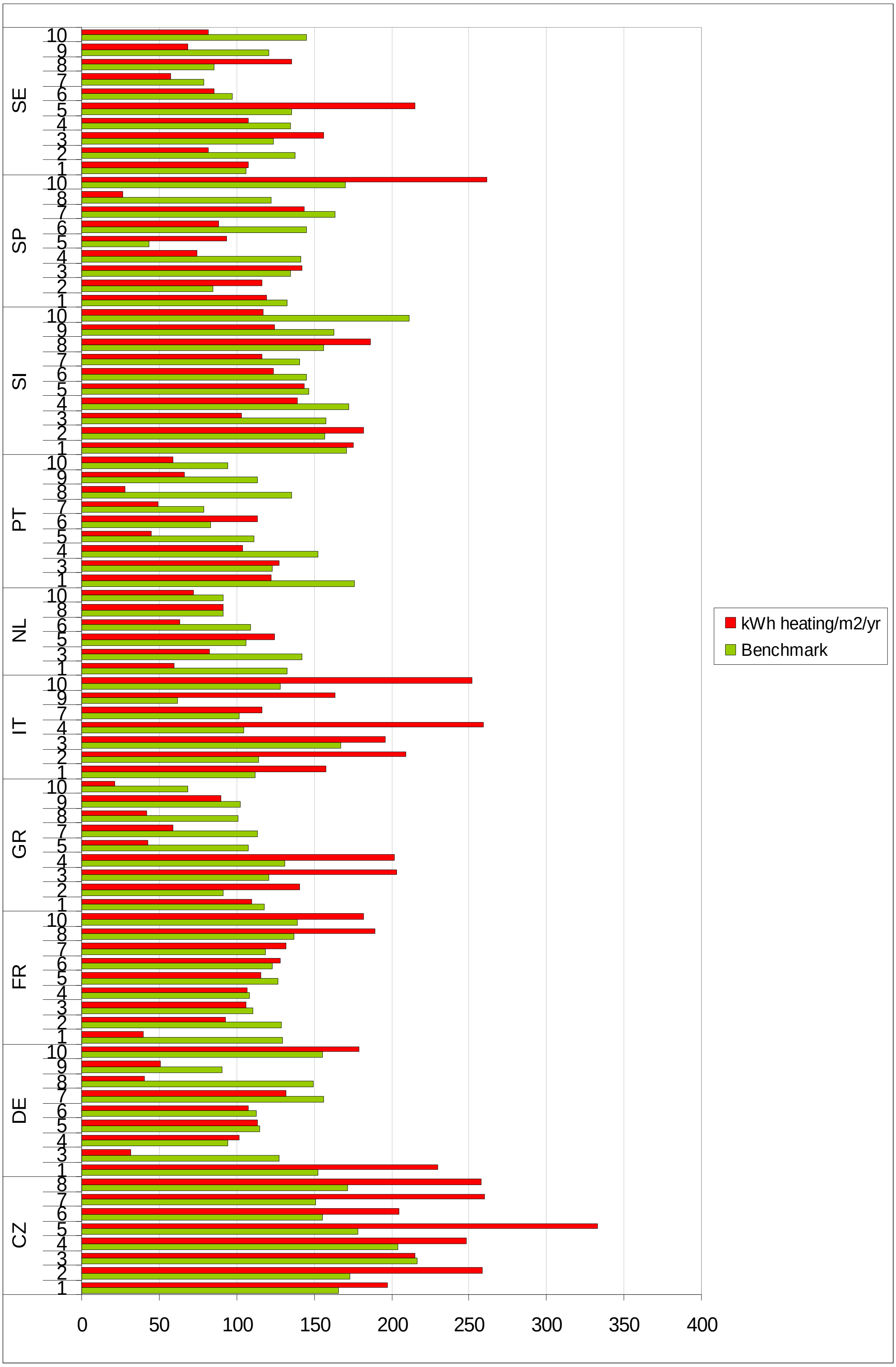


Figure 24: Real heating energy consumption per square meter, kWh heating/m2/yr, and the benchmark

In Figure 25 EUI3 is plotted against m^2. Like the EUI1 indicator the energy consumption per square meter per year decreases as the area of the building increases.

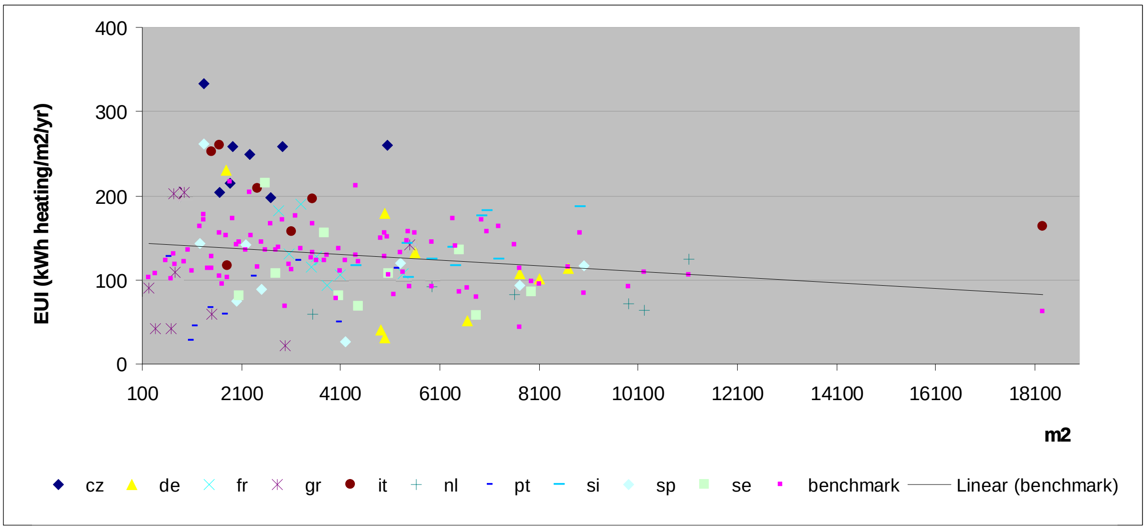


Figure 25: EUI3 (kWh heating /m2/yr) versus m2

In Figure 26 and 27 the EUI3 (kWhheating/m2/yr) is plotted against number of residents and number of employees, respectively. The benchmark estimated a positive correlation between the heating consumption per square meter and the number of residents. The correlation between the heating consumption per square meter and the number of employees is smaller as it can be seen in Fig. 27, there is no noticeable slop in the benchmark trend line.

