678: The Evolution of Energy Efficiency Policy in Germany and the EnEV 2007

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Abstract

The current requirements on buildings' energy efficiency stimulate the creation of standards and tools which allow to optimize new or existing buildings. The energy efficiency assessment in Germany leads to the new ordinance EnEV 2007, which is responsible to issue the actual energy passes. This paper shows the evolution of German energy efficiency policies between 1969 and 2007, and has been developed by deep research of norms and ordinances of energy efficiency, it shows in brief form the main features and evolution of norm DIN 4108 and the ordinances WSVO 1977, WSVO 1984, WSVO 1995 and EnEV 2002/2004. A work into details had been developed in the current EnEV 2007. The paper highlighted the main changes, methodologies, reference values as well as the positive and negative aspects.

Keywords: energy pass; EnEV 2007; energy balance

1. Introduction

It begins with a review of basic concept of energy efficiency in Germany, current energy scenario, units and general used methods. In sequence, there is presented an overview of the standards evolution, regulations, calculation methods and their impact in the national energy consumption. It is also discussed, the introduction of energy policies into the EU (***E**uropean **U**nion*) through the EPBD [1] (***E**nergy **P**erformance of **B**uildings **D**irective*) and its influence on the new ordinance of energy savings EnEV 2007 [2] (*Energieeinsparverordnung*) which uses as calculation method for residential buildings the DIN V 4108-6 [3], DIN V 4701-10 [4] and for the non-residential ones the new DIN V 18599 [5].

1.1 Overview

Germany is a major consumer and importer of energy. In 2007, 76% of total energy demand of the country was covered by import, among them 97% of oil, natural gas 82% and 66% of hard coal [6]. With an annual consumption of 9.299 Penta Joule, industrial processes, predominantly rail transport and heating, are the main consumers of energy. Figure 1 presents the energy consumption by sector.

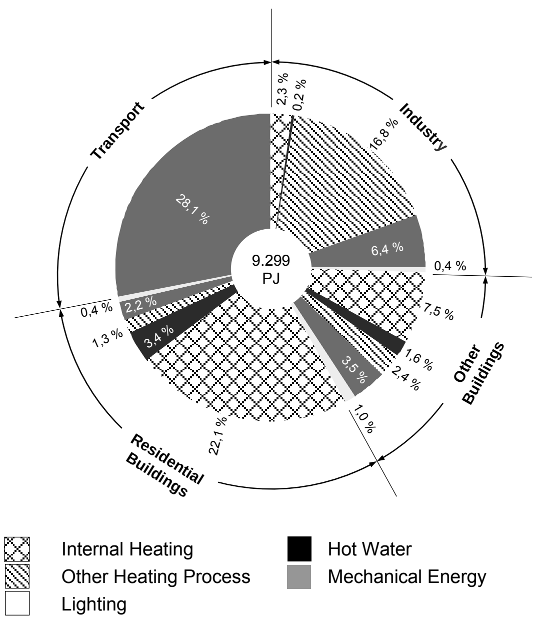


Fig 1. End Energy consumption in 2005 [7].

After the U.S., China, Russia, Japan and India, Germany is the sixth largest emitter of CO_2 (fuels burn) in the world with 813,48 million tons of CO_2 and 9,87 t CO_2/capita [8]. Therefore, in recent decades Germany has been consistently pursuing researches on the area of energy efficiency, optimizing the consumption and investing in development of renewable sources of energy.

Since 2006 the property market in Germany and other EU countries has been heavily influenced by the energy certification. For the first time is being required the Energy Performance Pass for existing buildings in case of sale, lease or large-scale renovation. Aftermath of the introduction of

the energy passes throughout the national territory, including public buildings, control of energy consumption in buildings become regulated and clear. Moreover, this triggered off large investments in development of materials and construction technology.
The certificates contain information about two classes of energy: one has an environmental character, refers to the energy embodied in the natural resources and the second one - financial, refers to the energy consumed by the final users. They are respectively defined as "Primary Energy" and "End Energy."

