



# BETTER SCHOOLS – BETTER CLIMATE

## REFURBISHMENT GUIDE FOR ROMANIAN SCHOOLS



**BEACON** Bridging European & Local Climate Action

On behalf of:



Federal Ministry  
for the Environment, Nature Conservation  
and Nuclear Safety

of the Federal Republic of Germany



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The information and views set out in this guideline are those of the author(s) and do not necessarily reflect the official opinion of the Federal Ministry for the Environment, Nature Conservation and Nuclear Safety.

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# 1 Objectives of the guideline

Between 2018 and 2021 the project “Bridging European and Local Climate Action (BEACON)” supported energy saving measures in Romanian schools. It became evident that many Romanian school buildings have a very poor energy performance. In many cases school visits revealed the lack of basic technical system components such as thermostats, flow controls, or the possibility for nocturnal or weekend setback of indoor temperatures. The starting point for measures must, hence, be at a fundamental level.

This guideline shall support technical and administrative staff of local authorities in addressing the right measures for energy efficiency improvements of schools and where to apply for funding. It addresses key aspects for a successful implementation of energy saving measures and for efficient operations and maintenance afterwards.

This refurbishment guide has the following five objectives:

1. Tackles wide-spread basic deficiencies in technical building systems.
2. Presents measures and solutions that do not create lock-in effects, especially for subsequent implementation of deep renovation measures.
3. Provides an estimate of savings (energy, cost, greenhouse gases) typically related to these measures.
4. Links these measures with available funding in Romania.
5. Supports Romanian municipalities on their pathway to reduce greenhouse gas emissions and reaching climate targets.

## 2 How to read this guide

Chapter 3 presents in detail the energy related situation of the secondary school in Râmnicu Vâlcea, the “Școala Gimnazială Anton Pann”. The two buildings (school building and gym) function as reference building for the calculations in the scope of this study and all relevant data (energy consumption, energy costs etc.) in this guide is based on this school.

Chapter 4 refers to recommendation and measures for the optimization of school buildings. In chapter 4.1 we have described some general aspects of preparing and planning renovation works. In chapter 4.2 the scope is on a single classroom, with its indoor quality indicators, necessary for optimal learning and teaching activities. The data for this single room should be used to multiply it and to implement it within a period of time for the whole school.

In chapter 4.3 we determine the savings potential of the optimization measures of the technical building system according to the methodology of GUIDEHOUSE (2017)<sup>1</sup> for the “Școala Gimnazială Anton Pann”. We present the potential that can be exploited according to Article 8 of the EU regulation on Energy Performance of Buildings (EPBD), by bundling several single optimization measures into two different packages:

- a) *Get the basics right*-package and
- b) *High performance*-package.

While the *Get the basics right*-package bundles quick-win, “no-regret” measures, the *High performance*-package mainly adds more advanced building automation and control measures to it.

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<sup>1</sup> GUIDEHOUSE (formerly Ecofys) (2017): Optimising the energy use of technical building systems – unleashing the power of the EPBD’s Article 8.



The outcome of this analysis is a factsheet, containing information about the specific reference case (base case) and the saving potential for improving the building systems performance. The following activities have been conducted to assess the saving potential of “Anton Pann school”:

- Identification of a set of typical basic operation and maintenance deficiencies of heating, ventilation and lighting systems through interviews with project partners and technical/administrative staff of the school.
- Development of a preliminary set of suitable technical measures addressing also operation and maintenance aspects to improve the technical building systems as well as the indoor comfort.
- Check of eligibility of those preliminary measures for potential funding sources.
- Provision of a rough estimate of typical investment and savings (cost, energy, CO<sub>2</sub>).

Finally, in chapter 4.4 we have gathered information on the optimization of the building envelope, not based on the reference building “Anton Pann secondary school”, but on own calculations<sup>2</sup> in terms of different building standards and renovation targets.

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<sup>2</sup> By GUIDEHOUSE

### 3 Reference building

As reference building a secondary school with additional gym was chosen to illustrate a typical situation of Romanian schools. This school was renovated in 2017 prior to the activities conducted.

#### 3.1 Școala Gimnazială Anton Pann

The school complex of the Școala Gimnazială Anton Pann from Râmnicu Vâlcea has two buildings: The school building which has a total floor area of 4.175 m<sup>2</sup> was built in 1977 and the 1.628 m<sup>2</sup> gym which was constructed in 2008.

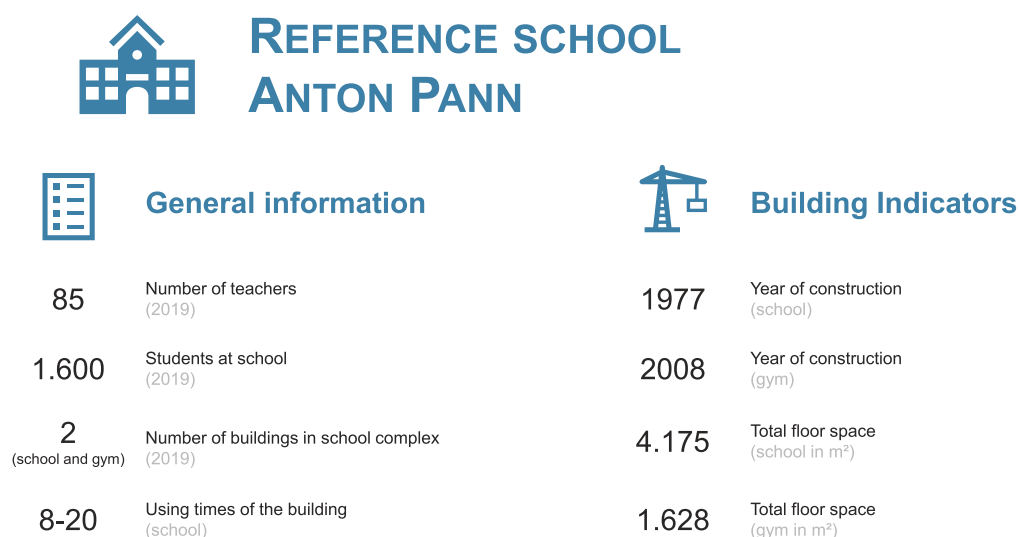


Figure 1: Reference school overview



*Figure 2: Școala Gimnazială Anton Pann from Râmnicu Vâlcea from outside (left) and inside (right)*

Both buildings were renovated in recent years to increase the energy efficiency and indoor quality: The school building's windows were replaced in 2005, followed by a renovation of the roof and façade in 2017 with thicker insulation. About 80% of the windows of the school gym were replaced with double glazed windows in 2019.