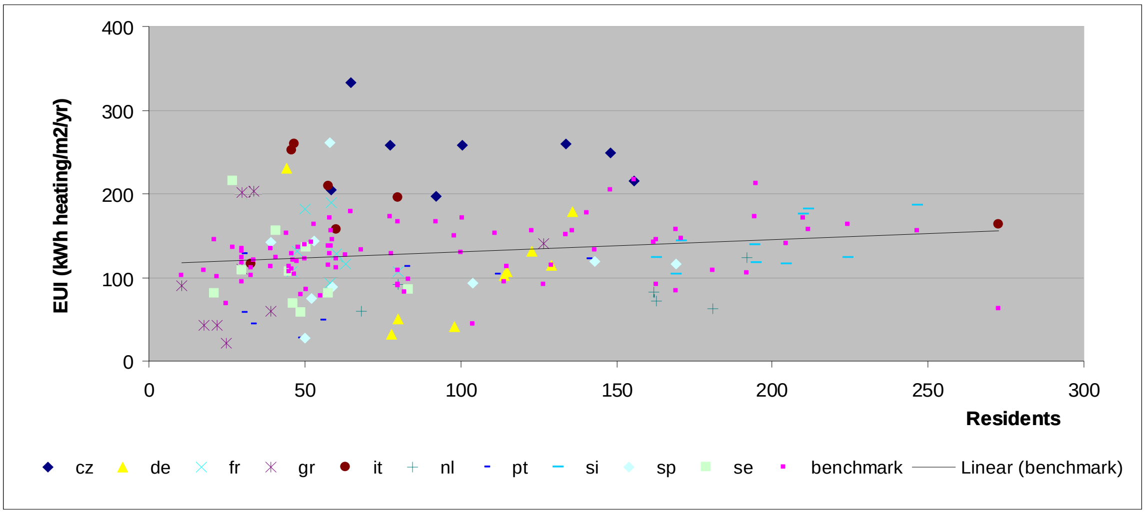


Figure 26: EUI3 (kWh heating /m2/yr) versus residents

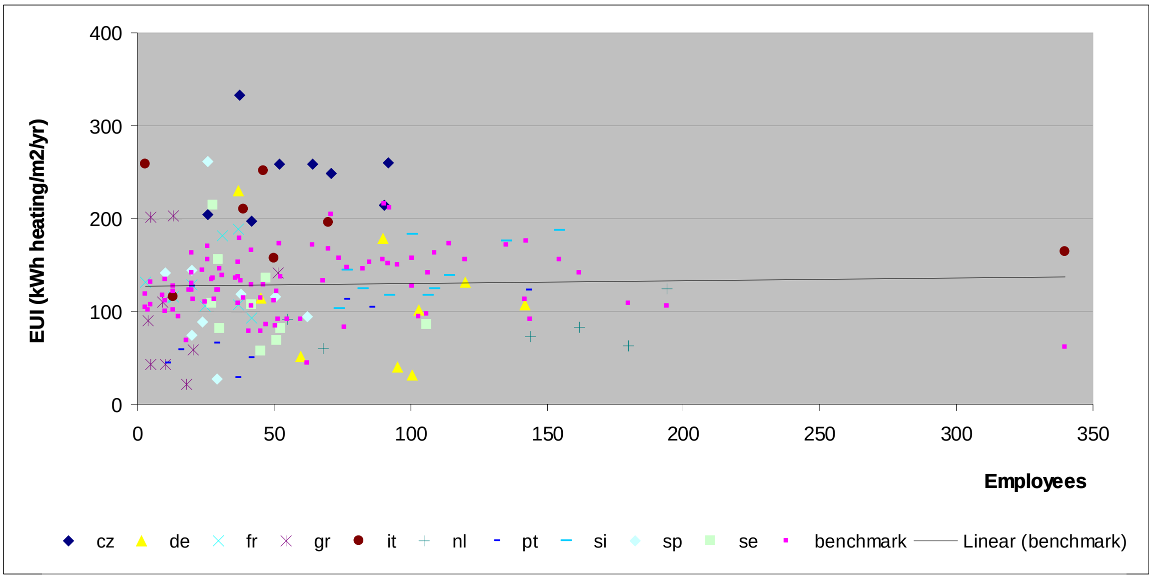


Figure 27: EUI3 (kWh heating /m2/yr) versus employees

Figure 28 shows that the benchmark estimated a positive correlation between the indicator heating consumption per m2 and the HDD.

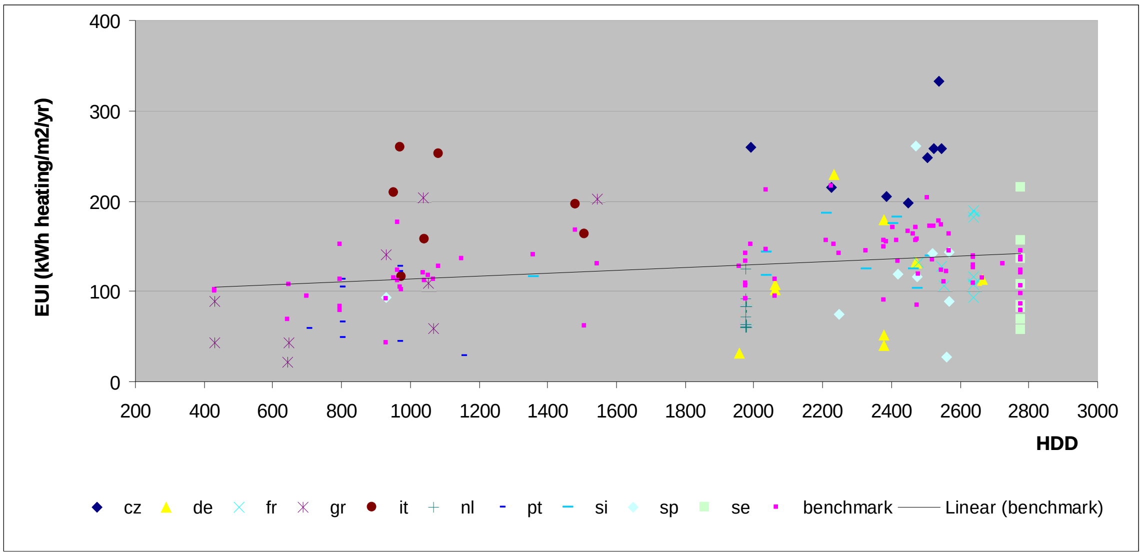


Figure 28: EUI3 (kWh heating /m2/yr) versus HDD

For the same number of HDD, in the same country, it is possible to find very different heating consumptions per square meter. This is mainly the case for Italy, GR, DE, and SE.

Figure 29 shows that the model estimated a negative correlation between year of construction and heating energy consumption. This can be interpreted as a sign of the improvement in the buildings performance, but there is not enough information to make a definite conclusion about this.

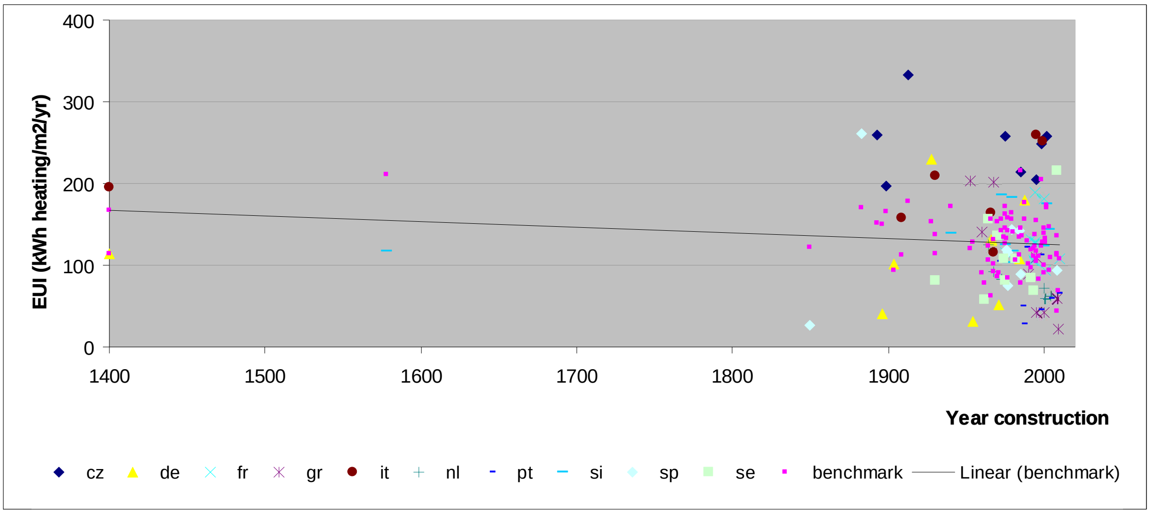


Figure 29: EUI3 (kWh heating /m2/yr) versus year construction

6.7 EUI4 (kWh heating/resident/yr)

Table 14 summarizes the statistics of the survey results for EUI4. It presents the minimum and maximum values, the average and the standard deviation of EUI4 and the explanatory variables under evaluation. The linear coefficient generated by the model and the sensitivity of the model to a given variable (the product of the standard deviation of that variable by the linear coefficient generated by the model) is also presented in the Table 14.

