Interreg
CENTRAL EUROPE
ENERGY@SCHOOL

European Union
European Regional Development Fund

ENERGY AUDIT REPORT SCUOLA MEDIA INFERORE (SECONDARY SCHOOL) "RENATO EMALDI" - FUSIGNANO (RA) REQUIRING DEVELOPMENT OF AN ENERGY GUARDIAN SMART SCHOOL MANAGEMENT PLAN

N. DELIVERABLE D.T2.1.1

Version 01

20 06 2017

http://www.interreg-central.eu/Content.Node/ENERGYATSCHOOL.html

Edited by Unione Bassa Romagna

In cooperation with Naxta Ltd

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1. Background

In Fusignano (RAVENNA - Italy) there are 4 municipal schools. In 3 of them, a systematic inventory was carried out in the autumn of 2016, on the initiative of the European research project energy@school, on the basis of which a comprehensive report of the inventory of each city was prepared (Deliverable D.T1 .1.3, January 30, 2017, edited by CertiMaC, Italy).

The goal of ENERGY @ SCHOOL is to simplify the introduction of smart energy schools. With an integrated approach, teachers and students are trained as Senior and Junior Energy Guardians (EGs).

They are committed to a sustainable increase in the energy efficiency of buildings and an understanding of the appropriate energy consumption ("energy culture") of a school building.

ENERGY @ SCHOOL aims to achieve the following results:

I. Optimization of energy consumption in schools,
II. Concrete and progressive increase of EE and RES use in schools not only thanks to technical application of smart solutions, but also to non-technical factors such as a better management capacity and responsible behavior toward energy use,
III. Increase of capacity of public sector to deal with increase of EE and RES use in schools thanks to strategy, action plans, tools (methods, approaches), trainings, pilot actions defined and implemented within the project,
IV. Increase in managerial and organizational competences as well as in human resources to ensure the progressive and sustainable energy efficiency and renewable energy se in public schools (trainings),
V. Creation of conditions for new job opportunities (trainings),
VI. Creation of “energy culture”, thus responsible attitude towards energy use, thanks to education and raising awareness activities, as it is demonstrated that amount of saved energy can noticeably increase if energy retrofit interventions are associated to behavioral changes.

In the research project, 12 project partners (PP) from seven Central European countries are represented:

PP 1. Union of Municipalities of Low Romagna Region , Lead Partner – Italy
PP 2. CertiMaC s.c.r.l. - Italy
PP 3. City of Bydgoszcz - Poland
PP 4. ENERGY AGENCY OF SAVINJSKA, ŠALEŠKA AND KOROŠKA REGION - Slovenia
PP 5. City of Karlovac - Croatia
PP 6. University of Bologna - Dept of Industrial Chemistry - Italy
PP 7. Municipality of the CITY Szolnok with County Rank - Hungary
PP 8. Local Government of Town Újszilvás - Hungary
PP 9. City of Stuttgart - Germany

PP 10. Klagenfurt - Austria
PP 11. Graz Energy Agency - Austria
PP 12. City Municipality of Celje - Slovenia

From the examined schools, five schools joined up to be actively involved in energy@school.

These schools receive an individual report on the energy audit with this document. This report is intended to serve as the basis for the development of an energy action plan (Energy Guardian Smart School Management Plans - EGSMPs) to the school's managers and, in addition to inventory analysis, includes investive and non-investive measures for energy saving.

These actions help to develop individual actions in the respective school and a common strategy for smart schools (CSSS).

Further information are available at the following link **http://www.interreg-central.eu/Content.Node/ENERGYATSCHOOL.html**

2. Summary

The examined school had an average energy performance indicator of electricity of 34,38 kWh/m² per year and 27.09 m3 of natural gas per year for m2. The share of renewable energies in the electricity sector is 0 % in the heating sector 0 %.

Energy Performance Indicators

		Total consumption per year	Consumption per volume	Consumption per heated area	Consumption per classrooms area	Consumption per number of students	Consumption per number of days	Total energy consumption per year	kg CO2 equivalent per year	Tonnes of oil equivalent per year
Energy carrier/Fuel/ Power source	u.m.	u.m.	u.m./m³	u.m./m²	u.m./m²	u.m./student	u.m./day	kWh	kg CO_2 equiv	tep
Electricity	kWh_{el}	66695	5,73	34,38	54,83	323,76	226,85	66695	28892	12
Natural gas	Sm3	52553	4,51	27,09	43,20	255,11	178,75	504508	10500	44
Fuel oil/Diesel	t	0						0		0
GPL	t	0						0		0
Biomass	t	0						0		0
District heating	kWh_t	0						0		0
District cooling	kWh_f	0						0		0
Photovoltaics	kWh_{el}	0						0		0
Solar thermal collectors	kWh_t	0						0		0
Geothermal	kWh_t	0						0		0
Other - energy produced	0	0						0		0
Tonnes of oil equivalent	tep	56,41	0,00	0,03	0,05	0,27	0,19		39392	56

Table 1 - Energy performance indicators

The following measures are recommended for the order of implementation.

Measure	Investment costs €	energy savings kWh/a	cost savings €/a	return of invest a	Kg CO_2-savings to (CO_2)/a
Measure 1: Retrofit external walls with insulation	**723.133,00**	414.506,15	24.279	29,8	6.930
Measure 2: Replace lights with LED	**6.525**	10.128 (-57%)	2.430,72	2,7	4387
Measure 3: Install Energy Saving Switch and Presence Sensors	**12.500**	1780 (-10%)	427,2	29	771
Measure 4: Install a photovoltaic system	**32.000,00**	22.000	5.280	6	9.530
Measure 5: Install a solar thermal system	**2.400**	1.600	120	20	33
Measure 6: Install building automation system (automatic centralized control of a building's heating, ventilation and air conditioning, lighting...)	**48500**	(10%) 69.282,50	5.929	8,2	3939
Measure 7: Change end-user behaviour: control devices stand-by (monitors, PCs, laboratory equipment, lights, etc.)	**0**	(5%)	2.964,5	0	1969,5

3. Generalities of the school

Figure 1 1 shows the Scuola media inferiore “Renato Emaldi” – Fusignano (Secondary School). School building was built in several steps: first block in 1900, following several exlargement in 1920, 1960 and a refurbishment of the south facace.