*Figure 3: Gym from inside and school from outside*

The heating source of the school building is not the same as that of the gym. The school building is connected to district heating and space heating is done through radiators, while the gym is heated by three central gas heating systems which also operate during weekends when the gym is used for other extracurricular activities. The flow temperatures for the space heating of the school building can be set manually. It is adjusted depending on outside temperature and individual preference. There are also strict indications from the municipality based on annual measurements, which are used for on and off steering of the system. Actual indoor temperatures during operation time are 26°C (summer) and 23°C (winter) in the school building and 24°C (summer) and 19°C (winter) in the gym.





*Figure 4: Heating system for the gym*



*Figure 5: Smart board and light blocked*

The school building is equipped with ten air conditioning systems located in classrooms that are exposed to high temperatures in summer, whereas the gym building only has two ventilation units.

The main light sources in the school building are old fluorescent tubes and LEDs in the gym building. No presence or daylight control sensors are installed in the school complex.

The following overview summarizes the current condition of Anton Panns chool as results of a survey and an energy tour by BEACON experts:










		School	Gym
 <b>General information</b>	Construction year of building	1977	2008
	Monumental protection	No	No
	Total floor space	4.175 m <sup>2</sup>	1628 m <sup>2</sup>
	Floor space of main use	2.400 m <sup>2</sup>	1100 m <sup>2</sup>
	Floor space of secondary use	1.775 m <sup>2</sup>	528 m <sup>2</sup>
	Average storey height	2,5 m	4,37 m
	Clear basement height	2 m	0 m
	Number of full storeys	3	1
	Roof type	Pitched roof, not heated (2017)	Flat roof
 <b>Insulation</b>	Wall construction	Multi-layered concrete wall with natural stone slabs	Lightweight construction
	Lower end of the building	Heated area	Heated area
	Exterior wall	25 cm before renovation 35 cm after renovation (2017)	5 cm
 <b>Windows</b>	Percentage of window area on facade	50% 100% single glazed (2005) 30% no sun protection 70% sun protection only inside	50% 100% wood/plastic double glazed (2019) No sun protection
	Actual interior temperature during operation time	26°C (summer) 23°C (winter)	24°C (summer) 19°C (winter)
 <b>Heating &amp; water</b>	Heated areas	> 90%	100%
	Heating type	District heating	Three gas condensing boilers (central heating system): • Two low-eff. boilers from 2005 • One high-eff. boiler 2015
	Heat transfer	Radiator	Ceiling (central) heating
	Hot water	Not available	Yes (produced by heating system)
 <b>Air conditioning</b>	Refrigerated areas	< 10%	None
	Number of AC systems	10 cooling generators	0
 <b>Ventilation</b>	Ventilated area	Not available	50-70%
	Ventilation type		2 ventilation units (supply and exhaust air)
	Significant openings	30 m <sup>2</sup>	30 m <sup>2</sup>
 <b>Lighting</b>	Presence/daylight control	Not available	Not available
	Main light source	Old fluorescent lamps	LED
	Specific installed lighting power	11,32 W/m <sup>2</sup>	20 W/m <sup>2</sup>
 <b>Renewable energy</b>	Solar heating	Not available	Not available
	Photovoltaic	Not available	Not available
 <b>Specific energy consumption (district heating)</b> <b>Specific energy consumption (electricity)</b> <b>Specific energy consumption (gas)</b>		76 kWh/m <sup>2</sup> (2019 – school)	-
			11 kWh/m <sup>2</sup> (2019 – school and gym)
		-	85 kWh/m <sup>2</sup> (2019 – gym)

Figure 6: Overview of information received via questionnaire

## 3.2 Energy consumption

The following charts show the consumption for space heating with district heat in the school building (7) as well as the natural gas consumption for space heating and hot water in the gym (8) and the overall electricity consumption in the school and the gym (9).<sup>3</sup> The graphs describe the usual annual bending, with some additional hot water consumption in summer in the gym.

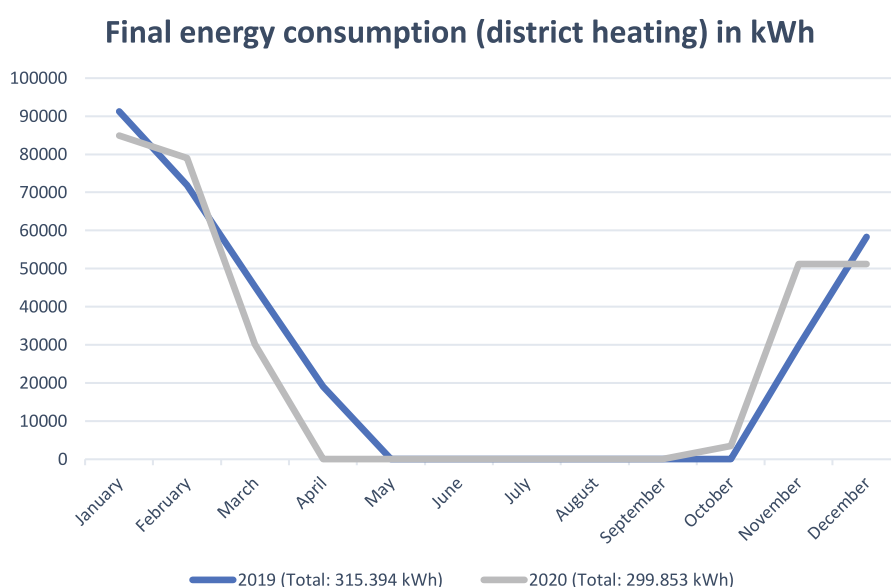


Figure 7: Final energy consumption (district heating) of the Anton Pann school building

<sup>3</sup> Due to Covid-19 and related school closures, energy consumptions in 2020 are lower than normal. Therefore we used the energy consumptions for 2019 for all further calculations.



