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The European GreenBuilding Programme 2006-2009 Evaluation

Paolo BERTOLDI
JOINT RESEARCH CENTRE

Michaela VALENTOVÁ
Czech Technical University in Prague

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European Commission
Joint Research Centre
Institute for Energy

Contact information
Address: Via E. Fermi, 2749, I-21027 Ispra (VA), ITALY
E-mail: paolo.bertoldi@ec.europa.eu
Tel.: +39 0332 78 9299
Fax: +39 0332 78 9992

http://ie.jrc.ec.europa.eu/
http://www.jrc.ec.europa.eu/
http://re.jrc.ec.europa.eu/energyefficiency/

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Executive summary

GreenBuilding is a voluntary programme aiming at improving the energy efficiency of non-residential buildings in Europe on voluntary basis. The programme addresses owners of non-residential buildings to realise cost-effective measures which enhance the energy efficiency of their buildings in one or more technical services.

The present report summarizes the results of the first four-year operation of the GreenBuilding Programme, in terms of the main energy efficiency measures in the buildings and related savings, as well as the GreenBuilding Partners' motivations and experience in carrying out the efficiency measures.

The analysis is based on the Partners reports of measures and savings, which are part of the GreenBuilding Partner applications. Furthermore, a questionnaire survey was carried out to discover more details on the Partner experience and motivations with the energy efficiency projects and the GreenBuilding Programme.

Until December 2009, total of 167 Partners have joined it with 286 Partner buildings. The total savings achieved by the Partners are 304 GWh/year. In 2020, the savings will have accumulated to almost 3.3 TWh. The average percentage savings amount to 41 %, which is well above the GreenBuilding Programme requirements (25 %).

In most of the buildings, to achieve the above savings, more than one energy efficiency measure has been implemented. Most often, it was a combination of three to four measures. Most frequently, those entailed heating (85 % of the buildings), air conditioning and ventilation (60 %), building envelope (58 %) and lighting (53 %). The reasons for implementing more measures at once are the economic effectiveness, but also design needs. If not done at once, it may leave some of the measures unimplemented as there will not be a sufficient potential for savings. Also, it is clear that it is ineffective to change a heating system and only subsequently deal with the building envelope and heating losses.

The economic effectiveness is a prerequisite for joining the GreenBuilding Programme. Therefore, the Partners have rarely reported on the economic features of their projects and all of the projects are supposed (and assumed) to be economically viable.

The projects are mostly financed from the future cash flow, i.e. from the achieved energy cost savings. The Partners tend not to use external experts (ESCOs) for the improvements and rather take advantage of the in-house specialists. Even less common is the use of Energy Performance Contracting. The reasons for this were not explored in the survey, but may constitute a basis for further research among the Partners.

There are two findings that are very important for the promotion of efficiency measures. First, that the Partners have not faced highly increased costs for the energy efficiency investments. The additional costs for increased efficiency were less than 10 % of the investment. Second, that most of the projects brought more savings than was estimated in the projects. Better actual results improve the overall effectiveness of the measures.

The GreenBuilding Programme has been successful over its four year operation. The number of Partners is growing on an increasingly growing rate. Nevertheless, in the future, the Programme may need to be more widely promoted among stakeholders. This way the Programme can serve as the benchmarking tool and in the same time promote the Partners and their achievements to the general public. Wider publicity of the Programme will help to achieve its main goal: promotion of energy efficiency in buildings.

Introduction

In 2005, the European Commission initiated the European GreenBuilding Programme (GBP, "Programme"). This programme aims at improving the energy efficiency and expanding the integration of renewable energies in non-residential buildings in Europe on a voluntary basis. The Programme encourages owners of non-residential buildings to realize cost-effective measures which enhance the energy efficiency of their buildings in one or more equipment systems. The Programme is managed by the Joint Research Centre (JRC) of the European Commission. It is operational in all 27 European Union (EU) Member States, European Economic Area (EEA) countries, Switzerland, Croatia and Turkey.

Any owner of non-residential building, be it a public or private organization, can join the GreenBuilding Programme as a GreenBuilding Partner (the Partner). Partner organizations commit to undertaking energy efficiency actions, which they describe in an action plan. If the action plan is accepted by GreenBuilding, the company is granted Partner status.

Businesses from the building sector, contributing to energy efficiency in the non-residential building sector with their products or services, can join as the GreenBuilding Endorsers. The Endorsers help in promoting GreenBuilding Programme to potential participants and support already registered GreenBuilding Partners in their efforts to reduce energy consumption. The Endorsers must have assisted at least one building owner in becoming a GreenBuilding Partner and are expected to submit a promotion plan, in which they specify further activities to promote the GBP[1].

Next to the main GreenBuilding Programme administration, the Joint Research Centre, the so called National Contact Points (NCP) have been established in the countries participating in the GreenBuilding Programme[2]. The NCPs represent the main intermediary between the JRC and the Partners/Endorsers. They assist the organizations in their efforts to join the GreenBuilding Programme, provide information about the Programme and organize promotional activities.

The GreenBuilding Programme provides support to the Partners in the form of information resources and public recognition, such as press coverings in newspapers and magazines, presentation at fairs and conferences across Europe, a regular newsletter, and a brochure and a catalogue of success stories. The GBP plaque allows Partners to show their responsible entrepreneurship to their clients.

1. Objectives

The aim of the current report is to provide a summary analysis of the results of the GreenBuilding Programme (GBP) in its four year operation – from the launch of the programme in 2006[3] until the end of 2009.

So far, 167 partners have joined the programme with almost 300 buildings, coming from various fields and sectors of operation. The buildings themselves vary in age, size and use, but they all have in common the energy performance, which goes far beyond the average performance of buildings in the respective sectors in the participating countries. The quite well large sample of buildings provides a basis for some conclusions to be drawn.

[1] In the time of writing the Report (February 2010) there was a total of 66 GreenBuilding Endorsers.

2 List of National Contact Points can be found in the Annex and also on the website of the project: http://re.jrc.ec.europa.eu/energyefficiency/greenbuilding/index.htm.

[3] The first stage of the GreenBuilding Programme was launched in 2005, but the years 2005 and 2006 are considered as pilot phase of the Programme.

The present report focuses mainly on efficiency measures in the Partner buildings and related savings, but also assesses the GreenBuilding Partners' motivations and experience in carrying out the efficiency measures.

The report is divided into two main parts. First, the main results of the GreenBuilding Programme are presented. In this section, building technical data, building technologies and design and energy saving of each participant are analyzed. Second, the GreenBuilding Partners motivations and experience with the Programme and experience with the energy efficiency projects are assessed, based on the questionnaire survey answers from the Partners.

2. Methods

Partners who join the GreenBuilding Programme with their buildings include a report to their application, in which they provide information on the level of achieved savings and a description of the efficiency measures through which they achieved the declared savings. These reports served as a basis for the first part of the analysis – Results of the GreenBuilding Programme. Secondly, GBP Partners' motivations and experience are evaluated based on a questionnaire, which was sent out to all Partners in 2008 and 2009[4].

The assessed period is identical to the duration of the Programme – 2006 – 2009.

The buildings are assessed as to their year of construction (and related to this whether the buildings were new or refurbished), floor area and prevalent use. As there are relatively many types of buildings, the following table (Table 1) shows the main categories, into which the buildings were sorted out, in order to allow the analysis, while capturing the prevalent uses of the building.

Table 1 Building use

Commercial center	Offices, but also including restaurants, shops, conference rooms, etc
Education	From kindergardens up to universities
Healthcare	Hospitals, but also rehabilitation, day care, etc
Industry	Warehouse, storage, production hall, manufacturing buildings, workshops. (There can also be offices, but not representing he main part of the building)
Office	Buildings mainly for office use
Leisure	Spa, leisure centers, swimming pools
Public administration	Municipal halls, courts, penitentiaries
Retail	Supermarkets, shops
Other	Church, canteen, community center, social housing, library, social care, airport, train station

The achieved savings are analyzed as to their absolute levels (MWh/year) and in relative terms (% of the consumption before refurbishment for existing buildings or of relevant (legally required) consumption for new buildings). The above mentioned general characteristics of the buildings (type and area of the building, year of construction, country) are also taken into account.

[4] The questionnaire can be found in the Annex of the Report.

The efficiency measures varied to certain extent among partners (given the different use, geographical area or year of construction). Nevertheless the measures were categorized into 8 main areas, which were found as the common denominator.

The categories were: Heating, Ventilation/Air-conditioning, Cooling, Building envelope (including façade, roof and/or basement insulation and windows), Lighting, Renewable energy sources (RES), Control systems and Other. Within the general category of Heating, Combined Heat and Power generation (CHP), heat pumps and biomass boilers were earmarked (the last two in the same time may be categorized under RES). The RES were further split into solar panels and photovoltaic installations. From building envelope measures, summer heat protection was emphasized. Under the category "Other" mostly (but not only) water saving systems are hidden.

What is private and what is public building? Some partners are private companies but are doing public buildings, such as public administration buildings. In this case, the decisive point is the building use. The rationale behind is, that the GreenBuilding is awarded to the specific building, on a case by case basis.

It is important to emphasize that not all the information was provided from all Partners. Nevertheless, the missing pieces of information were relatively negligible - there were only 2 buildings for which no report has been provided. Yet, as there exists no common format of the reporting form in the participating countries, for many partners only partial information was provided[5]. As a result, the sample for analysis differs as to analysed topic. In the following analysis, this is always acknowledged either by including a "n/a" (not available) share or by stating the total population of the sample.

The only section though, where the number of provided sets of data is significantly lower, is the information on economic characteristics of the projects. This analysis is therefore more of qualitative nature and the conclusions are to be taken with caution.

The report is based on Partners' information only. The reporting forms are always being checked by the National Contact Points for inconsistencies, before being sent to the JRC, and then also checked by the JRC, before granting the Building and the organization a GreenBuilding Programme Partnership status. Nevertheless, the analyzed data has to be taken keeping this limitation in mind.

[5] The obligatory part of the report is % savings, as this is one of the requirements to join the GreenBuilding programme.

3. Results – the GreenBuilding Programme

3.1. General description of the Partner buildings

There is a difference between the number of Partners, who joined the GreenBuilding Programme and the number of Partner Buildings, which have received the GreenBuilding Certificate. The GBP Certificate is always granted to a specific building. Therefore one GBP Partner can join the Programme with more buildings. Each of these buildings is assessed separately and receives the certificate on an individual basis[6].

As of the end of December 2009, the total number of GreenBuilding Partners amounted to 167. The total number of GreenBuilding certified buildings was 286. Five companies have become Corporate GreenBuilding Partners.

The GreenBuilding Programme has been thriving the last two years of operation. During the first three years of operation of the Programme (2005 - 2008), 71 Partners have joined with 87 Buildings[7]. Since then the number of Partners more than doubled and the number of Buildings more than tripled.

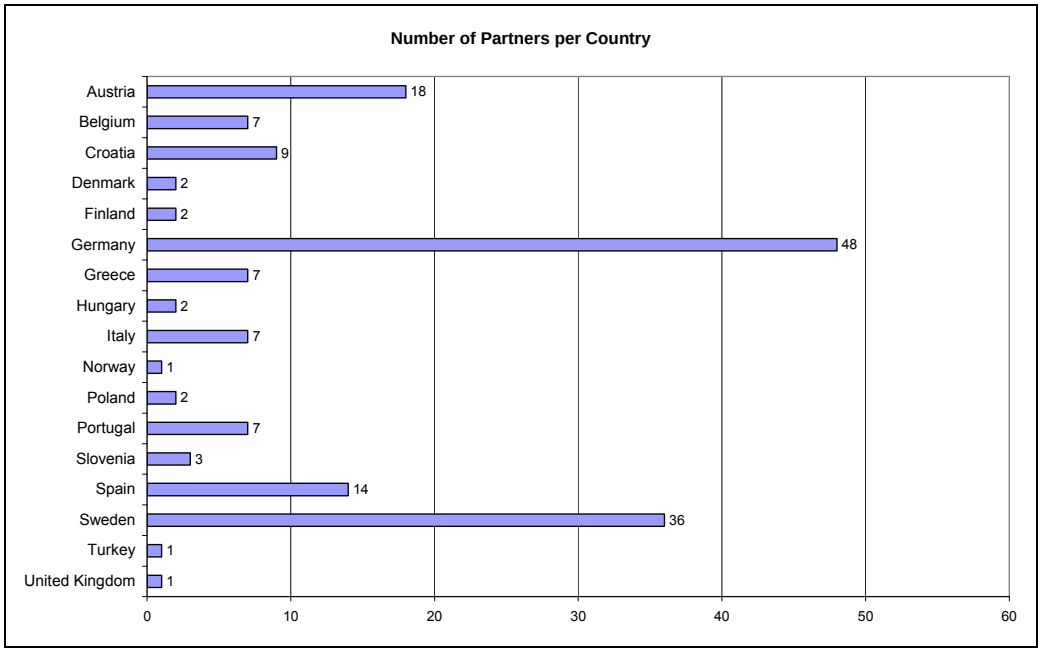
The Partners come from 17 countries, from which 14 are part of the EU (Figure 1). Geographically, both southern and northern countries are represented. The highest number of GBP Partners come from Germany (48), followed by Sweden (36). Austria has 18 Partners and Spain 14. From non-EU countries, there is one Partner from Norway and Turkey and 9 Partners from Croatia.

There have been a few international companies, which have joined the GBP in different countries, such as NCC Development, Skanska or Siemens. In this case, the country versions of the companies are taken separately (Therefore, e.g. Skanska Poland and Skanska Hungary are considered as two Partners).

[6] Recently, an institute of so called GreenBuilding Corporate Partners has been initiated. An organization can achieve the "GreenBuilding Corporate Partner" status if it owns at least 10 buildings and its commitment covers a large proportion of its buildings owned or on long term lease at all of its European buildings or sites. The corporate commitment means that at least 30% of the company's existing buildings and 75% of the new buildings have met the GreenBuilding requirements.

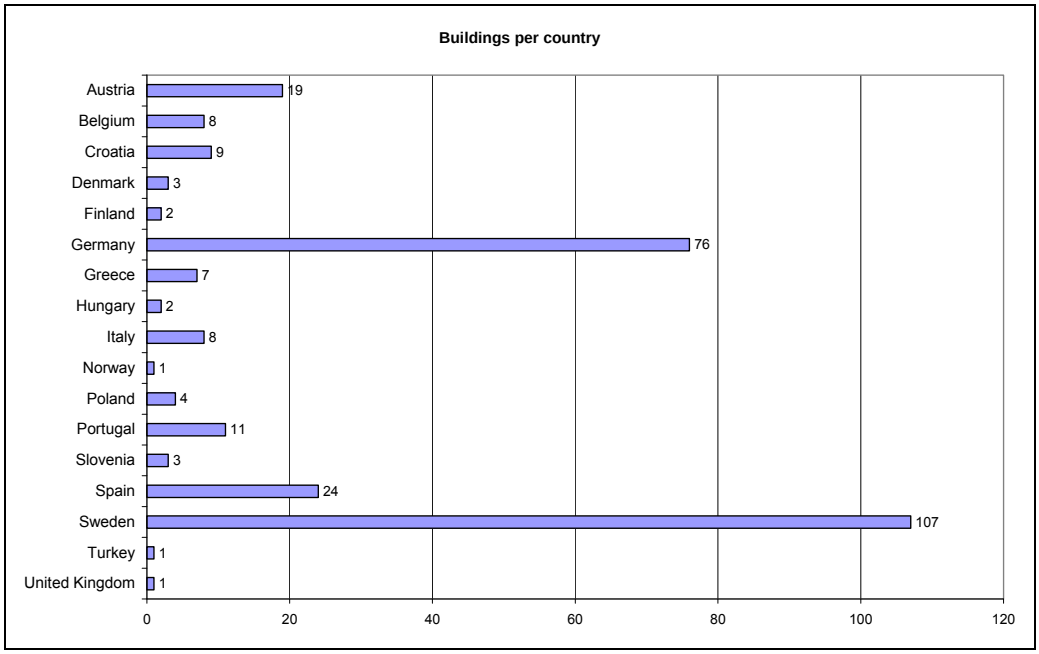
[7] Valentova, M., Bertoldi, P.: Analysis of the Building Owners' Motivations for Investing in Energy Efficiency: Results from the GreenBuilding Programme, Proceedings of the IEECB Focus 2008, http://re.jrc.ec.europa.eu/energyefficiency/pdf/IEECB08/IEECB08%20proceedings/098_Valentova_Final.pdf (Accessed March 2010)

Figure 1 Partners per country



The highest number of buildings have been registered in Sweden (107), which means more than three buildings per Partner on average, followed by Germany with 76 buildings (i.e. ca 1.5 building per Partner on average). In most countries though, the number of buildings to large extent copies the number of Partners (Figure 2).

Figure 2 Buildings per country



Almost 60% (167 out of 286) of the Partner buildings are offices (Figure 3). Importantly, of course other buildings may (and surely do) include offices as well. However, the offices do not represent the main use of the building and serve more as background space. This is mainly the case for e.g. the category of industry, commercial centres or public administration. The second largest group of buildings (although far after the first one) are education

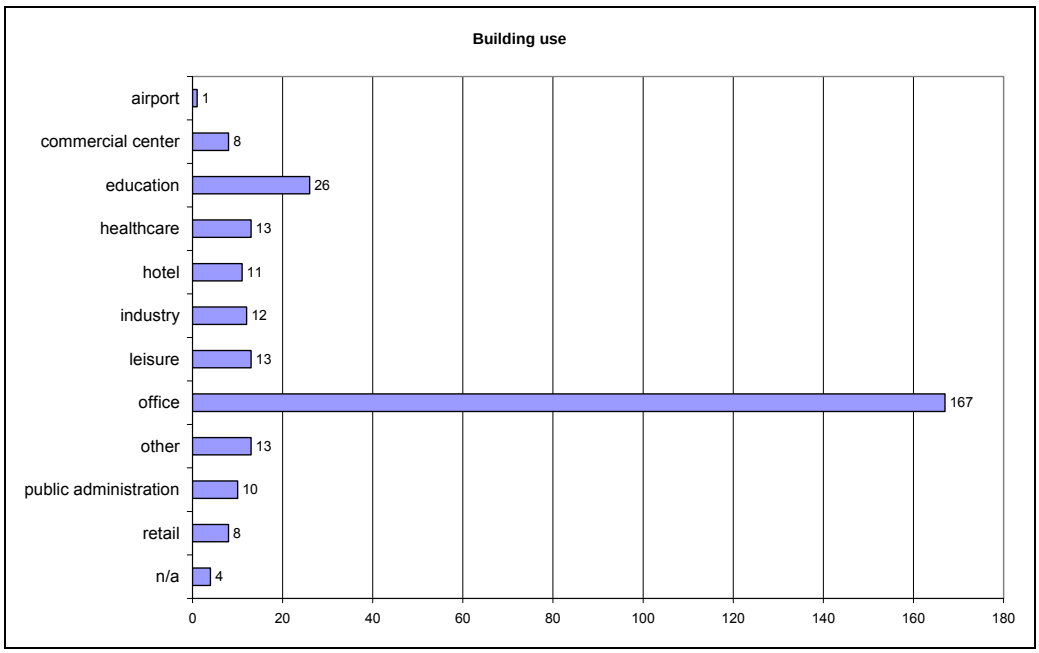
buildings (8.8% of the GBP buildings). These include kindergartens, primary schools, high schools and universities.

Healthcare, hotels, industry and leisure centres are then all represented by 11 to 13 buildings (ca 4% of total number of Partner Buildings). The public administration buildings (10 in total) cover municipal houses, but also courts or penitentiaries.

There were two airports, which joined the GBP. In one case however, the building serves mainly as office building and thus was included in this category. In the second case, a set of buildings and facilities was incorporated, such as satellite building, ramp service or ramp service building, thus a special category was devoted to it. For 4 buildings, the information on their prevalent use was not available.

Among other buildings, there is for example a church, technology centre, research institute, canteen, libraries, train station or social care and social housing centres.

