LE GOUVERNEMENT
DU GRAND-DUCHÉ DE LUXEMBOURG
Ministère de l'Économie
et du Commerce extérieur

National Plan for Luxembourg to increase the number of nearly zero-energy buildings

pursuant to Directive 2010/31/EU of 19 May 2010
on the energy performance of buildings (recast)

Luxembourg, July 2013

Contact details for the report

'National Plan for Luxembourg to increase the number of nearly zero-energy buildings'

Organisation	Gouvernement du Grand-Duché de Luxembourg Ministère de l'Économie et du Commerce extérieur Direction générale de l'Energie
Postal address	19-21 boulevard Royal, L-2449 Luxembourg
Fax:	+352 247-84311

This report was produced by

Dr Markus Lichtmess
Dr Jens Knissel

1 Introduction

The recasting of Directive 2010/31/EU of the European Parliament and of the Council of 19 May 2010 on the energy performance of buildings (the '*Directive')* introduces the term 'nearly zero-energy buildings', abbreviated to '*nZEB'.* The Directive stipulates that by 31 December 2020, all new buildings should conform to this standard. Moreover, the Member States must ensure that by 31 December 2018, buildings owned and occupied by public authorities are nearly zero-energy buildings (1). In this way, the public sector should act as a role model.

To achieve implementation of the new energy-related building standards in practice, it is necessary not only to produce amended regulations but also to prepare the market and the sector. To this end national implementation and action plans to increase the number of nearly zero-energy buildings are needed. This is called for in Article 9 of the Directive (1). This document describes the current status of the national definition of nearly zero-energy buildings and sets out the strategy and actions to be taken to increase the number of nearly zero-energy buildings.

1.1 The requirements of the Directive

Article 9 of the Directive (1) sets out the requirements for the national plan to increase the number of nearly zero-energy buildings as follows:

Article 9(1): [...] Member States shall draw up national plans for increasing the number of nearly zero-energy buildings. These national plans may include targets differentiated according to the category of building.

Article 9(2): Member States shall furthermore, following the leading example of the public sector, develop policies and take measures such as the setting of targets in order to stimulate the transformation of buildings that are refurbished into nearly zero-energy buildings; [...]

Article 9(3): The national plans include the following information:

a) the Member State's detailed application in practice of the definition of nearly zero-energy buildings [...] including a numerical indicator of primary energy use expressed in kWh/m2 per year. Primary energy factors used for determining the primary energy use may be based on national or regional annual average values [...];

b) intermediate targets for improving the energy performance of new buildings by 2015, with a view to preparing the implementation of paragraph 1;

c) information on the policies and financial or other measures adopted in the context of paragraphs 1 and 2 for the promotion of nearly zero-energy buildings, including details of national requirements and measures concerning the use of energy from renewable sources in new buildings and existing buildings undergoing major renovation [...].

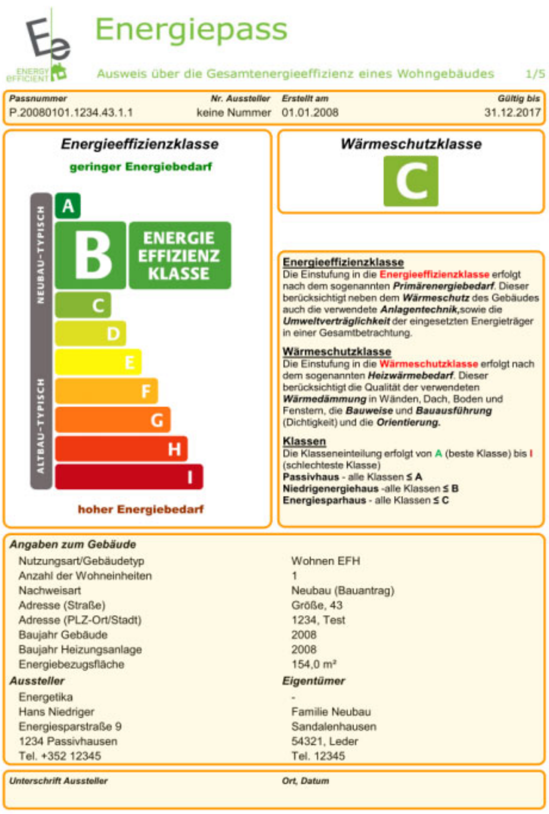
1.2 The situation in Luxembourg

In 1995, the Thermal Insulation Regulation [Wärmeschutzverordnung] introduced the first statutory requirement to limit energy use in new residential and non-residential buildings. This regulation limited heat loss through the building envelope and ensured a minimum level of thermal insulation.

The Energy Saving Regulation [Energieeinsparverordnung] for residential buildings in Luxembourg entered into force in 2008, based on the requirements of Directive 2002/91/EC of the European Parliament and of the Council of 16 December 2002 on the energy performance of buildings (2). In addition to requirements for the thermal insulation of buildings, this limits the maximum primary energy demand of new buildings in particular. Minimum thermal insulation requirements were also set for replacement building components in all buildings being modernised. Since then, all new and existing buildings have been graded according to a classification system from A to I. The Energy Saving Regulation 2008 also tightened the thermal insulation requirements for non-residential buildings (3).

The Energy Saving Regulation for non-residential buildings of 31 August 2010 extended the general requirements to new non-residential buildings (entry into force January 2011) (4). These also include requirements for thermal insulation and primary energy demand as well as a classification system for new and existing buildings. The classification system for new non-residential buildings is based on the calculated energy demand, whereas the system for existing non-residential buildings relies on the consumption measured. The following illustrations show the first page of the energy performance certificate for new residential and non-residential buildings.

Energy performance certificate for new and existing residential buildings, page 1


Energiepass

Ausweis über die Gesamtenergieeffizienz eines Wohngebäudes 1/5

Passnummer	Nr. Aussteller	Erstellt am	Gültig bis
P.20080101.1234.43.1.1	keine Nummer	01.01.2008	31.12.2017

Energieeffizienzklasse

geringer Energiebedarf

NEUBAU-TYPISCH / ALTBAU-TYPISCH

A, B (ENERGIE EFFIZIENZ KLASSE), C, D, E, F, G, H, I

hoher Energiebedarf

Wärmeschutzklasse

C

Energieeffizienzklasse
Die Einstufung in die Energieeffizienzklasse erfolgt nach dem sogenannten *Primärenergiebedarf*. Dieser berücksichtigt neben dem *Wärmeschutz* des Gebäudes auch die verwendete *Anlagentechnik*,sowie die *Umweltverträglichkeit* der eingesetzten Energieträger in einer Gesamtbetrachtung.

Wärmeschutzklasse
Die Einstufung in die Wärmeschutzklasse erfolgt nach dem sogenannten *Heizwärmebedarf*. Dieser berücksichtigt die Qualität der verwendeten *Wärmedämmung* in Wänden, Dach, Boden und Fenstern, die *Bauweise* und *Bauausführung* (Dichtigkeit) und die *Orientierung.*

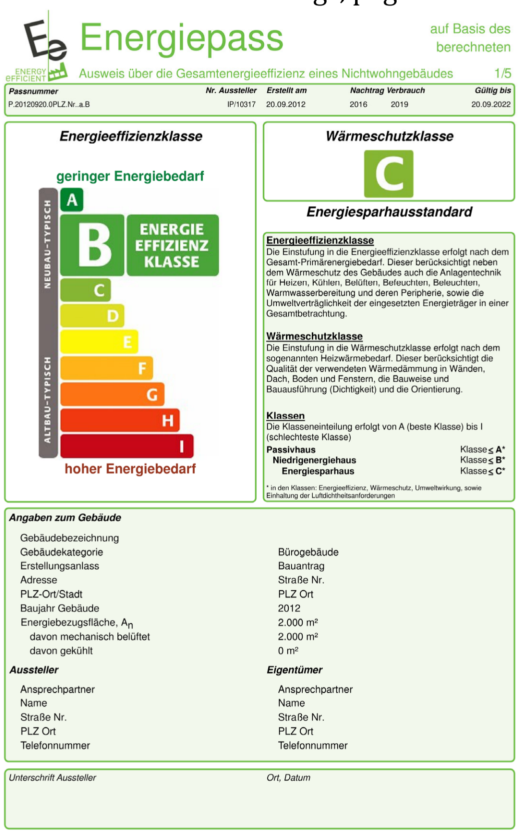
Klassen
Die Klasseneinteilung erfolgt von A (beste Klasse) bis I (schlechteste Klasse)
Passivhaus - alle Klassen ≤ **A**
Niedrigenergiehaus -alle Klassen ≤ **B**
Energiesparhaus - alle Klassen ≤ **C**

Angaben zum Gebäude

Nutzungsart/Gebäudetyp	Wohnen EFH
Anzahl der Wohneinheiten	1
Nachweisart	Neubau (Bauantrag)
Adresse (Straße)	Größe, 43
Adresse (PLZ-Ort/Stadt)	1234, Test
Baujahr Gebäude	2008
Baujahr Heizungsanlage	2008
Energiebezugsfläche	154,0 m²
Aussteller	*Eigentümer*
Energetika	-
Hans Niedriger	Familie Neubau
Energiesparstraße 9	Sandalenhausen
1234 Passivhausen	54321, Leder
Tel. +352 12345	Tel. 12345

Unterschrift Aussteller *Ort, Datum*

Energy performance certificate for new non-residential buildings, page 1


Energiepass

auf Basis des berechneten

Ausweis über die Gesamtenergieeffizienz eines Nichtwohngebäudes 1/5

Passnummer	Nr. Aussteller	Erstellt am	Nachtrag	Verbrauch	Gültig bis
P.20120920.0PLZ.Nr..a.B	IP/10317	20.09.2012	2016	2019	20.09.2022

Energieeffizienzklasse

geringer Energiebedarf

NEUBAU-TYPISCH / ALTBAU-TYPISCH

A, B (ENERGIE EFFIZIENZ KLASSE), C, D, E, F, G, H, I

hoher Energiebedarf

Wärmeschutzklasse

C

Energiesparhausstandard

Energieeffizienzklasse
Die Einstufung in die Energieeffizienzklasse erfolgt nach dem Gesamt-Primärenergiebedarf. Dieser berücksichtigt neben dem Wärmeschutz des Gebäudes auch die Anlagentechnik für Heizen, Kühlen, Belüften, Befeuchten, Beleuchten, Warmwasserbereitung und deren Peripherie, sowie die Umweltverträglichkeit der eingesetzten Energieträger in einer Gesamtbetrachtung.

Wärmeschutzklasse
Die Einstufung in die Wärmeschutzklasse erfolgt nach dem sogenannten Heizwärmebedarf. Dieser berücksichtigt die Qualität der verwendeten Wärmedämmung in Wänden, Dach, Boden und Fenstern, die Bauweise und Bauausführung (Dichtigkeit) und die Orientierung.

Klassen
Die Klasseneinteilung erfolgt von A (beste Klasse) bis I (schlechteste Klasse)
Passivhaus Klasse ≤ **A***
Niedrigenergiehaus Klasse ≤ **B***
Energiesparhaus Klasse ≤ **C***

* in den Klassen: Energieeffizienz, Wärmeschutz, Umweltwirkung, sowie Einhaltung der Luftdichtheitsanforderungen

Angaben zum Gebäude

Gebäudebezeichnung	
Gebäudekategorie	Bürogebäude
Erstellungsanlass	Bauantrag
Adresse	Straße Nr.
PLZ-Ort/Stadt	PLZ Ort
Baujahr Gebäude	2012
Energiebezugsfläche, A_n	2.000 m²
davon mechanisch belüftet	2.000 m²
davon gekühlt	0 m²
Aussteller	*Eigentümer*
Ansprechpartner	Ansprechpartner
Name	Name
Straße Nr.	Straße Nr.
PLZ Ort	PLZ Ort
Telefonnummer	Telefonnummer

Unterschrift Aussteller *Ort, Datum*

2 Definition of a nearly zero-energy building

In the Directive, the definition of a nearly zero-energy building and the classification of renewable forms of energy are defined qualitatively (1) as follows:

Article 2(2): 'nearly zero-energy building' means a building that has a very high energy performance [...]. The nearly zero or very low energy demand should be covered to a very significant extent by energy from renewable sources, including energy from renewable sources produced on-site or nearby;

Article 2(6): 'energy from renewable sources' means energy from renewable non-fossil sources, namely wind, solar, aerothermal, geothermal, hydrothermal and ocean energy, hydropower, biomass, landfill gas, sewage treatment plant gas and biogases.

2.1 Nearly zero-energy buildings in Luxembourg

As far as we are currently aware, no general definition or normative standards exist at a European level that specify precisely the objective of a nearly zero-energy building for building practice. The specification of measures and methods of calculation remains a matter for the Member States, and these respond differently to the requirements when they implement them. This is due in part to established national methods of assessment, but also to the varying energy requirements for buildings in different climatic areas.

Luxembourg takes the idea that the buildings must have very high energy performance from Article 2. That means a high level of thermal insulation and a low primary energy demand for heating, cooling, air-conditioning, hot drinking water, lighting, ventilation and auxiliary energy.

The overriding objective when planning high energy performance buildings is to reduce the energy demand of the building as much as possible by means of building measures and optimisation of the building's volume and the architectural design. The incorporation of the largest possible proportion of renewable energy is the second step to a nearly zero-energy building. The remaining energy demand must be produced and supplied by choosing the most efficient building systems. Figure 1 illustrates the procedure for planning energy-efficient buildings.

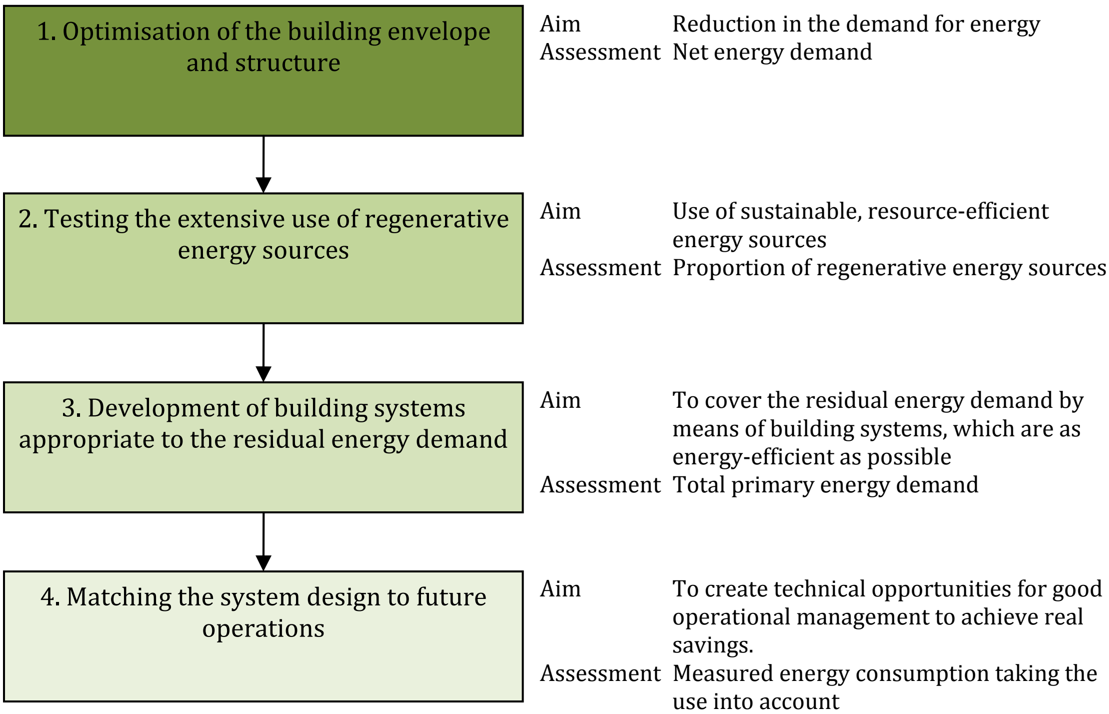


Figure 1: Procedure for planning energy-efficient buildings (5).

Application to Luxembourg

Luxembourg has had a classification system for new and existing residential buildings since 2008 and for non-residential buildings since 2011. The new requirements were first introduced for residential buildings. The experience gained from this was applied when drafting the regulations for non-residential buildings. For residential buildings and new non-residential buildings, the categories range from A (best energy performance) to I (worst energy performance). When the regulations were introduced, category D represented the level of energy performance required for new builds. Energy performance is shown for heat and electricity separately for existing non-residential buildings using a ribbon display (0 % – 400 %); 100 % corresponds to the average consumption of an existing building with the same use.

In addition to total primary energy efficiency, there is a further requirement category for new residential and non-residential buildings, the thermal insulation class. The building is assessed independently of the building systems installed for the thermal insulation class. It gives information about heat loss through walls, roofs, floors and windows, about the air-tightness of the building, the efficiency of the ventilation system and the energy aspects of the architectural design. Classes from A to I are also defined for this group. The energy performance certificate also assesses the environmental impact using a classification system based on the equivalent CO_2 emissions.

If level A is achieved in all three efficiency classes and the desired air-tightness is successfully demonstrated by means of a blower door test, then the building meets the Luxembourg passive house standard (classes A-A-A).

Classification of new and existing residential buildings

The following figure shows the classification of residential buildings on the basis of energy and emission indicators.

Building category	Class A	Class B	Class C	Class D	Class E	Class F	Class G	Class H	Class I
1 Residential, MFH*	≤ 45	≤ 75	≤ 85	≤ 100	≤ 155	≤ 225	≤ 280	≤ 355	> 355
2 Residential, EFH**	≤ 45	≤ 95	≤ 125	≤ 145	≤ 210	≤ 295	≤ 395	≤ 530	> 530

Figure 2: Assessment of total primary energy efficiency in kWh/(m^2a)

Building category	Class A	Class B	Class C	Class D	Class E	Class F	Class G	Class H	Class I
1 Residential, MFH	≤ 14	≤ 27	≤ 43	≤ 54	≤ 85	≤ 115	≤ 150	≤ 185	> 185
2 Residential, EFH	≤ 22	≤ 43	≤ 69	≤ 86	≤ 130	≤ 170	≤ 230	≤ 295	> 295

Figure 3: Assessment of heat conservation (heating energy demand) in kWh/(m^2a)

Building category	Class A	Class B	Class C	Class D	Class E	Class F	Class G	Class H	Class I
1 Residential, MFH	≤ 10	≤ 17	≤ 19	≤ 22	≤ 34	≤ 49	≤ 77	≤ 97	> 97
2 Residential, EFH	≤ 11	≤ 21	≤ 27	≤ 32	≤ 46	≤ 65	≤ 107	≤ 144	> 144

Figure 4: Environmental impact assessment in kgCO_2/(m^2a)

* MFH: apartment block
** EFH: single-family

Classification of new non-residential buildings

Non-residential buildings are not assessed directly by comparison with banded energy performance indicators, but by using the reference building method. This is primarily because fixed performance indicators do not take the use of the building or the energy demand arising out of that use into account. The geometry and use of the reference building is the same as the building being assessed and the reference performance indicator is calculated using structural and technical fittings predefined in the legislation. The energy demand calculated for the building being assessed is compared to the reference value and the percentage difference from the reference value is derived. The following table shows the classification based on this difference. The energy requirements to be evaluated apply to the total primary energy demand and heating energy demand classes.