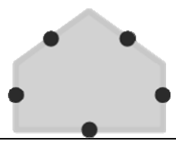
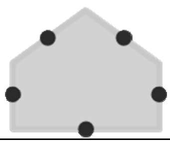
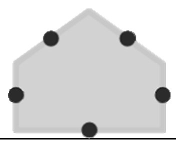
1.2 Main Aspects

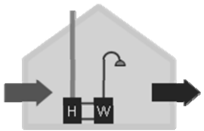
In the calculations of energy efficiency in Germany, the standards like DIN V 4108-6 [3], DIN V 18599 [5] and ordinance EnEV 2007 [2] are instruments widely used, but with different characteristics. In brief, the standards as instructive character define the calculation method. The ordinances as mandatory character, define the values of energy demand to be achieved and determine what standards should be taken into account in the calculations.
Some basic concepts should be considered to avoid errors in the use of these norms. The energy efficiency calculations can present results on demand and/or consumption. The first is simulated or calculated the second is measured and both results are presented in kWh/(m²·a). The energy legislation classifies the energy in 3 ways: (1) Primary energy, energy resource available in nature, such as oil and natural gas, (2) End energy, delivered to the building and (3) Building energy use, energy required. Among the extraction and the End Energy, different forms of energy suffer losses during the extraction, processing and transport to the buildings. To assess the actual CO_2 emissions and energy requirements, the current norms use the Primary Energy as reference. For the conversion are used Primary Energy factors "f_p", which are possible to calculate the amount of primary energy related to the energy delivered to the building.
There are different conversion factors for each energy source. Examples commonly used and their factors (non-renewable energy sources): Electricity Mix (2,7); natural gas (1,1); anthracite coal (1,2) and wood (0,2). As example, in Electricity Mix 2,7 kWh of Primary Energy corresponds to 1 kWh of End Energy [5]. By this way, it is possible to calculate the individual performance of the energy sources and use them more efficiently according to the final use.

2. Evolution of the Ordinances

The first ordinance on energy savings in Germany was the WSVO 1977 [10]. However, the norm DIN 4108: 1969 [11] aiming the physical protection of the building against humidity and mould on the walls, limited the minimum resistance values "R" (Table 1), contributing to reduce the heat losses and heating energy demand. Thus, the Table 1 begins with DIN 4108: 1969 [11], a summary of the evolution of the main standards and Germans technical ordinances from 1969 to 2004.

Table 1: Evolution between 1969 – 2004.

ORDINANCE/ NORM	SCHEME	GENERAL REQUIREMENTS	SPECIFIC REQUIREMENTS
- DIN 4108:1969 [11]		• Minimum values of "R" in reason of buildings physics and financial aspects.	• Minimum limits of thermal resistance "R" (not included in this calculation R_{si}+R_{se}). • Reference values on buildings fabric.
WSVO 1977 [10]		• Average limits for thermal transmittance "U_{max}".	• Limits for thermal transmittance "U_{max}" depending on A/V_e. • Reference values on buildings fabric. • Envelope tightness.
WSVO 1984 [12]		• Idem WSVO 1977 [10] with: - 20% in requirements.	• Idem WSVO 1977 [10].
WSVO 1995 [13]		• Balance of the annual heating demand, applying balance methodology during heating periods. • From 20 to 30% less heating demand than WSVO 1984 [12]. • Beginning to use kWh/(m²·a) as reference.	• Annual heating demand "Q_h" depending on A/V_e. • Reference values on buildings fabric in small residencies. • Envelope tightness. • Thermal protection in summer. • Considerations in buildings renovation. • Certificate in heating demand.

		• Type: Building Energy Use.	
EnEV 2002 [14] **DIN V 4108-6:2000/11 [15]** **DIN V 4701-10:2001/02 [16]** **EnEV 2004 [17]** **DIN V 4108-6:2003 [3]** **DIN V 4701-10:2003 [4]**	 Domestic Hot Water "Q_W" Equipments losses on "e_P"	• Annual balance demand on Primary Energy "Q_p" applying monthly balance methodology or during heating periods. • 30% less demand of End Energy than WSVO 1995 [13]. • Considerations on technical equipments losses.	• Annual heating demand "Q_h" depending on A/V_e. • Requirements on specific heating losses by transmission "H'_T". • Envelope tightness. • Thermal protection in summer. • Considerations in buildings renovation. • Requirements on thermal bridges. • Mandatory equipments substitution for existing buildings. • Requirements in boilers, central control, hot water tanks and isolation on facilities. • Energy certificate on demand.

3. EPBD in EU

The EPBD [1] works on new energy policies in Europe focusing on the reduction of CO_2 emissions, increasing of energy efficiency and renewable energy. In 2006, the EC (***E**uropean* ***C**ouncil*), developed new energy policies seeking to combat the climate changes and to reduce the dependence of imported energy in EU.

