Evaluation of the GreenBuilding Programme

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ABSTRACT

In early 2006 the European Commission launched the GreenBuilding Programme (GBP), which aims at improving the energy efficiency of existing as well as newly constructed non-residential buildings in Europe on a voluntary basis. Building owners from different sectors are participating in the programme e.g. public authorities with schools, hospitals or swimming halls, companies from the services and industry sectors with office buildings, sport centres and hotels. The aim of the paper is to provide a summary analysis of the results of the GBP in its almost four year operation – from the launch of the programme in 2006 until the end of 2009.

By the end of 2009, 167 partners have joined the programme with almost 300 buildings, coming from all sorts of fields and sectors of operation. The total savings achieved by the Partners are 304 GWh/year. 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 participating countries. The paper focuses on efficiency measures implemented in the participating buildings and the energy savings achieved.

Introduction: the GreenBuilding Programme

In its 2006 Action Plan on Energy Efficiency (EC 2006), the European Commission (EC) identified the building sector as an area where important improvements in energy efficiency can be realised. According to the Action Plan, the building sector accounts for more than 40% of the final energy demand in Europe. At the same time, improved heating and cooling of buildings constitutes one of the largest potentials for energy savings and thus reduction of CO_2 emissions. Such savings would also improve the energy supply security and the EU's competitiveness, while creating jobs and raising the quality of life in buildings.

In early 2006, the European Commission initiated the GBP. 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 realise cost-effective measures which enhance the energy efficiency of their buildings in one or more equipment systems. The GBP is complementary to the EU Energy Performance of Buildings Directive (EPBD) as it will stimulate additional savings in the non-residential building sector.

To become GBP Partner, building owners perform an energy audit of their existing buildings and formulate an action plan to improve energy efficiency. By applying potential Partners agree to reduce their primary energy demand of the building by at least 25% (if economically viable) and to report the results of the renovation measures. The energy consumption is measured before and after the renovation. For new construction investors or building owners design a building using at least 25 % less energy than requested by the building code in force at the time. The energy savings are calculated from modelled energy use. Fourteen organisations from thirteen European countries are supporting the implementation of the GBP in the national context; these organisations are called National Contact Points (NCP) and they assist building owners in this process by providing guidelines for energy saving renovation, and a website in national language with an inventory of best-practices. Other private and public organisations may help potential Partners join the programme as Endorsers. Besides reducing energy as well as operational costs, other reasons for building owners to join GBP are:

- Public recognition for the participating organisations;
- Practical help by the NCP
- Public commitment for environmentally friendly behaviour
- Corporate Social Responsibility
- Reduction of CO_2-emissions

Participation in the GBP for existing buildings starts with the submittal of an action plan defining the scope and nature of the company's commitment. Based on an initial energy audit, the action plan must define the buildings in which energy efficiency actions will be undertaken as well as the energy services (heating, lighting, water heating, ventilation, air-conditioning, office equipment, etc.) and the specific measures, to which the commitment applies. If the action plan is accepted by GreenBuilding, the company is granted Partner status. For new buildings energy modelling and a description of the building is needed to prove to be 25% below the building code. The GBP encourages its Partners to tap a large reservoir of profitable investments without the need for specific incentives from the public authorities. GBP investments use proven technology, products and services for which efficiency has been demonstrated. It is thereby considered to make good business sense for companies to join the GBP.

GreenBuilding 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.

Results of the GreenBuilding Programme

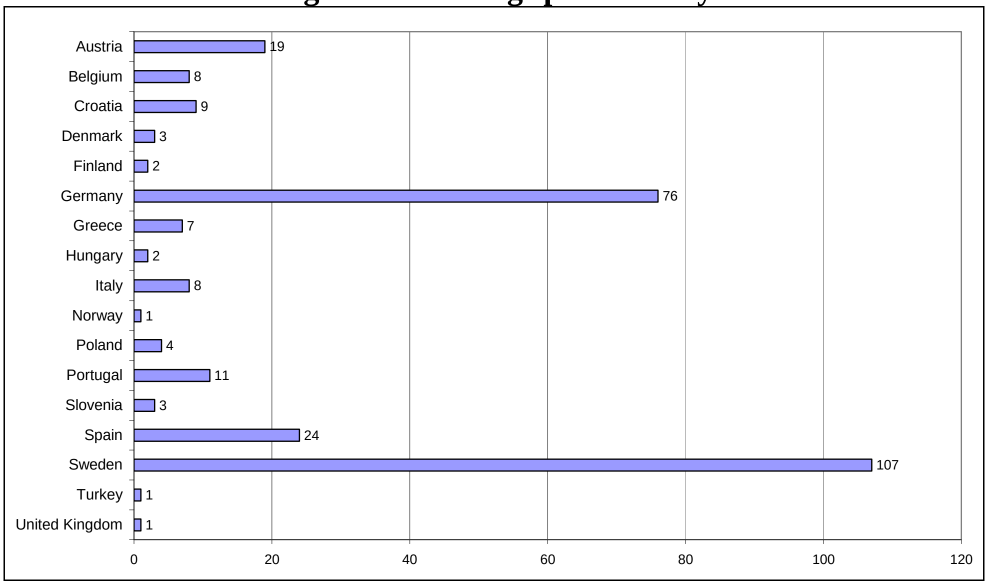
Number and Type of Participating Buildings

