Energy Efficient and Sustainable – Federal Buildings in Germany

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Born 1970, studied Energy Engineering at the TU Berlin. After graduating in 1998, he worked as a Research Associate at the TU Berlin (Hermann-Rietschel-Institute for Heating, Ventilation and Air Conditioning, PhD there in 2003). Since 2006 at the Institute for Rehabilitation and Modernization of Buildings (IEMB). Since 2009 Head of Division "Energyoptimized Building" at the Federal Institute for Research on Building, Urban Affairs and Spatial Development (BBSR) within the Federal Office for Building and Regional Planning (BBR). Since November 2008 Federal Energy Commissioner by order of the Federal Ministry of Transport, Building and Urban Development (BMVBS).

Introduction

After the German reunification in 1990 the German Government has decided to move from Bonn (former capital city) to Berlin. In association with that move lots of Federal Buildings in Berlin had to be refurbished for that purpose or were newly erected. It was a main objective of the German Government that the Federal Buildings have a very high sustainable and energetic standard in general. For that reason, already in 1991 it was decided by the Federal Government to establish a Commissioner for Energy in Federal Buildings. First the focus of the work was on the Federal Buildings in Berlin, but meanwhile it is widened to all Federal Buildings. The main tasks for that person are:

- Minimization of the energy demand/ consumption in Federal Buildings
- Optimization of the energy supply concepts in Federal Buildings
- Monitoring of assorted Federal Buildings in the first years of operation
- Certification of the Energy demand of assorted Federal Buildings regarding to the German Energy Saving Ordinance
- Consulting the Federal Ministry for Transport, Building and Urban Development in questions of energy efficiency in buildings, and technical components and systems

In addition to the work of the Commissioner for Energy and to support a consistent high standard in Federal Buildings, a "Guideline for Sustainable Building"

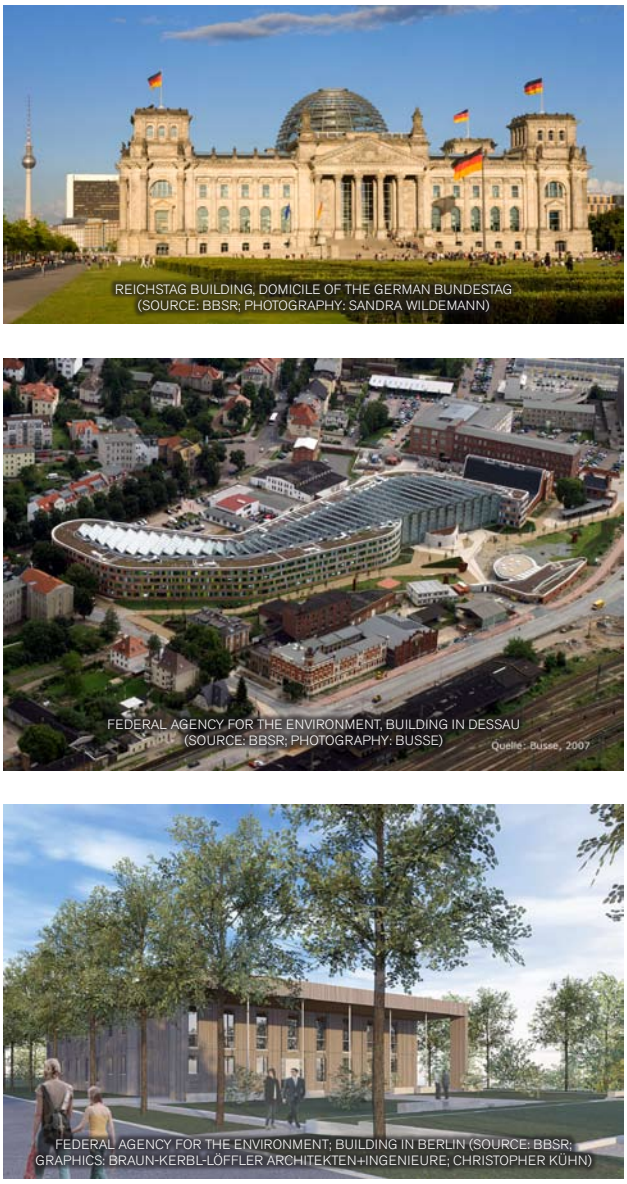

Figure 1. 20 Years Commissioner for Energy in Federal Buildings – Examples of a successful work.