Efficiency class	Class A	Class B	Class C	Class D	Class D	Class F	Class G	Class H	Class I
Total primary energy demand	≤ 55 %	≤ 70 %	≤ 85 %	≤ 100 %	≤ 150 %	≤ 200 %	≤ 300 %	≤ 400 %	> 400 %
Total CO_2 emissions performance indicator	≤ 55 %	≤ 70 %	≤ 85 %	≤ 100 %	≤ 150 %	≤ 200 %	≤ 300 %	≤ 400 %	> 400 %
Heating energy demand	≤ 45 %	≤ 60 %	≤ 80 %	≤ 100 %	≤ 150 %	≤ 200 %	≤ 300 %	≤ 400 %	> 400 %
Primary energy demand, heating	≤ 45 %	≤ 60 %	≤ 80 %	≤ 100 %	≤ 150 %	≤ 200 %	≤ 300 %	≤ 400 %	> 400 %
Primary energy demand, cooling	≤ 45 %	≤ 60 %	≤ 80 %	≤ 100 %	≤ 150 %	≤ 200 %	≤ 300 %	≤ 400 %	> 400 %
Primary energy demand, air supply	≤ 65 %	≤ 75 %	≤ 85 %	≤ 100 %	≤ 150 %	≤ 200 %	≤ 300 %	≤ 400 %	> 400 %
Primary energy demand, lighting	≤ 55 %	≤ 70 %	≤ 85 %	≤ 100 %	≤ 150 %	≤ 200 %	≤ 300 %	≤ 400 %	> 400 %
Weighted final energy demand	≤ 55 %	≤ 70 %	≤ 85 %	≤ 100 %	≤ 150 %	≤ 200 %	≤ 300 %	≤ 400 %	> 400 %

Figure 5: Assessment in terms of the percentage difference from the reference building

Energy performance paramount

Reducing the building's energy demand (high performance) is paramount in achieving nearly zero-energy buildings. As applied to Luxembourg, nearly zero-energy buildings would in principle need to conform at least to thermal insulation and energy performance class A (passive house standard). To meet the passive house standard, a building must be good at conserving heat and need less heating. In addition to the requirements for insulation of the building envelope, the system of assessment based on energy performance indicators (residential buildings) and the reference building method (non-residential buildings) also indirectly encompasses energy aspects of the chosen architectural design.

Incorporation of forms of renewable energy into the building itself is the second step towards nearly zero-rated buildings. In this connection, the aim is to ensure that the residual energy required is produced and distributed round the building as efficiently as possible. Under the Luxembourg Energy Saving Regulation this is assessed by means of the energy efficiency class (total primary energy demand). In residential and non-residential buildings, the calibration of energy efficiency class A is based on a passive house standard with a thermal solar energy system and efficient technology at the date of entry into force of the relevant Energy Saving Regulation (2008 for residential and 2011 for non-residential buildings).

In order to make inspection and monitoring of the management of the building possible, the Energy Saving Regulation for non-residential buildings provides for mandatory meters.

2.2 Incorporation of renewable forms of energy

Built into the building

Built-in forms of renewable energy are generally taken into account in energy accounting under the current Luxembourg Energy Saving Regulations, but subject to certain limitations. An important issue in the definition of nearly zero-energy buildings is giving credit for renewable forms of energy, which produce different amounts of energy at different times. In deriving a definition of nearly zero-energy buildings, the question arises as to the amount of energy produced, especially electricity, which should be credited to the building and treated as a portion that is not fed into the public supply network. In developing such an approach, the accounting period for production and consumption by the building is critical to the amount of energy attributable to it. The longer the period chosen, the greater the attributable share of energy from renewable sources. The primary objective of a nearly zero-energy building is to satisfy the building's energy demand at any given time, so the accounting period chosen should not be too long. For example, if the accounting is done over a year, there will be a seasonal transfer of a large amount of electricity produced in the summer months by means of a photovoltaic system to the winter months, for example. Selecting a period of one month seems sensible, as this is also the period used for calculating the energy demand. However, use of short-term storage, e.g. on a daily cycle, should also be given credit because this can be very important for balancing the load in the network.

Local group of buildings

Where buildings are directly connected to each other – e.g. by a shared heating system – this is already taken into account in the energy balances under the current Energy Saving Regulations.

System expenditure figures and adjusted primary energy factors, which allow an assessment of these systems, are available for this purpose. A proviso here is that the supply network is not connected to a public network that supports feed-in.

Public networks

Ecological purchases of electricity over public networks are not credited to the buildings in the energy balances. This is primarily because a change of electricity supplier or electricity product could lead to the building being reclassified. As, under the Directive, the energy performance certificate issued on the basis of the classification is valid for ten years, provision for electricity products cannot be represented. This would require fixed contract terms to be introduced and linked to the energy performance certificate. The electricity purchased from the public network will then be taken into account on the basis of a mix of electricity selected at national level.

New technologies

The deployment of new technologies in the current national Energy Saving Regulations is permitted in principle. However, one must ensure that reliable findings about the energy efficiency of these technologies are available. The rules for calculating the energy balances introduce interfaces for including new technologies in the areas of heating, cooling, hot drinking water, lighting, ventilation and auxiliary energy applications.

2.3 Accounting method for residential and non-residential buildings.

2.3.1 Connection to existing methods

Energy performance assessment for **residential buildings** includes the energy systems for heating, ventilation, hot drinking water and the associated auxiliary energy demand. The energy balances are based on CEN standards and the timescale used is one month. Solar thermal installations, where the energy produced is fed straight to the building, are already taken into account in the balances. The energy demand for cooling and energy produced by PV is not taken into account. The impact of cogeneration is only partly taken into account. The Energy Saving Regulation for residential buildings contains a reference to dispensing with air conditioning devices in residential buildings, which is not legally binding. As regards limiting the energy demand for cooling, requirements are imposed indirectly on summer heat conservation (glazing and shading) in residential buildings.

Energy assessment of new **non-residential buildings** includes the energy systems for heating, cooling, hot drinking water, ventilation, lighting, humidifying and dehumidifying and the associated auxiliary energy demand. Until now, the electricity produced has not been included for most technologies.

In energy accounting for nearly zero-energy buildings, the balance thresholds for residential and non-residential buildings are to be extended to take energy production into account. Where energy is produced, only the proportion of the energy production which benefits the building directly (in the accounting period), is taken into account. Surplus energy is fed into the public network and is not included in the balance.

The following diagram shows the current (left-hand diagram) and proposed future (right-hand diagram) assessment of built-in energy production using the example of a photovoltaic facility in an all-electric building (non-residential).

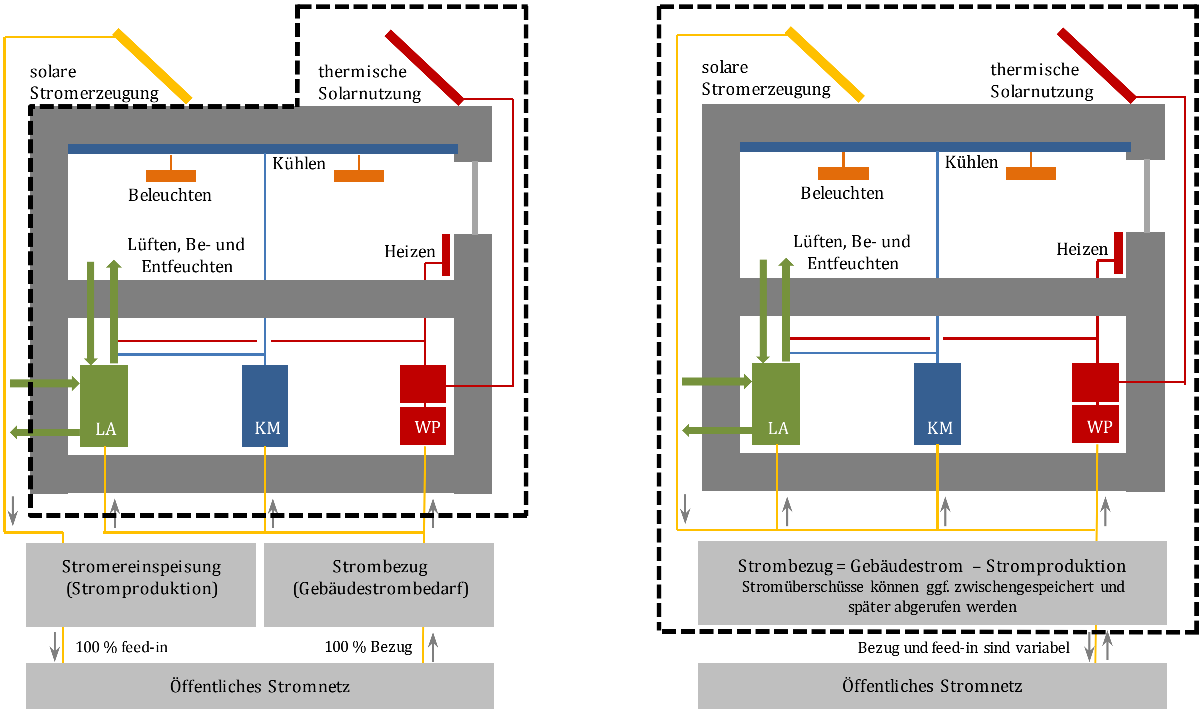


Figure 6: Explanation of the energy balance threshold. The lefthand picture shows the method currently used in assessing residential and non-residential buildings. Electricity from built-in facilities is fed entirely into the grid and there is no own use of electricity. The right-hand diagram gives the future model for the balance threshold. Electricity generated is used primarily for the building itself. Any excess is either fed into the grid or it may be stored. VS=ventilation system, HP= heat pump, CU=cooling unit.

2.3.2 Energy accounting for residential and non-residential buildings

The accounting in the energy performance certificate for a building is done on the basis of a monthly primary energy balance. In order to match demand and production over time, the attributable share of energy credits is limited, for example, by the monthly demand of the building – a monthly balance is the shortest period under current balancing methods. This produces the following results:

- Adjustment of seasonal transfers from summertime to wintertime where, for example, PV is used to produce electricity;
- Adjustment of seasonal transfers from wintertime to summertime where, for example, built-in heat-driven cogeneration is used.

The attributable amount is limited by the following equation.

$$Q_{P,nZEB} = \sum_{i} max\left\{ \begin{matrix} Q_{P,Gebäude,i} & Q_{P,Produktion,i} \\ & 0 \end{matrix} \right\}$$

where

$Q_{P,nZEB}$	The primary energy credit required for a net zero-energy balance as an annual energy performance indicator
$Q_{P,Building,i}$	Primary energy demand of the building in month i for the energy systems for heating, hot drinking water, cooling, humidifying and dehumidifying, lighting and ventilation, and the auxiliary energy demand of the building systems in month i.
$Q_{P,Production,i}$	Primary credit for built-in technical facilities in month i

Ways of taking account of storage technologies should be included in the method of calculation. In addition to seasonal or monthly storage, systems with daily or weekly storage cycles should be taken into account. These enable any surpluses produced in the daytime, for example, to be used at night. Figure 7 shows the proposed method for defining a nearly zero-energy building and the associated net zero primary energy balance using the example of an office building.

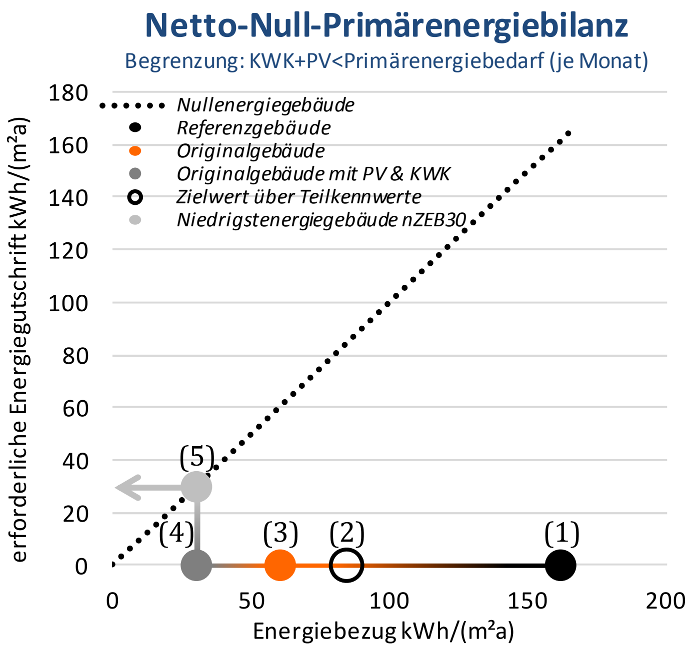


Figure 7: Method for a nearly zero-energy building. Illustration based on (6)

The diagram shows differing energy levels for a building being assessed.

1) Statutory requirements for the energy performance of non-residential buildings. The level required for a sample office building under the 2011 Energy Saving Regulation for new non-residential buildings is shown. Under the current classification system, this standard corresponds to energy efficiency class (total primary energy demand) D.

2) Future level of energy performance required for buildings based on the tighter energy requirements by 2018/2020. The level required for a sample office building is illustrated, but taking account of potential savings in energy performance. This standard corresponds to the highest energy performance class (total primary energy demand) A in the current classification system – the passive house standard.

3) The energy performance value achieved by the building in question taking account of all construction and technical measures planned and envisaged for the property. This illustrates the level achieved by a sample office building under the calculation rules in the 2011 Energy Saving Regulation for new non-residential buildings. The standard achieved in this example lies somewhat below energy performance class (total primary energy demand) A.

4) The energy performance value achieved by the building in question taking account of the attributable electricity production by means of PV, cogeneration, wind etc. The attributable primary energy credit from own energy production is compared to the monthly demand and set off up to the monthly energy demand of the building. Surpluses are fed in and benefit the network or reduce the national or Europe-wide primary energy factor for general electricity purchases. Primary energy factors, which are symmetrical (i.e. the same from month to month) over the course of the year, are taken into account in the balance.

5) Performance indicator for the primary energy credit still required for a net (≈ nearly) zero-energy building. This illustrates the shortfall covered by a primary energy credit required for the building to show a net zero-energy balance under the calculation rules. The performance indicator can be interpreted as follows: the smaller the indicator,

   - the larger the amount of energy produced in the building; or
   - the better the match between the monthly energy demand and the monthly energy production (seasonal information); or
   - the higher the energy performance of the building.

Monthly balance

The primary energy demands of the energy systems (heating, hot drinking water, cooling, humidifying and dehumidifying, lighting, ventilation and the auxiliary energy demand of the building systems) are aggregated monthly and constitute the attributable limit. For a zero-energy balance, energy credits from PV, wind power, fuel cells or cogeneration are taken into account. The monthly balance shows the residual demand (without primary energy credits), which cannot be covered by energy production (energy credits).

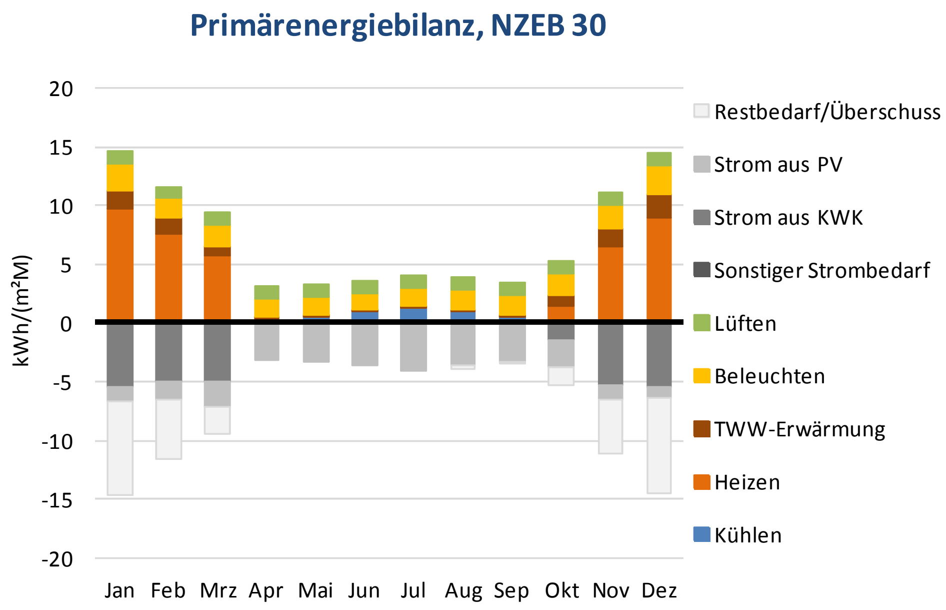


Figure 8: monthly attribution of energy production in the nZEB balance. The amount of the energy credit is restricted to the monthly energy demand of the building. The balance corresponds to an office building conforming to the passive house standard with PV and cogeneration using fossil fuels.

Labelling

Adding up the remaining monthly primary energy demand gives an annual primary energy indicator that documents the difference from a net zero-energy building. Unlike most past energy performance indicators, this indicator not only expresses the building's primary energy demand, but also the demand that would produce an equal balance. The calculation rules indicate a residual primary energy demand of 30 kWh/(m^{2}a) to cover the total primary energy demand. The building's energy standard might be designated nZEB 30.

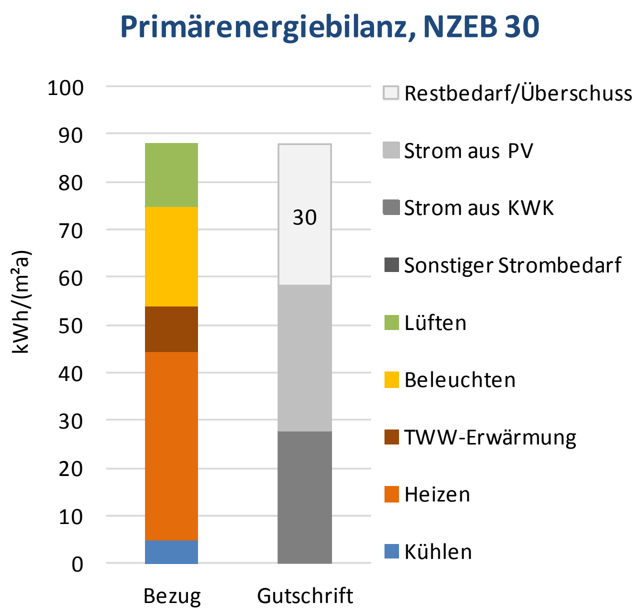


Figure 9: Attribution of energy production in the nZEB balance. The total annual outcome is illustrated. The balance corresponds to an office building conforming to the passive house standard with PV and cogeneration using fossil fuels.