Table 14: Summary of statistics of survey results of EUI4

	N	Min	Max	Mean	SD	β	Sensitivity
EUI4 (kWhheating/res/yr)	86	903	20556	6109	3566		β*SD
X1 (HDD)	86	432	2775	1975	740	1,8183	1341,28
X2 (Net area, m2)	86	220	18270	4278	2994	0,5494	1645,23
X3 (Year of Construction)	86	1400	2010	1957	102	-1,285	-130,54
X4 (Number of residents)	86	11	273	91	61	-34,8	**-2137,59**
X5 (Number of employees)	86	3	340	62	54	5,327	286,25

As it can be seen the standard deviation is significant for all the explanatory variables. This is an indicator of large variability in the data sample.

The model for EUI4 is:

EUI4=5531,25+1,8183*X1+0,5494*X2-1,28509*X3-34,800*X4+5,32744*X5, with an R^2=0,31.

This indicator relates the energy used for heating for each resident with the explanatory variables namely square meters, nº of residents, nº of employees, HDD and year of construction. It gives an indication of the performance of heating systems within the RCHEP. Next Table shows the input data to model this indicator.

Table 15: Input data to model EUI4

	HDD	m2	Yr Construct	Residents	Employees	Benchmark	kWh Heating/res/yr	Difference	Difference %
1	2448	2681	1899	92	42	6024	5734	290	-4,8%
2	2545	1930	2002	77	52	6232	6453	-221	3,5%
3	2225	1879	1985	156	90	3123	2593	530	-17,0%
4	2506	2267	1998	148	71	3994	3807	187	-4,7%
5	2540	1353	1913	65	38	6373	6934	-561	8,8%
6	2386	1648	1995	58	26	6321	5781	540	-8,5%
7	1990	5054	1893	134	92	5332	9819	-4487	84,1%
8	2524	2927	1975	101	64	6031	7498	-1467	24,3%
1	2231	1783	1928	44	37	6756	9321	-2564	38,0%
3	1957	5000	1954	78	101	7148	2018	5129	-71,8%
4	2063	8100	1904	114	103	7867	7221	647	-8,2%
5	2665	8697	1400	129	45	9107	7670	1438	-15,8%
6	2063	7720	1984	115	142	7729	7200	528	-6,8%
7	2470	5600	1966	123	120	6932	5991	941	-13,6%
8	2377	4919	1896	98	95	7217	2043	5174	-71,7%
9	2377	6663	1971	80	60	8517	4254	4263	-50,0%
10	2377	5000	1988	136	90	5792	6588	-796	13,7%
1	2725	4420	1989	100	20	6985	1747	5238	-75,0%
2	2638	3839	2001	58	42	8070	6161	1909	-23,6%
3	2552	4100	1993	46	25	8396	9466	-1070	12,7%
4	2639	5358	2010	80	37	8103	7171	932	-11,5%
5	2639	3500	1975	63	13	7591	6441	1150	-15,2%
6	2546	3606	1994	60	20	7598	15000	-7402	97,4%
7	2480	3063	1992	48	3	7521	8450	-929	12,4%
8	2639	3306	1994	58	37	7750	10728	-2977	38,4%
10	2639	2836	2000	50	31	7742	10313	-2571	33,2%
1	1053	771	1995	30	9	4321	2846	1475	-34,1%
2	931	5500	1960	127	51	3593	6123	-2529	70,4%
3	1037	936	1953	34	13	4320	5654	-1334	30,9%
4	1543	738	1968	30	5	5196	4962	233	-4,5%
5	649	375	1995	18	5	3765	903	2862	-76,0%
7	1069	1500	2008	39	20	4458	2250	2208	-49,5%
8	432	672	2000	22	10	3403	1292	2110	-62,0%
9	432	220	1990	11	4	3530	1847	1682	-47,7%
10	642	2974	2009	25	18	4977	2552	2425	-48,7%
1	1040	3112	1909	60	50	4857	8182	-3325	68,5%
2	953	2436	1930	58	39	4324	8842	-4519	104,5%
3	1481	3535	1400	80	70	5956	8653	-2697	45,3%
4	970	1650	1995	47	3	4029	9163	-5133	127,4%
7	975	1820	1968	33	13	4696	6406	-1709	36,4%
9	1507	18270	1966	273	340	8104	10971	-2868	35,4%
10	1083	1500	1999	46	46	4400	8214	-3814	86,7%
1	1978	3540	2001	68	68	6497	3111	3386	-52,1%
3	1978	7604	1973	162	162	5995	3883	2112	-35,2%
5	1978	11124	1964	192	194	7067	7198	-131	1,9%
6	1978	10212	2004	181	180	6823	3560	3263	-47,8%
8	1978	5940	1968	80	55	7371	6795	576	-7,8%
10	1978	9904	2000	163	144	7105	4397	2708	-38,1%
1	964	3200	1988	141	142	2350	2786	-437	18,6%
3	964	570	1998	30	19	4086	2425	1661	-40,6%
4	796	2294	1970	111	85	2296	2149	147	-6,4%
5	964	1105	1997	33	10	4229	1496	2733	-64,6%
6	796	5170	1997	82	76	4803	7137	-2333	48,6%
7	796	4000	1985	55	41	4929	3596	1333	-27,0%
8	1150	1013	1986	48	36	4147	5000	-853	20,6%
9	796	1420	2008	45	28	3761	2092	1668	-44,4%
10	699	1700	2003	30	15	4209	3361	849	-20,2%
1	2405	6953	2002	210	135	4565	5808	-1243	27,2%
2	2415	7056	1979	212	101	4427	6077	-1650	37,3%
3	2476	5469	1977	169	74	5010	3348	1663	-33,2%
4	2512	6375	1940	194	114	4953	4561	392	-7,9%
5	2036	5450	2003	171	77	4111	4580	-469	11,4%
6	2327	5934	2000	163	83	5220	4515	705	-13,5%
7	1356	6410	1980	205	106	2418	3650	-1231	50,9%
8	2212	8936	1973	247	155	4167	6763	-2597	62,3%
9	2462	7288	1975	224	109	4247	4042	205	-4,8%
10	2036	4397	1578	195	92	3327	2643	683	-20,5%
1	2421	5300	1976	143	38	5532	4419	1113	-20,1%
2	2474	9000	1977	169	51	6810	6186	625	-9,2%
3	2519	2200	1984	39	10	7456	7943	-487	6,5%
4	2250	2000	1977	52	20	6477	2856	3621	-55,9%
5	928	7700	2008	104	62	5580	6933	-1353	24,3%
6	2568	2500	1985	59	24	7097	3743	3354	-47,3%
7	2568	1250	1979	53	20	6606	3392	3214	-48,7%
8	2561	4186	1850	50	29	8527	2240	6287	-73,7%
10	2473	1350	1883	58	26	6469	6083	387	-6,0%
1	2775	5073	1982	45	42	9476	12099	-2623	27,7%
2	2775	4069	1930	58	53	8607	5755	2852	-33,1%
3	2775	3777	1964	41	30	8872	14525	-5653	63,7%
4	2775	2803	1974	30	27	8681	10079	-1398	16,1%
5	2775	2583	2008	27	28	8623	20556	-11932	138,4%
6	2775	7961	1992	83	106	10057	8133	1923	-19,1%
7	2775	6843	1962	49	45	10351	8070	2281	-22,0%
8	2775	6506	1970	50	47	10120	17515	-7395	73,1%
9	2775	4455	1993	46	51	9124	6593	2530	-27,7%
10	2775	2061	1975	21	30	8601	8005	596	-6,9%