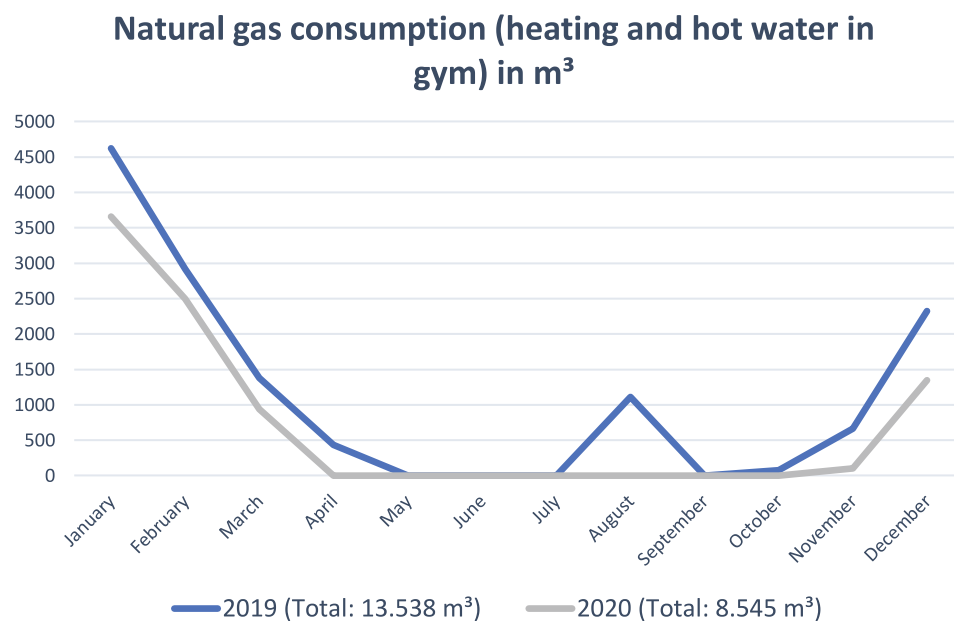


Figure 8: Natural gas consumption of the gym for space heating and hot water

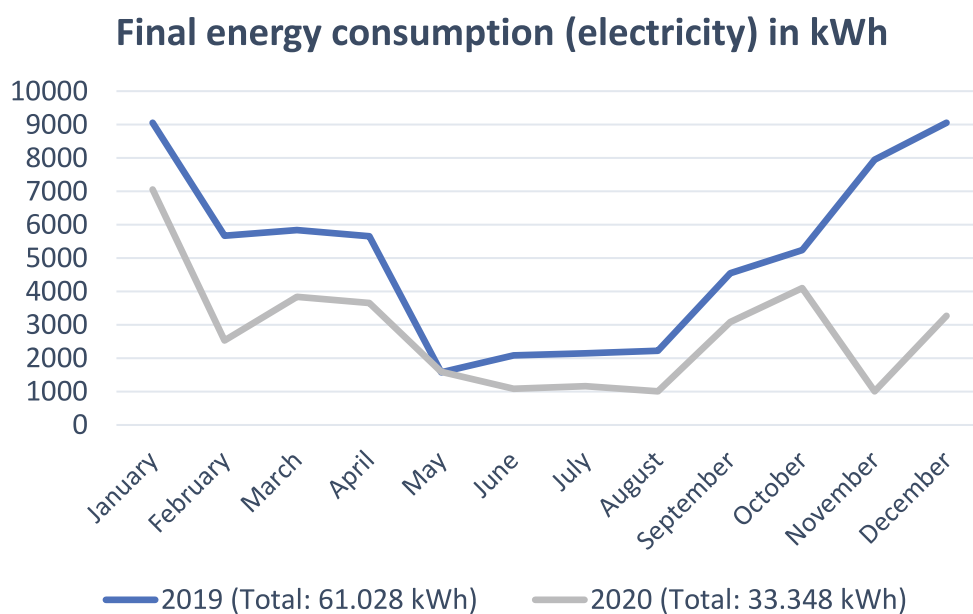


Figure 9: Final energy consumption (electricity)

### 3.3 Basic deficiencies








 <b>BASIC DEFICIENCIES ANTON PANN SCHOOL AND GYM</b>		
Technical Building System (TBS)	School	Gym
 <b>Heating</b>	<ul style="list-style-type: none"> <li>On/off thermostats only (ground floor)</li> <li>No thermostats at the second floor</li> <li>No automatic control system for heating</li> </ul>	<ul style="list-style-type: none"> <li>Low indoor temperature</li> <li>Low efficient heating systems</li> <li>On/off thermostats only - complicated regulation</li> </ul>
 <b>Cooling</b>	<ul style="list-style-type: none"> <li>High indoor temperature (25 degree)</li> <li>Manual setting of temperature of district heat by care-taker</li> <li>No solar shading</li> </ul>	<ul style="list-style-type: none"> <li>No solar shading</li> </ul>
 <b>Ventilation</b>	<ul style="list-style-type: none"> <li>Poor indoor air quality</li> <li>High CO<sub>2</sub> concentration on 1<sup>st</sup> and 2<sup>nd</sup> floor</li> <li>No ventilation system</li> </ul>	<ul style="list-style-type: none"> <li>2 ventilation system for training rooms, no AC</li> </ul>
 <b>Water</b>	<ul style="list-style-type: none"> <li>No hot water available</li> </ul>	<ul style="list-style-type: none"> <li>High water consumption</li> </ul>
 <b>Insulation</b>	<ul style="list-style-type: none"> <li>Heat pipes not insulated</li> <li>Roof not insulated</li> </ul>	<ul style="list-style-type: none"> <li>Heat pipes not insulated</li> <li>Lightweight construction</li> </ul>
 <b>Lighting</b>	<ul style="list-style-type: none"> <li>No presence/daylight control</li> <li>Iluminant: Old fluorescent tubes</li> <li>Daylight blocked by curtains</li> </ul>	<ul style="list-style-type: none"> <li>No presence/daylight control</li> </ul>

Figure 10: Overview of basic deficiencies in Anton Pann school complex

Figure 1 provides an overview of deficiencies that were captured during the energy tour and interviews at the school complex.

As a result, it was found that the main deficiencies in the school building are the non-regulability of the space heating as well as the high CO<sub>2</sub> concentration in classrooms, which has a negative impact on the overall indoor quality. The energy tour also revealed that the insulations of the heating pipes and the roof are not sufficient.

### 3.4 Saving potential

The overview below shows the energy consumption for the year 2019 (heat generation: district heat for the school building and gas boiler for the gym; overall electricity) for the school building and the gym and also refers to the specific final energy per m<sup>2</sup> of floor space.