In sequence, the EC adopted an Action Plan for Energy Efficiency, followed by an integrated package of energy and climate changes in January 2007. Thus the EU seeks to reduce the greenhouse gases emission and global primary energy consumption in 20% by 2020 (related to data from 1990) and increase the rates of renewable energy from the current 7% to 20% by 2020 [1]. With this, the intelligent energy became the main subject of discussion as energy of the future and the new IEP (Intelligent Energy Program) - Europe (IEE-II), will have a leading role on this regard.

By January 2006 all EU members were obliged to adapt their national energy efficiency standards in accordance with the guideline of EPBD [1]. This community guideline sets different requirements, particularly in the context of minimum requirements in energy performance for new buildings and large-scale renovations. The introduction of the buildings certification system is intended to become the energy consumption more transparent to buyers, users and sellers.

4. The EPBD Introduction into Germany

According to the EPBD [1], the energy certification should be applied by 04/01/2006, or 04/1/2009 if there are no qualified experts in this scope. In the 1st half of 2007, Denmark was the only country in the EU where the energy certification was considered mandatory in all sectors (residential or services buildings, new or existing).

In the ordinance EnEV 2007 [2], Germany adapted the EPBD [1] guidelines. The new German legislation was amended mainly in non-residential buildings, in questions like: new limits on energy demand using a Reference Building system, building certification in demand or energy consumption and equipments inspection. Nevertheless, there are no significant changes for residential buildings. Regarding the norm DIN V 18599 [5], changes occurred in the calculation method for general energy demand for new and/or existing buildings.

5. The Ordinance EnEV 2007

This part of the article tries to explain briefly by schemes and tables the most important points and advances of EnEV 2007 [2]. The chapters from 1 to 5 have been discussed in this article. The chapter 6 about responsibilities and chapter 7 with reference tables, can be easily found in EnEV 2007 [2]. The ordinance uses as calculation reference in non-residential buildings the standard DIN V 18599 [5], divided into 10 shares and for residential buildings DIN V 4108-06: 2003 [3] changed by DIN V 4108-06: 2004 [18] correction 1, 2004-3 and DIN 4701-10: 2003 [4] changed by DIN 4701-10/A1 [19].

The EnEV 2002/2004 [14, 17] considered in the energy balance only heating, ventilation and hot water. With the inclusion of air-conditioning and lighting, the new EnEV 2007 [2] determines the full calculation of heating demand, cooling and electricity (Figure 2). The general balance of energy efficiency is applied in residential and non-residential buildings using the method of monthly balance or winter heating periods, controlling the limits of annual demand for primary energy.

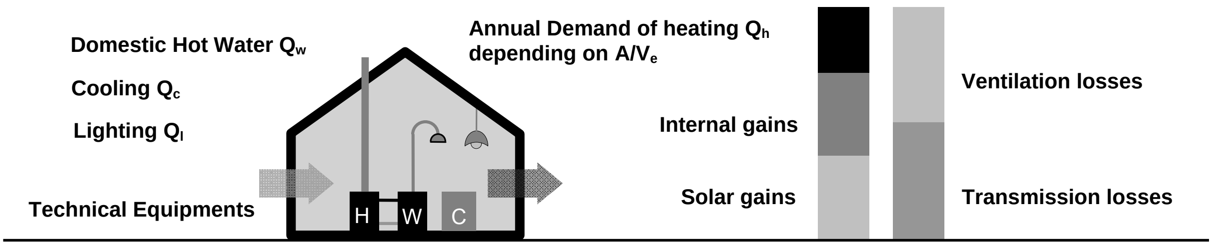


Fig 2. Scheme of integral balance of EnEV 2007.
*Legend: **H**: Heating, **W**: Domestic Hot water, **C**: Cooling.*

Taking into account the higher energy demand for heating (Figure 1) the EnEV 2007 [2] maintains the annual demand for heating "Q_h" dependent of the relation A/V_e, however with stricter values. Others important points, discussed in EnEV 2007 [2] which were originated in the Ordinance EnEV 2002 [14] and have more stricter limits, are: (1) The specific heat losses by transmission "$H´_T$", (2) requirements on the envelope tightness and thermal bridges to prevent heat losses, (3) Shadow devices in the summer to avoid excessive heating, (4) considerations in buildings renovations and (5) requirements in boilers, central control, hot water tanks and isolation facilities.