Figure 3 Type of buildings



Majority of the Partner buildings belong to private organizations (77 %), only 23 % of the Partner buildings are public[8] (Table 2). All of the educational facilities and obviously public administration buildings in the GreenBuilding Programme are run by public organizations. In healthcare facilities, there are both public and private organizations involved, the same for leisure centres (public are for instance municipal spa) or offices. On the other hand, commercial centres, hotels or industry buildings in the GreenBuilding Programme are operated purely by private organizations.

[8] In case of the train station, the facility was refurbished by a private company, however, the facility itself is of public use, thus was categorized under public.

Table 2 Private and public organizations

Building use	Private	Public
airport	1	
commercial centre	8	
education		26
healthcare	2	11
hotel	11	
industry	12	
leisure	5	8
office	165	2
other	7	6
public administration		10
retail	8	
n/a	2	2
Total	**221**	**65**

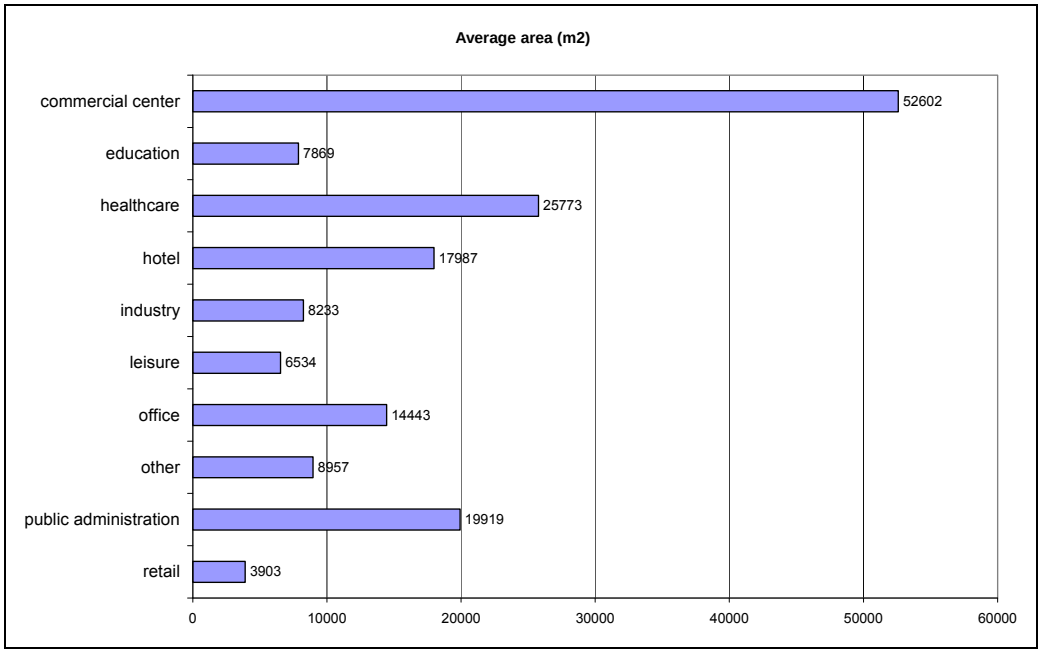
The average area of the Partner buildings was more than 15 595 m2[9]. However, the median of the sample is nearly half of the average – 8 957 m2 – meaning that 50 % of the buildings are actually smaller than 9 000 m2. The sample is to large extent skewed by commercial centres, which have the highest average floor area – more than 52 000 m2 (Figure 4).

The smallest building only has 414 m2, therefore could easily pass as a slightly bigger family house. Specifically, it is a historical building built in 1900, used as an office building of a regional association, with the primary energy savings reaching 455 MWh/year. The largest building of the GreenBuilding programme has 200 000 m2 and it is one of the new commercial centres, built in 2009, with savings compared to conventional building of 7 329 MWh/year.

The buildings also differ in height. On average the Partner buildings have six above-ground floors. However, the differences are big. Among GBP Partner buildings, there are ground-floor buildings but also skyscrapers with 40+ floors.

[9]This is a net floor area. In 19 cases, the net floor area was not reported, thus the gross floor area was used instead as a proxy.

Figure 4 Average area of buildings per building use



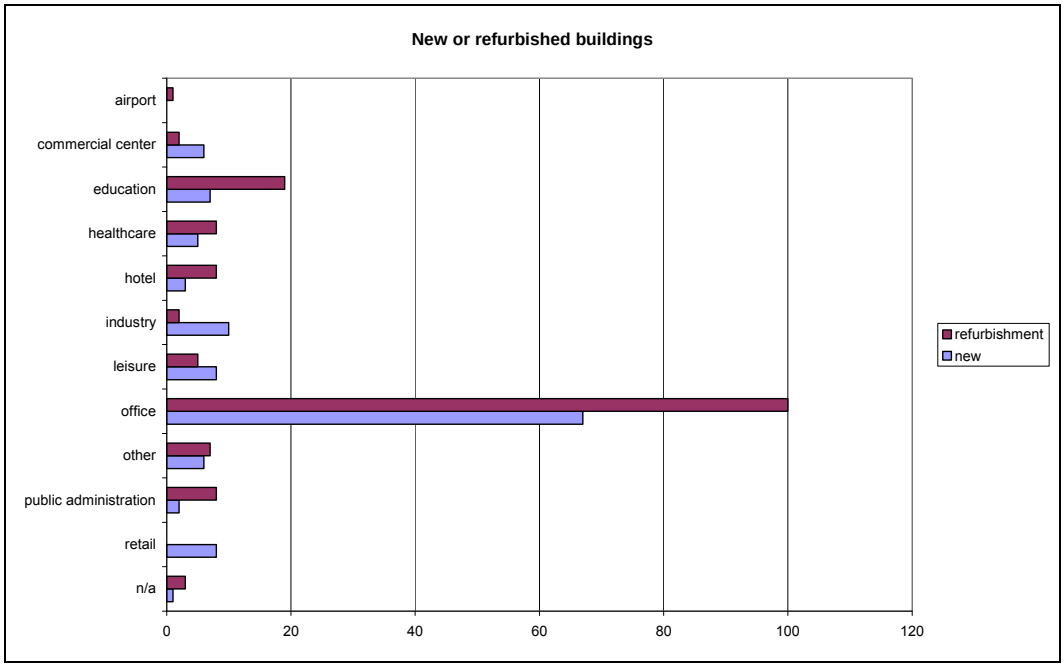
Note: the airport is not included here, because the data on area are missing.

Two types of projects are reported under the GreenBuilding Programme. Either it is new buildings, which have recently been constructed or are still under construction, or it is refurbishments of existing (albeit not necessarily old) buildings.

In the former case the buildings have to achieve primary energy consumption which is 25 % below the relevant building standard in force or compared to “conventional” new buildings. In the latter case the energy consumption before and after refurbishment is decisive (again at least 25 % difference is required).

Out of 286 buildings, there are 123 new buildings and 163 existing, refurbished buildings. Among hotels, office buildings, public administration buildings or education facilities the refurbished buildings prevail (Figure 5) – there are around twice as much existing buildings than new buildings. Conversely, there are much more registered new commercial centres, industry buildings or leisure facilities.

Figure 5 Number of new or refurbished buildings per building use



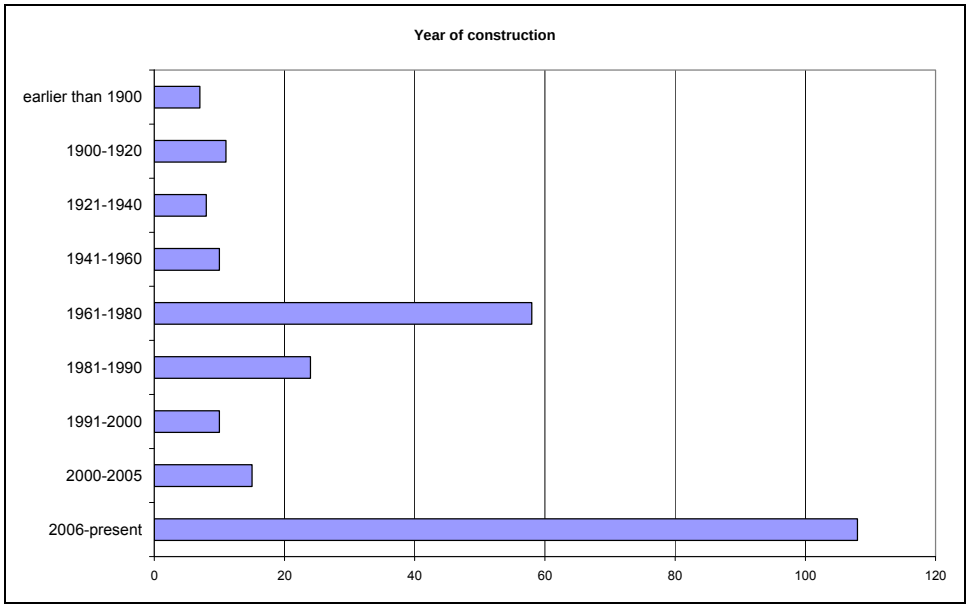
Most existing buildings have been built in the years 1961 to 1980 (Figure 6). The oldest building of the GreenBuilding Programme was constructed in 1600. Other 9 buildings were built in or before 1900. From the opposite side, the newest refurbished building was constructed in 2004.

It must be noted though that these are the years of original construction. In many cases, the buildings were of course reconstructed several times, or some parts of the buildings were added. This was however disregarded in the present analysis, as the original year of construction seems the most relevant in terms of energy performance and options for efficiency measures.

The new buildings were constructed in the range of years 2004 to 2011. This means that the new buildings almost overlap with the existing, already refurbished buildings, and in the same time, some buildings are still under construction.

In absolute terms, most of the Partner buildings were finished in 2009 (35 Partner buildings out of 251 where this information was available), followed by constructions finished in 2010 (33 Partner buildings) and in 2008 (20 Partner buildings).

Figure 6 Year of construction of the buildings



3.2. Achieved Savings

The GreenBuilding Partners usually report their savings in two ways: either as absolute yearly savings or as kWh per m2 and per year. In some case, both sets of data are reported. In case of relative savings (%) it is not important which method of reporting is used. However, if we are to analyze the absolute savings, in case of the latter method (reporting kWh/m2.y), recalculation is necessary.

In the analysis, the reported net floor area was used as a proxy for this recalculation. (I.e. the specific consumption was multiplied by the net floor area.) Consistency of such calculation was checked with the partners, who have reported all three pieces of information: the absolute savings, the specific (per m2) savings and the net floor area[10]. The calculated values differed in less than 1% on average from the reported absolute savings.

In about 7% of the buildings final energy savings instead of primary energy savings were reported. In half of the cases, distinction between electricity and heat savings was made. In these cases, a factor of 2.5 was used to recalculate the electricity savings into primary energy savings. In the rest of the cases, the heat energy was reported, which uses a factor of 1 for recalculation.

Energy savings are closely related to cost savings. However, most partners only reported on energy savings and only 20 partners reported on costs savings as well. Therefore, this section mostly focuses on energy savings. The economic aspects of the projects are analyzed in section 3.5.

3.2.1. Absolute savings

Total primary energy savings of the GreenBuilding Programme so far (GreenBuilding Partners until the end of 2009) have amounted to **304 GWh/year**. It means that in 2020, the savings will have accumulated to almost 3.3 TWh.

The savings are most likely underestimated to some extent. There are two reasons for this. Firstly, the reported savings have often been only estimates (e.g. for new buildings). As will be shown later in section 4.3.3, the verified savings tend to be higher than the calculated levels. Secondly, there were 40 GBP Partner buildings for which no data on absolute energy savings were available (ca 14 % of the buildings)[11].

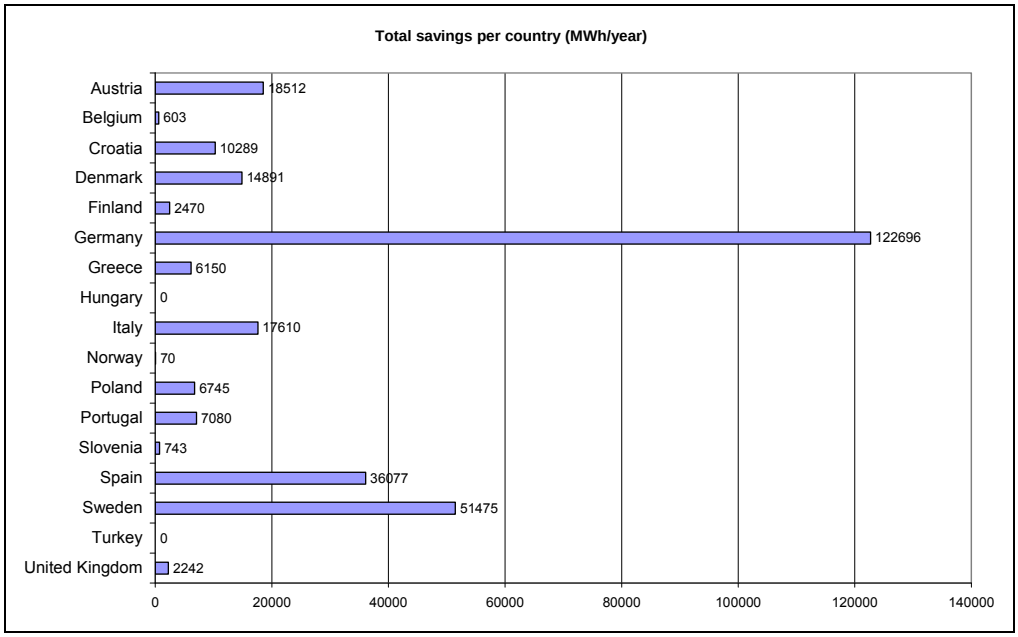
Figure 7 depicts the total savings (MWh/year) per country. Maximum absolute savings were achieved in Germany – more than 116 GWh/year (interestingly) despite the fact that Germany is only second in terms of number of Partner buildings. Sweden follows with total savings of 51 GWh/year, Spain being third with 19 GWh/year. When we relate the savings to number of Partner buildings in these three countries, then the average savings per Building are 1500 MWh/year in Germany, 480 MWh/year in Sweden and 1000 MWh/year in Spain. This infers that both in Germany and Spain, larger but fewer projects prevail, whereas in Sweden, it is a great number of relatively smaller projects.

From individual projects, maximum absolute savings were achieved in the Test center for transformers in Nürnberg, operated by Siemens. The maximum primary energy demand, which is legally required for such building is 984.3 kWh/m²a, whereas the test center achieved the primary energy demand of only 23.3 kWh/m²a, which means 97.5 % less than required. In absolute terms, it gives a saving of 11.83 GWh/year (almost 4 % of total achievements of the Programme).

[10] There were 18 such partners.

[11] In some cases, the Partners provided the percentage savings, but not the absolute levels.

Figure 7 Total savings per country (MWh/year)

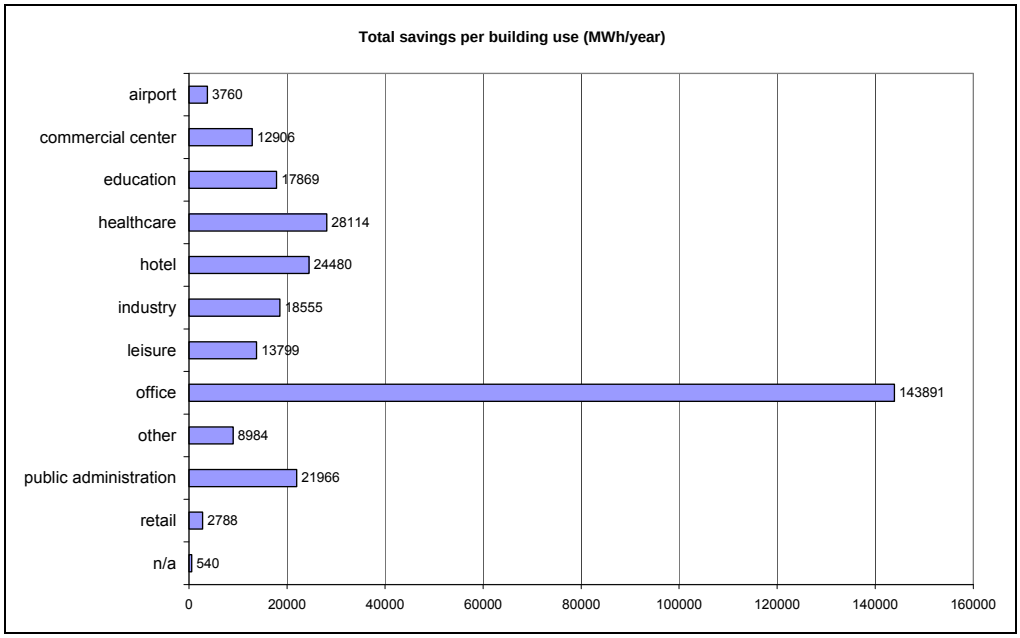


When looking at specific building use and related total savings, obviously, the highest total savings have been reported from by far the most frequent building use - offices, more than 140 GWh/year (Figure 8).

The healthcare facilities in the GreenBuilding Programme tend to embody high savings potential. Total savings reached almost 30 GWh/year. The hotels in the GreenBuilding Programme have together achieved more than 24 GWh of savings per year, followed by public administration and industry (ca 21.9 and 18.6 GWh/year respectively).

The second most frequent building use – education facilities is “only” fifth in terms of absolute savings (17.9 GWh/year). The reason is that the education facilities are relatively small as to their area and as shown in Figure 9**Error! Reference source not found.** further below, there is a direct relationship between absolute savings and area of the buildings.

Figure 8 Total savings per building use (MWh/year)



The average savings per building use are depicted in Table 3. For airport, the average savings are interchangeable with total savings, as that is the only building in this category. Apart from this building use, the highest average savings per Partner building are reported in commercial centres, healthcare (as mentioned) and public administration (2581 MWh/year, 2556 MWh/year and 2441 MWh/year respectively). Therefore these building types seem to offer the highest potential savings.

On the contrary, the savings in office building, which reach the highest absolute savings, average at 991 MWh/year. Thus, the decisive determinant here is the number of Partner buildings, unlike e.g. at commercial centres, where the decisive factor is the size of the centres.

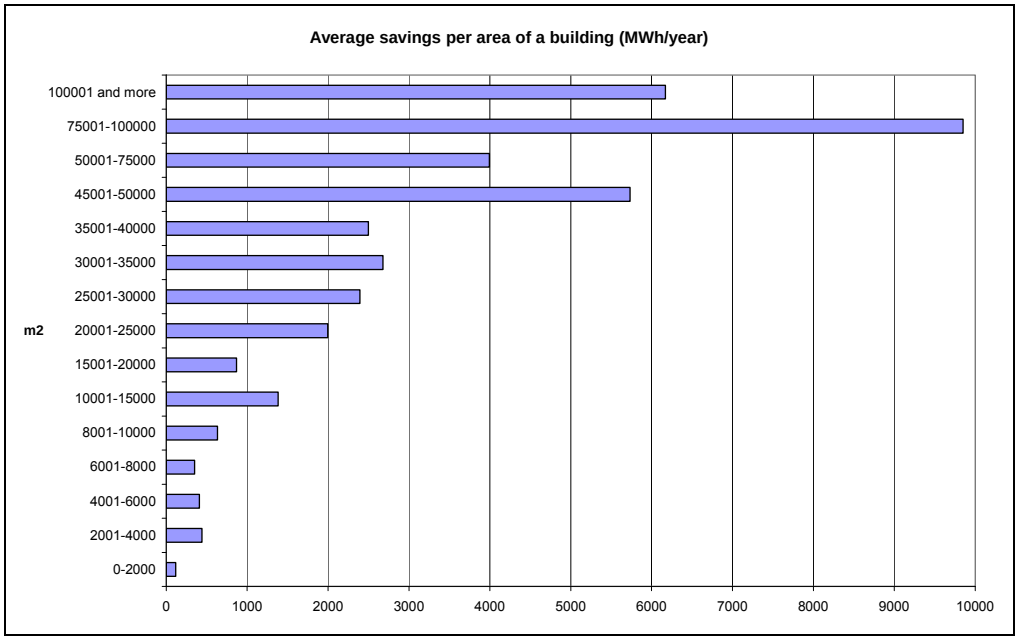
Table 3 Average savings per building use (MWh/year)

Type of building	Average savings (MWh/year)
airport	3760
commercial centre	2581
education	745
healthcare	2556
hotel	2225
industry	1687
leisure	1380
office	979
other	1123
public administration	2441
retail	348
n/a	540
Total average	**1801**

Note: n/a means that the type of the building was not clearly specified, but still savings were reported.