Coverage by primary energy

The primary energy coverage fraction $f_{C,Prim}$ is a parameter for quantifying the match between energy production and energy demand in a nearly zero-energy building. It is the ratio of the attributable primary energy production to the building's primary energy demand. A factor of 100 % indicates total coverage of the primary energy demand by own production – in terms of the monthly assessment.

$$f_{C,Prim} = \frac{\sum_i min\left\{ \begin{matrix} Q_{P,Produktion,i} \\ Q_{P,Gebäude,i} \end{matrix} \right\}}{\sum_i Q_{P,Gebäude,i}}$$

where

$f_{C,Prim}$	Coverage by primary energy as an annual figure
$Q_{P,Building,i}$	Primary energy demand of the building in month i for the energy systems for heating, hot drinking water, cooling, humidifying and dehumidifying, lighting and ventilation, and the auxiliary energy demand of the building systems in month i.
$Q_{P,Production,i}$	Primary credit for built-in technical facilities in month i

The following figures show the cumulative monthly energy demand (primary energy) and the primary energy production achieved in the same period (left-hand diagram in each case). The base line (bisecting line) in the diagram shows the ideal gradient, where demand and production are equal. The right-hand diagrams show the monthly coverage from primary energy. The black line represents the primary energy demand for the building, while the red one shows primary energy produced.

Building with PV facility and heat pump (geothermal energy)

From April to July, the PV facility generates surplus energy. The attributable share is limited to the building's energy demand; surpluses are fed into the electricity grid. In the wintertime, the PV facility does not supply enough energy to balance the energy demand of the building. The annual average primary energy coverage factor $f_{C,Prim}$ is 44 %. The residual energy demand to produce a zero-energy balance is 39 kWh/(m²a).

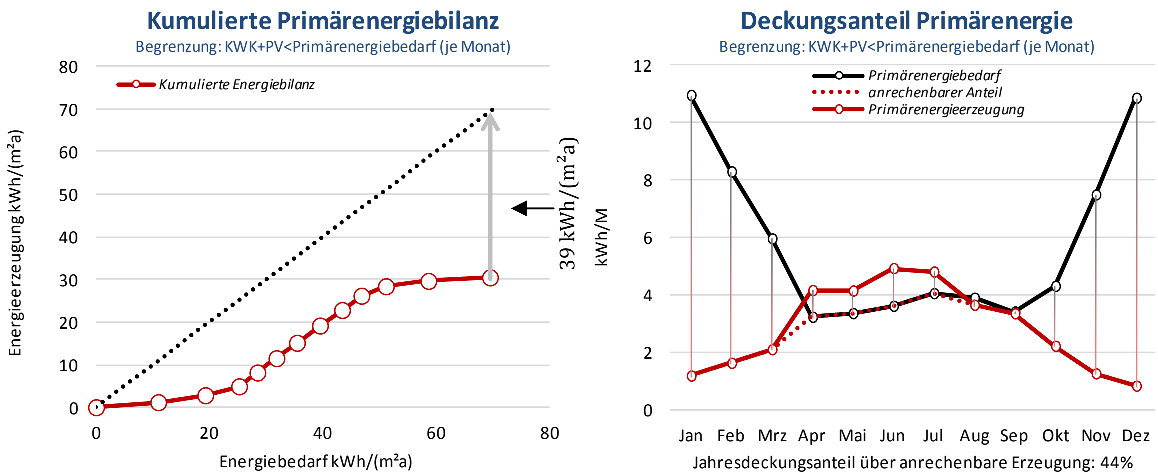


Figure 10: Illustration of the cumulative annual primary energy balance and the coverage factor for primary energy $f_{C,Prim}$, using the example of PV use.

Building with PV facility, heat pump (geothermal energy) and cogeneration using fossil fuel.

The fuel used increases where the cogeneration plant produces a combination of heat and electricity. On the other hand, the electricity produced at the same time can be used to cover the building's own demand and, in this example, it can also be fully attributed. The PV facility acts in the same way as in the variant without cogeneration, because in summer the building does not need heating. The primary energy coverage factor $f_{C,Prim}$ is 66 % in this example and the residual energy demand for an equal zero-energy balance is reduced from 39 kWh/(m²a) to 30 kWh/(m²a).

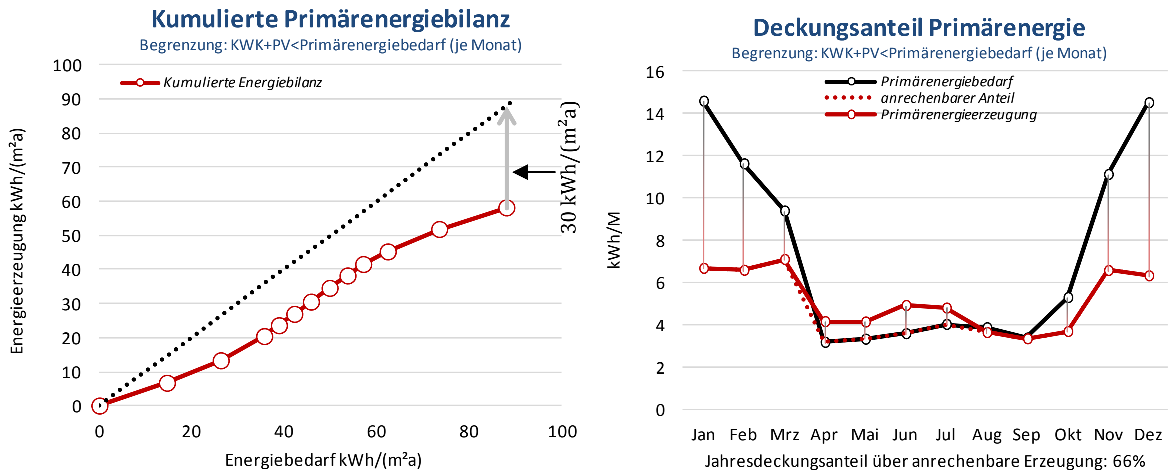


Figure 11: Illustration of the cumulative annual primary energy balance and the primary energy coverage factor $f_{C,Prim}$, using the example of PV use and cogeneration based on a fossil fuel.

<u>Building with PV facility, heat pump (geothermal energy) and cogeneration using renewable energy.</u>

The attribution changes if the cogeneration facility uses renewable energy. The cumulated annual primary energy balance is considerably closer to the zero-energy line in the left-hand diagram. The residual energy demand decreases from 30 kWh/(m^{2}a) to 3 kWh/(m^{2}a). The monthly balance shows that in the cold winter months when the need for heating is greatest, the electricity credit from the cogeneration in this example is not yet quite sufficient to cancel out the primary energy demand of the building. From February onwards, production exceeds demand. As attribution is restricted to the maximum monthly demand, this surplus cannot be offset. The primary energy coverage $f_{C,Prim}$ is 94 %.

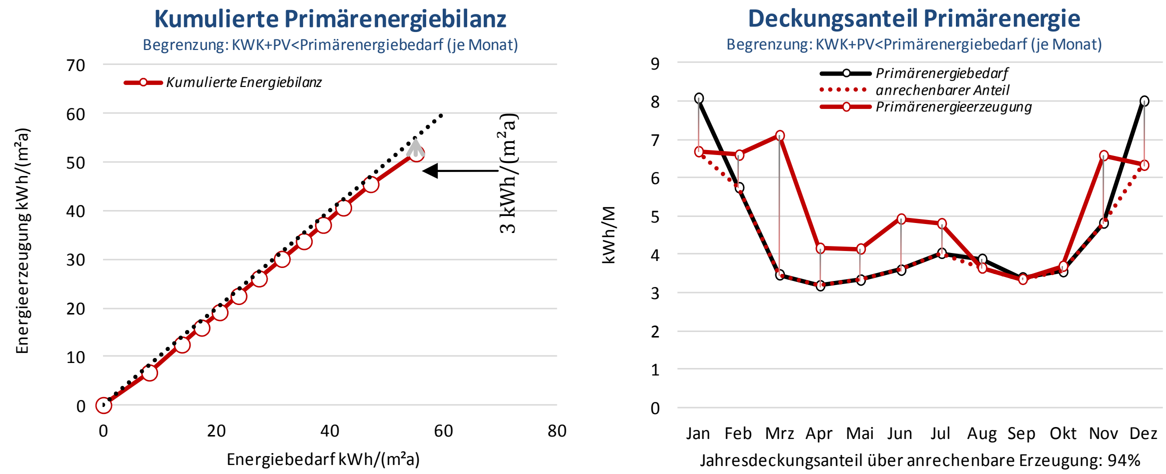


Figure 12: Illustration of the cumulative annual primary energy balance and the coverage factor $f_{C,Prim}$ using the example of PV use and cogeneration based on renewable fuel.

2.3.3 Potential opportunities for saving

The proposed method is applied to four different non-residential buildings. The analyses are carried out for a simple 4-storey building with a simple footprint. The construction and building system boundary conditions are the same for all the buildings and variations. Only the usage structure within the building is varied as follows.

- School;
- Office/administrative building without server rooms;

- Office/administrative building with server rooms
  (6.5 % of the energy reference area A_n is server rooms);
- Hotel with average facilities.

The calculation is based on the following boundary conditions.

Table 1: Boundary conditions for calculating the primary energy indicators

Class D-D-D Energy Saving Regulation 2011	Corresponds largely to the current level of requirements (class D) for new non-residential buildings in the thermal insulation, energy efficiency (total primary energy demand) and environmental impact (CO_2 emissions) categories.
Class A-A-A Energy Saving Regulation 2011	Corresponds to the requirements for achieving the passive house standard in the thermal insulation, energy efficiency (total primary energy demand) and environmental impact (CO_2 emissions) categories.
Class A-A-A Energy Saving Regulation 2011 with a PV system	Corresponds to the requirements for achieving the passive house standard in the thermal insulation, energy efficiency (total primary energy demand) and environmental impact (CO_2 emissions) categories, including a PV system on 60 % of the roof area.
Class A-A-A Energy Saving Regulation 2011 with a PV and cogeneration facility	Corresponds to the requirement level for achieving the passive house standard in the thermal insulation, energy efficiency (total primary energy demand) and environmental impact (CO_2 emissions) categories, including a PV system on 60 % of the roof area and cogeneration (20 % $output_{th}$) using fossil fuel.
Class A-A-A Energy Saving Regulation 2011 with a PV and cogeneration facility based on a renewable energy source	Corresponds to the requirement level for achieving the passive house standard in the thermal insulation, energy efficiency (total primary energy demand) and environmental impact (CO_2 emissions) categories, including a PV system on 60 % of the roof area and cogeneration (20 % $output_{th}$) using renewable fuel.

The total primary energy demand is illustrated. The level of primary energy demand is currently between 139 kWh/(m²a) and 220 kWh/(m²a) for the buildings in question With the construction and building system boundary conditions required to achieve a passive house standard, the energy demand is reduced to between 59 kWh/(m²a) and 114 kWh/(m²a). In relation to the class D-D-D variant, this represents a reduction of about 48 % to 58 %. If a PV system is put on 60 % of the roof area, placed in an optimum position (a 35° gradient facing south) and the attribution limit of the maximum monthly balance is taken into account, the primary energy demand can be reduced by 60 % to 73 % by own energy use to 38 kWh/(m²a) to 89 kWh/(m²a) compared with variant D-D-D. Incorporation of a heat-driven cogeneration facility based on a fossil fuel (e.g. gas or diesel) also results in an increased proportion covered by own production because the system is more efficient. The primary energy indicators are between 27 kWh/(m²a) and 72 kWh/(m²a). Compared to the D-D-D variant, there are potential savings of between 67 % und 81 %.

If the cogeneration facility uses a renewable energy source (biogas, rapeseed oil etc.), the primary energy cost is reduced further. The school building comes out of the total balance at about zero. The residual primary energy demand for the other three buildings is about 8 kWh/(m²a) to 28 kWh/(m²a). In relation to the D-D-D base variant, the saving is between 87 % and 100 %. The nearly zero-energy designation of the building under this concept is therefore as follows:

- School: nZEB 0
- Office: nZEB 8

– Office with server rooms: nZEB 28
– Hotel: nZEB 25

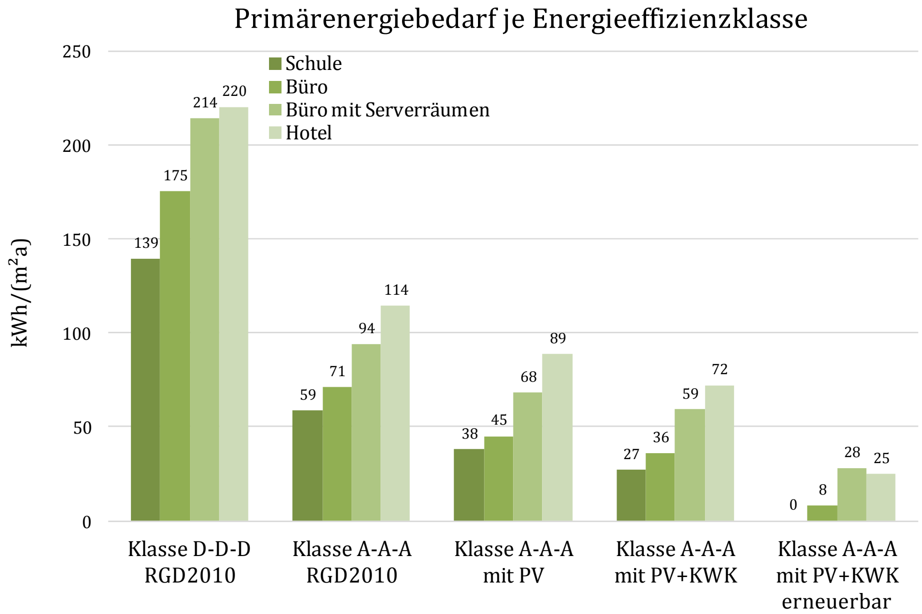


Figure 13: Illustration of possible primary energy indicators for different uses of the building (example)

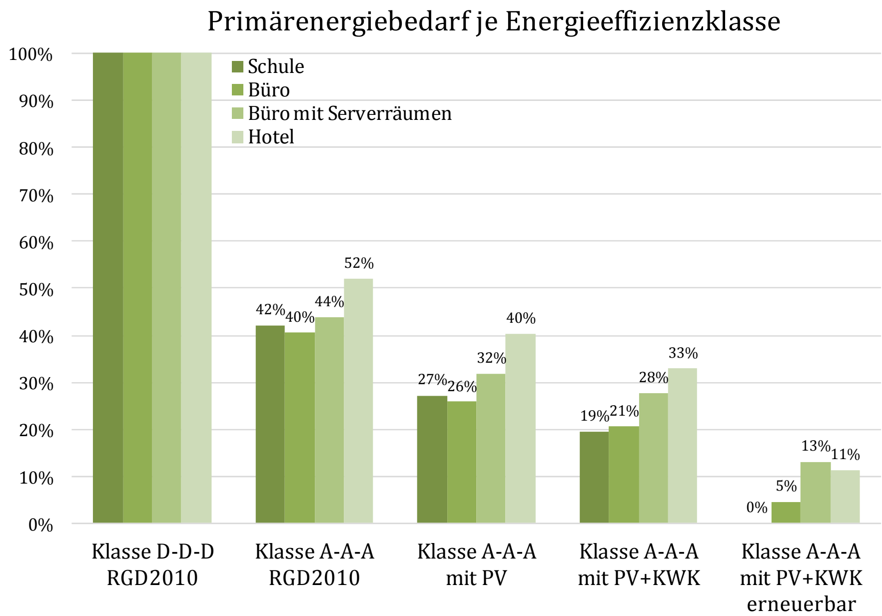


Figure 14: Illustration of potential savings for different uses of the building (example).

This shows that a zero-energy balance is not possible for all types of building and all uses. A residual energy demand will remain, depending on the building's characteristics and energy demand.

2.3.4 Required value for nearly zero-energy buildings

A zero-energy balance cannot be achieved for all buildings because of building geometry and usage. For example, on high and multi-storey buildings there is relatively little roof area available to incorporate photovoltaic systems in an optimum way. PV integration then has to be carried out on the frontage, which is less efficient. Integration on the frontage is not always possible in inner city areas, which are often very shady.

Buildings with high energy demand specific to their use, such as hospitals, swimming pools and administrative buildings with a large number of servers, sometimes cannot incorporate enough renewable electricity production in a building to achieve a net zero-energy balance.

The definition of a maximum required value for these categories of buildings is covered by the term nZEB (**nearly** zero-energy building). In order to establish the nearly zero-energy standard for Luxembourg, which might also be referred to as an A^+ standard, a method of assessing these buildings must be developed. Two solutions are being discussed.

- **Solution 1:** After the required A-A-A threshold has been met – the passive house standard – a residual energy demand (primary energy demand) is established on the basis of the usage and the building geometry. A nearly zero–energy building would need to be below this indicator by a certain percentage, the size of which might depend either on the use or type of building. Example: the primary energy indicator after achieving the passive house standard (class A) is 60 kWh/(m^2a). In establishing the nZEB threshold value (A^+) the required credit for this type of building is, for example, 25 %. The required threshold value, as adjusted, for the A^+ category is then 45 kWh/(m^2a). **All technologies** may be used to achieve this A^+ threshold value.
- **Solution 2:** Based on the available roof and frontage area or the energy reference area, a performance indicator is defined, which can be achieved by using photovoltaic facilities and other means to produce electricity. This specific performance indicator would be applied to the building being evaluated, resulting in a figure for the required primary energy credit which the building would have to achieve by means of renewable energy. Example: the primary energy indicator after achieving the passive house standard (class A) is 60 kWh/(m^2a). The building has an energy reference area of A_n of 1,000 m^2, a specific roof area of 0.3 m^2_{Da}/m^2_{An} and an opaque frontage area of 0.5 m^2_{Da}/m^2_{An} (both output control values from the energy performance certificate). Factors of 0.06 m^2_{PV}/m^2_{An}[1] and 0.075 m^2_{PV}/m^2_{An} are applied to the roof and frontage respectively.[2] . The attributable PV size is 135 m^2. For a specific output of 9 m^2/kW_p, this corresponds to an output of about 15 kW_p. With an average annual production (mean of roof and frontage) of about 700 kWh/a per kW_p, this gives a primary energy equivalent of 28 kWh/(m^2a). This value is deducted from the required performance indicator for class A. The new threshold value is nZEB 32 (= 60 – 28 kWh/(m^2a)). In this example, the definition of the required value is limited to the incorporation of PV alone. The question whether other production technologies should or must be included could also be considered. **All possible technologies** can be used to meet the requirements in the original building.

How good these proposals will prove in practice for setting the required level for A^+ buildings and what further specifications and parameterisation are needed will be examined in a

[1] Corresponding to covering 50% of the roof area with PV; 35- degree slope and space needed (distance between rows) 2.5 m^2_{DA}/m^2_{PV}.
[2] This is equivalent to covering 15 % of the frontage area with PV.

subsequent phase. Experience gained in the pilot and monitoring projects must also be taken into account in addition to science-based investigations.

2.3.5 Adjustments to the current regulation for residential buildings

The accounting rules for evaluating the energy performance of residential buildings are described in full in the amended Energy Saving Regulation 2008. The calculation rules are based largely on CEN standards and on DIN 4108-6 for thermal energy balances and DIN 4108-10 for evaluating the building systems. The calculation rules in the regulation would have to be adjusted to be able to determine the nZEB balance. The following changes are required here.

