CONCERTED ACTION
ENERGY PERFORMANCE OF BUILDINGS

Implementation of the EPBD Luxembourg

Status in 2020

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NATIONAL WEBSITES
https://mea.gouvernement.lu/fr/energie.html;
http://www.gouvernement.lu/4067443/energie;
https://www.myenergy.lu/;
http://www.gouvernement.lu/4067443/energie

1. Introduction

In Luxembourg, the implementation of the EPBD has been the overall responsibility of the *Ministry of Energy and Spatial Planning* since December 2018, with the *Department of Energy, Directorate for Energy Efficiency*, as the managing body. Before December 2018, the *Ministry of Economy* was in charge of transposing the EPBD. The EPBD is implemented by regulations based on the *Loi modifiée du 5 août 1993 concernant l'utilisation rationnelle de l'énergie* (Law 1993)[1]. This law is the legal basis for setting up the requirements for the energy performance of buildings. In 1995, Luxembourg implemented the first mandatory requirements for residential and non-residential buildings.

In 2008, the requirements for residential buildings were modified in order to transpose the EPBD into national law, *Règlement grand-ducal modifié du 30 novembre 2007 concernant la performance énergétique des bâtiments d'habitation*[2] (RGD 2007), and the EPC became mandatory for residential buildings.

The implementation of the EPBD, including the mandatory issue of EPCs for non-residential buildings, came into force in 2011 through *Règlement grand-ducal modifié du 31 août 2010 concernant la performance énergétique des bâtiments fonctionnels*[3] (RGD 2010).

Over the years, many regulatory changes entered into force. The most important changes concerned:

- a strengthening of the overall energy performance of buildings on a defined timeline, and the definition of NZEB;
- the introduction of the 'as-built' EPC;
- the obligation to indicate the energy performance of buildings in advertisements;
- the obligation to control a representative percentage of EPCs.

Some major changes (detailed in chapter 2) concerning residential buildings were published and entered into force in 2016 and 2019.

2. Current Status of Implementation of the EPBD

In Luxembourg, with regard to energy performance requirements, a distinction is made between residential and non-residential buildings, but not between public and private buildings. Nevertheless, the public sector has a leading role in this and has to act as an example. Minimum requirements for technical building elements and building envelope elements apply in the same way for new and existing buildings. New buildings have to comply with overall energy performance requirements (heat energy demand and primary energy needs).

2.I. Energy performance requirements: NEW BUILDINGS

Besides minimum requirements for building envelope elements and technical equipment, all new residential and non-residential buildings have to fulfil global requirements expressed in heating energy needs and primary energy needs.

2.I.i. Progress and current status of new buildings (regulation overall performance)

A timetable to reinforce energy performance requirements for residential buildings and a first step to reinforce energy performance requirements for non-residential buildings have been defined in 2012 and 2014, respectively.

A new step on the path towards the non-residential NZEB entered into force in 2015, with the non-residential NZEB entering into force by mid-2021.

For residential buildings, a similar stepwise approach was used with reinforcements in 2012 and 2015. The last step of the reinforcement for new residential buildings entered into force in 2017 and thereby introduced the residential NZEB as a standard.

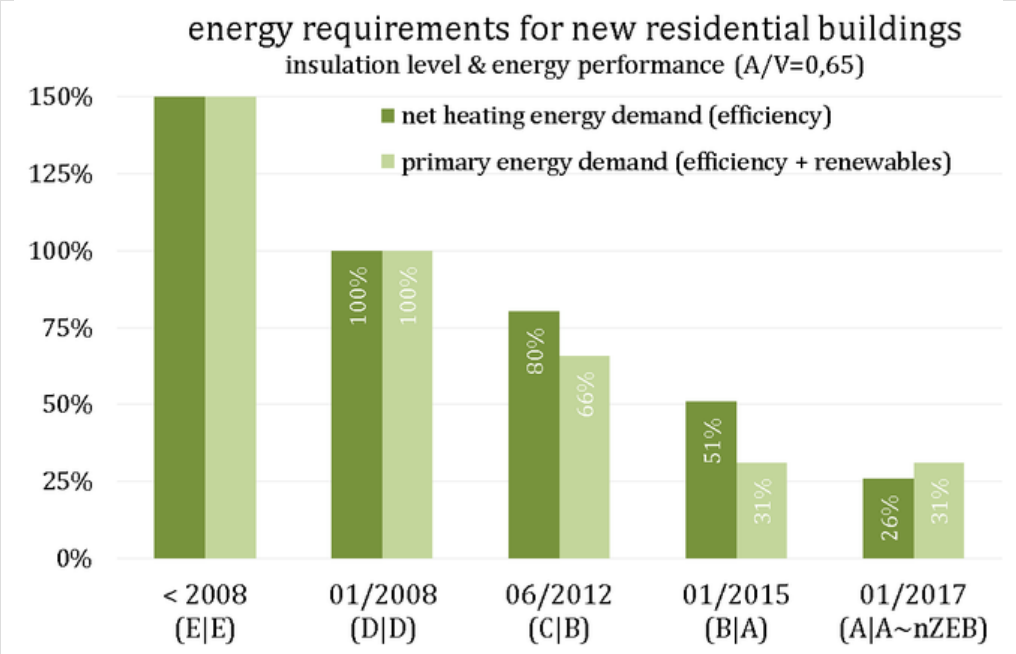

Figure 1. Reduction of energy needs over time for residential buildings. Source : Dr. Markus Lichtmess, Goblet Lavandier & Associés Ingénieurs-Conseils S.A.

Implementation of the EPBD in Luxembourg

In 2020, Luxembourg implemented the following important requirements for residential buildings:

- new buildings need to be equipped with ducting infrastructure for electromobility and photovoltaics;
- mandatory 'as built' EPC;
- the definition of the NZEB standard as the new standard from 1 January 2017 onwards;
- changes to the requirements and calculation methods for thermal protection in the summer, with the aim of limiting summertime overheating;
- the ability to take photovoltaic production into account, at least partly;
- a change in the calculation method for global requirements (primary energy needs and heating energy needs) towards implementing the reference building procedure;
- the adjustment of calculated energy needs in the EPC to more adequately reflect the real energy consumption;
- the introduction of an interface in the EPC calculating tool for measured airtightness values.