Figure 30 shows the real heating energy consumption per resident, kWh heating/resident/yr, and the benchmark obtained through the modeling, for each RCHEP. IT, SE, FR and SI are the countries in the worst situation in terms of heating energy consumptions per resident.

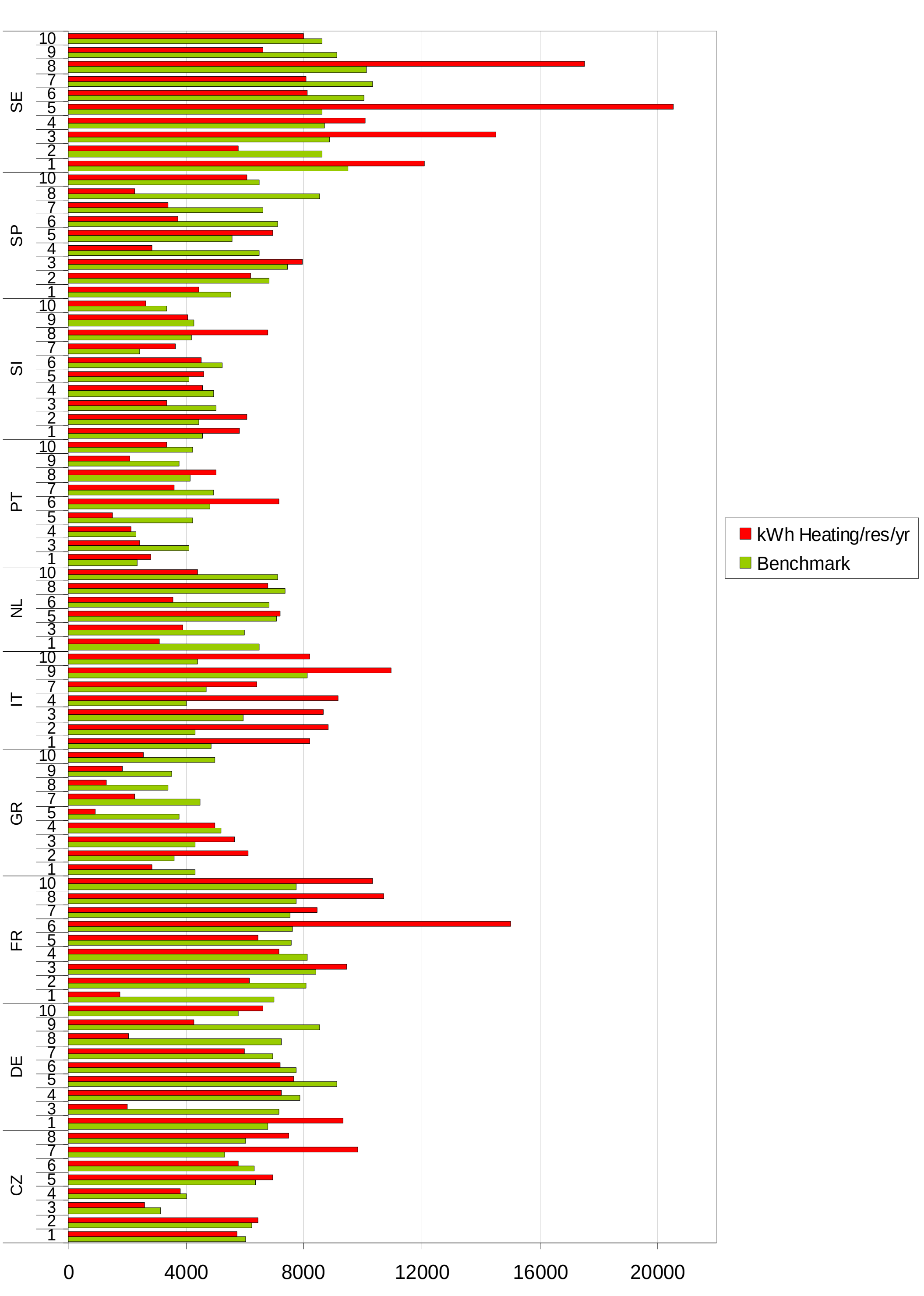


Figure 30: Real heating energy consumption per resident, kWh heating/resident/yr, and the benchmark

Figure 31 plots the EUI4 (kWh heating/resident/yr) against the net area of the building.. As it can be seen there is a positive correlation between the indicator and the variable square meters.

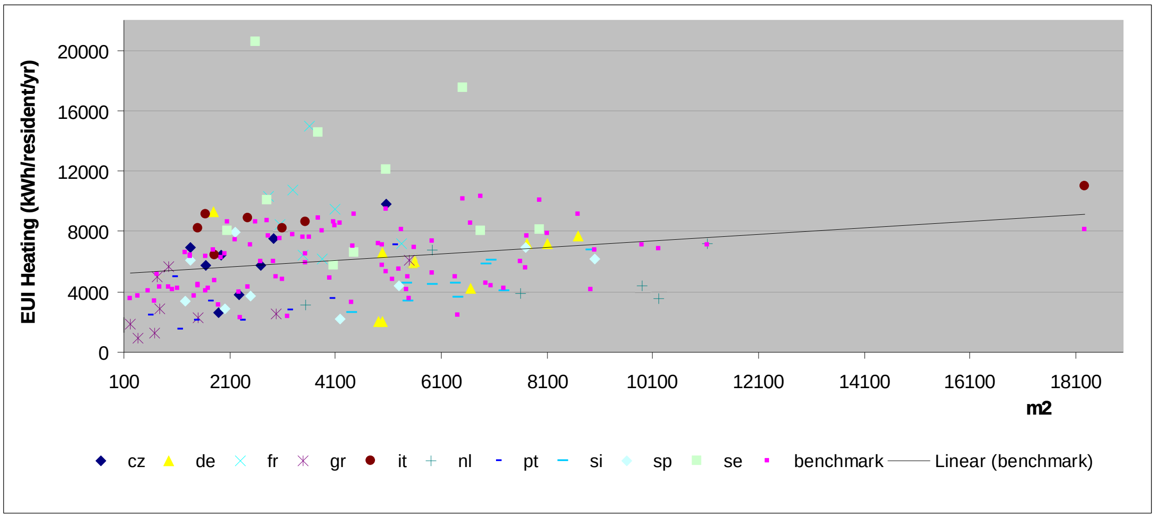


Figure 31: EUI4 (kWh heating /resident/yr) versus m2

Figure 32 and 33 plot the EUI4 (kWh heating/resident/yr) against the number of residents and the number of employees, respectively. As it can be seen in both situations the trend line is almost horizontal, meaning that there is no influence in the heating energy consumption per resident in relation to these variables.