The relationship between the area of the Partner buildings and the reported absolute savings is illustrated in the following Figure (Figure 9). With little surprise, the average absolute savings increase with the total area of the Partner building.

Figure 9 Total savings per m2



When tested statistically, there has been found a statistically significant (positive) relationship between the two variables (area of a building and absolute yearly savings) on a 99 % confidence level. A linear trend could be used to fit the model (or better square root-Y model), which explains 39 % (and 43 %) of the values. The relationship can be described as moderately strong (with correlation coefficient of 0.63 for linear trend and 0.66 for square root-Y).

Figure 10 Regression analysis: linear and square-root y model

Regression Analysis - Linear model: Y = a + b*X

Dependent variable: savings
Independent variable: m2

Parameter	Estimate	Standard Error	T Statistic	P-Value
Intercept	223,847	150,771	1,48469	0,1391
Slope	0,066058	0,00560725	11,7808	0,0000

Analysis of Variance

Source	Sum of Squares	Df	Mean Square	F-Ratio	P-Value
Model	4,82893E8	1	4,82893E8	138,79	0,0000
Residual	7,51541E8	216	3,47936E6		
Total (Corr.)	1,23443E9	217			

Correlation Coefficient = 0,625448
R-squared = 39,1186 percent
R-squared (adjusted for d.f.) = 38,8367 percent
Standard Error of Est. = 1865,3
Mean absolute error = 835,525
Durbin-Watson statistic = 1,90431 (P=0,2406)
Lag 1 residual autocorrelation = 0,0472011

Regression Analysis - Square root-Y model: Y = (a + b*X)^2

Dependent variable: savings
Independent variable: m2

Parameter	Estimate	Standard Error	T Statistic	P-Value
Intercept	17,5119	1,32983	13,1685	0,0000
Slope	0,00063535	0,0000494571	12,8465	0,0000

Analysis of Variance

Source	Sum of Squares	Df	Mean Square	F-Ratio	P-Value
Model	44671,0	1	44671,0	165,03	0,0000
Residual	58467,0	216	270,68		
Total (Corr.)	103138,0	217			

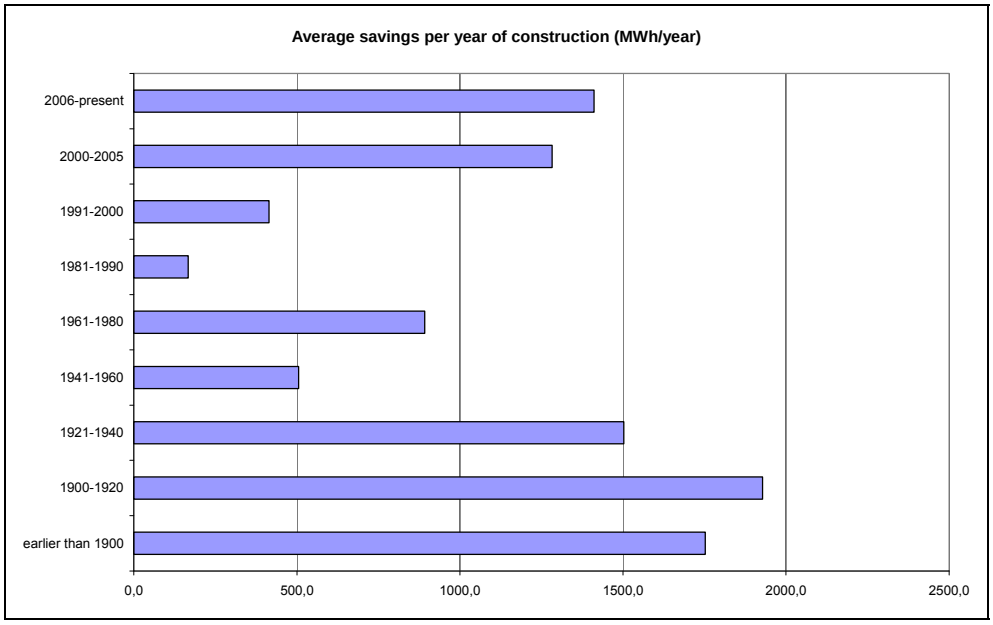
Correlation Coefficient = 0,658118
R-squared = 43,3119 percent
R-squared (adjusted for d.f.) = 43,0494 percent
Standard Error of Est. = 16,4524
Mean absolute error = 11,1784
Durbin-Watson statistic = 1,6674 (P=0,0069)
Lag 1 residual autocorrelation = 0,165116

Source: Authors' own analysis using Statgraphics SW.

Similarly to the previous case, one could assume that the elder the building, the higher potential for savings in such buildings. Nevertheless, from the GreenBuilding Programme buildings data, such relationship has not been proven (Figure 11). On the contrary, when

tested, there seemed to be no statistically significant relationship between the variables savings and year of construction at the 90 % or higher confidence level. Evidently, the absolute savings depend much more on the building area than on the year of construction.

Figure 11 Total savings according to year of construction



3.2.2. Relative savings

One of the requirements for organizations to become a GreenBuilding Partner is to achieve primary energy savings of at least 25 % (for new buildings the requirement is pertaining to building code or conventional buildings). Therefore, there should not be any building reaching less than 25 % savings[12]. In practice, there were five buildings out of 286 that have not achieved the 25 % savings. The reasons for this are diverse.

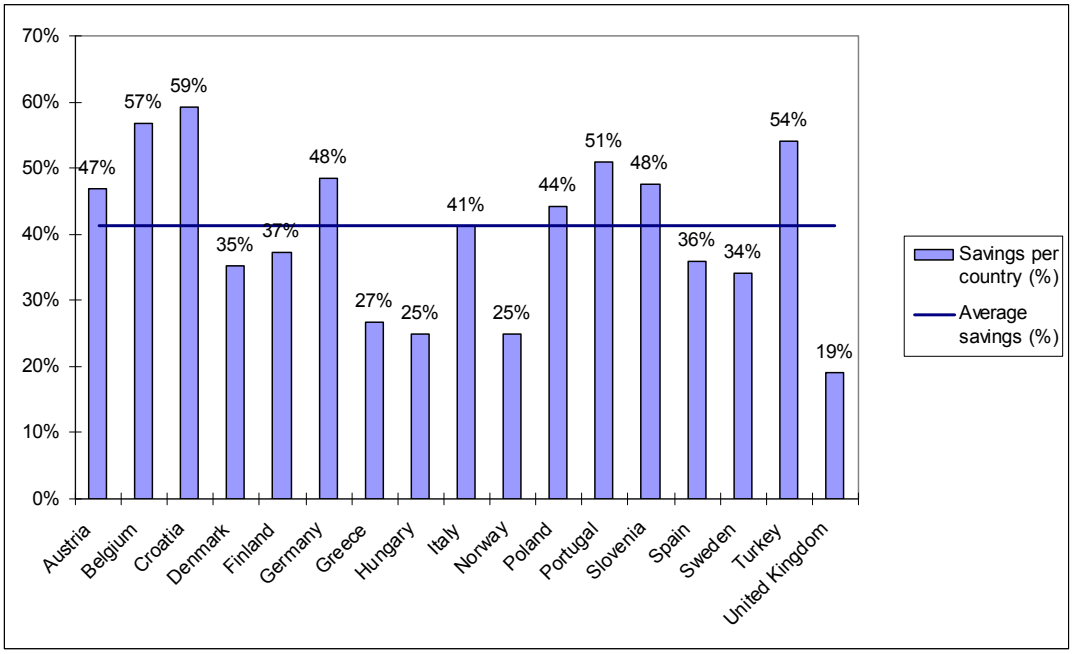
For example, there is one building which actually reaches only 19 % of savings. However, the energy consumption goes 30 % below the respective regulation in force. Therefore the building was still accepted as GreenBuilding Partner. Similarly, another Partner got below the legal requirements by 21 %. However, there are photovoltaic and solar systems installed in the building, together with tri-generation plants, which can produce 160 % of primary energy demand of the building. In other case, one of the hotels achieved 21 % of total energy savings, but only measures in lighting brought savings of 67 % and the hotel, due to various economic reasons, only implemented measures with pay back time lower than 4 years.

For 15 Partner buildings, no clear information on % savings has been provided, or it could not be calculated from the reported savings. From the total 271 Partner buildings, who reported the percentage savings, more than two thirds (179) achieved more than 30 %. The average achieved savings are **41.2 %**, the median is 36.5 %.

As to countries, the average percentage savings range from 59 % (Croatia) to 25 % (Norway and Hungary) and 19 % in the United Kingdom. In some cases, the average savings mean the savings of the one Partner from that country (such as in case of Norway, Turkey or United Kingdom) or the average of two partners (Finland and Hungary).

[12] There is a certain space for flexibility if the 25% requirement cannot be achieved e.g. because of historical building constraints or from operational reasons.

Figure 12 Percentage savings per country



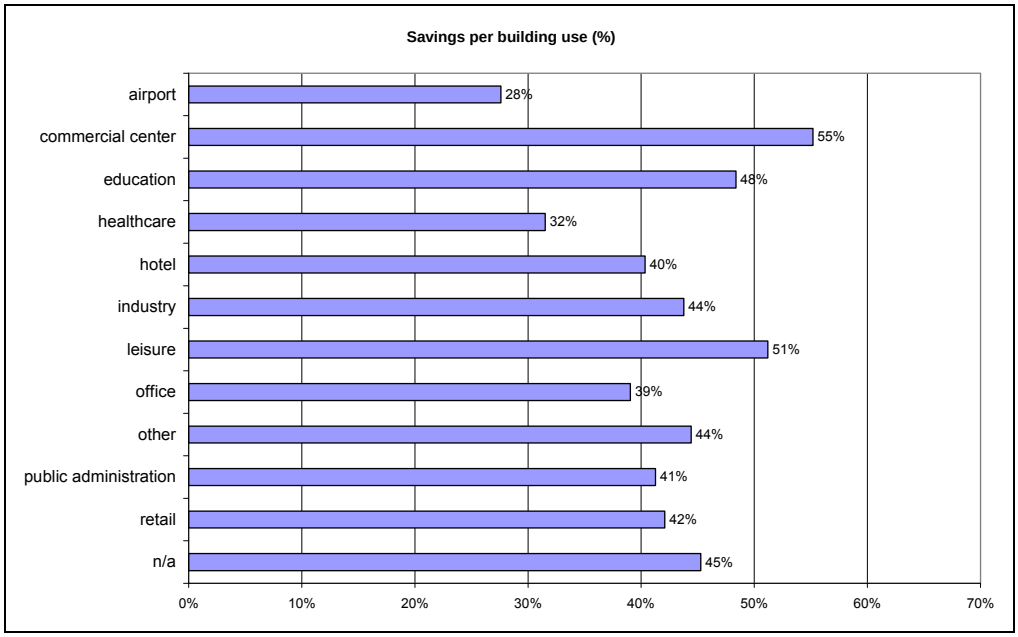
The maximum achieved savings on the individual basis were more than 97 % (97.6 %) through use of district heating, efficient lighting and thermal insulation in the building[13]. There are other five buildings in which primary energy savings of more than 80 % have been achieved. In all cases, the measures included building envelope and heating systems; in four cases the efficient lighting was installed.

Interestingly, there is one building from before 1900, which have reached high percentage savings. The former canteen and office building of an abattoir was reconstructed to a nursery house with offices. Despite the fact that the area of the building increased, the primary energy savings reached more than 80 %. The main measures included building envelope, heating and hot water preparation (including floor heating, temperature regulation or installation of water saving sanitary equipment or efficient gas condensing boiler). The important message is that the resulting primary energy consumption goes even beyond the current building requirements, thus showing that low energy standard is viable even for historical buildings.

When looking at relative savings per building use, the distribution of % savings is relatively similar to the one according to country. The average percentage savings range from 55 % in commercial centre and leisure facilities (51 %) to 28 % at the airport (Figure 13Figure 13 Percentage savings per building use). The relative savings in offices, the most important building use as to total savings and total number of buildings, averages at 39 %.

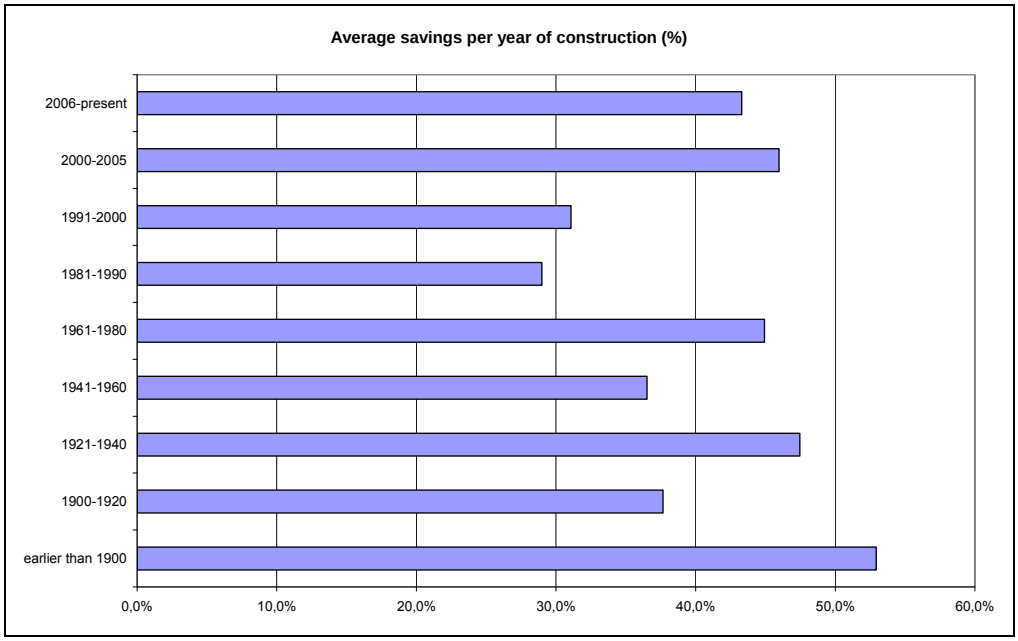
[13] It is a new building thus the savings mean comparison to respective legal requirements.

Figure 13 Percentage savings per building use



It was not that surprising that the absolute level of savings does not correlate with the year of construction. However, it is probably more surprising that neither does the relative level of savings (Figure 14). The Figure serves just to give an idea of the level of percentage savings in different years of construction of the buildings. Nevertheless it is apparent that it is hard to find a pattern between the age of the building and the achieved relative savings.

Figure 14 Percentage savings per year of construction



Testing the two variables, there has been found no statistically relevant relationship between the variable year of construction and percentage share of savings in the 90 % confidence level or higher (Figure 15).

Figure 15 Regression analysis: year of construction vs % savings

Regression Analysis - Linear model: Y = a + b*X

Dependent variable: savings
Independent variable: year

Parameter	Estimate	Standard Error	T Statistic	P-Value
Intercept	2411,84	7169,67	0,336395	0,7369
Slope	-0,655503	3,61813	-0,181172	0,8564

Analysis of Variance

Source	Sum of Squares	Df	Mean Square	F-Ratio	P-Value
Model	167992,0	1	167992,0	0,03	0,8564
Residual	1,09015E9	213	5,11807E6		
Total (Corr.)	1,09032E9	214			

Correlation Coefficient = -0,0124127
R-squared = 0,0154076 percent
R-squared (adjusted for d.f.) = -0,454004 percent
Standard Error of Est. = 2262,32
Mean absolute error = 1146,12
Durbin-Watson statistic = 1,87792 (P=0,1860)
Lag 1 residual autocorrelation = 0,0605838

Source: Authors' own analysis using Stagraphics SW.

Therefore, one cannot say that the older the building, the higher the potential for savings. In historical buildings, the reason may be the restrictions as to cultural preservation of these buildings. Nevertheless, the correlation could not be found even for the buildings from the 20th century.

3.3. Specific energy demand in office buildings

One of the most important indicators of efficiency with respect to buildings is the primary energy demand per m2 and year (kWh/m2.y). In the same time, both building regulations for new buildings and the demand as such largely depend on the building use and climate. Therefore, here only one building use is analyzed – office buildings, which is the most frequent building use in the GreenBuilding Programme and thus offers the largest sample for analysis.

In total the sample consists of 167 office buildings. From this, there are 100 existing buildings and 67 new buildings. The following analysis is divided according to this characteristic.

It is important to keep in mind, that the analysed values (demand before and after refurbishment, the reference building standards) do not represent the values in the respective countries, but are a result of the sample of buildings in the Programme.

3.3.1. Existing buildings

The average primary energy demand per m2 before the refurbishment of existing office buildings in the sample was 150 kWh/m2.y. The lowest value was only 34 kWh/m2.y. The maximum demand before refurbishment reached 558.4 kWh/m2.y.

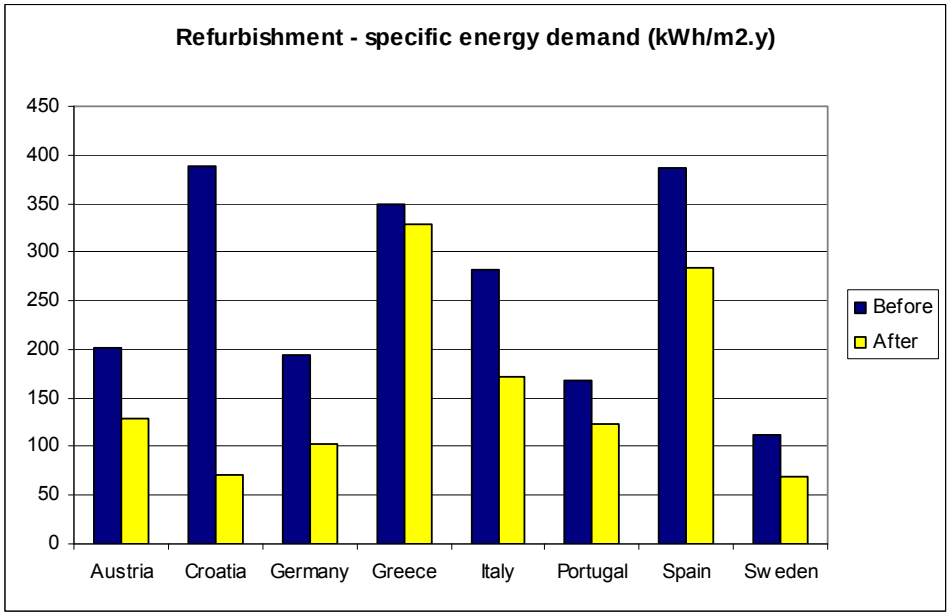
The refurbished buildings reduced the specific primary energy demand on average to 87.2 kWh/m2.y. The highest specific primary energy demand after refurbishment was 328.6 kWh/m2.y, whereas the minimum value reached only 11.1 kWh/m2.y, thus basically getting to the passive house standard.

Therefore, on average, the energy efficiency measures brought a decrease of the specific consumption of 58 kWh/m2.y. The highest absolute difference between the specific primary energy demand before and after refurbishment was 496.4 kWh/m2.y (from 558 to 62 kWh/m2.y), the lowest absolute difference reached 11.9 kWh/m2.y (from 45.5 to 33.6, which however means savings of 26 %).

Figure 16 depicts the energy demand before and after refurbishment in the Partner countries. The specific energy consumption at existing office buildings seems on average the lowest in Sweden – ca 100 kWh/m2.y. Conversely, the highest consumption of conventional buildings is observed in Spain, Croatia, Greece or Italy (over 250 kWh/m2.y), thus also offering the highest potential for savings. This potential is clearly shown in case of Croatia, where the average energy consumption after refurbishment decreased more than 5 times (from 390 kWh/m2.y to 70 kWh/m2.y).