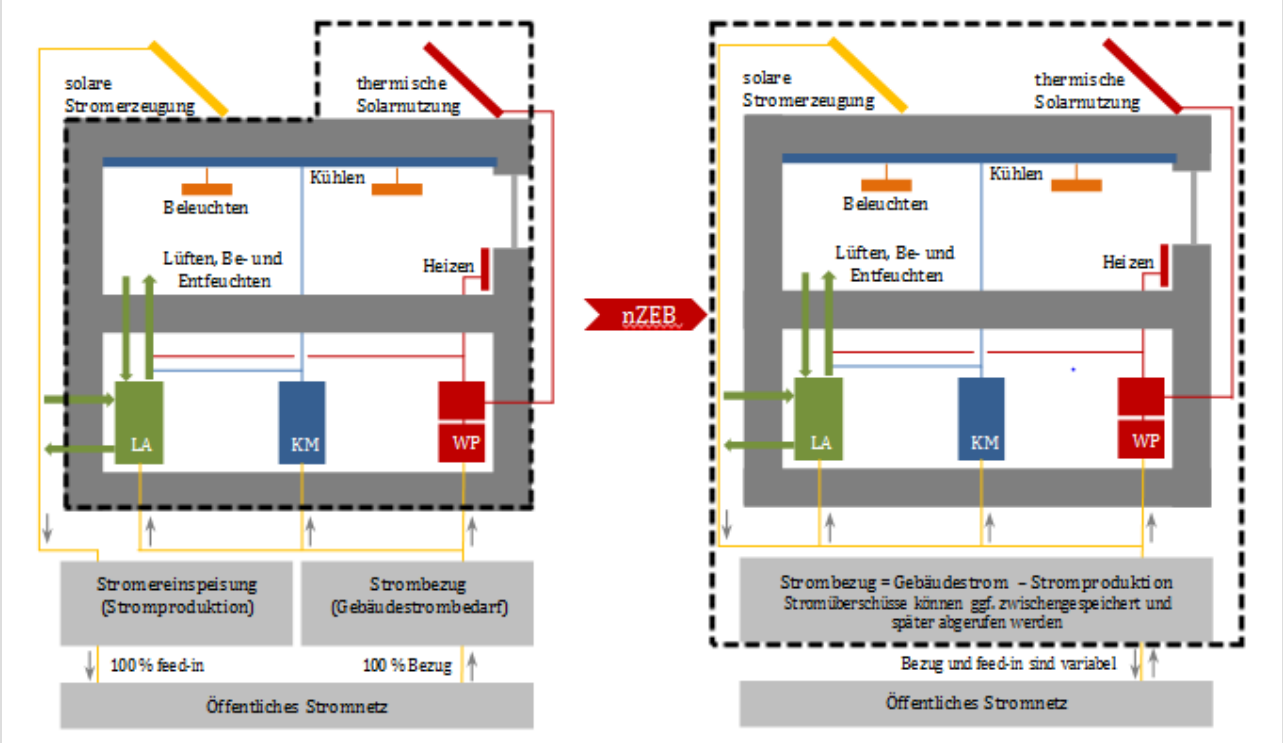

Figure 2. Integration of photovoltaic production. SOURCE: Dr. Markus Lichtmess, Goblet Lavandier & Associés Ingénieurs-Conseils S.A.

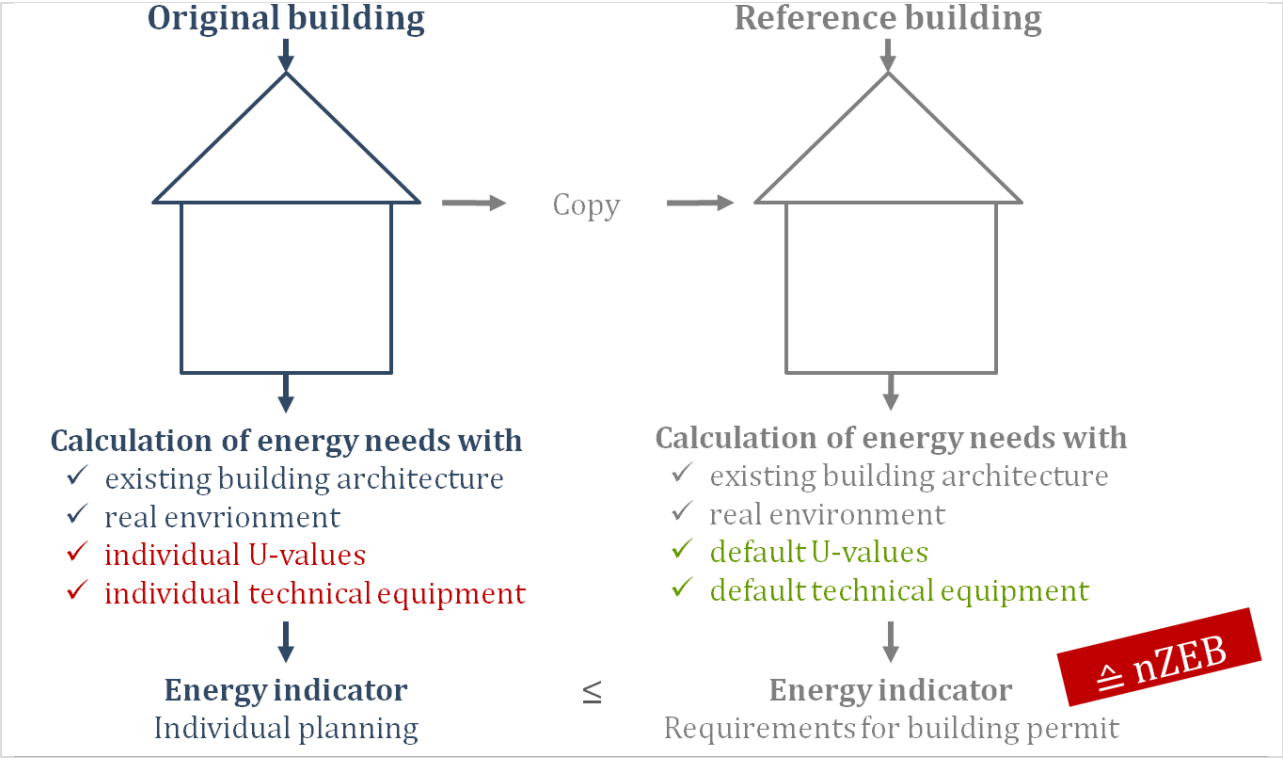

Figure 3. Methodology of the reference building. SOURCE: Dr. Markus Lichtmess, Goblet Lavandier & Associés Ingénieurs-Conseils S.A.

2.I.ii. Format of national transposition and implementation of existing regulations

For residential buildings, the energy performance calculation for new and existing buildings is based on the calculated energy needs for heating, domestic hot water, ventilation and auxiliary needs. The results are expressed in terms of primary energy needs, heating energy needs and CO_2 emissions. Since 2016, photovoltaic production can be partly taken into account (only the part that is consumed by the technical equipment of the building).