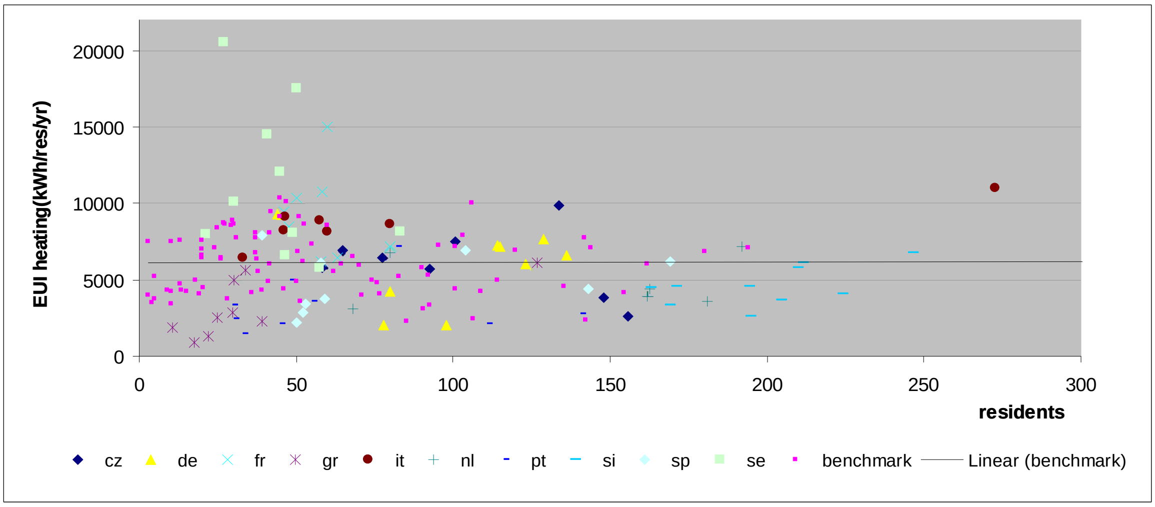


Figure 32: EUI4 (kWh heating /resident/yr) versus residents

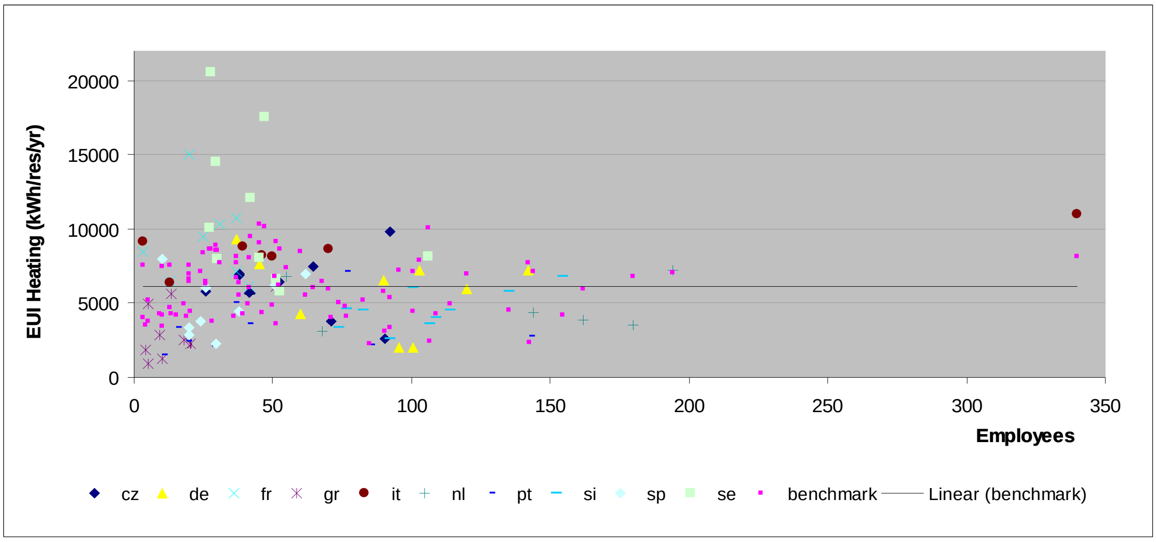


Figure 33: EUI4 (kWh heating /resident/yr) versus employees

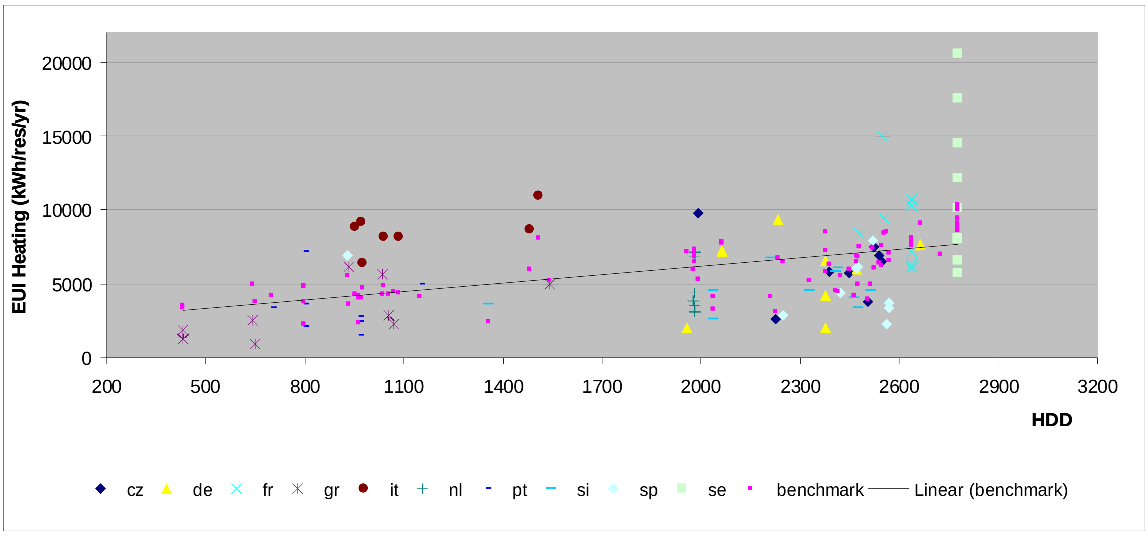


Figure 34: EUI4 (kWh heating /resident/yr) versus HDD

Like the EUI2, the energy consumption used for heating purposes, per resident per, year has a positive correlation with the HDD. In the same country, with the same HDD, it is possible to find RCHEP with very different heating consumptions per resident per year. This is particularly significant for SE and FR but is also true in other countries like IT, GR and DE.