*Table 1: Overview of specific energy consumptions*

	School	Gym
Floor area [m <sup>2</sup> ]	4.175	1.628
Final energy consumption (electricity) 2019 [kWh]	61.028	
Specific final energy (electricity) 2019 [kWh/m <sup>2</sup> ]	11	
Final energy consumption (district heating) 2019 [kWh]	315.394	-
Specific final energy <sup>4</sup> (district heating) [kWh/m <sup>2</sup> ]	81	-
Final energy consumption (natural gas) 2019 [kWh]	-	138.042
Specific final energy <sup>3</sup> (natural gas) [kWh/m <sup>2</sup> ]	-	91
<b>Total specific final energy consumption<sup>3</sup> [kWh/m<sup>2</sup>]</b>	<b>92</b>	<b>102</b>

The following tables show the main results of the optimization packages (final energy savings, energy cost savings, GHG (CO<sub>2</sub>) savings and investment) which can be applied in the school and the gym building.

The energy costs refer to the local price for electricity of 0,15 €/kWh (0,53 lei/kWh)<sup>5</sup>, the local price for district heat of 0,056 €/kWh ( 259 lei/Gcal) and the price for natural gas of 0,046 €/kWh (1,92 lei/m<sup>3</sup>)<sup>6</sup>.

<sup>4</sup> Climate adjusted

<sup>5</sup> Currency conversion: InforEuro, 04/2021, 1EUR = 4.921 RON

<sup>6</sup> Energy prices from the energy bills of Anton Pann school, 2021



The GHG-emissions (CO<sub>2</sub>) are based on the following indicators:

- Electricity<sup>7</sup>: 264,69 g CO<sub>2</sub>/kWh,
- Natural gas<sup>8</sup>: 239,85 g CO<sub>2</sub>/kWh,
- District heating (mainly coal based)<sup>9</sup>: 340g CO<sub>2</sub>/kWh.

The investment costs are based on data from the technical staff of the school and data from GUIDEHOUSE (2017)<sup>10</sup> with adjustments to the Romanian construction price index (Eurostat).

Reference building	Packages	Final energy savings [%]	Energy cost savings [EUR/a]	GHG savings [CO <sub>2</sub> /a]	Investment [EUR]
Anton Pann "school"	Get the basics right	15%	3.351 €	16	10.881 €
	High performance	38%	9.730 €	50	26.611 €

Table 2: Savings potential of optimisation packages school building

Reference building	Packages	Final energy savings [%]	Energy cost savings [EUR/a]	GHG savings [CO <sub>2</sub> /a]	Investment [EUR]
Anton Pann "gym"	Get the basics right	5%	477 €	2	1.382 €
	High performance	38%	3.651 €	15	10.506 €

Table 3: Savings potential of optimisation packages gym building

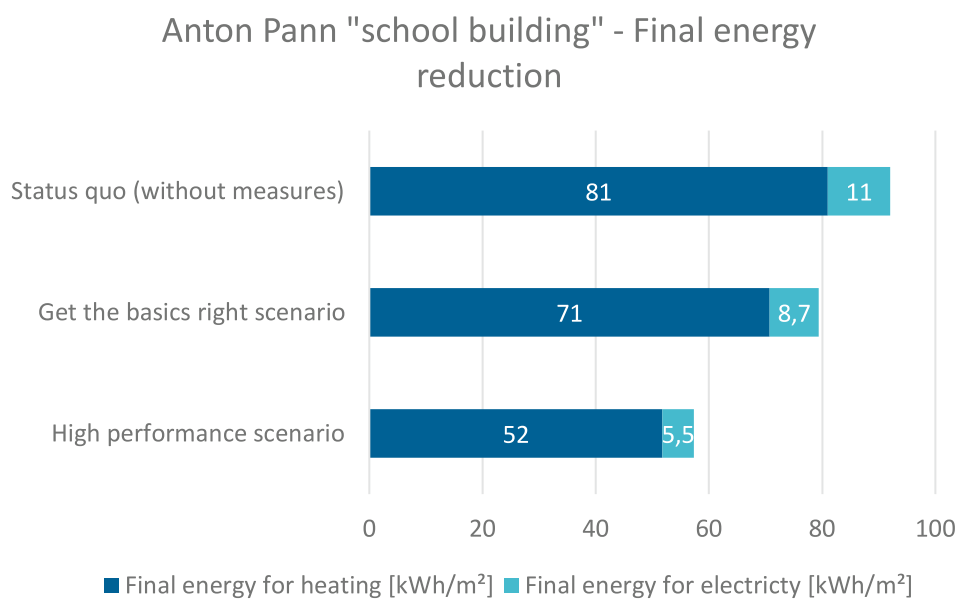
<sup>7</sup> Provided by the supplier to end customers in a competitive regime for 2019

<sup>8</sup> according to the Mc001 Methodology for calculating the energy performance of buildings from Romania

<sup>9</sup> For this study it was used the indicator 340g/kWh, which was taken as example from the DH system of city of Hamburg

<sup>10</sup> GUIDEHOUSE (formerly Ecofys) (2017): Optimising the energy use of technical building systems – unleashing the power of the EPBD's Article 8.

As shown in Table 2 and Table 3, the energy savings of a relevant amount can be reached by implementing the measures described in detail in chapter 4.3. These savings can be reached even in a school building, which is already partly renovated like Anton Pann school and has a lower consumption pattern. The final energy parameters for the school building are described in Figure 11.



*Figure 11: Overview of final energy consumption at Anton Pann school in status quo, get the basics right and high performance scenario*

## 4 Optimization of school buildings

### 4.1 Preparation and planning

#### 4.1.1 Analysis of the situation

To decide on the renovation measures of a school building it is advisable to take all relevant information related to the required work into account, in order to obtain a complete overview already before the planning has started. Relevant in this sense are:

- Energy data and construction plans of the respective building,
- Problems and malfunctions encountered within the building and the technical system,
- Overall quality of the school building and of the construction elements to be refurbished,
- Needs, expectations and capacities of the various actors (teachers, students, housekeeper, schoolmaster, municipality staff).

#### 4.1.2 Priorities and first steps

Firstly, behavioral aspects and technical optimization measures should be taken into account to reduce energy consumption. The following aspects should always go together with the renovation of a school building and its services:

- Make maximum use of natural or existing sources of heating, cooling and lighting
- Inform teachers and pupils about the functioning of the systems and their possible contribution to saving energy

Secondly, regulation and adjustment of building services (in terms of volume, temperature, time etc.) play a major role with regard to both comfort levels and energy saving.

