Building energy standards and labelling in Europe

Imprint

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Index of Abbreviations, Units und Symbols

ADENE ....Agência para a Energia (Portugese Energy Agency)
ASIEPI .... Assessment and Improvement of the EPBD Impact
BBR...Swedish National Building Regulations
Boverket.......................................Swedish National Board of Housing, Building and Planning
BPIE.. Buildings Performance Institute Europe
BUDI ....Pilot Actions to develop a functioning market for energy performance certificates
CDD .... Cooling Degree Day
CE)...Conformité Européenne, (European Conformity)
CTE.............................. Código Técnico de la Edificación (Spanisch Technical Energy Code)
dena .... Deutsche Energie-Agentur (German Energy Agency)
DHW ....Domestic Hot Water
DIBt...Deutsches Institut für Bautechnik
DIN..German Institute for Standardization
EBF ....Energiebezugsfläche (Energy reference area)
EC .... European Commision
EEWärmeG..German Renewable Energies Heat Act
EN ....European Standard
EnEV.. German Energy Efficiency Ordinance
ENFORCE ....European Network for the Energy Performance Certification of Buildings
EPBD ....Energy Performance Building Directive
EPC.. Energy Performance Certificate
ERA..Energie Reference Area (MINERGIE)
EU ....European Union
GBPN..Global Buildings Performance Network
GEG ....German Building Energy Ordinance
GIS...Geographic Information System
HDD .... Heating Degree Day
HULC ....Unified Tool Lider and Calener
HVAC...Heating, Ventilation and Air-Conditioning
ICF ....Insulating Concrete Framework
IMPACT .... Improving energy Performance Assessments and Certification schemes by Tests
ISO..International Organization for Standardization
KfW ....Kreditanstalt für Wiederaufbau (Reconstruction Credit Institute)
LCA .... Life-cycle assessment
MFH ....Multi-Family House
MFOM..Spanish Ministry of Public Works
MINERGIE .... Swiss Energy Standard for low Energy Buildings
MINETUR .... Spanish Ministry of Energy, Tourism and Trade
MOHURDMinistry of Housing and Urban-Rural Development of the People's Republic of China
MQS.. MINERGIE Qulitätssiegel (Quality Certificate)
MS.. Memeber State
MSME ....Micro, Small and Medium Enterprises
MuKEn ....Swiss Model regulations of the cantons in the field of energy
NZEB ....Nearly Zero-Energy Building
PE ....Primary Energy
PER...Primary Energy Renewable
PH ....Passive House
PHI ....Passive House Institute

PHPP .... Passive House Planning Package
PV .... Photovoltaic
RES.......... Renewable Energy Sources, *Renewable Energy Source*
RITE.......... Reglamento de Instalaciones Térmicas en los Edificios
SFH.......... Single Family House
SIA .... Schweizerische Ingenieur- und Architektenverein Standard
SME .... Small and Medium Enterprises
SVEBY...... Swedish program for standardizing and verifying energy performance in buildings
SWEDAC .... Swedish Board for Accreditation and Conformity Assessment
WI.......... Wuppertal Institute
WP .... Work Package

Units and Symbols

$	US-Dollar
%	Prozent
€	Euro
°C	Grad Celsius
a	annum / Jahr
Ag	Silber
Al	Aluminium
Au	Gold
CO_2	Kohlenstoffdioxid
CO_2-Äq.	Kohlenstoffdioxid-Äquivalente
Dy	Dysprosium
g	Gramm
Gt	Gigatonne
h	Stunde
H_2	Wasserstoff
H_2O	Wasser
In	Indium
kg	Kilogramm
km	Kilometer
kt	Kilotonne
kW	Kilowatt
kWh	Kilowattstunde
l	Liter
Li	Lithium
Mio.	Million
MJ	Megajoule
Mrd.	Milliarde
Mt	Megatonne
Nd	Neodym
Nm^3	Normkubikmeter
pkm	Personenkilometer
ppm	Parts per million
s	Sekunde
t	Tonne
Vol.-%	Volumenprozent

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2 Introduction

An effective policy framework is crucial for systematically driving the entire building supply chain towards sustainable development and for driving MSMEs to take up sustainable building practices. Building energy standards and labelling is a key policy, of such a framework, that helps in accelerating the shift from conventional buildings towards sustainable low to ultra-low energy buildings. In this regard, Europe (both at the EU and the national level) can offer lessons to be learnt from its experiences in the development and implementation of building energy standards and labelling. This report presents a study on mandatory and 3rd party (voluntary) building energy standards and labelling policies at the European level and in three European countries. These include Energy Performance Certificates (EPCs) and its implementation in each member states as well as voluntary labelling such as Passive House Standard,KfW Efficiency House (Effizenzhaus),Active House, and MINERGIE.

These countries have climates similar to the climate zones of the project regions in China (Yunnan Province and Chongqing City)- cold (Sweden), temperate (Germany) and warm (Spain) – and are therefore selected.

3 Climate zoning

In order to provide relevant lessons about standards and labelling policies in Europe to China, this section identifies European countries with similar climate zones to those of the project regions in China (Yunnan Province and Chongqing City).

The climate zones of Europe and China were compared according to their heating degrees days (HDD) based on a set temperature of 18°C and cooling degree days (CDD) based on a set temperature of 10°C. Sources such as Eurostat and Degreedays.net for Europe and Meteonorm for China are considered for defining climate zones. European countries are classified into cold, temperate and warm zones based on the number of HDD and CDD (Table 3-1) and various regions in China were classified, correspondingly (Table 3-2). As a result, three European countries, Sweden (cold), Germany (temperate) and Spain (warm), were selected to exemplify how building labels differ across climate zones.

Country	Capital City	Region	HDD18°C (2010-2014)	CDD10°C (2010-2014)	Climate Zone
Estonia	Tallinn	Northern	4462	840	Cold
Finland	Helsinki	Northern	4583	892	Cold
Latvia	Riga	Northern	4218	986	Cold
Lithuania	Vilnius	Northern	4223	1040	Cold
Sweden	Stockholm	Northern	4063	878	Cold
Bulgaria	Sofia	Eastern	2915	1812	Temperate
Croatia	Zagreb	Eastern	2663	1835	Temperate
Czech Republic	Prague	Eastern	3559	1109	Temperate
Hungary	Budapest	Eastern	3012	1681	Temperate
Poland	Warsaw	Eastern	3614	1246	Temperate
Romania	Bucharest	Eastern	2831	2091	Temperate
Slovakia	Bratislava	Eastern	2924	1633	Temperate
Slovenia	Ljubljana	Eastern	3251	1393	Temperate
Austria	Vienna	Western	2773	1610	Temperate
Belgium	Brussels	Western	2886	1128	Temperate
Denmark	Copenhagen	Western	3321	961	Temperate
France	Paris	Western	2548	1419	Temperate
Germany	Berlin	Western	3147	1313	Temperate
Ireland	Dublin	Western	3112	699	Temperate
Luxembourg	Luxembourg	Western	3186	1122	Temperate
Netherlands	Amsterdamn	Western	2864	1093	Temperate
United Kingdom	London	Western	2451	1245	Temperate
Cyprus	Nicosia	Southern	970	3715	Warm
Greece	Athens	Southern	1136	3349	Warm
Italy	Rome	Southern	1557	2522	Warm
Malta	Valletta	Southern	721	3354	Warm
Portugal	Lisbon	Southern	1094	2543	Warm
Spain	Madrid	Southern	1989	2467	Warm

Source: Eurostat and Degreedays.net

Climate definition

	Description	HDD 18 °C	CDD 10 °C
Cold (Climatic regions with a high heating load)	Cold climates have a high heating demand for all or part of the year and no or little cooling demand. Climatic conditions are cool with four distinct seasons cold to very cold winters, with cool to warm summers and variable spring and autumn conditions	>3500	<5500
Temperate (Climatic regions with a medium heating load and low cooling load)	Temperate climates have both a heating and cooling demand for all or part of the year. Climatic conditions are with four distinct seasons cool to cold winters, mild to warm summers and variable spring and autumn conditions. These climatic regions require no or very little cooling in summer.	>2000	<3500
Warm (Climatic regions with a high cooling load and low humidity levels)	Hot and Arid climates have a cooling and no heating demand throughout the year as well as low relative humidity levels throughout the year. These climates have hot to very hot summers with little rainfall and low humidity throughout the year. In addition to this the solar insolation tends to be extremely high. The difference between diurnal and nocturnal temperature is quite high. Depending on location the temperatures can become cool during the winter.	>500	>2000

Table 3-1 : Climate Classification of European countries. (Source: Eurostat and Degreedays.net)

Country	Region	Capital City	HDD18°C (2010-2014)	CDD10°C (2010-2014)	Climate Zone
China	Hainan	Haikou	121	5016	Warm
China	Guangdong	Shenzhen	239	4909	Warm
China	Guangdong	Guangzhou	446	4328	Warm
China	Fujian	Fuzhou	835	3583	Warm
China	Zhejiang	Hangzhou	1220	2781	Warm
China	Chongqing Municipality	Chongqing	1303	2917	Warm
China	Yunnan	Kunming	1487	1871	Warm
China	Jiangxi	Nanchang	1514	3141	Warm
China	Sichuan	Chengdu	1574	2590	Warm
China	Hunan	Changsha	1598	3047	Warm
China	Hubei	Wuhan	1662	3033	Warm
China	Shanghai Municipality	Shanghai	1925	2681	Warm
China	Anhui	Hefei	1983	2650	Warm
China	Jiangsu	Nanjing	2016	2641	Temperate
China	Henan	Zhengzhou	2352	2512	Temperate
China	Shandong	Jinan	2406	2656	Temperate
China	Shaanxi	Xian	2521	2262	Temperate
China	Hebei	Shijiazhuang	2652	2416	Temperate
China	Shandong	Qingdao	2653	1981	Temperate
China	Tianjin Municipality	Tianjin	2995	2232	Temperate
China	Beijing Municipality	Beijing	3035	2164	Temperate
China	Qinghai	Xining	3503	1498	Cold
China	Shanxi	Taiyuan	3504	1679	Cold
China	Gansu	Lanzhou	3521	1504	Cold
China	Xinjiang Uighur	Ürümqi	3764	2311	Cold
China	Ningxia Hui	Yinchuan	3824	1604	Cold
China	Tibet	Lhasa	3826	652	Cold
China	Liaoning	Shenyang	4139	1760	Cold
China	Jilin	Changchun	4719	1537	Cold
China	Innern Mongolia	Hohhot	5081	1221	Cold
China	Heilongjiang	Harbin	5804	1254	Cold

Source: Meteonorm

Table 3-2 : Climate classification of Chinese Regions and Cities. (Source: Meteonorm)

4 Mandatory Energy standards and labelling

4.1 European Level - EPBD and the EPC

The Energy Performance Building Directive (EPBD), Directive 2002/91/EC, aims to steer the building sector towards ambitious energy efficiency standards and an increased use of renewable energy sources (Geissler and Altmann-Mavaddat 2015). European Member States (MSs) and Norway have been in a process to finding the best ways to implement EPBD after its introduction in 2002. The recast EPBD (the Directive 2010/31/EC) replaced EPBD 2002/91/EC and allows for setting minimum energy performance requirements that lead towards achieving Nearly Zero-Energy Buildings (NZEBs) by 2020 based on cost-optimal calculations (ADENE 2015). However, achieving NZEBs by 2020 seems to be a major challenge for most of the MSs, especially, for renovating the huge stock of existing buildings with poor energy performance. Therefore, many MSs have started to implement more effective enforcement and quality control procedure through the Energy Performance Certificates (EPCs) (ADENE 2015).

The EPCs are a powerful tool to create a demand-driven market for energy efficient buildings, which allow estimating the costs in relation to energy consumption and efficiency of a building. The EPC schemes vary throughout selected Member States, based on the specific needs, structure of building stock and various climatic conditions (Atanasiu and Constantinescu 2011). The EPCs show information to consumers and authorities on building energy efficiency levels in comparison to reference minimum energy performance values and they also serve as the basis for loan applications for renovation works (ADENE 2015). This section will discuss the main actions of MSs to achieve NZEBs by 2020 and the implementation of the building label and EPC in various MSs.

The EBPD defines an energy performance certificate as an "certificate recognised by a Member State or by a legal person designated by it, which indicates the energy per-formance of a building or building unit, calculated according to a methodology adopted in accordance with Article 3" of the EPBD.

4.1.1 EPBD actions towards 2020 NZEB

According to the Article 9 of the EPBD, "Member States shall ensure that:

(a) by 31 December 2020 all new buildings are nearly zero- energy buildings; and
(b) after 31 December 2018, new buildings occupied and owned by public authorities are nearly zero-energy buildings" and "draw up national plans for increasing the number of nearly zero-energy buildings".

According to Article 2(2) of the Directive 2010/31/EU *"a nearly zero-energy building means a very high energy performance, as determined in accordance with Annex I. The nearly zero or very low amount of energy required should be covered to a very significant extent by energy from renewable sources, including energy from renewa-ble sources produced on-site or nearby"*

To support this, the EPBD defined a timeline for implementation of NZEB-related actions, which are shown in Figure 4-1.

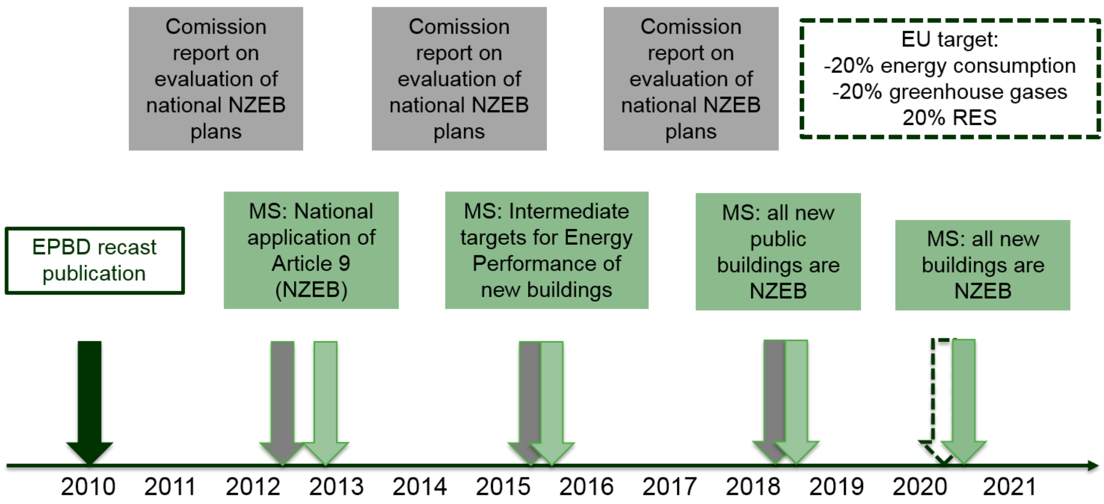


Figure 4-1 : Timeline of NZEB-related actions according to the EPBD
(Source: Erhorn and Erhorn-Kluttig 2015 in ADENE 2015)

As of April 2015, about 60% of the MSs have worked out on the detailed NZEB definition in a legal document and the vast majority of MSs use a primary energy indicator in kWh/m^2.year (ADENE 2015). The approaches to handling Renewable Energy Sources (RES) in the energy performance calculations and legislation for NZEB differ among MSs. Energy from RES can include those located on-site or nearby the building. Beside RES, NZEB considers building envelope constructions and types of building service systems, which depends on climatic conditions. In countries with a warm climate, a combination of NZEB requirements for energy performance with specific comfort criteria is advisable. Ten MSs undertook a cost-optimal study for 2019/2021 (e.g., for NZEBs), taking into account evolving parameters such as primary energy conversion factors, estimated energy prices, investment costs, and technology efficiency developments and innovations. Figure 4-2 shows the timing of planned intermediate targets for energy performance requirements in the different MSs as stated in the national plans for NZEBs, and the deadline for NZEBs in 2019/2021. The black lines show foreseen time spans in which a tightening of energy performance requirements is planned in a country.

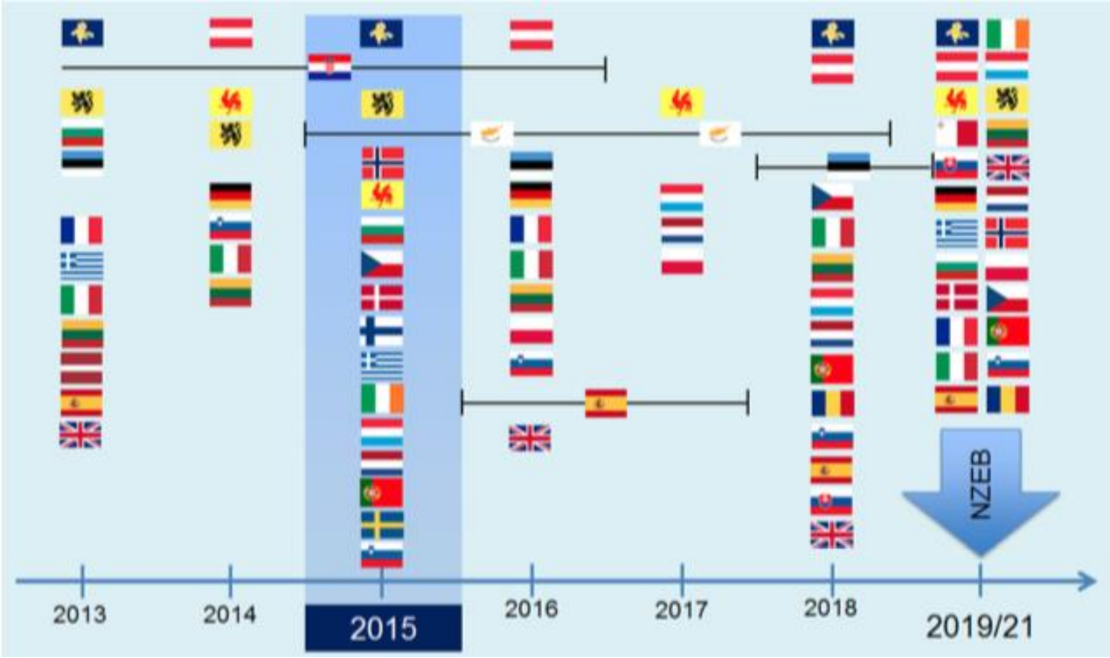


Figure 4-2 : Timing of planned intermediate targets for energy performance requirements in the different MSs (Source: Erhorn and Erhorn-Kluttig 2015 in ADENE 2015).

4.1.2 Implementation of the building label EPC in Member States (MSs)

The Article 3 of EPBD recast provides guidance for Member States regarding the EPC calculation methodology, in accordance with EU standards. While the building energy performance can be evaluated using two methods: on the basis of the calculated (or asset rating) or actual energy consumption (or operational rating), the rating needs to reflect the energy needs associated with a typical use. The adoption of energy performance methodology varies among MSs. Among the 28 EU countries, 14 have adopted the methodology based on calculated energy consumption. In other countries, both the actual and calculated energy consumptions are foreseen, which depends mainly on the building type or building age. In country such as Slovenia, the actual energy performance methodology applies only for non-residential buildings, while in Estonia and Latvia the evaluation of the actual energy consumption is extended to all the existing buildings along with new buildings. In Sweden, a calculated rating is performed before the construction of a new building, and it is compulsory to issue an EPC based on measured energy consumption when completed and occupied. In Luxembourg, Belgium, Malta and Lithuania, the public software can be used for the calculation of the energy indicators. In 12 other countries, both public and commercial software, which are mostly approved by the government, are accepted (BPIE 2014).

The EPBD also provides guidance on the comparative methodology framework for calculating cost-optimal levels of minimum energy performance requirements for buildings and building elements, i.e. the energy performance level to the lowest cost during the estimated economic lifecycle. It has two perspectives: financial (looking at the investment itself at the building level) and macro-economic (looking at the costs and benefits of energy efficiency for society as a whole). MSs have calculated the cost-optimal levels of minimum energy performance requirements using the compar-

ative methodology framework and relevant parameters, such as climatic conditions and the practical accessibility of energy infrastructure, and compared the results of this calculation to the minimum energy performance requirements that are presently in force. The EPBD also requires MSs to report on the comparison between their legal minimum energy performance requirements and calculated cost-optimal levels using the comparative methodology framework. Most MSs have experienced that one or more building types have more lax energy performance requirements than the calculated cost-optimal levels (with more than 15% difference between the two). For reference buildings and energy saving measures for cost-optimal calculations, there is a large variation among MSs' approaches to calculating cost-optimal levels, ranging from a few combinations of measures per reference building up to 100,000 (e.g. Belgium) (Thomsen and Wittchen 2015).

4.1.3 Costs of Certificates

The cost of an EPC is directly related to the time required for the assessment and the accuracy of the assessment method used in its calculation. Simplified schemes make generic assumptions to reduce the associated time and costs, but it may lead to a less substantial assessment and thus inaccuracies, which lowers the quality of the EPCs. EPC costs varies in MSs between ca. 100 € and 400 €[1] for single family buildings, but can also be higher theoretically based on the level of information required and that is provided. In non-residential buildings the prices vary between 1-2 €/m^2 and 5 €/m^2.

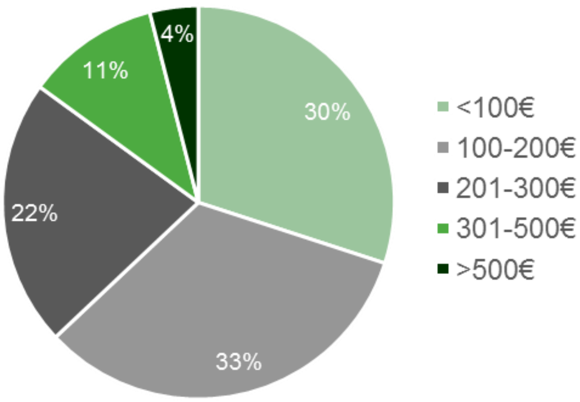


Figure 4-3 : Cost of EPCs for single-family houses based on national reports 2014. (Source: 2016 Implementing the Energy Performance of Buildings Directive)

4.1.4 Compliance and Penalties

For the successful implementation of the EPBD, compliance with the energy performance requirements and control of the EPCs are the vital elements. As per EPBD Article 27, MSs shall lay down the rules on penalties for non-compliance, including for the poor quality of the EPCs. The compliance and control issues vary according to

[1] 2016 Implementing the Energy Performance of Buildings Directive

the MSs. MSs apply both random control to assess the rate of compliance, as per the requirement of the EPBD, and targeted controls to enforce the quality and compliance of the EPCs and inspections. Several MSs have developed smart options for control, through linking different databases and validation rules. MSs check compliance with building regulations at the design stage and/or at the completion of the construction (Roelens, Loncour and Antinucci 2016). Improvements in the efficiency of the regulations are still a challenge for MSs as the compliance rate and a clear picture of the quality of EPCs and inspections are essential information needed to evaluate and improve the efficiency of the regulation.

The penalty for the non-compliance with the energy performance requirement is defined by national legislation but the implementation process is at the regional level in many MSs. These penalties can be administrative and/or monetary. In 15 out of 28 Member States, administrative penalties are foreseen for qualified and/or accredited experts/companies for non-compliance with the EPBD, in the form of a warning procedure (Finland), mandatory training (e.g. Belgium-Wallonia), periodic suspension of licence (e.g. Greece and Hungary up to 3 years, Portugal up to 2 years), and loss of accreditation (e.g. France, Czech Republic, Cyprus, Lithuania, Poland). The administrative penalty issued across MSs is an official warning to the qualified experts and re-certification. A penalty point system has also been introduced in some MSs (e.g. Ireland and Latvia) for wrong certification. The exceeding in the limitation of a certain number of points leads to corrective training or suspension of licence. A maximum of 10 points in 2 years is allowed for EPC experts in Ireland, otherwise the assessor's licence may be suspended (for a period of 3 to 12 months) or terminated (at a second or subsequent offence). In Latvia, the licence is terminated for 6 months if the expert has received 7 or more penalty points and for 12 months if points reach up to 10. Likewise, monetary penalties might be imposed on the qualified experts for non-compliance with the EPBD in 12 out of 28 countries (such as Austria, Flanders, Portugal and the Netherlands). The penalty amount can vary between different Member States, as well as for individual experts (physical persons) and legal entities. Some MSs such as Bulgaria, Czech Republic, Hungary, Croatia, and Slovenia still have not, in practice, imposed fines. In the case of non-compliance with the EPBD, the qualified experts will receive a warning and/or request to correct the EPC at their own expense (BPIE 2014).

4.1.5 Inspection and monitoring

For the inspection and monitoring of building energy performance, MSs have to ensure that independent control systems for EPCs and reports on the inspection of heating and air conditioning systems are established (EPBD Article 18). Most MSs have formally transposed the aim of EPBD's Article 18 into national legislation. The system has been introduced and revised only in 2012-2014 in some countries, such as Greece, Hungary, Latvia, Czech Republic, Croatia, Germany, Romania and Slovenia. In Italy, the system of control systems is being revised and the responsibility is planned to change from the regional to a national level. The bodies responsible for performing quality checks on EPCs can be the central government (e.g. Bulgaria, Denmark, Finland, Greece, Ireland, Portugal, Romania and the Netherlands), the

regional government (i.e. Italy, Spain and Austria), professional associations (i.e. Hungary and Latvia) and third party bodies (i.e. France and Sweden) (BPIE 2014) (see Figure 4-4 : Bodies responsible for performing quality checks on EPCs. (Source: BPIE).

The choice to implement regular inspections of energy performance differs in MSs, some of which can have alternative measures in place of the inspection of the EPCs such as the inspection of the heating systems or air-conditioning inspection. The frequency of inspection varies widely among MS (Young 2016 in ADENE 2016).