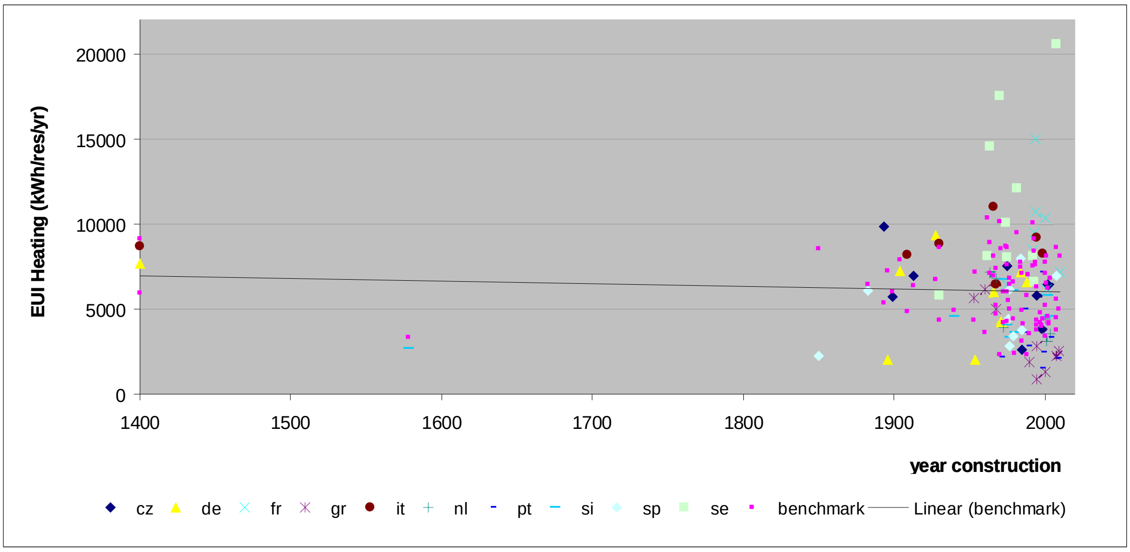


Figure 35: EUI4 (kWh heating /resident/yr) versus year construction

7 Conclusions

There is a large heterogeneity in the collected data, reflected by the sparse point clouds in the figures 12-16, 19-23, 25-29 and 31-35. Additionally, no non-linear tendency can be observed, therefore, in an attempt to establish benchmarks in the 10 countries, multivariate linear regressions was applied to the collected data, in order to model the energy consumption data. Considering such sparse data, large global deviations between the models and the data were obtained, reflected by relatively small values of R^2.

Considering the sensitivity of the model to a given variable as the product of the standard deviation of that variable by the linear coefficient obtained by multi-linear regression, we can conclude that the most relevant variable to EUI1 and EUI3 is the area and for EUI2 and EUI4 is number of residents.

The average value for EUI1 is 252 kWh/m2/yr. Within the sample, it varies from 46 kWh/m2/yr in one RCHEP in FR to 551 kWh/m2/yr in one house in Czech Republic. Based on the model, the maximum kWh/m2/yr should be 443. Czech Republic, Italy and Sweden are the countries where more RCHEP are using more energy than the model estimated.

Table 16 shows the real average consumption per square meter and the predicted average consumption per square meter in each country. The difference between the real and the estimated values are also shown.

Table 16: Real kWh/m2/yr versus estimated kWh/m2/yr

EUI1	Estimated with the benchmark	Real	Difference (Real-Estimated)
	kWh/m²/yr		%
CZ	344	435	26,5
DE	244	227	-7,0
FR	236	186	-21,2
GR	214	187	-12,6
IT	234	312	33,3
NL	237	187	-21,1
PT	252	236	-6,3
SI	326	301	-7,7
SP	228	215	-5,7
SE	203	241	18,7

In what concerns the indicator EUI2, it can range from 2215 kWh per resident per year in one house in GR to the huge amount of 36349 kWh/resident/year in one house in Sweden. Within the same country, the variation in terms of energy consumption per resident per year can vary significantly. The maximum kWh/resident/yr achieved with the model is 20156kWh per resident. Czech Republic, Italy, Portugal, Slovenia and Sweden are the worst countries in terms of total energy consumption per resident.

Table 17 shows the real average consumption per resident and the predicted average consumption per resident in each country. The difference between the real and the estimated values are also shown.

Table 17: Real kWh/resident/yr versus estimated kWh/resident/yr

EUI2	Estimated with the benchmark	Real	Difference
	kWh/resident/yr		%
CZ	10012	10311	3,0
DE	14463	12275	-15,1
FR	14468	10983	-24,1
GR	7984	6241	-21,8
IT	10498	13855	32,0
NL	14204	10744	-24,4
PT	7857	8008	1,9
SI	7887	9741	23,5
SP	12266	9229	-24,8
SE	17618	24521	39,2

EUI3 relates to the heating energy consumption and represents the heating consumption per square meter per year. The average heating consumption is estimated to be 129 kWh/m2/yr, however the maximum reaches 333kWh/m2/yr in one RCHEP in Czech Republic, while the model predicts 216kWh/m2/yr. Czech Republic and Italy, are the worst positioned countries in terms of this heating indicator. Table 18 shows the real average consumption for heating purposes, per square meter, and the predicted average consumption for heating purposes, per square meter in each country. The difference between the real and the estimated heating consumption values are also shown.

Table 18: Real kWh/m2/yr versus estimated kWh/m2/yr

EUI3	Estimated with the benchmark	Real	Difference
	kWh heating/m^2/yr		%
CZ	177	247	39,5
DE	128	110	-14,1
FR	125	121	-3,2
GR	106	101	-4,7
IT	113	193	70,8
NL	112	82	-26,8
PT	119	79	-33,6
SI	162	141	-13,0
SP	127	118	-7,1
SE	117	110	-6,0

The heating consumption per resident per year, like it happen with the EUI2, reaches the maximum value in one house in Sweden, with 20556 kWh/resident per year, while the model maximum value is: 10351kWh/resident per year. The average heating consumption value per resident per year is 6109kWh. The countries which are in a bad situation when the heating consumption per resident is analyzed are Czech Republic, France, Italy, Slovenia and Sweden.

Table 19 shows the real average consumption for heating purposes, per resident, and the predicted average consumption for heating purposes, per resident in each country. The difference between the real and the estimated heating consumption values are also shown.

Table 19: Real kWh/resident/yr versus estimated kWh/resident/yr

EUI4	Estimated with the benchmark	Real	Difference
	kWh heating/resident/yr		%
CZ	5429	6077	11,9
DE	7452	5812	-22,0
FR	7751	8386	8,2
GR	4173	3159	-24,3
IT	5195	8633	66,2
NL	6810	4824	-29,2
PT	3868	3338	-13,7
SI	4245	4599	8,3
SP	6728	4866	-27,7
SE	9251	11133	20,3

The collected data was compiled in a simple benchmarking tool (see Figure 36) that enables to estimate the energy consumption of a RCHEP based on simple criteria such as the size, location (HDD), number of residents, number of employees and year of construction.