Fig 1 - Renato Emaldi Secondary School

GENERALITIES

School type	Secondary
Student age range	11-14

GEOGRAPHICAL LOCATION AND WEATHER CONDITIONS

Country	Italy
City	Fusignano (RA)

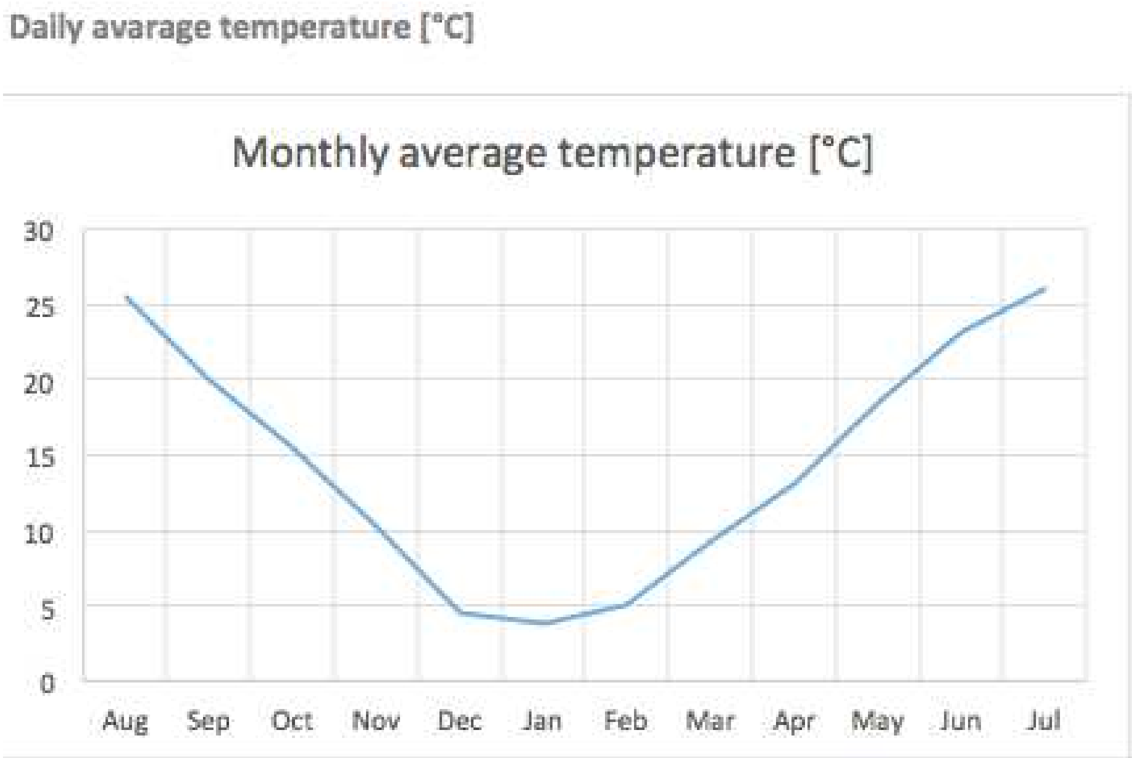
BUILDING GEOMETRY

Total floor heated area [m^2]	1940
Volume [m^3]	11640
S/V	0,62

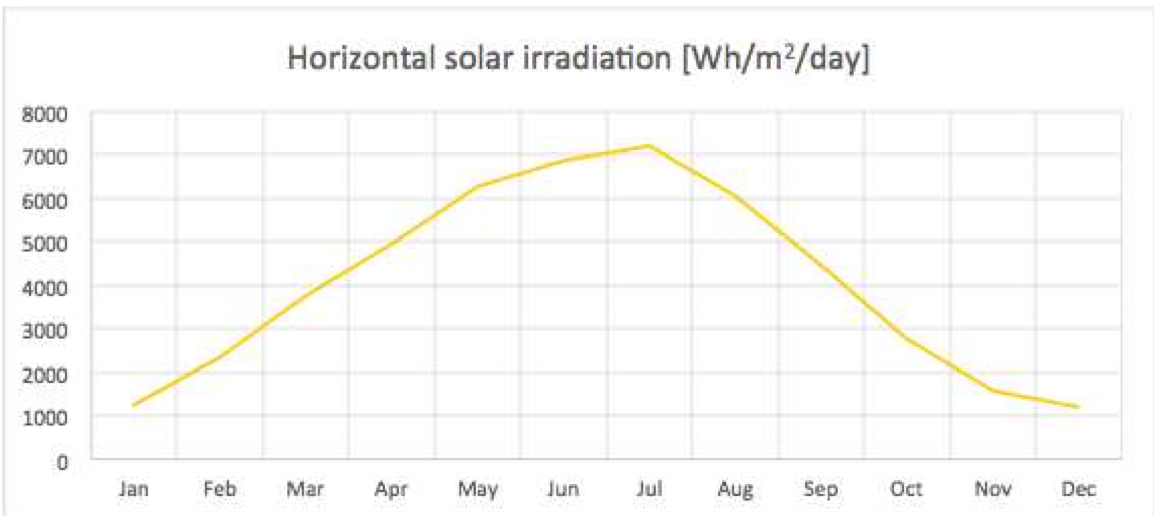
OCCUPATION AND USE OF THE BUILDING

Number of students	206
Total days of use	294
Daily hours of use	8
Total area allocated to classrooms [%]	64