Adjustments required to the amended Energy Saving Regulation 2008

- Introduction and revision of accounting rules for off-setting energy credits against primary energy used;
- Introduction of assessment rules to take account of new technologies and to reflect storage systems;
- Introduction of a new thermal insulation class A+;
- Introduction of new assessment rules for solar, wind power and cogeneration facilities;
- Introduction of a new A+ primary energy efficiency class and a description of the indicator for a nearly zero-energy building;
- Definition of the future requirements for nearly zero-energy buildings;
- Preparation and integration of alternative and equivalent requirements where the nearly zero-energy standard cannot be met for practical and/or legal reasons.

2.3.6 Adjustments to the current regulation for non-residential buildings

The accounting rules for assessing the energy performance of non-residential buildings are contained in the amended Energy Saving Regulation 2011 for non-residential buildings (4). Individual energy systems are calculated on the basis of the German DIN V 18599 standard, 2007 edition.

The incorporation of nZEB balances requires adjustments to the regulation, an updated standard reference and adjustments to the calculation rules in DIN V 18599: 2007 or 2011-12. This affects the following issues:

Required adjustments to the amended Energy Saving Regulation 2011

- Introduction and revision of accounting rules for off-setting energy credits against primary energy used;
- Introduction of assessment rules to take account of new technologies and to map out storage systems;
- Introduction of a new A+ energy performance class and a description of the performance indicator for a nearly zero-energy building, whilst retaining thermal insulation class A;
- Definition of future requirements;
- Preparation and integration of alternative and equivalent requirements where the nearly zero-energy standard cannot be met for practical and/or legal reasons.

Adjustments to the method of calculation in DIN V 18599:

- Adjustments to how cogeneration facilities are accounted for; Introduction of a monthly method of accounting for cogeneration facilities;
- Updating of all references in DIN V 18599: 2007 and 2011-12, for which different accounting rules apply in the DIN V 18599 standard.

3 National Plan for increasing the number of nZEBs

The successful and speedy introduction of nearly zero-energy buildings into construction practice requires measures and actions to be taken in a wide variety of areas. The strategy for implementation focuses on the following 6 segments.

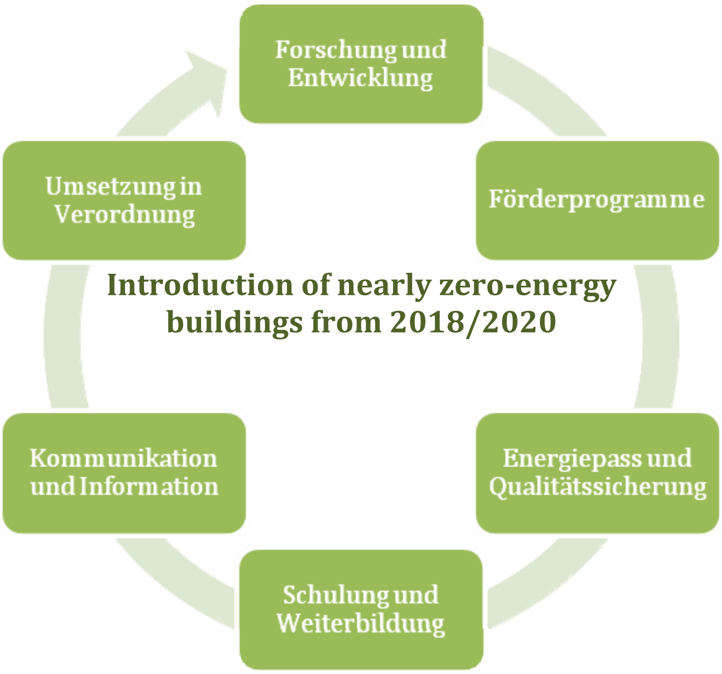


Figure 15: Strategic segments with measures and actions for the introduction of nZEB in the near future

As far as **research and development** is concerned at a scientific level, theoretical and technical principles and opportunities and accounting methods should be developed and key factors identified, which are essential to the successful implementation in construction practice. We must ensure that the criteria for success identified in this way are consistent with construction practice. To this end, pilot projects must be carried out and evaluated.

Economic incentives need to be created for the implementation of projects in the near future by means of **start up aid programmes** adapted in good time for nearly zero-energy buildings in both the public and private sectors. The aid programmes should be designed in such a way as to enable quantitative evaluation by technical means so that the pilot projects will become useful sources of information.

The **energy performance certificate** is of major importance in demonstrating the energy performance of buildings. The current method of assessment should be expanded to include nearly zero-energy buildings (A^+ buildings); at the same time, the **quality** of energy performance certificates and of the construction and technical implementation should be further improved through monitoring mechanisms and central recording of all energy performance certificates.

Current **training programmes** must be adjusted to the new requirements for nearly zero-energy buildings and to the findings from the monitoring and pilot projects.

The provision of **information** (experts, public, citizens etc.) is an important key element contributing to a successful introduction of nearly zero-energy buildings and to increasing the level of acceptance for them. Findings and information obtained through research projects, pilot projects etc. should be compiled for the individual target groups.

The current legislation must be amended to reflect the new requirements for nearly zero-energy buildings; this should come into force at a time consistent with the aims of their introduction and the provisions of the Directive. The findings in all areas must be reflected in the **implementation of national regulations**.

The staggered implementation up to 2017 of the following measures and actions – described in more detail in the following sections – is also envisaged in order to increase the number of nZEBs.

Research and development

- Priority given to these issues at the national level
- Aid for research activities
- Aid for the development of simple tools

Aid programmes

- Adjustments to the requirements and levels of support

Quality assurance and energy performance certificates

- Further linking of the energy performance certificate with aid instruments.
- Quality assurance by means of automatic plausibility checking
- Preparation of a central database for energy performance certificates
- Quality control by means of database and spot checks

Programmes for training, education and continuing professional development

- Further development of the existing offerings on the nZEB proposal
- Implementation of the conclusions of the LuxBuild project (in the context of the European BUILD UP project) and creation of the link to the nZEB proposal.

Transposition into national regulations

- Tightening of the requirements for non-residential buildings
- Introduction of the methodological basis and definition of the requirement level for nZEBs.

3.1 Research and development

In Luxembourg, several establishments have been carrying out research in the area of energy and sustainability for many years, particularly at the University of Luxembourg, the Centre de Recherche Public (CRP) Gabriel Lippmann and the CRP Henri Tudor as well as the Resource Centre for Environmental Technologies (‘*Centre de Ressources des Technologies de l’Environnement’*, or CRTE), which is attached to it. Many private-sector undertakings are also engaged in research in the fields referred to above. In 2007, the Luxembourg government set out its core areas for public research, in which the key area of *'sustainable resource management in Luxembourg'* was divided into the following areas:

- Sustainable management of water resources;
- Sustainable energy use and sustainable sources of energy;
- Ecosystems and biodiversity;
- Sustainable management of agricultural systems;
- Spatial and urban development.

These priorities are implemented primarily by means of programmes under the National Research Fund ('*Fonds National de la Recherche',* or FNR).

3.1.1 Priorities of the National Research Fund

Experience from recent calls for tenders by the FNR showed, however, that the definitions referred to above need to be reviewed in order to maximise the effect of the research projects in question. This process of adjustment was carried out with the involvement of domestic and foreign researchers and with the cooperation of ministries and the public administration. The various consultations led to the conclusion that, in view of the priorities currently applied, the topic of *'sustainable resource management in Luxembourg'* should be divided into four areas:

- Water resources under change;
- Sustainable management and valorisation of bioresources;
- Sustainable building and bioenergy;
- Spatial and urban development.

In the consultations, the National Research and Innovation Advisory Board ('Conseil Supérieur de la Recherche et de l'Innovation', or CSRI) and the Ministry of Economic Affairs and Foreign Trade, which was also involved, likewise called for the priorities to be redefined. The following key areas were defined in the area of sustainable construction and bioenergy:

Integrated building systems

- Eco-balance and life-cycle energy use;
- Efficient generation, usage, storage and recovery of energy;
- Development and integration of renewable energy technologies;
- Climate-adaptive building form and envelope;
- Passive, active and hybrid HVAC and controls;
- Materials life cycle assessment;
- Water use and management.

Interaction of buildings with the local environment

- Ecosystems and site design;
- Land use, building location and transportation.

Quality of the indoor environment

- Pollutants and stressors;

– Occupant health and performance.

Research activities relating to nearly zero-energy buildings

Research activities are to extend to various types of building, including residential buildings, non-residential buildings, public buildings and industry buildings. A number of the research activities referred to above require inter-disciplinary cooperation and development, which should promote interaction and connections to other national research priority areas. This refers, for example, to optimisation in the traffic and transport field, which are covered by the topic of spatial and urban development

There is no doubt that the building sector plays a fundamental role globally, across Europe as well as nationally as regards the use of energy and resources and the associated emissions and environmental impact. In preparing the action plan for eco-technology, headed by the Ministry of Economic Affairs and Foreign Trade, the topic of sustainable buildings was also identified as being very promising. Energy-efficient and increasingly sustainable buildings as well should be an absolute priority for Luxembourg. In order to give priority to research activities in the field of sustainable buildings in a structured way, more thought will be given in future to appropriate structures at national level, which could cover these areas of research. The competitiveness of research in this field in Luxemburg should be increased in an international context and a lasting scientific quality and level of excellence built up. The involvement of the political players concerned with energy issues and the undertakings based in Luxembourg that are active in the field of sustainable buildings is of crucial importance in this respect.

Future structures should also include the following issues and areas of activity:

- Supporting pilot projects in the fields of construction, technical building equipment, implementation in building practice, monitoring and evaluation, as well as identifying success and risk factors;
- Research and development projects for new materials and processes in cooperation with the industrial and construction sectors;
- Identifying and developing measures and actions to implement the findings obtained in the various systems;
- Scientific following of nearly zero-energy buildings in the framework of model projects.

3.1.2 State aid for research in the corporate sector

The Act of 5 June 2009 on aid for research, development and innovation allows the Ministry of Economic Affairs and Foreign Trade to give financial aid to innovative research projects and feasibility studies in the area of *'sustainable building'* and hence provides a suitable basis for supporting research in the corporate sector. Without the development of suitable technologies, components and standards, it will be difficult for more energy-efficient and sustainable buildings, up to and including nearly zero-energy buildings, and more far-reaching sustainability standards to find an entry into building practice. The Ministry of Economics and Foreign Trade supports promising projects submitted by undertakings to improve environmental protection and the rational use of natural resources under the Act of 18 February 2010 '*relative à la protection de l'environnement et à l'utilisation rationnelle des ressources naturelles*' (7). The following measures in the following areas may be supported:

- Investment in energy-saving measures;
- Investment in energy production from renewable energy sources;
- Studies on environmental impact;
- Promising pilot projects reflecting the spirit of the law.

Neobuild innovation pool[3]

For example, support was given to the *Neobuild* structure in relation to the concept of a technological innovation pool. This innovation centre is the first of its kind in Luxembourg and sees itself as a platform for developing and supporting innovative projects in the building sector where the focus is on supporting innovative SMEs. *Neobuild* is a private sector initiative and its objective is to promote research, development and innovation in the sustainable construction industry.

As the first centre of excellence in Luxembourg, *Neobuild* will serve as a platform for developing innovations and, at the same time, support the formation and establishment of SMEs[4] in Luxembourg and the wider region. *Neobuild's* specialist areas primarily include the environmental and energy efficiency of buildings. As far as is possible financially, *Neobuild* also supports other innovations for promoting economic viability in the building trade.

It focuses on the following areas in particular:

- Sustainable building materials;
- Environmental technologies;
- Green information construction technology;
- Management und support for participants in the building sector.

3.1.3 Standards for easier calculation of nearly zero-energy buildings

Free software (the LuxEeB tool) for issuing energy performance certificates for residential buildings is available to all experts. An interactive online energy performance certificate simulation has been developed for private and public use. The simulator '*myenergy home*'[5] enables the energy performance of a residential building to be estimated.

Standard software for experts has been developed to account for non-residential buildings. The software will be issued subject to successful participation in the national training programme for assessing the energy performance of non-residential buildings (1 or 4-day course).

Energy management software for municipalities known as *Klimapakt* is currently being developed, which municipalities can use to administer their buildings. Linked to this are extensive energy assessments with the objectives of a) obtaining a comprehensive overview of the energy situation in the building stock and b) identifying the buildings with the greatest potential for modernisation and specifying energy modernisation measures, as well as setting energy priorities.

Simpler tools for accounting for nearly zero-energy buildings are to be produced to prepare and train the experts and the building sector. Tools of this sort are intended to increase

[3] Source: http://neobuild.lu/index (accessed on 30 July 2013)
[4] Abbreviation for "small and medium-sized enterprises";
[5] www.myenergyhome.lu

understanding and to illustrate the accounting method in a transparent way. The *EnerCalC* tool, which was used in the past to develop the structure of energy accounting for non-residential buildings, provides a comprehensive but at the same time simple tool for energy assessment and for zero-energy balances[6]. This tool will continue to be used in the further development of the approach to nearly zero-energy buildings where required.

3.2 Aid programmes

In Luxembourg, aid is currently given for the construction of low-energy and passive houses in both the private and public sectors. These aid programmes need to be adapted to the requirements for nearly zero-energy buildings once a definition of these has been introduced, to make the early implementation of nearly zero-energy buildings attractive from a financial perspective as well. As part of this aid programme, measures should be considered to evaluate and monitor these buildings, in order to apply any findings made to the construction industry where possible.[7]

3.2.1 Promoting energy advice

Aid is currently given for energy advice in connection with modernising residential buildings. Requirements are set for the scope and content of this energy advice.

Existing buildings

- Assessment of the thermal insulation properties of all components of the thermal envelope (outside walls, roof, floor, windows etc.).
- Assessment and classification of the current position regarding consumption.
- Assessment of the installed building systems, particularly the efficiency of the heat generators, the hydraulics and insulation of heat distribution and the type of transfer and control.
- Proposals for modernising the building and the building systems in an ecological and economic sense.

New builds

- Presentation of variants and lists of actions needed to achieve energy standard A or B.
- Presentation of added costs/economic viability as a basis for decisions made by building owners.

The aid for energy advice is currently seen as satisfactory. When the definition for the nearly zero-energy building standard is introduced, an analysis will be carried out to identify the extent to which additional incentives to construct nearly zero-energy buildings can be incorporated into the present system at an early stage.

3.2.2 Aid for new builds

Aid is currently given for the construction of new single-family houses and apartment blocks that conform to the passive house (class A-A-A) or the low-energy standard (class B-B-B). The

[6] e.g. EnerCalC – Excel tool for simplified energy accounting under DIN 18599, the current version of which can also be used to carry out zero-energy balancing, http://www.enob.info/?id=enercalc (accessed on 20 December 2012).
[7] The passages quoted in sections 3.2.1 to 3.2.4 are taken from a study on the new aid programme (6).

aid is tied to all the requirements demanded under the Energy Savings Regulation to achieve this standard (e.g. successful blower door test, etc.). It is also stipulated that no fixed air-conditioning system may be installed. For new single-family houses, the amount of aid for a passive house is currently set at EUR 160/m^2 (up to 150 m^2) and for a low-energy house at EUR 45/m^2 (up to 150 m^2) (8). With the revision to the aid rules in 2012, the aid rates were modified and aid for installing automated systems to control sun shading was added.

3.2.3 Aid for the existing building stock

Aid for thermal insulation in existing buildings was previously based on component-level aid rates granted below a maximum U-value. An incentive to implement overall modernisation measures was provided by a grant of 20 % awarded in this case. When the aid programme was revised in 2012, this approach was developed further with the aim of providing incentives to implement more demanding energy standards and to bring forward modernisation measures (8). This can be achieved by including a 'bonus factor'. The total aid amount is then the product of the basic aid and the bonus factor.

Aid amount = Basic aid * Bonus factor

The amount of the bonus factor is based on the quality of the thermal insulation achieved by the building after modernisation. The quality level is documented by way of the thermal insulation class on the energy certificate.

Basic aid

The condition for aid is that the measure must serve to adhere to a minimum energy standard in relation to the component concerned. For structural thermal insulation, a fixed grant per m^2 component area is paid as basic aid.

Aid for more efficient insulation

For individual component groups (outside walls, windows, roof etc.), four efficiency standards are defined. Efficiency standard IV matches the requirements for basic aid. Efficiency standards III to I represent more energy-efficient component design (thicker insulation and better quality windows). The amount of aid is adjusted according to the efficiency standard achieved. Basic aid has advantages for the beneficiary and the donor of the aid.

<u>Beneficiaries</u>

- **Partial modernisations:** It is possible to carry out partial modernisations, e.g. alongside maintenance and renovation work that is needed in any case. The economically viable link between energy improvements and renovation work being done anyway is then taken into account in the aid.
- **Low cost:** The cost of applying is low, as the basic aid essentially requires documentary evidence of the thickness of insulation.
- **Transparency and incentives:** The building owner is told simply and quickly how much aid he is to receive for a measure in any case.

<u>Donors</u>

- **Targeted use of funds:** The amount of aid may be directly matched to the typical costs of energy improvements to a component. Components with low typical costs can then be given a smaller amount of aid than more costly components.
- **Controllability:** If aid is requested for a measure too seldom or too often, the aid rate per component may be adjusted. It is then possible to respond quickly and appropriately to over- and under-allocation of aid.
- **Simple processing:** Payment of the aid merely requires the minimum requirements to be met and a figure (e.g. insulated area) to be stated and documented. Copies of the invoices are generally sufficient here.
- **Aid for efficiency measures**: The minimum requirements tied to the basic aid ensure that energy standards only receive financial support if they exceed the statutory minimum standards. This reduces 'dead weight' effects and contributes to the long-term reduction in energy consumption that is urgently needed for climate protection reasons, among others.
- **Implementing higher efficiency standards in the event of partial renovation**: For partial renovation projects too, the aid for efficiency improvements provides an incentive to implement thermal insulation measures to an efficiency standard in excess of the minimum requirements. A larger amount of aid is dependent on increased efficiency satisfying the conditions for allocating a bigger subsidy.

Bonus aid

The basic aid may be supplemented by 'bonus aid'. The bonus factor has the effect of increasing the aid. A bonus will be granted where improving the thermal insulation achieves a higher thermal insulation class (C to A) for the whole building. Evidence of the thermal insulation class achieved, or of compliance with the requirement class for individual components, is always provided by the energy performance certificate. The advantages of bonus aid are:

<u>Beneficiaries</u>

- **Good standards in the event of complete modernisation**: Incentives are provided in the event of a full modernisation to go beyond the minimum requirements (class C, B, A), as the aid is increased by the bonus factor in this case.
- **Bringing measures forward in the event of partial renovation**: In the event of partial modernisations, the bonus aid also provides an incentive to bring forward measures that can be carried out at any time e.g. insulating basement ceilings, attics or top-floor ceilings etc.). If bringing the measures forward achieves thermal insulation class C or better, the amount of aid is increased.

<u>Donors</u>

- **Controllability:** Depending on the effect of the programme, the incentives to implement good standards may be adjusted. This guarantees both sufficient utilisation of the programme and also efficient use of funding (prompt reaction to over- or under-allocation).