Thus, technical aspects with high priority to be addressed in school building refurbishment are:

- The heating system and its regulation
- The ventilation and its regulation
- The lighting system and its control

Thirdly, the building envelope with its diverse materials of different quality should be optimized, according to the most urgent needs but with focus on the overall energy performance of the building. Most important is to avoid lock-in effects with measures of lower performance than required by the national energy performance standards. The decision on whether to renovate parts or the whole building should be based on previously implemented measures, the necessity for maintenance measures, the target energy performance of the building and the financing options available.

### 4.1.3 Works scheduling

To optimize the required work on the building, occupation periods of the building should be taken into account and the schedule should be adapted to the teaching activities. The following questions could help to develop an adequate schedule:

- What types of work are proposed? Structural work, demolition work, interior fitting out, utilities renewal, extension work, replacement of windows and doors, roof insulation etc.
- Is there space within the school or areas adjacent to the school to install that construction site's infrastructure?
- What sort of discomfort will those works involve (noise, dust, other)?
- What demands will those works impose in terms of supply and construction plant traffic?

These initial questions will enable the assessment of whether the refurbishment work can conceivably be carried out, while the school operates indoors.

There are several possible scenarios:

- Some classes might have to be relocated; the school may have adequate vacant premises to enable this relocation;
- The works proposed might be carried out in several phases, during school holidays or, on the contrary, they might have to be carried out over several consecutive months, in a single phase;
- The works proposed might require the school to be closed for several months and involve relocation of all teachers and pupils<sup>11</sup>.

## 4.2 Improvement of indoor comfort in classrooms

Looking from inside the classroom to renovation measures of school buildings, increasing well-being, comfort and quality of use are essential. The most important improvements are targeting the following aspects:

- Increasing thermal, acoustic and visual comfort
- Improving air quality
- Enhancing the quality of outdoor spaces and landscaped areas whether within the school or adjoining public areas
- Enhancing the building's functionality and quality of use increasing its adaptability and ease of maintenance

An improvement of the indoor comfort can be reached by implementing the following measures:

### 4.2.1 Cooling

Sun protection systems should be in place to provide adequate glare protection, keep away unwanted heat radiation and should provide the rooms with sufficient daylight.

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<sup>11</sup> Sustainable Refurbishment - School Buildings; A guide for Designers and Planners, IEA Solar Heating and Cooling Programme, 2014

Automatically controlled external blinds should serve as sun and overheating protection and additionally natural night ventilation (via windows or ventilation openings) can avoid overheating of central rooms.

### 4.2.2 Ventilation

CO<sub>2</sub> concentration has proven itself as a practicable indicator for assessing the indoor air quality. CO<sub>2</sub> is not a pollutant, but it is an excellent quality parameter because it is relatively easy to measure. Various studies have shown that learning ability and concentration decrease above 1,000 ppm. In a normal classroom, with the windows closed, it takes about 25 minutes for the CO<sub>2</sub> concentration to rise to 1,500 ppm<sup>12</sup>.

A sound solution for renovation is the installation of decentralized individual devices with heat recovery. However, the devices must be housed in the classroom and openings in the outer wall are necessary for the supply and exhaust air. The installation of exhaust air systems (exhaust fans) can be viewed as a further option for the subsequent installation of ventilation technology. Since only exhaust air pipes have to be laid, the space requirement for the pipes is reduced. However, no heat recovery is possible with these systems.

A more advanced ventilation concept includes decentralized devices, a highly efficient heat recovery of approx. 85% and enables demand-based control.

### 4.2.3 Lighting

According to the recommendation of the Lighting Technology Society (LiTG), illuminance levels of 600 lx horizontally and 300 lx vertically at 8,000 K (Kelvin) are appropriate for young people from the point of view of the biological (circadian) effect of light. With the relevant lighting systems in schools, the illuminance levels are designed for 300 lx in classrooms.

A daylight-dependent and occupancy-dependent control of the lighting in classrooms is recommended. Experience shows that automated systems are mostly only accepted if they can be easily overridden (by the teaching staff).

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<sup>12</sup> Energieeffiziente, energetisch nachhaltige und lernförderliche Sanierung von Schulgebäuden – Anhang, Fraunhofer-Institut für Bauphysik, 2013

<sup>13</sup> Energieeffiziente, energetisch nachhaltige und lernförderliche Sanierung von Schulgebäuden – Anhang, Fraunhofer-Institut für Bauphysik, 2013

## 4.2.4 Building automation

With the help of a building management system (BMS) it is possible to link the window ventilation, the regulation of the exhaust fans and the electromotive radiator valves with each other. The building services should be controlled by a building management system.

## 4.2.5 Overview of priority optimization measures in classrooms

Optimization measure	Final energy savings <sup>14</sup> [%]	Estimated investment costs (per classroom) [EUR]
<b>Heating: exchange of simple thermostats into thermostatic valves</b>	<b>8%</b>	<b>150</b>
Heating - Control of heat emitters provided by individual room control with communication	18%	260
<b>Lighting - Occupancy and daylight control</b>	<b>1%</b>	<b>130</b>
<b>Lighting - LED illuminants (medium quality)</b>	<b>2%</b>	<b>270</b>
Lighting - LED illuminants (premium quality)	2%	560
Cooling - Emitters control provided by Individual room control with communication	0.50%	130
<b>Cooling - External sun screens (3 windows of 4 m²)</b>	<b>4%</b>	<b>1800</b>
<b>Ventilation - Installation of ventilation system (exhaust fans)</b>		<b>4500</b>
Ventilation - Installation of ventilation system (with heat recovery)		18000
<b>Ventilation - Room control (all-air systems) - demand control (sensors measuring indoor air parameters)</b>	<b>4%</b>	<b>250</b>

Table 4 Final energy savings and invest costs of optimization measures in classrooms

<sup>14</sup> Estimation according to GUIDEHOUSE (formerly Ecofys) (2017): Optimising the energy use of technical building systems – unleashing the power of the EPBD's Article 8.



## 4.3 Improvement of the technical building system

The measures of the technical system that are recommended in this refurbishment guide are measures addressed under Article 8 of the EPBD and structured into the following four categories:

- Appropriate dimensioning (e.g. space heating and hot water circulation pumps)
- Proper installation (e.g. insulation levels of the space heating and hot water pipework)
- Adjustment (e.g. night setbacks for space heating and hot water, manual hydronic balancing)
- Automation, control and monitoring systems (e.g. active control/building automation and installation of modern thermostatic valves)

To further prioritize the different measures, they are bundled into two packages:

### **Package 1: Get the basics right optimisation**

In the *Get the basics right* package measures are included regarding appropriate dimensioning (of space heating and hot water circulation pumps), proper installation (concerning a higher insulation level of space heating and hot water pipework) system adjustments (such as night setbacks<sup>15</sup> for space heating and hot water, automatic hydronic balancing<sup>16</sup> and installation of modern thermostatic valves).