General information about the climate



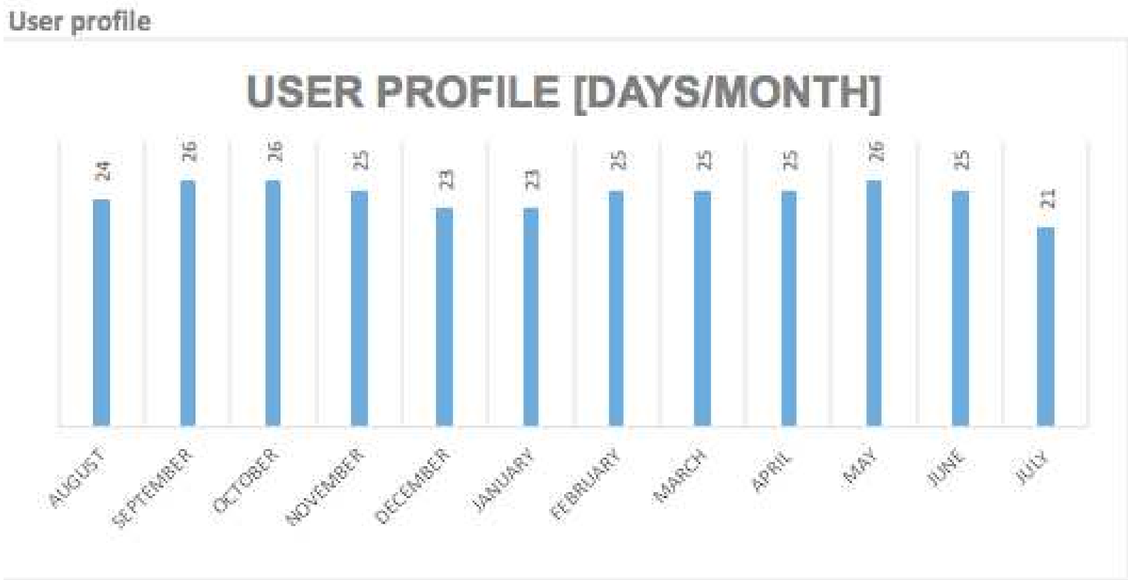
Picture 2- Graphic representation of monthly average temperature [˚C]



Picture 3 - Graphic representation of the Horizontal solar irradiation [Wh/m^2/day] per Months. This value is the monthly/yearly average of the sum of the solar radiation energy that hits one square meter in a horizontal plane in one day.

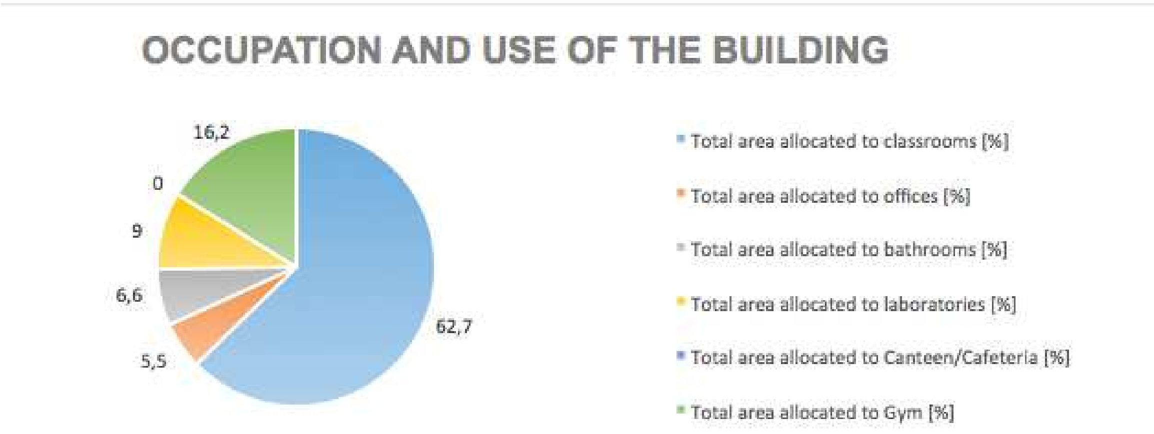
General information about the use of the school

Picture 4 shows the school's use profile and the holiday's period. In total the school comes on 294 (Saturday included) days of operation.



Picture 4 - Graphic representation of the user profile during school period [working days/month]

Picture 5 shows the different uses in the school building. 62,7% of the area is allocated to classrooms. 16,2 % of the area is Gymnasium, 9% to laboratories and 6,6% to bathrooms laboratory space for e.g. physics or chemistry.