As of the end of December 2009, the total number of GBP Partners reached 167. The total number of GBP certified buildings was 286[1]. The GBP 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 (Valentova and Bertoldi 2008). 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. 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.

[1] 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

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 1).

Figure 1. Buildings per Country



Almost 60 % (167 out of 286) of the Partner buildings are offices. The second largest group of buildings are education buildings (8.8 % of the GBP buildings). These include kindergartens, primary schools, high schools and universities. The public administration buildings (10 in total) cover municipal houses, but also courts or penitentiaries. Healthcare, hotels, industry and leisure centres are then all represented by 13 buildings (ca 4 % of total number of Partner Buildings). There were two airports which joined the GBP. Among other buildings, there is for example a church, technology centre, research institute, canteen, libraries, train station or social care and social housing centres. Majority of the buildings belong to private organizations (77 %), only 23 % of the Partner buildings are public. All of the educational facilities and obviously public administration buildings in the GBP 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 GBP are operated purely by private organizations. The average area of the Partner buildings was more than 15 595 m2[2]. 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 a large extent skewed by commercial centres, which have the highest average floor area –more than 52 000 m2.The smallest building only has 414 m2; 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 m^2 and it is one of the new commercial centres, built in 2009, with savings compared to the building code in force of 7329 MWh/year.

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

Out of 285 buildings (for one building the information was not available), there are 126 new buildings and 159 existing, refurbished buildings. Among hotels, office buildings, public administration buildings or education facilities the refurbished buildings prevail – 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.

Most existing buildings have been built in the years 1961 to 1980. The oldest building of the GBP 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[3]. 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).

Energy Savings

The GBP Partners usually report their savings in two ways: either as absolute yearly savings or as kWh per m^2 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 the case of the latter method (reporting $kWh/m^2.y$), recalculation is necessary.

Total savings of the GBP so far (GBP Partners until the end of 2009) have amounted to **304 GWh/year**. The savings may be underestimated. There are two reasons for this. Firstly, these savings have often been only estimated savings (e.g. for new buildings). As will be shown later in the paper, the verified savings tend to be even 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).

Maximum absolute savings were achieved in Germany – more than 116 GWh/year 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 a Test Centre for Transformers. The maximum primary energy demand, which is legally required for such building is $984.3 kWh/m^2a$, whereas the test centre achieved the primary energy demand of only $23.3\ kWh/m^2a$, which means 97.5 % less than required. In absolute terms, it gives a saving of 11.83 GWh/year.

In total there were five buildings out of 286 that have not achieved the 25 % savings[4]. The reasons for this are diverse. For example, there is one building which actually reaches only

[3] 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.

[4] Savings of modeled energy use compared to either previous consumption for existing buildings or to legal requirements or conventional buildings for new buildings.

19 % of savings. However, the energy consumption goes below 30 % compared to 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 another case, one of the hotels achieved 21 % of total energy savings only implementing measures with pay back time lower than 4 years, which included measures in lighting that brought savings of 67 %..

From the total 271, who reported the percentage savings, more than two thirds (179) even achieved more than 30 %. The average achieved savings are 41.2 %, the median is 36.5 %. 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[5]. There are 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 efficient lighting was installed. Interestingly, there is one building from before 1900, which has 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.

The average percentage savings range from 55 % in commercial centre and leisure facilities (51 %) to 28 % at the airport. The relative savings in offices, the most important building use as to total savings and total number of buildings, averages at 39 %. 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. 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.

Specific Energy Demand in Office Buildings

One of the most important indicators of efficiency with respect to buildings is the primary energy demand per m^2 and year ($kWh/m^2.y$). 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 GBP 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.