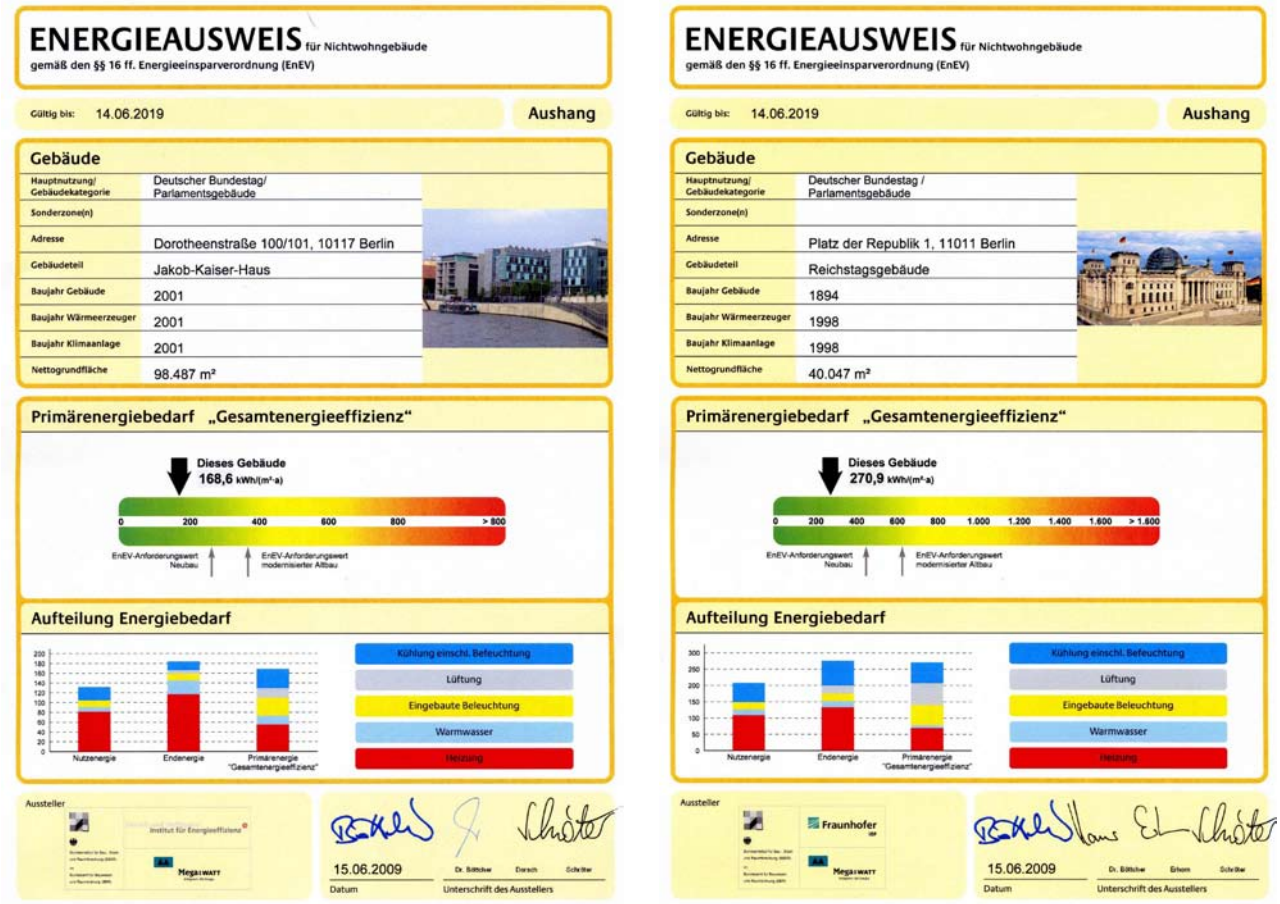

Figure 2. Energy Certificates of the Jakob-Kaiser-Haus (left) and the Reichstag Building (right). (source: BBSR)