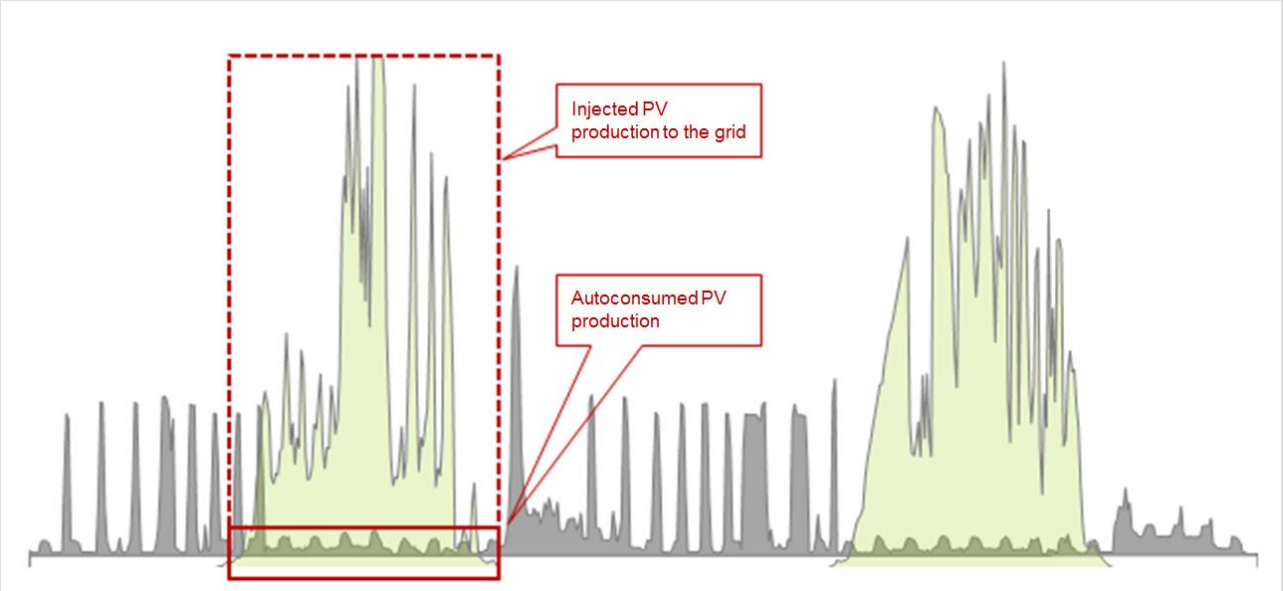

Figure 4. Integration of photovoltaic production. SOURCE: Dr. Markus Lichtmess, Goblet Lavandier & Associés Ingénieurs-Conseils S.A.

For non-residential buildings, the energy performance calculation for new buildings is also based on the calculated energy needs for heating, domestic hot water, ventilation and auxiliary needs, but also on AC, lighting, humidification and dehumidification. For existing non-residential buildings, the real energy consumption (metered energy) is taken into account in the form of an established EPC based on the measured consumption. An EPC based on the calculated consumption is only foreseen for new constructions.

Besides minimum requirements for building envelope elements and technical equipment, all new residential and non-residential buildings have to fulfil global requirements expressed in heating energy needs and primary energy needs. These requirements are cost-optimal.

In order to raise consumer awareness of the strengthening of building energy performance requirements and more generally energy-efficient policies, the government is operating a consumer hotline through *myenergy*[4] (the national body for information and advice in the fields of energy efficiency and renewable energy), providing support to all sectors with respect to building refurbishment. Further, the *Ministry of Energy and Spatial Planning* takes part in expert meetings and exchanges on best practices within the building sector. The ministry regularly updates FAQ documents that are made available to the public.

Concerning quality controls, the EPC database for residential buildings is an important tool. A plausibility check of each EPC is integrated into the software that is calculating the EPCs. Controls of EPCs take place regularly. A few experts who had issued EPCs containing errors have been penalised with a temporary ban, mandatory advanced training and the correction of errors in the EPCs.

2.I.iii. Action plan for progression to NZEB for new buildings

As of mid-2021, all new buildings have to be NZEB. The NZEB standard entered into force in 2017 for residential buildings. For non-residential buildings, it is scheduled for mid-2021.

An example of a very energy-efficient new public building is the one housing the *Nature and Forestry Administration*[5], which obtained an excellent score in its sustainability certification. This building is equipped with a water/water heat pump, a rainwater utilisation system, a LED-lighting system, a photovoltaic installation and an energy management system. The calculated heating energy demand of the building is 26.4 kWh/m^2.year and the primary energy demand is 70.6 kWh/m^2.year.

In the field of communication and information, free basic advice with respect to the energy-efficient renovation and construction of energy-efficient buildings has been provided since 2010 by *myenergy*.

2.I.iv. Requirements for building components for new buildings

Requirements for technical building systems are set in different regulations covering gas-, wood- and oil-fired boilers, AC systems, heat pumps and ventilation systems.

Some decades ago, Luxembourg established a mandatory technical acceptance procedure for new oil- and gas-fired boilers as well as regular inspections of these boilers in existing buildings. Newly installed boilers need to be technically accepted before they can be used (acceptance procedure). However, an operator is not obliged to get an authorisation in order to be allowed to install a boiler (approval procedure). For wood-fired boilers this system became mandatory in 2014. The acceptance procedure and the regular inspection of AC systems have been mandatory since 2009 in residential as well as non-residential buildings. The acceptance procedure checks the conformity of the security equipment, the location, the smoke exhaust and the combustion quality and efficiency. Dimensioning is not checked at this stage but is

done so during the periodic inspection. Since Luxembourg imports nearly all appliances and equipment, European standards as well as standards valid in the import countries are also applicable in Luxembourg.

RGD 2007 and RGD 2010 set energy performance requirements concerning building envelope elements, pipework insulation, ventilation and AC systems.

2.I.v. Enforcement systems new buildings

The construction of a new building as well as the modification of an existing building requires a building permit to be issued by the municipality in which the building is to be constructed. To decide whether a building application is acceptable, the mayor checks whether the building project is in compliance with the rules prescribed by the building codes. This check includes compliance with energy performance requirements. The mayors also act as the building police in the sense that they are responsible for ensuring that constructions conform to the building permit. In this role, the mayor can order building inspections to verify the conformity of the building.

To support the municipalities in verifying the aspects of energy performance in building applications, *myenergy* offers a series of checklists[6].

2.II. Energy performance requirements: EXISTING BUILDINGS

For existing buildings, minimum requirements have to be respected in case of a modification. These minimum requirements are set for building envelope elements and technical equipment and they have to be respected for the modified parts. Large extensions additionally need to respect limitations concerning their needs in heating and primary energy.

2.II.i. Progress and current status of existing buildings (regulation overall performance)

As described in the requirements for new residential buildings, the same requirements apply also to existing residential buildings (with the ability to partly take into account photovoltaic production: aligning real energy consumption in the EPC with the calculated theoretical energy need and introducing an interface in the EPC calculating tool for measured airtightness values).

Subsidy schemes for the refurbishment (*PRIMe-House*[7]) of existing residential buildings are frequently updated. These schemes have been reviewed and a top-up was introduced in mid-2020 as part of the Covid-19 recovery programme (*Neistart Lëtzebuerg*). The priority is on deep renovations reaching a very good energy class after refurbishment[8]. The extent of the grant is related to the degree of insulation, expressed by the level of performance (U-value) that is reached after insulation. More sustainable insulation materials are also promoted by a bonus system.

2.II.ii. Regulation on individual parts, distinct from whole building performance

Requirements for technical building systems and building envelope elements are set in multiple regulations[2,3,9] concerning the respective buildings or technical elements.

These regulations cover gas-, wood- and oil-fired boilers, AC systems, heat pumps, ventilation systems and components of the building envelope. The *Ministry of the Environment, Climate and Sustainable Development* and the *Ministry of Energy and Spatial Planning* share the responsibility with respect to these areas.

Every new individual building element has to fulfil minimum requirements defined in these regulations.