Please fill in blue cells with data for your institution:

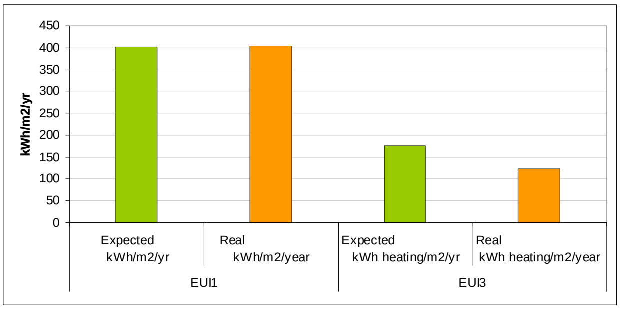
Total energy consumption per year in kWh	1290743
Total heating energy consumption per year in kWh	391927
Heating Degree Days	964
Heated area in m2	3200
Year of construction	1988
Number of residents	141
Number of employees	142

EUI1	Expected	kWh/m2/yr	401,15
	Real	kWh/m2/year	403,36

EUI2	Expected	kWh/resident/yr	5922,48
	Real	kWh/resident/year	9154,21

EUI3	Expected	kWh heating/m2/yr	176,35
	Real	kWh heating/m2/year	122,48

EUI4	Expected	kWh heating/resident/yr	2337,11
	Real	kWh heating/resident /year	2779,62



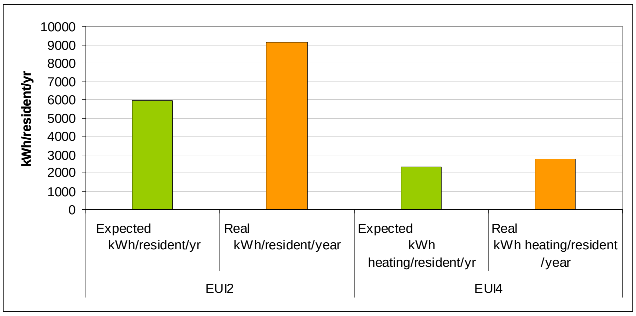


Figure 36: Layout of benchmarking tool to calculate EUIs – one example

7.1 Future work

There is a need to complete the missing information in the scope of WP2 of the Save Age Project. Since some outliers were found, it is advisable to double-check the information relative to those houses and eventually to carry out more detailed analysis in the future. As it is the basic idea of descriptive statistics, when encountered with an outlier, we have to go further on the analysis and find the cause of the outlier. Insignificant explanatory variables should also be eliminated.

In future works one should also study the fitting of non-linear models, to calculate the benchmark.

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9 ANNEX 1

EU Project SAVE AGE – Case Study Nº 00_ Country__

Questions for RCHEP managers / housekeepers / …

1.	**Type of company/institution** ☐ Private standalone ☐ Subsidiary of a private group ☐ Public institution NACE____________________
2.	**Characterisation of the building** Type of building: ☐ Single storey ☐ Multi storey ☐ Other (Specify) Number of floors .... Type of construction: ☐ Light ☐ Heavy Location ____(City) Type of terrain: ☐ Slope ☐ Hill ☐ Plain ☐ Valley External Envelope Area of the building ____________________ (m^2) / Cleaning Area __________ (m^2)

Net Area of the building (excluding garages, storage rooms and balconies)____________________ (m^2)

Floor Height of the building ____________________ (m)

Year of construction _________________

Last refurbishment or retrofitting (year) _________________

Surrounding vegetation outside:

None ☐

Garden ☐

small trees (they do not shade to the building) ☐

large trees (make shading to part of the building) ☐

Type of insulation:

None ☐

Double wall with air cavity ☐ depth: _____ (cm)

Double wall with insulation ☐ depth: _____ (cm)

Fiber glass ☐ depth: _____ (cm)

Rock wool ☐ depth: _____ (cm)

Cellulose ☐ depth: _____ (cm)

Polystyrene ☐ depth: _____ (cm)

Other (specify): ______________ ☐ depth: _____ (cm)

Window frame type:

Aluminium frame with thermal cut ☐ Aluminium frame without thermal cut frame ☐

Wooden frame ☐ PVC frame ☐

Other ________ ☐

Window glaze type:

Single glazing ☐ Double glazed ☐

Low emissivity glass ☐

Other ____________ ☐

Window type:

Horizontal Sliding ☐ Vertical Sliding ☐

Casement Window ☐ Hoper Window ☐

Fixed Pane ☐

Other ____________ ☐

Blinders / Shadows:

No ☐ Yes ☐ (percentage of windows or/and doors shaded______)

Indoor ☐ Outdoor ☐

	Doors Type: Wood ☐ PVC ☐ Aluminium ☐ Steel ☐ Insulated ☐ Uninsulated ☐ Poor condition (infiltration) ☐ Good condition ☐ **Elevators and Escalators:** Number of elevators: .... Type of technology: .... Maximum weight: .... Installed power: .... Number of escalators: .... Type of technology: .... Installed power: ....
3.	**Short description and Google photo location (building orientation):**
4.	**Residents** ***Note: annual information about residents, for the last 3 years, must be provided, in the annex residents.***
5.	**Characteristics of energy supply contracts** Contracted Power ....kW or kVA Maximum current: ....A/phase Voltage level supplied: ....Volt Installation Type Single-phase installation ☐ or Three-phase installation ☐

6. **Reactive Energy**

Reactive energy/year: ....kVArh/year

Not applicable ☐

Power factor correction?

Yes ☐ Capacitors power: ....kVAr

No ☐

7. **Disaggregation of consumption**

Note: monthly information about energy consumption, for the last 3 years, must be provided, in the annex energy consumption.

Average electricity: ________ kWh/year _______ €/year

Average natural gas: ________ kWh/year _______ €/year

Average district heating: ________ kWh/year _______ €/year

Other sources:

Biomass ☐ ________ Kg/year _______ €/year

Coal ☐ ________ Kg/year _______ €/year

Oil ☐ ________ m^3/year _______ €/year

Hot Water:

Average hot water: ________ m^3/year _______ €/year

Type of Energy: ☐ Gas ☐ Solar ☐ Electric ☐ Biomass ☐ Fuel

Type of System: ☐ Boiler ☐ Heater ☐ Solar Thermal

Solar thermal:

Area of panels .... m^2

Capacity of the water tank .... (m^3)

	Photovoltaic: Type of panels .... (technology) Power installed .... (kW) **Geothermal heat pump:** Thermal Power of pump .... (kW thermal) Electrical Power of pump .... (kW electrical)
8.	**HVAC:** Type of Ventilation .... Ventilation flow (air changes per hour) _____________ (m^3/h.m^2) and _____________ (m^3/h.occupant) Area of conditioned rooms _________________________(m^2) Volume of conditioned rooms ______________________ (m^3) Annual consumption of ventilation......... kWh COP/EER .... Or Nominal power .... kW Time of use per month .... hours Type of heating .... Area of conditioned rooms _________________________(m^2) Volume of conditioned rooms ______________________ (m^3) Annual consumption of heating .... kWh/BTU/Therm/kcal COP/EER .... Or Nominal power .... kW Time of use per month .... hours Type of Cooling .... Area of conditioned rooms _________________________(m^2) Volume of conditioned rooms ______________________ (m^3) Annual consumption of cooling .... kWh/BTU/Therm/kcal COP/EER ....

Or

Nominal power .... kW   Time of use per month .... hours

Temperatures and Humidity:

Winter confort temperature: .... ºC (for calculating the Heating Degree Day)

Average indoor Winter temperature: .... ºC

Summer confort temperature: .... ºC (for calculating the Cooling Degree Day)

Average indoor Summer temperature: .... ºC

Confort Relative Humidity: .... %

Average indoor Relative Humidity: .... %

Value of Degree Days *(to be answered by the questioner)*

Note: monthly information about degree-days, for the last 3 years, must be provided, in the annex degree-days.