was published by the Federal Ministry for Transport, Building and Urban Development in 2001. This guideline has to be taken into account in the planning process of all Federal Buildings. Meanwhile it became a standard planning tool in other public or private building projects too. A revision of that guideline for new buildings was done, which was inaugurated by an edict in 2011 and completed by the Assessment System for Sustainable Building. The revision of the guideline for existing buildings and for the operating of buildings, including the particular assessment systems, is still in process. It is foreseen to finish the work in 2012.

After 20 years of implementation the position of a Commissioner for Energy in Federal Buildings, it is time to look on the achieved results. For that the energetic quality of governmental buildings in Berlin was analyzed and is shown below. Further more it is reported about a former Lighthouse-project which is still in operation and an actual Lighthouse-Project, which is still in erection-phase.

Results

By order of the Federal Ministry for Transport, Building and Urban Development, the Commissioner for Energy in Federal Buildings has certified 39 assorted Buildings of the German Government in Berlin. As examples, the results for the Jakob-Kaiser-Haus (new erected) and the Reichstag Building (energetically refurbished) are shown in **Figure 2**.

The certificates are documenting the high energetic quality of both buildings. The calculated specific Primary Energy Demand (arrow above the multicoloured bar) of the buildings in both cases is significant below the reference values from the Energy Saving Ordinance 2007 (arrows beneath the multicoloured bar). For the comparison between the results for the "real" building and the requirements of the Energy Saving Ordinance, each certificate contains two reference values - the reference value for new erected buildings and the reference value for energetically refurbished buildings. The latter refer-

ence value is 40 percent higher than the reference value for a new erected building.

The results shown in **Figure 2** are typical for all of the 39 certified Federal Buildings. All observed buildings were found to have a higher energetic standard than required by the German Energy Saving Ordinance 2007. This is especially mentionable because the buildings were planned regarding to the energetic specifications and requirements of the German Thermal Insulation Ordinance of 1995. Often already the harder energetic requirements of the EnEV 2009 (came into effect at 1st October 2009 and is still actual) were adhered.

Regarding to the requirements of the Energy Saving Ordinance 2007, the span of undercutting the reference values is from 20 to 60 percent for the specific annual Primary Energy Demand Q_P respectively up to 75 percent for the specific Heat Flow by transmission H_T'.

As the result of the strategic work in the planning process of the different buildings, a high sustainability and energy efficiency were achieved. The main principles of this strategic work are the reduction of the energy demand of a building to a minimum as the most important task, followed by the implementation of the most efficient and ecological energy supply concept. Some detailed measures are mentioned as follows:

- no cooling in rooms with normal use (for instance offices)
- no domestic hot water supply
- maximization of using daylight
- broad use of renewable energies
- preferable use of combined heat and power generation
- high level of heat protection for winter and summer cases

As example for the realization of the above mentioned measures, the energy supply concept of the Buildings of the German Bundestag and the Office of the Federal Chancellor in the Spreebogen is going to be explained a little bit deeper.

The core of the energy supply concept for the Buildings of the German Bundestag in the Spreebogen is the use of 8 combined heat and power generators with a total electrical power of 3 200 MW in sum. The generators are using bio fuel. All buildings are connected to each other to ensure an optimal distribution of the produced heat and electricity. In addition with PV-systems on the roofs of different buildings (see **Table 1**) and the use of

Table 1. Photovoltaic systems in Federal Buildings in the Spreebogen in Berlin.