5.1 General Instructions – Chapter 1. EnEV 2007

The buildings that do not need to follow the rules can be divided into 3 categories; use/type, operation time and time of heating/cooling. By use are exempted from the rule, for example, industrial buildings for breeding animals or cultivation of plants, large industries or wholesalers sectors in the logistic area, underground constructions, inflatable buildings and tents. By operation time and time of heating/cooling, are exempt from norm the provisional buildings with operation time lesser than 2 years, churches with heating period lesser than 4 months, households operation time lesser than 4 months and industrial buildings with work temperature < 12°C or annual heating < 4 months, combined with cooling < 2 months.

5.2 Construction of new Buildings – Chapter 2. EnEV 2007

Chapter 2 refers to requirements on new buildings with floor area larger than 50m² and inform about the calculating methods of the Reference Building. The application of EnEV 2007 [2] for residential buildings works through limits values and for non-residential building by a system known as Reference Building, in which according to the use, size and other parameters, a table system provides the designer information about the reference values that must be taken in the energy efficiency calculations, the same procedure is applied to determine the equipments (Figure 3). Briefly, in residential buildings (except buildings with air conditioning) the demand for primary energy "Q_P" and the specific heat losses transmission "$H´_T$", are used as limits for the envelope and equipment, thus $Q_{P\ Residential} \leq Q_{P\ limit}$ and $H´_{T\ Residential} \leq H´_{T\ limit}$. In non-residential buildings, it is estimated from [5], using the Reference Building methodology where $Q_{P\ Non\text{-}residential} \leq Q_{P\ Reference\ Building}$ and $H´_T \leq H´_{T\ limit}$.

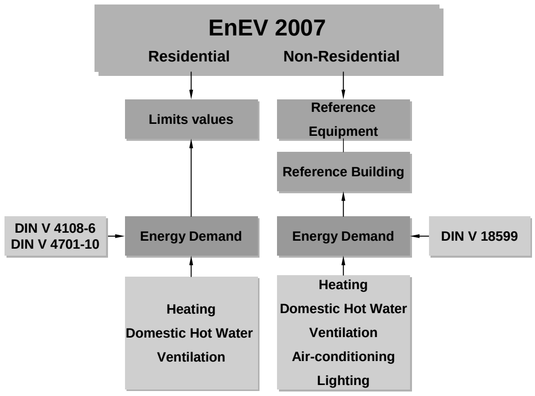


Fig 3. General outline EnEV 2007.

5.3 Existing Buildings and Equipments – Chapter 3. EnEV 2007

There are important considerations made in large-scale renovations. In renovation of residential buildings, it is not allowed that maximum values of "Q_p" and "$H´_T$" exceed 40%. In renovations of non-residential buildings, it is not allowed the primary energy demand of the reference building and the specific coefficient of thermal transmission exceed 40%. The renovations can not reduce the quality of the buildings' thermal efficiency, by changing the constructive elements, systems and equipments. Stringent inspections of cooling systems are adopted, resulting not only on indication of improvements, but also to the replacement of equipment. The inspections frequency depends on the age of equipment, but the minimum is about every 10 years.

5.4 Equipment for Heating, Cooling, Ventilation and Domestic Hot Water – Chapter 4. EnEV 2007

The cooling systems required to meet this norm must have installed power > 12 kW and insufflations volume > 4000 m³/h. In new constructions or retrofit in the cooling system, humidification equipments and automatic operating systems must be installed. Some equipments can continue with their old limits as:

individual fans, insufflation and exhaustion air equipments (renewal of air) respecting certain medium power values [20].

5.5 The Energy Certification – Chapter 5. EnEV 2007

A building can receive only one energy certificate valid for 10 years. The certification by sector can only be issued when they have different occupations. The certificate can be issued by two methods, one calculated on demand through the buildings data and the second by consumption, through the history of energy consumption in recent years. Figure 4 shows what are the criteria to issue a certificate by energy demand or consumption.

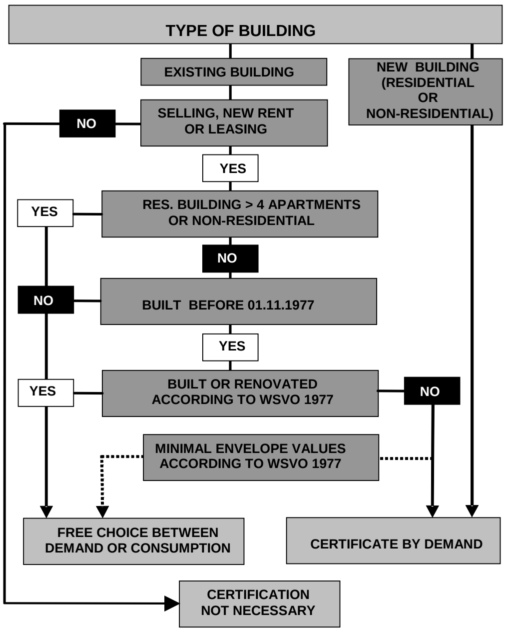


Fig 4. Scheme of certification by demand or consumption.