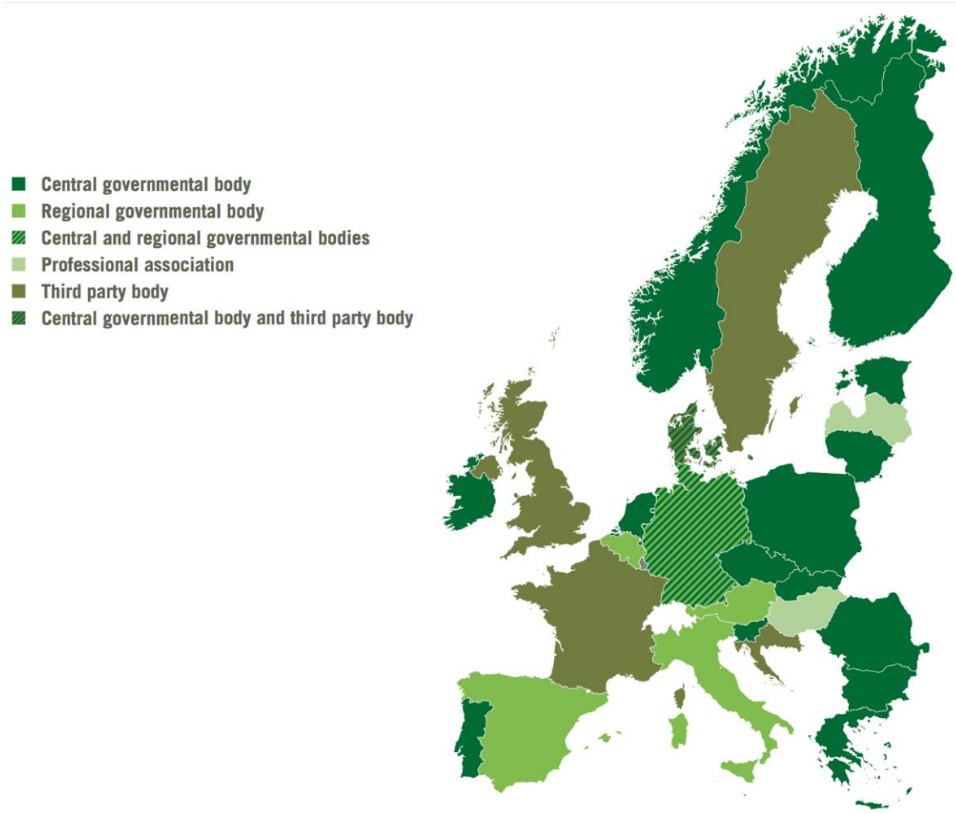


Figure 4-4 : Bodies responsible for performing quality checks on EPCs. (Source: BPIE)

4.1.6 Expert competence and Training

4.1.6.1 Expert competence

The competence of the experts carrying out the EPC assessment is one the most influential factors that effects the cost and quality of the EPCs. As per the Article 17 of the EPBD, MSs must ensure that the energy performance certification and the associated inspections are carried out independently by qualified and/or accredited experts (Sternova et al. 2015). MSs are accorded some flexibility in designing the system of training and/or accreditation of qualified experts. In 20 MSs, a mandatory examination of the certifiers' skills is recognised as a best practice.

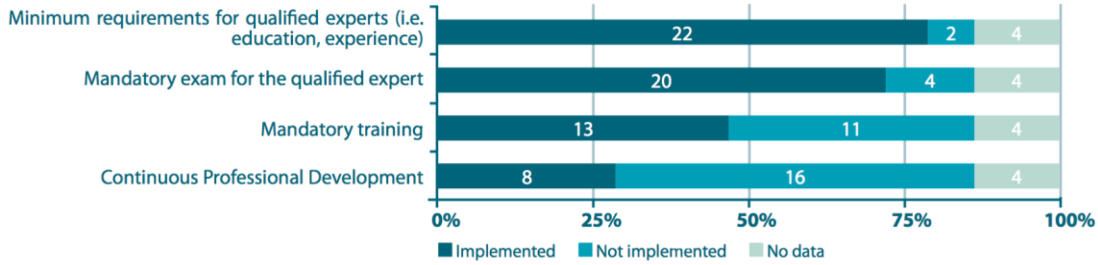


Figure 4-5 : Requirements for qualified and/or accredited expert in EU 28. (Source: BPIE 2014)

4.1.6.2 Training

Mandatory training is required in only 14 MSs, and in a few other MSs, it is required only when the experts lack related education and professional experience. 8 MSs implement programmes for a continuous professional development of the experts and the accreditation must be renewed periodically (See Figure 4-5). The EPBD re-cast 2010 does not require significant re-training of experts in MSs, however 25 MSs indicated the need for additional training. The additional training is useful to support the amended national legislation, NZEB requirements and integration of RES and innovative technologies. Although most MSs concluded that a special training on EPCs for NZEB was not necessary (i.e., specific training for producing EPCs or NZEB), in 12 MSs, raising awareness and educating all professionals in the sector is a crucial policy instrument to support NZEBs (as opposed to training only for already registered experts). The experts should be aware of the technical problems associated with NZEBs, how to integrate RES into existing buildings, advanced building, i.e. heating and cooling, technologies and new building materials. Expert training is required for on-site inspections and they should be provided access to the building and its technical systems (Sternova and Berecova 2015).

4.1.7 Display of EPC and usability of EPC data

According to Article 12 of the EPBD, an EPC must be shown and handed over to the prospective tenant or buyer, and according to EPBD Article 13, EPCs must be displayed on buildings occupied by public administration and frequently visited by the public, and on buildings frequently visited by the public in general, if an EPC has been issued according to Article 12. In creating awareness of a buildings' energy performance with potential buyers or tenants and other stakeholder, publication and advertising of EPC indicators in the commercial media or public building are used. In some MSs, displaying EPCs in public buildings that are visited by the public is important and has created awareness of energy efficient buildings (see Figure 4-6 for an example EPC in Germany). The EPC layout and content can the adapted according to the needs of the users (authorities, experts, the general public and building owners). Besides creating awareness, the EPC can also act as a supporting document for subsidies. In many MSs, EPCs are used as a necessary evidence of increased building energy efficiency to reward building owners e.g. by means of subsidies or tax reduction (Geissler and Altmann-Mavaddat 2015). The EPC information (including the energy performance of the building's envelope, use of technical installations, primary energy consumption and many others) can be useful for various pur-

poses by a wide range of stakeholders (BPIE 2014). The data from the national/regional EPC databases are also being used intensively in several MSs for developing policy documents, improving building regulations, conducting research on building stock, preparing statistics or training energy experts (Geissler and Altmann-Mavaddat 2015).

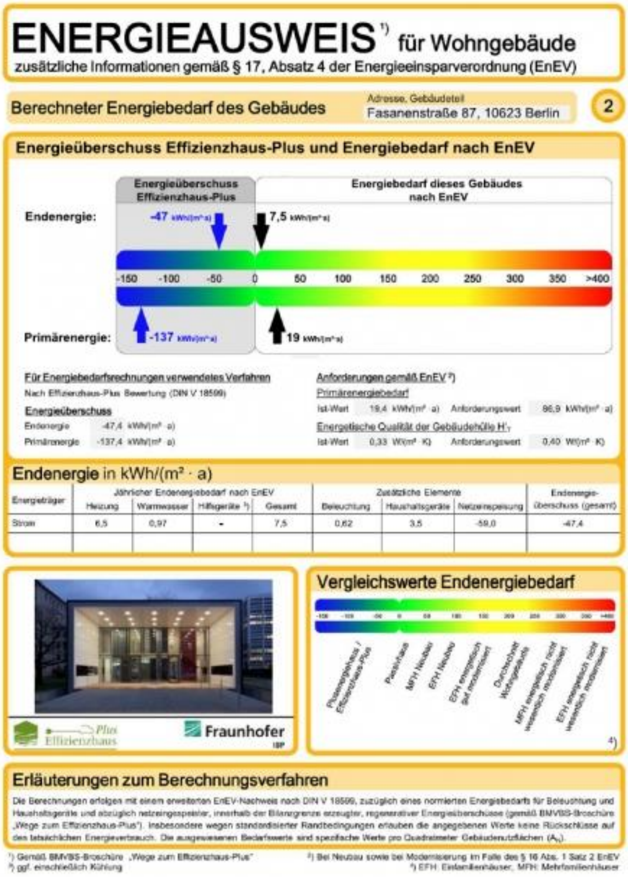


Figure 4-6 : EPC in Germany for Plus Energy House (Source: BuildUp 2014)

5 Country level – Building energy standards

5.1 National building Energy Efficiency code/standard

This section provides an overview of government initiatives to increase energy efficiency in buildings through national building energy efficiency codes in Sweden, Germany and Spain - the selected European countries representing three different climate zones. It lays out the status of the building energy code stringency, minimum technical/energy requirements, code compliance and enforcement, monitoring and evaluation of the certified building and other supporting measures and policies to increase building energy efficiency in the selected countries, as listed in the table below and explained for each country in the following sections.

Table 5-1 : Overview of selected European countries and their building codes.

	Sweden	Germany	Spain
General information (Year of adoption, date of enforcement, Authority in charge)	x	x	x
Minimum requirement, cold climate zone specific requirement	x	x	x
Minimum requirement, warm climate zone specific requirement			x
Certification process	x	x	x
Certifier	x	x	x
Compliance and enforcement	x	x	x
Monitoring and Evaluation	x	x	x
Supporting measures/policies (incentives, capacity building)	x	x	x

5.2 Sweden: Boverket's Building Regulations

5.2.1 General Information and Background

National Board of Housing, Building and Planning (Boverket) lays down the regulation for buildings in Sweden. Boverket's building regulations cover residential and non-residential buildings that "shall be designed in such a way that energy use is limited by low heat losses, low cooling demands, efficient use of heat and cooling and efficient use of electricity." (BFS 2016a). The Planning and Building Act and the Environmental Code are the most significant pieces of legislature that regulate building energy performance in Sweden. The Environmental Code indicates how a building should operate, e.g., thermal comfort, ventilation rates, etc. The Planning and Building Act sets out the role of the building in achieving the minimum criteria laid down in the "Environmental Code" by laying down the requirements to achieve these. The EPCs are regulated by a separate legislative system.

The first prescriptive requirements for energy efficiency in buildings in Sweden were implemented in 1946. The first mandatory performance-based code arose however after the EPBD came into effect in 2002. This was followed with the Act on the Energy Certification of Buildings from 2006 with the implementation into Swedish national law through the SFS 2006:985, which came into force on the 1st of March 2007. It has since then, in implementing the EPBD, has been altered in 2006, 2009, 2012, 2015 and 2017 and the Swedish National Building Regulations (BBR) was implemented in 2012. The latest Boverket's Building Regulations (BBR) encompasses many dynamic aspects including low overall U-values requirements, mandatory energy measurements, specific fan power requirements, performance requirements for buildings undergoing renovation and interim performance targets for most buildings which support the national nZEB target of 2020 (GBPN 2013). In addition to the BBR, Sweden has developed a nearly Zero-Energy Building action plan which sets the national nZEB target of 2020 mentioned above. Energy classification was introduced in the certificates on 1 January 2014. Earlier energy performance certificates did not have this information included.

The energy efficiency standard is based on the premise of cost-optimality. As a result, Boverket is continuously monitoring the results of the cost-optimal calculation requirements. It also examines the possible effect of a further tightening of requirements on the basis of cost-optimal calculations for the three categories according to the latest revision-, i.e., single-family houses, multi-family houses and non-residential buildings. Whenever there are favourable economic conditions, the regulations are tightened.

The Energy Performance Certificate system is also run by Boverket, which is responsible for supervision and control, as well as management of the national EPC database.

5.2.2 Climate

The Swedish building regulation originally defined three climate zones as the basis of the energetic calculation, due to the extremely different climates in different regions of the country. In 2014 the BBR underwent a correction of the climate zones. A fourth climate zone was introduced in order to more accurately correct the climatic conditions in southern Sweden (EC, 2014). The climate data used for the calculation is representative of one normal year for that location.

- Climate Zone I (in the north of Sweden)
- Climate Zone II (in the middle-north of Sweden)
- Climate Zone III (in the middle-south of Sweden)
- Climate Zone IV (in the south of Sweden)

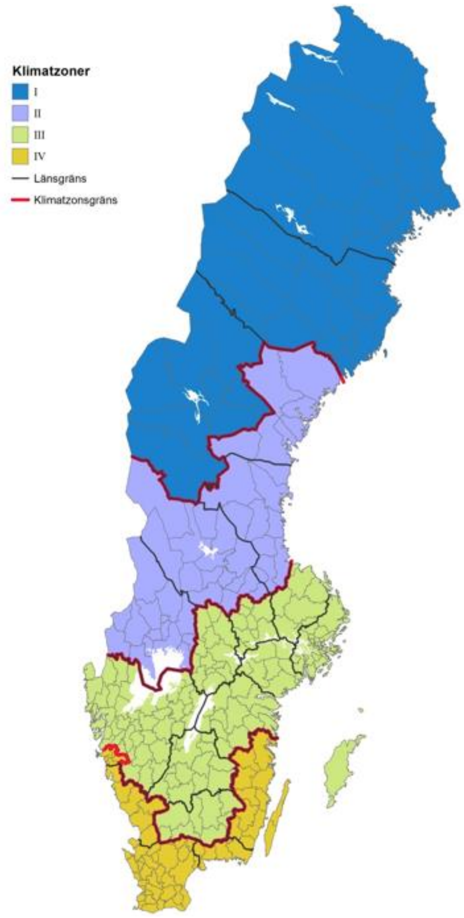


Figure 5-1 : Swedish Climate Zones. (Source: ADENE 2015)

5.2.3 Minimum technical and energy requirements

Boverket's building regulations, BBR, are required for both new buildings and for the renovation of buildings. As of 2009 the following buildings must have Energy Performance Certificates:

- New buildings
- Rental Building (multi-dwelling blocks and detached and semi-detached buildings)
- All detached and semi-detached buildings, at latest at sale date
- Cooperative buildings/tenant-owner flat buildings
- Non-residential buildings on lease
- Special-purpose buildings over 1000 m^2

Exempt are among others:

- Buildings with industrial operations,
- Holiday houses and buildings under 50 m^2,
- Buildings for agriculture and fishery,
- Temporary use,
- Historical buildings
- Religious buildings.

The BBR are based on the measured delivered energy, for heating, cooling, domestic hot water and other general uses of the building (pumps, fans and lighting for all buildings). This does not include household appliances. The main indicator, used to set energy performance criteria, is the specific purchased energy (kWh/m^2).

The specific purchased energy is defined as the energy supplied to the building's technical installations for building services and energy system, normalized by the floor area heated above 10 °C. That is only the supplied energy that the building owner has to pay for (not "free" energy such as solar or geothermal).

The BBR consists of mandatory provisions that need to be fulfilled and also provides general recommendations to fulfil the mandatory provisions. In general there is no requirement to measure individual building parameters as long as the measured value complies with the building code. For example, if the measured energy is within the specified limits, there is no reason for measuring airtightness or how it is regulated. Thus, the building owners are free to choose where to focus their efforts for achieving energy efficiency. As a result, there are no qualitative figures on the specific parts of the system (e.g., boiler efficiency). As long as a total value measured is lower than the requirements, the building is regarded as compliant. However, all installations must be designed so as to provide adequate efficiency during normal operation.

There are nevertheless general recommendations such as the minimum requirements for the U-Values and airtightness, to ensure thermal comfort that must be met. In case of implementation of design options beyond the ones stated in the general recommendations, verification is required to make sure that the mandatory provisions are fulfilled (Boverket 2017).

Compliance with the specific purchased energy criteria is achieved through measurements of the actual energy use of the building after occupancy, which should be less than or equal to the allowable energy frame. The final energy [kWh/m² A_{temp}][2] includes energy for heating and cooling, ventilation, domestic hot water and for the property's energy, including for example pumps and lighting in public spaces; which is divided by the area [A_{temp}] of the building that is intended to be heated to over 10°C (GBPN 2013) (Table 5-2). For residential buildings the indoor temperature used for the calculation is 21°C. The factors for the calculation of the final energy are implemented according to whether or not electricity is used for space heating.

Table 5-2 : The building's specific purchased energy use (kWh per m^2a_{temp}). (Source: BFS 2016:6)

	Zone I	Zone II	Zone III	Zone IV
	kWh/m²a	kWh/m²a	kWh/m²a	kWh/m²a
Buildings without electrical heating				
Single Family Housing	130	110	90	80
Multi-Apartment Housing	115	100	80	75
Commercial Buildings	105	90	70	65
Buildings with electrical heating				
Single Family Housing	95	70	65	50
Multi-Apartment Housing	85	65	50	45
Commercial Buildings	85	65	50	45

In addition to the criteria for the specific energy use, there are requirements for the maximum U-values as well as the air-change rate.

Residential

Table 5-3 : Air exchange rate in residential buildings. (Source: BFS 2016:6)

Building Envelope Insulation	U ≤ 0.4 W/m2.K
Air exchange rate	Between 0.35 and 1.0 l/s.m2,

Non-Residential

Table 5-4 : Air exchange rate in non-residential buildings. (Source: BFS 2016:6)

Building Envelope Insulation	U ≤ 0.6 W/m2.K
Air exchange rate	Between 0.35 and 1.0 l/s.m2,

Buildings are also categorised under the energy classes from Energy Class A to E. These are based on the energy consumption of the building (Table 5-6).

[2] Atemp is heated area inside the buiilding

Table 5-5 : Energy Performance classes. (Source: BFS 2016:6)

Energy Class	Energy Performance
A	≤ 50 per cent of the requirement for a new building.
B	> 50 - ≤ 75 per cent of the requirement for a new building.
C	> 75 - ≤ 100 per cent of the requirement for a new building.
D	> 100 - ≤ 135 per cent of the requirement for a new building.
E	> 135 - ≤ 180 per cent of the requirement for a new building.
F	> 180 - ≤ 235 per cent of the requirement for a new building.
G	> 235 per cent of the requirement for a new building.

In the cases of design phase verification and when buildings are sold before the post occupancy measurement period is finished, compliance is checked through standardised calculation including the use of standardized input data (average values based on surveys and measurements) for climate, building operation, and user behaviour from the Swedish program for standardizing and verifying energy performance in buildings (Allard, Olofsson & Nair, 2017). When a building is renovated or refurbished, it is the altered part of the building that should comply with the regulations for new buildings. Requirements are set in relation to the “size of the alteration” and “the technical possibilities for changes in the building”.

5.2.4 Certification process

The Energy Performance Certificate (EPC) system is run by Boverket, which is responsible for supervision and control, as well as management of the national EPC database. Certification is done by a registered third party assessor accredited by the Boverket.

For new buildings, during the planning phase of the project an energy consumption calculation must be presented before commencing construction. After the completion of the construction, the energy consumption for the EPCs must be verified by measurement, for a period of one year, no later than 24 months after completion of the building. Only in cases where the building is sold in the first 24 months are the certificates based on the calculated consumption. Certification following a major renovation is not mandatory, but is normally performed because of the owners’ wish to update the value of the new reduced consumption relative to the reference benchmark.

On completion of the building and the two year measurement period the energy assessor registers the building electronically in the national database with the National Board of Housing, Building and Planning and sends the building owner a copy of the certificate as well as a summary for display in the building.

Documentation to be submitted for certification include:

- Number of flats, offices, shops etc.
- Drawings,
- Year of construction,
- Alterations,
- Type of insulation,

- Floor area,
- Heated or cooled surfaces,
- Heating and ventilation
- Systems, water heating,
- Window surfaces,
- Fans and pumps,
- Various types of energy and annual costs.
- And whether compulsory ventilation controls and
- Radon measurements have been carried out.

On submission of the relevant documents, these aspects are checked. If errors are found, the Municipality Building Board/Boverket gives the building owner the chance to have the assessor correct the mistakes.

On approval, by Boverket, an EPC is issued. These are valid for 10 years from date of certification. In addition to the building energy performance information, the energy performance certificate also contains information on the energy performance class as well as means to reduce energy consumption.

EPCs are issued only at a building level, and thus, there are no EPCs for individual apartments. If any EPC has been issued for a public building, with useful floor areas over 1000 m², or a non-residential building, the EPC must be displayed, clearly visible, in a public area. It is mandatory that the energy performance, as an absolute number, of the EPC be displayed, as an energy label i.e. A-G labelling, in all advertisements, i.e. sale or renting of a building. In addition the certificate must be shown prior to sale or renting and is to be handed over to the new owner or tenant after the deal is completed.

The national database is accessible and searchable, by address, allowing relevant actors to access the building information including ID and energy performance. Only the building owner can access the full information on the building, as declared in the EPC. The information that can be obtained online is the ID-number of the EPC, the date of issuance, the energy performance rating (given as a single value of specific energy in kWh/m²year and energy class), and finally, whether radon measurements and compulsory ventilation controls have been executed. In improving the transparency of the EPCs, for relevant actors, it is the aim to implement a geographic information system (GIS) application that would enable people to look for certified buildings via app (Karlsson Hjorth et al.,2014).

5.2.5 Cost of certificates

The average cost of EPCs is given as around 1000 € and has been rather stable since the implementation of EPCs. However, there may be variations depending on the type, size and complexity of the building (increasing costs for increasing complexity) (Karlsson Hjorth et al.,2014).

5.2.6 Compliance and Penalties

The responsibility for compliance lays with the developer/building owner and their representative, the certified building energy assessor responsible for inspections and

verification. The compliance check is based on measured values and takes place during the second year of operation. There is no requirement to measure individual parameters as long as the measured value complies with the building code.

The enforcement of the building energy code is at a local level and is supervised by the local Municipality Building Board. In addition, the Boverket has the responsibility to check if an EPC has been issued for a specific building. The EPC database offers Boverket a means of control to monitor compliance of new buildings as well as missing EPCs for existing buildings. This is done through a crosschecking of the EPC database and the national cadastre of the building stock. In terms of compliance the focus on control has been on buildings that must be certified. If an EPC is missing, contact is made by Boverket to the building owners and is repeated on a weekly basis until an EPC has been issued. If non-compliance persists, Boverket may impose a fine against the owner. For buildings that only need EPCs under certain conditions, the checks are only on complaints from the relevant actor. If an EPC is missing, a penalty will be issued.

In addition, if no EPC is shown to buyer or tenant the building developer/owner is subject to penalties. In such a case, if an EPC is missing, the buyer also has the opportunity, within a 6-month period, to have the building certified at the cost of the previous building owner (Karlsson Hjorth et al.,2014).

5.2.7 Monitoring and Evaluation

According to the Swedish Legislation Planning and Building Act, the Swedish Board for Accreditation and Conformity Assessment is responsible for monitoring and assessment of the technical assessment bodies. In the case of their non-compliance with the requirements as listed in the Regulation (EU) No. 305/2011 Ordinance (2013:308), the Swedish Board for Accreditation and Conformity Assessment shall immediately notify the Government after consulting the National Board of Housing, Building and Planning (Boverket 2016).

The energy assessor makes the first validity checks of the EPCs during the certification. Energy-related aspects of existing buildings are monitored by means of checklist and done by a technical advisor on behalf of the building's owner (PRC, 2011). In addition, automatic checks are made by the certification software on the plausibility of the input data, such as climate data. Furthermore, checks are made if values are outside of a reasonable range. The software also makes checks the plausibility of the calculation of the energy performance.

On submission of the certificates to the database the planning department in the relevant municipality is responsible for the compliance. Random quality checks are made both for the incoming validation of the incoming certificates as well as more through quality checks.

In addition to the plausibility check and random controls, the Swedish legislation requires compulsory ventilation checks, before the building can be used as well as regular checks thereafter. In both cases these are to be made by a certified assessor.

5.2.8 Expert competence and training

In 2007 the Boverket introduced a regulation, BFS (2007) defining the competence of the energy experts as decreed by the accredited body.

Energy assessors are divided in two groups:

- One for simple buildings i.e. single-family houses and smaller multi-family houses
- And the second for more complicated buildings i.e. buildings with air-conditioning, public buildings, as well as all buildings with cultural value.

The energy assessor issuing the EPCs must be a registered accredited third party independent assessor. Up to 2014 the energy assessor was associated to a registered and accredited company. The system changed in 2014 from accrediting companies to accrediting experts

The certification and register of energy assessors is by the Swedish Board for Accreditation and Conformity Assessment (SWEDAC). SWEDAC examines and approves the person who applies to become a certified energy expert. In addition, this can be through certification bodies. These (certification bodies) that issue certificates to energy experts are approved and accredited by the SWEDAC. Both the SWEDAC and the certification bodies have the right to revoke a license if the expert has shown incompetence, or has issued an incorrect or false EPC (SWEDAC, n.a.).

In addition to the energy assessors, there are assessors for mandatory ventilation checks. The assessors, certified for ventilation checks, must also give advice on energy efficiency measures if a cooling system is attached to the ventilation.

The requirements for qualification as an energy assessor, for both levels, requires a university level education such as a Masters or a Degree in Architecture or other technical education with a focus of energy efficient buildings. In addition, the assessor must have professional experience in the last 5 years in which at least 2 are in connection to energy use in buildings and indoor-environment. If these requirements are met a mandatory exam, showing competence, must also be passed. This exam differs according to the certification level of the assessor. This exam must be repeated every 5 years to renew the license.

In addition to the energy assessors accredited by the SWEDAC, Sweden recognizes assessors from other EU countries through a vis-à-vis system.

5.2.9 Supporting measures/policies

Incentives

The Swedish Government supports the encouragement of the population to go beyond the minimum levels of energy use by means of incentives and subsidies. These are administrated by Boverket and supporting relevant data is published on their official website.