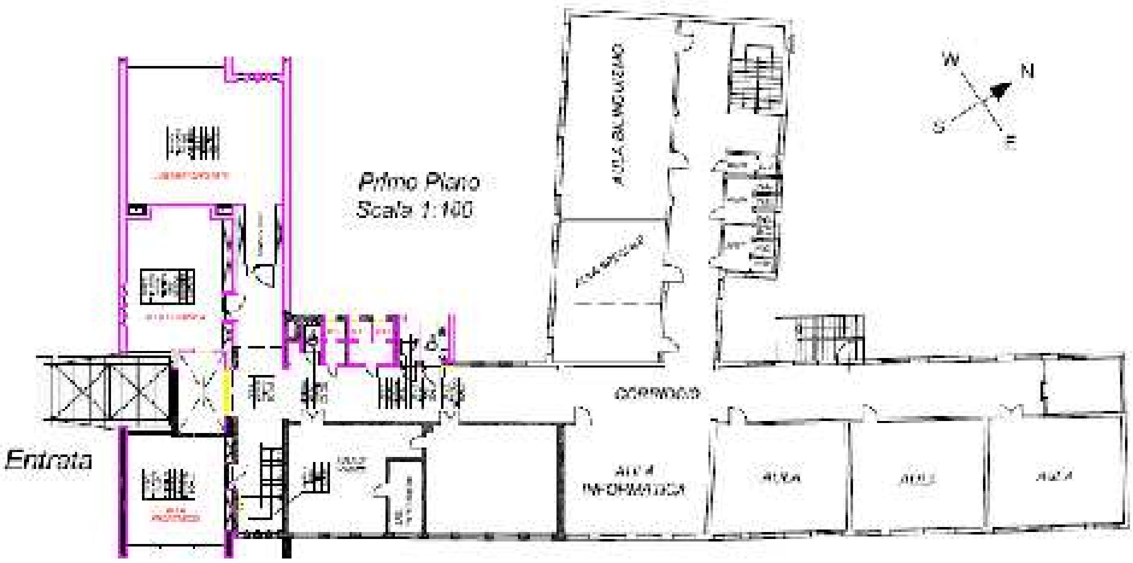


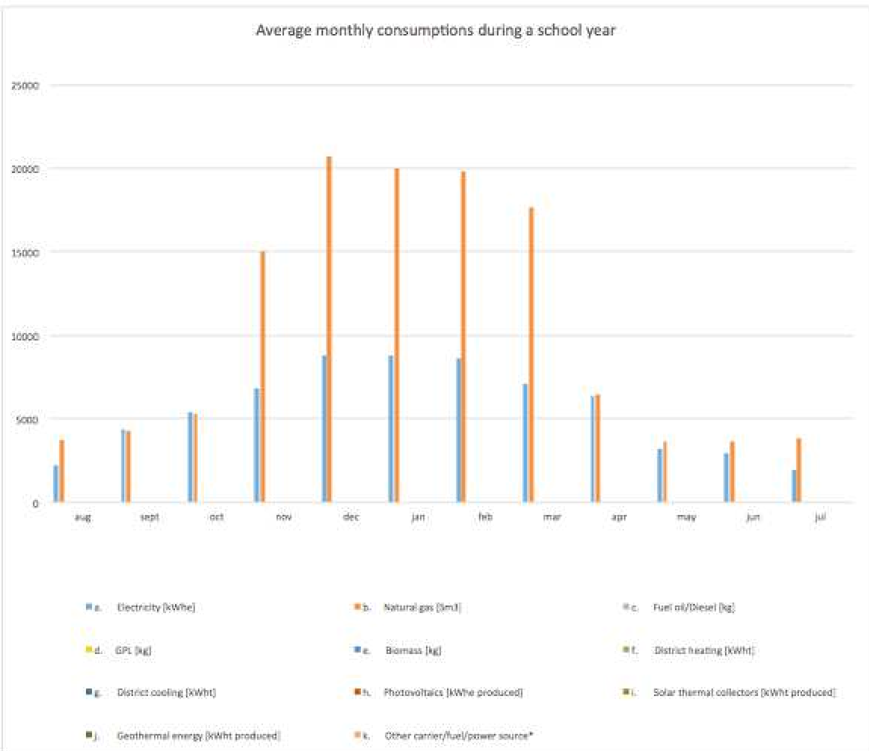
Picture 5 - Division of the School areas for intended use [%]

4. Description of the current state

General information about the current state

The building is entirely used as a school plexus and energy consumption is due to heating, lighting and power supplies.





Picture 6: average monthly consumption (electricity and gas) during a school year

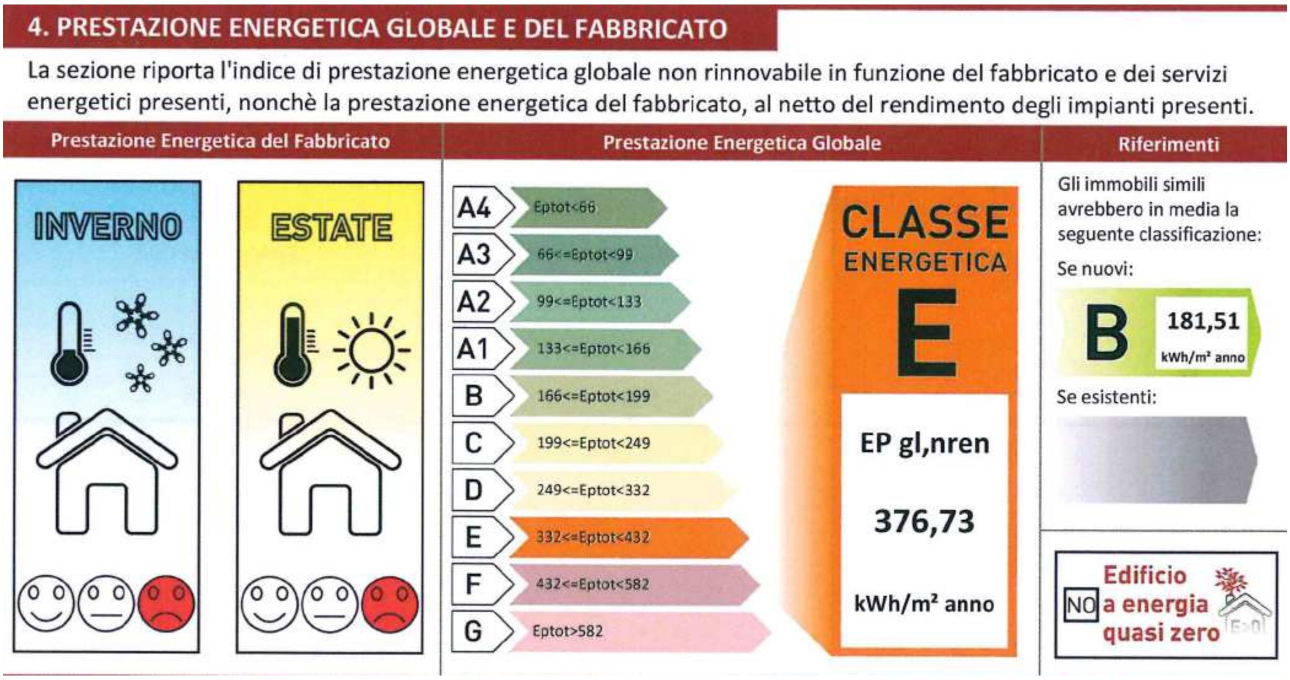
4.1. Building

Current state of the building

School building was built in several steps: first block in 1900, following several exlargement in 1920, 1960 and a refurbishment of the south facace.

The masonry structure is a full brick walls without hollow Insulated space (30 cm thick), the fully refurbished South front has reinforced concrete pillars with insulated overlay walls made of exterior brick and internal brick (40 cm thick).

The building is equipped with an Energy Performance Certificate drawn up on 25/05/2016 which certifies a building energy requirement of 376,73 kWh/m^2/year (E Class).



BUILDING ENVELOPE

Year of construction	1900 - 1930
Type of structure	masonry structure is a full brick walls without hollow Insulated space
External wall insulation	No insulation

4.2. Water and energy supply

Current state of the energy suply

The heating system of the schools is provided by a district heating system whose thermal plant is located in a specially built exterior building.

In the latter there are 4 boilers (cascading) that are connected to 3 branch units, characterized by pumps that circulate the hot water in the building to which they are responsible.