### **Package 2: High performance optimisation**

In the *High performance*-package measures of the *Get the basics right*-package are included, e.g. with even better insulation levels. Advanced automation and control and monitoring systems are added to this package (e.g. measures concerning boiler and pump optimisation and the installation of electronic thermostatic radiator valves).

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<sup>15</sup> Adjusted settings (from 11pm to 6am, 2K temperature reduction)

<sup>16</sup> Continuous control of flow and pressure in the piping system and radiators leading to an optimised generation, distribution and emission of heat throughout the building.

Table 5: Overview of optimization measures shows the main results (final energy savings, energy cost savings, GHG savings (CO<sub>2</sub>) and investment) per single optimization measure which can be applied in the school and/or the gym buildings and whether it is part of the *Get the basic right* and/or *High performance* package. Please note that the final energy savings (%) correspond to GUIDEHOUSE (2017)<sup>17</sup> and are based on the total final energy (heating, cooling, hot water, lighting, ventilation, auxiliary energy). Therefore, measures with a high impact within their category (e.g. occupancy control within lighting) can show saving percentages that may seem low at first sight as the space heating demand dominates the total final energy demand.

All other results of Table 5 relate to the data of the reference building “Anton Pann Secondary school”.

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<sup>17</sup> GUIDEHOUSE (formerly Ecofys) (2017): Optimising the energy use of technical building systems – unleashing the power of the EPBD’s Article 8.

Table 5: Overview of optimization measures

Optimization measure	Scope [school / gym / both]	Final energy savings <sup>18</sup> [%]	Energy cost savings [EUR/m <sup>2</sup> ]	GHG savings CO <sub>2</sub> _eq [g/m <sup>2</sup> ]	Estimated investment costs - school [EUR]	Estimated investment costs - gym [EUR]
<b>Package 1: Get the basics right</b>						
Proper dimensioning of pumps (space heating and cooling)	both	0.5%	0.03	122	500	500
Pipework of heating distribution system: Better insulation (accessible at nonheated zones, min. 100% of diameter)	both	0.5%	0.03	156	480	300
Adjustment of pump volumes (automatic space heating and cooling)	both	0.5%	0.03	156	48	48
Adjustment of system temperatures (space heating and cooling)	both	0.5%	0.03	156	72	72
Adjustment of heating and cooling supply (night/holiday/weekend switch-off)	both	1%	0.06	312	72	72
Heating - Exchange of simple thermostats	school	8%	0.49	2498	5000	-
Lighting - Occupancy control	both	1%	0.06	243	1069	130
Lighting - Daylight control	both	1%	0.06	243	3640	260

<sup>18</sup> Estimation according to GUIDEHOUSE (formerly Ecofys) (2017): Optimising the energy use of technical building systems – unleashing the power of the EPBD's Article 8.

Optimization measure	Scope  [school / gym / both]	Final energy savings <sup>18</sup>  [%]	Energy cost savings  [EUR/m <sup>2</sup> ]	GHG savings  CO <sub>2</sub> _eq [g/m <sup>2</sup> ]	Estimated investment costs - school  [EUR]	Estimated investment costs - gym  [EUR]
<b>Package 2: High performance</b>						
Pipework of heating distribution system: Better insulation (accessible at nonheated zones, 200% of diameter)	both	0.75%	0.05	234	640	400
Heating - Boiler - use weather compensation (supply/return temperature)	both	11%	0.68	3434	4487	4487
Heating - Control of heat emitters provided by individual room control with communication	both	18%	1.11	5620	7280	520
Lighting - LED illuminants	school	2%	0.12	486	7560	-
Cooling - Use of weather compensation (supply/return temperature)	school	0.5%	0.03	122	598	-
Cooling - Optimum start/stop	school	0.5%	0.03	122	144	-
Cooling - Emitters control provided by Individual room control with communication	school	0.5%	0.03	122	500	-
Ventilation - Room control (all-air systems) - demand control (sensors measuring indoor air parameters or adapted criteria (e.g. CO <sub>2</sub> , mixed gas or VOC sensors))	gym	4%	0.23	1078	-	4016
Ventilation - Installation of ventilation system	gym	Increases indoor quality without direct energy cost savings.				

In the context of this guideline we have considered two standards:

- The „retrofit average“ standard refers to the (cost optimized) standard for building renovation according to the specific energy performance regulation of Romania.
- The „retrofit zero emission“<sup>20</sup> standard is more ambitious and refers to the EnerPHit standard of the Passivhaus Institute.

The respective standards can be reached with insulation or exchange of building elements of a specific quality, meeting the heat transmission coefficient (U-value) as shown in Table 6.

Quality of building element	Retrofit average U-value [W/m <sup>2</sup> K]	Retrofit zero emission [W/m <sup>2</sup> K]
U-value (wall)	0,27	0,18
U-value (window)	1,14	0,85
U-value (slab)	0,30	0,36
U-value (roof)	0,25	0,12

Table 6: U-values of building elements according to retrofit standard

Table 7 shows possible useful energy<sup>21</sup> savings for heating and cooling by a complete renovation of the building envelope, depending on the preliminary construction date, the state of former renovation and the targeted renovation standard.

<sup>20</sup>Overall retrofit plan for step-by-step retrofits to EnerPHit Standard; Passivhaus Institut, April 2021, [https://passipedia.org/planning/refurbishment\\_with\\_passive\\_house\\_components/overall\\_retrofit\\_plan\\_for\\_step-by-step\\_retrofits\\_to\\_enerphit\\_standard](https://passipedia.org/planning/refurbishment_with_passive_house_components/overall_retrofit_plan_for_step-by-step_retrofits_to_enerphit_standard)

<sup>21</sup> Useful energy describes the heating and cooling demand of the building without considering the energy system.