Knowledge dissemination

To increase the knowledge about energy use and energy supply in Sweden, statistics are an important tool, Swedish Energy Agency is therefore also responsible for making public energy demonstrations, relevant facts and figures. Information for the general public is also made available by Boverket and Omboende.

Stakeholder involvement & Education and training

The development of the Boverket Building Regulation (BBR) code is supported by stakeholders who are allowed to express their own opinion on its improvement. The implementation of the code is performed by professionally trained and educated personnel. Usually, the national board delegates municipalities to train the public personnel, and education companies train local stakeholders.

Certification schemes/labels

Important tools in reinforcing the reduction of energy use in buildings are labelling and certification schemes.

A major actor in promoting energy efficient schemes and labels is the Sweden, Svanen (The Nordic Swan Ecolabel), which is a state owned non-profit company that helps consumers, since 1989, to make conscious decisions in choosing environmentally friendly products and services.

5.3 Germany: Energy Conservation Ordinance

5.3.1 General Information and Background

Germany introduced an energy ordinance with the Energy Saving Act in 1977 to reduce the dependency on energy imports and to empower the Federal Government to legislate ordinances to that effect. The Thermal Insulation Ordinance 1977 was first among such ordinances issued for regulating building energy performance requirements, this was followed by the Heating Appliance Ordinance in 1988. Both of these ordinances were replaced by the first comprehensive Ordinance on building performance requirements, Energy Efficiency Ordinance - called EnEV (Energieeinsparverordnung), which first came into force on 01.02.2002. The main purpose of this ordinance was to bring all components related to building energy efficiency in Germany under its ambit. The EnEV was further amended in 2004, 2007, 2009 and 2014 to bring the ordinance under the requirements set by European Directive on Energy Performance of Buildings (EPBD) and within the context of the German government's energy revolution program, Energiewende.

In addition to the requirements of EnEV, new buildings, with a floor area over 50 m^2, have to comply with the Renewable Energies Heat Act (EEWärmeG) 2009. The Act requires a certain proportion of building's energy to be derived from renewable energy sources. The exact proportion varies as per the energy source. This Act was further amended in 2011. If this is not met, the Primary Energy consumption must be 15% lower than what would be normally required (if renewable energy sources were used).

To further simplify and harmonize the ordinances that impact building energy performance, in the near future, the EnEV and the Renewable Energy Act will be combined into a single Ordinance, the Building Energy Ordinance - Gebäudeenergiegesetz (GEG). This stepwise tightening of requirements, through the amendments, towards the EU 2020 nearly Zero Energy Building goals is designed to allow a gradual implementation of newer energy efficient technologies and thus an optimal cost effectivity of the buildings as new technologies become mainstream.

The EnEV Ordinance is applicable for all buildings that are conditioned i.e. heated or cooled and the associated equipment, fixtures and fittings. However, the following buildings are exempt from the ambit of the Ordinance:

- Farm buildings for animals,
- Buildings that must be kept open to the nature of production,
- Buildings underground,
- Temporary buildings,
- Religious buildings and
- Residential buildings that are only used for less than 4 months a year or used for a limited time and the energy consumption in this period is less than 25% of the whole year.

The Ordinance regulates the following:

- Standards for new buildings;
- Standards for existing buildings in case of major renovations;
- Building installations: standards for new heating, cooling or ventilation systems; and
- Design, content and obligations for the implementation and use of Energy Performance Certificates (EPCs).

The EnEV states that an energy performance certificates are mandatory for all residential buildings and non-residential buildings. The EPCs are issued either based on the calculated energy demand (asset rating) or based on the measured energy consumption (metered rating), although the latter is only allowed for multi-family buildings (more than 5 dwellings) and residential buildings built after 1977. The measured data can be collected, for example, from the heating cost bills. If the certificates are issued based on metered demand, both the final energy and the primary energy demands must be weathered corrected. EPCs can only be issued by a qualified energy assessor. The certificates issued to the building owner contain detailed information on the buildings including:

- Selected calculation measure
- Source of information
- Assessor information
- Asset rating or metered rating
- Recommendations for cost effective energy efficient refurbishments

The certificate for non-residential building has more information including energy performance values for a reference building. Further, the energy performance certificate for existing buildings must include recommendations for a cost-optimal energy efficient refurbishment. From 2014, the certificates should present the energy demand of the building as an absolute value of the consumption and as an energy efficiency class letter rating (A+ to H) corresponding to the consumption (Table 5-6).

Table 5-6 : Energy Efficiency Classes. (Source: EnEV)

Energy Efficiency Class	Final Energy demand kWh/m^{2}a
A +	< 30
A	< 50
B	< 75
C	< 100
D	< 130
E	< 160
F	< 200
G	< 250
H	> 250

At the earliest, EPCs must be presented to potential buyers or renters at the time of the first visit to the building. If this does not take place the building owner must pre-

sent this to the relevant actor at the earliest possible opportunity. EPCs must also be shown in any advertisements for selling or renting of a building. This must include the type of EPC, the energy consumption of the building, the heating system and fuel source, the year the building was built, and the building energy efficiency class. All EPCs are valid for 10 years from the date of issue.

The implementation of the energy saving requirements is through the Federal Legislation. Since local building codes fall under the state legislation, they must ensure that energy saving requirements are implemented in the local building codes, while taking considering any overlaps. The responsibility for verification and enforcement of the EPCs lies with the building control authority (local level).

5.3.2 Minimum technical and energy requirements

The minimum building energy performance requirements are calculated by comparing the building against the energy performance of a "twin" reference building. This theoretical twin building is identical to the actual building in its location, size, geometry, orientation etc. and uses standard reference values for components and technologies for calculating energy performance, as defined in the Annex of EnEV. At minimum, the (real) building must meet the calculated values for yearly primary energy consumption for heating, domestic hot water, ventilation, cooling as that of a twin reference building.

The energy performance is calculated using the DIN V 18599 standard, which is a steady state calculation. This calculation method is inline with that of the Mandate 343 (which is a Standardisation mandate of the European Commission for a methodology calculating the integrated energy performance of buildings and estimating the environmental impact) of the European Union. Other essential standards of EnEV include:

- DIN 4701-12: heating energy assessment and ventilation systems in existing buildings - Part 12: Heat generation and domestic hot water.
- DIN V 4701-10: Energy efficiency of heating and ventilation systems - Part 10: heating, water heating, ventilation.
- DIN V 4701-10: heating Energy efficiency and ventilation systems
- DIN V 4108-6: Basics of heat, humidity and rain protection
- DIN V 18599-1 to 11: Energy performance of buildings - Calculation of energy demand (useful, final and primary energy demand) for heating, cooling, ventilation, domestic hot water and lighting of buildings

In general, the buildings have to be constructed to achieve minimum levels of airtightness and thermal bridges, and to keep internal air and surface temperatures within the acceptable levels of human thermal comfort satisfaction. In addition, overheating in summer should be prevented. Furthermore, buildings must also meet minimum requirements for the specific heat transmission (Ht´). The minimum requirement for the specific heat transmission of the building envelope is to so as to ensure that even when using energy systems with high renewables, and thus having a low

primary energy consumption, that the minimum thermal and energy requirements are met. For non-residential building the minimum specific heat transmission requirement is defined via minimum U-values instead of the average heat transmission coefficient. Further requirements include:

- Buildings with cooling units with more than 12 kW must be inspected by a certified person at the latest every 10 years.
- All building materials and technologies must have at least a CE-Label
- Requirements for technical building systems
- Non-residential buildings also have a requirement for lighting.

New buildings must also incorporate the use of renewable energy. When using renewable energy generated on site, it is subtracted from the final energy demand of the building, whether immediately used or stored for later use. The minimum amount of renewable energy use requirement depends on the type of renewable energy source. For example, 50% of the total energy consumption must be met using renewables if using geothermal and 15% if using solar thermal (Table 5-7). If the minimum amount of on-site renewable energy cannot be generated and used, the building should comply with alternatives such as using reducing the heat transmission losses by more than 15% compared to a standard building.

Table 5-7 : Minimum requirements for renewables and substitute measures. (Source: EnEV)

		Minimum Share
Renewable source	Energy from solar radiation (collectors)	15%
Renewable source	Alternative minimum default collector size for 2 ≤ dwellings	0.04 (m^2/m^2)
Renewable source	Alternative minimum default collector size for > 2 dwellings	0.03 (m^2/m^2)
Renewable source	Geothermic energy or ambient heat by heat pumps	50 %
Renewable source	Biomass (gaseous) mostly restricted to CHP use only	30 %
Renewable source	Biomass (fluid) mostly restricted to CHP use only	50 %
Renewable source	Biomass (solid) mostly restricted to CHP use only	50 %
Substitute measure	Heat from waste combustion	50 %
Substitute measure	CHP plants	50 %
Substitute measure	District heat	100 %
Substitute measure	Measures to save energy in buildings	EnEV - 15%
Substitute measure	Combinations of several measures	

Existing buildings also have some mandatory requirements as per the EnEV. All existing residential buildings must have their roof or upper ceiling as well as any pipes in unheated rooms insulated as of 01.01.2016 and boilers older than 30 years must be replaced.

For residential buildings undergoing major renovation, i.e. more than 10% of any building component, the level of refurbishments must be inline with that of the minimum requirements for new buildings. Alternatively, the building must not exceed 140% of the minimum requirements of the energy performance of a new building. For non-residential buildings undergoing major renovation (over 20%), the use of on-site renewable energy is mandatory and the insulation requirements are similar to those of existing residential buildings.

In addition, all new buildings and buildings undergoing major refurbishments that are connected to the grid must have smart meters. It also has to be ensured that the building envelope and technologies are not changed at any point so as to worsen the energy performance of the building against the existing state.

5.3.2.1 Reference values for Residential buildings

The following are reference values needed for the calculation of the minimum energy performance requirements for residential buildings (Table 5-8, Table 5-9, Table 5-10). *Note: The information for non-residential is too large for this document, but in principal it similar to the residential buildings in nature.*

U-Values

Table 5-8 : U-Values for reference residential building. (Source: EnEV)

Building Element	EnEV Reference U-Value (W/m^{2}K)
External wall	0.28
Walls to unheated rooms	0.35
Walls to ground soil	0.35
Pitched roof	0.20
Dormer roofs	0.20
Dormer side walls	0.28
Flat roofs (<10 °)	0.20
Topmost ceiling to unheated area	0.35
Cellar ceiling	0.35
Lowest slab to external air	0.35
Lowest slab to ground soil	0.35
Windows, Balcony doors	1.30
Safety windows	1.30
Roof windows	1.40
Rooflight dome	2.70
External Door (to heated rooms)	1.80

Solar Factor of Windows

Table 5-9 : Solar Factors for windows. (Source: EnEV)

Window Element	EnEV Reference Solar Transmittance g⊥
Windows, Balcony doors	0.60
Safety windows	0.60
Roof windows	0.60
Rooflight dome	0.64

Table 5-10 : Maximum specific transmission heat loss Residential buildings. (Source: EnEV)

Building Type	Heated floor area A_n	Max. Value Transmission Heat Loss H'_T
Detached res. building	≤ 350 m^2	0.40 W/m^2K
Detached res. building	> 350 m^2	0.50 W/m^2K
Semi-detached res. building	-	0.45 W/m^2K
All other res. buildings	-	0.65 W/m^2K
Extension to buildings	-	0.65 W/m^2K

Thermal Bridges

The thermal bridges in the reference building are calculated using the ΔU_{WB} = 0.05 $W/(m^2 \cdot K)$

Ventilation

Ventilation is via a central exhaust air system with a on-demand controlled DC fan

Air Tightness

Air tightness for buildings without ventilation must not be below 3.0 h^{-1} and for buildings with ventilation 1.5h^{-1}

Heating System

The reference heating system is a condensing boiler (improved), heating oil EL, the location of the heating system is to be:

- for buildings up to 500 m² treated floor area - inside the thermal envelope
- for buildings with more than 500 m² treated floor area - outside the thermal envelope

The design temperature is set at 55/45° C, with a central distribution system within the building envelope. Internal strands and connection lines, standard cable lengths are according to DIN V 4701-10: 2003-08 Table 5.3-2, pump designed on demand (regulated, Δp constant), pipe network hydraulically balanced.

Domestic hot water

Domestic hot water (DHW) is provided via a central hot water through joint heating with the space heating system.

Alternatively either:

- A solar system with flat collector and storage tank designed in accordance with DIN V 18599-8: 2011-12 (Table 15 of DIN V 18599).
- Solar system with flat collector used exclusively for DHW heating in accordance with the specifications of DIN V 4701-10: 2003-08 (Table 5.1-10 of DIN V 18599) with storage, indirectly heated (upright), the location for heating system is the same as for the heat generator,
  - small solar system at AN ≤ 500 m² (bivalent solar storage tank)
  - large solar system at AN> 500 m²

Distribution systems within the building envelope, internal strands, common installation wall, standard cable lengths are according to DIN V 4701-10: 2003-08 Table 5.1-2 with circulation.

5.3.3 Climate

The climate zone used for the calculation of the EnEV is valid for the whole of Germany. The climate of Potsdam city is used as the reference climate.

5.3.4 Certification process

The energy performance calculations and certification are done by a registered third party assessor. Building energy assessors are accredited by the Deutsches Institut für Bautechnik (DIBt). The certification can be either:

- During construction, pending verification and application for registration upon completion, or;
- done directly upon completion.

The data required for the energy performance calculation can be provided by the building owner or collected by the assessor. This must however be noted in the certificate. If there are grounds for doubt on the data provided by the building owner, the assessor has the right to deny issuing a certificate. The assessor is required to keep all copies of the data used for calculation for two years for verification and control.

Upon completion, each building receives an individual ID on application for an EPC with the central registration authority. During registration, basic information on the building must be provided to the registering authority. Due to the strict privacy laws of Germany, the data is limited to the meta-data of the building only. This is limited to ID number, type of certificate, building type, federal state and the assessor. Detailed information is only collected when the buildings and/or the energy certificates are controlled during random testing. This data is only accessible by the assessor or the relevant authority. Once approved, by the DIBt the building receives its energy performance certificate. All EPCs are valid for 10 years from date of certification. EPCs are for the whole building and must be issued upon the completion of the building, at the latest. For existing buildings, if the building is to be sold or rented, the certificate must be presented to the potential client during the visit to the building, at the latest. It is also mandatory that the energy performance class of the building, i.e. A-G labelling, be displayed in all advertisements for sale or for renting.

In addition to the calculated certification process, multifamily buildings with at least 5 units or residential buildings built after 1977 can be certified via measured data. In such cases the measured consumption must be corrected for the different weather conditions experienced in different years. If the building was empty for any of part of this time this must be accounted for.

New certificates must be issued with every refurbishment that might affect the energy consumption of the building. Buildings over 500 m^2 (200 m^2 for public authorities), which are open to the public, must display energy performance certificates in the public space.

5.3.5 Cost of certificates

There are no regulations or recommendations for determining the costs of energy performance certificates. Prices are determined by the market and the assessors and can range between 50 € to 800 € for residential buildings, depending on the choice of a simple or more complicated methodology, i.e., measured rating or calculated rating (table 5-9). According to surveys the hourly rate is on average between 30 € to 60 €. The only pre-determined costs are for the registration number of the EPC with 5.50 €.

Table 5-11 : Example price ranges of Energy Performance Certificates in Germany. (Source: EnEV)

	New Buildings (2011)	Existing buildings (2011)
Single Family House	300 – 500 €	100 – 1000 €
Multi Family Houses	300 – 1000 €	200 – 2000 €
Non-residential buildings under 1000 m^2	1000 – 2000 €	2000 – 4000 €
Non-residential buildings over 1000 m^2	2000 – 8000 €	5000 – 20000 €

5.3.6 Compliance and Penalties

The building owner or any person authorised by the building owner is responsible for ensuring EPC compliance. Since 2014, the building owner or the assessor acting in the building owner's name must send the EPC and other relevant data to the central data gathering authority, the Deutsches Institut für Bautechnik (DIBt). The Federal States are responsible for the control and enforcement of the building energy performance certification. However the DIBt acts as an interim controlling authority. Non-compliance can result in various penalties from fines to refusal of permission to occupy the building (Table 5-12).

If the assessor has reason to believe that the data provided for calculation by the building owner are not correct, he has the right not to issue a certificate.

During refurbishment, the building owner must acknowledge in written form with the relevant authority if any building components have since been replaced upon the issuance of EPC, e.g., replacing envelope, or heating system.

A specific German market instrument that has resulted in high compliance rate for displaying EPC certificates is that legal professionals have specialised themselves in

observing the market either on behalf of stakeholder organisations or real estate agencies and sending "warning letters" with fees for the lawyer and request for compensation for the competitor and the threat of legal proceedings for non-compliance. In addition, there are regulations on the regular inspection of the heating and cooling systems, which ensure the compliance of the boilers and insulation of the pipes.

Table 5-12 : Penalties for violation. (Source: EnEV)

New buildings	Do not build new residential buildings according to the EnEV requirements	up to € 50,000
New buildings	Do not build new non-residential buildings according to the EnEV requirements	up to € 50,000
Technology installation	New heating not installed according to the requirements of EnEV	up to € 50,000
Technology installation	Installed technology does not meet requirements of the EnEV	up to € 50,000
Technology installation	Pipes and fittings does not meet requirements of the EnEV	up to € 50,000
Technology installation	No declaration of conformity that technologies meet requirements of the EnEV	up to 5.000 €
Building changes	Changes to building envelope do not meet EnEV requirements	up to € 50,000
Building changes	No declaration of conformity that envelope meets requirements of the EnEV	up to € 5,000
Building retrofit	No declaration by contractor of completion of upper floor insulation	up to 5.000 €
Building retrofit	Do not retrofit the central heating system as required to law	up to € 50,000
Building retrofit	Using data for the energy passport although they are not correct	up to € 15,000
Building retrofit	Unauthorized issue of energy passport	up to € 15,000
Building retrofit	Missing registration number in energy passport	up to 5,000 €
Building retrofit	A copy of the energy passport and the data used is not sent to the relevant authority for inspection	up to € 5,000
Energy passport in Stock	No registration number in the energy passport	up to 5.000 €
Energy passport in Stock	A copy of the energy passport and the data used was not sent to the relevant authority for inspection	up to € 5,000
Government authority controls	A copy of the energy passport and the data used was not sent to the relevant authority for inspection	up to € 5,000

5.3.7 Monitoring and Evaluation

Quality assurance of the EPCs is conducted on a random sample basis from the EPC registry. This random sampling of the energy performance certificates and buildings is done on a statistically significant number of cases by the Deutsches Institut für Bautechnik (DIBt) – the DIBt acts as an interim control authority for the Federal States who are responsible for compliance.

While most controls are just a validity check of the input data, more detailed controls exist. These can sometimes even include a site visit. These are in accordance with the EPBD and can take place on one or more of three levels:

- Validity check (carried out by the DIBt for the Federal states)
- Check of input data and verification of results
- Full detailed checks of input data, calculation and results with possible site visits

Checks at all levels can be only performed after the responsible energy expert has provided all the required input data. Therefore, experts are required to store all relevant EPC data for at least two years post certification date. Any detailed information gathered by authorities during controls must be anonymised after use. Further detailed controls are through experienced third party assessors commissioned by the Federal State. The threat of possible fines has resulted in a high level of compliance.

Inspection of the heating and cooling system is via regular mandatory inspections. The inspecting actor must inform the building owner of non-compliance and request correction with a certain period. If this does not take place he is required to inform the relevant authority.

5.3.8 Expert competence and training

The training and competence requirements of the assessor vary depending on whether the qualification is for new or for existing buildings. For existing buildings, the EnEV defines these requirements. For new buildings, the Federal States decide on these requirements and these vary with some States requiring certified and authorised appraisers while others having the same requirements as required in the EnEV for existing buildings.

Training and competence requirements for existing buildings is limited to certain occupations and based on previous education, training or professional experience. These being:

- Persons with a university degree in architecture, engineering, physics etc.
- Persons within and qualified for a registered trade in the building industry, but only for existing residential buildings.
- Interior designers (with the appropriate qualification) but only for existing residential buildings.
- State-approved or certified technicians in the field of buildings, but only for existing residential buildings.

For non-residential buildings only experts with a university degree and appropriate training may issue certificates.

The training must give the assessor the necessary knowledge to issue certificates according to the EnEV and must include practical exercises, such as:

- Measurement of the building
- Analysis of the building envelope

- Analysis of the heating and cooling systems
- Analysis of the ventilation system
- Analysis of the lighting system (only for non-residential)
- Issuance of certificates
- Recommendations of cost effective improvements.

On completion of the necessary requirements and before issuance of any certificate the assessor must register with the central registration authority, which is run by the DIBt. Enforcement of the qualifications is however through the Federal States. Any professional person issuing a certificate without the correct qualifications can be prosecuted by law, in the form of fines.

5.3.9 Supporting measures/policies

The government-owned banking group Kreditanstalt für Wiederaufbau (KfW) plays a vital role in promoting energy savings and CO_2 reduction in the buildings sector by providing subsidies. In 2009, total subsidies were to the sum of 16.9 billion Euros, of which 10.6 billion Euros were for energy efficiency and 6.3 billion Euros were for renewable energies (GBPN 2013a).

5.4 Spain: Documento Básico DB-HE Ahorro de Energía - CTE, Código Técnico de la Edificación (Technical Energy Code)

5.4.1 General Information and Background

In Spain, responsibility for the implementation of the Energy Performance of Buildings Directive (EPBD) lies with the Ministry of Industry, Energy and Tourism, the Ministry of Public Works and Transport, and regional administrations. The national implementation of the EPDD in Spain is through the mandatory standard Documento Básico DB-HE Ahorro de Energía - CTE, Código Técnico de la Edificación (Technical Energy Code).

The very first ordinances for thermal insulation in buildings in Spain were issued in 1969. Consequently, the first energy code with prescriptive energy efficiency requirements for buildings was implemented in 1979, but this only covered the building envelope. These were later bought into conformance with the European Energy Efficiency Directive.

Further revisions followed in 2006 and 2010, which increased the requirements in order to meet the expectations of the EPBD. The latest revisions to the energy requirements took place in 2013, with Order 1635/2013. This included supporting policies that encompass progressive aspects including, mandatory renewable energy requirements (solar hot water and photovoltaic systems), compulsory post occupancy testing of boilers and HVAC systems, bioclimatic design considerations, mandatory performance requirements for existing buildings and low energy classes through Energy Performance Certification levels A, B & C. These being among others the Technical Code for Construction (Codigo Técnico de la Edificación) which covers the requirements for the building envelope, heating and cooling systems and ventilation. In addition to the CTE, Spain has adopted the Regulation of Thermal Installations in Buildings (Reglamento de Instalaciones Térmicas en los Edificios, RITE, Royal Decree 1027/2007, 20th July). This was updated with the Royal Decree 238/2013. With more detailed technical regulations, this regulation is applied to fixed installations (e.g., lighting), Heating, Ventilation and Air-Conditioning systems (HVAC), and production of Domestic Hot Water (DHW), and is designed to meet the requirements for thermal comfort and indoor air quality and helps Spain partially transposes the European Energy Efficiency Directive. It is required that all codes be updated every 5 years.

The objective of RITE, is to lay down the energy efficiency and safety requirements for heating and cooling systems in buildings, for thermal comfort and hygiene demands of people, during their design, construction, maintenance and use (GBPN, n.a.). In addition to this, the building code is divided into 5 parts:

- HE.1: Limiting energy demand (heating and air conditioning).
- HE.2: Efficiency of heating/air-conditioning systems.
- HE.3: Energy efficiency of lighting systems.
- HE.4: Minimum solar contribution to the hot water supply.
- HE.5: Minimum photovoltaic contribution to the electrical power supply.

Initially, Spain adopted RITE as a separate regulation, but later incorporated it into CTE.

In developing the energy performance certificate, most of the 17 regional governments played an active role in developing administrative procedures for the registration, control and inspection. In addition various Spanish municipalities also have their own, stricter building energy codes.

The CTE applies to both residential and non-residential and includes:

- New buildings
- Major renovations of existing buildings;
- Elements of existing buildings that are undergoing renovation (only the relevant parts).

and covers:

- Residential buildings
  - Single Family Homes (SFH)
  - Multi-Family Home (MFH)
- Commercial buildings
  - Offices
  - Retail and wholesale
  - Hotels
  - Hospitals
  - Educational buildings
- Public Buildings
  - Offices
  - Hospitals
  - Educational buildings

Buildings that are exempt include:

- Those under 50m^2,
- Industrial buildings used for production,
- Buildings that were purchased with the aim either to demolish or under go major renovation,
- National monuments,
- Places of religious worship
- And temporary building with a use of less than 2 years.

It requires a manual/simulation performance-based reference building calculation to show compliance for most building types. A simplified or prescriptive method only applies for buildings where the glazing area is less than 60% of the total building, and where skylight surface area is less than 5% of total roof area. The CTE addresses thermal envelope requirements and energy efficiency standards in the calculation, including, HVAC, hot water, lighting and auxiliary systems (GBPN, 2013b).

5.4.2 Climate

Due to the different climates experienced in Spain, the Spanish building energy regulation divided the country into 12 climatic zones, each defined through a combination of one of the 5 climatic winter zones and one of the 4 climatic summer regions. The Winter climate zones are defined from A to E, and the summer climate zones are defined by I to V. The combination of the relevant conditions in the winter and summer months gives the climatic region for the calculation of the energy performance certificates.