HVAC AND RES SYSTEMS

Heat generation system	Natural gas boiler
RES systems	None

4.3. Builiding automation system

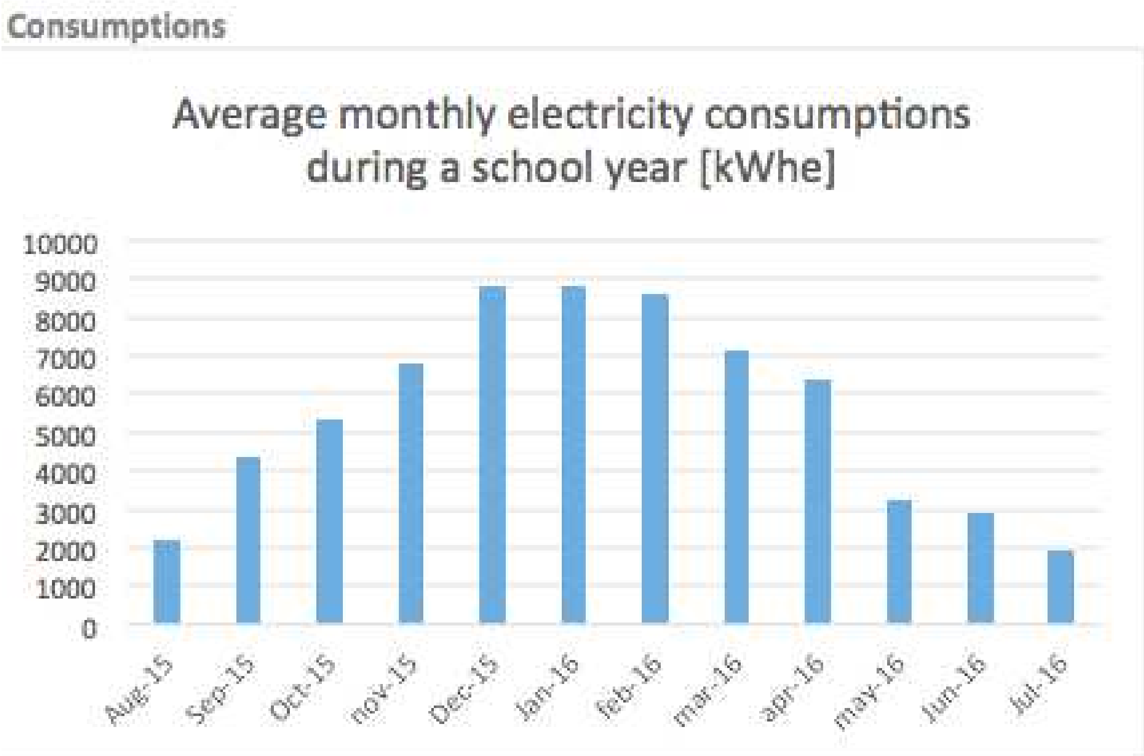
General information about the builging automation system

There is a temperature control thermostat. There are no separate heat accounting systems or other building automation or home automation systems.

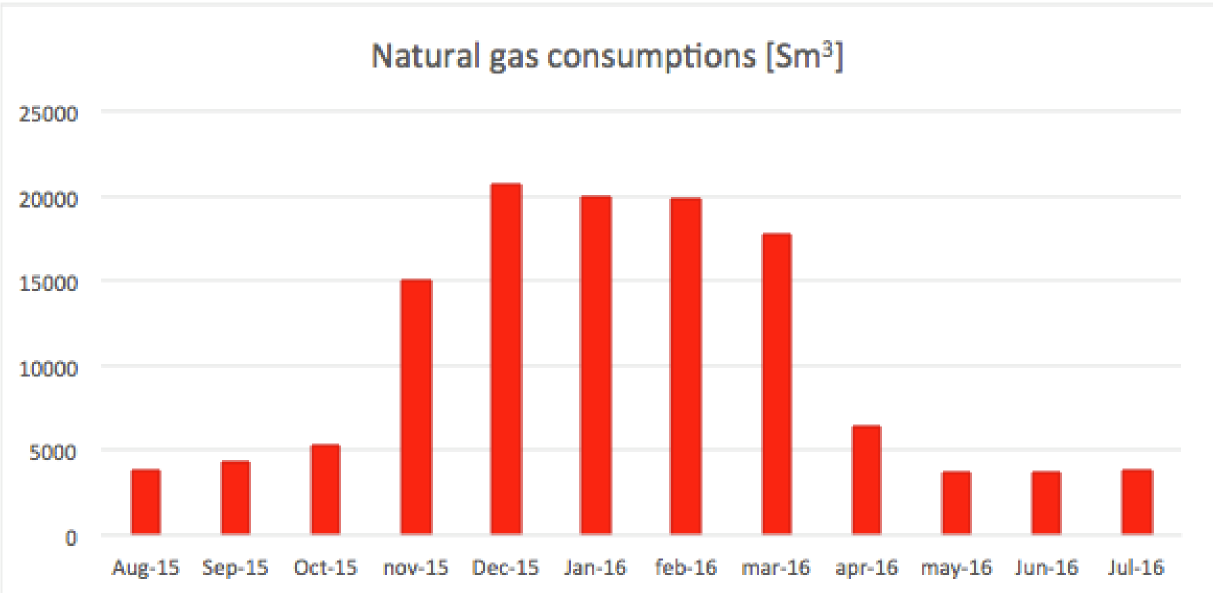
4.4. Recording Energy Consumption

There is monitor Energy consumption for lighting but no monitoring for other energy use. The energy and costs have been elaborated from the energy invoices.

There is no solar generated electricity. (Picture 6, Picture 7) show the monthly consumption values.



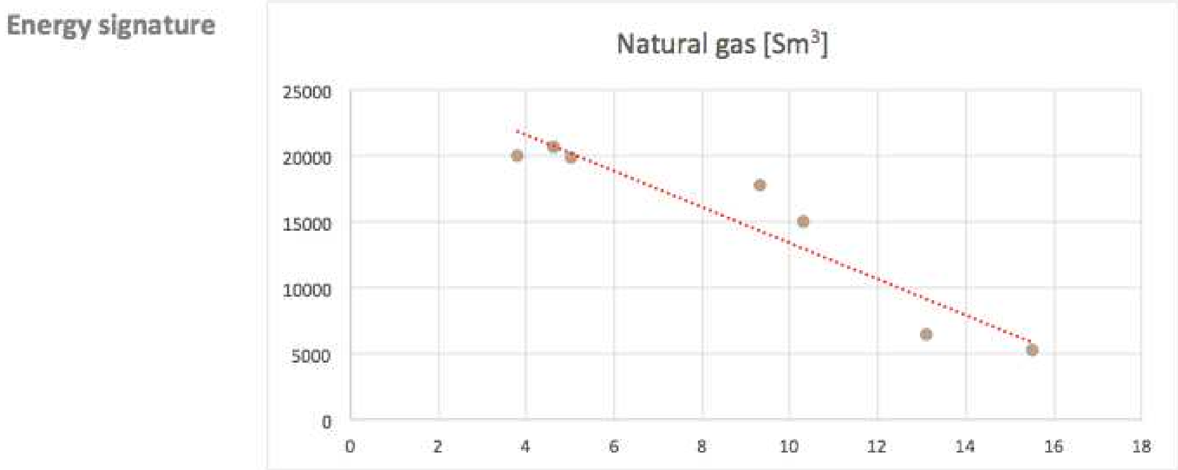
Picture 6 - Average monthly electricity consumptions during a school year [kWhe]