Defined what are the buildings with mandatory certification, the ordinance stipulated deadlines to issue the certificates. The residential buildings constructed before 1965 must have the certificates from 01.07.2008, the buildings built after 1965 start from 01.01.2009. The Non-residential buildings start from 01.07.2009.

The energy certificates are divided into two distinct categories, one for residential buildings (Figure 5) and other non-residential (Figure 6). This form presents more building details, like applied calculations and types of energy. For non-residential buildings, there are two types of certificates used for mandatory exposition in public place. These two are different in the fundaments, one estimated by energy demand and the other by consumption. The second one is designated for existing buildings, which are shown the improvements to be made.

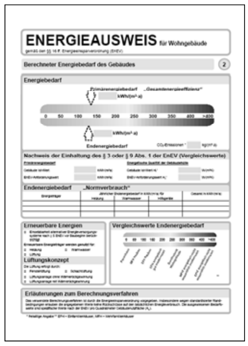


Fig 5. Energy certificate.

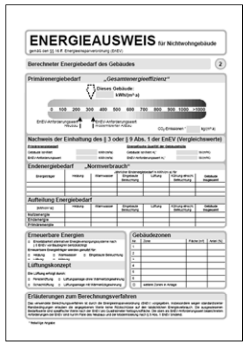


Fig 6. Energy certificate.

6. Conclusion

After the two major oil crisis and the Gulf War, Germany highly dependent on imported energy, seeks by a consistent way the reduction of energy demand through more rigorous standards and ordinances. Figure 7, demonstrates the increasing of energy efficiency with the optimization of equipments and mainly through minimum requirements on thermal insulation. In the last 40 years the heating energy demand has been reduced from 300 kWh/(m²·a) to 50 kWh/(m²·a) for new buildings.

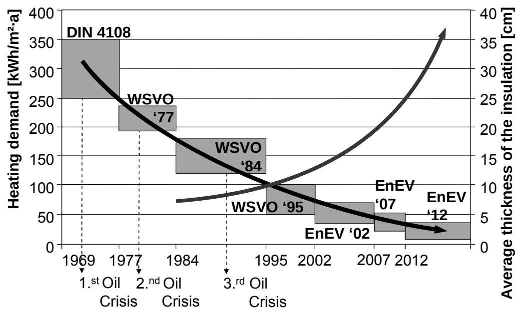


Fig 7. Evolution of German energy efficiency, reduction of heating demand and increase of envelope insulation [21].

However, the use of very isolated envelopes in warmer climates countries in Europe such as Portugal, south of France and Greece is generating discussions about the transposition of EU directives which requires well isolated envelopes. Recently researches [22] show that very dense envelopes, with inadequate shadow devices, hamper the dissipation of solar and internal gains during the summer, canceling the energy savings accumulated during the winter times.

6.1 Positive Aspects

- The EnEV 2007 takes into consideration the total energy of the building (heating, cooling, domestic hot water, ventilation, lighting and auxiliary equipment such as pumps and controls).
- The end result is verified by a mandatory energy certificate, informing consumers and pressing the entrepreneurs (transparency in the real estate market).

- Viability of alternative systems for energy supply (renewable energy sources, cogeneration, heating and cooling originated from industrial processes, heat pumps, etc.).
- Buildings that have received energy certificate, receive also additional technical recommendations that can be implemented in a future renovation.
- The use of primary energy in the certification leads to the correct use of energy source according to final use. This avoids, for example, the use of electricity in the processes of heating water.

6.2 Negative Aspects

- The calculation done by consumption and not by demand has direct influence from the user, which makes difficult to analyze results.
- The procedure for calculating is complex, time consuming and needs specialists.
- The qualification of specialists to issue the energy certificate is a long-term process.

7. Acknowledgements

The author would like to thank CNPq - *Conselho Nacional de Desenvolvimento Científico e Tecnológico* - National Counsel of Technological and Scientific Development, whose sponsorship is allowing the development of a PhD thesis, from which this article is derived and to Professor Dr. M. N. Fisch of IGS - *Institut für Gebäude- und Solartechnik* - Institute for Building Physics and Energy Design for his support in Germany.

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