To calculate the degree days we prepared an excel file (how to calculate _dd_20101223) that will help you to calculate the HDD and CDD automatically, by filling in the average daily temperatures for each month.

9. **Kitchen equipment**

Equipment type	Hours of Use	Power (kW)	Energy (kWh)
washing machine 1			
washing machine 2			
washing machine 3			
clothes dryer 1			
clothes dryer 2			
Refrigerator 1			

Refrigerator 2			
freezer			
microwave			
stove			
Oven			
industrial fryer			
kitchen hood			
other			

Office equipment

Equipment Type	**Stand-by (Yes or NO)**	**Nº units**	**Room**	**Hours of Use**	**Power (kW)**	Energy (kWh)
Computer						
Server / Switch / Router						
Printer						
Photocopying						
Other						

10. **Entertainment equipment**

Equipment Type	**Stand-by (Yes or NO)**	**Nº of units**	**Room**	**Hours of Use**	**Power (kW)**	**Energy (kWh)**
Computer						
TV						
Game console						
Stereo						

	DVD video						
	Video projector						
	Other						

11. **Type of indoor lighting**

Room		Hours of Use	Bulbs			Control type[2]	Illuminance (lux)
Type	Area (m^2)		Lighting type[1]	Power (W)	n.º of Lamps		

[1]Tubular fluorescent with electromagnetic ballast/ Tubular fluorescent with electronic ballast/ Incandescent/ CFL/ Halogen/ LED/ Other *(specify)*

[2]Dimmer (*adjustable*)/ Time switch/ Twilight switch/ Simple switch/ motion detector/ other *(specify)*

12. **Type of outdoor lighting**

Hours of Use	Bulbs			Control type[4]
	Lighting type[3]	Power (W)	n.º of Lamps	

[3]CFL/ Halogen/sodium lamp/ mercury lamp/ LED/ Other (specify)
[4]Time switch/ Twilight switch/ other *(specify*

13. What is the role of energy efficiency in the company/institution?

Is it an issue for investment decisions? ☐ always ☐ partially ☐ seldom or never

	yes	no
Is there an "energy-responsible position/person"?	☐	☐
Is there a position/person for environmental management?	☐	☐
Is there a yearly energy report?	☐	☐
Is there a yearly environmental report?	☐	☐
Are there any energy saving instructions for employees?	☐	☐
Is energy efficiency used in the company's (institution's) image?	☐	☐

14. Energy-efficiency activities:

	yes	no
Measures were taken in the past 5–7 years.	☐	☐
Measures are ongoing or planned in the near future.	☐	☐
There is need for action.	☐	☐

15. What type of actions are needed?

Building renovation.

- Walls insulation ☐
- Roof ☐
- Bathrooms ☐
- Windows ☐
- Piping ☐

	Other	☐	
	Appliances / End Use technologies.		
	Heating system	☐	
	Cooling system	☐	
	Ventilation system	☐	
	Hot water system	☐	
	Lighting	☐	
	Entertainment loads	☐	
	Office loads	☐	
	kitchen	☐	
	Washing	☐	
	refrigeration	☐	
	Other	☐	
	Equipments / furniture, etc.		
	beds	☐	
	space environment	☐	
	sofas	☐	
	arm chairs	☐	
	garden	☐	
	other	☐	
	Management		
	Energy management system	☐	
	Management practices	☐	
	Other___________________	☐	
16.	Type of investments made or measures taken:		
		yes	no
	washing machines	☐	☐

	refrigeration	☐	☐
	insulation of the building (walls, windows)	☐	☐
	heating equipment improvement	☐	☐
	energy saving lamps or lighting systems	☐	☐
	improvement of air condition or ventilation systems	☐	☐
	improvement of heating system	☐	☐
	investments in energy-saving office equipment	☐	☐
	energy management, energy controlling	☐	☐
	switch off electric appliances as far as possible	☐	☐
	switch off lamps not used, use of daylight as much as possible	☐	☐
	Installation of thermal solar panels	☐	☐
	Installation of PV panels	☐	☐
	Others, please specify		
17.	Are there defined profitability criteria for investments in energy efficiency? ☐ pay-back period ☐ life cycle costing ☐ others ☐ no Is the profitability of energy-saving investments defined in a similar way to other investments? ☐ yes ☐ shorter pay-back periods required ☐ longer pay-back periods accepted		
18.	Are there conflicts between energy saving and comfort requirements?	Yes	No
	Energy saving measures result in loss of comfort.	☐	☐
	Comfort aspects are more important than energy saving.	☐	☐
	Energy efficiency improves the quality of working conditions.	☐	☐

19.	Is energy consumption recorded? How often? ☐ yearly ☐ every 3–6 months ☐ monthly ☐ daily ☐ not recorded

	In which detail? ☐ per department ☐ per end-use ☐ per equipment ☐ not recorded in detail Are energy costs attributed to departments? ☐ yes ☐ no
20.	Are these data evaluated? ☐ continuously ☐ about once a year ☐ occasionally ☐ rarely or never
21.	Manager's assessment of the percentage of turnover spent on energy .... % (institutions: percentage of operational costs: ....) How do you consider these energy cost? ☐ high ☐ medium ☐ low ☐ neglectable Role of electricity cost compared to fuel cost ☐ electricity cost more important ☐ fuel cost more important ☐ same importance How do you expect energy prices to develop? ☐ increase strongly ☐ increase slowly ☐ stagnate ☐ decrease
22.	Do Government or other subsidies/loans/fiscal schemes exist for energy-saving investments for your type of organisation? ☐ yes ☐ no ☐ don't know If yes: ☐ subsidies ☐ loans ☐ tax credits ☐ tax deduction ☐ low interest rate ☐ rebates ☐ White certificates ☐ other, specify ……………………………………………..
23.	Did your company/institution ask advice from an energy consultant in the past? ☐ for a general energy check ☐ for a special area or equipment ☐ for advice on energy supply contracts, tariffs, etc.
24.	Do you exchange experiences of energy issues with other companies/institutions?

	☐ often ☐ sometimes ☐ no
25.	How often do you (or the person responsible for energy) keep informed about energy-efficiency issues? ☐ continuously ☐ occasionally ☐ rarely or never From whom do you receive information in this area? ☐ other companies ☐ associations ☐ expert journals ☐ equipment producers ☐ government ☐ others, which? ....
26.	How do you think employees or building users influence energy consumption? They have … ☐ high influence ☐ some influence ☐ little or no influence How motivated are the employees or users to save energy? ☐ highly motivated ☐ partly motivated ☐ not motivated Certain persons, e.g. operators of heating equipment, IT responsibles, janitors, etc. have ☐ high influence ☐ some influence ☐ little or no influence
27.	Which measures are taken to motivate employees or building users? ☐ information ☐ incentives ☐ instructions, rules ☐ training ☐ others, which? .... ☐ none
28.	Which are the main **barriers/obstacles** avoiding to invest in energy efficiency? ☐ short of budget ☐ difficult financing ☐ split budgets ☐ lack of awareness ☐ strict comfort requisites Others? .... ☐ none
29.	In the acquisition of new equipment is there any concern for energy efficiency No ☐ Yes ☐ criteria's for procurement concerning energy efficiency ☐ other (*identify*) ....

Thank you very much!