Existing buildings. The average primary energy demand per m^2 before the refurbishment of existing office buildings was 150 $kWh/m^2.y$. The lowest value was only 34 $kWh/ m^2.y$. The maximum demand before refurbishment reached 558.4 $kWh/m^2.y$. The highest specific primary

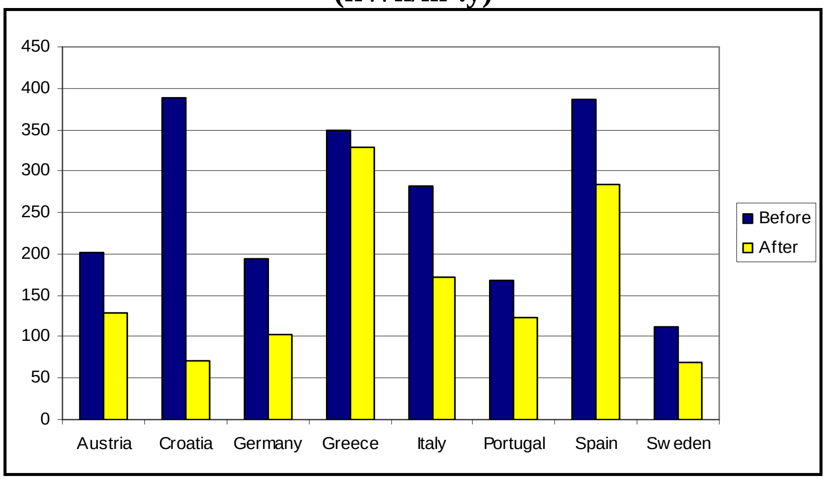
[5] It is a new building thus the savings mean comparison to respective legal requirements.

energy demand after refurbishment was 328.6 kWh/m^2.y, whereas the minimum value reached only 11.1 kWh/m^2.y, thus basically getting to the passive house standard.

On average, the energy efficiency measures brought a decrease of the specific consumption of 58 kWh/m^2.y. The highest absolute difference between the specific primary energy demand before and after refurbishment was 496.4 kWh/m^2.y (from 558 to 62 kWh/m^2.y), the lowest absolute difference reached 11.9 kWh/m^2.y (from 45.5 to 33.6, which means savings of 26 %).

The building energy consumption at existing buildings seems on average the lowest in Sweden – ca 100 kWh/m^2.y, where a lot of heating and cooling is supplied by district heating (Figure 2). Conversely, the highest consumption of conventional buildings is observed in Spain, Croatia, Greece or Italy (over 250 kWh/m^2.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/m^2.y to 70 kWh/m^2.y).

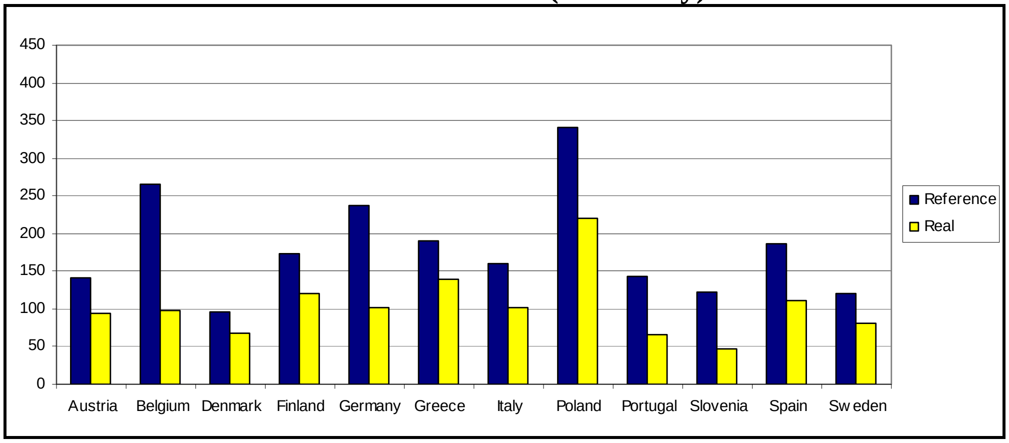
Figure 2. Primary Energy Demand of Existing Buildings Before and After Refurbishment (kWh/m^2.y)



On the other hand the existing office buildings in Sweden already tend to have a relatively lower specific energy demand (average of 111 kWh/m^2.y). Nevertheless, the average difference between the values before and after refurbishment are 40 kWh/m2y, i.e. still 36 % of the original primary energy demand.

New buildings. Figure 3 depicts the increased in efficiency of newly constructed office buildings in the GBP. 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.