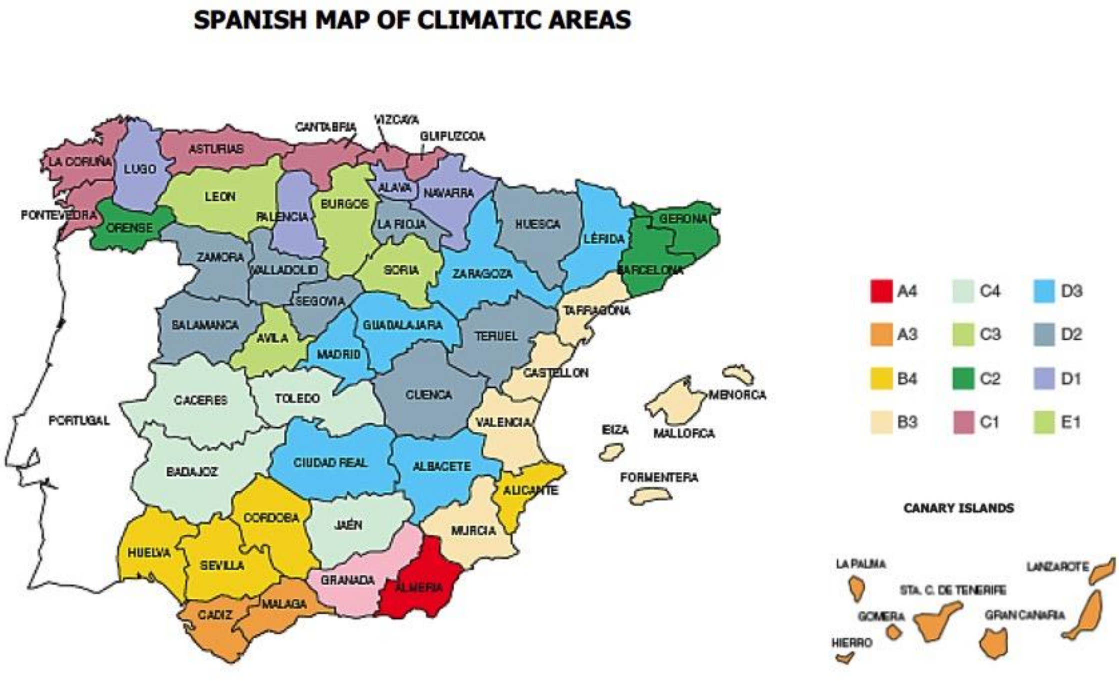


Figure 5-2 : Map of Spanish Climate Zones. Source (EPBD Buildings Platform, 2008)

5.4.3 Minimum technical and energy requirements

As of the 17th of September 2006, the CTE prescribes minimum energy requirements for new buildings and for the existing housing stock. The calculation of the requirements is via limitation of primary energy consumption and limitation of energy demand. In addition, it is required that the building should guarantee the thermal comforts of its inhabitants and minimize the risk of condensation in the building envelope, for example, through thermal bridges. This is achieved through a prescribed minimum level of insulation for avoiding condensation and mould and prescriptive limits for thermal transmittances for opaque components and glazing. For summer conditions maximum values of modified solar factors for windows have been selected, depending on the internal gains of the buildings.

The calculation of the minimal energy consumption requirements is done through the comparison against a calculated reference “twin” of the same type building. The type and level of the performance requirements are determined through a set of reference

values. These depend on the climatic zone where the building is located, with more extreme climates both hot and cold having more stringent requirements, and cover (EPBD Buildings Platform, 2008):

- Maximum U-values for different building elements;
- Solar factors for windows, roof lights, etc.;
- Minimum Efficiency performance for thermal installations, depending on ‘solar zones’ (see map below);
- Minimum Efficiency performance for lighting installations;
- Minimum natural lighting contribution;
- Minimum solar contribution to Domestic Hot Water (DHW); and
- Minimum photovoltaic contribution to electric power.

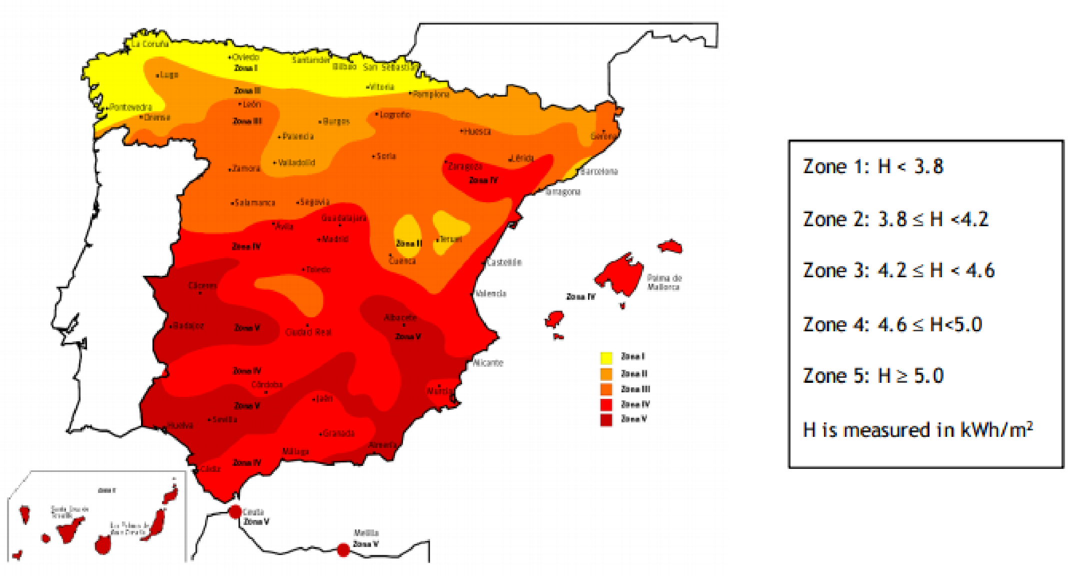


Figure 5-3 : Specific energy performance distributed by climate zones, Source (EPBD Buildings Platform, 2008)

This is then used to calculate the energy consumption of the building, for heating, cooling domestic hot water and other general use or global appliances such as pumps.

In addition to the minimum requirements for energy demand, there is also a requirement for a minimum level of air exchange in residential buildings, and the same for the air exchange in non residential buildings, according to the building type, plus an indication in terms of indoor (operative) temperature and relative humidity for winter and summer periods.

For buildings with heating systems over 20 kW there is a mandatory requirement for regular inspections. If the heating system is older than 15 years, irrelevant of size, there are also requirements for inspection. Depending on the region these inspections are carried out every 2 to 4 years. The inspector must have the necessary qualifications from an accredited authority for the relevant system.

Reference Values

The minimum values for the reference building for the calculation of the energy consumption are given in the table below (Table 5-13):

Table 5-13 : Values for the reference building for the calculation.

	Floor	Roof	Walls
	(W/m².K)	(W/m².K)	(W/m².K)
Climate Zone α1, A1 - α3, A3	0.53	0.50	0.94
Climate Zone B1 – B3	0.52	0.45	0.82
Climate Zone C1 – C4	0.50	0.41	0.73
Climate Zone D1 – D3	0.38	0.49	0.66
Climate Zone E1	0.48	0.35	0.57

The set point temperature for residential building heating is 17°C and for cooling between 25 °C and 27°C, depending on the time of day.

The set point temperature for non-residential building heating is 20°C and for cooling 25 °C.

Primary Energy Demand

This is based on the calculated net energy demand against that of a reference building built with prescriptive elements. The reference building is a building obtained from the building data, with its same shape, size, orientation, interior zoning, use of each space etc.

The non-renewable primary energy consumption of (new) buildings is given as:

$C_{ep,\ lim} = C_{ep\ base} + F_{ep,\ sup} / S$

Where:

$C_{ep,lim}$ is the limiting value of the non-renewable primary energy consumption for services of heating, cooling and DHW,

C_{ep}, base is the base value of the non-renewable primary energy consumption, dependent on the winter climatic zone corresponding to the location of the building

F_{ep}, sup is the correction factor by surface of the non-renewable primary energy consumption,

S is the usable area of the living spaces of the building, or the enlarged part, in m².

Table 5-14 : Energy consumption and correction factors for calculating the primary energy consumption

		α	A	B	C	D	E
		kWh/ m²a	kWh/ m²a	kWh/ m²a	kWh/ m²a	kWh/ m²a	kWh/ m²a
Energy Consumption	$C_{ep\ base}$	40	40	45	50	60	70
Correction factor	$F_{ep,\ sup}$	1000	1000	1000	1500	3000	4000

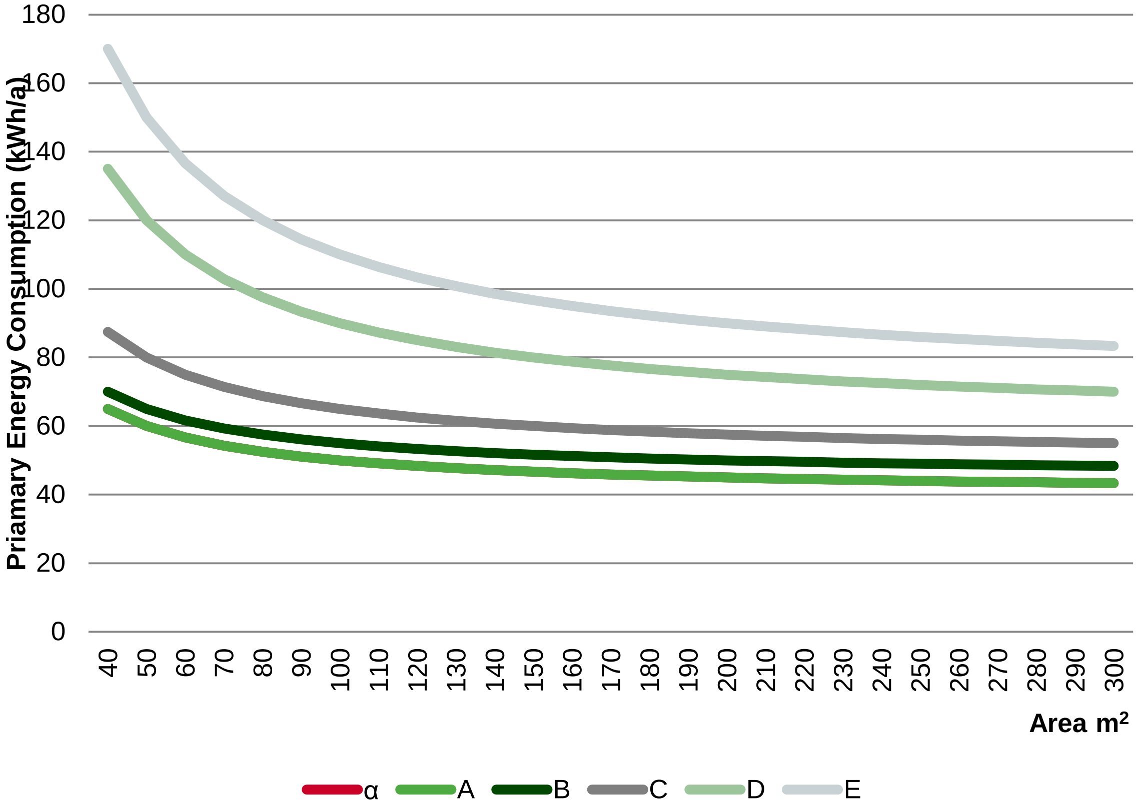


Figure 5-4 : Primary Energy Demand kWh/a

Final Energy Demand

The final energy demand is given as:

$D_{cal,\ lim} = D_{\ cal,\ base} + \ _{cal,\ sup} / S$

Where:

$D_{cal,lim}$ is the limit value of the heating energy demand , expressed in kW · h/m ^{2} · year, considered the useful surface of the habitable spaces ;

$D_{cal,base}$ is the base value of the heating energy demand , for each climatic zone of the building corresponding to the building

$F_{cal,sup}$ is the correction factor per surface of the heating energy demand ,

S is the useful surface of living spaces in the building, in m^2.

Table 5-15 : Energy consumption and correction factors for calculating the final energy consumption

		α	A	B	C	D	E
		kWh/ m2a	kWh/ m2a	kWh/ m2a	kWh/ m2a	kWh/ m2a	kWh/ m2a
Energy Consumption	D cal, base	15	15	15	20	24	40
Correction factor	F cal, sup	0	0	0	1000	2000	3000

Cooling Demand

Table 5-16 : Values for cooling demand.

	1	2	3	4
	kWh/m2a	kWh/m2a	kWh/m2a	kWh/m2a
Cooling Demand	≤ 15	≤ 15	≤ 15	≤ 20

Solar Hot Water

Thermal solar energy is mandatory for all Domestic Hot Water (DHW) installations, in all types of buildings with a DHW demand. The use of solar for domestic hot water for new buildings or existing buildings that have been completely renovated is required when the water requirement is higher than 50 l/d. For existing building (with no renovation) this is only required when the demand is higher than 5000 l/d. The minimum contribution is determined by the climate zone.

Table 5-17 : Percentage of yearly thermal solar energy coverage for hot water

	Climate Zone				
Water demand l/d	I	II	III	IV	V
50 - 5000	30%	30%	40%	50%	60%
5000 - 10000	30%	40%	50%	60%	70%
> 10000	30%	50%	60%	70%	70%

In protecting the system, consideration should be made that the system does not cover more than 110% in month of the year and 100% in 3 months of the year.

Photovoltaic

New buildings or existing buildings that have been completely renovated are required to use renewable solar energy through photovoltaic (PV). This also applies for buildings over 5000 m^2 such as hypermarkets, distribution centres, hospitals, exhibition pavilions. Historic buildings are exempted.

The basic requirement of the building standard is of energy efficiency first and then a rational use of energy within the buildings.

Air exchange rates

The summer air exchange rate for residential buildings should be 4 times an hour between 1 and 7 in the morning to allow night cooling. No other requirements are given for the day or winter. The requirements for air tightness are not tested.

Non-residential buildings need to be mechanically ventilated

Windows

Windows also need to take into account solar transmittance to avoid overheating. Maximum levels of (modified) solar factors have been prescribed for windows

5.4.4 Certification process

Certification is done either by an assessor or company, which has been accredited as certifier by the relevant authority. The certificate is obtained in the project phase and is necessary for obtaining a building permit. In addition, the certification must be confirmed on completion of the building.

The certification can be for a whole building or part of it, i.e. for an apartment with its own AC. In the case of the apartment certification, assumptions and simplifications are made in the calculation. If an apartment has its own AC then this is used for the calculation. If the system is centralised, the values are in proportion to the apartment against the total conditioned space.

Compliance can be achieved either through a prescriptive method or through a performance method.

Following information is required for certification:

- Definition of the climatic zone
- Geometric description, construction and uses of the building
- Use profile and where appropriate, level of conditioning of living spaces
- Procedure for calculating the energy demand
- Values of energy demand and where applicable, percentage of savings against a reference building, necessary for the verification of the requirement;
- Minimum technical characteristics that must be met by the products that are incorporated into the works and are relevant to the energetic behaviour of the building.

For new buildings, the certification process should include, an analysis of the energy efficient alternatives.

Compliance must be verified through the use of the latest version of the accredited calculation tool HULC (Unified Tool Lider and Calener). Introduced in 2013, the existing software tools were fused together into a single tool: HULC , as a result of the revision of CTE. This tool is compulsory for practitioners. The program is used to calculate the energy consumption of the building. In addition, there are three simplified tools for existing buildings in aiding the calculation of the EPCs, all of which have been approved by the Ministry of Energy, Tourism and Trade (MINETUR) and the Ministry of Public Works (MFOM).

During the construction or renovation phase the assessor must monitor the characteristics of the materials and technologies used. On completion of the building the building is recalculated according to the implementation and the certificate is adjusted.

After the final calculation is done, the building is registered in the regional registration office. The regional office enters the data into their databases and sends this information bi-annually to the central administration.

On compliance the building receives an energy performance certificate. The EPC contains information on the location, the assessor, building features including dimensions, envelope and systems. The building must also be documented by photograph.

On certification, the building owner receives a document (in PDF format) showing the entire calculation, suggestions for renovations and illustrates how the rating can be improved with renovations, the actual label including the level reached and the date registered. For existing buildings an energy performance certificate is required if the building is sold or is to be rented. The EPC is valid for 10 years from issue.

5.4.5 Cost of certificates

The costs of certificates are not fixed or predetermined. Qualified energy certification assessors and companies can freely set their own prices. The Ministry of Finance and Public Administration has however developed recommended rates for non-residential buildings for the issue of EPCs. Other sources give the prices as 500 € for a non-residential under 1000 m^2 and 1000 € for a building over 1000 m^2 (in 2011[3])

For residential buildings the prices in the literature varied from around € 450 to € 1,400 - €1,500 for SFH detached house and € 800 and €2,000-€2,500 for issuing a certificate for a block of flats. These are comparable prices to that of non-residential buildings. In addition, a tax must be paid to receive the certificate usually between 10 € to 25 € depending on region.

Table 5-18 : Recommend Prices Non-Residential (Avergae) for EPC. (Source: Ministry of Finance[4])

Floor Area	Price
m2	€
0 - 80	184.34
80 - 150	222.69
150 - 250	339.61
250 - 500	633.22
500 - 800	929.29
800 - 1200	1264.50
1200 - 3000	1596.81
3000 - 5000	2286.95
5000 - 8000	2665.84
8000 - 10000	3056.70
over 10000	3233.4 + 0.2 €/m^2

5.4.6 Compliance and Penalties

Spain's building energy code, CTE, is legally mandatory at the national level, but enforcement is regional. Regional government officials are responsible for checking

[3] BPIE: (2011): Energy Performance Certificates across Europe: From design to implementation

[4] Concerted Action Energy Performance of Buildings (2016) Implementing the Energy Performance of Buildings Directive (EPBD)

plans, energy efficiency compliance at design phase and construction inspection. In those jurisdictions with insufficient resources, the Ministry of Public Works and Transport may take over. Additionally, the Assessment Report of Buildings (IEE)[5] is partially done by third parties (GBPN, n.a.).

Regional government is also responsible for the issuing penalties in case of non-compliance. There are three laws pertaining to penalties for non-compliance:

- If the building does not comply to the requirements
  - The relevant actor is liable for 10 years if the non-compliance affects the stability
  - And 3 years if the habitability is affected.
- If the building installations are non-compliant - different fines apply from economic fines to activity suspension
- If no EPC is issued - administrative penalties as well the possibility of civil and penal penalties

The penalties for non-compliance are listed in Law 8/2013. The level of sanctions are also determined by the regional government with penalties varying from 300 € to 6000 €. In addition, energy performance certificates must be prevented to the relevant notary on sale of a building. Failing to do this can result in the building not being able to be sold.

Some more information on compliance and enforcement of CTE are (GBPN 2013b):

- Enforcement Status of Code: Mandatory
- Type of Enforcement: Local enforcement, Third party inspection
- On-site Inspections Occur: During construction, Post completion
- Certification to Support Enforcement of Code: Energy Performance Certificate support BC, Positive labelling for building beyond the minimum BC level, Inspection of boilers, Inspection of HVAC systems
- Penalties for Non-compliance: Refusal of permission to occupy, Refusal of permission to construct
- Measures Supporting Enforcement: Commissioning requirements, Training of Inspectors.

5.4.7 Monitoring and Evaluation

The regional government office is responsible for ensuring that the required quality of the EPC has been reached. A minimum documentary control and basic check for plausibility is made for all certificates on registration. In different regions this can however go further with detailed controls of the EPC data registered, and if necessary on-site controls. In other regions certified third party verification must be made before registration. Here a building supervision is mandatory and a check of imple-

[5] IEE- a technical element that forces the review exhaustively comprehensive collective housing buildings. This new document deals not only with safety issues but with the review of conservation issues, accessibility and energy efficiency (certificate) of all existing multi-family buildings that pre-date 1980.

mentation is made on completion of the building. The checking of the energy performance certificates is by the regional government. In addition to this there are mandatory inspections for boilers and HVAC systems.

5.4.8 Expert competence and training

The energy assessors qualified for the issuance of an EPC are the same as those who design buildings and the technical installations, such as architects and engineers. The requirements are covered in the Royal Decree 235/2013.

The assessor must have a degree in architecture or relevant engineering. There is no mandatory training or exam but assessors must show the necessary knowledge to issue EPCs. Firms can also be registered as assessors - they must, however, name a qualified person who can carry out this work.

5.4.9 Supporting measures and policies

Incentives

The Spanish Government supports its citizens to go beyond minimum levels of energy use by offering grants for energy efficiency in buildings (2004-2020), gas and electricity tax revenues disbursed to regional governments, and topped up with private funds (65%). The grants are proportional to the different energy requirements and efficiency measures related to the codes and the EPC labels.

Knowledge dissemination

The dissemination of the knowledge about the new CTE and its use among industry actors is the responsibility of the Ministry of Housing.

Stakeholder involvement

Stakeholders are usually asked to review the new requirements to be established in the next recast of the CTE, which is underway by the Ministry of Public Works (Ministerio de Fomento) of the Spanish government.

Capacity building and education

When the new CTE was been approved, the Ministry of Housing and the Institute for the Diversification and Saving of Energy, representing the Ministry of Industry, organizes training sessions for the 17 regions in Spain. The regions and the "Engineers and Architects associations" gave CTE interpretation courses, as well as a trainings to learn to use the official software LIDER and the CALENER (today HULC).

Supporting certification schemes

Spain has introduced a new law (Real Decreto 235/2013) obliging property owners to obtain energy efficiency certificates for their houses before they can sell or rent. This allows the public and potential buyers to assess and compare the energy characteristics of different buildings in their decision prior to procurement or signing of a lease.

The energy efficiency rating of the existing buildings could be taken into account to regulate a greater, or lower, tax burden based on the energy rating of individual properties.

Certificado de Eficiencia Energética del Edificio (EPC in Spain) is applicable to all new buildings, and buildings which are sold/rented to new owners/tenants, with the exception of buildings with a total useful floor area less than 50 m^2 and buildings used for either less than four months a year or for a limited time a year with expected energy consumption of less than 25% of yearly consumption.

5.5 Programs to promote and improve EPCs

Within the European Union, there are numerous programs both on a EU level as well as at national level to promote EPCs. Programs such as Horizon 2020 aid this process through the funding of projects. Examples of projects include:

5.5.1.1 ASIEPI (Duration: 01/10/2007 to 31/03/2010)

The project Assessment and Improvement of the EPBD Impact (ASIEPI) dealt with the assessment and improvement of the EPBD Impact (for new buildings and building renovation). The ASIEPI project also developed a benchmarking method and tool to compare energy performance requirement levels in the European Member States. The project came to the conclusion that a comparison of energy requirements between countries (and thus EPCs) is extremely difficult. This alone even if the definition is in the same units of kWh/m^2 as for example the definition of the relevant treated floor area is most often different. Here the same building calculated with two different methods for the treated floor area would have two different energy consumption levels.

5.5.1.2 BUDI (Duration: 01/01/2005 to 31/07/2007)

The project Pilot Actions aimed to develop a functioning market for energy performance certificates via a regional approach. It focused on two key building types: apartment blocks and public buildings. The project rolled out pilot actions, information campaigns, tools and advice, training sessions for independent experts, accreditation schemes, as well as developed regional information and competence centres within the countries of Austria, Finland, France, Germany, Ireland and Slovenia.

5.5.1.3 ENFORCE (Duration: 01/09/2009 to 31/08/2012)

The European Network for the Energy Performance Certification of Buildings (ENFORCE) project helped the diffusion of energy certification (Energy Performance of Buildings Directive 2002/91/EC). It aimed to give final consumers independent, qualified, information and assistance on energy certification of their buildings, allowing them to make informed decisions.

5.5.1.4 IMPACT (Duration: 01/01/2005 to 31/01/2007)

This project Improving energy Performance Assessments and Certification schemes by Tests (IMPACT) dealt with the removal of barriers such as information and lack of expertise, notably auditing skills in the deployment of EPCs. IMPACT, set about conducting pilot tests in different countries in order to identify best practices, share experiences and produce recommendations for improvements to building certification schemes. These experiences were publicly aired in national and regional workshops and shared with the governmental institutions for creating the building certification schemes in every country of the European Union.

6 3rd Party (Voluntary) Energy standards and labelling

This section gives a brief overview of voluntary standards for increasing energy efficiency in buildings. The voluntary standards presented in this section are Passive House Standard, The Active House Standard, KfW Standard and the MINERGIE Standard. In addition to the national standards, some of these voluntary standards have become mandatory for specific regions or cities due to their higher energy efficiency requirements such as the Passive House in Frankfurt, Germany, Brüssel - Region Brussels-Capital and Wels, Austria or the Minergie Standard in Switzerland, which has become the de facto energy efficiency standard in Switzerland. For reasons of complexity a list of these regions is not covered in this handbook. It provides information on the standards, their minimum technical/energy requirements, compliance and enforcement measures, and monitoring and evaluation procedures of the certified building.

6.1 Passive House Standard

6.1.1 General Information and Background

The Passive House Standard is a renowned third party energy building standard and is commonly used across Europe. It presents a (cost effective) ultra-low energy-building standard, which uses highly insulated airtight construction with heat recovery ventilation systems to achieve high indoor thermal comfort conditions as defined per the ISO 7730 standard. The choice of building materials including insulation, heating and cooling systems as well as the energy sources are open for designers. Since the first Passive House was built in 1991 in Kranichstein, Darmstadt, Germany there are now over 30000 Passive House certified buildings in Europe. It is one of the few standards used throughout Europe and is not limited to a Member State defined by a central entity.

> *“Passive Houses are buildings in which a comfortable temperature in winter as well as in summer can be achieved with only a minimal energy consumption.”*
>
> (Feist 2013)

The Passive House Institute has developed three different building standards to cater for different building types. These are for:

- New buildings,
- Existing buildings
- Buildings in regions, which are not optimal for PH standard.