Picture 7 - Natural gas consumptions during a school year [Sm^3]

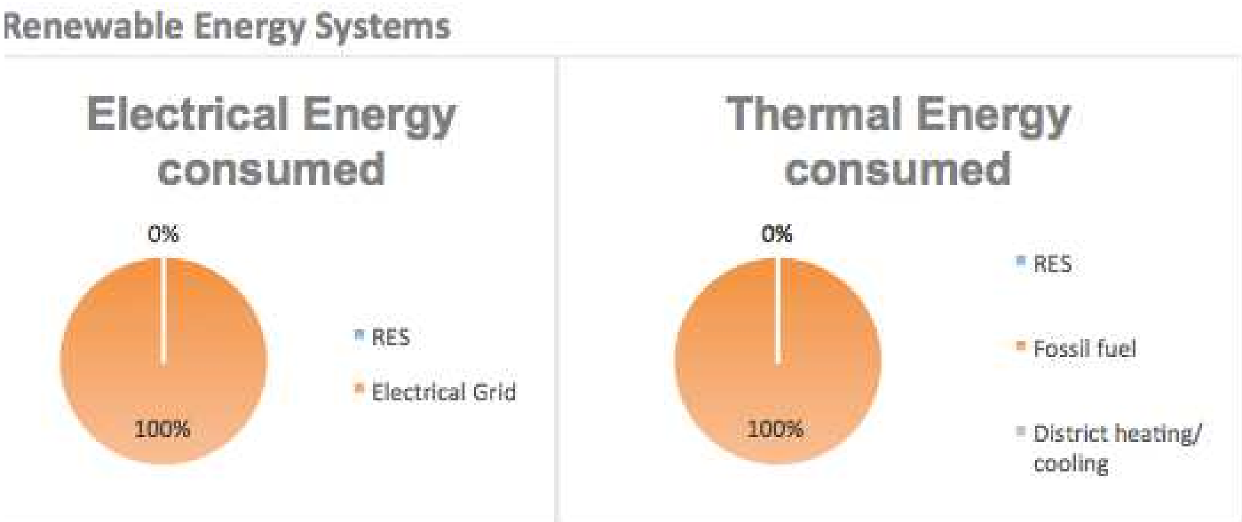
The higher demand of both types of energy is clearly visible in winter. While the higher demand of electricity is influenced in particular by the longer lighting time in winter, the heating energy demand depends on the weather and/or on the outside temperature.

The following figure (Picture 8) shows the relationship between the average outside temperature and the monthly gas requirement.



Picture 8 - Energy signature representation: Natural gas consumptions [Sm^3] vs External Temperature [°C]

The share of renewable energies (see Picture 9) is 0 % in the electricity sector. In the heating system the RES contribute is 0 %.



Picture 9 - Pie Graph of Electrical and Thermal energy consumptions, related to the different energy carriers/fuels or systems [%] in use into the school.

4.5. Energy Performance Indicators

General information about energy performance indicators

Energy performance indicators are necessary for comparability with other schools. There are constant reference values, such as, e.g. the heated area or the volume, or slightly fluctuating reference variables such as the number of pupils or the working days.

A very important reference is the heating degree-days. Over the past few years, these have seen a deviation of approx. +/- 12%.

The heating performance indicator in relation to the area and the heating degree-days therefore allows a consideration of the consumption figures irrespective of the weather. Table 2 shows the indicators of the examined school.

Energy Performance Indicators

Energy carrier/Fuel/ Power source	u.m.	Total consumption per year (u.m.)	Consumption per volume (u.m./m³)	Consumption per heated area (u.m./m²)	Consumption per classrooms area (u.m./m²)	Consumption per number of students (u.m./student)	Consumption per number of days (u.m./day)	Total energy consumption per year (kWh)	kg CO2 equivalent per year (kg CO_2 equiv)	Tonnes of oil equivalent per year (tep)
Electricity	kWh_{el}	66695	5,73	34,38	54,83	323,76	226,85	66695	28892	12
Natural gas	Sm3	52553	4,51	27,09	43,20	255,11	178,75	504508	10500	44
Fuel oil/Diesel	t	0						0		0
GPL	t	0						0		0
Biomass	t	0						0		0
District heating	kWh_t	0						0		0
District cooling	kWh_f	0						0		0
Photovoltaics	kWh_{el}	0						0		0
Solar thermal collectors	kWh_t	0						0		0
Geothermal	kWh_t	0						0		0
Other - energy produced	0	0						0		0
Tonnes of oil equivalent	tep	56,41	0,00	0,03	0,05	0,27	0,19		39392	56

Table 2 - Energy performance indicators

4.6. Energy consumers

The analysis of the energy consumers is intended to show the most important consumption points with the highest potential.