Figure 3. Specific Primary Energy Demand of Newly Constructed Buildings and Related Reference Values (kWh/m^2.y)



It is important to keep in mind that the values to which the buildings are compared to are not a representative sample of the current legal requirements in the country. Nevertheless, some patterns can be seen. 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/m^2.y (95.6); however, there was only one building in the sample. The average reference requirements in Slovenia are 122 kWh/m^2.y and 120 kWh/m^2.y in Sweden.

In Germany, the results are biased by one building, where the legal requirements would be more than 980 kWh/m^2.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 goes down to 190 kWh/m2y. Two buildings related the consumption to m^3 instead of m^2. The legal requirements are 14.7 kWh/m^{3}y and 12.8 KWh/m^3.y.

The average specific primary energy consumption to which the new buildings are compared to is 184 kWh/m^2.y. The highest reference value reached 984.3 KWh/m^2.y and the lowest was a legal requirement for passive houses: 21.6 KWh/m^2.y.

The maximum absolute difference reached between the legal requirement and the real energy demand of the building was 961 kWh/m^2.y (the already previously mentioned Test centre for transformers). When disregarding this uncommon case, the highest absolute difference is 226 kWh/m^2.y (40 kWh/m^2.y instead of 266 kWh/m^2.y, which is the reference national standard).

On average, the new buildings consume 87 kWh/m^2.y less than the respective national standards (71 kWh/m^2.y if disregarding the value of the Test centre).The smallest achieved difference is only 10.7 kWh/m^2.y. Therefore the ca 11 kWh/m^2.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%[6].

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

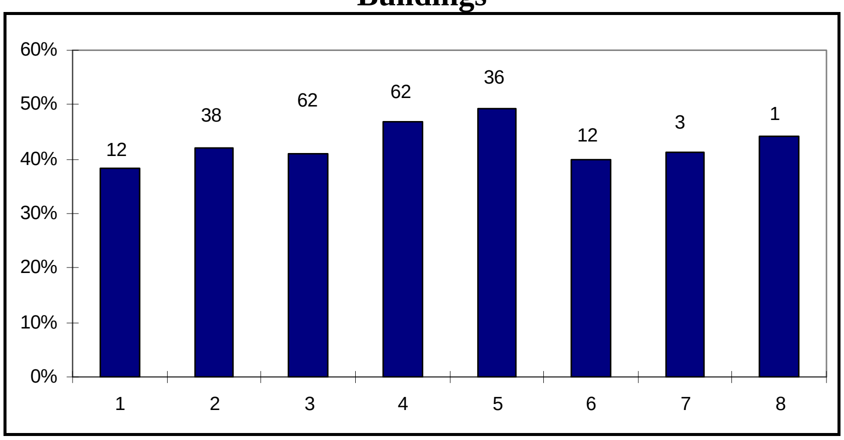
Energy Efficiency Measures

The energy efficiency measures are what makes the energy efficiency improvement (or energy savings) possible. From the total of 286 Partner Buildings, 227 of them (79 %) have reported on the implemented measures.

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 the number of measures and relative savings (%) is shown in Figure 4. The numbers on top of the columns represent the number of buildings in which the respective number of measures was implemented[7]. Therefore, it can be seen that, respecting the average number of measures, in the most building 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.

Figure 4. Average Savings (%) per Number of Implemented Measures in the Partner Buildings