On the other hand the existing office buildings in Sweden already tend to have a relatively lower specific energy demand (average of 111 kWh/m2.y). Nevertheless, the average difference between the values before and after refurbishment are 40 kWh/m2.y, i.e. still 36 % of the original primary energy demand.

Figure 16 Primary energy demand before and after refurbishment



There does not seem to be any significant relationship between the year of construction of the buildings and the baseline specific energy demand (kWh/m2.y) in the existing buildings. The reason may be the various geographical and other features of the buildings, which render the relationship statistically insignificant (despite the common denominator of building use).

The relative savings of existing, refurbished office buildings average at 36.8 %, which is less than the overall average (41.2 %). The savings range between 19 % and 88 %[14].

3.3.2. New buildings

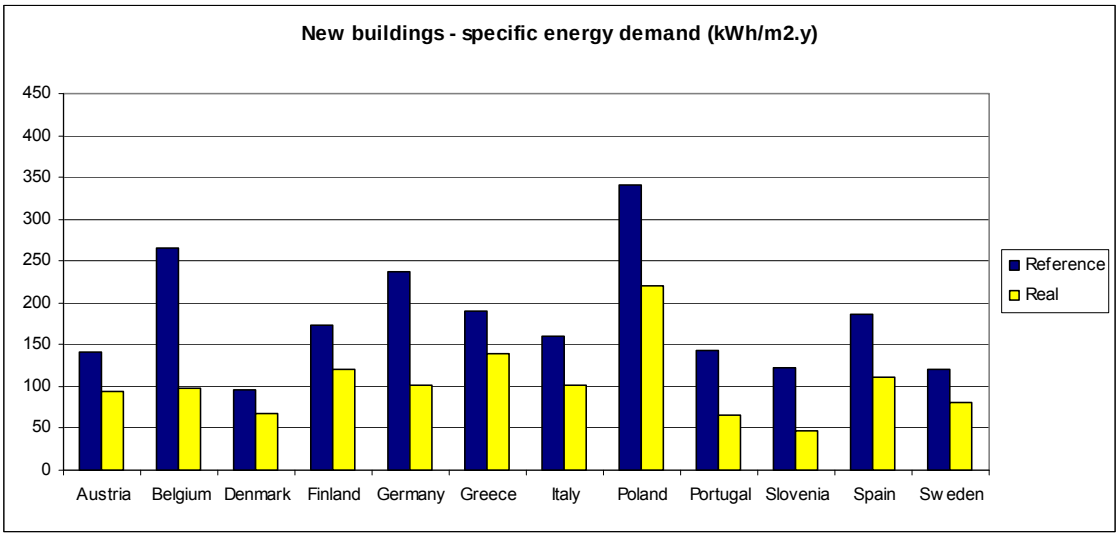
Figure 17 depicts the increased efficiency of newly constructed office buildings in the GreenBuilding Programme. The reference values of the new buildings basically mean the building standards in force in the respective year to which the primary energy demand of the newly constructed buildings is compared to, or it can be the levels of consumption in reference "conventional" newly constructed buildings in the country.

Even though the values to which the buildings are compared to are not a representative sample of the current legal requirements in the country, some patterns can be observed. One of the toughest requirements for (GBP Partner) buildings could be observed in Denmark, Slovenia and Sweden. In Denmark the average primary energy consumption, to which the newly built buildings relate to, is lower than 100 kWh/m2.y (95.6); however, there was only one building in the sample. The average reference requirements in Slovenia are 122 kWh/m2.y and 120 kWh/m2.y in Sweden.

In Germany, the results are biased by one building, where the legal requirements would be more than 980 kWh/m2.y (a test centre for transformers, which was nevertheless declared as office building by the Partner). If this value is removed, then the average requirements of the Partner buildings go down to 190 kWh/m2.y. Two buildings related the consumption to m3 instead of m2. The legal requirements are 14.7 kWh/m3.y and 12.8 KWh/m3.y.

[14] The 19 % is less than the required 25 %, but as described above, the value was in the same time 30 % below the regulation in force.

Figure 17 Primary energy demand of newly constructed buildings and related reference values



The average specific primary energy consumption to which the new buildings are compared to is 184 kWh/m2.y. The highest reference value reached 984.3 KWh/m2.y and the lowest was a legal requirement for passive houses: 21.6 KWh/m2.y.

The maximum absolute difference reached between the legal requirement and the real energy demand of the building was 961 kWh/m2.y (the already previously mentioned Test center fro transformers). When disregarding this a little uncommon case, the highest absolute difference is 226 kWh/m2.y (40 kWh/m2.y instead of 266 kWh/m2.y, which is the reference national standard).

On average, the new buildings consume 87 kWh/m2.y less than are the respective national standards (71 kWh/m2.y if disregarding the remote value of the Test centre).The smallest achieved difference is only 10.7 kWh/m2.y. However, this relates to the passive house. Therefore the ca 11 kWh/m2.y mean a 50% lower consumption even compared to the tough passive house standards.

The relative savings in new office buildings average at 42.6 % percent, thus slightly exceed the overall average (41.2 %). The savings range between 21 % and 97 %[15].

[15] The 21 % is less than the required 25 %, but as described above, the demand is more than covered by the own production from RES.

3.4. Energy efficiency measures

The energy efficiency measures are what makes the energy efficiency improvement (or energy savings) possible. From the total of 286 Partner Buildings the measures that were implemented have been described at 227 of them (79 %).

The measures have been categorized into 8 main groups: building envelope, heating, ventilation/air-conditioning/cooling, summer heat protection, lighting, control systems, renewable energy sources and other. The category “Other”, incorporates different sorts of measures from water saving systems (rain water use) through procurement of efficient (IT) appliances, optimization of use hours to soft measures such as staff education.

The Partners implement 3.5 measures per building on average. The relation between number of measures and relative savings (%) is shown in Figure 18. The numbers on top of the columns represent the number of buildings in which the respective number of measures was implemented. Therefore, it can be seen that, respecting the average number of measures, in most buildings 3 to 4 measures have been realized. There is a statistically significant relationship between the variable number of saving measures and percentage savings (on a 99 % confidence interval). However, the relationship is very weak and the fitted models only explain 10 % of the variability.

Therefore, it can be concluded that based on the sample, no real correlation between the number of measures and the percentage savings has been found. It seems that other determinants (such as character of the buildings and of the region, quality of the measures) will be decisive.

Figure 18 Average savings (%) per number of implemented measures in the Partner buildings

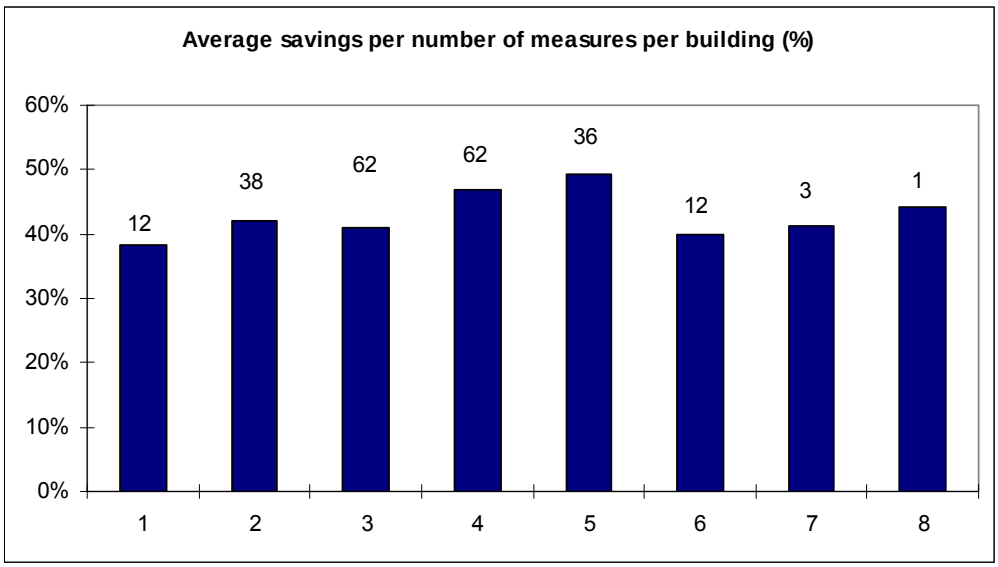
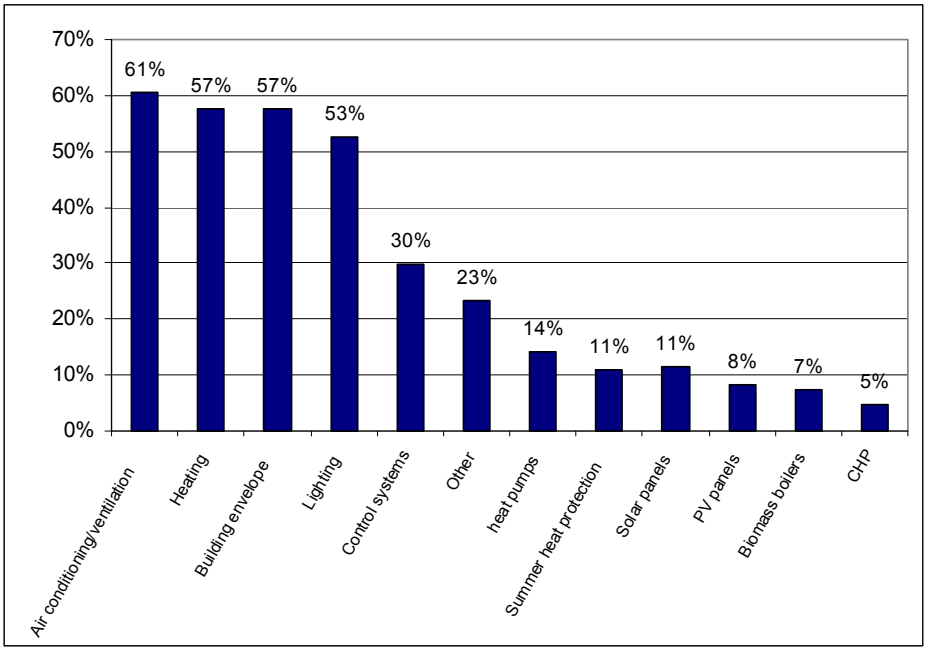


Figure 18, also implies that the highest average savings are achieved when four to five measures are implemented (47.3 % and 49.9 % respectively). The typical measures are heating, air conditioning and ventilation, building envelope and lighting, following the distribution of measures in the subsequent Figure.

Figure 19 depicts the main measures according to their proportional representation in the projects. The graph is divided into the 8 main categories of measures as mentioned above. Additionally, some of the groups have been divided into subcategories, to give a better picture of the implemented measures. This way, specifically heat pumps, CHP and biomass

boilers are presented separately from heating (and renewable sources). Solar panels and photovoltaic installations are also depicted independently. Furthermore, summer heat protection stands separately from building envelope.

Figure 19 Measures in buildings (%)



About 52 % of energy consumption in tertiary buildings goes to space heating[16]. Heating systems (together with building envelope) offer a significant potential for savings. Therefore the most often, the GreenBuilding Partners chose heating as their main target for efficiency measures. In Figure 19, the measures under "Heating", which are present in 57 % of buildings, only entail reconstruction or dealing with the distribution systems within the building, use of district heating and/or conversion from one fuel type to another (not to biomass, but usually from oil to natural gas).

Additionally, depicted separately in the Figure, heat pumps have been installed in 14 % of the Partner buildings. Where specified, those were unanimously geothermal heat pumps. In 7 % of the Partner Buildings, fossil fuel boilers have been replaced by biomass boilers. In one case the boiler burns biogas.

The Combined Heat and Power generation (CHP) was used in 5 % of the buildings (some buildings are also connected to district heating from CHP: see next paragraph). All these "heating" measures added together, heating systems have been upgraded or dealt with in 85 % of the Partner buildings.

A very frequent measure is connection to district heating systems, as countries, in which these systems are commonly utilized, are highly represented among the GreenBuilding Partners (Germany and Sweden). 8 Partner buildings (from Germany and Austria) have connected the buildings to district heating from either renewable energy sources (biomass) or from cogeneration units (CHP). In one building, heat and power from a tri-generation plant is used. Together with solar and PV panels, the building produces 160 % of the energy it consumes. Importantly, the opposite way, none of the Partners reported to have disconnected the building from district heating system.

[16] http://re.jrc.ec.europa.eu/energyefficiency/greenbuilding/pdf%20greenbuilding/GB_WP2_HEATINGModule_V2_BE.pdf (accessed February 2010)

More than 60 % of the Partner Buildings (61 %) have focused on ventilation/air conditioning and cooling systems. The measures mostly included heat recovery (from 75 % up to more than 90 %), replacement and proper dimensioning of pumps and fans (frequency transformers), resizing of the ducts or the overall system optimization (zone regulation, optimization of operation time, reduction of flow rates).

The building envelope represents further significant potential for savings. The Partners have included it in the main measures in 57 % of the cases. Yet, the scope of the improvements in the envelope systems differs to large extent. It ranges from a total insulation of the building, including the whole building envelope (roof, facade, ground and windows), to only featuring some parts of the envelope (such as better glazing or low u-values of the facade). Specifically, some buildings are equipped with summer heat protection (11 %), which basically means external shading devices, to protect the building from excessive summer heat gains. The shading devices tend to be movable, electronically controlled and automated. There were several cases, in which the vegetation was used as a natural shading and air temperature reducing instrument.

Lighting usually does not represent a high portion of energy costs in the companies' budgets and thus may be regarded as "not worth" dealing with. However, lighting also represents one of the most easily achievable energy efficiency improvements with usually very short payback times. This is why more than half of the Partners (53 %) have included lighting upgrading among the efficiency measures. The measures mostly include use of more efficient lighting (compact fluorescent lamps, efficient fluorescent tubes, electronic ballasts, LED lights). New lighting systems in the Partner buildings are also often managed through motion/occupancy detectors, daylight sensors or through localized lighting.

The Partner buildings are often using building energy management and control systems (30 % of the cases). The systems (the term often used is Building Energy Management System, BEMS) control and monitor all the buildings' (above mentioned) equipment, such as HVAC or lighting[17]. The control systems also help in monitoring and evaluation of the energy consumption of the buildings, which provides a basis for energy savings.

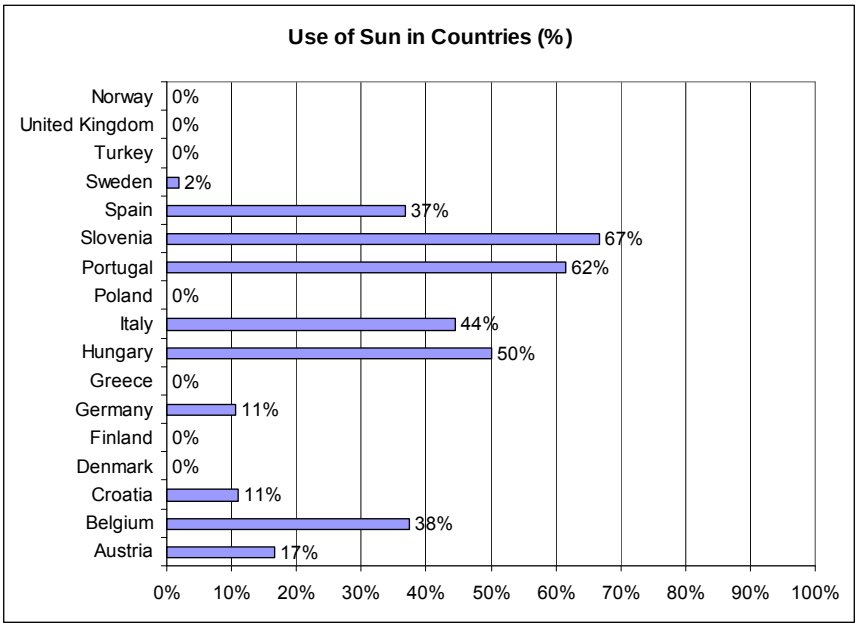
Other measures (23 %) included water saving systems, activities to raise staff awareness or energy efficiency appliances (mostly IT). The water saving system was often used in leisure centers or hotels, which include spa and swimming pools, but also in hospitals, where the use of sanitary hot water is high. The systems include use of rain water, hot water recovery system or low flow taps.

The use of sun is relatively frequent in the Partner buildings[18]. One fifth of the buildings have installed a photovoltaic system or solar panels (8 % and 11 % respectively). The installed powers of the PV systems differ a lot. They range from small systems of 4 to 5 kWp to tens of kWp. There is one photovoltaic power plant with 1 MW installed capacity. Roughly, the total installed capacity in GBP buildings amounts to 1400 kWp. The area of the solar panels ranges from 5 m2 up to 300 m2.

The effectiveness of solar systems largely depends on climatic conditions. It is therefore not that surprising that mostly (even though there are exceptions) the solar and PV systems have been used in southern countries, rather than northern (Figure 20). Most frequently (expressed as % of the Partner buildings in the country) the PV or solar systems were used in Slovenia, Portugal and Italy (67 %, 62 % and 44 % respectively). There is also Hungary (not a typical representative of a southern country) with 50 %. Nevertheless, the high percentage in this case is pertains to the total number of buildings (2). The solar and PV systems are much less present in Austria, Germany or Sweden (17 %, 11 % and 2 % respectively).

[17] The building management system can be further used to control security or fire systems
[18] One building uses wind power for their electricity demand.

Figure 20 Use of PV and solar panels per country



On the contrary, none such clear pattern could be observed as to building envelope. In other words, the insulation and better glazing are implemented disregarded from the geographical region. The only difference may be in the characteristic of the measures, for instance focus on windows in southern countries versus focus on the façade and roof insulation in the northern countries.

3.5. Economic aspects of selected projects

Economic effectiveness of the projects is one of the prerequisites to become a GreenBuilding Partner. Only few partners have reported on this feature. The economic aspects of the GreenBuilding Programme buildings could therefore be evaluated only to a limited extent. Furthermore, since there is no common format to report on the economic features, the economic indicators that the Partners reported on varied. They were mainly the pay back time, Net Present Value (NPV), Internal Rate of Return (IRR), cost of the investment or the yearly cost savings.

There were 26 partners who reported the investment costs[19]. In case of new buildings, only additional costs for the energy efficient measures were included. On average, the cost of 1 kWh/year saved was 0.21 EUR[20], or the opposite way, on average 131 MWh/year were saved for 1 EUR of (additional) investment. The latter result is however skewed by one Partner building, at which the savings were achieved at zero costs. If this one case was disregarded, then 1 EUR of investment would correspond to 33 kWh/year.

In the one case, in which the efficiency measures in the building were carried out at no cost, a total of 3 411 MWh/year (29.9 %) was saved just through the optimization of the HVAC system as to time and use.

[19] Plus there was one partner who reported costs, but the overall savings were not available.
[20] Annualizing the investment costs and assuming the discount rate of 4 % and lifetime of the measures of 10 years.

In 23 cases, the yearly monetary savings were provided. The average financial savings reach 84 837 EUR/year. The relationship between energy savings and financial savings is that 1 MWh saved corresponds to 97 EUR of yearly financial savings in the sample.

22 Partners have reported on both the cost of investment and yearly cost savings. The main conclusions from their reporting are shown in Table 4.

Table 4 Economic aspects of the GreenBuilding Partner buildings (averages)

Cost of investment (EUR)	Financial savings (EUR/year)	Payback time (years)	Savings (MWh/year)
683 744	84 837	8.8	1334

When looking at the payback times of the investments, the numbers vary greatly. The average simple payback time is 8.8 years[21]. There are several extreme values in the sample (e.g. payback period of several tens of years). Therefore, median, which is 6.3 years, probably better describes the mean value. There are 7 buildings at which the payback time varies around 1 to 4 years. Some Partners set this even as a requirement for the energy efficiency measures (to have a payback time of less than 4 or 3 years) and adapted the measures to it (implementing less costly measures with short payback time such as e.g. lighting).