Furthermore, large installations must comply with certain requirements set by the environmental and safety impact authorisation procedure[10]; such requirements depend on the scale and type of the installation. They can be grouped into general security requirements, technical requirements and energy performance requirements (according to the best available technology).

2.II.iii. Initiatives/plans to improve the existing building stock

In 2017 and 2018, together with the relevant actors in the construction sector, Luxembourg organised multiple workshops to identify the main barriers and challenges to improving the existing building stock. As part of this initiative, Luxembourg's energy renovation strategy was developed. The various themes of these workshops focused on finding ways to remove natural architectural constraints as well as regulatory and financial barriers, motivating building owners to refurbish and encouraging refurbishment as an opportunity for the construction sector in Luxembourg. These workshops concluded that financially supporting energy refurbishment programmes, providing information and energy advice and raising awareness play an important role in this area. As described above, Luxembourg tries to promote major renovations through aid schemes that are regularly updated. Deep renovations are promoted where EPCs have to be issued before and after refurbishment. In relation to the obtained energy class after refurbishment, a bonus is granted in addition to the previously received aid. The better the energy class after refurbishment, the higher the bonus.

myenergy, the national body for information and advice in the fields of energy efficiency and renewable energy, provides support to all sectors with respect to building refurbishment. Various market analyses performed by *myenergy* have identified barriers to information that affect the public's perceptions and the motivations of building owners to finance renovations. Significant efforts have been made to remove these barriers by creating national information points all over the country. The information points are organised by *myenergy* in cooperation with the municipalities.

In recent years, Luxembourg has introduced several measures for promoting the energy refurbishment of buildings. These range from regulatory measures to financial incentives, an increase in information and advisory measures and improvements to education and training.

RGD 2007 and RGD 2010 define minimum requirements for extensions or renovations of existing building elements. Furthermore, besides the subsidy programme *PRIMe-House*, an energy efficiency obligation scheme (*EEOS*) has been applied since January 2015. The *EEOS* obliges all electricity and gas suppliers (obligated parties) to achieve energy savings among energy end-users. The obligated parties have to deploy efforts (financial and non-financial incentives) that result in customers gaining access to information on energy efficiency, encouraging them to implement energy efficiency measures. Further initiatives and plans to improve the existing building stock are described in section 2.II.iv.

2.II.iv. Long Term Renovation Strategies, status

Luxembourg has submitted its LTRS to the Commission in June 2015. Hereafter follows an executive summary of the LTRS highlighting the key points of the strategy:

The document contains Luxembourg's long-term renovation strategy (LTRS) for residential and non-residential buildings, both private and public, in line with the requirements of Article 2a of Directive (EU) 2018/844. According to the Directive, the LTRS is intended to support the renovation of the national stock of buildings to a very high standard of energy efficiency and to replace fossil fuels for heating with

renewable energy, in both cases as cost-effectively as possible. The buildings sector is responsible for approximately 36% of all CO_2 emissions in the Union (Directive on the energy performance of buildings (EPBD), 2018) and the long-term renovation strategy is, accordingly, a key factor in progress towards the EU's target of achieving a socially just transition to net-zero greenhouse gas (GHG) emissions by 2050. Luxembourg's LTRS clarifies the goals and measures set out in Luxembourg's National Energy and Climate Plan (NECP) 2020 (NECP, 2020) for the buildings sector in greater detail and describes how the sector – in particular through the renovation of buildings – can help to achieve the national targets of a 55% reduction in GHG emissions and a 40–44% reduction in final energy demand compared to EU PRIMES 2007 (DGET, 2008) by 2030, with more ambitious long-term targets by 2050 at the latest.

According to the NECP, energy savings associated with building renovations hold the second-largest potential for cumulative energy savings by 2030 (after energy savings in the Transport sector).

Sector	GWh	%
Transport	9 618	66.4%
Industry	863	6.0%
Commerce, trade and services	986	6.8%
Private households	3 013	20.8%
• of which regulatory provisions governing new buildings	834	5.8%
• of which regulator provisions governing existing buildings	532	3.7%
• funding for building envelope	944	6.5%
• funding for heating system	702	4.8%
Total	14 480	100.0%

Table 1: Cumulative energy savings by 2030, broken down by sector (NECP, 2020).

The LTRS contains an up-to-date analysis of the country's building stock and outlines recent developments in relation to strategic planning and the design of implementing measures. It is intended to consolidate previous work performed in these areas. The most important stakeholders have been involved in its drafting and the measures it describes will be implemented on a gradual basis over the coming months.

Luxembourg's newly built and demolition rates are well above those of most other EU Member States. This can be attributed to the strong economic growth recorded by the country and the resulting strong population growth (in relative terms, Luxembourg has the strongest population growth of any OECD country, outpacing even Mexico). To ensure that this large stock of new builds is constructed using 'climate-friendly' methods, Luxembourg – as the first country in the EU – introduced the 'near zero energy building' (NZEB) standard on a mandatory basis for residential buildings on 1 January 2017. The early introduction of this demanding standard has allowed Luxembourg to achieve CO_2 emission reductions in the residential buildings sector despite population growth. In summer 2020, this successful policy will be complemented by a new regulation that introduces climate-neutral standards on a mandatory basis for new builds in both the residential and non-residential sector; these standards will be rolled out gradually between 2020 and 2023.

Although high demolition rates and a high standard for new builds means Luxembourg's building sector achieves a higher proportion of energy and climate reductions than any other EU Member State, the country still faces substantial renovation-related challenges. To remain within the target corridor for the 2030 and 2050 climate targets, Luxembourg must significantly increase both the depth of renovation (the amount of energy saved compared to the pre-redevelopment condition) and the renovation rate (how many buildings are renovated per year). 'Business as usual' alone will not be sufficient.

To accelerate progress in this area, a whole range of well-integrated implementing tools will need to be put into practice, including the following:

- regulatory provisions (regulations and standards);
- promotional and funding instruments;
- tax instruments;
- training;
- awareness raising and publicity work;
- research and model projects.

These tools will be aligned with each other in such a way that their effects are mutually reinforcing.

From a technical perspective, emphasis is on energy-related improvements to the building envelope (insulation) and improvements to the energy efficiency of technical installations, with a particular focus on fossil-free energy sources (replacement of old heating systems based on fossil fuels). Accompanying measures such as further training, awareness raising and research are aimed at identifying and prioritising savings potentials and at highlighting possible improvements and supporting measures.

Alongside the impact on energy savings and climate, a further key indicator for assessing the mix of measures is the impact on those individuals who live in and use the buildings, in particular those who are at risk of energy poverty because their incomes are low but their energy consumption is relatively high. An analysis of energy poverty in Luxembourg is thus a key component of this LTRS. The analysis reveals that Luxembourg is among the EU Member States with the lowest rates of energy poverty. According to Eurostat, around 5,000 households in the country are unable to heat their homes appropriately or need to rely on state benefits to pay their fuel bills. An analysis of the energy poverty situation also reveals that the problem is not caused by energy prices (price per litre of heating oil or per cubic metre of gas), since Luxembourg has some of the lowest energy costs in the EU in terms of absolute value and particularly in terms of the purchasing power parities, but rather by rental prices rising at a significantly faster rate than purchasing power in recent years, particularly in lower-income groups.