## 4.4 Refurbishment of the building envelope

Sustainable refurbishment of school buildings demands the optimisation of the envelope of the building with regard to energy savings as well as to thermal, visual and acoustic comfort it shall provide. The basic aspects a low energy building should fulfil in terms of more balanced indoor climate means:<sup>19</sup>

- Reducing heating needs in winter
- Avoiding overheating and use of air conditioning in summer
- Enabling a degree of self-sufficiency in mid-season

To accomplish a comprehensive renovation of the building envelope, the following elements must be taken into account as far as possible:

- Replacement of defective or inefficient glazing and window frames
- Improving insulation and airtightness of the solid envelope (walls, roof, basement, doors)
- Protecting south- east- and west-facing openings against solar gains and glare

Important for the planning of refurbishment measures is the initial situation of the building. Depending on the original construction date and thus the age of the building, as well as already implemented retrofit measures, different starting points in terms of its energy consuming condition are usually the case. Also, different targets regarding the favoured renovation standard are relevant for the kind and scope of measures.

Whether the respective retrofit measures (thickness of insulation, quality of windows etc.) are following the current national renovation standards or are heading towards a more ambitious standard, like the zero emission building standard, need to be determined in advance.

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<sup>19</sup> IEA Solar Heating and Cooling Programme (2014): Sustainable Refurbishment - School Buildings; A guide for Designers and Planners

Age group building	Current state of building	Optimization standard	Useful energy savings (Heating demand) [%]	Useful energy savings (Cooling demand) [%]
Pre 1945	Non renovated building	Retrofit average	59	37
Pre 1945	Already renovated building	Retrofit zero emission	43	22
1945-1990	Non renovated building	Retrofit average	54	33
1945-1990	Already renovated building	Retrofit zero emission	29	18
1991-2020	Non renovated building	Retrofit average	28	17
1991-2020	Already renovated building	Retrofit zero emission	25	9

Table 7: Useful energy savings according to building age and renovation standard

The respective investment costs of the various retrofit measures need to be inquired from local companies. Table 8 provides an estimate of potential investment costs in Romania.

Optimization measure	Estimated investment costs <sup>22</sup> [EUR/m <sup>2</sup> ]	Estimated investment costs [lei/m <sup>2</sup> ]
Windows	180-350	887 - 1724
External walls	80-100	394 - 492
Roof	70-80	344 - 394
Basement	25	123
External sun screens	150	739

Table 8: Investment cost building elements

<sup>22</sup> GUIDEHOUSE (formerly Ecofys) (2016): Ex-ante evaluation and assessment of policy options for the EPBD



## 5 Eligibility for available funding of optimization measures

The national “Program for Increasing Energy Efficiency and Intelligent Energy Management in Public Buildings” managed by Environmental Fund Administration provides financial support to the renovation of school buildings in Romania<sup>23</sup>. The program is multi-annual and focuses on diverse sets of measures to increase the energy efficiency of school buildings:

### **A. Thermal rehabilitation works of the building's envelope elements**

This includes thermal insulation of exterior walls, roofs and floors over unheated ground/basements as well as all glazed parts of the facades (windows).

### **B. Ensuring the heating system / hot water supply system**

This includes replacement of the distribution system of heat or hot water, including its thermal insulation, as well as the installation of automatic valves. And the replacement of the boiler or the installation of a new heating system and new hot water supply system. The balancing of thermal installations with thermostatic head valves is eligible as well.

### **C. Rehabilitation / modernization works of lighting installations in buildings**

This includes modernization of the lighting system and replacement of luminaires with high energy efficiency LEDs combined with presence sensors.

### **D. Installation/modernization works for air conditioning and / or mechanical ventilation systems**

This includes mechanical ventilation or hybrid ventilation with thermal energy recovery in a proportion of at least 75% with centralized units or individual units.

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<sup>23</sup> The program is under review (05/2021) and it has changed its name. Other things might be changed as well.

**E. Installation of alternative systems for the production of electricity and / or heat for own consumption**

This includes installation of decentralized energy supply systems using renewable energy sources, such as solar thermal panel installations, and / or photovoltaic solar panels, micro power plants operating by high efficiency cogeneration, heat pumps, biomass cogeneration plants, ground-to-air heat exchangers, heat recuperators, etc.

**F. Integrated energy management systems**

This includes installation of intelligent energy metering, monitoring and recording systems and the installation of integrated energy management systems.

All measures must be based on the DALI<sup>24</sup> and the technical design, taking into account a technical expertise report or an energy audit.

**Objective eligibility**

The building or ensemble of buildings for which a financing application is submitted, has not received public funding from the state budget or European funds in the last 5 years and the energy audit estimates a percentage reduction of the total final energy consumption of at least 10%.

**Performance indicators**

Reduction of the annual final energy consumption and estimated annual reduction of greenhouse gases (equivalent to tons of CO<sub>2</sub>).

**Funding**

The maximum amount that can be requested is :

- a) 1,500,000 Lei for the local authority with a population of up to 5,000 inhabitants
- b) 3,000,000 Lei for the local authority with a population of over 5,001 inhabitants.

This represents the sum that a municipality can request per grant application, the sum can cover several investment objectives or just one. The funding is granted for up to 90% of the eligible expenditure of an investment objective.

More info: [https://www.afm.ro/eficienta\\_energetica\\_scoli\\_ghid\\_finantare.php](https://www.afm.ro/eficienta_energetica_scoli_ghid_finantare.php)

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<sup>24</sup> Digital Addressable Lighting Interface (DALI) is a trademark for network-based products that control lighting.

## 6 Conclusion

As the case of the reference building “Școala Gimnazială Anton Pann” is illustrating, the energy consumption can be reduced to a high extent (~40%) by optimizing the technical systems, even if major parts of the building envelope are already renovated. A building with a lower energy efficiency standard, has even a higher potential to reduce the overall energy consumption. The amount of energy, necessary to guarantee an optimal indoor climate, can be reduced by up to 60% in space heating demand, as well as over 30% in cooling demand.

Around 17% of non-residential buildings in the EU are educational buildings.<sup>25</sup> Thus, energy efficiency renovation and optimization of school buildings is not only revealing a high CO<sub>2</sub> saving potential with relevant effects on the global climate and the aim of a decarbonised buildings stock by 2050, but also supports well being, health and education opportunities of children and young.

A prerequisite for a successful building optimization and renovation is extensive knowledge about the building’s quality, its conditions and current operation processes.

It is advisable to sort the measures according to their urgency. The planning of all activities needs to be categorized into short-term priorities as well as medium and long-term measures, and to be scheduled accordingly. Important is an effective deep renovation status as final destination in view of a zero carbon building standard in 2050, whether it’s reached via staged renovations or a complete onetime remodelling of the building.