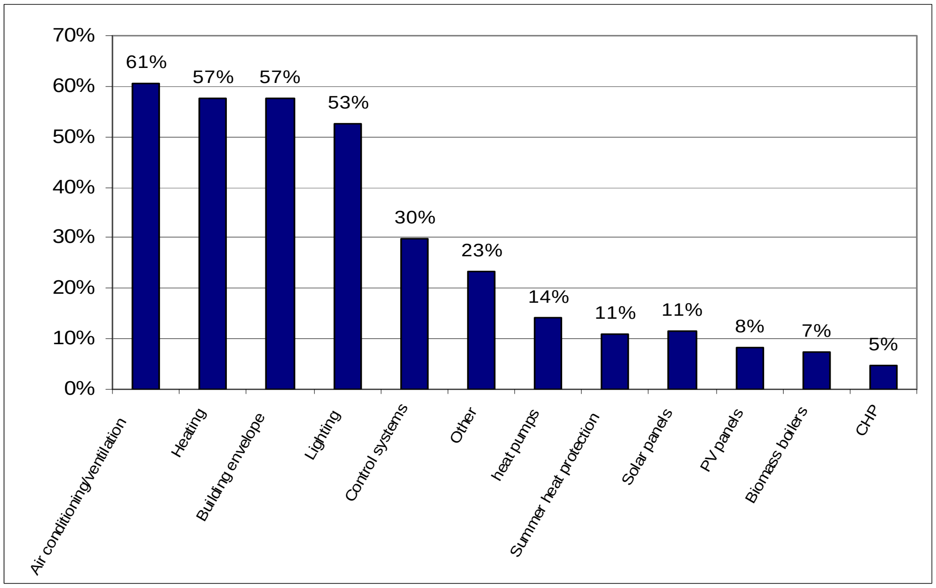


Therefore, it can be concluded that based on the sample, no real *(significant)* correlation between the number of measures and the percentage savings has been found (only a weak one). Nevertheless, the highest average savings are achieved when four to five measures are implemented (47.3 % and 49.9 % respectively). The typical measures are heating, air conditioning and ventilation, building envelope and lighting, following the distribution of measures in the subsequent. Figure 5 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

[7] The "number of measures" means how many measures, structured as in Figure 5, were implemented in the respective building.

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

Figure 5. Measures in Buildings (%)



About 52 % of energy consumption in tertiary buildings goes to space heating. Heating systems (together with building envelope) offer a significant potential for savings (GBP 2006). Therefore the most often, the GBP chose heating as their main target for efficiency measures. In Figure 19, the measures under "Heating", which are present in 57 % of buildings, mean basically 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 used for heating 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 of these "heating" measures added together, heating systems have been upgraded or dealt with in 85 % of the cases.

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 –Combined heat and Power systems). 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.

More than 60 % of the Partner Buildings (61 %) have focused on the ventilation/air conditioning and cooling systems. The measures mostly concern the 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 of 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, the 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 and thus may be seen 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). To add more savings, lighting is 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[8]. 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. 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 1MW installed capacity. Roughly, the total installed capacity in GBP buildings amounts to 1400 kWp. The area of the solar panels ranges from 5 m^2 up to 300 m^2.

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. Most frequently (% 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).

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[8] The building management system can be further used to control security or fire systems

Economic Aspects of Selected Projects

Economic effectiveness of the projects is one of the prerequisites to become a GreenBuilding Partner and only few partners have reported on this. The economic aspects of the GreenBuilding Programme buildings could therefore be evaluated only to a limited extent. Also, there is no common format to report on the economic features. Therefore the Partners reported different economic indicators, such as pay back time, NPV, IRR, cost of the investment or the yearly cost savings.

Only a small fraction of Partners (less than 8 % of the Partner buildings) reported on the financial features of the energy efficiency investment. The main conclusions from their reporting are shown in Table 1.

Table 1. Economic Aspects of the GreenBuilding Partner Buildings

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

There were 25 partners who reported the costs of the investment[9]. 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, or the opposite way, on average 131 MWh/year were saved for 1 EUR of (additional) investment. This 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 corresponds to 32 KWh/year. When looking at the payback times of the investments, the numbers vary greatly. The average simple payback time is 8.8 years[10]. 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 to measures to it (implementing less costly measures with short payback time such as e.g. lighting).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.

Conclusions

Within the four year operation of the GreenBuilding Programme, a total of 167 Partners have joined with 286 Partner buildings. The total savings achieved by the Partners are 298 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).

Office buildings are the most represented building type use among the Partner buildings and therefore also represent almost half of the total savings (141 GWh/year). Among countries,

[9] Plus there was one partner who reported costs, but the overall savings were not available.

[10] 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.

the highest savings so far have been achieved in Germany and in Sweden, together representing more than half of the savings (166 GWh/year). There is a quite strong relationship between the total area of the buildings and the absolute savings. The average percentage savings amount to 41 %, which is well above the GreenBuilding Programme requirements (25 %). The highest average relative savings have been achieved in commercial and leisure centres (55 %), the lowest in healthcare facilities (32 %)[11]. The percentage savings (statistically) depend neither on the year of construction of the buildings, nor on the building type. There is also a weak correlation between the number of measures and percentage savings.

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 85 kWh/m^2.y. In new office buildings, the average specific savings were a little lower (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 (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 (Valentova and Bertoldi 2008).

Economic effectiveness is a prerequisite for joining the GreenBuilding Programme, all of the projects are assumed to be economically viable (this is also why Partners have rarely reported on the economic features of the projects).

The GreenBuilding Programme has been successful over its four year operation. The number of Partners is growing increasingly. The aim is now to promote these good practice examples to a wider public.

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