Based on the analyses carried out in connection with the drafting of the LTRS, the following implementing measures have been identified as priorities:

Regulatory provisions

- introduction of stricter minimum requirements in terms of thermal insulation for individual components in the form of new energy efficiency regulations (for non-residential buildings from 2021 and for residential buildings from 2023);
- checks to ensure that renovation works comply with the requirements (energy passport checks) (revision of existing system of checks);
- introduction of ‘renovation passports’ (a renovation roadmap) to ensure that the overall sum of individual measures gradually results in full renovations with sufficient depth (‘deep renovation’);
- obligation to build up financial reserves for the renovation of owner-occupied and rented apartments (based on the example of Austria’s ‘Maintenance and Improvement Contribution’);

- reduction in the quorums for majority decisions in co-owned multi-family dwellings concerning general renovation and maintenance works and energy efficiency measures in particular;
- hiatus in the expansion of gas networks in residential areas;
- requirement to install photovoltaic systems on all public buildings by 2030 (with the exception of buildings protected as historical monuments);
- preparatory measures for the installation of photovoltaic systems on the roofs of other non-residential buildings during renovation (with the exception of buildings protected as historical monuments and heavily shaded buildings) from 2023.

Promotional and funding instruments

- revision of the *PRIME-House* scheme for residential buildings: funding of individual measures for building envelope components in combination with a tightening up of minimum efficiency standards (heavily scaled to promote high levels of performance);
- 'zero-interest climate loan' for renovations under the *PRIME-House* scheme to be rolled out to all households (instead of just low-income households);
- access to the *PRIME-House* funding scheme for certified tradespeople who carry out individual measures; access to a bonus for full renovations provided that a certified energy consultant is consulted, with a significant increase in the funding available for consultation costs;
- funding for energy-efficiency measures in buildings protected as historical monuments;
- *PRIME-House* funding in combination with a switch to renewable energy carriers ('mazut replacement scheme').

Tax law

- gradual introduction of a carbon tax (CO_2 pricing based on the 'polluter pays' principle) from 2021 onwards;
- harmonised reduced VAT rate of 3% for energy renovations that comply with the requirements of the *PRIME-House* scheme for residential buildings;
- further incentives for renovations by owners, such as accelerated depreciation allowances.

Training

- training on the energy-efficient optimisation of non-residential building renovations;
- training on ways to reduce energy demand for cooling as a means of adapting to future climate change.

Awareness raising and publicity work

- further development of the existing 'myrenovation' app for residential buildings;
- information campaign on energy efficiency in non-residential buildings in connection with the introduction of the new regulations.

Research and model projects

- prefabrication of the components required for renovations with a view to shortening the timeframe of renovations and combating labour shortages, in cooperation with other countries;

- model projects for the renovation of residential developments with poor energy ratings and heating systems based on fossil fuels:

  o trial of funding schemes based on energy performance contracting;
  o opening up of the *PRIMe-House* funding scheme to cover measures implemented by contractors;
  o more generous recognition of CO_2 savings achieved through renovations carried out by energy suppliers (measure currently under consideration);
  o strict energy-related requirements under the *PRIMe-House* funding scheme;

- model projects involving highly energy efficient and economical renovations of non-residential buildings.

Success stories in the new residential buildings sector can be used as a foundation for implementing the aforementioned measures. Luxembourg has succeeded in introducing one of the most ambitious standards in Europe in this market segment within a period of around ten (10) years.

As noted above, the LTRS is intended to serve as a basis for summarising, clarifying and further developing the implementing measures. The most important stakeholders in the sector are involved in this process by means of regular workshops.

A 'Renovation Day' event was planned for May 2020 for the purpose of allowing public participation, but this event could not take place as a result of COVID-19 restrictions. Since a comprehensive public participation process in relation to the topics covered in the LTRS was carried out when drafting the previous version of the building renovation strategy three years ago and when drafting the NECP in 2019, it was decided that a similar process involving events aimed at providing information on forthcoming implementing measures (e.g., details of the revised *PRIMe-House* funding scheme) should be carried out in autumn 2020 (subject to COVID-19 restrictions) and in spring 2021 at the latest.

Additional key steps during the drafting of the renovation strategy included a detailed analysis of the current non-residential building stock and systematic evaluations of energy-related data from the EPC database and other sources. Energy demand/consumption data and energy generation data are to be localised in a geographic information system on this basis.

2.II.v. Financial instruments and incentives for existing buildings

The financing mechanism in place for technologies based on RES (solar panels, heat pumps, wood-fired boilers, etc.) and the refurbishment of building envelope elements set minimum energy efficiency requirements. For building envelope elements, the aid scheme has been linked to the use of sustainable insulation materials.

Subsidy schemes for the refurbishment (*PRIMe House*[7]) of existing residential buildings have been reviewed, are regularly updated and a top-up was introduced mid-2020 as part of the Covid-19 recovery programme (*Neistart Lëtzebuerg*). Priority is put on deep renovations where a very good energy class is reached after refurbishment[8]. In addition, the more a building element is insulated, the more specific aid is granted. More sustainable insulation materials are also promoted by a bonus system.

Another new feature is *Climate Bank*, which provides a zero-interest rate or a reduced interest rate for loans granted for energy refurbishment projects. Mandatory energy advice is foreseen for this aid and the energy expert is required to control the implementation of the measures.

The zero-interest-rate loan is reserved for low-income households in order to unlock such investments (with a maximum loan of 50,000 € over a period of 15 years). In addition to granting investment aid, costs for the mandatory energy advice are paid directly by the state budget. Households above the low-income threshold can apply for loans with reduced interest rates (the measure is limited to a loan of 100,000 € over a period of 15 years, with the loan rate in principle being reduced by 1.5%).

Further financial instruments are described under section 2.II.iv.

2.II.vi. Information campaigns / complementary policies

Over the last few years, Luxembourg has made numerous efforts to provide detailed information on energy savings and the use of RES to energy consumers.

These efforts are illustrated by the achievements of the public energy advisory and information provider *myenergy*, whose activities include raising awareness as well as informing and assisting households, companies, municipalities and professionals regarding energy savings, the use of renewable and sustainable energy and the development of sustainable residential buildings.

The website www.myenergy.lu is the major official tool for informing all the aforementioned target groups.

The free, impartial and basic advice to private individuals is provided over phone (hotline number 8002 11 90) or in personal advisory sessions held in one of the numerous regional *myenergy* information points. These information points are part of a large network of *myenergy's* local advice centres.

Representatives of *myenergy* also organise action weeks, on-site consultations and information events with presentations and awareness-raising activities, attend national trade shows, create information flyers and internet platforms and ensure a regular presence in the national media. *myenergy* has also developed virtual interactive gamification tools, providing key messages in the conception of energy-efficient buildings.

2.III. Energy performance certificate requirements

For residential buildings, one single type of EPC exists. The EPC has not been changed as regards the modifications of the energy performance requirements until 2020, meaning that the classes remain the same. This is essential to ensure the comparability of the issued EPCs within the buildings market.