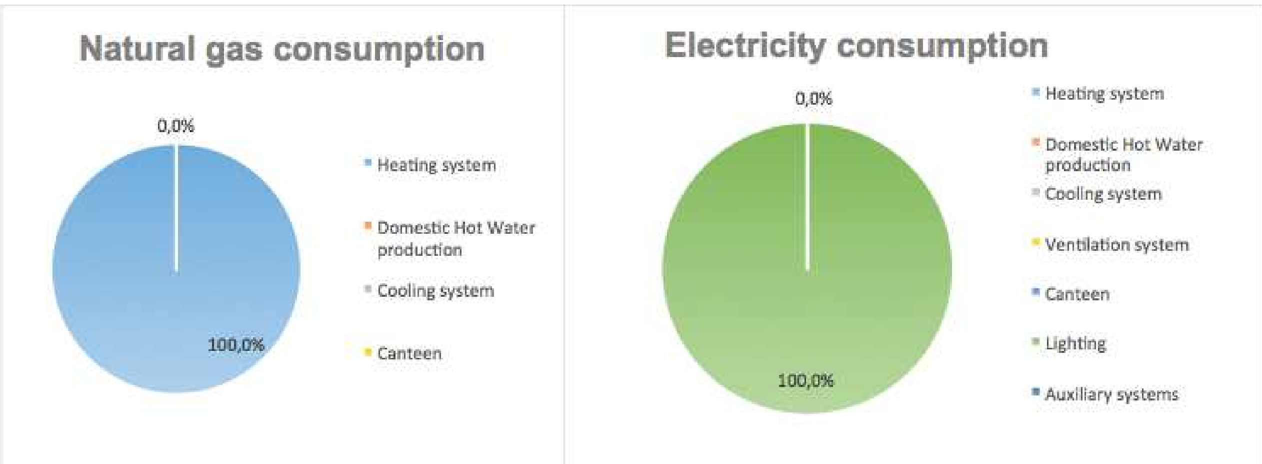
In the case of heat supply, the heat requirement for the domestic hot water supply and the heat demand play a role.

The heat demand for space heating is the sum of the heat loss caused by the transmission of heat through the walls and windows and the heat loss due to the ventilation of the windows minus the solar gains over the window surfaces.

Simplified, the heat required for the shower water is very low (we are in a primary school). In the school building, the fresh air demand is only realized with window ventilation.

The underlying value is therefore based on a fresh air requirement of 30 m³ / h per person. The share of end users for electricity and heat demand is shown in Picture 10.

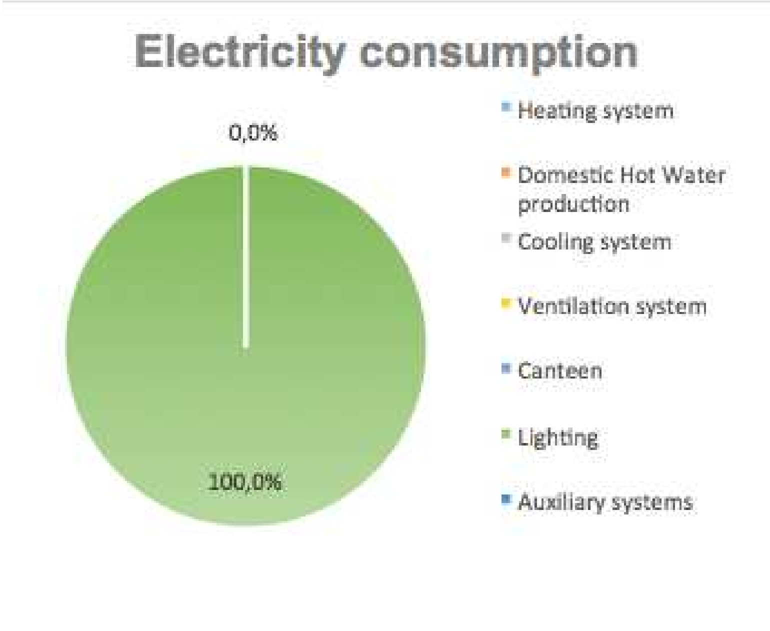
Consumptions subdivision



Picture 10 - Natural gas and electricity consumptions subdivision [%] for each final intended use

The lighting mainly influences the electricity consumption. The electricity requirement of the electric water heaters on the hand-washing basins is based on the fact that each user needs an average of about one liter of hot water.

Picture 11 shows that a share of 99% is used for lighting.



Picture 11 - Electrical consumptions subdivision [%] for each final intended use

5. Ways to improve energy efficient

The following section is concerned to ways to improve energy efficiency.

5.1. Building envelope

General information about the improvement at the buildingside

The exterior walls of the existing buildings correspond to the constructional "non" insulation standard of the builted year. Subsequent insulation of the walls, together with roof insulation, reduces heat losses by 66%.

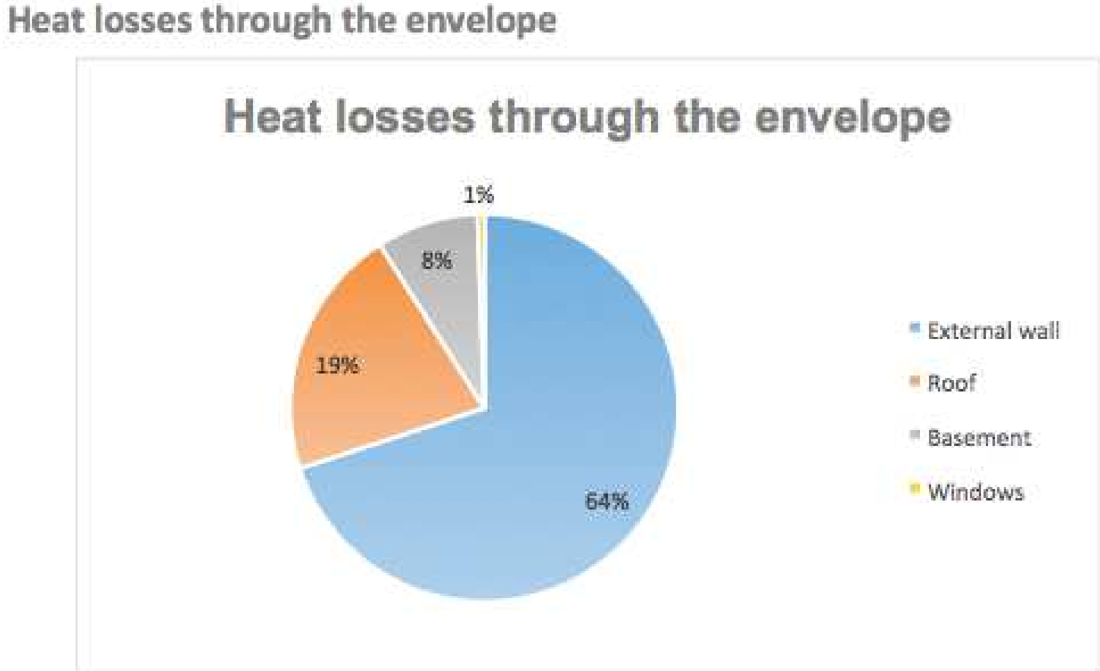
Windows replacement have not been considered because of the total amount of the costs, referred to the energy saving.