- **Increased CO_2 savings**: The incentives to bring forward measures in the event of partial renovation or to carry out efficient complete modernisation increase the implementation rates for energy-efficient modernisation projects. Along with high quality assurance in terms of energy, this is one of the key tasks of the general aid programme.
- **Incorporating the energy performance certificate:** To qualify for bonus aid, the thermal insulation class achieved must be demonstrated by means of the energy performance certificate. The bonus aid thus ties the energy performance certificate into the aid procedure in a sensible way.

The figure below shows the system of bonus aid.

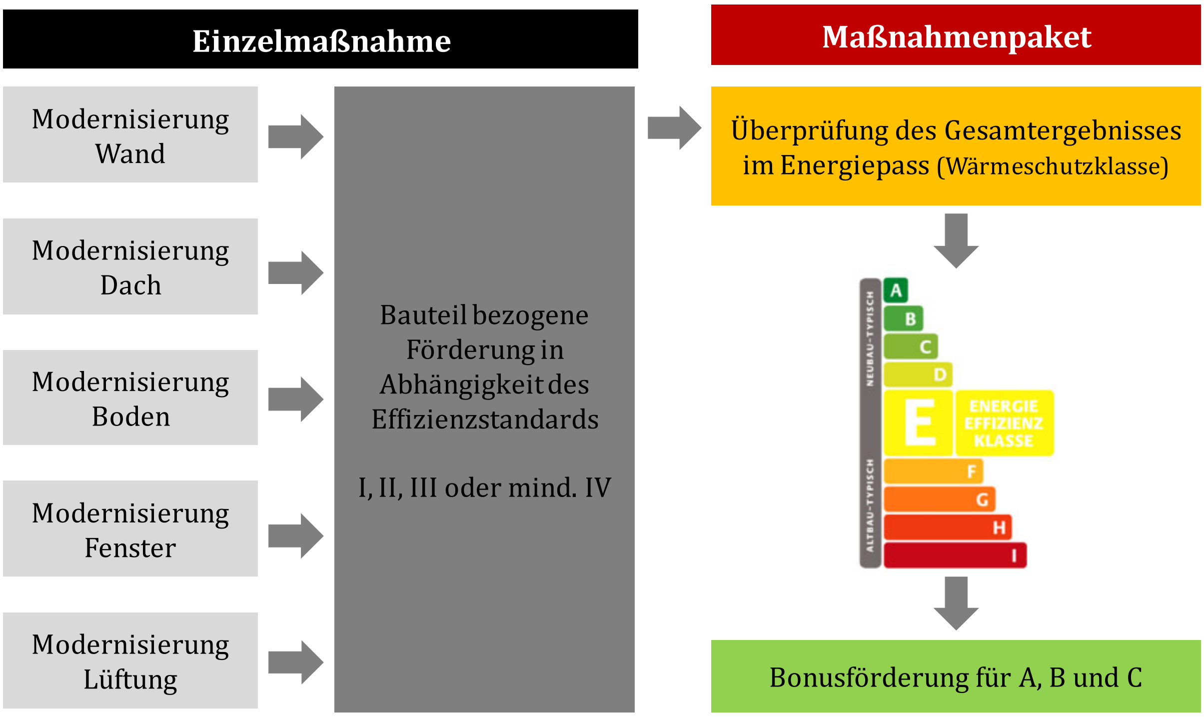


Figure 16: Schematic representation of the system of basic, efficiency and bonus aid (8).

3.2.4 Inclusion of aid for nearly zero-energy buildings

In future revisions of the general aid programme, the inclusion of aid for nearly zero-energy buildings will be a major issue. In particular, their implementation calls for renewable energy sources to be integrated into the existing aid rules. In this context, the following aspects in particular will have to be analysed in more detail:

1) How will the quantitative assessment be performed as part of energy accounting? Along with the calculation rates for the amount of energy produced from renewable energy sources, issues related to off-setting energy production against energy consumption need to be clarified.

2) What quantitative requirements should be set for nearly zero-energy buildings? What effect the use of the building (home, office, school etc.) and its geometry (e.g. size of roof area, aspect, shade etc.) have on the proportion of the energy demand that can be covered (substituted) by renewable energy needs to be clarified here.

As a reliable answer to these questions requires not only an enhancement to the methodology but possibly also a practical application test, it will probably not be possible to include aid for nearly zero-energy buildings in the general aid programme until it is revised in 2015 or 2016.

3.3 Communication and Information

Activities in the area of communication, information and basic advice have been substantially increased in recent years, including a reform of the structures active in this area. The ongoing, completed and planned actions and measures in the field of energy-efficient buildings are presented below. These concern both new builds and renovations.

3.3.1 Free energy advice as entry-level or basic advice

As part of the publicity work and raising of public awareness, free basic advice on energy renovation and on the construction of energy-efficient buildings has been provided since 2010. The aim of this basic advice is to provide objective and neutral explanations and to dispel preconceptions regarding energy-efficient buildings and the technologies used in them. Apart from technical aspects, details of the energy certificate or of possible financial assistance can also be requested. The programme runs through the national *myenergy* structure created for this purpose[8] and has been well received by the population. In this connection, *myenergy* has a nationwide advice network set up in collaboration with the municipalities (myenergy infopoint). In the course of introducing nearly zero-energy buildings, the range of advice is to be further expanded and adapted to people's needs.

myenergy also provides awareness-raising activities, information and basic advice to businesses. The programme, which has been in development since 2012, offers a platform to communicate the necessary information to the owners of single-purpose buildings.

3.3.2 Information campaigns

Running information campaigns on the construction of energy-efficient buildings is a joint exercise between the State and the municipalities. Under the *Climate Pact*, municipalities can initiate public information events (free basic advice, passive house days, etc.). The State supports the municipalities e.g. by providing information material and experts. It motivates the municipalities, consolidates and coordinates the relevant activities. It also runs information campaigns of its own. As an organisation attached to the Ministry, *myenergy* is part of this concept, so information on this topic can be presented at all the relevant events[9].

The *myenergy days* trade fair has been held in Luxembourg since 2010. Briefings, seminars, exhibitions and campaigns on the subject of energy-efficient renovation are organised in relation to the building envelope, building systems and services, and a discussion platform has been launched with conferences, presentations and talks for practitioners. The theme of the 2013 fair is the energy-efficient modernisation of buildings. This trade fair also covers

[8] http://www.myenergy.lu/de/ueber_uns/dienstleistungen/hotline (accessed on 14 September 2012)
[9] http://www.myenergyinfopoint.lu/de/ (accessed on 14 September 2012)

the nearly zero-energy building.

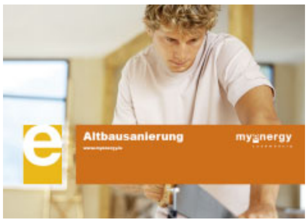
myenergy has also been organising its annual passive house weeks since 2012 in collaboration with the Ministry of Housing. The next time around, this event will also be based on the nearly zero-energy building.

3.3.3 Advertising and publicity work for energy-efficient construction

Information in the media (TV, radio, Internet), notices on public transport and flyers on energy efficiency sent to every household have been used in recent years to inform the public of the benefits of energy-efficient buildings and possible funding options. This publicity work will be stepped up as nearly zero-energy buildings are introduced. Flyers have so far been published on the following topics[10].

The national structure for energy advice

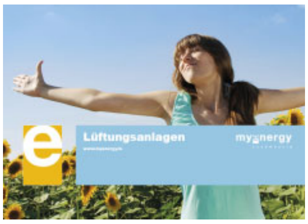
Renovating old buildings



Renovating old buildings – outside walls

Renovating old buildings – building systems

Ventilation systems



Energy-efficient new builds

Heating with wood

Heat pumps

Solar technology

State aid

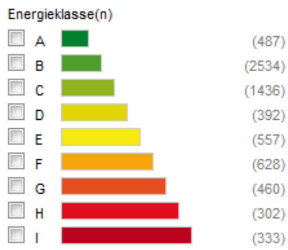
Everyday energy savings

Energy performance certificate – residential building

[10] http://www.myenergy.lu/de/download/themenflyer (accessed on 14 September 2012)

3.4 Quality assurance and energy certificates

The energy certificate is a proven method of assessing the energy efficiency of new and existing buildings in Luxembourg. A stable classification system in which the assessments do not change is a prerequisite for broad acceptance by the public. The far-reaching statutory tie-in between the energy certificate and the promotion of energy modernisation projects, the promotion of new passive houses and the concepts being developed by various private Luxembourg banks to offer reduced interest for very energy-efficient buildings shows this. Since the energy certificate was introduced, Luxembourg has also seen a change in the level of awareness in the construction sector. For example, project signs at building sites generally also display the resulting energy performance class – voluntarily. The energy performance of buildings has also been included as a selection criterion to search for apartments and houses on Luxembourg's largest online property portal since 2011.



Screenshot of

To improve the quality of the energy certificates and the advice given for new builds and renovation projects, the following actions have been taken.

3.4.1 Database of energy performance certificates and automated plausibility testing

A database for central storage and evaluation options of all energy certificates for residential and non-residential buildings is currently being implemented and should be completed in 2013. Linked to this are automated plausibility tests on all energy certificates and the selection of controls. Statistical analyses can also be run to adapt aid programmes more effectively to the predominant needs. The database provides a more detailed picture of the building stock.

To improve the quality of energy certificates further, additional expert training sessions with certification will be provided.

It is proposed to incorporate plausibility checks into the national energy certificate software, so that potential errors can be reduced at the point where the energy certificates are first produced. Important input such as details of the building envelope, heat transfer values and the age of the building and combinations of technical systems will be compared against statistical reference values and checked for logic. These implausible values will be displayed directly in the national energy certificate software. The expert will be alerted to them and will have to confirm the figures.

3.4.2 Expert monitoring

To improve and maintain the quality of energy certificates, the automated plausibility checks in the database can be used to identify unusual certificates and check them where necessary. Here, multi-stage control procedures are being considered, which should allow non-compliant energy performance certificates to be identified and checked. This systematic approach will supplement and extend the controls applied already.

3.4.3 Monitoring the quality of implementation at the building

For the purposes of quality control at the site, discussions with the municipalities are sought in order to implement further measures to increase control and to tie them into the ongoing activities of the municipalities in the areas of climate protection, energy efficiency and renewable energies at municipal level. Enhanced controls should send a clear signal to the construction sector that the production of high-quality, energy-efficient buildings is a priority for State and municipal bodies. The quality of implementation is also a major factor in the effective attainment of Luxembourg's energy-efficiency targets.

3.5 Programmes for training, education and continuing professional development

Training for the individual players involved in the narrower and the broader sense in implementing energy efficiency in the construction sector is crucial to the effective implementation of the goals of the Energy Efficiency Directive. Training for the parties involved is also considered very important when it comes to introducing nearly zero-energy buildings.

In the course of introducing the 2008 Energy Savings Regulation for residential buildings and the 2011 Regulation for non-residential buildings, the *Ministry of Economic Affairs and Foreign Trade* launched training programmes for experts, to make an orderly and prompt implementation of these new Energy Saving Regulations possible. Apart from these training sessions, market operators also offered courses in the marketplace after the introduction of the Energy Savings Regulations to supplement those provided by the Ministry. It can now be assumed that the range of suitable training courses on offer is varied and diverse and enables the relevant players in the areas affected to receive the appropriate training. The list below provides an overview of current training activities on offer on the subject of energy efficiency of buildings in Luxembourg.

- 1-day training session on energy accounting for new and existing residential buildings (2007 onwards);
- 4-day training session on energy accounting for new non-residential buildings (2010 onwards);
- 1-day training session on energy accounting for existing non-residential buildings (2010 onwards);
- Advanced training on energy accounting for new and existing residential buildings (2011 onwards);
- Introduction of certified 'passive house designer' for residential buildings with testing as an internationally certified 'passive house designer' (2012 onwards);

- Introduction of certified ‘passive house trades people’ for residential buildings with testing as an internationally certified ‘passive house tradesperson’ (2012 onwards);
- Training to become a certified energy advisor for residential buildings (2012 onwards);
- Individual training as ‘energy performance certificate energy coach’ (2012 onwards);
- Course series on ‘Building and energy’ covering various topics to do with building and energy (established for many years);
- Training in thermal bridge optimisation ‘Recognising, calculating and assessing thermal bridges’ (2012 onwards).

The existing training programme is to be enhanced in the years ahead. Priority will be given to training in the following areas:

- Energy advice for residential and non-residential buildings (certified energy advisors);
- Advanced training on accounting for new non-residential buildings and new technologies;
- Energy audits in non-residential buildings;
- Energy monitoring and smart metering;
- Energy management systems in non-residential buildings;
- User behaviour and energy consumption in non-residential buildings;
- Sustainability certification of buildings.

The range of training will be extended to cover aspects of nearly zero-energy buildings at the appropriate time. When it comes to improving the building envelope (general thermal insulation, thermal bridges and air-tightness), the existing offerings are already well positioned. With regard to nearly zero-energy buildings, a more far-reaching tie-in between building systems and energy demand is required. In particular, the training must cover the ***practical incorporation of renewable energies*** and the ***potential for building systems*** to use them. In drawing up the training programmes, the findings from pilot projects that have been evaluated will also be incorporated. In the initial phase, the nearly zero-energy training programme will concentrate on housing construction, as the technical requirements of the systems are less complex than for non-residential buildings. Particular emphasis will be placed on the following areas of training.

- Technical solutions to implement the energy requirements for nearly zero-energy houses, for new and existing buildings;
- Basic knowledge: technical systems in nearly zero-energy residential buildings;
- Basic knowledge: technical systems in nearly zero-energy non-residential buildings;
- Expert knowledge: Designing, planning and installing technical systems in highly energy-efficient residential buildings;
- Expert knowledge: Designing, planning and constructing technical systems in highly energy-efficient non-residential buildings;
- Practical integration, construction, adjustment and operation of technical installations on the basis of renewable energies in new and existing buildings;
- Training: ‘From old stock to nearly zero-energy building’. Findings from pilot projects and implementation examples, risk and success factors.

3.6 Transposition into national regulations

Findings from research and pilot projects should be quickly incorporated, where reasonable, in the revision of the standards, Energy Savings Regulations and national aid programmes so that these standards and programmes can be promptly applied in the construction industry. In this context, the possibility of financial aid for new technologies and more stringent standards than the statutory requirements could also be analysed.

Statutory energy standards for buildings should be set at a cost-effective level. This is also called for in the revised Directive. The aid programme for new and existing residential buildings was revised in 2012 and, among other things, the aid rates were adjusted to the energy efficiency standard achieved. In the course of revising the legal requirements, the findings from studies to determine the most cost-effective level will be analysed and, where necessary, applied to national subsidies and/or energy efficiency standards.

Figure 17 shows the roadmap agreed for residential buildings to tighten up the energy requirements for new residential and non-residential buildings. The details are explained in the following sections.

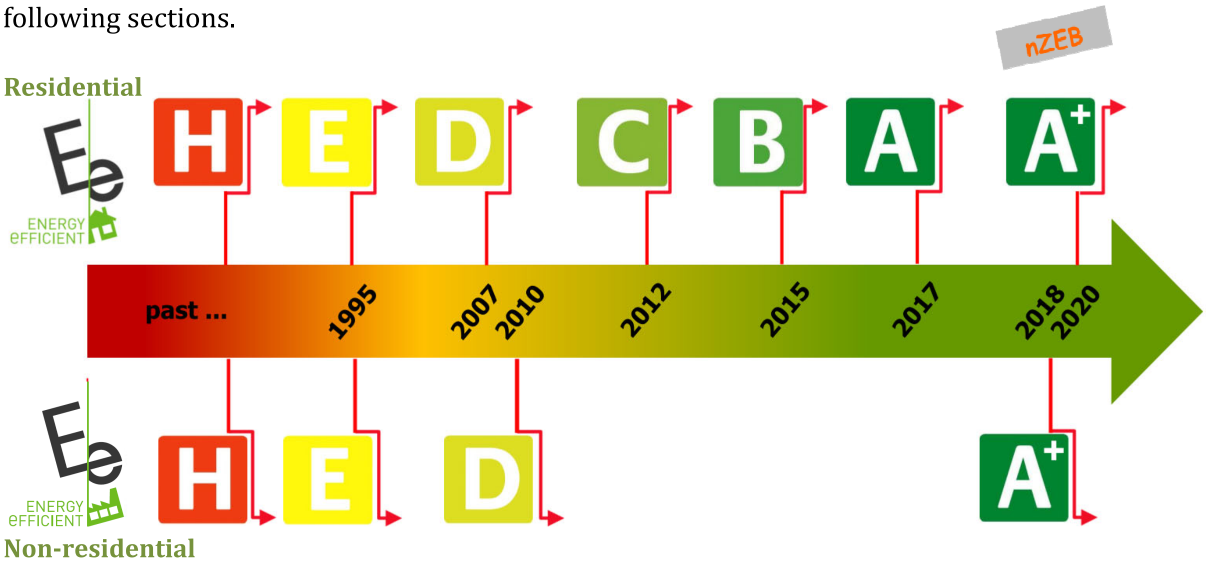


Figure 17: Roadmap to tighten up the energy requirements for new residential and non-residential buildings. This shows the energy performance requirements (thermal insulation). For residential buildings, the requirements until 2017 have already been implemented in the Energy Savings Regulation of 11 May 2012. The amended requirements for non-residential buildings are still in preparation and will probably be set out in a modified Energy Savings Regulation in 2013/14. For nearly zero-energy buildings (2018/2020), there are as yet no requirements defined in the current legislation. Source from (9).

3.6.1 Residential building

The amendment of **11 May 2012** revised the 2008 Energy Savings Regulation for residential buildings with the aim of increasing the number of energy-efficient buildings (10). The revision both tightens up the energy requirements and aims to increase the proportion of renewable energy. This is governed by the existing system of energy efficiency classes. Until now, the legal requirement for the thermal insulation standard (*efficiency*) and the total energy performance class (*efficiency + primary energy and renewable energy*) was class D in both cases. From July 2012, class C applies simultaneously for thermal insulation and class B for total energy efficiency. To achieve class B energy performance, assuming that class C thermal insulation is implemented, the use of renewable energy sources (geothermal and solar energy, sustainable energy sources etc.) is required.

The images below show the changes in effect since July 2012 with regard to the specified requirement classes and performance indicators. The specific heating energy demand for a **typical detached single-family house** is limited to approx. 22 kWh/(m²a) until 2017, while the primary energy demand is limited to 43 kWh/(m²a). When the Regulation was introduced (2008), the maximum for the heating energy demand was 86 kWh/(m²a) and for the primary energy demand 137 kWh/(m²a). The target values in force since 2012 are 69 kWh/(m²a) for the heating energy demand and 91 kWh/(m²a) for the primary energy demand. In interpreting the energy indicators, one should note that these cannot necessarily be compared with indicators in other countries, for example, or other categories of building, because the level of the indicator is also influenced by the method of calculation and the boundary conditions (interior room temperature, internal loads etc.). The target performance values for apartment blocks, for example, are much lower.