The Passive House Standard for new buildings is further categorised as Classic, Plus and Premium representing increasing levels of energy efficiency, as shown below:

- Passive House Standard (a nearly-zero-energy building)
  - Passive House Classic
  - Passive House Plus (with renewables)
  - Passive House Premium (with renewables)

- EnerPHit (for existing buildings that use Passive House components but do not quite reach the Passive House Standard)
- PHI Low Energy Building (for regions which are not optimal for PH)

6.1.2 Climate

All of the standards of the Passive House Institute are valid worldwide and in all climates. As the standard exists for all climates it has no fixed reference value as the conditions for heating and cooling vary and thus different criteria or alternative criteria might apply for the different climates worldwide. . Although the specific design of Passive Houses may vary with circumstances, the leading principle remains the same. Each Passive House Standard is defined by its allowance for maximum energy consumption of the building. In climates with space cooling requirements and high humidity, maximum allowance also factors in energy required for dehumidification.

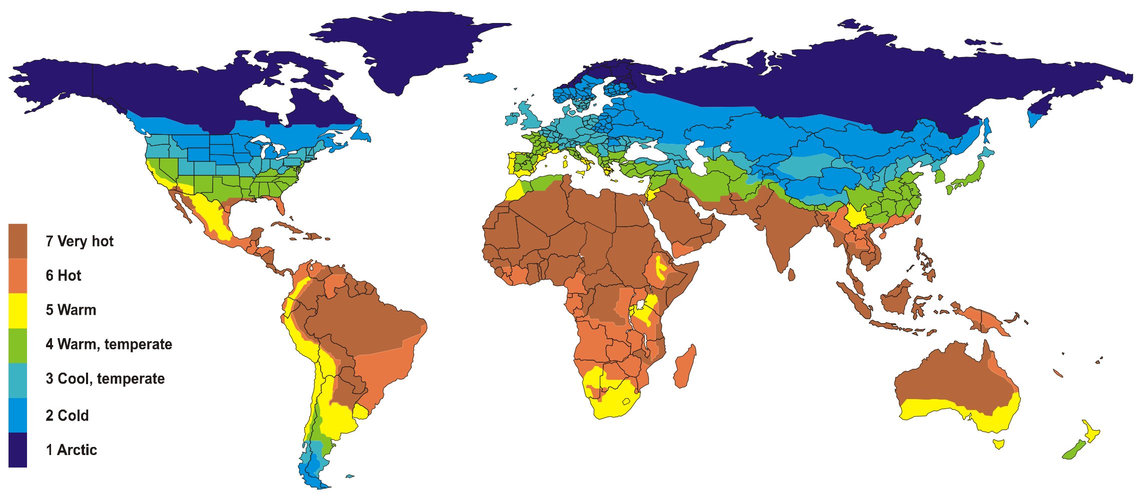


Figure 6-1 : Passive House Climate Zones (Regions with identical requirements. (Source: PHI)

6.1.3 Minimum technical and energy requirements

The Passive House standard is a functional standard certified by the Passive House Institute in Darmstadt.

> *"A Passive House is a building, for which thermal comfort (ISO 7730) can be achieved solely by post-heating or post-cooling of the fresh air mass, which is required to achieve sufficient indoor air quality conditions – without the need for additional recirculation of air."*
>
> Definition of a Passive House

The basic idea of a Passive House is to provide high thermal comfort through passive measures such as excellent insulation, airtight construction, energy recovery, passive solar use and internal heat gains achieving a high-energy efficiency/ performance, in winter as well as in summer at a low building cost. It is not limited to the

choice of building materials including insulation, heating and cooling systems as well as the energy source if the relevant criteria are achieved.

Note: All criteria of all Passive House Standards are described in the document "Criteria for the Passive House, EnerPhit and PHI Low Energy Building Standard". This represents the legally binding definition of the Passive House Standards and their criteria. The document can be found on the Passive House website as well as the Chinese Passive House Website https://phichina.com/ .

All Passive House Buildings are rated according to the their Heating Demand and either the Primary Energy Demand (PE) or the Primary Energy Renewable Demand (PER) (both including house-hold appliances and work equipment). This is due to the fact that the Passive House Standard is at present (2018) in a transition phase in the evaluation procedure moving from a definition based on Primary Energy (PE) to that of the Primary Energy Renewable (PER). In addition to these two definitions, there are general criteria that all Passive Houses must meet.

Note: The values listed here are for residential buildings, and typical administrative buildings. Buildings where the use deviates and with extremely high electricity demand higher limit values can be used, as provided by the Passive House Institute. The reference area for any Passive House Calculation is that of the treated Floor Area as defined in DIN 277.

6.1.3.1 Primary Energy Method

The Primary Energy method is being phased out and may only be used to evaluate Passive House Classic and PHI Low Energy Buildings. The Primary Energy demand includes Energy for heating, cooling, dehumidification, DHW, lighting, auxiliary electricity and electrical appliances.

Table 6-1 : Heating Demand and Primary Energy Demand. (Source: PHI)

	Heating Demand	PE Demand	
Classic	15 kWh/(m^{2}a)	120 kWh/(m^{2}a)	

6.1.3.2 Primary Energy Renewable Method

Under the Primary Energy Renewable Method, Passive House Certification can be achieved in Classic, Plus and Premium for any European Climate. A proof of renewable energy generation must be provided for achieving Passive House Plus and Premium certification. The Primary Energy Renewable demand includes energy for space heating, cooling, dehumidification, domestic hot water (DHW), lighting, auxiliary electricity and electrical appliances.

Table 6-2 : Heating Demand and Primary Energy Renewable Demand. (Source: PHI)

	Heating Demand	PER Demand	PER Production
Classic	15 kWh/(m2a)	60 kWh/(m2a)	-
Plus	15 kWh/(m2a)	45 kWh/(m2a)	60 kWh/(m2a)
Premium	15 kWh/(m2a)	30kWh/(m2a)	120 kWh/(m2a)

Note: there can be a deviation from the above listed criteria by ± 15 kWh/(m²a) with compensation by different amounts of generation.

Primary Energy Renewable (PER)

PER describes how much renewable energy is generated, including that lost in storage, to cover the energy demand of the building. The specific energy losses of an energy application describes the respective PER factor, the lower the factor the lower the losses. Solar energy used directly has thus a PER of 1.0. For PER Production the area refers to the area covered by the building.

6.1.3.3 General Criteria

In addition to the main criteria, all standards contain minimum requirements for thermal comfort, user satisfaction and structural integrity. For European climates these include (for a temperate European Climate):

Table 6-3 : Example parameters: Parameters for Residential Passive Houses New and Existing in a Temperate Climate. (Source: PHI)

Building Envelope Insulation	U ≤ 0.15 W/(m²K)
Windows	Ug ≤ 0.8 W/(m²K), g-value (SHGC glass) > 50%
Mechanical Ventilation	Ventilation with ≥ 75% heat recovery over total system (ηHR,eff ≥ 75 %)
Pressurization Test Result	max. 0.6 ACH @ 50 Pa (pressurizing and depressurizing)
Thermal Bridging	(near to) thermal bridge free
Heating load	max. 10 W/m²
Space heating demand	max. 15 kWh/(m²a)
Space cooling demand	max. 15 kWh/(m²a)
Dehumidification demand	variable limit value
Total primary energy consumption	max. 120 kWh/(m²a)
Electricity consumption	Max. 0.45 Wh/m³
Thermal Comfort	< 10% over 25°C per annum

Furthermore, the following criteria should also be met:

- Frequency of overheating
  - The number of hours over 25°C without active cooling must be ≤ 10%
- Frequency of excessively high humidity
  - The number of hours over 12g/kg indoor air humidity without active cooling must be ≤ 20%
  - The number of hours over 12g/kg indoor air humidity with active cooling must be ≤ 10%
- Minimum thermal protection
  - The minimum thermal protection requirements must be achieved with surface temperatures not more than 4.2°K below that of the operative temperature.
- Occupant satisfaction

- Rooms should have operable windows
- Operable lighting and temporary shading elements.
- Operable temperature regulation for the conditioning system installed
- Conditioning systems must be able to maintain temperature under all conditions.

6.1.3.4 EnerPHit (Certification Criteria for Energy Retrofits with Passive House Components)

EnerPHit certification is applicable for existing buildings that are renovated to meet the Passive House criteria. However, in existing buildings it is often difficult to reach the levels required for certified Passive House criteria due to various factors, such as air tightness, unavoidable thermal bridges, listed or historical buildings, and/or when economically unviable. Such buildings can still achieve Passive House certification provided that all the relevant building components are replaced with Passive House certified components or that the building complies with the energy demand but may not meet a few other criteria. The EnerPHit Standard provides the certainty that an optimum thermal protection has been implemented. If more than 25% of the exterior wall area has interior insulation the certification is given as EnerPHit +i to denote the internal insulation.

As with the Passive House Standard EnerPHit Certification can be achieved in:

- Classic
- Plus
- Premium

To achieve EnerPHit Plus and Premium certification, proof of renewable energy generation must be provided.

Buildings that are renovated to high energy efficiency standards are often renovated in a step-wise manner i.e. the heating system is still within its lifetime at the start of the renovation and is only replaced at the end of this. The EnerPHit system offers a simple yet effective step-by-step solution to ensure that buildings are renovated to a ultra-low-energy efficient standard in a cost effective manner. This could be for example when the building is renovated but a component has not reached its viable lifetime and is thus makes more economical sense to renovate this at a later date. This requires however careful planning as single renovation steps must fit together when completed. An online tool offered by the PHI helps to streamline the Retrofit Plan by organising and storing necessary verifications and documents over long periods.

6.1.3.5 General Criteria

For EnerPHit Buildings the following general criteria are applicable irrespective of the chosen method:

Table 6-4 : General EnerPHit criteria. (Source: PHI)

			Criteria[1]			Alternative Criteria[2]
Airtightness						
Pressurization test result n_{50}	[1/h]	≤	1.0			
Renewable Primary Energy (PER)[3]			Classic	Plus	Premium	
PER demand[4]	[kWh/(m²a)]	≤	60 + (Q_H - $Q_{H,PH}$) • $f_{ØPER,H}$ + (Q_C - $Q_{C,PH}$) • 1/2	45 + (Q_H - $Q_{H,PH}$) + (Q_C - $Q_{C,PH}$) • 1/2	30 + (Q_H - $Q_{H,PH}$) + (Q_C - $Q_{C,PH}$) • 1/2	±15 kWh/(m²a) deviation from criteria...
Renewable energy generation[5] (with reference to projected building footprint)	[kWh/(m²a)]	≥	-	60	120	...with compensation of the above deviation by different amount of generation

[3] The requirements for the PER demand and generation of renewable energy were first introduced in 2015. As an alternative to these two criteria evidence for the Passive House Classic Standard can continue to be provided in a transitional phase by proving compliance with the previous requirement for the non-renewable primary energy demand:
Q_P ≤ 120 kWh/(m²a) + (Q_H - 15 kWh/(m²a)) • 1.2 + Q_C - $Q_{C,\ Passive\ House\ criterion}$
In the above mentioned formula if the terms "(Q_H - 15 kWh/(m²a))" and " Q_C - $Q_{C,\ Passive\ House\ criterion}$" are smaller than zero, then zero will be adopted as the value.
PHI may specify other national values instead of the base value of 120 kWh/(m²a) based on national primary energy factors. The desired verification method can be selected in the PHPP worksheet "Verification". The primary energy factor profile 1 in the PHPP should be used.

6.1.3.6 Component Criteria method

Passive House certified building components must be used or evidence must be provided that components used to meet criteria as laid down by Passive House. Thermal bridges must also be avoided or at least minimised.

Table 6-5 : EnerPHit criteria for the building component method. (Source: PHI)

Climate zone according to PHPP	Opaque envelope[1] against... ...ground: Insulation	...ambient air: Exterior insulation	...ambient air: Interior insulation[2]	...ambient air: Exterior paint[3]	Windows (including exterior doors): Overall[4]			Glazing[5]	Solar load[6]	Ventilation: Min. heat recovery rate[7]	Ventilation: Min. humidity recovery rate[8]
	Max. heat transfer coefficient (U-value)			Cool colours	Max. heat transfer coefficient ($U_{D/W,installed}$)			Solar heat gain coefficient (g-value)	Max. specific solar load during cooling period		
	[W/(m²K)]			-	[W/(m²K)]			-	[kWh/m²a]	%	
Arctic	Determined in PHPP from project specific heating and cooling degree days against ground.	0.09	0.25	-	0.45	0.50	0.60	U_g - g*0.7 ≤ 0		80%	-
Cold		0.12	0.30	-	0.65	0.70	0.80	U_g - g*1.0 ≤ 0		80%	-
Cool-temperate		0.15	0.35	-	0.85	1.00	1.10	U_g - g*1.6 ≤ 0		75%	-
Warm-temperate		0.30	0.50	-	1.05	1.10	1.20	U_g - g*2.8 ≤ -1		75%	-
Warm		0.50	0.75	-	1.25	1.30	1.40	-	100	-	-
Hot		0.50	0.75	Yes	1.25	1.30	1.40	-		-	60 % (humid climate)
Very hot		0.25	0.45	Yes	1.05	1.10	1.20	-		-	60 % (humid climate)

Note: If for any reason the U-Value of a component does not meet the requirements then the average U-Value (area weighted U-Value) may be used.

The above listed values may only be exceeded among others if for example the building is a historical building, the cost effectiveness is no longer assured, due to legal requirements or other compelling reasons.

6.1.3.7 Energy Demand method

For the Energy Demand method it must be shown, using Passive House Planning Package (PHPP), that the EnerPHit building reaches the Criteria for EnerPHit Energy Demand as described below:

Table 6-6 : EnerPHit criteria for the building energy demand method. (Source: PHI)

Climate zone according to PHPP	Heating	Cooling
	Max. heating demand	Max. cooling + dehumidification demand
	[kWh/(m²a)]	[kWh/(m²a)]
Arctic	35	equal to Passive House requirement
Cold	30	
Cool-temperate	25	
Warm-temperate	20	
Warm	15	
Hot	-	
Very hot	-	

6.1.3.8 PHI Low Energy Building

The PHI Low Energy Building Standard is a low energy building standard for buildings that do not reach the minimum requirement for the Passive House standard. This could be for various reasons, such as buildings in regions, which are not optimal for Passive Houses i.e. shaded by hills in cold locations or in countries where no or not all Passive House suitable components are available. In such cases, with consultation with the Passive House Institute, certification of a building as a PHI Low Energy Building can be obtained. The required documentation and certification process are the same as for Passive House Buildings even though some of the criteria may vary.

Table 6-7 : PHI Low Energy Building Criteria. (Source: PHI)

			Criteria[1]	Alternative Criteria[2]
Heating				
Heating demand	[kWh/(m²a)]	≤	30	
Cooling				
Cooling + dehumidification demand	[kWh/(m²a)]	≤	Passive House requirement[3] + 15	
Airtightness				
Pressurization test result n_{50}	[1/h]	≤	1.0	
Renewable Primary Energy (PER)[4]				
PER demand[5]	[kWh/(m²a)]	≤	75	Exceeding the criteria up to +15 kWh/(m²a) is permitted...
Renewable energy generation[6] (with reference to projected building footprint)	[kWh/(m²a)]	≥	-	...with compensation of the above deviation by additional generation

6.1.4 Certification process

Certification is done either by the Passive House Institute or another Institute, which has been accredited as certifier by the Passive House Institute using its seal as per the Passive House Standards.

It is recommended by the PHI that an accredited designer accompany all phases through to the certification process, although, buildings can still be built and certified without the assistance of an accredited designer.

Passive House Standard compliance must be established through the use its calculation tool Passive House Planning Package (PHPP). Actual software files need not be submitted by a registered Passive Consultant/Planer, although, this is recommended by Passive House as a quality control.

For each project the Passive House Certifier will create an account for that project with all the relevant information and checklist that is needed to complete the application for certification. The Passive House Designer will receive the login details for this project and can then enter and upload the data required for the certification. The online certification platform is especially relevant for the EnerPHit process where a step-by-step renovation is made. The platform allows for an easy interactive communication between the designer and the certifier and offers the possibility for guidance throughout the certification process. The platform offers a structured checklist, following an interactive workflow, which is charted with comments, reminders and checkboxes. All documents need for certification are submitted digitally via the platform.

All energy relevant documents and technical data as well as the completed PHPP file are submitted to either the Passive House Institute or an accredited certifying institute before the commencement of actual construction process. The relevant certifier then checks this. The certifier will recommend that corrections be made to the calculations, if necessary. In complicated cases the certifier may suggest solutions to improving the energy efficiency of the building. After assessment the client will receive the results with corrected calculations and suggestions for improvement. The calculation of the building includes the space heat demand and the total primary energy consumption including energy consumption for household appliances and work equipment.

It is to be noted that the certification only assures the correctness of the documentation submitted. If additional quality assurance is needed this can be provided by the certifier. The onsite confirmation of completion is not part of the certification process. The liability for correct implementation and quality control remains with the accredited planner and (in the last instance) the building owner.

On completion of the building, the final documents as built including all energy-relevant changes are to be submitted for final review. Relevant documents include, among others:

- Completed PHPP file containing all the relevant data.
- Architectural planning documents
- Standard and connection details including thermal bridges.

- All documents relevant for the necessary energy efficiency measures for example:
- Data sheets of energy relevant materials and technologies.
- Description of building services (heating, cooling, domestic hot water, waste water, ventilation, (including flow rates), renewable energy production and electrical devices and lighting), where necessary with schematic diagrams and technical information.
- Air tightness test (from a registered Airtightness expert in accordance with EN 13829 (Method A) or alternatively using ISO 9972 (Method 1)
- Construction manager declaration

In aiding the certification, it is recommended that photo documentation be provided as documentation of the energy relevant measures. Furthermore, assembly verification of moisture protection must be shown when extra clarification is required for buildings or construction components.

All documents showing the U-Value compliance of the materials must be presented to the PHI for certification. In Germany, this must be in compliance to the DIN V 4108-4. In the absence of national standard, verification is through an independent third party. The value of CE Label, for example, may be used for verification. Alternatively, materials and technologies accredited and tested by the PHI may be used.

Stringent quality checks of the PHI criteria are made before certification. The relevant certification including the seal is issued only after the technical accuracy of the required documentation is confirmed and the criteria are fulfilled. If however the building has deficiencies in any area then the certification can be withheld by the Passive House Institute.

On approval of the building by the Passive House Institute, the building owner will receive the Passive House Building Certificate with a unique identification number. The certifier is also required to present the building owner with a “User Handbook” of how to use the building as well as a supplementary booklet documenting the energy balance calculation as well as all the building characteristics. A building wall plaque declaring that the building is a Passive House Building, which can be displayed to show conformity with the Passive House Standard, is also issued.

Figure 6-2: Passive House, EnerPHit, EnerPHit interior insulation and Low Energy Building Seals. (Source: PHI)

The issued certificates and seals are only to be used for the relevant building. Any certification is also only valid for the building as implemented and used, as intended and documented in the booklet accompanying the certification. Any energy –relevant changes to the building will make the certification invalid.

Certification is always based on the currently valid version of the standard and the corresponding criteria. However, criteria that are updated during the building process need not be adhered to. It is thus recommended to contact the PHI early in the process to ensure under which the version of the standard the building is being constructed.

All verification calculations and reports are stored confidentially for future reference and possible monitoring by the Passive House Institute.

6.1.4.1 EnerPHit certifcation

As with the Passive House certification, an EnerPHit House is calculated through the Passive House Planning Package (PHPP) and similar in the methodology. To increase quality assurance and to ensure that building reaches its intended energy efficiency targets, the building can be certified with a pre-certification for step-wise renovation. An EnerPHit Retrofit Plan is a prerequisite for this. In addition, the pre-certificate can only be issued if 20% (in terms of energy savings of the intended target) of the renovation has taken place. The PHPP calculation system provides a tool for the development of an EnerPHit Retrofit Plan.

For certification as an EnerPHit building following, but not limited to, documents must be provided:

- Completed EnerPHit Retrofit Plan
- Architectural planning documents
- Plans of existing building
- Plans of fully refurbished building
- Completed PHPP Excel File containing all the relevant data.
- Standard and connection details including thermal bridges.
- All documents relevant for the necessary energy efficiency measures for example:
- Data sheets of energy relevant materials and technologies.
- Description of building services (heating, cooling, domestic hot water, waste water, ventilation, renewable energy production and electrical devices and lighting), where necessary with schematic diagrams and technical information.
- Air tightness test
- Construction manager declaration

During the certification process the building is closely analysed including the detailed planning. Certification is only granted if all criteria are met.

Certificate

Certified Passive House Premium

Passive House Institute
Dr. Wolfgang Feist
64283 Darmstadt
Germany

End-of-terrace Passive House
Example Street 99, 99999 Example City, Germany

Certified Passive House
Passive House Institute
classic | plus | premium

Client	Passivhaus Association of Owners Example Street 99 99999 Example City, Germany
Architect	Example Architectural Firm Example Street 99 99999 Example City, Germany
Building Services	Example Mechanical Services Firm Example Street 99 99999 Example City, Germany
Energy Consultant	Example Energy Consultant Example Street 99 99999 Example City, Germany

Passive House buildings offer excellent thermal comfort and very good air quality all year round. Due to their high energy efficiency, energy costs as well as greenhouse gas emissions are extremely low.

The design of the above-mentioned building meets the criteria defined by the Passive House Institute for the 'Passive House Premium' standard:

Building quality		This building		Criteria	Alternative criteria
Heating					
Heating demand	[kWh/(m²a)]	13	≤	15	-
Heating load	[W/m²]	10	≤	-	10
Cooling					
Cooling + dehumidification demand	[kWh/(m²a)]	-	≤	-	-
Cooling load	[W/m²]	-	≤	-	-
Frequency of overheating (> 25 °C)	[%]	1	≤	10	
Frequency of excessively high humidity	[%]	0	≤	20	
Airtightness					
Pressurization test result (n_{50})	[1/h]	0,2	≤	0,6	
Non-renewable primary energy (PE)					
PE demand	[kWh/(m²a)]	40	≤	-	
Renewable primary energy (PER)					
PER-demand	[kWh/(m²a)]	32	≤	30	32
Generation (reference to ground area)	[kWh/(m²a)]	125	≥	120	124

The associated certification booklet contains more characteristic values for this building.

Darmstadt, 01. June 2017
Certifier: John Smith, Passive House Institute

www.passivehouse.com 0

Figure 6-3 : Example of a Passive House Building Certificate. (Source PHI)

6.1.5 Cost of certificates

There are no fixed prices for the certification of a building. Each certification is according to the time and effort required for a specific project. Certification costs also include a “licence” to cover support and resources provided to the certifiers.

6.1.6 Compliance and Penalties

Any certification given for a building is only valid for the building that is built as shown in the construction drawings in the documentation provided to the PHI. Any deviations from the documentation would require a new calculation. The PHI reserves the right to take legal action in the case of non-compliance.

6.1.7 Inspection Monitoring

The initial certification and the only “inspection” of a Passive House are based on calculation as well as a project documentation submitted and not on an on-site visit.

The project documentation must contain all the information needed for a full calculation and be transparent and consistent in the methodology. The evaluation of the data is made by the accredited designer/consultant and only certifies the correctness of the documents submitted. Any further inspection, monitoring and quality control of the Passive House building is the responsibility of the Passive House Designer/Planner.

6.1.8 Materials and technologies

In addition to certifying building, Passive House also certifies materials and technologies. These materials and technologies have been tested and certified by the Passive House Institute for their energy-relevant performance. All testing is via established and accredited methods. Passive House certified materials and technologies offer a quality assurance for the construction of a highly efficient building.

All components are certified for a specific climatic region in regards to the optimal relation between performance and life cycle cost efficiency. This is especially relevant as the requirements vary per region and climatic conditions and no one component can fit all conditions. These are chosen to be easily verifiable and clearly identifiable and are oriented on the building practice.

The criteria are based on two categories:

- Health and living comfort (“comfort criteria”)
- Energy Balance in practice (“energy criteria”)

The stringent testing along with specific criteria allows an easy comparison of the Passive House accredited materials and technologies.

All certified components are listed in an online database as well as in the PHPP excel file for transparency and ease of access to the relevant information.