	Area in m^2	installed Power in kW_{Peak}	Form
Reichstag	300	39	monocrystalline
Jakob-Kaiser-Haus	420	46	monocrystalline
Paul-Löbe-Haus	3.240	123	amorphous
Office of the Federal Chancellor	1.270	149	monocrystalline

two separated storages (Aquifer) in the ground (60 m depth for cooling purposes, 300 m depth for heating purposes), with this concept up to 60% of the total energy demand of the buildings could be covered by renewable energies. The Office of the Federal Chancellor has a combined heat and power generator too and is also equipped with PV-systems on the roof. A subsurface connection to the Buildings of the German Bundestag is possible in general but in practice not in use.

One of the more recent Lighthouse-projects for energy efficiency and sustainability in Federal Buildings is the new Main Building of the Federal Agency for the Environment (UBA) which was erected in Dessau. This building went in operation in 2005 after ten years of planning and erection. During the planning phase it was implemented a broad monitoring concept. The energetic monitoring of the building was intensively accompanied by the Commissioner for Energy in Federal Buildings in the first years of operation. The energy supply concept and an image of the building are shown in **Figure 3**.

The building is mainly heated by district heating. But, there are also some assistance systems to support the heat production. The ventilation system is equipped with high efficient heat recovery systems and a huge ground to air heat exchanger (5 000 m^2 of heat exchanging surface) is used to pre-heat or pre-cool the outside air. Furthermore solar thermal collectors were installed, which are mainly producing the heat for an adsorption chiller. This chiller is producing about 40% of the required cooling. About 50% of the cooling demand is produced by using free cooling systems (i.e., the use of the recooling plants without a simultaneous use of the chillers) and a compression chiller is in operation for less than 10%. The electricity predominantly comes from

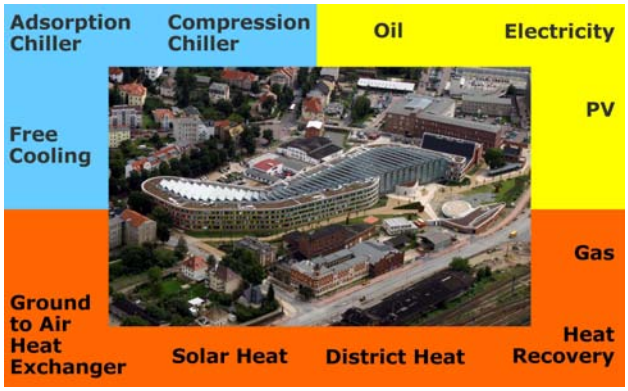

Figure 3. Energy supply concept of the Federal Agency for the Environment in Dessau. (source: BBSR; photography: Busse)

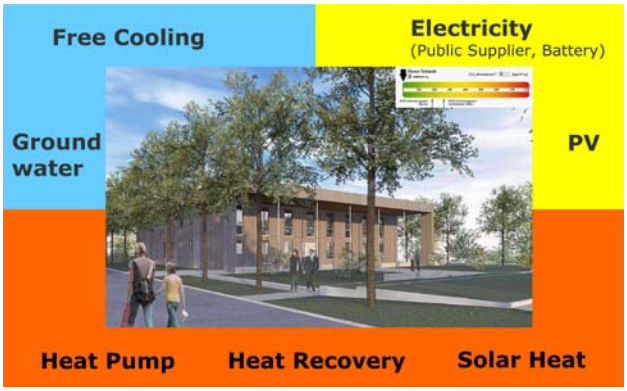

Figure 4. Image and Energy-Supply-Concept of the Net-Zero-Energy-Building of the Federal Agency for the Environment in Berlin (source: BBSR; graphics: Braun-Kerbl-Löffler Architekten + Ingenieure; Christopher Kühn)

the public grid complemented by a PV-system with an installed power of about 32 kWpeak. Gas is exclusively used for the staff-restaurant (a separate building on the site) to cook and to produce heat and domestic hot water.