The analysis did not show, whether the Partners used some of the international or national subsidy programmes[22]. In case of a financial subsidy the Partners may be more likely to undergo investments with (otherwise) higher payback times.

The requirement to join the GreenBuilding Programme is that the economic efficiency should be ensured (the savings should not be implemented "at any cost"). The economic viability is defined wither through Internal Rate of Return (IRR)[23] or through Net Present Value (NPV) [24]. Either the IRR should be of 20 % calculated over a period of 15 years or alternatively the least Life Cycle Cost rule over the project's lifetime (minimum 5 years). For a stream of equal cash flows, an IRR of 20 % over a 15-year period corresponds to a payback time of 4.7 years. The least Life Cycle Cost rule consists in accepting an energy-efficient investment when the resulting Net Present Value (NPV) of the investment is above or equal to 0.

Only five Partners have reported values of those criteria. The IRR ranged from 9 % to 20 % and the NPV from 6 800 EUR to 330 000 EUR. For other investments, it may be assumed that the levels of NPV or IRR correspond to the GreenBuilding Partnership criteria.

[21] There was one building at which the simple playback period exceeded 100 years. However, there may have been a mistake in the recordings. This extreme value was disregarded for the calculation of the average.
[22] Question on subsidy programmes was included in the questionnaire, distributed among all the Partners. However, only a fraction of them replied to this question – as analyzed in the next section.
[23] "The Internal Rate of Return is the interest rate that equates the present value of expected future cash flows to the initial cost of the project. Expressed as a percentage, IRR can be easily compared with loan rates to determine an investment's profitability".
[24] The Net Present Value is the total cash flow that the project generates over its lifetime, including first costs (counted negatively), with discounting applied to cash flows that occur in the future (money savings, counted positively).

3.6. Summary

Within the four year operation of the GreenBuilding Programme, total of 167 Partners have joined with 286 Partner buildings. The total savings achieved by the Partners are 304 GWh/year. In 2020, the savings will have accumulated to almost 3.3 TWh. On an individual basis, the maximum savings per one project were 11.8 GWh/year (4% of the overall savings).

The office buildings are the most represented building use among the Partner buildings and therefore also represent almost half of the total savings (144 GWh/year). Among countries, the highest savings so far have been achieved in Germany and in Sweden, together representing more than half of the savings (174 GWh/year). There is a quite strong relationship between the total area of the buildings and the absolute savings. Clearly, the bigger the building, the higher the total savings.

The average percentage savings amount to 41 %, which is well above the GreenBuilding Programme requirements (25 %). The percentage savings (statistically) depend neither on the year of construction of the buildings, nor on the number of measures. The building use was not determining either. The highest average relative savings have been achieved in commercial and leisure centres (55 %), the lowest in healthcare facilities (32 %)[25].

The office buildings have been assessed as to their specific energy demand (in kWh/m2.y). In the refurbished buildings the average decrease of the specific primary energy demand was 58 kWh/m^2.y. In new office buildings, the average specific savings were a little higher (71 kWh/m^2.y).

In most of the buildings, to achieve the above savings, more than one energy efficiency measure has been implemented. Most often, it was a combination of three to four measures. Most frequently, those entailed heating (85 % of the buildings), air conditioning and ventilation (61 %), building envelope (57 %) and lighting (53 %). The reasons for implementing more measures at once are the economic effectiveness, but also design needs. If not done at once, it may leave some of the measures unimplemented as there will not be a sufficient potential for savings. Also, it is clear that it is ineffective to e.g. change a heating system and only subsequently deal with the building envelope and heating losses.

The economic effectiveness is a prerequisite for joining the GreenBuilding Programme. Therefore, the Partners have rarely reported on the economic features of their projects and all of the projects are supposed (and assumed) to be economically viable.

[25] And at the airport (28 %), but only one Partner building represents this building use.

4. GreenBuilding Partners Motivations and Experiences with the Programme

4.1. Introduction

In the years 2008 and 2009, the Joint Research Centre carried out two sets of surveys among the GreenBuilding Partners. The main aim of the surveys was to obtain information on the Partners' motivations and experience with the GreenBuilding Programme so far and with their energy efficiency projects. Therefore, the questions related to two main areas:

- **Implementation of efficiency measures** – experience with the preparation, realization and monitoring and verification of the measures (Questions 1 – 12, c.)
- Experience with the **GreenBuilding programme** itself – main motivations to join, promotion of the programme and overall satisfaction (Questions 1, 13 - 16), certification of buildings other than the GBP (Questions a. and b.)

The population of the surveyed sample represents ca 30% of the total number of Partners (not Buildings). Therefore, a quantitative analysis has been used, but with a strong focus on qualitative analysis.

4.2. Data input

The questionnaire was distributed among all Partners in two phases. First set of questionnaires was distributed in winter 2008, while the first interim report of the GreenBuilding programme was prepared. The second phase of the survey was carried out in winter 2009/2010, to cover the whole four year period that the GreenBuilding Programme is in place.

The two questionnaires were not totally identical[26]. They both included 10 questions, which aimed at retrieving the Partners perceptions and observations on:

- their main motivations and/or obstacles with respect to efficiency measures – Question 1, 2
- implementation of the efficiency measures (financing) – Question 4, 7, 8
- the experience with the efficiency measures and the follow up (monitoring and verification) – Question 5, 6, 12
- overall satisfaction with the GreenBuilding Programme – Question 15, 16

The second questionnaire was updated to total of 19 questions, adding enquiries on Partners experience and perception of:

- the cost of investment and verification of savings – Question 5 (second part), 9, 10
- the main benefits (or drawbacks) of the energy efficiency measures and further commitment to efficiency projects – Question 3, c
- marketing of the energy efficiency improvements and marketing of the GreenBuilding Programme Partnership – Question 11, 13, 14

[26] See Questionnaire in the Annex.

- certification of the Partner buildings – Question a, b

All Partners have received the second questionnaire. However, in order to facilitate the response for the Partners who have already replied to the first one, those Partners were only asked to fill out the 9 additional questions.

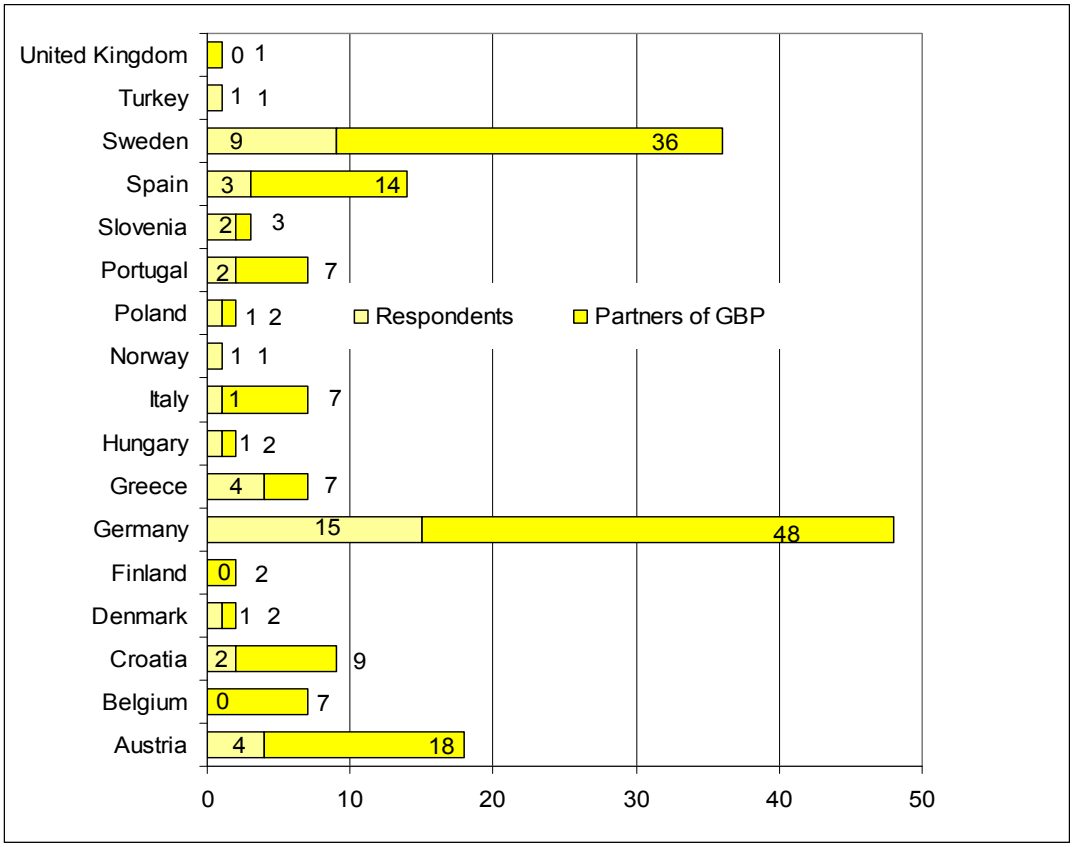
The overview of the distribution of the response rate is shown in Table 5. Total of 27 Partners have responded to the questionnaire in 2008. The response level was 40 % compared to the number of Partners at the time of sending out the questionnaire (67). In 2009/2010 the questionnaire was sent out to all 167 Partners and 30 questionnaires were collected. There was duplication in 10 cases meaning that 10 Partners have replied to both questionnaires. The response level was clearly lower in the second time. This may have been caused by the time of sending out the second questionnaire (in the time of economic and financial crisis, before Christmas, etc). Also, some Partners may have not responded as they have done so already in 2008. These are however only assumptions, no further enquiries were made in this sense.

Table 5 General response to the questionnaire

Partners	**167**
Questionnaires received in 2008	27
Questionnaires received in 2009/2010	30
Duplicated questionnaires	10
Total questionnaires	**47**

In total, 47 questionnaires have been received for both periods, which gives an overall response rate of 28 %. The responses came from 14 countries out of the total 17 (Figure 21). In most cases, the geographical distribution of the questionnaire responses is similar to the distribution of Partners across the countries participating in the Green Building Programme countries. Greece, Norway, Slovenia and Turkey have higher representation in the survey than in the Programme (Greece 8.5 % instead of 4 %, Norway 2 % instead of 0.6 %, Slovenia 4 % instead of 1.8 % and Turkey 2 % instead of 0.6 %). In Norway and Turkey, both the Partners replied to the questionnaire, thus making the reply rate 100 %. In Slovenia and Greece, more than 50 % of Partners filled in the questionnaire (66 % and 57 % respectively). Conversely, there was zero response from Belgium. Therefore, the representation in the programme is 4 %, whereas in the survey it is 0 %.

Figure 21 Distribution of countries in the survey



Note: The total number of received questionnaires was 47. Total number of Partners in the assessed period was 167. The light yellow colour indicates the number of received responses; the dark yellow indicates the total number of Partners in the country.

The ratio between the new and existing (refurbished) buildings in the survey and in the whole GreenBuilding Programme corresponds (Table 6). In the survey, there were 40 % new buildings in the population sample and 60 % refurbishments, whereas in the Programme, the ratio is 44 % and 56 % respectively, from the total number of buildings.

The pattern is less observed when it comes to the structuring to private and public buildings (Table 7). Three quarters of the buildings in the GreenBuilding Programme are private and ca one quarter are public buildings; whereas the ratio in the survey was two thirds and one third respectively.

Table 6 New and refurbished buildings in the survey and in the Programme

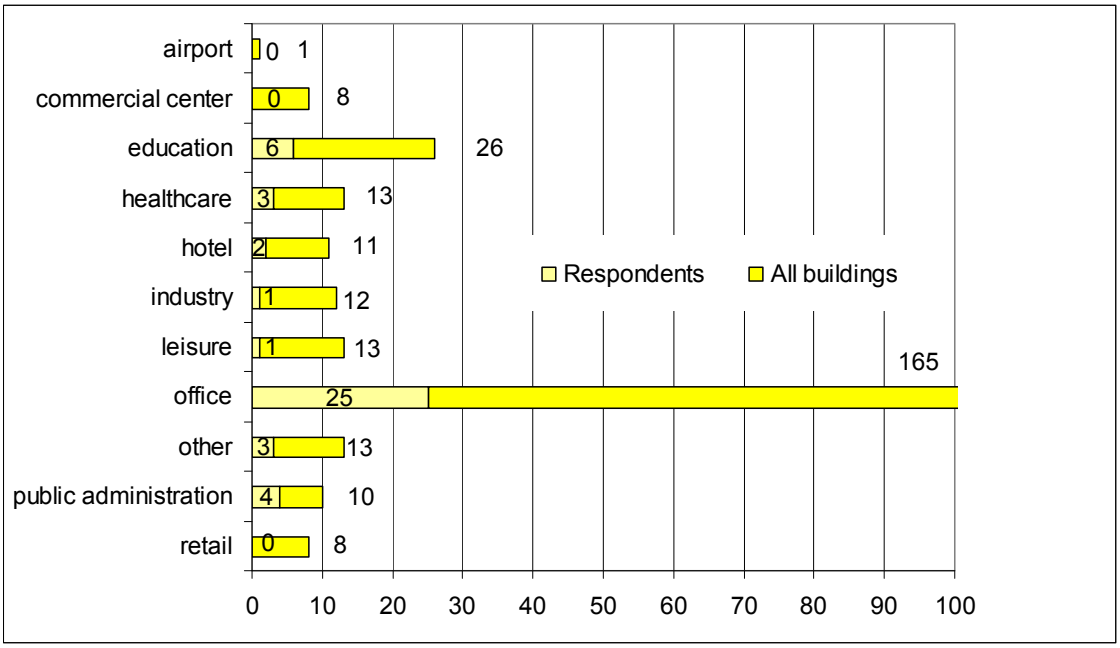
	Respondents	All Buildings
New	40.0%	44.4%
Refurbishment	60.0%	55.6%

Table 7 Public and private organizations in the survey and in the Programme

	Respondents	All Buildings
Private	68%	77%
Public	32%	23%

The responses represent most of the building uses as well (Figure 22). With a few exceptions the survey responses follow the structure of the whole sample of all the GreenBuilding buildings as to building use. The most important building use – the offices – represented by 58 % in the whole Programme and by 56 % in the survey. There were however no answers from any retail stores or commercial centres, which both have a 3 % share in the Programme. On the other hand public administration or education facilities are overrepresented in the survey (9 % compared to 3 % in the Programme and 13 % compared to 9 % respectively). The reason may have been that the public organizations (under which the education facilities also mostly fall) tend to be more responsive to such kind of enquiries, compared to private organizations (this pattern can also be observed from Table 1Table 7).

Figure 22 Distribution of building uses in the survey



Note: The total number of received questionnaires was 47. Total number of buildings in the assessed period was 286 (and for 6 buildings the use was not clear). The light yellow colour indicates the number of received responses, the dark yellow indicates the total number of buildings per building use.

The percentage savings of the respondents to the survey are 46 %, thus slightly above the whole GreenBuilding Programme average (41.2 %).

As indicated above, there were two questionnaire templates, the latter of which contained additional questions. Therefore, the 17 Partners who only filled out the first questionnaire from 2008 (see Table 5) did not reply to the additional 9 questions of the second questionnaire. Thus for these questions the population sample goes down to 30.

Furthermore, there were Partners who did not fill in all the questions as such. In the analysis, this is indicated by n/a abbreviation (not available) or mentioned in the explanatory note at the Figures. The n.r. (not relevant) abbreviation then indicates the cases where the question was not relevant to the Partner.

There were two multiple choice questions. Partners were not asked to state preferences in their choices. Therefore, if they stated two motivations, these were taken as equal. The rest of the questions were open-ended questions, therefore allowing for qualitative analysis. Nevertheless, some of the questions were more yes/no questions, or the Partners have given similar answers. In such cases, the responses could be assessed quantitatively as well.

4.3. Results

The analysis is divided into five subchapters. The structure is based on the main themes derived from the questionnaire, rather then on separate questions. First, the motivation to undergo energy efficiency measures is explored followed by the main benefits of the efficiency measures as perceived by the Partners. These are also linked to the main aspects in persuading the company board about the project. Next, the main features of the projects are assessed, including methods and sources of financing, or verification and monitoring of the level of achieved savings. Finally, the commitment of Partners to undertake further efficiency projects and overall satisfaction with the GreenBuilding Programme are assessed.

4.3.1. Motivation

The Partners were asked to express their motivations to implement energy efficiency measures. They were given a multiple choice question and could select one or more answers. The Partners see the major motivation in environmental considerations (Figure 23). More than 80 % of Partners indicated this as the most important determinant. Little less frequently, the Partners identified the actual energy cost reduction as the main motivation (in 68 %).

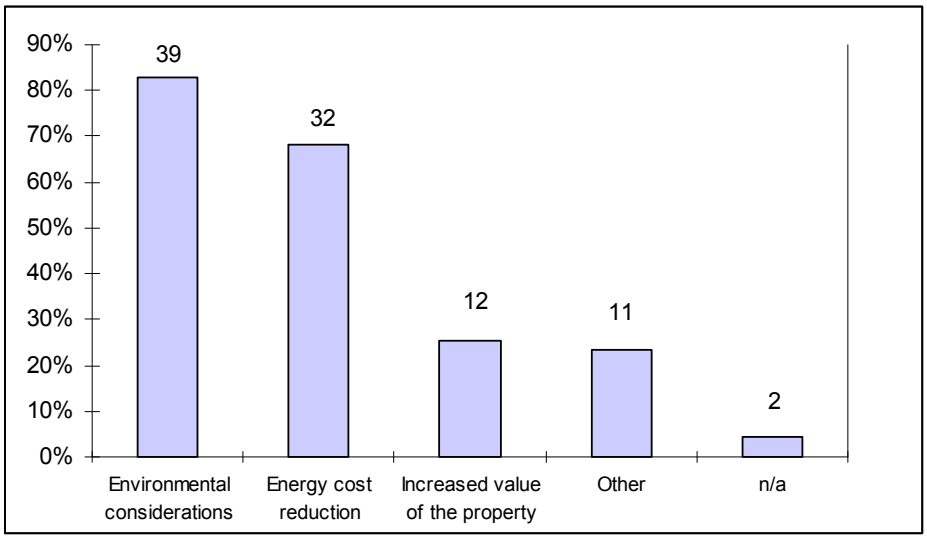
One of the co-benefits of improved energy efficiency in buildings is the potential increase in the value of the property[27]. Among the respondents, 26 % considered such benefit as another important motivation to undergo efficiency measures. In all but one case, they however chose this motivation as a complementary to both environmental and cost reduction reasons (9 cases) or to cost reduction as such (2 cases). (One Partner stated this parameter as the only and major motivation).

Other motivations were key in 23 % of cases. They included:

- market requirements (competitive advantage, attitude of clients)
- best practice example
- effective use of public money
- thermal and environmental conditions in the buildings

[27] E.g. in Metz, B. Davidson, O.R., Bosch, P.R., Dave, R. Meyer (eds.). Climate Change 2007: Mitigation. Contribution of Working Group III to the Fourth Assessment Report of the Intergovernmental Panel on Climate Change, L.A., Cambridge University Press, Cambridge, United Kingdom and New York, NY,USA.

Figure 23 Partners' motivation to invest into energy efficiency



Note: 45 out of 47 respondents answered this question. Thus, the 2 n/a answers.

The results have shown that the Partners mainly implement energy efficiency improvements because of their care for environment. Nevertheless, the financial matters (reduced energy and thus financial costs) seem almost equally important. One can speculate, whether the fact that environmental considerations were cited more frequently than the economic aspects can be attributed to the sample of respondents, which are already biased to some extent. In other words, it is likely, that the population of GreenBuilding Partners will also think more "green" than the average building owners.

One Partner (developer) clearly stated that the increased value of the property were the only reason for undergoing the efficiency measures, as the more efficient buildings can be than better marketed, thus making a pure business of the energy efficiency.

Apart from energy cost saving benefits per se, it seems that the public organizations are also seeking to demonstrate a good use of public money. As also stated in the Energy Service Directive, the public sector should play an exemplary role in energy savings. Further, they noted that e.g. restoring a historical monument to today's energy standards serves as a good practice example.