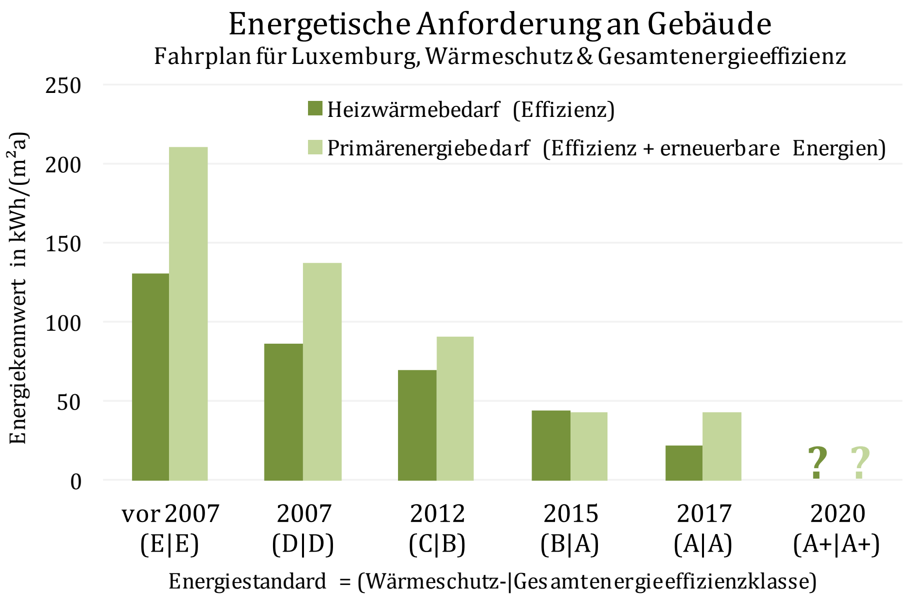


Figure 18: Roadmap to tighten up the energy requirements for new residential buildings – for single-family houses here. The shaded bars are not set out in the Regulation. Energy performance indicators for residential buildings are shown.

There are as yet no legal requirements defined for nearly zero-energy buildings. These will **only** be adjusted on the basis of guidelines contained in this document. As the use of renewable energy sources spreads, bigger savings can be made in primary energy demand.

Along with the specific energy performance indicators, the savings achieved are also of interest for making a more general statement on the reduction in energy demand in the residential sector. The chart below shows the forecast savings in primary energy and heating energy demand that should be achieved for residential buildings by 2017 with the amendment to the Energy Savings Regulation of 11 May 2012.

From July 2012, the specification for the maximum heating energy demand has been reduced to 80 % on average (from D to C) and for the primary energy demand to 66 % on average (from D to B). From 2015, the thermal insulation standard is to be reduced further to an average of 51 % (from D to B), at which point a ventilation system with heat recovery will be required for the first time in new residential buildings. The primary energy demand will be limited to 31 % on average (from class D to A).

From 2017, the passive house standard (class A) will be mandatory for new residential buildings. The requirements for thermal insulation will be reduced to an average of 25 % (from D to A) assuming the requirements remain the same for primary energy demand.

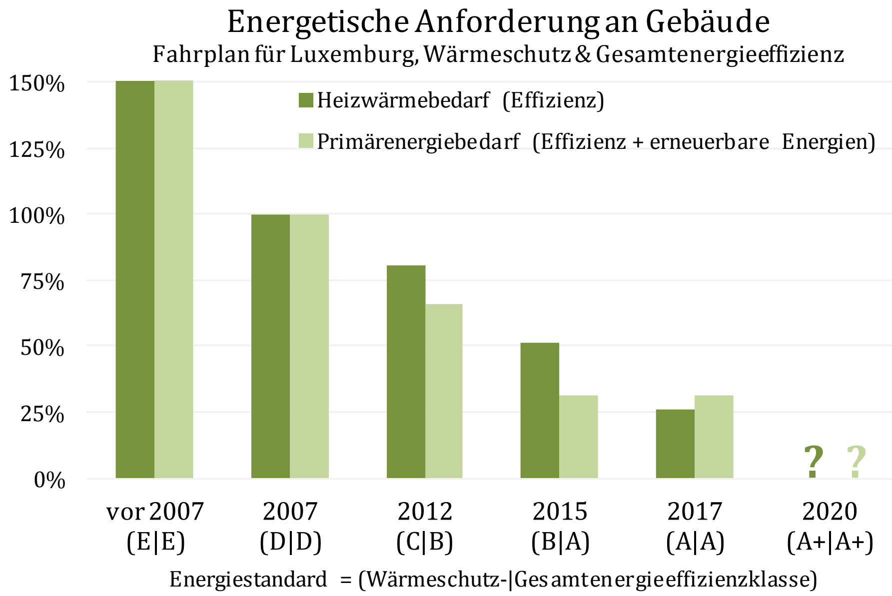


Figure 19: Roadmap to tighten up the energy requirements for new residential buildings –for single-family houses here. The shaded bars are not set out in the Regulation. Savings are shown relative to 2008.

3.6.2 Non-residential buildings and public buildings

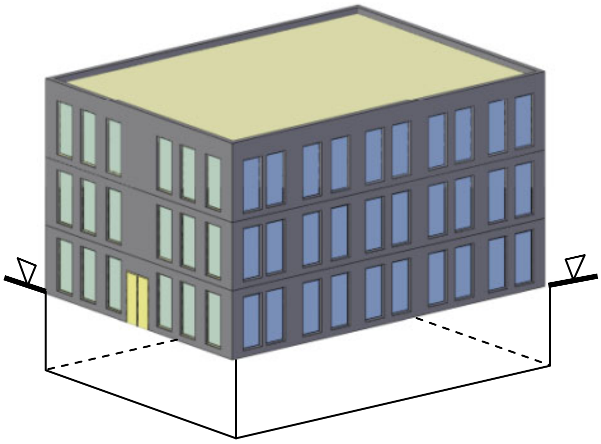
The plan is to revise the 2011 Energy Savings Regulation for non-residential buildings in the course of 2013. Apart from an adjustment to comply with the current standards for accounting, the requirements for new buildings will also be tightened. The thinking behind the adjustment will be based on the Energy Savings Regulation for residential buildings.

3.7 Economic viability of nearly zero-energy buildings

The construction of nearly zero-energy buildings should be cost-effective. In other words, the added costs of constructing these buildings should be in reasonable proportion to the energy savings achieved. The new Directive calls upon the Member States to set the requirements for the energy efficiency of new buildings and for modernising existing buildings at a reasonable level in economic and commercial terms. Among other things, this will also help to define sensible aid programmes and amounts of aid. In the overall view, these may also be technology-specific, however.

The new aid programme for new and existing residential buildings was set out in this light. The amounts of aid were based on the shortfall to be made up if implementation is to be viable and the aid rates were also adjusted (usually increased) to provide additional incentives for claiming support. The analyses to determine the most cost-effective requirements are now in progress. Luxembourg is part of the working group convened by the European Commission. The findings will be used to determine the minimum requirements and the requirements for the energy quality of the building envelope and systems and also to decide on a sensible level of subsidies under aid programmes.

4 Annex – Sample building



Gebäudedaten

Beheiztes Bruttovolumen, V_e	2.996 m²
Energiebezugsfläche, A_n	821 m²
Lichte Raumhöhe, h_R	2,75 m

Zonendaten

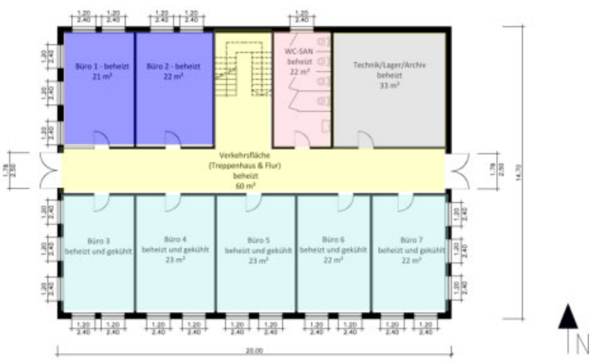
Zone 1: Einzelbüro, gekühlt	333 m²
Zone 2: Einzelbüro, nicht gekühlt	129 m²
Zone 3: Seminarräume	66 m²
Zone 4: Verkehrsflächen	194 m²
Zone 5: WC-/Sanitärräume	66 m²
Zone 6: Archiv/Lager	33 m²
Zone 7: Parkhaus (Büronutzung)	258 m², therm. nicht konditioniert

Gebäudehüllflächen

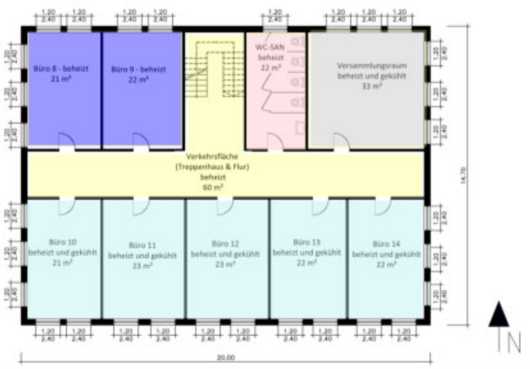
Süd	Fassade	200 m²	geg. ungeheizt 10,3 m²
	davon transparent	86,4 m²	
Nord	Fassade	200 m²	geg. ungeheizt 10,3 m²
	davon transparent	60,5 m²	
West	Fassade	147 m²	geg. ungeheizt 17 m²
	davon transparent	56,3 m²	
Ost	Fassade	147 m²	geg. ungeheizt 17 m²
	davon transparent	47,7 m²	
Dachfläche		294 m²	
Bodenfläche (gegen Parkhaus)		294 m²	

Sonstige Daten

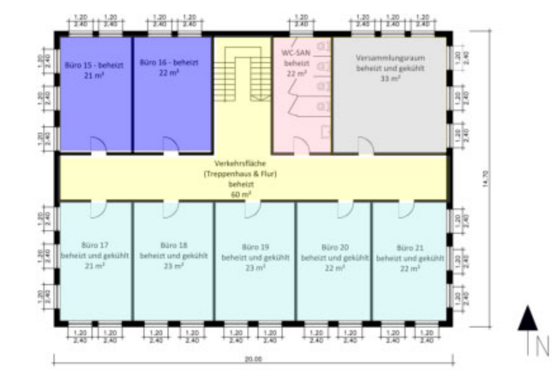
Bodentiefe Fenster → Fenstersturz h_{st} 0,35 m (von UK Decke)



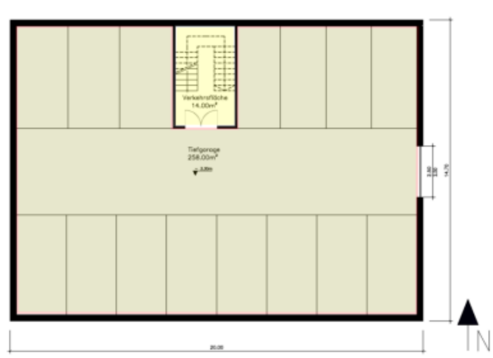
Ground floor



1st floor



2nd floor



Basement

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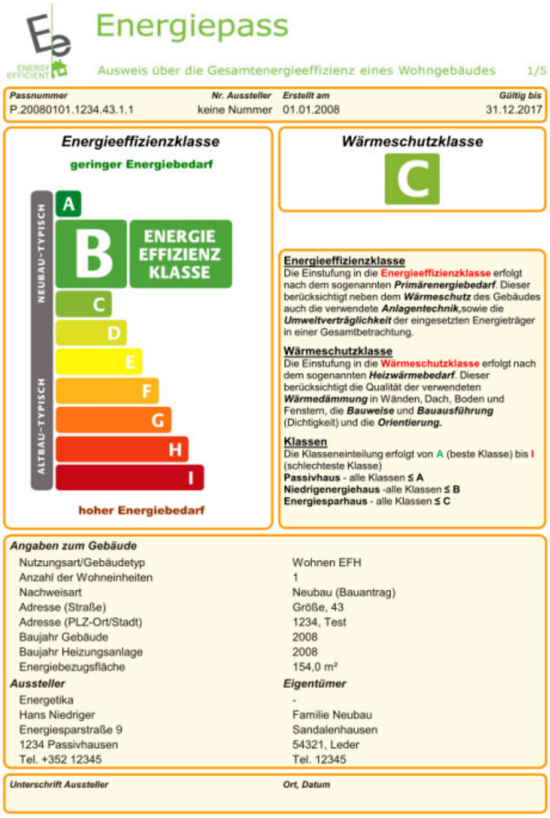
10. **Grand Duchy of Luxembourg.** *Règlement grand-ducal du 5 mai 2012, performance énérgetique des bâtiments d'habitation et fonctionnels [Grand-ducal regulation of 5 May 2012 on the energy performance of residential and non-residential buildings].* Luxembourg: Grand-Duchy of Luxembourg, 11 May 2012



Energiepass

Ausweis über die Gesamtenergieeffizienz eines Wohngebäudes 1/5

Passnummer	Nr. Aussteller	Erstellt am	Gültig bis
P.20080101.1234.43.1.1	keine Nummer	01.01.2008	31.12.2017

Energieeffizienzklasse

geringer Energiebedarf

NEUBAU-TYPISCH

A

B ENERGIE EFFIZIENZ KLASSE

C

D

E

F

G

H

I

ALTBAU-TYPISCH

hoher Energiebedarf

Wärmeschutzklasse

C

Energieeffizienzklasse
Die Einstufung in die Energieeffizienzklasse erfolgt nach dem sogenannten ***Primärenergiebedarf***. Dieser berücksichtigt neben dem ***Wärmeschutz*** des Gebäudes auch die verwendete ***Anlagentechnik***,sowie die ***Umweltverträglichkeit*** der eingesetzten Energieträger in einer Gesamtbetrachtung.

Wärmeschutzklasse
Die Einstufung in die Wärmeschutzklasse erfolgt nach dem sogenannten ***Heizwärmebedarf***. Dieser berücksichtigt die Qualität der verwendeten ***Wärmedämmung*** in Wänden, Dach, Boden und Fenstern, die ***Bauweise*** und ***Bauausführung*** (Dichtigkeit) und die ***Orientierung.***

Klassen
Die Klasseneinteilung erfolgt von A (beste Klasse) bis I (schlechteste Klasse)
Passivhaus - alle Klassen ≤ **A**
Niedrigenergiehaus -alle Klassen ≤ **B**
Energiesparhaus - alle Klassen ≤ **C**

Angaben zum Gebäude

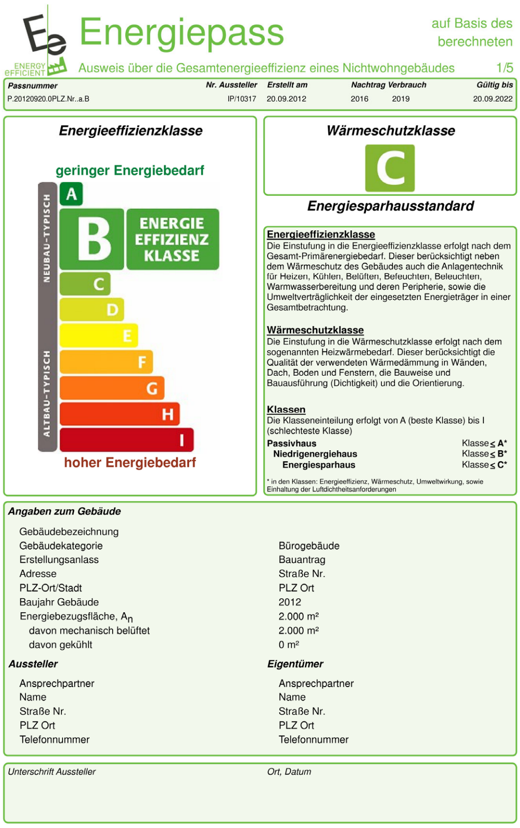
Nutzungsart/Gebäudetyp	Wohnen EFH
Anzahl der Wohneinheiten	1
Nachweisart	Neubau (Bauantrag)
Adresse (Straße)	Größe, 43
Adresse (PLZ-Ort/Stadt)	1234, Test
Baujahr Gebäude	2008
Baujahr Heizungsanlage	2008
Energiebezugsfläche	154,0 m²
Aussteller	***Eigentümer***
Energetika	-
Hans Niedriger	Familie Neubau
Energiesparstraße 9	Sandalenhausen
1234 Passivhausen	54321, Leder
Tel. +352 12345	Tel. 12345

Unterschrift Aussteller ***Ort, Datum***

Energieausweis für neue und bestehende Wohngebäude, Seite 1
(Page 5)

Energy performance certificate	Energiepass
Energy performance certificate for a residential building	Ausweis über die Gesamtenergieeffizienz eines Wohngebäudes
Certificate no	Passnummer
Issuer no	Nr. Aussteller
Issued on	Erstellt am
Addendum	Nachtrag
Consumption	Verbrauch
Valid until:	Gültig bis
Energy efficiency class	Energieeffizienzklasse
lowenergy requirement	geringer Energiebedarf
TYPICAL FOR EXISTING BUILDINGS	ALTBAU-TYPISCH
TYPICAL FOR NEW BUILDINGS	NEUBAU-TYPISCH
high energy requirement	hoher Energiebedarf
Thermal insulation class	Wärmeschutzklasse
Energy efficiency class	Enerqieeffizienzklasse
The energy efficiency class depends on the “primary energy” needed. This is an overall evaluation that considers not only the thermal insulation of the building, but also the buildings' systems and how environmentally friendly the forms of energy used are overall.	Die Einstufung in die Energieeffizienzklasse erfolgt nach dem sogenannten Primärenergiebedarf. Dieser berücksichtigt neben dem Wärmeschutz des Gebäudes auch die verwendete Anlagentechnik, sowie die Umweltverträglichkeit der eingesetzten Energieträger in einer Gesamtbetrachtung.
Thermal insulation class	Wärmeschutzklasse
The thermal insulation class depends on the amount of “heating energy” needed. This considers the quality of the insulation in the walls, roof, floor and windows, the building method and how well it is	Die Einstufung in die Wärmeschutzklasse erfolgt nach dem sogenannten Heizwärmebedarf. Dieser berücksichtigt die Qualität der verwendeten Wärmedämmung in Wänden, Dach, Boden und

built (air-tightness) and the aspect.	Fernsten, die Bauweise und Bauausführung (Dichtigkeit) un die Orientierung.
Classes	Klassen
The classes range from A (the best) to I (the worst)	Die Klasseneinteilung erfolgt von A (beste Klasse) bis I (schlechteste Klasse)
Passive house – all classes ≤ A	Passivhaus – alle Klassen ≤ A
Low-energy house – all classes ≤ B	Niedrigenergiehaus - alle Klassen ≤ B
Energy-saving house – all classes ≤ C	Energiesparhaus - alle Klassen ≤ C
Details of the building	Angaben zum Gebäude
Use/type of building	Nutzungsart/Gebäudetyp
Number of housing units	Anzahl der Wohneinheiten
Documentation	Nachweisart
Address (street)	Adresse (Straße)
Address (postcode/town)	Adresse (PLZ-Ort/Stadt)
Year of construction	Baujahr Gebäude
Year heating system constructed	Baujahr Heizungsanlage
Energy reference area	Energiebezugsfläche
Residential, one family house	Wohnen EFH
New builds (planning application)	Neubau (Bauantrag)
Size	Größe
Test	Test
Issuer	Aussteller
Owner	Eigentümer
The Newbuild Family	Familie Neubau
Tel.	Tel.
Signature of issuer	Unterschrift Aussteller
Place and date	Ort, Datum



Energiepass

auf Basis des berechneten

Ausweis über die Gesamtenergieeffizienz eines Nichtwohngebäudes 1/5

Passnummer	Nr. Aussteller	Erstellt am	Nachtrag Verbrauch		Gültig bis
P.20120920.0PLZ.Nr..a.B	IP/10317	20.09.2012	2016	2019	20.09.2022

Energieeffizienzklasse

geringer Energiebedarf

NEUBAU-TYPISCH

ALTBAU-TYPISCH

A B C D E F G H I

ENERGIE EFFIZIENZ KLASSE

hoher Energiebedarf

Wärmeschutzklasse

C

Energiesparhausstandard

Energieeffizienzklasse
Die Einstufung in die Energieeffizienzklasse erfolgt nach dem Gesamt-Primärenergiebedarf. Dieser berücksichtigt neben dem Wärmeschutz des Gebäudes auch die Anlagentechnik für Heizen, Kühlen, Belüften, Befeuchten, Beleuchten, Warmwasserbereitung und deren Peripherie, sowie die Umweltverträglichkeit der eingesetzten Energieträger in einer Gesamtbetrachtung.