During the certification process, the Passive House Institute works closely with the manufactures to ensure high quality of the components. The certification is process is as shown below:

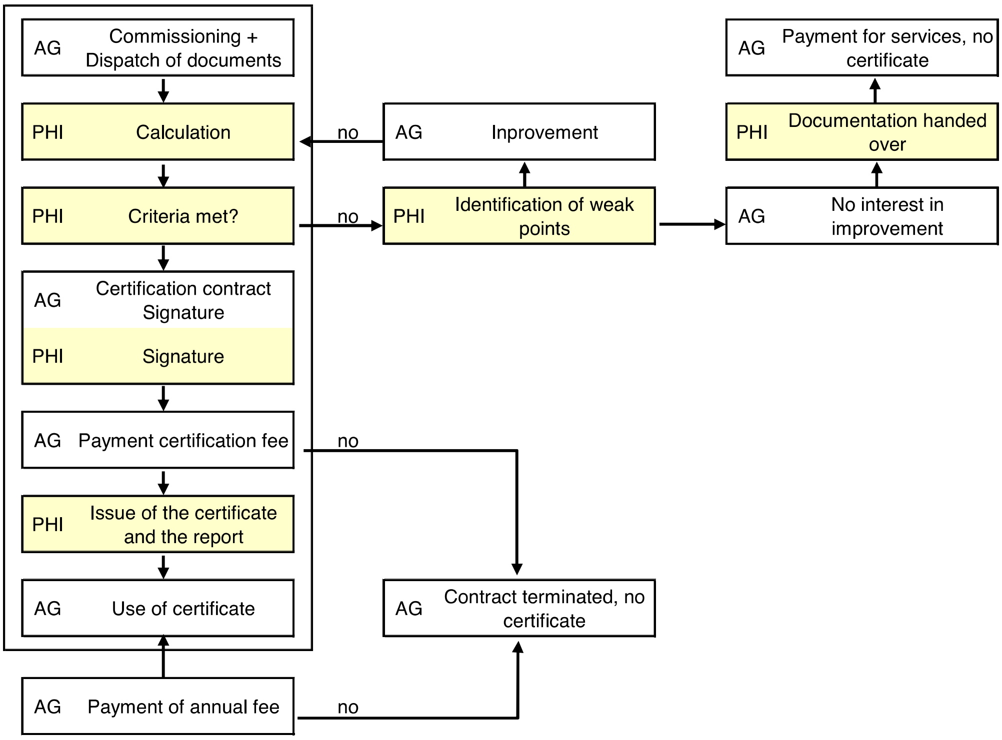
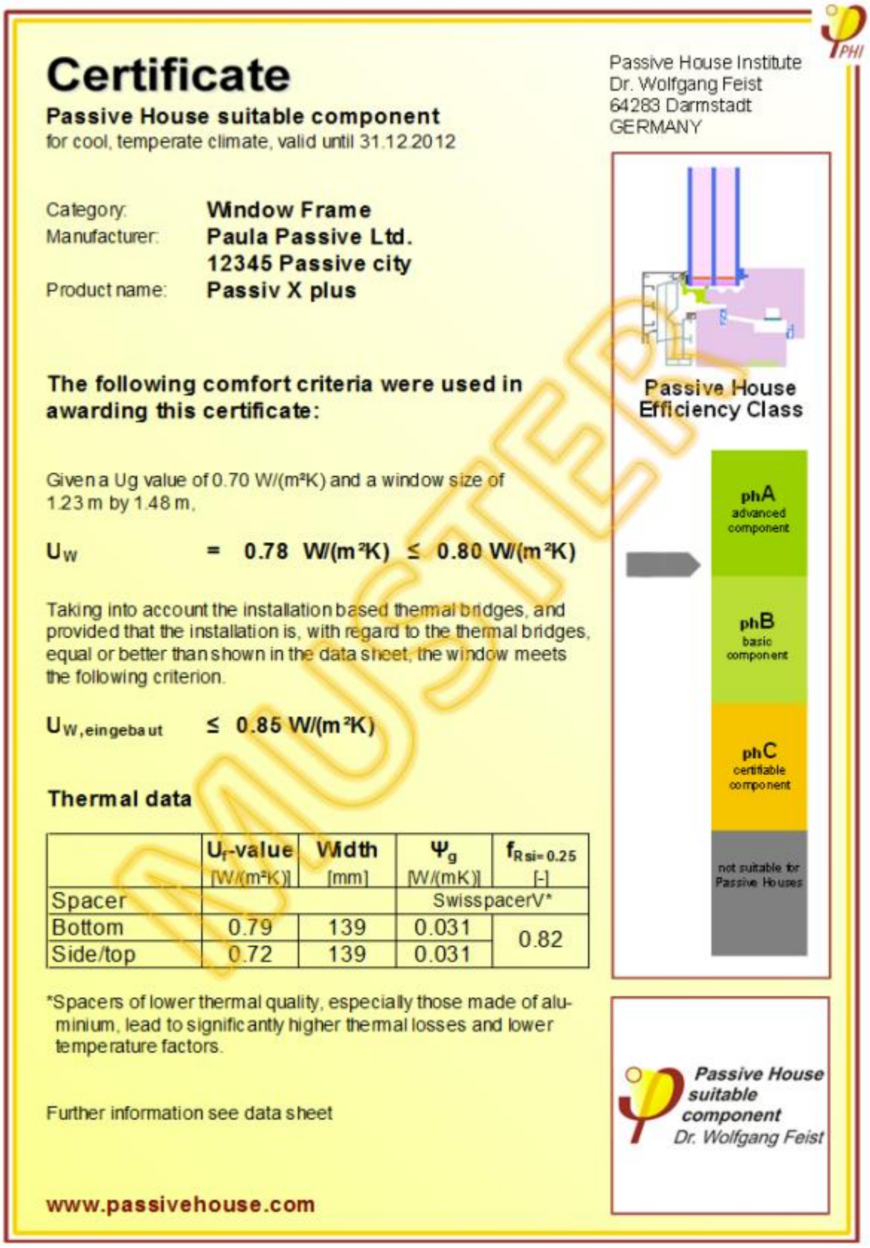


Figure 6-4 : Passive House certification process. (Source: PHI)

Passive House certified materials and technologies are divided into three main categories, opaque building envelope, transparent building envelope and mechanical systems with relevant sub-categories. Categories include:

- Transparent building envelope
  - Windows
  - Roof windows
  - Skylights
  - Curtain wall systems
  - Glass roofs
  - Open able glass roof elements
  - Shutters
  - Entry doors
  - Sliding doors
  - Glazing
  - Spacers
- Opaque building envelope
  - Wall and construction systems
  - Façade anchors
  - Insulating Concrete Framework (ICF) for roof parapets
  - Flue systems
  - Balcony connections
  - Attic staircases

  - Airtightness systems
- Building services
  - Compact heat pump units
  - Ventilation systems < 600 m³/h
  - Ventilation systems > 600 m³/h
  - Drain water heat recovery



Certificate

Passive House suitable component

for cool, temperate climate, valid until 31.12.2012

Passive House Institute
Dr. Wolfgang Feist
64283 Darmstadt
GERMANY

Category: **Window Frame**
Manufacturer: **Paula Passive Ltd.**
12345 Passive city
Product name: **Passiv X plus**

The following comfort criteria were used in awarding this certificate:

Given a Ug value of 0.70 W/(m²K) and a window size of 1.23 m by 1.48 m,

U_W = **0.78 W/(m²K) ≤ 0.80 W/(m²K)**

Taking into account the installation based thermal bridges, and provided that the installation is, with regard to the thermal bridges, equal or better than shown in the data sheet, the window meets the following criterion.

$U_{W,eingebaut}$ **≤ 0.85 W/(m²K)**

Thermal data

	U_f-value [W/(m²K)]	Width [mm]	Ψ_g [W/(mK)]	$f_{Rsi=0.25}$ [-]
Spacer			SwisspacerV*	
Bottom	0.79	139	0.031	0.82
Side/top	0.72	139	0.031	

*Spacers of lower thermal quality, especially those made of aluminium, lead to significantly higher thermal losses and lower temperature factors.

Further information see data sheet

www.passivehouse.com

Figure 6-5 : Example of a Passive House Component Certificate. (Source: PHI)

6.1.9 Expert competence and training

6.1.9.1 Certified Passive House Designer / Consultant

A Passive House qualified expert can be certified either as a Passive House Designer or a Passive House Consultant depending on the educational qualifications of the applicant. A Passive House Designer has educational qualifications, such as a bachelor´s or master´s certificate, which allow the planning of buildings or technical systems. For the certification as a Passive House Consultant no further training is required. Certification as a Passive House Designer/ Consultant is through either/or:

- Advanced training through seminars, training courses or private study and eventually passing a written exam.
- Presentation of a Quality Approved Passive House construction project planned responsibly by the applicant and properly documented.

The certification and seal are of a personal nature and are bound to a specific person. Certification is limited to a five-year period after which it must be renewed. Certification can be renewed either through PH project documentation or through proof of continuing education or regular training.

6.1.9.2 University

Several universities have adopted Passive House topics into their curriculum e.g Erfurt University of Applied Sciences – Faculty of Architecture.

6.1.9.3 Certified Passive House Tradesperson

Tradespersons can be certified as a Certified Passive House Tradesperson. This certifies their expertise in the construction of highly energy-efficient buildings. Qualification is via a written exam with no other prerequisites. General course material developed by the Passive House Institute is available on request. On successful completion of the examination the tradesperson is certified as a Certified Passive House Tradesperson. The certification is divided into specialisations with a common basic core:

- Specialisation in Building Envelopes
- Specialisation in Building Services

The certification and seal are of a personal nature and are bound to a specific person. The certificate must be renewed every five years by providing evidence of participation in a certified Passive House project or through proof of further training credit points. Proof shall be provided through documentation of the model project.

The certified tradesperson is also listed on a special publicly accessible website run by the PHI. Publication of the certified tradespeople on this website allows for transparency with all those involved in construction able to access information about qualified trades and businesses.

6.1.9.4 Accredited Building Certifier

In addition to a certification directly by the PHI, there are accredited Passive House Certifiers. These are contractually authorised by the PHI to perform certification using its seal and in accordance with its standards.

The certifiers must have a vast knowledge and experience with Passive House Buildings, having worked on several certified Passive House, in addition to this they must undergo a two-stage training process. Furthermore, a building certifier has to be an expert in the Passive House Planning Package (PHPP) as this is used to evaluate the building's energy performance.

Candidates, wishing to become a certifier, must make an application directly to the Passive House Institute, with accreditation showing that they have:

- PHPP experience and have work experience on three certified Passive House or EnerPHit projects
- Passed the Passive House Designer/Consultant exam successfully
- Participated in a certifier course
- Participated and successfully passed. a certifier course exam

If all of the above requirements are met, a contract between the PHI and the certifier, to become an accredited building certifier, is offered. On completion of the training, accredited certifiers are listed with the Passive House Institute and have the right to bear the accredited Passive House Certifier seal.

Figure 6-6 : Passive House Certifier Label. (Source PHI)

6.2 KfW Efficiency House (Effizenzhaus) – National Level

6.2.1 KfW new Building and Renovation/Refurbishment programs

Introduced by the KfW Bank, the KfW (Energy) Efficiency House “standard” defines buildings against the legal framework of the German Building Standard EnEV and how efficient these are when compared to this.

Note: The EnEV or Energy Conservation Ordinance is the German Standard which applies for all new buildings. The EnEV is the German implementation of the country overarching EU Standard EPBD, the EU´s main legislative instrument to promote the improvement of the energy performance of buildings. See Chapter 5.3 for more information.

The KfW Efficiency House Standard has become a market standard in Germany for new and existing buildings. The most efficient levels, the KfW 55 and the KfW 40, have become well known examples for ultra Low Energy Buildings in Germany. It is part of the KfW Program for Energy Efficient Buildings, which offers low-interest loans and grants to homeowners that meet the energy efficiency criteria as laid down in the KfW Standard. Since the previous program, from 2006, the level of subsidy was linked to the levels of energy efficiency achieved. (Under the KfW CO_2 Building rehabilitation Program)

It offers a consistent standard, controlled by the Deutsche Energie-Agentur GmbH (dena), has energy auditor approval, and also translates a complicated energy efficiency regulation into an easy to understand standard.

The current KfW scheme was launched in 2009, although similar schemes have existed as early as 1996, such as KfW Energy Efficiency Renovation as well as the Construction Program. Since implementation in its current form in 2006, around 3.5 million housing units or around 9% of the building stock in Germany have been refurbished. It was estimated that the standard as well as the promotional program contributed from 2006 to May 2016 to a reduction of 8.28 million tons CO_2-Emissions per year. Savings in heating costs in 2011, in the KfW Program for Homeowners, were estimated at 3.3 billion Euros, covering three quarters of the investment over 30 years. The Program also has an economic stimulus package for SMEs which created and safeguarded 446,000 jobs in 2015 and it is further estimated that it creates and safeguards around 300000 jobs annually.

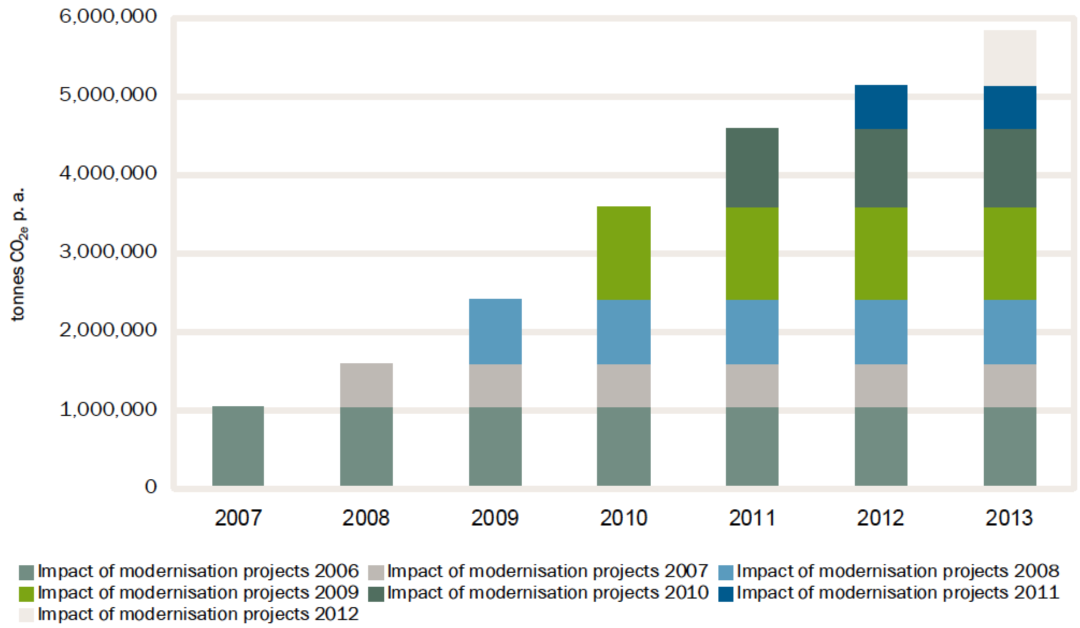


Figure 6-7: Accumulated CO^2 reduction from 2006 to 2012 (tonnes p.a). (Source IWU/BEI 2012)

The standard is technology neutral. The key feature is reduction of the energy consumption in a cost-effective manner. The standard is thus open and allows for the free choice of technologies, such as building envelope or heating technologies. The EnEV defines the minimum with regards to the envelope and technologies as well as the calculation method. The standard defines a KfW Efficiency House 100 i.e. that uses 100% of the energy that a building built exactly to KfW minimum standard would consume, and is called a “Standard EnEV” building. The more efficient the building is, the lower the number is. Thus a KfW-70 uses only 70% of the energy of a “Standard EnEV” building and is 30% more efficient. The KfW Efficiency House standard is the same for both new and existing buildings.

Table 6-8 : Conditions for KfW Efficiency House as of 03.02.2017. (Source: KfW)

Building type	KfW Level	Annual Primary Energy Demand	Transmission Heat Loss
		(Q_p)	($H_T{}'$)
New	KfW 40 Plus	40%	55%
New	KfW 40	40%	55%
New + Existing	KfW 55	55%	70%
Existing	KfW 70	70 %	85 %
Existing	KfW 85	85 %	100 %
	EnEV 2014 (1.1.2016)	75%	100%
	Ref. EnEV	100%	100%
Existing	KfW 100	100%	115%
Existing	KfW 115	115 %	130 %
Existing Monument	KfW Monument	160 %	175 %

On achieving the relevant standard, an application for a loan or grant can be made to the KfW.

6.2.1.1 New Residential Sector

New Buildings are subjected to a complete package of energy efficiency measures with the aim to achieve a KfW energy efficiency house level. The KfW Energy Efficiency House comes in 3 Standards for new buildings of:

- KfW 55 Energy Efficiency House
- KfW 40 Energy Efficiency House
- KfW 40 Plus Energy Efficiency House

KfW 40 Plus are built to at least the KfW 40 Standard and must include following features:

- A electricity producing unit on the basis of renewable energy of at least 500 kWh/Residential Unit + 10 kWh * Treated floor area
- A stationary battery storage system (current storage), usable storage capacity of either PV peak power and / or power of the wind turbine multiplied by an hour
- PV peak power and / or power wind turbine multiplied by an hour Ventilation heat recovery system with at least 80 % heat recovery
- A user interface to visualize energy consumption

All buildings are subject to air tightness tests on completion, which can only be carried out by a trained accredited expert and meet the airtightness of $n5_0 < 0{,}7\ h^{-1}$. In addition, a hydraulic balance test of the heating system must be conducted.

Alternative Verification

An alternative simplified verification procedure for the KfW 55 has been implemented. The proof is now linked to the reference values and no longer to complicated mathematical calculations. Following requirements have to be met to meet these simplified criteria.

Table 6-9 : Renovation/Refurbishment criteria for the KfW 55 simplified verification method.

Renovation/Refurbishment measure	Building Element	KfW 55 Ref. Value (W/m^2K)
Wall insulation	External wall	≤ 0.20
Wall insulation	Walls to unheated rooms	≤ 0.25
Wall insulation	Walls to ground soil	≤ 0.25
Roof insulation	Pitched roof	≤ 0.14
Roof insulation	Dormer roofs	≤ 0.14
Roof insulation	Dormer side walls	≤ 0.20
Roof insulation	Flat roofs (<10 °)	≤ 0.14
Floor slab insulation	Topmost ceiling to unheated area	≤ 0.25
Floor slab insulation	Cellar ceiling	≤ 0.25
Floor slab insulation	Lowest slab to external air	≤ 0.20

Floor slab insulation	Lowest slab to ground soil	≤ 0.25
Windows	Windows, Balcony doors	≤ 0.9
Windows	Roof windows	≤ 0.9
External Doors	External Door (to heated rooms)	≤ 1.2

(Source: KfW)

In addition, one of the six following heating systems must be installed.

- A condensing boiler, solar hot water (Standard values according to DIN V 4701-10), central ventilation system with heat recovery (heat supply level> 80%)
- A district heating system with a certified primary energy factor fp ⩽ 0.7, central ventilation system with heat recovery (heat recovery> 80%)
- A central biomass heating system based on wood pellets, wood chips or logs, central exhaust air ventilation system (or heat recovery (heat supply level> 80%))
- A brine-water heat pump with surface heating system for heat transfer, central exhaust air system
- A water-to-water heat pump with surface heating system for heat transfer, central exhaust air system
- An air-to-water heat pump with surface heating system for heat transfer, central ventilation system with heat recovery (heat supply level> 80%)

6.2.1.2 Existing Residential Buildings

Existing Residential Buildings are subjected to a complete package of modernisation with the aim to achieve a KfW energy efficiency house level. Similar to new buildings energy targets are fixed for existing buildings under the following categories:

- KfW Monument – a special case for listed buildings that implement energy efficiency measures.
- KfW 115 Energy Efficiency House – the total energy consumption of a building must not exceed 115% of the reference building according to the minimum EnEV requirements
- KfW 100 Energy Efficiency House – the total energy consumption of a building must equivalent to a house built to the minimum EnEV requirements
- KfW 85 Energy Efficiency House – the total energy consumption of a building must not exceed 85% of the reference building according to the minimum EnEV requirements
- KfW 70 Energy Efficiency House – the total energy consumption of a building must not exceed 70% of the reference building according to the minimum EnEV requirements
- KfW 55 Energy Efficiency House – the total energy consumption of a building must not exceed 55% of the reference building according to the minimum EnEV requirements

The maximal U-Value can also not be greater than the reference value given in the EnEV. Where only the windows are replaced it must be shown that the U-Value of the windows is lower than that of the walls surrounding it to prevent condensation and building damage.

Table 6-10 : Minimum U-Value requirements for the energy efficient renovation/refurbishment of individual measures

Refurbishment measure	Building Element	Maximal U-Value (W/m^2K)
Wall insulation	External wall	0.20
Wall insulation	Core insulation	Therm. cond. ≤ 0.035 W/(mK)
Wall insulation	External wall monuments	0.45
Wall insulation	Intern. Insulation (timber frame)	0.65
Wall insulation	Walls to unheated rooms	0.25
Wall insulation	Walls to ground soil	0.25
Roof insulation	Pitched roof	0.14
Roof insulation	Dormer roofs	0.20
Roof insulation	Dormer side walls	0.20
Roof insulation	Flat roofs (<10 °)	0.14
Roof insulation	Alternative monuments	Therm. Cond. ≤ 0.045 W/(mK)
Floor slab insulation	Topmost ceiling to unheated area	0.14
Floor slab insulation	Cellar ceiling	0.25
Floor slab insulation	Lowest slab to external air	0.20
Floor slab insulation	Lowest slab to ground soil	0.25
Windows	Windows, Balcony doors	0.95
Windows	Safety windows	1.10
Windows	Renovation/Refurbishment of windows	1.30
Windows	Roof windows	1.00
Windows	New windows monuments	1.40
Windows	Renovation/Refurbishment of monument windows	1.60
External Doors	External Door (to heated rooms)	1.30

(Source: KfW)

For refurbished buildings the building must meet the airtightness of $n5_0 = 3.0\ h^{-1}$. An airtightness test is not needed for KfW buildings 85,100,115 and Monuments. As with new buildings, a trained accredited expert must carry out the airtightness tests. In large buildings, at least 25% of the building must be tested with at least one apartment on the top floor, one in the middle floor and one on the ground floor.

The heating system must undergo a hydraulic balancing if more than 50% of the building envelope is refurbished. The hydraulic balancing must be carried out and

confirmed by a qualified tradesman. When the heating system is replaced, it must be shown that the radiator systems are appropriate for the new heating system. A hydraulic balance must be made in this case. The ventilation system must meet the requirements of the European Ecodesign Directive. The ventilation systems and the rate of ventilation should guarantee protection against condensation due to humidity.

6.2.2 Climate

As the KfW Program is specific to Germany, the climate under which it is run and that of the national energy efficiency code the EnEV. The reference climate is of the Potsdam city in Germany, which has a temperate climate.

6.2.3 Certification process

The certification process is similar to that of the EnEV but with some differences. A KfW-certified energy consultant is mandatory for the planning, application and construction supervision. The consultant must not have any conflict of interest such as financial connections to the project (see expert compliance). The energy expert should also be listed in the Federal Program Energy Efficiency Experts.

The energy assessor evaluates the present situation of the building. This should include the building envelope, including insulation levels and thermal bridges as well as the heating/technologies. Any weakness or future problems that might occur with an energy efficient renovation/refurbishment should be identified at this point. Based on the assessment a portfolio of suggestions should be made on how to make the building more energy efficient as well as how to deal with any problematic areas. In addition, the costs and possible payback times should be made transparent.

The expert carries out the professional planning including detail planning according to requirements of the target value of the KfW standard, for example, KfW 70. In addition, the expert issues the pre-certification and during the building process further processes this with the KfW for application of the credit as part of the KfW Promotional program (see 6.2.9 Promotional Program). On receiving the grant, the energy assessor must monitor the energy efficient works on-site and on completion certify that all measures have been completed as applied for. The expert then registers the building for EnEV as well for the KfW.

6.2.4 Cost of certificates

There are no defined costs for the certification of KfW buildings. The costs are market driven.

6.2.5 Compliance and penalties

Since calculations are done based on EnEV, the control system for the KfW Program is similar to EnEV energy performance certificates.

There are however there are some extra measures. The contractor or sub-contractor must confirm the compliance of the U-Value of the building envelope. The type of insulation and wall build up also must be described. In the case where internal insulation is applied, confirmation must be presented that all relevant measures from plan-

ning to implementation are taken to reduce thermal bridging and possible building damage. The compliance of the heating, cooling or ventilation system must be made through the relevant contractor.

In addition to the KfW's standard, there is the seal of approval "Efficiency House" of Deutsche Energie-Agentur GmbH (dena). The seal confirms the KfW standard through an extra quality-assured process.

In the case where there are violations of the provisions, penalties include having to reimburse any funds received, penalties according to the EnEV as well as possible further civil proceedings.

6.2.6 Inspection and monitoring

Mandatory construction supervision through an accredited energy efficiency expert must be shown to obtain the labelling of a KfW Efficiency House.

The energy efficiency expert conducts intense checks if all data presented, materials used and services meet the requirements. This could include, for example, separate testing of the materials used if quality and source of materials are uncertain or second consultation and calculation of results.

The energy expert must develop a concept for an energy efficient build or refurbishment. This should include energy consumption for heating and cooling as well as lighting. In addition a concept for sustainability should be made. A list of tasks for an energy efficiency expert are, but not limited to, as follows:

- Concept for energy relevant technologies
- Issuing of the energy passport for the building
- Concept for minimisation, detail planning and calculation of thermal bridges
- Development of a concept for, detailing and planning, controlling of and testing of airtightness.
- Thermal calculations.
- Solar simulations and calculations for PV
- Preparation and aiding in the call for tenders
- On-site coordination for energy relevant matters.
- Checking of product information.
- Approval of any changes on-site and in necessary recalculation of building characteristics.
- Documentation of the project.
- Infra-Thermography of the building at relevant stages.
- Documentation of hydraulic balance.
- Checking of documentation from consultancy companies working as sub-contractors
- Calculation of Efficiency House
- Preparation of all documentation for the KfW, including plans, all product information, thermal bridging, protocols of blower-door, hydraulic testing and infra-red thermography among others.

- Issuance of energy passport.
- Preparation of a Building Handbook for the building users on energy efficient and sustainable use of the building.
- All documentation is to be saved for the period of 10 years by the expert as well as the building owner.

An energy efficiency expert will need to supervise the construction. This is to make sure the energy efficiency potential is fully met and to avoid any possible future structural damage due to poor construction. In doing so they must complete or organise for a qualified completion of the following:

- Proof must be shown of planning for reduction of thermal bridging.
- The energy expert must take part in the development of the tender for the call for bids.
- At least one site visit must take place for plastering, of energy relevant areas that cannot be seen on completion. In addition at least one site visit for thermal bridging controls, air tightness test and for the technical systems.
- The ventilation system must be checked.
- An airtightness test must be completed and checked
- Check and documentation of all implemented materials against planned. If deviating new calculation of energy consumption of building.
- Proof of hydraulic balance and adjustment of the heating system
- The energy efficient planning and supervision must be documented.
- Completion and presentation to the building owner and relevant authorities of the Energy Passport for the building.