For private organizations it is important to follow their customers' requirements, which currently tend to include environmental friendly solutions among others. The private companies also emphasized the benefit of comparative advantage towards their competitors. This is mostly the case for real estate and developers sector.

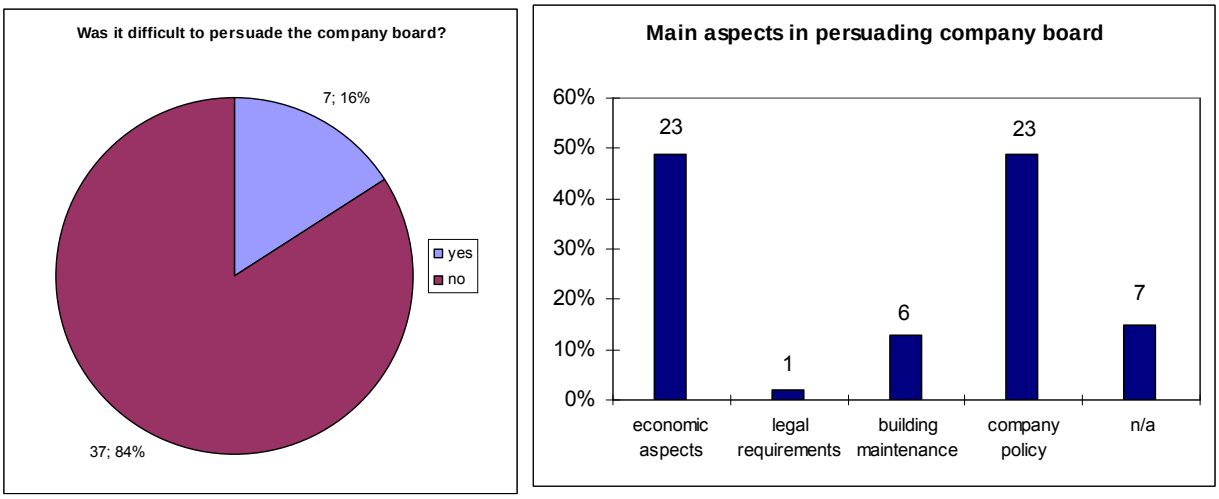
Furthermore, the energy efficiency improvements lead to better thermal and environmental conditions in the buildings, thus improving the working environment. This was highlighted both by Partners from public (e.g. schools) and private sector.

4.3.2. Benefits of energy efficiency measures

The idea to either improve energy efficiency in existing buildings or to build a more efficient than standard, new building can come from the energy units in the organizations, or it is incorporated in the policy of the organization. In the survey, the latter option was more often the case.

Vast majority of Partners have not encountered any problems in persuading their company board to undertake the efficiency measures (Figure 24). Only 16 % of respondents said it was difficult.

Figure 24 Difficulty in (right) and the main aspects of (right) persuading the Partners' decision makers

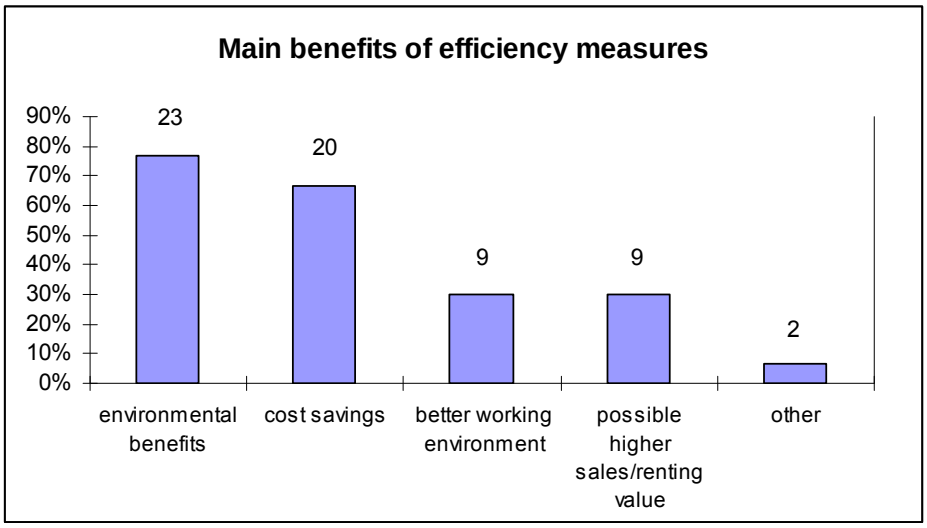


Note: The right graph depicts the main aspects in persuading the company board expressed by all the respondents, not only those, who answered "yes" in the graph on the left.

Disregarded from whether the persuasion process was difficult or not, all the respondents were asked to state what the main aspects of persuading the decision makers were. Almost one half of the Partners (49 %) stated that the main determinants were the economic aspects (the economic effectiveness of the project, which is also one of the criteria to become a GreenBuilding Partner).The same percentage of Partners also said that the energy efficiency measures were in line with the overall company policy. For many private companies (the ones that mentioned this aspect) environmental aspects (and energy efficiency) tend to be incorporated in the company's decision making. The respondents further highlighted the necessary maintenance of the building as one of the decisive factors (13 % of the respondents). One Partner stressed out the legal requirements of the respective country as the main point. There were 7 Partners who did not reply to this question (n/a in Figure 24).

Subsequently to the implementation of the measures, Partners were asked to assess the main benefits of the efficiency improvements. The question was included in the second questionnaire, thus only 30 of the respondents answered it. The perceived benefits of efficiency measures closely follow the main motivations of Partners (Figure 25). Similarly to motivations, 77 % of respondents have seen the environmental improvements as the main benefits. Just close are the energy costs savings (67 %). Also, the higher sales or renting value was evaluated by the respondents as important in 30 % of the responses. Unlike in the case of main motivations, the benefit of better working environment was stressed out after implementation of the measures (30 % of answers). Among "Other" benefits (two answers), the Partners mentioned the positive example to public (in case of public organizations) and the possible use of the GreenBuilding Certificate.

Figure 25 Main benefits of efficiency measures



The results show that the Partners seem to have a relatively clear idea of the major benefits of energy efficiency measures already in the preparation phase. Therefore, the motivations to undertake the efficiency improvements correlate with the expected or actual benefits. In other words, there does not seem to be a discrepancy between the expectations and the reality. To support or disprove this, the GreenBuilding Partners were also asked, whether they have seen any disadvantages of the measures. Three quarters of Partners[28] did not see any drawbacks of the efficiency measures. However, there were Partners (25 %) who expressed some concerns. Those included mostly maintenance and operation problems (due to also higher complexity of the systems).

The only "supplementary" advantage is the better working environment, which was seen as a benefit of the measures, but was not perceived as a possible motivation among most of the Partners.

4.3.3. Features of the energy efficiency measures

There are several stages of the implementation of the energy efficiency measures. The stages will typically include a decision making process (evaluation of the project as to selected criteria), the implementation phase (financing of the project) and the monitoring and verification phase (verification of saving achievement). The GreenBuilding Partners evaluated these stages in the survey.

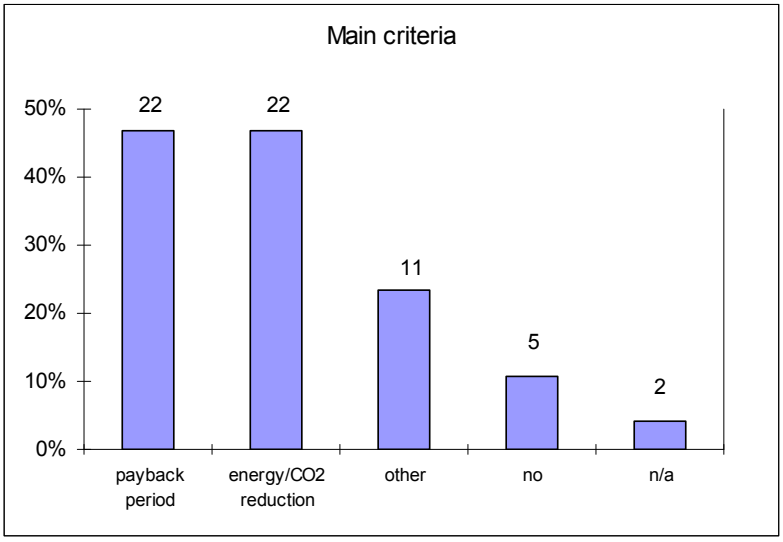
The main evaluation criteria in the decision making were the economic effectiveness of the project (the payback period, but also the Internal Rate of Return and/or Net Present Value). Almost 50 % of the respondents (22 out of 47) stated that they decided upon this main criterion (Figure 26). The Partners calculated the savings based on additionality. Therefore, they compared the additional costs needed for the efficiency measures and resulting energy costs savings.

Equal number of respondents stated that the main criterion in decision making was some sort of CO2 reduction target. It is mostly the international GreenBuilding Partners who claim to be bound by CO2 target, which tends to be set on the whole company level.

[28] The question was asked in the second questionnaire, thus the population sample was 30 Partners, of which 20 answered this question.

Among other criteria (23 % of respondents) were the building appreciation, marketing impact or long and short term investment plans and simulations of heating and cooling systems. Eleven respondents said they have not used any specific criteria in decision making about the efficiency measures and 2 respondents did not answer this question.

Figure 26 Main criteria for decision making

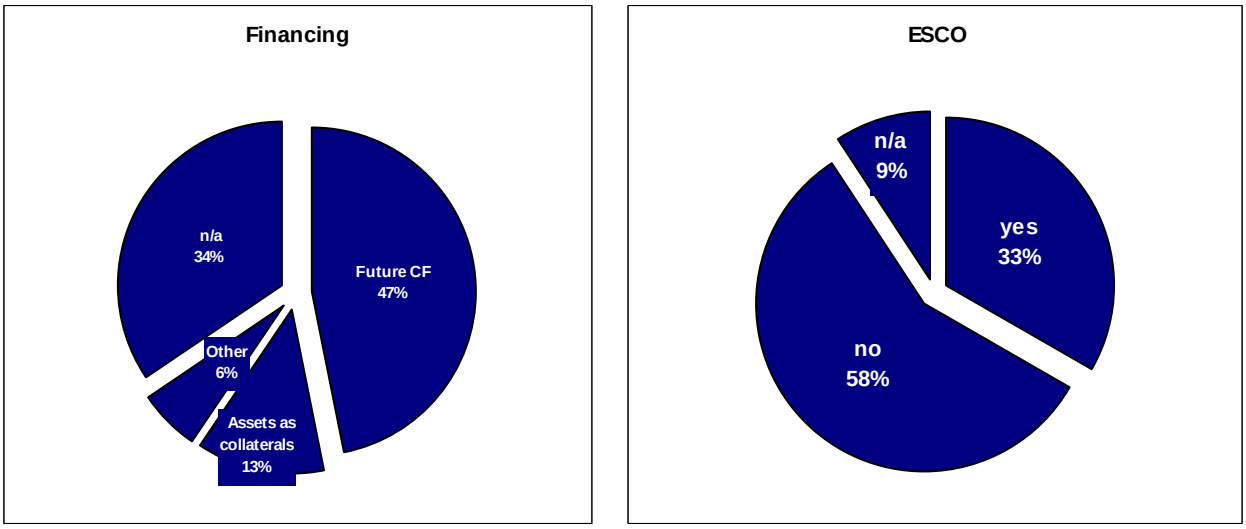


Importantly, additionality has been used among Partners, when evaluating the effectiveness of their Projects. The GreenBuilding Partners also seem to be quite active in setting up their own greenhouse gas (GHG) emission reduction targets. Similarly to the motivations, the sample may be biased in this direction though.

There were quite many respondents who seemingly have not used any specific criteria in decision making. Nevertheless, this most likely does not mean that the Partners had not used any criteria, but more probably they did not feel they should highlight the e.g. economic criteria, which tend to be rather automatic in (private) organizations.

The energy efficiency investments in refurbishments were re-financed either from the future energy savings (future available cash flow) or using the value of the purchased asset as collateral for the financing. The former option was used by 47 % of the respondents (15 out of 32), the latter by 13 % of them (Figure 27 left). More than one third of respondents have not replied to this question though. Two respondents have mentioned other sources of financing, which were own funds and member contributions in case of a regional association.

Figure 27 General types of financing (left) and use of ESCO (right)



Note: Not relevant for 16 Partners. Only refurbishments were asked.

If the organizations (if not large companies or with large share of energy costs) do not have an internal energy expert or energy management unit, for the energy efficiency improvements they may use the services offered by a specialized Energy Service Company (ESCO)[29]. Out of the 31 respondents who have refurbished their buildings, one third have profited from the help of an ESCO (Figure 27, right). They have not specified though, which type of services was contracted. Only one respondent has clearly stated to have been using the Energy Performance Contracting (EPC) for the efficiency project[30]. Almost 60 % of respondents have stated they have used their own, in-house expertise and for 9 % of respondents the answer was not available[31].

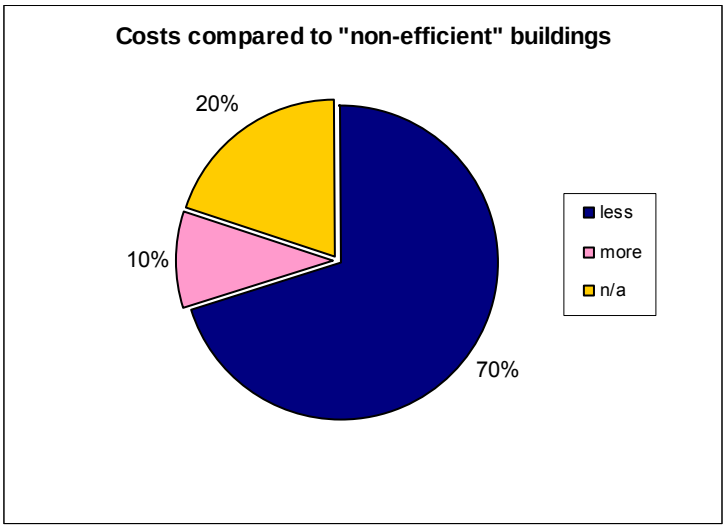
For new buildings, their costs compared to conventional ("non-efficient") buildings were assessed by the respondents. Only 10 % of them said that the costs of the new energy efficient building were higher than 10 % compared to conventional building (Figure 28). On the contrary, 70 % of respondents stated that they have not faced increased costs for the projects (or that the additional costs have not exceeded 10 %). One fifth of the relevant respondents have not answered the question.

[29] The definition of what constitutes an ESCO is still not resolved and exceeds the scope of this report. Nevertheless, in the Energy Service Directive (DIRECTIVE 2006/32/EC OF THE EUROPEAN PARLIAMENT AND OF THE COUNCIL of 5 April 2006 on energy end-use efficiency and energy services and repealing Council Directive 93/76/EEC), an ESCO is defined as "a natural or legal person that delivers energy services and/or other energy efficiency improvement measures in a user's facility or premises, and accepts some degree of financial risk in so doing. The payment for the services delivered is based (either wholly or in part) on the achievement of energy efficiency improvements and on the meeting of the other agreed performance criteria."
For detailed information on ESCOs, see the JRC Report (Latest Development of Energy Service Companies across Europe), available online from http://re.jrc.ec.europa.eu/energyefficiency/pdf/publications/ESCO%20report-edition%20version.pdf (Accessed February 2010).

[30] The EPC means guaranteed savings for a contracted period of time. The initial investment is then repaid from the achieved savings.

[31] It is important to note, that these results may over represent the situation in all buildings. This type of information (whether an ESCO helped in implementing the project) is not provided in the Partners reports. Nevertheless, from the experience of the authors, it seems that the % use of ESCOs among all GreenBuilding Partners may be significantly lower.

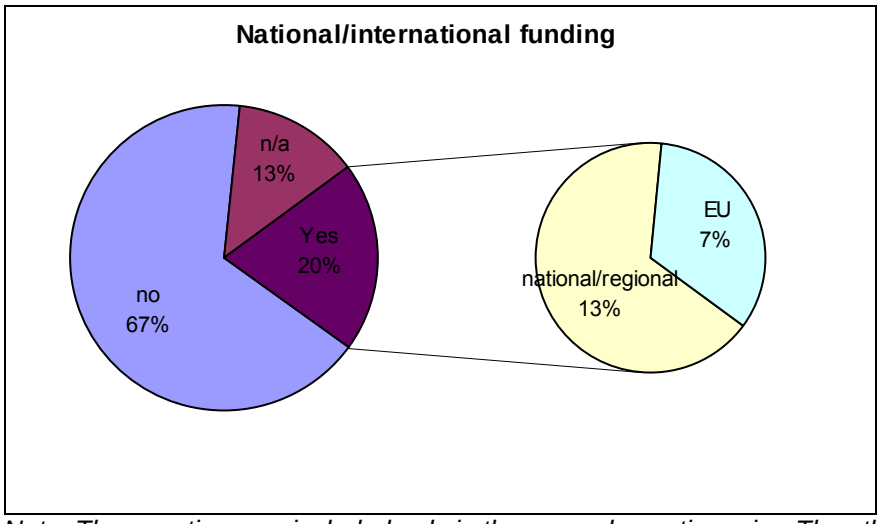
Figure 28 Costs compared to "non-efficient" buildings



Note: The question was included only in the second questionnaire. Thus the total sample is 30 respondents.

One fifth of respondents have used some form of public subsidy for the energy efficiency improvement (Figure 29). Of this, two thirds were national or regional subsidy programmes and one third was EU structural funds (available only for some EU countries). Two thirds of respondents have not reported any additional co-financing and 13 % of respondents have not answered this question.

Figure 29 Co-financing through national and/or EU funds

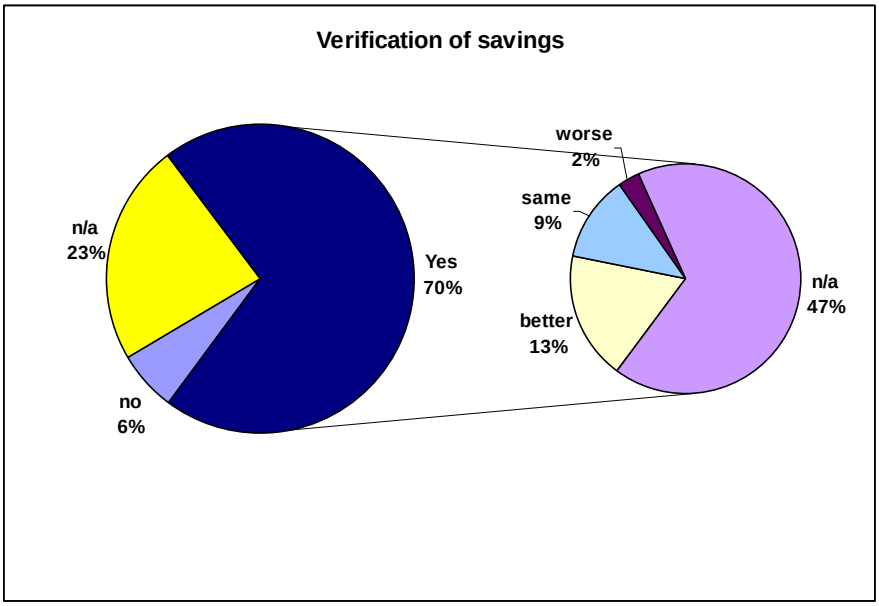


Note: The question was included only in the second questionnaire. Thus the total sample is 30 respondents.

All the respondents (42 who answered the question) stated they have installed a monitoring system and are regularly monitoring the energy consumption in building. The monitoring is done on a daily, monthly or quarterly basis. In some cases, the monitoring is done by the ESCO, as part of the contract. Or, the monitoring is a part of the building energy management system, such as BEMS or CAFM (as shown in the section on energy efficiency measures – Figure 19 – ca 30 % of GreenBuilding Partners have a control system in place).

Related to monitoring, verification of savings makes an important part of the whole energy efficiency improvement (in other words, it is important to verify, whether the estimated savings have been achieved in reality)[32]. Most of the respondents (70 %) have verified the savings after implementation of the measures (Figure 30). For 31 % of those the resulting savings were the same or even better than the estimated levels. Only 3 % of respondents have declared that they have not achieved the estimated savings. More than two thirds of those who affirmed to have verified savings have not specified what the results were though.