Wärmeschutzklasse
Die Einstufung in die Wärmeschutzklasse erfolgt nach dem sogenannten Heizwärmebedarf. Dieser berücksichtigt die Qualität der verwendeten Wärmedämmung in Wänden, Dach, Boden und Fenstern, die Bauweise und Bauausführung (Dichtigkeit) und die Orientierung.

Klassen
Die Klasseneinteilung erfolgt von A (beste Klasse) bis I (schlechteste Klasse)

Passivhaus Klasse ≤ A*
Niedrigenergiehaus Klasse ≤ B*
Energiesparhaus Klasse ≤ C*

* in den Klassen: Energieeffizienz, Wärmeschutz, Umweltwirkung, sowie Einhaltung der Luftdichtheitsanforderungen

Angaben zum Gebäude

Gebäudebezeichnung	
Gebäudekategorie	Bürogebäude
Erstellungsanlass	Bauantrag
Adresse	Straße Nr.
PLZ-Ort/Stadt	PLZ Ort
Baujahr Gebäude	2012
Energiebezugsfläche, A_n	2.000 m²
davon mechanisch belüftet	2.000 m²
davon gekühlt	0 m²

Aussteller	*Eigentümer*
Ansprechpartner	Ansprechpartner
Name	Name
Straße Nr.	Straße Nr.
PLZ Ort	PLZ Ort
Telefonnummer	Telefonnummer

Unterschrift Aussteller *Ort, Datum*

Energieausweis für neue Nichtwohngebäude, Seite 1
(Page 5)

Energy performance certificate	Energiepass
Energy performance certificate for a non-residential building	Ausweis über die Gesamtenergieeffizienz eines Nichtwohngebäudes
based on the calculated	auf Basis des berechneten
Certificate no	Passnummer
Issuer no	Nr. Aussteller
Issued on	Erstellt am
Addendum	Nachtrag
Consumption	Verbrauch
Valid until:	Gültig bis
Energy efficiency class	Energieeffizienzklasse
Low-energy requirement	geringer Energiebedarf
TYPICAL FOR EXISTING BUILDINGS	ALTBAU-TYPISCH
TYPICAL FOR NEW BUILDINGS	NEUBAU-TYPISCH
High-energy requirement	hoher Energiebedarf
Thermal insulation class	Wärmeschutzklasse
Energy-saving house standard	Energiesparhausstandard
Energy efficiency class	Enerqieeffizienzklasse
The energy efficiency class depends on the total primary energy needed. This is an overall evaluation that considers not only the thermal insulation of the building, but also the building systems used for heating, cooling, ventilation, humidifying, lighting and water heating, and how environmentally friendly the forms of energy used are overall.	Die Einstufung in die Energieeffizienzklasse erfolgt nach dem Gesamt-Primärenergiebedarf. Dieser berücksichtigt neben dem Wärmeschutz des Gebäudes auch die Anlagentechnik, für Heizen, Kühlen, Belüften, Befeuchten, Beleuften, Warmwasserbereitung, sowie die Umweltverträglichkeit der eingesetzten Energieträger in einer Gesamtbetrachtung.Umweltverträglichkeit der eingesetzten Energieträger in einer Gesamtbetrachtung.

Thermal insulation class	Wärmeschutzklasse
The thermal insulation class depends on the amount of heating needed. This considers the quality of the insulation in the walls, roof, floor and windows, the building method and how well it is built (air-tightness) and the aspect.	Die Einstufung in die Wärmeschutzklasse erfolgt nach dem sogenannten Heizwärmebedarf. Dieser berücksichtigt die Qualität der verwendeten Wärmedämmung in Wänden, Dach, Boden und Fernsten, die Bauweise und Bauausführung (Dichtigkeit) un die Orientierung.
Classes	Klassen
The classes range from A (the best) to I (the worst)	Die Klasseneinteilung erfolgt von A (beste Klasse) bis I (schlechteste Klasse)
Passive house – class ≤ A*	Passivhaus – Klasse ≤ A*
Low-energy house – class ≤ B*	Niedrigenergiehaus - Klasse ≤ B*
Energy-saving house – class ≤ C*	Energiesparhaus - Klasse ≤ C*
*in classes: Energy efficiency, thermal insulation, environmental impact and compliance with air-tightness requirements.	*in den Klassen: Energieeffizienz, Wärmeschutz, Umweltwirkung, sowie Einhaltung der Luftdichtheitsanforderungen
Details of the building	Angaben zum Gebäude
Name	Gebäudebezeichnung
Building category	Gebäudekategorie
Reason for issue	Erstellungsanlass
Address	Adresse
Postcode/town	PLZ-Ort/Stadt
Year building constructed	Baujahr Gebäude
Year heating system constructed	Baujahr Heizungsanlage
Energy reference area, A_n	Energiebezugsfläche, A_n
Of which mechanically ventilated	davon mechanisch belüftet
Of which subject to cooling	davon gekühlt
Office building	Bürogebäude
Planning application	Bauantrag
Street no	Straße Nr.
Issuer	Aussteller
Contact	Ansprechpartner
Name	Name
Postcode/town	PLZ Ort
Tel:	Telefonnummer
Owner	Eigentümer
Signature of issuer	Unterschrift Aussteller
Place and date	Ort, Datum

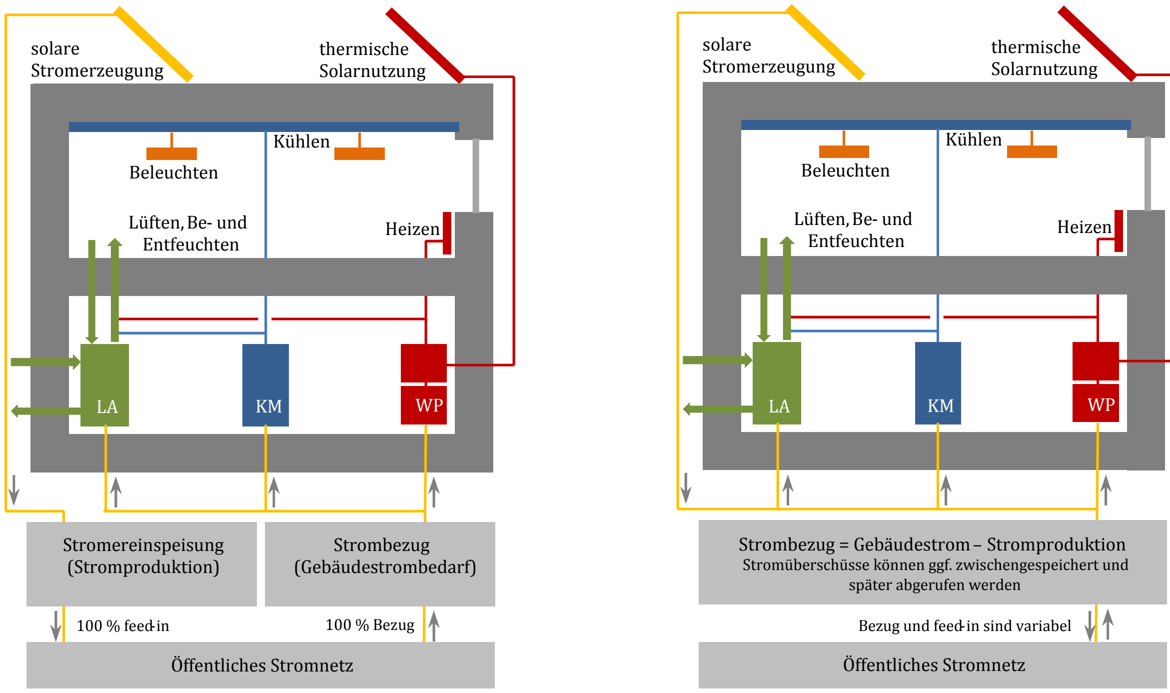


Abbildung 1
(Page 11)

solar electricity generation	solare Stromerzeugung
use of thermal solar energy	thermische Solarnutzung
solar electricity generation	solare Stromerzeugung
use of thermal solar energy	thermische Solarnutzung
Lighting	Beleuchten
Cooling	Kühlen
Ventilation, humidifying and de-humidifying	Lüften, Be- und Entfeuchten
Heating	Heizen
Electricity feed-in (power generation)	Stromereinspeisung (Stromp roduktion)
Electricity use (electricity required for building)	Strombezug (Gebäudestrombedarf)
100 % feed-in	100 % feed-in
100 % use	100 % Bezug
Public electricity grid	Öffentliches Stromnetz
Electricity use = consumption – generation	Strombezug = Gebäudestrom - Stromproduktion
Surplus electricity can be stored and accessed later if required	Stromüberschüsse können ggf. zwischengespeichert und später abgerufen werden
Use and feed-in are variable	Bezug und feed-in sind variabel

$$Q_{P,nZEB} = \sum_i max \left\{ \begin{matrix} Q_{D,Gebäude,i} - Q_{D,Produktion,i} \\ 0 \end{matrix} \right\}$$

(Page 12)

Building	Gebäude
Generation	Produktion

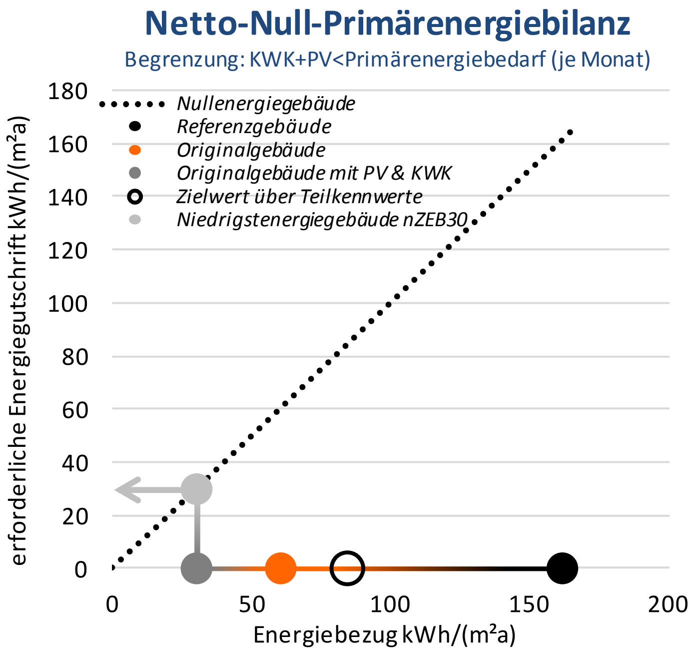
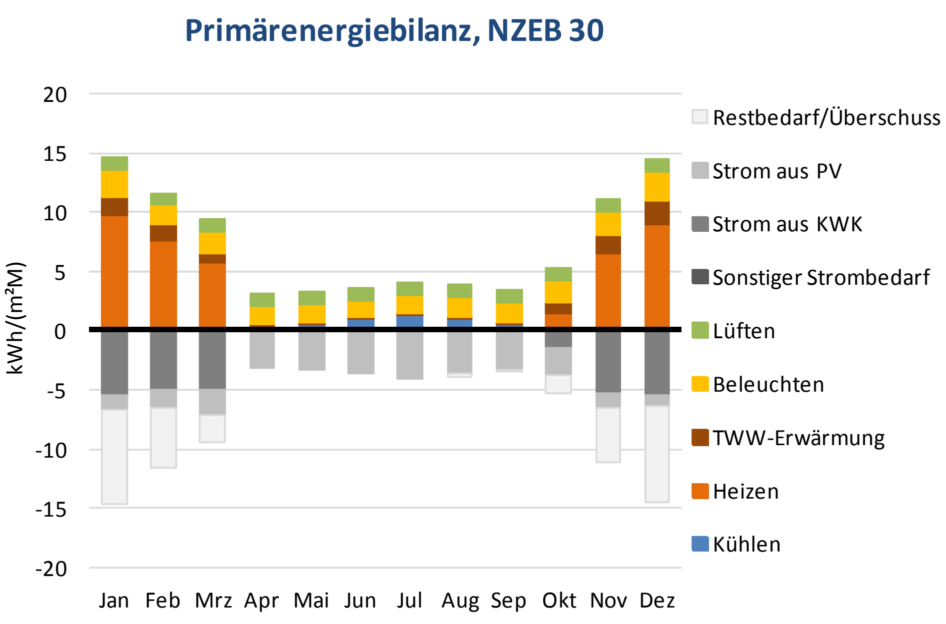


Abbildung 2
(Page 12)

Net zero primary energy balance	Netto-Null-Primärenergiebilanz
Limitation: Cogeneration+PV<primary energy required (per month)	Begrenzung: KWK+PV<Primärenergiebedarf (je Monat)
energy credit required: kWh/(m^2a)	erforderliche Energiegutschrift kWh/(m^2a)
Zero-energy building	Nullenergiegebäude
Reference building	Referenzgebäude
Original building	Originalgebäude
Original building with PV and cogeneration	Originalgebäude mit PV & KWK
Target value from sub-indicators	Zielwert über Teilkennwerte
nearly zero-energy building nZEB 30	Niedrigstenergiegebäude nZEB30
Energy use kWh/(m^2a)	Energiebezug kWh/(m^2a)



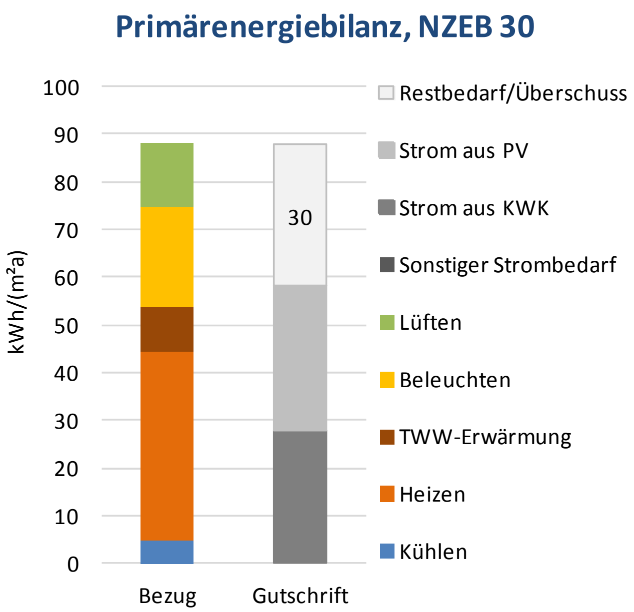


Abbildung 3 (Page 14) & *Abbildung 9* (Page 14)

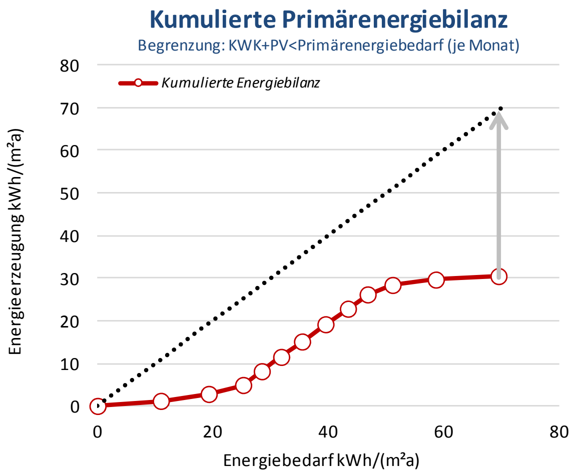
Primary energy balance NZEB 30	Primärenergiebilanz, NZEB 30
Residual requirement/surplus	Restbedarf/Überschuss
Electricity from PV (photovoltaics)	Strom aus PV
Electricity from cogeneration	Strom aus KWK
Other electricity required	Sonstiger Strombedarf
Ventilation	Lüften
Lighting	Beleuchten
Heating drinking water	TWW-Erwärmung
Heating	Heizen
Cooling	Kühlen
Jan Feb Mar Apr May Jun Jul Aug Sep Oct Nov	Jan Feb Mrz Apr Mai Jun Jul Aug Sep Okt Nov Dez

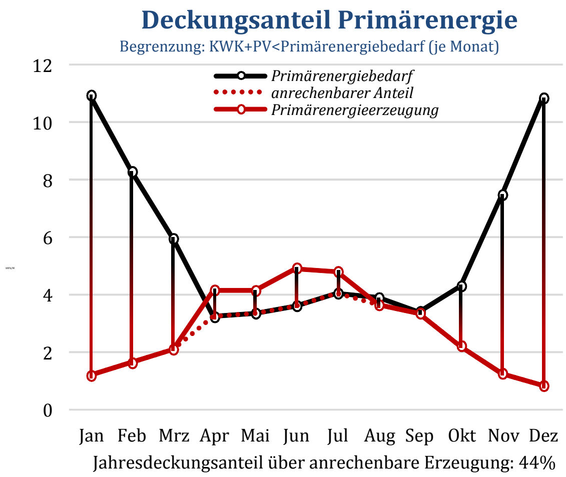
Dec	
Use	Bezug
Credit	Gutschrift

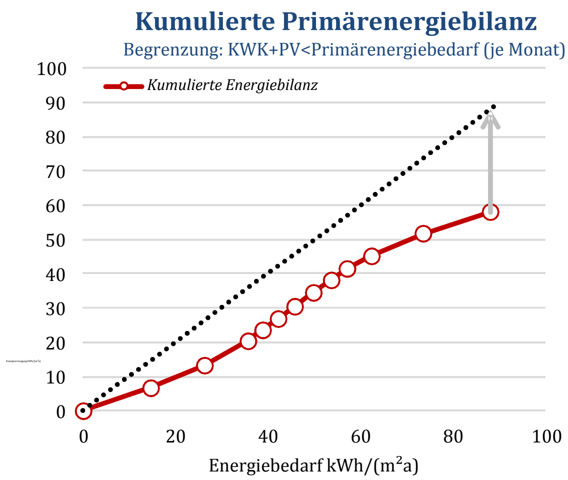
$$f_{C,Prim} = \frac{\sum_t min\left\{ \begin{matrix} Q_{P,Produktion,t} \\ Q_{P,Gebäude,t} \end{matrix} \right\}}{\sum_t Q_{P,Gebäude,t}}$$