For non-residential buildings, two types of EPCs exist. One type covers new buildings (based on calculated energy needs) and the other type covers existing buildings (based on metered consumption).

A national database has been developed which collects all residential building EPCs (existing and new) with the aim to draw statistics regarding the national building stock in the future. In a later phase, the database shall be extended to non-residential buildings.

2.III.i. Progress and current status on EPCs at sale or rental of buildings

A valid EPC is mandatory for all sale or rental transactions of buildings. The EPC for existing buildings requires the indication of energy efficiency improvement measures. The owner of a building must present a

valid EPC to a potential buyer or tenant. When issuing the EPC, a qualified expert visits the building and assesses the geometry and the type of construction (walls, windows, insulation, thermal bridges, ventilation and airtightness, etc.) as well as the type and quality of heating, ventilation, AC and hot water systems. The establishment of the EPC includes a calculation of the heating and primary energy needs of the building. In case of sale, the notary checks the presence of the EPC. They will not proceed to the sale if there is no EPC.

2.III.ii. Quality Assessment of EPCs

The *Ministry of Energy and Spatial Planning* organises random checks of EPCs in order to verify their compliance with the legal requirements. These controls comprise two levels. The first level consists of a plausibility check of the calculated values, whereas the second level is a deeper analysis of EPCs containing non-plausible elements. The control consists of a check of all data entered into the EPC. Penalties in the form of a time-limited suspension can be imposed on experts in case of deviations from the regulation.

2.III.iii. Progress and current status of EPCs on public and large buildings visited by the public

For residential buildings and non-residential buildings occupied by public authorities and frequently visited by the public with a surface exceeding 250 m^2, the EPC must be displayed in a clearly visible place. For residential buildings and non-residential buildings not occupied by public authorities but frequently visited by the public, this obligation applies when the surface exceeds 500 m^2.

2.III.iv. Implementation of mandatory advertising requirement – status

A modification of RGD 2007 and RGD 2010 has introduced the obligation to insert the overall energy performance class (primary energy) and the heating performance class in real estate advertisements in all commercial media (paper, internet, etc.).

This obligation came into force on 1 July 2012. A large number of real estate advertisements comply with this obligation and the ministry randomly checks compliance.

2.IV. Smart buildings and building systems

For heating and AC systems inspection regulations are defined by the *Ministry of the Environment, Climate and Sustainable Development*. The *Environmental Administration* is in charge of their execution. The inspection regulations are defined and implemented by the *Ministry of Energy and Spatial Planning*. Inspection obligations for heat pumps are currently under development.

Requirements on building automation and electronic monitoring of technical building systems will be implemented by mid-2021 with the regulation concerning the energy performance of buildings. According to this future regulation the building automation and control systems shall be capable of:

a) continuously monitoring, logging, analysing and allowing for adjusting energy use;
b) benchmarking the building's energy efficiency, detecting losses in efficiency of technical building systems and informing the person responsible for the facilities or technical building management about opportunities for energy efficiency improvement;
c) allowing communication with connected technical building systems and other appliances inside the building and being interoperable with technical building systems across different types of proprietary technologies, devices and manufacturers.

2.IV.i. Status and plans on smart buildings

Luxembourg has not yet implemented the smart readiness indicator for buildings. Luxembourg fully understands and supports the need for smart buildings but has decided not to be among the frontrunners on this topic as discussed in the CA-EPBD.

2.IV.ii. Regulation of system performance

Requirements for technical building systems are set in different regulations covering gas-, wood- and oil-fired boilers, AC systems, heat pumps and ventilation systems.

Some decades ago, Luxembourg established a mandatory acceptance procedure for new oil- and gas-fired boilers as well as regular inspections of these boilers in existing buildings. For wood-fired boilers this system became mandatory in 2014. The acceptance procedure and the regular inspection of AC systems have been mandatory since 2009 in residential as well as non-residential buildings. The acceptance procedure checks the conformity of the security equipment, the location, the smoke exhaust and the combustion quality and efficiency. Dimensioning is not checked at this stage but is done during the periodic inspection. Since Luxembourg imports nearly all appliances and equipment, European standards as well as standards of the countries of origin are applicable also in Luxembourg.

RGD 2007 and RGD 2010 set energy performance requirements concerning building envelope elements, pipework insulation, ventilation and AC systems.
Luxembourg has implemented a performance check for heating systems under the name *Heizungscheck*[11].

As heat pumps will become the standard heating system (reference building), a performance check for these installations is currently under development.

2.IV.iii. Building Automation and Controls (BACs)

Requirements on building automation and electronic monitoring of technical building systems will be implemented by mid-2021 with the regulation concerning the energy performance of buildings. According to this future regulation, the building automation and control systems shall be capable of:

a. continuously monitoring, logging, analysing and allowing for adjusting energy use;
b. benchmarking the building's energy efficiency, detecting losses in efficiency of technical building systems and informing the person responsible for the facilities or technical building management about opportunities for energy efficiency improvement; and
c. allowing communication with connected technical building systems and other appliances inside the building and being interoperable with technical building systems across different types of proprietary technologies, devices and manufacturers.

2.IV.iv. Status and encouragement of intelligent metering

Since 1 July 2016, all new gas and electricity meters installed in Luxembourg are smart meters. From 2016 to 2020, the plan has been to replace all existing electricity and gas meters with smart meters. In order to optimise operating costs, all meters will be read via a central system managed by an entity set up by the grid operators, *Luxmetering GIE*[12]. Besides electricity and gas meters, the system will be open to other flows such as water and urban heat. The rollout of smart meters for electricity and natural gas will be practically completed in 2020, as almost all conventional meters have been replaced by smart ones.

Each customer has received information about the meter's functionality, its use and the use of its data. Frequently asked questions and a point of contact are available on each grid operator's website as well as in leaflets distributed to customers. In 2020, electricity and gas suppliers have started offering additional services based on the smart meter data.

2.IV.v. Progress and current status on heating systems (Inspection / Equivalence)

Luxembourg implemented inspection systems for all kinds of heating systems. The report on equivalence is therefore not needed.

The inspections of heating systems (gas-, oil- and wood-fired systems) are regulated by their respective regulations (gas, oil or wood regulations). After the reception procedure, a periodic control of the heating system (every four (4) years for gas-fired heating systems and every two (2) years for oil- and wood-fired heating systems) is mandatory.

The periodic controls are carried out by installers who have successfully completed special training and certification and own the necessary tools that allow them to perform the inspection in a professional and cost-effective manner.

The *Ministry of the Environment, Climate and Sustainable Development* created a specific website (www.heizungscheck.lu) and distributed an informational advertisement (flyer) at fairs and via other media. The flyer is dedicated to informing the public on all the different aspects of heating system inspections (legal requirements, environmental issues and cost-optimisation).

2.IV.vi. Progress and current status on AC systems (Inspection / Equivalence)

New AC systems are subject to a similar reception procedure as heating systems, carried out by the experts of the *Chamber of Skilled Trades and Crafts* (*Chambre des Métiers*).

In existing buildings, inspection of AC systems is performed by certified refrigeration mechanics.

Experts are certified after having completed special training courses. Certifications issued in other Member States can be recognised by the Minister of the Environment, Climate and Sustainable Development.