Figure 30 Verification of savings – verified savings better or worse than calculations



In the second questionnaire (the sample thus consisted of 30 answers), the relation to other certification systems has been explored. Only 30 % of respondents have stated to have applied for another type of voluntary certification apart from the GreenBuilding Certificate. Those included national specific certificates, ISO, EMAS or LEED[33]. More than half of respondents (53 %) have not applied for any other voluntary certificate and 17 % have not answered the question.

Following the EU Directive on Energy Performance of Buildings[34], for new and some existing buildings (rented or sold or public with area higher than 1000 m2), the certification is obligatory. Almost half of the respondents (43 %) have the Energy Performance Certificate issued in the Partner Buildings. About one quarter of respondents does not have such certificate, partly because they come from countries where this is not required (Norway, Croatia) or because it is nor required for the given type of building. A third of the respondents have not answered this question.

More importantly, the Partners have been asked, whether the energy efficiency improvements have helped them in improving the score in the certificate. However, the

[32] Verification of savings is automatic in case of e.g. the aforementioned EPC, as the guaranteed savings are the crucial part of the whole contract.
[33] ISO are international standards on many subjects, managed by the International Organization for Standards. EMAS means Eco-Management and Audit Scheme and it is an EU tool for organizations to improve their environmental performance. LEED means Leadership in Energy and Environmental Design and it is a set of voluntary standards on sustainable construction. More on the certification systems at: www.iso.org, http://ec.europa.eu/environment/emas/index_en.htm and www.usgbc.org.
[34] Directive 2002/91/EC of the European Parliament and of the Council of 16 December 2002 on the energy performance of buildings

respondents failed to answer this supplementary question. Nevertheless, it remains a question to be explored.

In spite of the limited sample of responses, there are some common features in the GreenBuilding Partner projects. Most of the Partners use the economic (payback period) and environmental (CO2 reduction) criteria in decision making. They tend to use the future cost savings for financing the upfront investment costs.

Most Partners tend to carry out the efficiency measures with the in-house experts, rather than hiring a specialized ESCO. The use of EPC method has not been reported (even though it is possible that some ESCOs actually used the EPC). One of the reasons may be the lack of knowledge about this type of service or the type of measures. The building envelope is very often one of the set of measures (Figure 19) and for this type of measures the EPC is not suitable yet.

The important message from the survey is that the average additional costs for efficiency (more than 25 % more efficiency than building standards) do not exceed 10 % of the costs of conventional buildings. Keeping the population of the sample in mind, the message is that energy efficiency does not necessarily mean high additional costs.

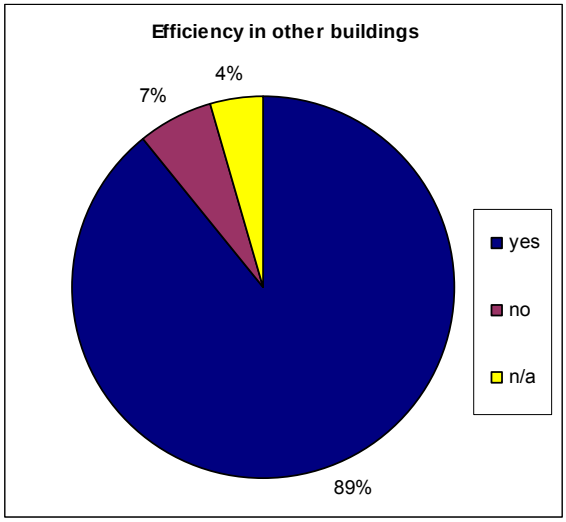
Only 20 % of projects have been co-financed through subsidy programmes. Therefore the rest of the projects can be seen as economically effective (when we consider the subsidy programmes as an instrument to help otherwise non-viable efficiency improvements), even though two respondents mentioned they have not used any subsidy, because none suitable was available.

The actual achieved savings were reported to be at least the same or even higher than were the estimates when designing the projects. Therefore, in such cases, the economical effectiveness of the measures even increases compared to plans.

4.3.4. Commitment

Most of the respondents (89 %) are willing and planning to improve energy efficiency in other buildings (Figure 31). The rest either have not replied to this question (4 %) or said they were not planning to undertake other efficiency measures in other buildings (7 %). One apparent reason for the latter was there was no other building in the respondents' possession, or the rest of the facilities were not suitable for refurbishment. On the other hand, public organizations (municipalities) expressed their willingness to continue in refurbishments of schools, hospitals and other buildings under their administration. In private organizations, the commitment to continue in energy efficiency improvements in other (existing and new) buildings is closely related to the respective company policies.

Figure 31 Commitment to implement efficiency measures in other buildings



In the second questionnaire, the Partners were asked, whether they planned to introduce further energy efficiency measures **in the same** (already certified) building. More than 50 % of respondents (16 of 30) said they would, provided there was a potential for savings or because the type of certification in the organization required continuous energy management improvements. On the contrary, 14 respondents do not plan any further improvements, partly because the building is not under their operation any more, partly because in their view the buildings' energy consumption has reached certain threshold and was already rather low.

All Partners (29 who answered the question) have used the energy efficiency improvements in their marketing activities, both towards their own employees or users of the building and of the company (or building) as such. The efficiency improvements are used towards the potential clients of the companies. The projects tend to be showcased within the promotional events and have often been used to educate the employees or tenants of the building.

Not only the efficiency improvements, but also the GreenBuilding Certificate has been marketed by most of the respondents (76 % of 30 respondents), yet with various reported results. The majority of the respondents stated that the Certificate has helped them in supporting their environmental policies and has been an added value. One of the quantity evaluations stated that the result of the GreenBuilding certification was a 7 % growth in the environmental part of the Consumer Satisfaction Index. Nevertheless, some of the Partners admitted that despite the promotional activities, due to low awareness among the stakeholders, the GreenBuilding has not been of great help. The rest of the respondents either have not used the Certificate (5 respondents, 16 %) or have not provided an answer (2 respondents).

4.3.5. Satisfaction with and promotion of the Programme

All of the Partners expressed overall satisfaction with the GreenBuilding Programme and appreciated its main goal to promote energy efficiency buildings. However, in the same time, the respondents would welcome much more promotion of the Programme. Their concern is that the GreenBuilding Programme is little known among the stakeholders – construction sector, developers, investors, universities, but also general public. More local and international promotional and advertising activities would be appreciated for the buildings that received the GreenBuilding certificate and/or also received the GreenBuilding Award, for the best projects. Otherwise, the advantages of the Programme as a voluntary certification scheme and a sort of benchmarking tool remain unexploited to large extent.

4.4. Summary

The main sample amounts to about 30 % of all Partners (47 from 167 Partners), even though for some questions[35], the sample was about one fifth (30 from 167 Partners). The geographical distribution of the survey sample is very similar to the one of all GreenBuilding Partners. The distribution of building uses follows the distribution of the whole population (with a few exceptions such as commercial centres or retail stores) and the distribution between new and existing buildings as well. Compared to all Partners, there is a slight overrepresentation of public organizations among the respondents. Some of the results may be taken with caution in this sense. Yet, wherever the responses are clearly stratified and show a main trend or results, the conclusions can be considered significant.

Here below the main overall findings and major trends are presented and are sum up into the following points:

- The Partners have clear motivations for undertaking the energy efficiency improvements. It is the environmental considerations and energy and cost reductions. The former motivation is clearly linked to the character of the population – the Partners who commit to the GreenBuilding are likely to be from definition more prone to environmental awareness.
- The Partner organizations tend to be well disposed towards energy efficiency and see clearly the benefits of improving energy efficiency in their buildings. The perceived benefits are in compliance with the initial motivations.
- The Partners seem well informed of what benefits they may expect from the energy efficiency improvements. The only exception is the improvement in indoor working environment. In this case, it was not mentioned among the motivations, but was perceived by the respondents as one of the quite important benefits. This implies, that the co-benefits of energy efficiency measures could be more emphasized.
- The perceived drawbacks are much scarcer and mostly turn around the complexity of operation of the new installations.
- The main criteria for evaluation of the projects are either the “classical” economic criteria for effectiveness or environmental criteria (CO2 reduction). In the latter case, the criterion is usually based on the common company policy, which sets up an overall environmental (CO2 reduction) target.
- The projects are mostly financed from the future cash flow, i.e. from the achieved energy cost savings. The Partners tend not to use external experts (ESCOs) for the improvements and rather take advantage of the in-house specialists. Even less common is the use of Energy Performance Contracting. The reasons for this were not explored in the survey, but may constitute a basis for further research among Partners.
- There are two findings that are very important for the promotion of efficiency measures. First, that the Partners have not faced highly increased costs for the energy efficiency investments. The additional costs for increased efficiency[36] are less than 10% of the investment.
- Second, that most of the projects bring more savings than estimated in the plans. Better actual results improve the overall effectiveness of the measures.

[35] See Annex.

[36] The higher efficiency is defined according to the Programme rules as at least 25% or more under the legal requirements or conventional buildings.

- Despite the general satisfaction of Partners with the GreenBuilding Programme, their main concern is about its publicity. The Partners would appreciate higher promotion of the programme, which would bring about the well-earned to the already certified GreenBuilding Partners.
- Related to this, it is evident that the organizations who commit to GreenBuilding Partnership are already aware of the benefits of energy efficiency improvements. This gives another reason for wider promotion of the GreenBuilding Programme and the Certificate – to promote energy efficiency in buildings with the GreenBuilding Partners as showcases.

5. Conclusions

The report provides an evaluation of the European GreenBuilding Programme, a voluntary programme, which aims at improving the energy efficiency and expanding the integration of renewable energies in non-residential buildings in Europe. The analysis covers the four year operation of the GreenBuilding Programme (2006 - 2009)

At the end of 2009, there were 167 Partners and 286 Partner buildings. All together, they achieved savings of 304 GWh/year. On average the savings amount to 41.2 % of the former (or reference) values. The savings are mostly concentrated in the two main countries as to number of buildings – Germany and Sweden, which together account for more than 50 % of the total savings. The reason may be the size of the country, tighter building codes, but also (especially in case of Sweden) the clear emphasis on environmental considerations. The savings depend on the area of the building, but do not seem to depend on the year of construction.

The reported information varied greatly. The sets of data provided by the Partners ranged from a few numbers (% savings) and short description of measures to extensive reports. Clearly, a standard format for the reports from Partners would greatly facilitate any future evaluation of this (and any other) voluntary programmes. The National Contact Points have indeed helped a lot in this sense, trying to unify the reporting forms, but also providing a communication bridge between the JRC and the Partners.

Another limitation in evaluating the Programme was the self-reporting of Partners. There is no way the reported data can be verified without sky-high transaction costs. Nevertheless, a double check (from the National Contact Point and from JRC) seems to be an effective instrument to spot the major inconsistencies or omissions.

The energy efficiency measures, reported by the Partners tend to be very case specific. The measures will largely depend on the type of the building, on the geographical location, decisions/requirement of the building owner or financial resources. It is not possible to give a panacea for the future Partners who decide to undertake energy efficiency improvements. Nevertheless, the analysis offers two general conclusions.

First, no significant relationship between the number of measures and achieved (%) savings has been found in the reports. Yet, it seems that a combination of measures tends to be more suitable than focusing only on one piece of equipment. Also, the highest savings have been achieved when a combination of 4 – 5 measures were implemented. Carrying out all the (relevant) measures at once can improve the economic effectiveness of the project, and in the same time it is ineffective from the energy point of view to e.g. replace the heating system before improving the building envelope.

Second, even though the measures are case specific, the highest savings in the sample tend to be achieved through a combination of the HVAC and lighting system upgrades. The building envelope is also frequent, but the extent and focus on particular parts of the envelope varies greatly. Often, a combination of energy efficiency improvements and renewable energy sources was used. In some cases, the energy demand was more than covered through RES generation.

The real, achieved savings in most cases exceed the estimated savings, which makes the projects even more economically effective. Similarly, from the Partners experience, the newly constructed buildings do not necessarily bring excessive additional costs. On the contrary, the majority of Partners (respondents) have asserted, that the increased efficiency “costed” less than 10 % more than the inefficient project would.

The use of energy service providers is relatively low; the Partners tend to utilize the know-how of in-house experts, instead of hiring ESCOs. Consequently, any form of energy service

contract (featuring guaranteed performance) is very rare. The future efforts thus may be directed towards promotion of this type of market.

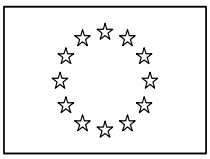
Specifically, apart from the main benefits of energy efficiency (environmental improvements and costs savings) attention should be paid to the co-benefits of improved energy efficiency. It has been shown, that even among the Partners (who tend to be better informed in the topic) the co-benefits came as a “supplementary” bonus of the energy efficiency improvements, rather than being a part of the decision making.

In general, the GreenBuilding Programme is well appreciated among the Partners and has been successful over its four year operation, which can be documented by the growing number of Partner buildings. Yet, the common agreement is that the Programme deserves wider promotion across the relevant stakeholders. This way the Programme can serve as the benchmarking tool and in the same time promote the Partners and their achievements to the general public. Wider publicity of the Programme will help to achieve its main goal: promotion of energy efficiency among building owners.

6. Annexes

Annex I: Questionnaire

Following is the Questionnaire, which was sent out in 2009/2010. Questions, which were included also in the questionnaire sent out in 2008, are marked blue.



EUROPEAN COMMISSION
DIRECTORATE-GENERAL JRC
JOINT RESEARCH CENTRE
Institute for Energy
Renewable Energy Unit

European GreenBuilding Programme Questionnaire

1. What was the main reason to undertake an energy efficiency project in your building(s)?
   a. Environmental considerations;
   b. energy cost reduction;
   c. to increase the value of your property
   d. different criteria

2. Was it difficult to persuade your company board to implement energy efficiency solutions? What was the crucial point in the decision making? (E.g. financial aspect - pay back time, return on investments, etc.)?

3. After implementing the project, what do you see as main benefits of the energy efficiency project? (
   a. Cost savings
   b. better working environment
   c. environmental benefits (CO2 reduction)
   d. possible higher sales/renting value, etc?

4. Did you use any specific methods/criteria for decision making e.g. criteria on the pay-back period, on life cycle costing, on total cost of ownership, on a target for the reduction of energy consumption, etc.)?

5. Did you verify the energy savings after the project was completed (only if you reported calculated savings)? If so, how did the verified savings compared with the calculated energy savings?

6. Do you have a regular monitoring of the energy consumption in your building(s)?

7. Only for building refurbishment: Did you use the Energy Service Companies (ESCO) in implementing the project? (If so, what type of energy service was provided by the ESCO? Was an EPC established?)

8. Only for building refurbishment: How was the financing of the project structured? (E.g. future cash flow (reduced energy costs) or on the value of the asset (collaterals))

9. Only for new construction: were the additional costs to design and construct the g more efficient building below 10% of the total cost? Will these additional costs be financed by the future energy savings.

10. Did you use any type of national or regional in co-financing for your project (e.g. EU funds, national programmes, etc)? Were you given any kind of other benefit from the public administration to facilitate the energy efficiency improvement (e.g. tax exemption, etc.)?

11. Would your company implement further energy efficiency projects **in the same** building(s)?

12. Would your company implement other energy efficiency projects (in other buildings)?

13. Did you use the **energy efficiency improvements** in the marketing of your company or of the building? Or towards your employees/users of the building?

14. Did you use the GreenBuilding Certificate in your marketing activities? Did it help you in your marketing activities?

15. Are you happy with the European GreenBuilding Programme and with the way it is promoting your project?

16. Any other comments/suggestions you would like to add.

SOME ADDITIONAL QUESTIONS

a) Did you apply for some other voluntary certification? (e.g. LEED, BREEAM or other?)

b) Does your building have an Energy Performance certificate issued? Did the energy efficiency project help you in improving your score in this certificate?

c) Have you seen any drawbacks of the energy efficiency projects (of the measures)? If so, which ones?

Annex II: Partners – alphabetical order

Partners and Partner buildings until December 2009

No.	Partner	No.	Building
1	**Aktor S.A.**	1	Central office building
2	**Albert-Ludwig University Freiburg, Kollegiengebaude III**	2	Albert-Ludwig University Freiburg, Kollegiengebaude III
3	**Allianz Elementar Versicherungs-AG**	3	office building
4	**AMF Fastigheter**	4	Pelarbacken mindre 23
5	**Area Hospitalaria Juan Ramon Jimenez de Huelva**	5	Hospital complex
6	**Aspholmen Fastigheter AB**	6	Kv Gjutjärnet 7
		7	Kv Virkeshandlaren 10
		8	Kv Boländerna 30:2
7	**Athens International Airport**	9	
8	**Banco de Sabadell S.A.**	10	Documentation Warehouse in Polinyà, Barcelona
9	**Bank of America**	11	
10	**BAU-schwede GmbH**	12	Administration building
11	**Bayer**	13	Kantoorgebouw Bayer
12	**Bezirksamt Charlottenburg-Wilmersdorf von Berlin,**	14	Grunewald Grundschule
		15	Herder Oberschule
13	**Billa AG – Penny Department**	16	Penny supermarket Feistritz
14	**Billa Aktiengesellschaft Klosterneuburg**	17	self service shop
15	**BIM Berliner Immobilienmanagement GmbH**	18	Rotes rathaus Berlin
16	**Binario S.p.A.**	19	Complesso Binario
17	**Bohnij Vodni park d.o.o.**	20	leisure complex
18	**Britalar Investimentos SA**	21	Hospital Privado Braga
19	**BUND Landesverband Bremen e. V.**	22	BUND Landesverband Bremen e. V., Geschäftsstelle
20	**Cacém Polis - Sociedade de Desenvolvimento do Programa Polis 0 Cacém**	23	Jardin de Infância Popular de Cacém
21	**Camara Municipal de Lisboa**	24	Restelo
		25	Alvito
		26	Vale Fundao
		27	Piscina Municipal de Santa Maria dos Olivais(oriente)
		28	Sete Rios
22	**City of Erlangen**	29	Kinderhaus Eltersdorf
23	**City of labin**	30	buildings in Kature area
24	**City of Regensburg**	31	Goethe Gymnasium
25	**City of Wertheim**	32	Comenius Realschule
26	**Club Natació Sabadell**	33	Can Llong
27	**Companhia Carris de Ferro de Lisboa s.a.**	34	Edificio a do complexo de Miraflores
28	**Comune di Faenza(Ra)**	35	Tolosano school
29	**Consejería de empleo y mujer de la comunidad de Madrid**	36	Office building
30	**Coperfil Inmobiliaria**	37	Logispark Meco
31	**Cornelsen Verlag GmbH & Co. KG/Verlagsgebäude (DE)**	38	Publishing house CORNELSEN
32	**Corpus Sireo Asset Management GmbH**	39	Büro- und Technikkomplex, Bauerbergweg 23-25, 22111 Hamburg
		40	DTAG Büro- und Technikgebäude, Budapester Straße 18, Hamburg