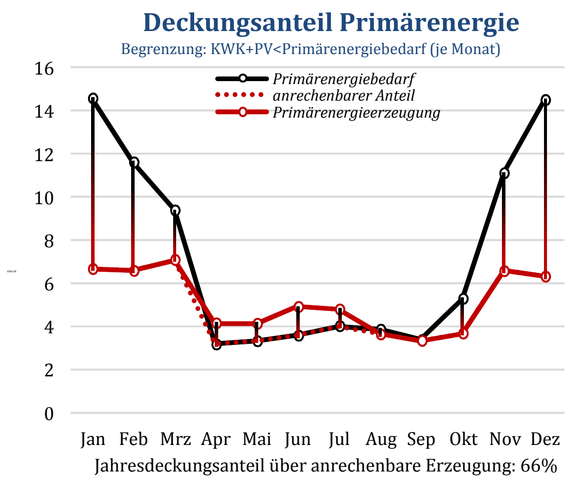
Deckungsanteil Primärenergie
(Page 15)

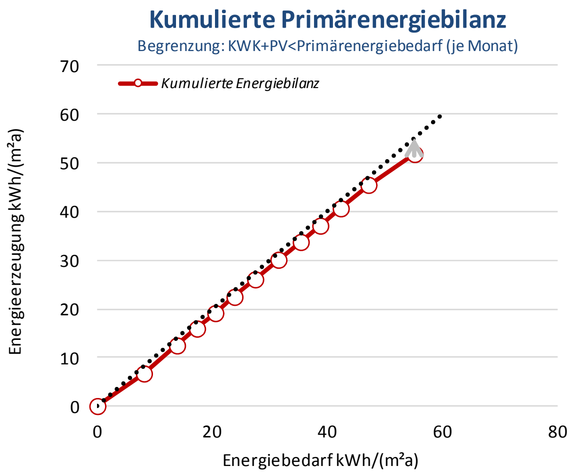
Generation	Produktion
Building	Gebäude











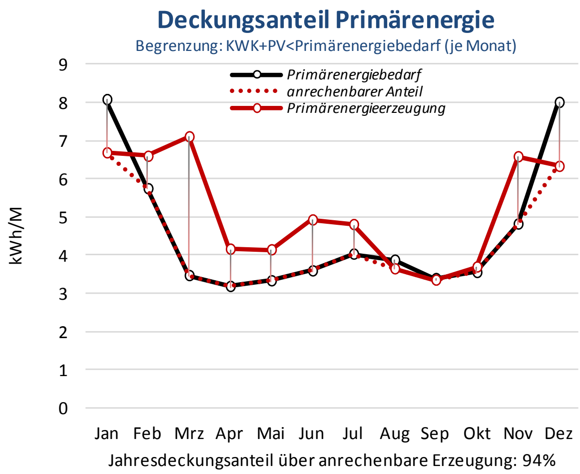
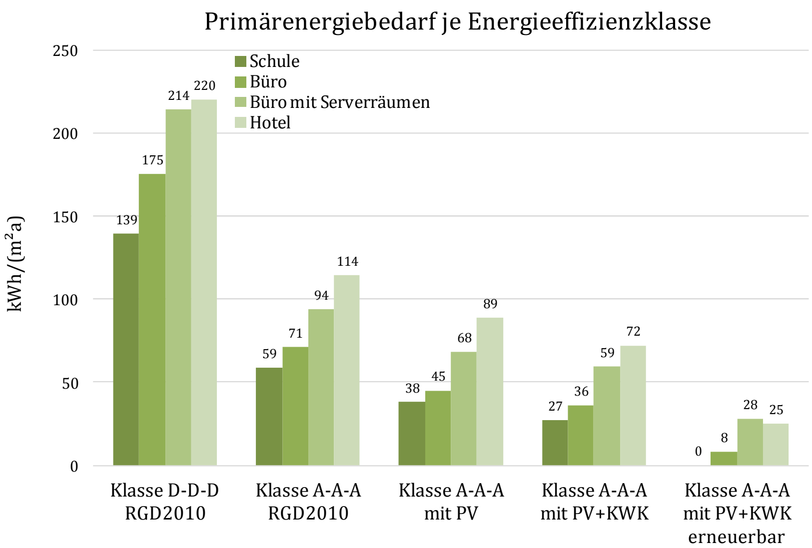


Abbildung 11 (Page 16), *Abbildung 10* (Page 15) & *Abbildung 12* (Page 16)

Cumulated primary energy balance	Kumulierte Primärenergiebilanz
Limitation: Cogeneration+PV<primary energy required (per month)	Begrenzung: KWK+PV<Primärenergiebedarf (je Monat)
Cumulative energy balance	Kumulierte Energiebilanz
Energy generation kWh/(m^2a)	Energieerzeugung kWh/(m2a)
Energy requirement kWh/(m^2a)	Energiebedarf kWh/(m2a)
Coverage by primary energy	Deckungsanteil Primärenergie
Limitation: Cogeneration+PV<primary energy required (per month)	Begrenzung: KWK+PV<Primärenergiebedarf (je Monat)
Primary energy requirement	Primärenergiebedarf
attributable share	anrechenbarer Anteil
Primary energy generation	Primärenergieerzeugung
Jan Feb Mar Apr May Jun Jul Aug Sep Oct Nov Dec	Jan Feb Mrz Apr Mai Jun Jul Aug Sep Okt Nov Dez
Coverage by attributable generation per year:	Jahresdeckungsanteil über anrechenbare Erzeugung:



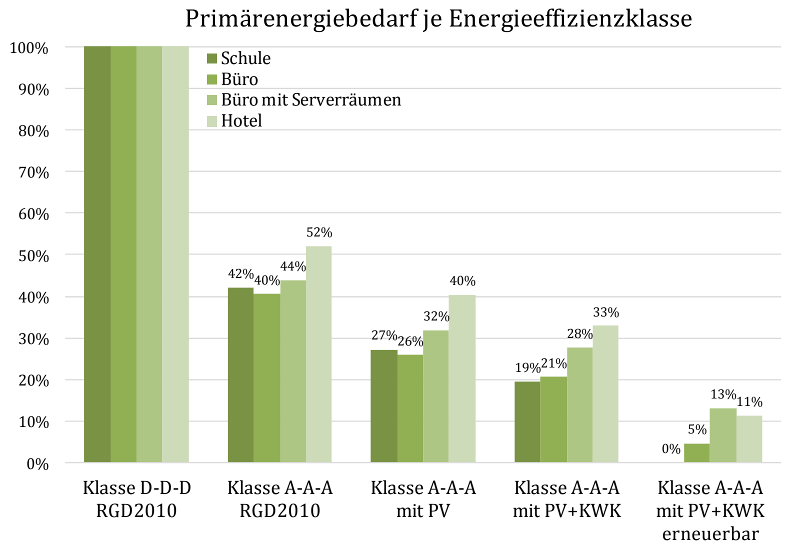


Abbildung 14 (Page 19) & *Abbildung 13* (Page 18)

Primary energy requirement per energy efficiency class	Primärenergiebedarf je Energieeffizienzklasse
School	Schule
Office	Büro
Office with server rooms	Büro mit Serverräumen
Hotel	Hotel
Class	Klasse
With PV	Mit PV
with PV+cogeneration	mit PV+KWK
renewable	erneuerbar

Abbildung 15
(Page 22)

Research and development	Forschung und Entwicklung
Aid programmes	Förderprogramme
Energy certification and quality assurance	Energiepass und Qualitätssicherung
Education and training	Schulung und Weiterbildung
Communication and information	Kommunikation und Information
Transposition into regulation	Umsetzung in Verordnung

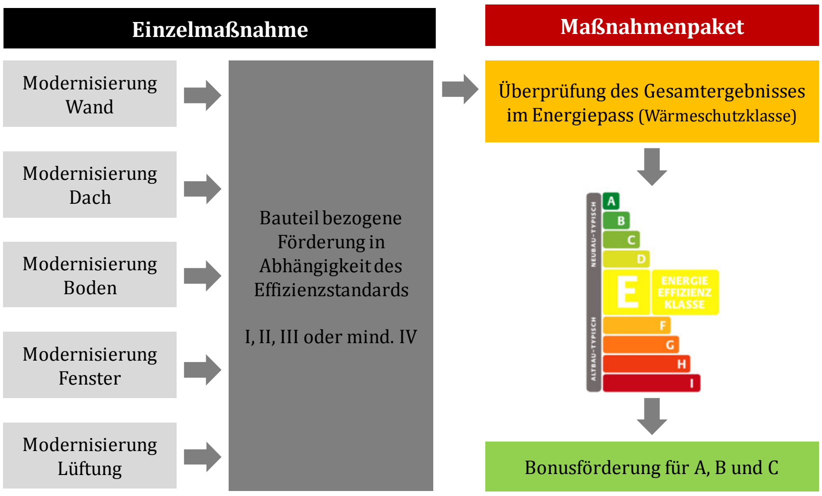
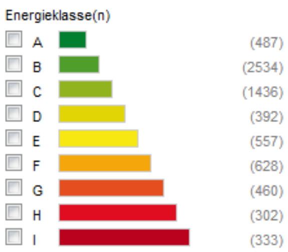


Abbildung 16
(Page 31)

Individual measure	Einzelmaßnahme
Modernisation wall	Modernisierung Wand
Modernisation roof	Modernisierung Dach
Modernisation floor	Modernisierung Boden
Modernisation windows	Modernisierung Fenster
Modernisation ventilation	Modernisierung Lüftung
Component-related support depending on the efficiency standards I, II, III or minimum IV. IV	Bauteil bezogene Förderung in Abhängigkeitdes Effizienzstandards I, II, III oder mind. IV
Package of measures	Maßnahmenpaket
Review total outcome in energy performance certificate (thermal insulation class)	Überprüfung des Gesamtergebnisses im Energiepass (Wärmeschutzklasse)
TYPICAL FOR EXISTING BUILDING	ALTBAU-TYPISCH
TYPICAL FOR NEW BUILDING	NEUBAU-TYPISCH
Energy efficiency class	Energieeffizienzklasse
Bonus aid for A, B and C	Bonusförderung für A, B und C



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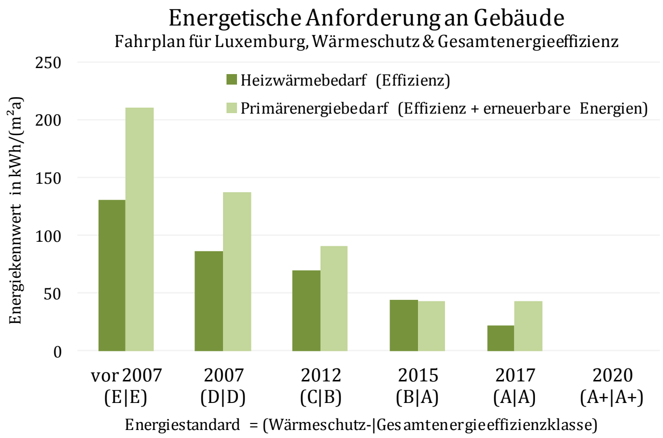
(Page 34)

Energy class(es)	Energieklasse(n)



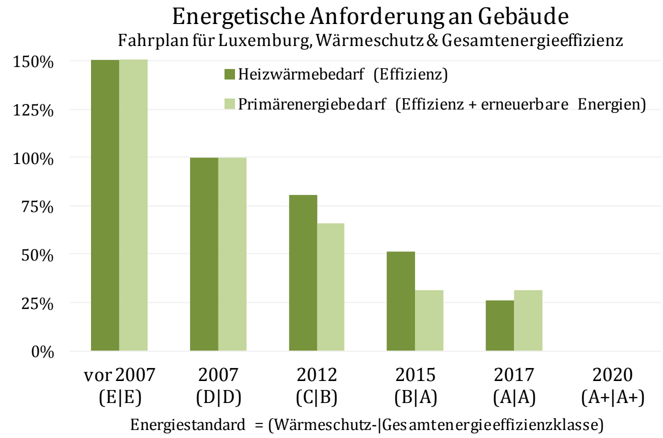


Abbildung 18 (Page 38) & *Abbildung 19* (Page 39)

Energy requirement for buildings	Energetische Anforderung an Gebäude
Road map for Luxembourg, thermal insulation and total energy performance	Fahrplan für Luxemburg, Wärmeschutz & Gesamtenergieeffizienz
Heating energy required (efficiency)	Heizwärmebedarf (Effizienz)
Primary energy required (efficiency + renewable energy)	Primärenergiebedarf (Effizienz + erneuerbare Energien)
Energy performance indicator in kWh/(m^{2}a)	Energiekennwert in kWh/(m2a)
Pre	vor
Energy standard = (thermal insulation class | energy performance class)	Energiestandard = (Wärmeschutz- |Gesamtenergieeffizienzklasse)

Gebäudedaten

Beheiztes Bruttovolumen, V_e	2.996 m²
Energiebezugsfläche, A_n	821 m²
Lichte Raumhöhe, h_R	2,75 m

Zonendaten

Zone 1: Einzelbüro, gekühlt	333 m²
Zone 2: Einzelbüro, nicht gekühlt	129 m²
Zone 3: Seminarräume	66 m²
Zone 4: Verkehrsflächen	194 m²
Zone 5: WC-/Sanitärräume	66 m²
Zone 6: Archiv/Lager	33 m²
Zone 7: Parkhaus (Büronutzung)	258 m², therm. nicht konditioniert

Gebäudehüllflächen

Süd	Fassade	200 m²	geg. ungeheizt 10,3 m²
	davon transparent	86,4 m²	
Nord	Fassade	200 m²	geg. ungeheizt 10,3 m²
	davon transparent	60,5 m²	
West	Fassade	147 m²	geg. ungeheizt 17 m²
	davon transparent	56,3 m²	
Ost	Fassade	147 m²	geg. ungeheizt 17 m²
	davon transparent	47,7 m²	
Dachfläche		294 m²	
Bodenfläche (gegen Parkhaus)		294 m²	

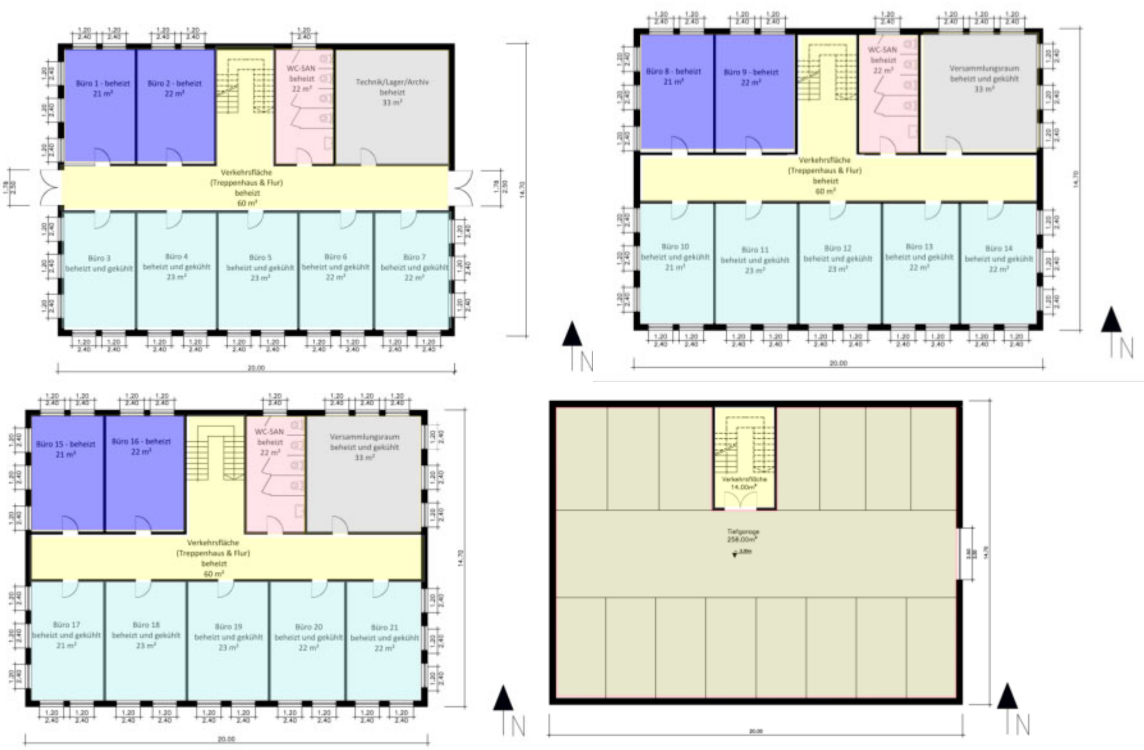
Sonstige Daten

Bodentiefe Fenster → Fenstersturz h_{st} 0,35 m (von UK Decke)

Anhang – Darstellung des Beispielgebäudes

(Page 41)

Building data	Gebäudedaten
Gross volume heated, Ve	Beheiztes Bruttovolumen, Ve
Energy reference area, A_n	Energiebezugsfläche, An
Clear room height, hR	Lichte Raumhöhe, hR
compared to unheated	geg. ungeheizt
Zone data	Zonendaten
Zone 1: Single office, cooled	Zone 1: Einzelbüro, gekühlt
Zone 2: Single office, not cooled	Zone 2: Einzelbüro, nicht gekühlt
Zone 3: Seminar room	Zone 3: Seminarräume
Zone 4: Circulation areas	Zone 4: Verkehrsflächen
Zone 5: WC and sanitary facilities	Zone5: WC-/Sanitärräume
Zone 6: Archive/store	Zone 6: Archiv/Lager
Zone 7: Car park (office use)	Zone 7: Parkhaus (Büronutzung)
No climate control	therm., nicht konditioniert
Building envelope surfaces	Gebäudehüllflächen
South frontage	Süd Fassade
of which transparent	davon transparent
North frontage	Nord Fassade
West frontage	West Fassade
East frontage	Ost Fassade
Roof area	Dachfläche
Floor area (above car park)	Bodenfläche (gegen Parkhaus)
compared to unheated	geg. ungeheizt
Other data	Sonstige Daten
Floor-length windows —> lintel 'hst' 0.35 m (from ceiling)	Bodentiefe Fenster —> Fenstersturz hst 0,35 m (von UK Decke)



(Page 41)

Office 1 - heated	Büro 1 – beheizt
WC – SAN heated	WC-SAN beheizt
Equipment/stores/archives heated	Technik/Lager/Archiv beheizt
Circulation areas (stairwell and corridor) heated	Verkehrsfläche (Treppenhaus & Flur) beheizt
Office 3 heated and cooled	Büro 3 beheizt und gekühlt
Meeting room heated and cooled	Versammlungsraum beheizt und gekühlt
Underground garage	Tiefgarage