The building owner must keep as reference:

- Proof of the KfW Energy Efficiency House documentation including the U-Value calculations and the information of the heating system.
- All plans of the building including detail plans.
- All other relevant plans and documentation.
- Confirmation from the relevant contractors for the hydraulic balance as well as blower door test.
- Energy Passport of the building

Confirmation of compliance must be given before the application and after completion of the building project. This must be done by an accredited energy efficiency expert listed in the Federal Energy Efficiency List.

For the controls, all the relevant information and documentation on the building, which the energy consultant completed, must be provided. This includes full documentation, building plans and drawings, other relevant plans, calculations, detailed thermal bridging calculations. This is done through the Building Data Transfer program “Gedatrans”. This is then checked through a plausibility check. This could be at

different levels including checking of documentation, on-site visits or checking of results from calculations and simulations by a third party expert. These checks are made if there are irregularities in the plausibility checks, if the expert has undergone previous checks due to irregularities, random sampling as well as on specific request from the KfW.

Random sampling is implemented to ensure compliance. Other controls are through the EnEV for new buildings and their registration. Here random sampling is done to test abidance of the code.

6.2.7 Expert competence and training

An accredited energy efficiency expert is needed for all KfW promotional programs. The experts must be accredited for the type of building being certified i.e. residential or non-residential, and should be able to issue EPCs for the type of building. Experts for Monuments must also be qualified with special expertise for architectural cultural heritage. All experts must meet the minimum standards for issuance of energy EPCs according to § 21 of the EnEV.

To avoid any conflict of interest it is a required that the expert be economically independent from the project and the client. Other than for the consulting, planning and construction supervision for the project, the expert may not be:

- In an ownership, company or employment relationship with the building contractors or suppliers or
- Be contracted by these companies or suppliers, or
- Deliver supplies or services.

Not covered by this scheme for economic independence:

- Experts directly employed by the applicant or seller of the housing units.
- Experts from construction or craft enterprises, whose products and services are defined and monitored according to a quality assurance.

Auditors/consultants must provide a proof of completion of a further training to the Federal Energy Efficiency Program, which is run by the German Energy Agency (dena). This is done through a declaration of completion from the certified trainer as well as energy certificate in addition to the prerequisites. The requirements for these trainings differ accordingly to the sector. The further training must itself be registered and accredited by the Federal Energy Efficiency Expert Program. Alternatively qualification can be achieved by presenting at least two buildings that they have consulted and which meet the requirements of the KfW Efficiency Houses. If required each expert is required to take part in the quality assurance testing by the dena. All originals of qualifications and trainings must be kept by the expert for checking by the dena or KfW.

Registration is through copies or scans to the registration authority. The registration authority dena controls all documents. The registration as an energy efficiency expert

is personalized and cannot be transferred within a company or to another person. If a company is registered it must list the energy efficiency expert by name.

Extension of the accreditation must be made after a period of two or three years depending on the sector in which the expert is accredited. To maintain the qualification regular training is required. In addition, the energy efficiency expert must have completed an energy consultancy with proof of practical experience (not necessarily within the KfW program but according to the guidelines laid done by the KfW). For the proof of experience a built project, for which the energy consultant has been completed, must be provided with all the relevant information and documentation on the building.

If no practical experience, of a built house, can be shown an extension of the accreditation, which is only possible once, can be made through an alternative of 32 extra training hours at a registered course for their topic category. Alternatively an energy efficiency expert can be further accredited in lieu of practical experience, if a training, instructor or teaching activity can be shown at a University or Institution which trains the content required for the further training.

All energy efficiency experts are also required to have appropriate liability insurance, which covers compensation for damages through consultancy, planning and supervision for their relevant competence i.e. residential or non-residential.

If an expert is unreliable or untrustworthy, undergoing insolvency proceedings, economically involved in the project they have certified, or has broken the law relevant to buildings, energy efficiency or promotion deception they will be removed from the list.

6.2.8 Display of EPC and usability of EPC data

The displaying of the KfW Label takes place on a voluntary basis. However, since the KfW must conform to the EnEV, the displaying of the EPC must also conform to these regulations (see EnEV). The control of the Program is through the dena.

6.2.9 Promotional Program

6.2.9.1 Residential Buildings

The KfW gives grants and loans to buildings that have been built better than the "Standard EnEV" Building. The amount being determined depending on the level of efficiency that has been reached.

Grants are available on reaching the relative KfW Standard and are as follows:

- 30.0 % for a KfW Efficiency House 55, but not more than EUR 30,000
- 25.0 % for a KfW Efficiency House 70, but not more than EUR 25,000
- 20.0 % for a KfW Efficiency House 85, but not more than EUR 20,000
- 17.5 % for a KfW Efficiency House 100, but not more than EUR 17,500

- 15.0 % for a KfW Efficiency House 115, but not more than EUR 15,000
- 15.0 % for a KfW Efficiency House Monument, but not more than EUR 15,000

The application for a grant is made directly to the KfW. The grant is transferred to building owner after completion of the refurbishment measures.

In addition to the grants, there is also the possibility to apply for a loan. The loan is up to EUR 100,000 per housing unit for energy-efficient refurbishment KfW 115 and better plus a repayment bonus up to EUR 27,500, which is calculated, based on the loan amount.

In addition, there is a 20 year fixed interest rate.

There is also a repayment bonus for the ultra energy efficient buildings with:

- KfW 40 Plus: 15% of the loan amount, up to EUR 15,000 for each housing unit
- KfW 40: 10% of the loan amount, up to EUR 10,000 for each housing unit
- KfW 55: 5% of the loan amount, up to EUR 5,000 for each housing unit

The loan application is initially submitted to a local bank, which when approved forwards the application to the KfW.

Table 6-11 : Promotional loans according to KfW level reached

Promotional Level based on EnEV	Promotional loan			Grant for investments
	Max. Amount	Interest rate	Partial Debt Relief	(alternative private clients)
KfW 55	100.000 €	0.75 % p.a. eff.	27.50%	30.00% not more 30000 €
KfW 70	100.000 €	0.75 % p.a. eff.	22.50%	25.00% not more 25000 €
KfW 85	100.000 €	0.75 % p.a. eff.	17.50%	20.00% not more 20000 €
KfW 100	100.000 €	0.75 % p.a. eff.	15.00%	17.50% not more 17500 €
KfW 115	100.000 €	0.75 % p.a. eff.	12.50%	15.00% not more 15000 €
KfW Monument	100.000 €	0.75 % p.a. eff.	12.50%	15.00% not more 15000 €

(Source: KfW)

In addition, to ensure the quality of the building construction, a promotional grant for professional construction supervision can be made. This is to a maximum level of

either 50% of the costs or a maximum of 4000 €. The application for the grant is also made directly to the KfW.

6.2.9.2 Non-Residential Sector

There are small differences between the public sector and corporate sector non-residential programs as can be seen below in Figure 6-11.

Table 6-12 : Energy-efficient construction and renovation

Promotional Level based on EnEV	Promotional loan		
	Maximum amount	Interest rate	Partial Debt Relief
New Construc-tion			
KfW 55	up to 25 million €	Risk adjusted from 1% p.a. eff.	5 % (max 50€/m^2)
KfW 70	up to 25 million €	Risk adjusted from 1% p.a. eff.	-
Renovation Re-furbishment			
KfW 70	up to 25 million €	Risk adjusted from 1% p.a. eff.	17.5 % (max. 175€/m^2)
KfW 100	up to 25 million €	Risk adjusted from 1% p.a. eff.	10 % (max. 100€/m^2)
KfW Monument	up to 25 million €	Risk adjusted from 1% p.a. eff.	7.5 % (max. 100 /m^2)

(Source: KfW)

Municipalities also need to apply directly the KfW and can receive a loan with 0.05% p.a. effective interest rate. Public/non-profit entities have the conditions adjusted on risk adjusted interest rates.

6.3 Active House

6.3.1 General information and background

activehouse

The Active House is an international holistic building standard, with a target framework for offering buildings that are healthy and comfortable without negatively impacting the climate and environment. Active house are based on the concept of "Buildings that give more than they take" and uses an equally integrated combination of comfort, energy and environment for evaluation. This is also known as the Trias Energetica approach to sustainable design, which advocates to:

- First, reduce the energy demand
- Then, use sustainable energy sources
- Furthermore, use fossil fuels efficiently

In doing this, the Active House Alliance considers that comfort is equally important to energy in the active house concept. This can thus be considered broadly as both a green building rating system as well as an energy assessment system. In addition, Active Houses completely forgo the use of fossil fuels and atomic energy and the use of renewables is strictly mandatory.

Note: The Active House is not to be confused with the German AktivHaus

6.3.1.1 Active House Criteria

The Active House uses a combination of qualitative and quantitative criteria for definition and evaluation. All criteria are evaluated separately and are calculated according to the Active House specifications.

6.3.1.2 Radar and Classification

The Active House uses calculation tools, radar and classification to describe and communicate the performance of a building. The most important of these is the Radar chart. One advantage of the radar system is that a quick and easy visual comparison against a reference can be made i.e. against minimum requirements of national standards. The criteria are quantified on a scale from 4 to 1, with 4 being the lowest and 1 the highest. The rating of the Active House is based on the points of the lowest criteria i.e. if one criteria is 4 and all others are 1, the building is still rated as category 4 Active House. For a building to be considered an Active House it must thus meet the minimum requirement in all the categories. All projects must be individually verified.

Note: The energy for appliances is not included in the Active House evaluation tools.

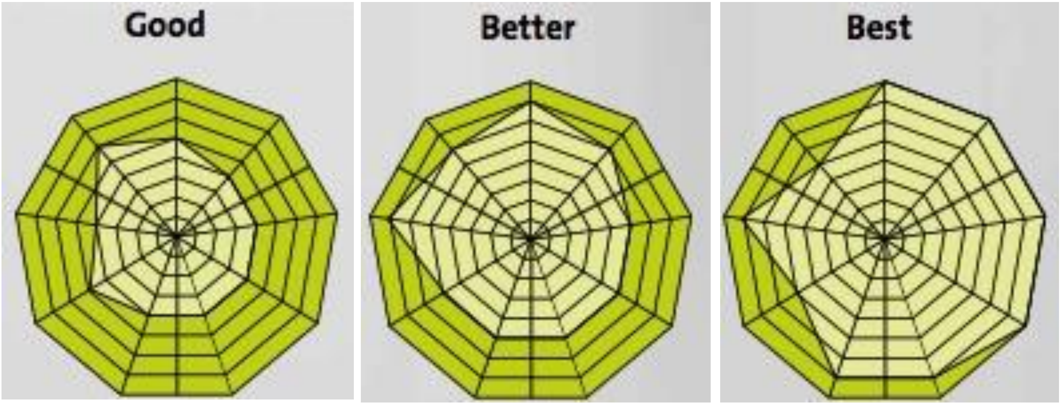


Figure 6-8 : Example of rating in Active House Radar. (Source: Active House Alliance).

Figure 6-9 : Comparison of Active House against a house built to standard. (Source: Active House Alliance).

6.3.2 Climate

The Active House Label is designed to be used worldwide an in all climates.

6.3.3 Minimum technical and energy requirements

6.3.3.1 Quantitative Parameters

The quantitative criteria are the most important and are divided according to the following:

- Comfort
  - Daylight
  - Thermal Comfort
  - Air Quality
- Energy
  - Energy Demand
  - Renewable energy
  - Primary Energy
- Environment
  - Environmental Load
  - Water consumption
  - Sustainable construction

Table 6-13 : Active House Criteria. (Source: Active House Alliance).

Parameter	Criteria	1	2	3	4
Comfort					
Daylight					
Daylight Factor	Daylight Factor on a horizontal work plane	> 5%	> 3%	> 2%	> 1%
Direct sunlight availability	Probable sunlight hours (in winter)	> 10%	> 7,5%	> 5%	> 2,5%
Thermal Comfort					
Maximum operative temperature	Indoor operative temperature (free running) T_{rm} > 12°C	< 0.33 x Trm + 23.8 °C	< 0.33 x Trm + 23.8 °C	< 0.33 x Trm + 23.8 °C	< 0.33 x Trm + 23.8 °C
	Indoor operative temperature (conditioned)	< 25°C	< 26°C	< 27°C	< 28°C
Minimum operative temperature	Indoor operative temperature Trm < 12°C	> 21°C	> 20°C	> 19°C	> 18°C
Air Quality					
Standard fresh air supply	CO_2 over outdoor concentration	500 ppm	750 ppm	1000 ppm	1200 ppm
Energy					
Energy Demand					
Annual energy demand		≤ 40 kWh/m^2	≤ 60 kWh/m^2	≤ 80 kWh/m^2	≤ 120 kWh/m^2
Renewable energy					
Origin of energy supply	Energy is produced on the plot or in a nearby system	100%	≥ 75%	≥ 50%	≥ 25%
Primary Energy					
Annual primary energy performance		< 0 kWh/m^2	0 - 15 kWh/m^2	15 - 30 kWh/m^2	> 30 kWh/m^2
Environment					
Environmental Load (during life cycle)					
Primary energy consumption		< -150 kWh/m^2a	< 15 kWh/m^2a	< 150 kWh/m2a	< 200 kWh/m^2a
Global warming potential		< -30 kg CO_2-	< 10 kg CO_2-	< 40 kg CO_2-	< 50 kg CO_2-

		eq./m^{2}a	eq./m^{2}a	eq./m^{2}a	eq./m^{2}a
Ozone depletion potential		< 2.25E-07 kg R_{11}-eq/m^{2}a	< 5.3E-07 kg R_{11}-eq./m^{2}a	< 3.7E-06 kg R_{11}-eq./m^{2}a	< 6.7E-06 kg R_{11}-eq./m^{2}a
Photochemical ozone creation potential		< 0.0025 kg C_3H_4-eq./m^{2}a	< 0.0040 kg C_3H_4-eq./m^{2}a	< 0.0070 kg C_3H_4-eq./m^{2}a	< 0.0085 kg C_3H_4-eq./m^{2}a
Acidification potential		< 0.010 kg SO_2-eq./m^{2}a	< 0.075 kg SO_2-eq./m^{2}a	< 0.100 kg SO_2-eq./m^{2}a	< 0.125 kg SO_2-eq./m^{2}a
Eutrophication potential		< 0.0040 kg PO_4-eq./m^{2}a	< 0.0055 kg PO_4-eq./m^{2}a	< 0.0085 kg PO_4-eq./m^{2}a	< 0.0105 kg PO_4-eq./m^{2}a
Freshwater consumption					
Minimisation of freshwater consumption	Water consumption improvement vs average	≥ 50%	≥ 30%	≥ 20%	≥ 10%
Sustainable Construction					
Recyclable content	Recycled content (by weight) for all building materials	≥ 50%	≥ 30%	≥ 10%	≥ 5%
Responsible sourcing	Certified Wood	100%	80%	65%	50%
	New Material	80%	50%	40%	25%

6.3.3.2 Qualitative Parameters

The qualitative parameters described in the Active House specification represent additional criteria that should be included in the global assessment of performance for an Active House. All evaluation concerning Lifecycle Analysis is based on a building lifetime, for benchmarking purposes, of an Active House, which is given as 50 years. Qualitative parameters include:

- Comfort
- Daylight
  - View
  - Visual Admittance
  - Glare Management
  - Daylight in secondary rooms
- Thermal Environment
  - Individual control, winter
  - Individual control, summer
  - System interface
  - Draught
- Indoor Air Quality
  - Individual control
  - Dampness
  - Low-emitting building materials
- Noise and Acoustics
  - Inside system noise
  - Outside noise
  - Acoustic privacy
- Energy
  - Energy Demand
    - Demand on individual products and construction elements
    - Architectural design solutions
    - Demand on individual appliances
  - Energy Supply
    - Design
    - Annual energy supply
  - Primary Energy Performance
    - Energy use and CO2 emissions
  - Energy Validation on Site
    - Onsite control of solutions and products
    - Air permeability of the building
    - Thermal bridges
    - Qualification of the controller
- Environment
  - Environment loads
    - LCA of the building
- Freshwater consumption
  - Appliances
  - Use of grey or rain water
- Ecological impacts
  - Job site management
  - Disassembly
  - Biodiversity

- External Context and accessibility
  - Building traditions
  - Active outdoor living
  - Streets and landscapes
  - Infrastructure
  - Accessibility
  - Ecology and land use
  - Climate changes
- Building Management
  - Management of energy
  - Management of indoor climate
  - Management of environment

6.3.4 Certification process

The certification (or verification according to the Active House Alliance) of a building and its Active House radar includes an examination of the completeness, plausibility, consistency and transparency of the calculations and the project report. Certification is done via the Active House calculation tool.

In applying for an Active House certification the relevant actor, building owner or Active House Commissioner sends a direct application for certification to the Active House Alliance. If the application meets the requirements, a guide for labelling and the manual for verification are sent to the relevant actor.

On application for verification the Active House Alliance will appoint a verifier for the project. It is recommended that the verifier be included in the process as early as possible to ensure a smooth certification process. Following the application for verification a dialog between the verifier and the commissioner takes place. This is to avoid misunderstandings and mistakes in the certification process.

The following documents that must be submitted for certification:

- The calculation (Radar) file as an excel file
- A file with the description of the relevant qualitative values
- Description and drawings of the technical installations.
- Architectural drawings
- Floor plan for each floor
- Sectional drawings
- Facade drawings
- Drawing or description of the technical installations
- File with calculated areas

In addition, the verifier can make further detailed investigations into 2-3 indicators of the Radar. These can include:

- Energy frame calculation
- Life-cycle assessment (LCA) calculation
- Daylight calculation
- Indoor environment calculation
- Calculation of freshwater consumption

- Calculation of sustainable construction

All information is kept confidential and is used for the internal calculation and verification of a building.

On submission of all final data, the verifier has 4 weeks to approve a project. If there are any deviations, these are to be reported by the Verifier to the Commissioner and a registered transparent dialogue is to be started to rectify this.

If the project report or calculations contain mistakes or the rating criteria are not met the building will receive a "*Project not approved in its present form*" statement*.* If a certification is still wished for, the deficits must be rectified and a new verification process started.

If any minor errors or discrepancies are found during the certification process the project will receive a certification with "*Project verified and approved with reservations". A* completed and signed verification including the reservations is also sent to Active House Alliance. The minor deficits must be rectified before final certification and issuance of the label by the Active House Alliance. On rectification, a new and final verification is sent to the Active House Alliance.

If the building passes the certification, a statement with "*Project verified and approved"* is issued by the Verifier. A completed and signed verification is then sent to Active House Alliance.

In aiding transparency for all cases a statement must be issued by the Verifier and include the following information:

- That the work concerned a verification (not a certification as this is issued by the Active House Alliance)
- That the verification was done by an independent 3rd party
- That the radar was verified according to the Active House Alliance checklist
- That the radar and documentation was verified according to Active House specifications version 2
- All mistakes found in the project, if any
- Important dialog between commissioner and verifier, if any
- Verified indicators

On certification, a label is presented for the specific building and may only be used for the verified and approved project as is.

6.3.5 Cost of certificates

The Active House Alliance makes recommendations for the fees for verification. These fees cover both screening and the verification of 2-3 selected indicators. The cost of certification for Active House certification is based on the building size, or the treated floor area (in m^2), and the number of evaluations for that specific certification.

Table 6-14 : Suggested Validation Fees. (Source: Active House Alliance).

Verification with either design or measured Radar	
Area of the house	**Fee**
≤350 m^2	1000 €
351-3000 m^2	650 € + 1 € /m^2
>3000 m^2	4000 €
Verification with design and measured Radar	
≤350 m^2	1500 €
351-3000 m^2	975 € + 1.5 € /m^2
>3000 m^2	5000 €

The costs for verification must be made paid when the verification process starts. All fees, both to the Verifier as well as the Commissioner, must be paid in full irrespective of grant of certification.

6.3.6 Compliance and Penalties

Certification is only valid for the building when it is built as per the documentation. Any changes require a revision of the building radar. These must be revised no later than a year. The building owner needs to notify the Active House Alliance of changes to the building, including those at a later date, which would have a direct influence on the building radar.

6.3.7 Monitoring and Evaluation

The initial certification of an Active House is based on calculation as well as a project report. These must contain all the information needed for a full calculation, be transparent and consistent in their methodology. The data is evaluated by the accredited Verifier. It is also strongly recommended that the building should be monitored for at least one year. If monitored, the differences between the calculated performance and actual performance should be then described in the Active House Radar and calculation tool. Based on the monitoring follow ups and adjustments on the building are recommended, where needed.

All verification calculations and reports are kept, confidential, for future reference and possible monitoring by the Active House Alliance.

6.3.8 Expert competence and training

The Active House Alliance is responsible for providing the training courses and ensuring that both certifiers and commissioners are qualified and competent. In addition, they register and keep records of all certified certifiers and commissioners.

6.3.8.1 Verifier

Persons who evaluate buildings for Active House certification are known as Verifiers. Verifiers are independent third party entities and shall ensure that all projects are evaluated under the same conditions.

In qualifying as a verifier, the relevant actor must have:

- Taken part in a 1-day Active House course
- Taken part in at least three validation of radars of the relevant building they wish to verify

For the verification of any project verifiers are required to:

- Retrieve basic information from the commissioner.
- Verify general project information
- Screen the project
- Further verify/investigate 2-3 indicators in the radar

All relevant communication between verifier and commissioners must be kept by the verifier for future reference by the Active House Alliance, if needed.

6.3.8.2 Commissioners

Persons who calculate and bring a building to verification are known as commissioners. In qualifying as a commissioner the relevant actor must have:

- An education in engineering, architecture or other relevant scientific education
- Thorough knowledge of buildings and their performance in relation to energy, indoor environment and environment (LCA)
- Knowledge with the relevant standards used in Active House eg. national energy standards, the EN15251 active house standard on indoor comfort and the EN15978 on Assessment of environmental performance of buildings.
- Participate in a one day Active House course (webinar)

Commissioners are required to collect and send all relevant data, information and documents to the verifier for certification. They are also responsible for all communication with the verifier.

6.3.9 Display of Active House Labels

The building owner is allowed to display the label, after completion, certification and registration of the building. Labels are not valid if any changes are made to the building that might affect the building radar. Misleading use or falsification of the label must not take place. At all times the Active House retains all rights to the label and use of such must be in accordance with the guidelines.

6.4 MINERGIE

6.4.1 Label

MINERGIE is a Swiss sustainability building standard/brand for new and existing buildings with low energy consumption. It is often seen as a certificate of quality for the energy efficiency in buildings.

First developed in 1994 by Heinz Uebersax und Ruedi Kriesi, it was taken over by the Swiss Cantons of Bern and Zurich in 1998, and has since been further developed into the standard it is today. Since then (till 2017) over 43,000 buildings with a total area of 50 million m^2 have been built under this standard.

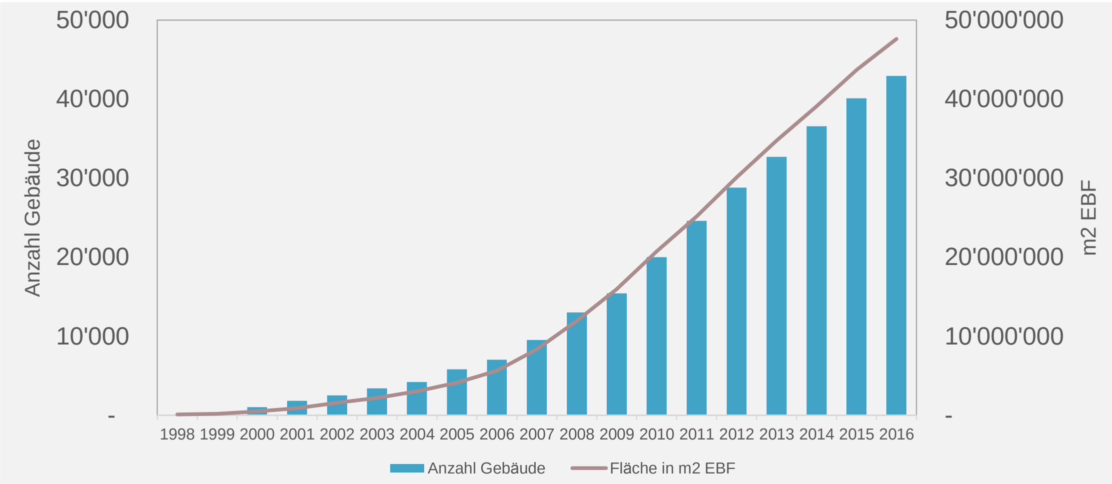


Figure 6-10 : Development of the MINERGIE standard. (Source: Energie Apéro Luzern 06.02.2017)

The key focus areas of the MINERGIE standards are the comfort of the inhabitants, the very low energy consumption and the retention of the buildings value while at the same time allowing a total freedom of design. This comfort is made possible by a highly insulated and air–tight building shell, highly efficient technology, controlled ventilation and the use of renewable energy. The energy consumption, which determines if a building is compliant, is for all phases of the buildings use but does not include the grey energy of the building.