The inspection of AC systems is enforced by the *Environmental Administration*.

In order to support refrigeration mechanics in carrying out the evaluation of the overall efficiency and dimensioning of AC systems, the *Environmental Administration* has produced a guide on the energy efficiency of AC systems[13]. Complementing this guide, a comprehensive checklist summarises the main aspects of energy efficiency and associated recommendations. This qualitative assessment tool is best suited to deal with the high complexity of AC systems, as it allows refrigeration mechanics to judge on-site which aspects of energy efficiency are best suited to the individual AC system.

2.IV.vii. Enforcement and impact assessment of inspections

Enforcement and penalties

With respect to heating systems, non-compliance with the regulatory requirements can be penalised. If a craftsman fails to follow the reception procedure, or if an owner fails to do an inspection, sanctions (penalties of up to 25,000 € and imprisonment of two (2) months) could be applied. The relevant ministries regularly remind owners to meet their obligations and the *Chamber of Skilled Trades and Crafts* (*Chambre*

des Métiers) regularly exhorts its members to respect the legal procedures. There are no records on levied penalties.

For AC systems, sanctions for non-compliance with existing European and national legal requirements can be inflicted, e.g., by cancelling an authorisation, by fines of up to 500,000 € and/or imprisonment of up to one (1) year, depending on the kind and severity of the infringement.

Quality control of inspection reports

Reception and inspection reports are randomly checked and centrally registered. Inspection reports are controlled with respect to their conformity and in case of non-conformity, sanctions (penalties) can be imposed or administrative procedures can be initiated.

3. A success story in EPBD implementation

Directive 2010/31/EU introduced the concept of NZEB. For residential buildings, Luxembourg defined this concept as being in principle an A-A-rated building (heating energy demand and primary energy needs). Luxembourg decided to advance the application of the NZEB standard in comparison to the EPBD. The NZEB standard is mandatory as of 1 January 2017. The timeline for NZEB, which was published in 2012, provided the sector sufficient time to create and adapt the training offer (*Luxbuild* project[14] under the *BUILD UP Skills* initiative to train blue-collar workers as well as planners). Thanks to *LuxBuild2020*, Luxemburg's construction sector considers itself ready to build new residential buildings in nearly zero-energy standard from 2017 onwards. The main results of the project are:

- creation of centres of excellence for craftsmen based on a competency framework[15];
- innovative training concept: practical training, internal and external coaches, pedagogical tool;
- gateway *LuxBuild2020*: support services and tools.

The *LuxBuild2020* initiative made it possible to improve the professional skills in the field of energy efficient constructions and to develop and promote a broad offer of related training programmes. This training and education offer can be split into theoretical and practical on-site courses (within a 'test house'). The organisation of the offer is a continuous work-in-progress, which is monitored by the *Conseil national pour la construction durable* (CNCD) to constantly adapt and improve the available structures.

Additionally, the construction sector has created the platform *Neobuild*[16], with the mission to identify innovative technological and managerial concepts and to develop tools, methods and protocols for their implementation. As part of its mission, a testing laboratory was built containing over 100 different materials, products and systems. This zero-energy building, unique in Europe, offers many possibilities for life-sized monitoring and testing. The building is a complementary tool – a kind of living laboratory – to observe and analyse innovations in real-life conditions.

4. Conclusions, future plans

Luxembourg has fully transposed the EPBD and is promoting increasingly more energy-efficient buildings through regulations. The aim is to further develop the energy efficiency renovation policy by granting relevant aids and low-interest loans.

In September 2015, the Government of Luxembourg, the Chamber of Commerce and IMS Luxembourg jointly launched the strategic study titled, *The Third Industrial Revolution Strategy*[17], in close collaboration

with American economist Jeremy Rifkin and his team of experts. This process, using an open-societal innovation approach, was aimed at making the existing economic model more sustainable and interconnected for future generations. It resulted in a comprehensive strategic study and a summary-synthesis with recommendations on how to deal with all these new challenges.

The EU population growth will increase by 0.1% annually over the years 2013 to 2050, while Luxembourg's population could grow by 1.8% per year over that same period. The potential increase in population could provide an opportunity to build and scale up a new generation of buildings and accompanying infrastructures.

Concerning the building level, the results identified by the strategic study are detailed as follows: buildings connected to a so-called '*Energy Internet*' will play an increasingly important role in data handling, green power production and energy storage and will act as transport and logistic hubs that will rise to the next stage – a smart-energy Luxembourg. The building-out and scaling-up of a new generation of neighbourhoods and buildings can develop aggregate efficiency, increase productivity and reduce marginal costs as well as the ecological footprint.

Within a district/eco-neighbourhood, buildings will become nodes connected to every other surrounding building to allow families, businesses and communities to analyse big data flows along the value chains and to perfect algorithms and applications foreseen to improve the energy efficiency of the interconnected neighbourhood.

With regard to energy, RES-harvesting technologies like solar, wind, geothermal and biomass will need to be further developed and installed in and around residential, commercial and industrial sites to generate green electricity and heat/cold for immediate use within the concerned area, or to inject the energy surplus into the electricity, heating and cooling networks. Energy storage technologies, notably including batteries, hydrogen fuel cells and thermal storage tanks, will need to be further developed and installed alongside the RES-harvesting technologies to store intermittent green energy for use or sale back to the energy grids to ensure a reliable energy supply.

Over the last years, Luxembourg has installed a relevant number of public electric charging stations, which set the foundations for further commercial development of the charging infrastructure. Considering the charging stations per capita, Luxembourg is among the leading countries in Europe. By installing basic charging infrastructure under public authority, Luxembourg was able to set a national standard that avoids the development of different incompatible systems. The standardised system, the *Chargy network*, is the reference for future public and commercial charging infrastructure[18]. The *Chargy network* already includes a significant number of charging points invested by third parties and accessible to the public, known as *Chargy OK*. A subsidy programme for private charging stations is already in place[19], while a new subsidy programme for enterprises which is compliant with state aid rules is currently under development.

The EPBD revision in 2018 further introduced new requirements for electromobility infrastructure. Luxembourg recognises the importance of electromobility and will implement corresponding requirements that go beyond the EPBD 2018. The corresponding acts are in the legislative procedure and will be implemented by mid-2021. Working in this dynamic and future-oriented environment will improve the capacities and adaptability of the stakeholders to address the upcoming challenges.

Luxembourg is looking forward to an ambitious revision of the EPBD in 2021 with a special focus on the following topics:

- definition of an NZEB standard for existing buildings, which aims for deep renovation without being equivalent to the very ambitious NZEB standard for new buildings;
- introduction of binding/non-binding renovation obligations that depend on the type of building (residential, non-residential, age of building, ownership structure) in order to boost the renovation rate;
- requirements for the integration of renewable energy in buildings (PV-ready or similar);
- electrification of buildings combined with a timeline for the phasing-out of fossil heating and cooling systems.