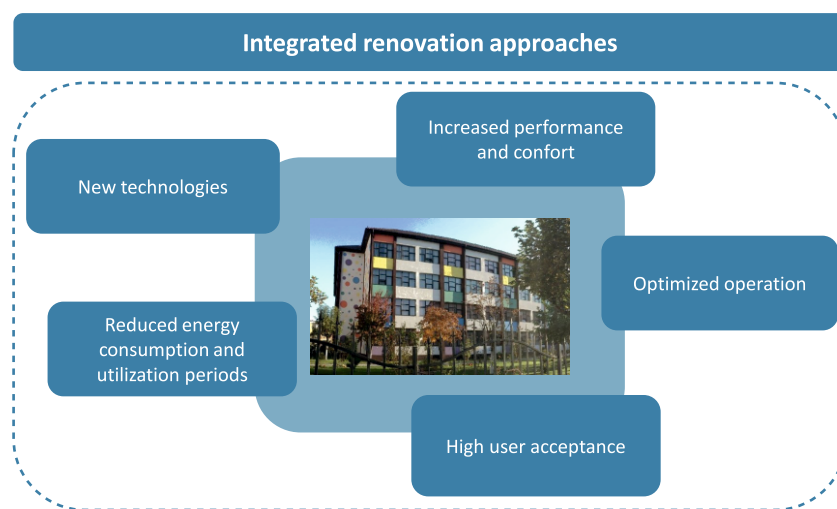
The main goal of a renovation may be a certain energy performance standard (e.g. zero emission building) and certain requirements for indoor functions and qualities. Minimum standards are provided by the European building legislation framework EPBD <sup>26</sup>, implemented by the national regulations, which address renovations by setting minimum performance requirements at cost-optimal levels for major renovations of individual building elements and technical building systems.

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<sup>25</sup> D. Österreichischer, S. Geissler; Refurbishment in educational buildings – methodological approach for high performance integrated school refurbishment actions, 2016

<sup>26</sup> Energy Performance of Buildings Directive

Only taking all relevant aspects of the building into account, like user behaviour, operation process, comfort and user requirements, physical quality, energy supply and energy consumption, climate-friendliness, investment costs and financing etc., will lead to an integrated approach.



*Figure 12: Integrated renovation approaches*

Despite careful planning, a permanent monitoring that begins with the final inspection is necessary. With regard to the maintenance of the technical system, the caretaker or an external company should be assigned to guarantee a regular service.

Information and participation of all those involved are also indispensable requirements for the handling of renovated buildings. Instructions and a joint assessment not only convey an understanding of concepts and details, they also ensure conscious handling. A high quality equipment cannot develop its positive effect without clear usage instructions.

The high visibility and role model function of school buildings require specific attention. There is a need for research from a structural and energy-related point of view to support renovation concepts for individual schools. A breakdown of the national school building stock according to type, age and state of construction and renovation in connection with overall concepts worked out in terms of energy, economy and function and architecture would support a holistic renovation strategy.

## 7 APPENDIX

### 7.1 Definitions

#### **Definitions Technical Building System (TBS)**

“Technical building system’ means technical equipment for the heating, cooling, ventilation, hot water, lighting or for a combination thereof, of a building or building unit; ...” (Source: EPBD recast 2010, Article 2 (3.))

#### **Building Automation and Control System (BACS)**

“System, comprising all products and engineering services for automatic controls (including interlocks), monitoring, optimization, for operation, human intervention, and management to achieve energy– efficient, economical, and safe operation of building services. NOTE 1 The use of the word ‘control’ does not imply that the system/device is restricted to control functions. Processing of data and information is possible. NOTE 2 If a building control system, building management system, or building energy management system complies with the requirements of the EN ISO 16484 standard series, it should be designated as a building automation and control system (BACS).” (Source: EN ISO 16484-2:2004, 3.31)

## 7.2 EPBD reference

Several regulations to promote energy efficiency of technical building systems are already in place on European level:

- Article 1 c (iii) EPBD clearly requires "the application of minimum requirements to the energy performance of ... technical building systems whenever they are installed, replaced or upgraded"
  - this puts an emphasis on TBS, as the overarching requirement in Article 1 for the application of minimum requirements to the energy performance of new buildings and existing buildings in practice will be met by both the building envelope and the technical building systems,
  - furthermore, it explicitly does not restrict requirements for technically building systems to new buildings or major renovations but to all cases where technical building systems are installed, replaced or upgraded ("whenever");
- Article 2 EPBD provides a definition for technical building systems including heating, cooling, ventilation, hot water, lighting or a combination thereof.
- Article 8 EPBD, "Technical building systems" asks for system requirements for technical building systems "which are installed in existing buildings".
- Article 14 and 15 EPBD set requirements for the inspection of heating systems and air conditioning systems.
- Ecodesign implementing regulations set efficiency requirements for products like boilers and pumps. As these will be used as parts within technical building systems, they indirectly influence their efficiency.
- Energy labelling delegated regulations such as the one on space heaters.

Article 8 EPBD "Technical building systems" is meant to be the central article to promote the exploitation of the untapped energy efficiency potential of technical building systems in all existing buildings.

Article 8 (1) currently says:

"Member States shall, for the purpose of optimizing the energy use of technical building systems, set system requirements in respect of the overall energy performance, the proper installation, and the appropriate dimensioning, adjustment and control of the technical building system which are installed in existing buildings. Member States may also apply

these system requirements to new buildings. System requirements shall be set for new, replacement and upgrading of technical building systems [...] The system requirements must cover at least (a) heating systems; (b) hot water systems; (c) air-conditioning systems; (d) large ventilation systems; or a combination of such systems.”

Article 8 specifies what was already mentioned in Article 1: requirements need to be set for new, replacement and upgrading of technical building systems, i.e. not just in case of major renovations. Furthermore, these requirements "shall be applied in so far as they are technically, economically and functionally feasible". While Article 8 makes it mandatory for Member States to set system requirements for technical building systems in existing buildings, Member States only may do so in new buildings.

The following table provides a systematic overview about the systems that according to Article 8 at least need to be addressed and the aspects that system requirements need to encompass for the purpose of optimizing the energy use of technical building systems.

*Table 9: Overview of (minimum) coverage of system requirements*

	Heating	Domestic hot water	Air conditioning	Large ventilation systems	Combination of such systems (alternative)
Overall energy performance	X	X	X	X	
Proper installation	X	X	X	X	
Appropriate dimensioning	X	X	X	X	
Appropriate adjustment	X	X	X	X	
Appropriate control	X	X	X	X	