The monitoring of the operation of the building in the first years was affected by lots of small successes but also failures. It took about 3 years to achieve a stable operating of the building in the boundary parameters that were expected. First, in 2008 there was a primary energy consumption less than 100 kWh/(m²a). But, the efforts of the monitoring process combined with lots of optimizations paid off, because since 2008 there is a permanently undercut of the mentioned energetic benchmark year by year.

One special task of the project was the optimization of the interacting of the ground to air heat exchanger and the heat recovery systems. Each system separately leads to a reduced demand of final energy. But, if both systems are working in line, they are influencing each other. As example, the optimized operation of the ground to air heat exchanger is reducing the potential of the heat recovery systems. However, monitoring allowed the development of an optimized strategy for the operation of both systems. So, the focus was the increase of the energy efficiency of the whole system and not only its single parts individually.

In a present Lighthouse-project, we are planning a Net-Zero-Energy-Building for Federal purposes. "Net-Zero" means that the annual energy demand of the building is totally covered by using renewable energies in an annual balance. To fulfil the plan of a Net-Zero-Energy-Building, consequently we decided to take into account in our energy balance not only the building related energy demand (Heating, Lighting, Cooling, Ventilation, and Domestic Hot Water) but also the user related energy demand (PC's, coffee machines, etc.).

The building will be an office. An image of that building and the energy supply concept is shown in **Figure 4**. The building is heated using an electrically powered water/water heat pump which is also mainly providing the heat for the required domestic hot water. Furthermore, a solar thermal collector is installed on the roof to assist the heat pump. As environmental source for the heat pump, ground water is used. The energy demand for heating is reduced by using a high efficient heat recovery system in the ventilation system. For cooling purposes it is foreseen to use ground water too. To reduce the energy demand for cooling, it is also possible to open the triple-glazed windows.

Realizing a building with highest energy requirements means a compact building form that has a relationship as ideal as possible between the external surfaces and the volume. At the same time, sufficient surfaces for solar energy use are also required. In the present case, the compact rectangular structure has got a large roof. On the one hand the roof is ensuring the required area for the solar systems and on the other hand it is optimizing the shading on the south side. The order of the functions and uses in the two floors has been optimized from an energetic perspective too. To protect the offices from overheating and at the same time to optimize the daylight use, they are orientated to west, east and north, while the meeting rooms in the upper floor and the showering areas, including the changing areas, are situated to the south. Auxiliary rooms are located in the building's core.

The façade consisting of prefabricated wooden panels. The U-values for the opaque parts of the building envelope are in the range of 0.10 W/(m²K). The windows with integrated sun protection can be opened and have an U-value of 0.80 W/(m²K) in total. The planned structure enables a high degree of air tightness and as few thermal bridges as possible.

Calculations indicate a total annual electricity demand of 48 000 kWh/a to run the building. The PV-System on the roof of the building was designed on the basis of that result. The 380 modules of the chosen PV system have a performance of about 58 kWpeak. With that system configuration, an annual power generation of about 50 000 kWh/a is forecasted. The generated power is directly used, stored in a small battery system or fed into the grid of the site.

In addition to energy efficiency and a broad use of renewable energies, the ecological focus of the planning measures lies in the resource-friendly use of building materials, a gentle approach to the surface area used and low local and global environmental effects. As result of the efforts in the planning phase, the global warming potential resulting from construction and operating the building is extremely low compared to a conventional building.

The operating of the building in an annual balance is climate neutral. Therefore it will be the first Federal Building which fulfils already the actual CO_2 saving policy of the Federal Government regarding to Federal Buildings. In 2010, as part of the Sustainability Strategy of the Federal Government, it was felt the decision to develop the Federal Building stock into a climate neutral one. That means that all new Federal Buildings from 2012 will be erected in a "Nearly Zero Energy Standard" and the stock of existing buildings will be energetic refurbished in a way that reduces the energy demand for room heating by 20% until 2020 and the primary energy demand by 80% until 2050. At present, the work on an energetic refurbishment roadmap with a view of achieving the political objectives and the definition of the above mentioned energetic standard for federal Buildings is in progress.