Endnotes

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   Règlement grand-ducal modifié du 7 octobre 2014 relatif a) aux installations de combustion alimentées en combustible solide ou liquide d'une puissance nominale utile supérieure à 7 kW et inférieure à 20 MW b) aux installations de combustion alimentées en combustible gazeux d'une puissance nominale utile supérieure à 3 MW et inférieure à 20 MW ; legilux.public.lu/eli/etat/leg/rgd/2014/10/07/n1/jo;
   Règlement grand-ducal du 22 juin 2016 relatif a) aux contrôles d'équipements de réfrigération, de climatisation et de pompes à chaleur fonctionnant aux fluides réfrigérants du type HFC, HCFC ou CFC; b) à l'inspection des systèmes de climatisation ; legilux.public.lu/eli/etat/leg/rgd/2016/06/22/n3/jo.
10. *Loi modifiée du 10 juin 1999 relative aux établissements classés* ; legilux.public.lu/eli/etat/leg/loi/1999/06/10/n5/jo

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Annexes -Key Indicators & Decisions

Key Indicators & Decisions – General Background General KIDS

no	Key Implementation Decisions – General Background	Description / value / response	Comments
01.01	Definition of public buildings (according to article 9 b)	Since 1 January 2017, all new residential buildings are NZEB. By mid-2021, all new non-residential buildings will be NZEB.	
01.02	Definition of public buildings used by the public (according to article 13)	Since mid-2014, article 13 is transposed for all buildings.	
01.03	Number of residential buildings	142,820 (in 2017)	(STATEC 2017, REGARDS 13)
01.04	Number of non-residential buildings	Approx. 11-14 Mio m^2 (in 2020)	LTRS 2020
01.05	If possible, share of public buildings included in the number given in 01.04	Approx. 34%-44% (in 2020)	LTRS 2020
01.06	If possible, share of commercial buildings included in the number given in 01.04	Approx. 56%-66% (in 2020)	LTRS 2020
01.07	Number of buildings constructed per year (estimate)	Approx. 900,000 m^2/year	
01.08	If possible, share of residential buildings constructed per year (estimate, included in the number given in 01.07)	Approx. 78%	
01.09	If possible, share of non-residential buildings constructed per year (estimate, included in the number given in 01.07)	Approx. 22%	
01.10	Useful floor area of buildings constructed per year in million square meters (estimate)	Approx. 0.9 Million m^2/year	

Key Indicators & Decisions – New Buildings

no	Key Implementation Decision – New Buildings	Description / value / response	Comments
02.01	Are building codes set as overall value, primary energy, environment (CO_2), reference building or other	Limitations are prescribed via calculated values of heat energy demand and primary energy needs of a reference building.	
02.02	Requirements for energy performance of residential buildings in current building code	The requirements specific to a given building are determined by its corresponding reference building.	
02.03	Requirements for energy performance of non-residential commercial buildings in current building code	The requirements specific to a given building are determined by its corresponding reference building.	
02.04	Requirements for energy performance of non-residential public buildings in current building code	The requirements specific to a given building are determined by its corresponding reference building.	
02.05	Is the performance level of nearly zero energy (NZEB) for new buildings defined in national legislation?	Yes	
02.06	Nearly zero energy (NZEB) level for residential buildings (level for building code)	The requirements specific to a given building are determined by its corresponding reference building.	
02.07	Year / date for nearly zero energy (NZEB) as level for residential buildings (as indicated in 02.04)	1 January 2017	
02.08	Nearly zero energy (NZEB) level for all non-residential buildings (level for building code)	The requirements specific to a given building are determined by its corresponding reference building.	
02.09	Year / date for nearly zero energy (NZEB) as level for non-residential buildings (as indicated in 02.06)	Mid-2021	
02.10	Are nearly zero energy buildings (NZEB) defined using a carbon or environment indicator?	No, but an indicative value of a carbon indicator has to be calculated.	
02.11	Is renewable energy a part of the overall or an additional requirement?	Renewable energy is part of an overall requirement.	
02.12	If renewable energy is an additional requirement to NZEB, please indicate level	Not applicable	
02.13	Specific comfort criteria for new buildings, provide specific parameters for instance for airtightness, minimum ventilation rates	Airtightness, minimum ventilation rate, heat protection in summer	

Key Implementation Decision – Existing Buildings

no	Key Implementation Decision – Existing Buildings	Description / value / response	Comment
03.01	Is the level of nearly zero energy (NZEB) for existing buildings set in national legislation?	Not yet, in development	
03.02	Is the level of nearly zero energy (NZEB) for existing buildings similar to the level for new buildings?	Not applicable	
03.03	Definition of nearly zero energy (NZEB) for existing residential buildings (if different from new buildings)	Not applicable	
03.04	Definition of nearly zero energy (NZEB) for existing non-residential buildings (if different from new buildings)	Not applicable	
03.05	Overall minimum requirements in case of major-renovation	No	
03.06	Minimum requirements for individual building parts in case of renovation	Yes, the same minimum requirements as for new buildings	
03.07	National targets for renovation in connection to Long Term Renovation Strategy (number or percentage of buildings)	1.6% per year in 2030 for residential buildings	
03.08	National targets for renovation in connection to Long Term Renovation Strategy (expected reductions and relevant years)	1,827 GWh (final energy consumption (FEC) in 2020 - FEC in 2030) for residential buildings	

Key Implementation Decision - Energy Performance Certificates

no	Key Implementation Decision – Energy Performance Certificates	Description / value / response	Comment
04.01	Number of energy performance certificates per year (for instance average or values for of 3-5 years)	Approx. 1,500 (only new buildings)	
04.02	Number of EPCs since start of scheme	>20,000	
04.03	Number of EPCs for different building types	No details available	
04.04	Number of assessors	>200	
04.05	Basic education requirements for assessors	At least a bachelor level or a similar professional experience (min. 5 years) in the concerned domain	
04.06	Additional training demands for assessors	Defined under the *myenergy*-certified label (see 04.07)	
04.07	Quality assurance system	*Myenergy*-certified label (https://www.myenergy.lu/fr/experts/comment-devenir-conseiller-myenergy-certified	
04.08	National database for EPCs	Existing for residential building	
04.09	Link to national information on EPCs / Database	No public access, for internal use only (GDPR)	

Key Indicators & Decisions – Smart Buildings and Building Systems

no	Key Implementation Decision – Smart Buildings and Building Systems	Description / value / response	Comment
05.01	Is there a national definition of smart buildings?	No	
05.02	Are there current support systems for smart buildings?	No	
05.03	Are there currently specific requirements for technical building systems (for instance in building codes)?	Yes	
05.04	Are there current requirements for automatics (for instance in building codes)?	Yes, from mid-2021	
05.05	Chosen option A or B for heating systems (inspection or other measures)	A	
05.06	Number of heating inspections; reports per year (if option A)		
05.07	Chosen option A or B for cooling systems (inspection or other measures)	A	
05.08	Number of air-conditioning / cooling system inspections; reports per year (if option A)	Approx. 3,500	
05.09	Is there a national database for heating inspections?	Yes	
05.10	Is there a national database for cooling / air-conditioning inspections?	Yes	
05.11	Are inspection databases combined with EPC databases for registration of EPCs and inspection reports?	No	
05.12	Link to national information on Inspection / Database	No public access, for internal use only (GDPR)	

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