The standard consists of three different building standards for achieving different levels of energy efficiency:

- MINERGIE (a low-energy building)
- MINERGIE-P (a nearly-zero-energy building)
- MINERGIE-A (a plus-energy building)

In addition, MINERGIE has three supplementary modules MINERGIE-Eco, MQS Building Site and MQS-Operation

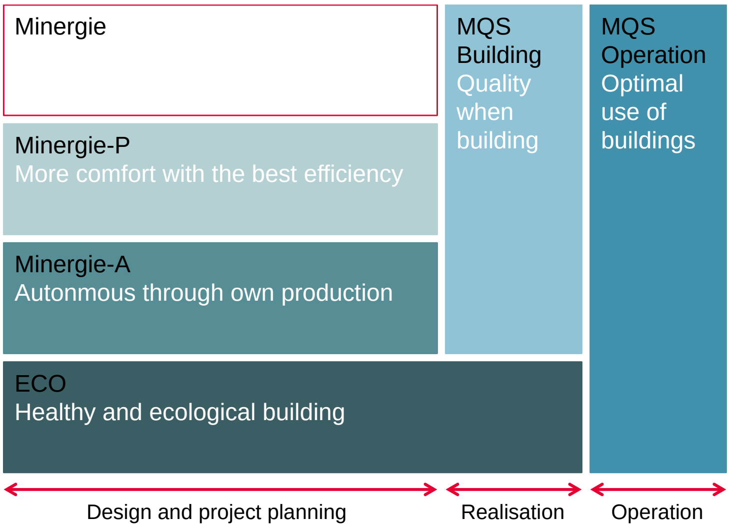


Figure 6-11 : Structure of the MINERGIE standard. (Source: adapted from MINERGIE)

The basis for all MINERGIE standards is the Swiss building energy standard "Mustervorschriften der Kantone im Energiebereich" (Model regulations of the cantons in the field of energy) MuKEn. All MINERGIE standards must fully comply with the MuKEn or be better (this is also compulsory for building renovation). This allows the latest MINERGIE 2017 to place more focus on energy efficient buildings with four main areas of focus:

- Efficient use of electricity in combination with the production of electricity on-site
- The economical and ecological renovation of existing buildings.
- The identification of relevant energy flows for energy efficient optimisation.
- The addition of supplementary standards MQS Building Phase and MINERGIE-Services for the operation phase.

For all MINERGIE standards the main requirement for classification is the net-final energy consumption based on the Energy Reference Area (EFA). The final energy consumption is made up of:

- Heating
- Ventilation
- Cooling
- Domestic hot water
- Lighting
- Appliances
- General building services

- Minus the electricity from self production (weighted accordingly to on-site and off-site use)

In addition to the main requirements, MINERGIE has three further requirements:

- Heating demand
- Threshold values for heating, ventilation, cooling and domestic hot water (according to MuKEn 2014)
- Compliance with the SIW 380/4 for lighting (only for non-residential)

(Note: The threshold value for energy demand for heating, domestic hot water, ventilation and cooling according to MuKEn 2014 does not allow a renewable energy credit in its calculation.)

Table 6-15 : Threshold value for (weighted) energy demand for heating, domestic hot water, ventilation and cooling according to MuKEn 2014. (Source: MINERGIE).

	Building Category*	MINERGIE-New Buildings**	MINERGIE-Renovation**
		kWh/m²a	kWh/m²a
I	Residential MFH	35	60
II	Residential SFH	35	60
III	Administration	40	55
IV	Schools	35	55
V	Retail	40	55
VI	Restaurants	45	65
VII	Assembly	40	60
VIII	Hospitals	70	85
IX	Industry	20	40
X	Lager	20	35
XI	Sport facilities	25	40
	*according to SIA 380/1:2009		

All new MINERGIE Buildings are CO_2 neutral and focus on renewable energies. The use of fossil fuels for heating and domestic water is not allowed. Exceptions are only made for the covering of the gaps in peak loads (less than 30% per annum), CHP (where the electricity produced is at least 35%) and for electric heating (when the fossil share is less than 50%). Buildings are also required to install systems for the production of renewable energy e.g. photovoltaic or wind energy. PV is not needed if the MINERGIE-Classification level is less than 5 kWh/m^{2}a. The self-produced energy can be deducted from the final energy consumption of the building, if produced on-site. Exported electricity can only be deducted up to 40%. Who the energy producing system belongs to or how it is traded with the building owner/user is irrelevant for the calculation of the final energy consumption.

In existing buildings, the use of fossil fuels shall not be more than 90% for heating and domestic hot water.

All buildings must meet the requirements for summer comfort with a summer thermal energy calculation. This was till date most often unproblematic in almost all certified buildings. The MINERGIE 2017 however gives the chance for buildings where for some reason this is not possible, for example with the ever increasing warmer summers, to integrate the recharging of heat storage and the use of PV for energy production for cooling systems in summer.

All MINERGIE Standard buildings over 2000 m^2 as well as all MINERGIE-A buildings must have an energy monitoring. This must include:

- Final energy consumption for room and water heating.
- Useful energy for heating and hot water.
- Electricity without heating
- Cooling in functional buildings
- Energy produced by the building

6.4.2 Climate

The MINERGIE Standards are limited to the regions of Switzerland and the Principality of Liechtenstein. Any use of the standards, as well as certification and fees in other climates and regions are regulated by the MINERGIE.

6.4.3 Minimum technical and energy requirements

6.4.3.1 MINERGIE

The MINERGIE-P standard is a low energy consumption standard. The requirements for this MINERGIE standard are described, but are not limited to, below:

- The main requirement is the net-final energy consumption of 55 kWh/m^2a for new residential buildings and 90 kWh/m^2a for renovations (see Table 6-16for other buildings)
- Verification of compliance to the MINERGIE Building Standards
- Individual energy production must meet the minimum requirements of the MuKEn 2014 of 10/Wm^2 ERA[6] but does not have to be more than 30 kWp per building.
- The weighted energy demand for heating, domestic hot water, ventilation and cooling, without PV, must be for 35 kWh/m^2a for new residential buildings and 60 kWh/m^2a for renovations (see Table 6-16 for other buildings)
- The heating demand must not be more than 100% of that required by the MuKEn 2014 for new buildings, with no requirements for renovations.
- New buildings must only use renewable energy
- Airtightness should be at least 1.2 m^3/(hm^2) for new buildings and 1.6 m3/(hm^2) for renovations (according the SIA 180:2014)
- All buildings should have controlled ventilation.

[6] EFA = Energy related Floor Area

- Buildings over 2000 m^2 EFA must have an energy monitoring. The Minenegrie provides a list of MINERGIE certified companies capable of caring out the monitoring

Table 6-16 : MINERGIE threshold performance value for (weighted) net-final energy consumption. (Source: MINERGIE).

	Building Category*	MINERGIE-New **	MINERGIE-Renovation**
		kWh/m²a	kWh/m²a
I	Residential MFH	55	90
II	Residential SFH	55	90
III	Administration	80	120
IV	Schools	45	85
V	Retail	120	140
VI	Restaurants	100	130
VII	Assembly	55	85
VIII	Hospitals	110	140
IX	Industry	80	130
X	Lager	55	70
XI	Sport facilities	55	70
	*according to SIA 380/1:2009		

For renovation, the MINERGIE System offers, a simplified system of certification. A certificate is given if documentation is provided demonstrating the building has been renovated to meets these standards with a prescribed systems solution (see Table 6-17).

Table 6-17 : MINERGIE systems for simplified certification. (Source: MINERGIE).

	System solution 1	System solution 2	System solution 3	System solution 4	System Solution 5
Roof	≤ 0.17 (W/m²K)	≤ 0.30 (W/m²K)	≤ 0.25 (W/m²K)	≤ 0.17 (W/m²K)	≤ 0.17 (W/m²K)
Façade	≤ 0.25 (W/m²K)	≤ 0.40 (W/m²K)	≤ 0.50 (W/m²K)	≤ 0.70 (W/m²K)	≤ 1.1 (W/m²K)
Windows	≤ 1.0 (W/m²K)	≤ 1.0 (W/m²K)	≤ 1.0 (W/m²K)	≤ 1.0 (W/m²K)	≤ 0.8 (W/m²K)
Floor	≤ 0.25 (W/m²K)	≤ 0.25 (W/m²K)	≤ 0.25 (W/m²K)	≤ 0.25 (W/m²K)	≤ 0.25 (W/m²K)
Or according to GEAK rating	B	C	C	C	C
Heating	Fossil with solar thermal energy		Brine- or Water-Heat pump (up to inlet flow 50°C),		
			District heating (under 50% fossil share)		
			Wood with solar thermal energy		
			Air-Water-Heat pump (up to inlet flow		

		35°C)
Electricity		Either 40% of the possible savings or through on site electricity production of at least 5Wp per m2 EBF
Ventilation	with heat recovery	With or without heat recovery

6.4.3.2 MINERGIE-P

The MINERGIE-P standard is a ultra low energy consumption standard and is similar to the Passive House Standard in terms of its energy consumption. Special influence is placed on an optimal insulation and use of passive heating sources such as solar. The MINERGIE-P was first introduced in 2003. Since then, over 4000 buildings have been certified. The requirements for a MINERGIE-P standard are, but not limited to, as follows:

- Main requirement is the net-final energy consumption 50 kWh/m^{2}a for new residential buildings and 80 kWh/m^{2}a for renovations (see Table 6-18 for other buildings). Energy from PV can used in the energy calculation as a bonus and electricity provided to the net to a certain extent
- The weighted energy demand for heating, domestic hot water, ventilation and cooling, without PV, must be for 35 kWh/m^{2}a for new residential buildings and 60 kWh/m^{2}a for renovations (see Table 6-18 for other buildings)
- Verification of compliance to the MINERGIE Building Standards
- The heating demand must not be more than 70% of that required by the MuKEn 2014 for new buildings and 90% for renovations.
- New buildings may not use fossil fuels i.e. 100% renewable energy.
- Renewable energy production to at least MuKEn 2014 (10 W/m^2 ERA) but does not have to be more than 30 kWp per building.
- Renewable energy should be produced onsite.
- Air tightness concept and air tightness testing. The airtightness level must be at least 0.8 m^3/(hm^2) for new buildings and 1.6 m^3/(hm^2) for renovation (according the SIA 180:2014)
- The building should have a controlled ventilation unit with heat recovery.
- The summer thermal protection is also checked.
- Buildings over 2000 m^2 ERA must have an energy monitoring. The MINERGIE provides a list of MINERGIE certified companies capable of caring out the monitoring

Table 6-18 : MINERGIE-P threshold performance value for (weighted) net-final energy consumption. (Source: MINERGIE).

	Building category*	MINERGIE New**	MINERGIE-Renovation**
		kWh/m²a	kWh/m²a
I	Residential MFH	50	80
II	Residential SFH	50	80
III	Administration	75	115
IV	Schools	40	75
V	Retail	110	130
VI	Restaurants	90	120
VII	Assembly	45	75
VIII	Hospitals	100	130
IX	Industry	70	120
X	Lager	45	60
XI	Sport facilities	45	60
	*according to SIA 380/1:2009		
	**in kWh/m²a final energy, weighted		

6.4.3.3 MINERGIE-A

MINERGIE –A is a Swiss plus-energy building standard. It combines all the requirements of an extremely energy efficient building and for energy autonomy with that of high quality and comfort within a building. MINERGIE-A buildings must cover at least their consumption in full through renewables. This is done through photovoltaic systems, batteries and an integrated load management. The MINERGIE-A was first implemented in 2011. The requirements for a MINERGIE-A standard are, but not limited to, as follows :

- Main requirement, for residential buildings, is the net-final energy consumption of 35 kWh/m^{2}a (see Table 6-19 for other buildings).
- Verification of compliance to the MINERGIE Building Standards
- The weighted energy demand without PV, for heating, domestic hot water, ventilation and cooling, must be for 35 kWh/m^{2}a for new residential buildings and 60 kWh/m^{2}a for renovations (see Table 6-19 for other buildings)
- The heating demand must not be more than 100% of that required by the MuKEn 2014 for new buildings, with no requirements for renovations.
- New buildings may not use fossil fuels i.e. 100% renewable energy.
- MINERGIE-A buildings must produce more than they consume.
- The self-produced energy must be consumed onsite to ensure the greatest autonomy.
- Renewable energy production to at least MuKEn 2014 (10 W_p/m^2 EBF) but does not have to be more than 30 kW_p per building.

- Air tightness concept and air tightness testing. The airtightness level must be at least 0.8 $m^3/(hm^2)$ for new buildings and 1.6 m3/(hm^2) for renovation (according the SIA 180:2014)
- The building should have a controlled ventilation unit with heat recovery.
- The summer thermal protection is also checked.
- Energy monitoring is required for all buildings

Table 6-19 : MINERGIE-A threshold performance value for (weighted) net-final energy consumption. (Source: MINERGIE).

	Building category*	MINERGIE New**	MINERGIE-Renovation**
		kWh/m^2a	kWh/m^2a
I	Residential MFH	35	35
II	Residential SFH	35	35
III	Administration	35	35
IV	Schools	20	20
V	Retail	40	40
VI	Restaurants	40	40
VII	Assembly	25	25
VIII	Hospitals	50	50
IX	Industry	30	30
X	Lager	25	25
XI	Sport facilities	25	25

***according to SIA 380/1:2009**
****in kWh/m2a final energy, weighted**

6.4.3.4 MINERGIE-Eco

The MINERGIE-Eco standard is a supplementary green building standard, which can be combined with the three standards MINERGIE, MINERGIE-P and MINERGIE-A. This is through a careful choice of materials, predictive design and intelligent architecture. MINERGIE-Eco offers healthy and ecological construction. MINERGIE-Eco looks at:

- Daylight
- Acoustics and noise protection
- Indoor thermal comfort
- Building concept
- Material use
- Building processes
- Grey energy of building materials

MINERGIE-Eco certification is through calculation and compliance with minimum criteria in a software based certification tool. If any of the criteria are not met, a MINERGIE-Eco certification cannot be given. In addition, MINERGIE-Eco is seen as tool, which should accompanying the planning and construction phases.

Since implementation up to 2017 over 1500 buildings had obtained the additional certification 0f MINERGIE-Eco. A MINERGIE-Eco standard cannot be given on its own.

6.4.3.5 MINERGIE Qualitätssystem Bau (MQS Bau)

The MQS Bau (Buildings Site) is a MINERGIE supplementary standard. It is designed to be used in the construction and approval phases. MQS Bau is designed to ensure a high quality of the building construction phase as well as that high quality materials are used and that they are of a high ecological quality and that the MINERGIE Standards are correctly implemented.

MQS Bau allows an early identification of processes which may deviate from the original plan. This is through a standardised control method with inspections at appropriate times during the construction process. It can be adjusted to meet the needs of each project. The structured documentation allows transparency on the building site and allows the relevant actors/building owner easy access to all the relevant information at the relevant stage. The validation of the processes is only for the MINERGIE relevant building services, materials and technologies.

MQS Bau is available in two variations MQS Bau Check (Building check) for residential buildings and MQS Bau Selection (Building selection) for non-residential and complicated residential buildings.

6.4.3.6 MINERGIE Qualitätssystem Betrieb (MQS Betrieb)

MQS Betrieb (MQS Operation) is a MINERGIE supplementary standard. MQS Betrieb regulates the energy efficient operation of a building during the operation phase. In addition, it ensures the comfort of the building users and helps to sensitize them for the energy efficient use of the building and at the same time ensuring conservation of the building´s value. It gives guidelines for the optimal use of building service technologies. The standard is based on three cornerstones of consulting, optimization and sensitization. The requirements for a MQS Betrieb are, but not limited to, as follows:

- The building services technologies are run energy efficient and to the building´s/user´s need.
- Regular inspections and maintenance are held.
- All relevant documents for running the services are available, including directions for the energy efficient running of the systems.
- The building envelope is completely insulated energy efficiently
- The users have been trained in an energy efficient use of the building.
- Energy efficient appliances are in place and correctly

MINERGIE Building classes I, II, III and IV can be certified as MQS Betrieb. Other building classes can only be certified in prior consultation with the MINERGIE authority.

6.4.4 Certification process

All information on the building is collected on the MINERGIE-Online-Platform. The certification process begins with the date of written submission for an application of certification. If a double certification is required, the applications must be sent within 15 days of each other. Following this, the paper dossier and all signed all documents must be submitted to the relevant certification authority. All documents must be submitted correctly and in full. The submitted documents are checked for their technical plausibility. A complete verification and re-calculation is not required. Incomplete or incorrect documents are sent back for rectification. This can be done up to a maximum of two times. The authority will contact the relevant person if the submitted documents contain any ambiguities, missing or wrong data. If corrections are not addressed within three months, the certification process is suspended. The certify authority does not take responsibility for the control of the quality of the planning or engineering services.

On completion of the assessment, a provisional certification will be issued. This is valid for a period of three years. This can be extended in well-founded cases by two years. If the building is not completed within this period the certification process is suspended.

On completion of the building the applicant must submit a signed confirmation that the building has been completed as applied for, as well as any final documents to the relevant authority. Any changes in the building from that of the application must be reported to the certifying authority. Major changes can be seen as major effort and thus as a new verification that must be completed including the extra fees associated with this. On completion of the verification the final certification and label will be presented to the building owner.

The label is unique to each building and contains a unique registration number, standard used and its version. The use of these does not have a time limit as long as the building has not undergone any energy relevant changes and is listed by the MINERGIE Authority as a MINERGIE building.

All data provided to MINERGIE for verification lie under strict confidentiality.

6.4.5 Supplementary standards

MINERGIE-Eco, MQS Bau and MQS Betrieb certification can only be given for buildings that are certified with a MINERGIE Standard. If a building does not receive a MINERGIE Standard for what ever reason it cannot receive a supplementary standard. Certification for supplementary standards must be submitted along with the application for a MINERGIE standard. The only exception is for an application for a MQS Bau certification, which must be submitted at least three months before the construction phase starts.

Certification for MINERGIE-Eco is via calculation and a catalogue of sustainable requirements. In addition, before the final certification can be given for MINERGIE-Eco indoor air-quality tests must be made.

For MQS Bau criteria points are given according to the catalogue of sustainable requirements. Certification of MQS Bau is through random onsite inspections, to check if the building is as constructed as planned to MINERGIE as well as any other relevant building standards. This looks at the building envelope, ventilation systems and ducts, building services as well as materials. It does not however involve full testing and control but concentrates on whether goals and principles of MQS Bau have been upheld. MQS Bau Check requires a MQS Trained Architect/construction supervisor to control the building site based on an MQS Bau audit report. MQS Bau Selection requires a third party trained MQS Building expert to continuously supervise construction work, control and document all processes on site. The building expert defines the criteria for verification depending on the building type. For both variations, the relevant audit and documentation are then sent to the MINERGIE Authority for verification. The documentation should include progress of work and photos, inspection results, verification and MINERGIE relevant operation and maintenance documentation. On certification, the building site is given the MQS Bau checked certification.

Certification of MQS Betrieb (Operation) is through an onsite inspection with checklist. This looks at the building services, building (primarily building envelope) and user behaviour.

6.4.6 Cost of certificates

The cost of a MINERGIE certification varies on the size and type of building as well as the type of the standard used. Payment is due at issuance of the provisional certificate. For mixed-use buildings, the fees are according to the category III to XII (Non-residential). For developments with several buildings of same type the total EFA of all buildings is used as the basis for the fees. Here only one Certificate is issued.

If a building is certified to more than one MINERGIE Standard i.e. MINERGIE–P and MINERGIE–A a 50% reduction on the cheaper certificate is offered.

The MINERGIE Authority covers the costs, in full, for random controls . If however there any inconsistencies with the submitted documents the costs are to be paid in full by the building´s owner. Within the random checks, costs for detailed verification, if deemed necessary are to be covered by the buildings owner.

All extra work and services provided, for example, more than two corrections of documents, are deemed extra. All fees due for extra work, services, checks and verification are due on completion. Extra certificates cost 600 CHF (ca. 525 € 01.11.2018)

MINERGIE

Table 6-20 : Costs for Minergie Certificates. (Source: MINERGIE).

Energy reference area	Costs in CHF	Costs in CHF
	Category I to II*	Category III to XII**
≤ 250 m^2	1200.–	1500.–
251 m^2 - 1000 m^2	1700.-	2100.–
1001 m^2 - 2000 m^2	2500.-	3200.–

2001 m² - 5000 m²	4000.-	5200.–
5000 m² - 10 000 m²	8500.-	10 000.–
> 10 000 m2	case specific	case specific
*Residential MFH, Residential SFH		
** Administration, schools, sales, restaurants, assembly, hospitals, industry, warehouses, sports facilities, indoor swimming pools		

MINERGIE – P

Table 6-21 : Costs for Minergie - P Certificates. (Source: MINERGIE).

Energy reference area	Costs in CHF	Costs in CHF
	Category I to II*	Category III to XII**
≤ 250 m²	2400.-	2700.-
251 m² - 1000 m²	3000.-	3500.-
1001 m² - 2000 m²	4200.-	5000.-
2001 m² - 5000 m²	6000.-	7200.-
5000 m² - 10 000 m²	10 500.-	12 000.-
> 10 000 m²	case specific	case specific
*Residential MFH, Residential SFH		
** Administration, schools, sales, restaurants, assembly, hospitals, industry, warehouses, sports facilities, indoor swimming pools		

MINERGIE – A

Table 6-22 : Costs for Minergie – A Certificates. (Source: MINERGIE).

Energy reference area	Costs in CHF	Costs in CHF
	Category I to II*	Category III to XII**
≤ 250 m²	2600.-	3000.-
251 m² - 1000 m²	3400.-	4000.-
1001 m² - 2000 m²	4900.-	5500.-
2001 m² - 5000 m²	6800.-	8000.-
5000 m² - 10 000 m²	11 500.-	13 000.-
> 10 000 m²	case specific	case specific
*Residential MFH, Residential SFH		
** Administration, schools, sales, restaurants, assembly, hospitals, industry, warehouses, sports facilities, indoor swimming pools		

MINERGIE-Eco

Table 6-23 : Costs for Minergie – Eco Certificates. (Source: MINERGIE).

Energy reference area	Costs in CHF			
	Category I, II, IV and XI	Category III, V, VI, VII	Category VIII	Category IX
≤ 250 m²	1900	5000	6500	5700

251 m² - 500 m²	2300	5000	6500	5700
501 m² - 1000 m²	5000	5000	6500	5700
1001 m² - 2000 m²	7000	7000	9100	8100
2001 m² - 5000 m²	9000	9000	11700	10300
5000 m² - 10 000 m²	11000	11000	14300	12600
> 10 000 m²	case specific	case specific	case specific	case specific

MQS Bau

Table 6-24 : Costs for MQS Bau Certificates.

Energy reference area	Costs in CHF	Costs in CHF
	Category I and II	Category III to XII
≤ 250 m²	2200	8500
251 m² - 1000 m²	2600	8500
1001 m² - 2000 m²	3400	8500
> 2001 m²	case specific	case specific

MQS Betrieb

Table 6-25 : Costs for MQS Betrieb. (Source: MINERGIE).

Energy reference area	Costs in CHF	Costs in CHF
	Category I to IV	Category V to XII
≤ 250 m²	1200.-	case specific
251 m² - 1000 m²	1700.-	case specific
1001 m² - 2000 m²	4900.-	case specific
> 2001 m²	case specific	case specific

6.4.7 Compliance and Penalties

If inconsistencies are found within the random checks and quality control, the MINERGIE Authority reserves the right for further sanctions. In cases where the data for the Label and/or certification is falsified or the Label and/or certificate are used in an illegal manner, following conventional fines are to be paid. This does not relieve the building owner from the right not to rectify. The fines are dependant on building size:

- Buildings under 5000 m² ERA 10000 CHF
- Buildings over 5000 m² ERA 50000 CHF
- In a MINERGIE-module up to 10000 CHF

Wilful falsification of submitted data will be criminally prosecuted, especially in the case of forged documents.

6.4.8 Monitoring and evaluation

The MINERGIE Authority reserves the right for random checking, with no prior notification, of any building. This can take place between the issuing of the provisional certificate to five years after the issuing of the final certificate. This takes place on at least 20% of all buildings. The building owner is required to cooperate in full with the provision of all documents and provide access to all relevant areas of the building.

Buildings over 2000 m^2 energy reference area (as well as all MINERGIE-A buildings) must have an energy monitoring system installed. The monitoring system should be used to control consumption and be used as a tool for system optimisation. Monitoring must include:

- Total final energy consumption for heating and domestic hot water
- Electricity (without heat use i.e. heat pump or direct hot water)
- Useful energy for heating and domestic hot water (individually)
- Cooling (only for functional buildings)
- On-Site self produced energy

In addition, it is required that comparisons of the year and a yearly average are made possible. The collection of data for monitoring and comparison should be done at the latest monthly, electricity daily.

6.4.9 Materials and technologies

Building elements and systems can be certified with the MINERGIE Module. This certification shows that the building elements and systems have the qualities required for a MINERGIE building. Buildings using these MINERGIE Module elements and systems thus normally have the requirements and are built to a quality that is MINERGIE compliant. Application for certification is made to the MINERGIE Authority. The authority in certifying an element or system will:

- Verify the registration, pre-examination and certification applications
- Assess the element or system for conformity to MINERGIE
- Conduct random sampling to ensure compliance with the regulations

Any application requires at least a pre-assessment or certification of the element or system. On certification the element or system will receive the MINERGIE Module certification and label. Costs for certification vary according to element and system and efforts required for the assessment.

6.4.10 Expert competence and training

Planning, construction and facility management firms involved in the construction industry can all become MINERGIE specialist partners. These must have completed at least two MINERGIE buildings and taken part in regular further training and events. These firms can only become registered specialist partners upon entering

into a contract with the MINERGIE Authority. These firms must then name one or more experts as the direct contact and competence person for the MINERGIE standard.

In becoming an MINERGIE Expert, the expert must have the relevant basic training for their trade and have taken part in a MINERGIE Basic course including a case study or through proof of experience through two MINERGIE Buildings. In keeping up their certification an expert must within a three year period of certification complete at least one MINERGIE building, partake in a further MINERGIE training and a MINERGIE event.

All MINERGIE specialist partners and experts are allowed to use the MINERGIE logo and are listed on the MINERGIE Authorities website. The cost for the basic membership runs at 500 CHF/a (ca. 440 € 01.11.2018)

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