33	**COSMOTE Mobile Telecommunications SA**	41	Head quarters and operation center
34	**DEFO (Deutsche Fonds für Immobilienvermögen GmbH)**	42	Bürohochhaus Hahnstraße
35	**Deloitte and Touche**	43	Spherion
36	**Deutsche Lufthansa AG**	44	Lufthansa Aviation Center
37	**Diligentia**	45	Dykaren 17 (Gyllen)
38	**Düsseldorfer Hypothekenbank AG**	46	Building in Berliner Allee 43 Düsseldorf
39	**EjendomsInvest Oy Ab**	47	Hyvinkää Home Center
40	**energosi**	48	Office building in Koprivnica
41	**ENERGOSISTEMI d.o.o.**	49	Office building - EE info corner
42	**EREC**	50	Renewable energy house
43	**Evangelische Kirche Stadl Paura**	51	Evangelische Kirche
44	**Fabege AB**	52	Paronet 8
45	**Fastighets AB Brostaden**	53	Kv. Vallonsmidet 8
46	**Fastighets AB Navet**	54	Lindholmspiren 3
47	**Fastighetsaktiebolaget Bangårdsposten**	55	Stockholm Waterfront Congress Centre
48	**FEZ Berlin – Kinder-, Jugend- und Familienzentrum**	56	FEZ Berlin – Kinder-, Jugend- und Familienzentrum
49	**Folksam**	57	Tullgården 2
		58	Manfred 7
50	**Foundation Hospital del Oriente de Asturias "Francisco Grande Covián"**	59	Hospital del Oriente de Asturias
51	**FRANKONIA Eurobau**	60	Friesenquartier Gebäude FQ 22 (Baufeld Süd 1 RU 1)
52	**FUNDAÇÃO CALOUSTE DE GULBENKIAN**	61	Edifício Sede e Museu buildings
53	**Galären i Luleå AB**	62	Ormen 1
54	**Gamla Livförsäkrings AB SEB Trygg Liv**	63	Kv. Siktet 5 hus 2
		64	Kv. Siktet 5 hus 1
55	**Gavlefastigheter AB**	65	Stadshuset
56	**Gebrüder Immler**	66	Passive House office building in Wangen, Allgäu
		67	discount store „Takko“ in Leutkirchen
57	**GEK S.A.**	69	Office building
58	**GMW Eigenbetrieb Gebäudemanagement**	68	Grundschule Haarhausen
59	**Greek Postal Savings Bank**	70	Greek Postal Savings Bank
60	**Gymnasium Bernadin Frankopan**	71	Gymnasium Bernadin Frankopan
61	**Halliburton-Tananger**	72	**Halliburton-Tananger**
62	**Harry Sjögren AB**	73	Vallmon 6
		74	Ängsviolen 1
		75	Stallet 3
		76	Flaggan 1
		77	Högsbo 38:9
		78	Skinntickan 1
		79	Hede 3:131
		80	Kungsbacka 4.47
		81	Tusenskönan 2
		82	Pottegården 4
		83	Varla 2:388
		84	Högsbo 28:3
		85	Flaggan 1
		86	Varla 2:380
		87	Syrgasen 8
		88	Ängsviolen 1
		89	Anisen 3
		90	Kobbegården 6:726
		91	Högsbo 24:12
		92	Anisen 3

		93	Riskullaverket 2
		94	Vallmon 2
		95	Generatorn 2
		96	Kobbegården 6:724
		97	Hede 3:127
		98	Rud 51:21
		99	Karossen 3
		100	Kobbegården 6:180
		101	Törnrosen 3
		102	Skinntickan 1
		103	Högsbo 20:22
		104	Högsbo 24:12
		105	Högsbo 20:22
		106	Kobbegården 6:360
		107	Vallmon 3
		108	Högsbo 40:1
		109	Vallmon 7
		110	Berguven 1
		111	Kobbegården 6:362
		112	Högsbo 27:7
		113	Tjärblomman 3
		114	Hönekulla 1:571
		115	Tulpanen 1
		116	Gaslyktan 11
		117	Konfektasken 15
		118	Högsbo 36:9
63	**Havenbedrijf Gent agh**	119	Passief kantoor
64	**HAVI Global Logistics GmbH (DE)**	120	Headquarters in Duisburg
65	**Hernandez Cabeza Hoteles SL**	121	Hotel Oviedo
66	**Hettich holding**	122	Neubau B 1; Ausstellungs- und Bürogebäude
67	**High school Duga Resa**	123	High school Duga Resa
69	**Hochbaumamt der Stadt Frankfurt, Abt.**	124	Primary school Frankfurt/Riedberg
68	**HOCHTIeF Developement Austria GmbH**	125	MARXIMUM Business park
70	**HOCHTIEF Projektentwicklung GmbH**	126	SMARTHOUSE
71	**Hospital Virgen de Las Nieves. Servicio Andaluz de Salud**	127	La Cartuja and Caleta
72	**Hotel am Stadtpark Hilden**	128	Hotel am Stadtpark Hilden
73	**Hotel ATLANTIS am Meer & Klinik Westfalen**	129	Hotel ATLANTIS am Meer & Klinik Westfalen
74	**Hotel JAKUE**	130	Hotel Jakue
75	**Hotel Princess Lanassa**	131	Hotel Princess Lanassa
76	**Hoval**	132	Hoval Marchtrenk
77	**Hufvudstaden AB**	133	Kv Packarhuset 4
78	**HUK Coburg**	134	HUK Coburg
79	**Humlegården Fastigheter AB**	135	Bremen 2
		136	Bremen 4
		137	Härden 16
80	**HUSÖ Fastighets AB**	138	Astern 1
		139	Tingshusbacken
81	**Chalmersfastigheter AB**	140	Vasa Hus 5.
		141	Kuggen
82	**Immobilienverwaltung, Schulgemeindeverband St. Veit/Glan**	142	Hauptschule Hüttenberg
83	**Ing. Siegfried Manschein GmbH**	143	Nullenergiebüro Mannschein building
84	**Italcementi**	144	Innovation and Technology Central Laboratory - ITCLab
85	**Jernhusen AB**	145	Kungsbrohuset

		146	Centralstation
86	**JM AB**	147	Frösunda Park
87	**Justizvollzugsanstalt Moabit**	148	Penitentiary Moabit (Justitzvollzugsanstalt/JVA Moabit)
88	**Justizvollzugsanstalt Schwalmstadt**	149	Penitentiary
89	**KfW Bankengruppe**	150	KfW haupthaus
90	**KiK Textilien and Non-Food GmbH**	151	KiK Freestand in G0ien
		152	KiK Freestand Neuried
91	**Kita-Rehazentrum / Bezirksamt Steglitz-Zehlendorf (DE)**	153	Day nursery with rehabilitation centre
92	**Koelnbader**	154	Ossendorfbad
93	**BIM Berliner Immobilienmanagement GmbH**	155	Kriminalgericht Moabit
94	**La VOLA**	156	Ecoedifici
95	**Landesimmobilien-GesellschaftmbH**	157	Bezirkshauptmannschaft Fürstenfeld
96	**Landratsamt Main-Spessart**	158	Realschule Gemünden
97	**Landstinget Dalarna/Landstingsfastigheter**	159	Avesta lasarett
98	**Landstingsfastigheter - Landstinget i Värmland**	160	Hus 2
		161	Hus 1
99	**Lantmännen**	162	HK Grodden, Hus
100	**Laura Diana GmbH**	163	Office building VZ13
101	**LIG**	164	Technikzentrum und Institut für Lebensmittelsicherheit und Veterinärwesen
		165	New Verwaltungszentrum Land Kärnten
102	**Magistrat der Stadt Wien**	166	Floridsdorf swimmin pool
103	**Marktgemeinde Grafenstein**	167	Primary school in the municipality of Grafenstein
104	**MAUSS BAU ERLANGEN GmbH & Co. KG**	168	Office building
105	**MEAG MUNICH ERGO AssetManagement GmbH**	169	Maximiliansplatz 12
		170	Cologne Oval Offices building No. 74
		171	Cologne Oval Offices building No. 72
106	**Menerga d.o.o.**	172	office building
107	**Merkur Warenhandels AG**	173	Merkur Klosterneuburg
108	**MP Holding**	174	Multipark Mönchhof II – Storage
		175	Multipark Mönchhof II – Office Building
109	**MSF**	177	NATURA TOWERS
110	**Natuurpunt (BE)**	176	Natur huis Mechelen
111	**NCC GmbH**	178	Nöthen Computer Center
112	**NCC Property Development**	179	Kv. Bilen 4, Kaggen
		180	COOP Kungsbacka
113	**NH Hoteles**	182	Hotel NH Central
		181	Hotel NH Podium
		183	Hotel NH Convenciones
		184	Hotel NH Principe de la Paz
114	**Nord-Grundschule / Bezirksamt Steglitz-Zehlendorf**	185	0rd Grundschule
115	**Objektgesellschaft Moosacher Straße mbH& Co. KG**	186	Olympia-Office-Tower (campus)
		187	Olympia-Office-Tower (skyscrapper)
116	**Österreichischer Gewerkschaftsbund ÖGB (Austrian Labour Union)**	188	Office building Biberstraße 5
117	**Peab AB**	189	Haga Vinge
118	**Pfizer**	190	Pfizer ABs office in Silverdal, Sollentuna
119	**Pharmaserv**	191	M202 Green Office
120	**Phoenix Park d.o.o.**	192	Phoenix Plaza
121	**Piraeus Bank**	193	Piraeus Bank
122	**Planbo Projekt AB**	194	Renaissance Malmö Hotel Rosen 8
123	**Primary school Ivan Goran Kovacic**	195	Primary school Ivan Goran Kovacic

124	**Prologis**	196	Arlanda
125	**Provincia di Venezia**	197	Administrative block of the Instituto Tecnico Industriale Statale "C Zuccante"
126	**Rehabilitationszentrum Althofen**	198	Humanomed Zentrum Althofen
127	**Rehau AG+CO**	199	GeoPark Y (Headquarters Rehau)
128	**Rist und Stamm GbR**	200	Solux GmbH
129	**Robert Murjahn Institute, Turkey Research and Development Institute**	201	RMI Türkyie building
130	**Rondo**	202	Rondo
131	**SeaBridge SA**	203	SeaBridge Logistics
132	**Servei Catala de la Salut**	204	Primary healthcare Centre
133	**Schulverband Hengersberg**	205	Hauptschule “Abt Bernhard Hilz” Hengersberg
134	**Siemens AG Siemens Real Estate**	206	SIEMENS FFM CB, Extension
		207	SIEMENS FFM CB, Extension II
		208	SIEMENS Power Generation Mittellasthalle 81 Rheinstraße 100 45478Mülheim an der Ruhr
		211	Halle 8 + 9, Görlitz
		213	Power Generation Building 60, Huttenstrasse 12, 10553 Berlin
		217	SIEMENS Office Building, Hofmannstraße 51, Building 1748, 82379 München (DE)
		219	SIEMENS Office Building, Hofmannstraße 51, Building 1752, 82379 München (DE)
		220	SIEMENS Office Building, Hofmannstraße 5, Building 1749, 82379 München (DE)
		209	SIEMENS Office Building, Hofmannstraße 51, Building 1755, 82379 München (DE)
		210	Power Generation Office Building 91, Rheinstraße 100, 45478 Mühlheim and der Ruhr
		212	SIEMENS Office Building 82, BA1 Erlangen, G. Scharowsky-Straße 21, 91058 Erlangen
		214	Neubau Bürogebäude Düsseldorf-Airport
		215	Test Center for transformers: Prüffeld 0rd, 90453 Nürnberg
		216	Siemens Power Generation Schwerlasthalle, Gorlitz
		218	Siemes AG Verwaltungsgebaude Berlin
		221	Lindenplatz 2
		223	Siemens AG Muenchen Perlach, Gebäude 9115
		224	Siemens Mitarbeiter Casi0 erlangen mitte, bau 205
		226	SIEMENS Amberg A & D Kantine
135	**SIEMENS S.p.A.**	227	Sede Roma Laurentina
		222	Vipite0 Office Building 1
136	**Sjælsø A/S Danmark**	225	Kopenhagen Towers, building 408
137	**Skanska Commercial Development Nordic**	228	Project Havneholmen Tower
		229	Alfa
138	**Skanska Commercial Development Nordic (SE)**	230	Scylla 3
		233	Sturegatan 1
		231	Österport 7
		232	Hagaporten III/Stora Frösunda 3
		234	Gårda 18:25
		235	Forskaren 3
		236	Bylingen 1
		237	Gångaren 11
139	**Skanska Commercial Development Finland oy**	238	Lintulahti Office Building
140	**Skanska Property Hungary Ltd.**	239	Népliget Center
141	**Skanska Property Poland**	240	Marynarska Point B2 (PL)

		241	Marynarska Point B1 (PL)
		242	Atrium City
142	**Sparkasse Vorderpfalz**	243	Sparkasse Vorderpfalz Ludwigshafen
143	**Stadt Mörfelden-Walldorf**	244	community centre Mörfelden-Walldorf
		245	city hall
		246	abattoir
144	**Statens Fastighetsverk / The National Property Board**	248	Stockholm Observatorium, i Saltsjöbaden
145	**Stebo vzw**	247	Stebo Homebase
146	**Strömberg Distribution Fastighets AB**	249	Jordbromalm 4:10
147	**Telge Fastigheter**	250	Hölö Förskola
		251	Kaxberg Förskola
		252	Ljungbacken Förskola
148	**Terme snovik – Kamnik d.o.o.**	253	Terme s0vik
149	**TGE SpA Partner**	254	via forcella 12
150	**THS GmbH**	255	Hauptverwaltungsgebäude 0rdstern
151	**TRIGRANIT Development Corporation**	256	
152	**Ultzama**	257	COLEGIO PÚBLICO
		258	SERVICIOS SOCIALES
		259	AYUNTAMIENTO
		260	Centro Cívico; ;
		261	Centro de Salud;
		262	Frontón Municipal;
		263	Polideportivo
		264	Piscinas municipales
153	**UniCredit RealEstate SpA**	265	Compleso "Sant'Elia"
154	**UNIQUA Immobilien Service GmbH**	266	UNIQUA Tower
155	**University of Arts in Berlin/Universität der Künste**	267	University of Arts in Berlin/Universität der Künste
156	**University of Split**	272	Library
157	**VALAMAR D.D.**	273	Auto kamp Politin,
158	**Vasakronan AB**	270	Riga 2
		271	Pennfaktaren 11
		274	Hekla building 10
		268	Spektern 13 B
		269	Kista Science Tower
		275	Tingsrätten Ullevi Park 2
		276	Vasakronan Ullevifastigheter AB
159	**Vastfastigheter**	277	Tehuset
160	**Vimusa**	278	Alexandra Building
161	**Viroc Portugal SA**	279	Viroc headquarters
162	**V-Port Real Estate AB (DE)**	280	Västerport in Stockholm
163	**VZW Rotonde**	281	Huize Goeyers
		282	Centrale campus Augustijnslei
164	**Wallfast AB**	283	Havsfrun 26
165	**Wihlborgs Fastigheter AB**	284	Dockum
166	**WWFF Business and Service Center GmbH**	285	ENERGYbase
167	**Zeolit Exploaterings AB / Fabege AB**	286	Paradiset 29

Annex III National Contact Points

AUSTRIA

Ms. Christina Spitzbart
Buildings & Heating
Austrian Eenergy Agency
Mariahilfer Straße 136
1150 Vienna, Austria
Tel: +43 1 586 15 24 - 119
Fax: +43 1 586 15 24 - 340
E-mail: Christina.Spitzbart@energyagency.at
Web: www.energyagency.at

BELGIUM

Mr. Johan Coolen
CENERGIE cvba
Gitschotellei 138
B-2600 Antwerp, Belgium
Tel: +32(0)3/271.19.39
Fax: +32(0)3/271.03.59
E-Mail: johan.coolen@cenergie.be
Web: http://www.cenergie.be/Greenbuilding/

CROATIA

Mr. Željka Hrs Borković
Energy Institute Hrvoje Požar
Department for RES and EE
Savska 163, P.O.B. 141,
10001 Zagreb, Croatia
Tel.: + 385 1 6326138
E-Mail: zhrs@eihp.hr
Web: www.eihp.hr

FINLAND

Mr. Kimmo Rautiainen
Motiva Oy
Urho Kekkosen katu 4-6 A
00101 Helsinki, Finland
Tel.:+358 424 281 220
Fax: +358 985 653 199
E-Mail: kimmo.rautiainen@motiva.fi
Web: www.motiva.fi

FRANCE

Mr. Alain Anglade
ADEME
Energy Efficiency Markets and Services division
Centre de Sophia Antipolis
500 route des Lucioles
06560 Valbonne, France
Tel.: +33-4-93 95 79 35
Fax: +33-4-93 65 31 96
E-Mail: alain.anglade@ademe.fr
Web: www.ademe.fr

Prof. Jerome Adnot
Ecole des Mines de Paris
60, boulevard Saint-Michel
75272 Paris Cedex 06 , France
Tel.: +33-1-40 51 91 74
Fax: +33-1-6 34 24 91
E-Mail: jerome.adnot@ensmp.fr
Web: www.ensmp.fr

GERMANY

Ms. Nana Doerrie
Deutsche Energie-Agentur GmbH (dena)
Chausseestr. 128a
10115 Berlin, Germany
Tel.: +49-30 726 1656 87
Fax.: +49-30 726 1656 99
E-Mail: doerrie@dena.de
Web: www.dena.de

Mr. Philipp Karch
Berliner Energieagentur GmbH
Französische Str. 23
10117 Berlin, Germany
Tel: +49-30 29 3330 68
Fax: +49-30 29 3330 99
E-Mail: karch@berliner-e-agentur.de
Web: www.berliner-e-agentur.de

Mr. Peter Radgen
Fraunhofer Institut für Systemtechnik
Breslauer Strasse 48
76139 Karlsruhe, Germany
Tel.: +49-7 21-68 09-0
Fax: +49-7 21-68 09-2 72
E-Mail: peter.radgen@isi.fhg.de
Web: www.isi.fhg.de

GREECE

Mr. Ilias Sofronis
Centre for Renewable Energy Sources (CRES)
19th Km Marathonos Avenue
19009 Pikermi, Attiki, Greece
Tel.: +30-2 10-66 03 32 87
Fax: +30-2 10-6 60 33 05
E-Mail: sofronis@cres.gr
Web: www.cres.gr/greenbuilding

ITALY

Prof. Lorenzo Pagliano
End-use Efficiency Research Group (eERG)
Building Engineering Faculty - Politecnico di Milano
Piazza Leonardo Da Vinci, 32
20133 Milano, Italy
Tel.: +39-02-23 99-38 93
Fax: +39-02-23 99-39 40
E-Mail: lorenzo.pagliano@polimi.it
Web: www.polimi.it, www.eerg.it

POLAND

Ms. Agnes Vorbrodt-Schurma
Polskie Stowarzyszenie Budownictwa Ekologicznego | Polish Green Building Council (PLGBC)
Kraków, ul. Wadowicka 6, Poland
Tel.: +48-501-110-777
Fax: +48-12-269-2096
E-Mail: agnes@plgbc.org
Web: www.plgbc.org

PORTUGAL

Deputy Dir. Diogo Beirao
ADENE -Agência para a Energia
Estrada de Alfragide, Praceta 1,
no 47, Alfragide
2610-181 Amadora, Portugal
Tel: +351-21-4722840
Fax: +351-21-4722898
E-Mail: diogo.beirao@adene.pt
Web: www.adene.pt

SLOVENIA

Mr. Marko Pečkaj
Project Leader
Jozef Stefan Institute
Jamova 39
1000 Ljubljana, Slovenia
Tel.: +3 86-1-5 88 53 25
Fax: +3 86-1-5 88 53 77
E-Mail: marko.peckaj@ijs.si
Web: www.ijs.si

SPAIN

Mr. Joan Carles Bruno
Mrs. Núria Quince
Universitat Rovira i Virgili National
Av. Països Catalans, 26
43007 Tarragona, Spain
Tel.: +34 977 257891
Tel.: +34 977 257887
Fax: +34 977 559691
E-mail: juancarlos.bruno@urv.cat, nuria.quince@urv.cat
Web: www.crever.urv.es

SWEDEN

Ms. Sofie Roy-Norelid
Fastighetsägarna Sverige AB
Box 16132
10323 Stockholm, Sweden
Tel.: +46-8-613 57 21
Fax: +46-8-613 57 01
E-Mail: sofie.roy-norelid@fastighetsagarna.se
Web: www.fastighetsagarna.se

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Abstract
GreenBuilding is a voluntary programme aiming at improving the energy efficiency of non residential buildings in Europe on voluntary basis. The programme addresses owners of non residential buildings to realise cost-effective measures which enhance the energy efficiency of their buildings in one or more technical services.
The present report summarizes the results of the first four-year operation of the GreenBuilding Programme, in terms of the main energy efficiency measures in the buildings and related savings, as well as the GreenBuilding Partners' motivations and experience in carrying out the efficiency measures.

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