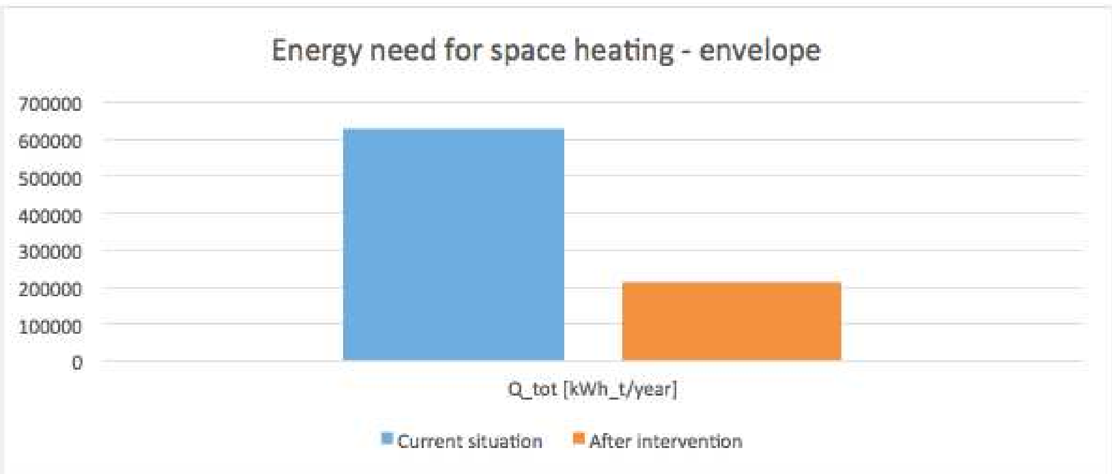
Measure 1: Retrofit the external walls and roof with insulation

The building envelope also offers opportunities for the user to actively contribute to energy saving. For example, sun protection can be used specifically to influence the solar gains: in winter they can reduce heating requirements and counteract heat build-up in the summer. Furthermore, the energy consumption can also be reduced to the necessary extent by means of a demand-oriented window ventilation.

Measure	Investment costs €	Energy savings kWh/a	Cost savings €/a	Return of invest years	CO_2-savings kg (CO_2)/a
Retrofit external walls with insulation and retrofit roof	**723.133,00**	**414.506,15**	**24.279**	**29,8**	**6.930**

Note: the evaluation of the investment doesn't take care of incentives. In affirmative case, the incentves is 40% of the total costs of the investment.





5.2. Replace light with LED

Replacing current lamps with new LED lamps gives an estimated 57% energy saving as regards electricity consumption. In the case of school, lighting is the almost exclusive cause of electricity consumption.

Even though LEDs reduce power consumption, Junior Energy Guardians can always check that energy is not wasted by illuminating the classrooms when they are not busy (recreation or lunch time, ecc.).

Measure 2	Investment costs €	Energy savings kWh/year	Cost savings €/year	Return of invest year	CO_2-savings to (CO_2)/year
Replace lights with LED	**6.525**	10.128 (-57%)	2.430,72	2,7	4387

Measure 2: replacement of the light with LED

5.3. Install Energy Saving Switch and Presence Sensors

The luminous flux regulators affect the amount of light to be delivered. The adjustment process, called "dimming", adjusts the amount of artificial light according to the amount of light set. A brightness sensor allows you to estimate the amount of light present in the compartment and to reduce the amount of artificial light depending on the presence of natural light, ensuring both an energy-efficient system, but above all a properly illuminated indoor environment depending on the activities that It takes place (studyng, working, ecc.).

The presence sensors, on the other hand, eliminate artificial light delivery if nobody is in the room, bathroom, ecc. This device is really useful for rooms that are used in a non-continuous manner such as bathrooms and storage rooms.

In the school it could also be useful for the classrooms to prevent the lights from turning on when students and teachers go away. This last activity, before the installation of presence sensors, may be carried out by the Junior Energy Guardian.

Measure 3	investment costs €	energy savings kWh/a	cost savings €/a	return of invest a	CO2-savings to (CO2)/a

Measure 3	investment costs €	energy savings kWh/a	cost savings €/a	return of invest a	CO2-savings to (CO2)/a
Install Energy Saving Switch and Presence Sensors	**12.500**	1780 (-10%)	427,2	29	771

Measure 3: Install Energy Saving Switch and Presence Sensors

5.4. Electrical energy reduction with PV system

The electricity used by the school is totally taken from the national electricity grid. A photovoltaic installation calculated on the possible 100% self-consumption will reduce the energy demand by self-production (when the school is open) and to avoid CO2 emissions because it should be Renewable Energy Source. The cost saving has been calculated with a 0,24€ per kWh of the actual costs, referred to the invoices.

Measure 4	Investment costs €	Energy savings kWh/year	Cost savings €/year	Return of invest year	CO_2-savings to (CO_2)/year
Install a photovoltaic system	**32.000,00**	22.000	5.280	6	9.530

Measure 4: Photovoltaic system for electricity production

5.5. Install a solar thermal system

Solar collectors are devices installed outside the building (usually on the roof). These are elongated tanks that contain water that, thanks to solar radiation, warms up. Heated water is accumulated in a tank and can be used as sanitary hot water without any needing of "energy" to heat it.

In summer time, the use of hot water from the exhaled collector allows the boiler not to activate (avoiding gas consumption) or not to use the electric boilers in the bathrooms (avoiding electricity consumption).

Some built-in systems allow you to use the collector's hot water in synergy with the heating system because, especially in the autumn, during sunny days the collector allows to heat the water thus "working" less the boiler.

As the collector water is heated (for free) from the sun, the produced energy is considered to be produced from a completely renewable source. In addition, sunbathing is completely free.

Measure 5	Investment costs €	Energy savings kWh/year	Cost savings €/year	Return of invest year	CO_2-savings to (CO_2)/year
Install a solar thermal system	**2.400**	1.600	120	20	33

Measure 5: solar thermal system for thermal production (hot water)

5.6. Install building automation system

Building Automation systems allow you to monitor and manage integrated building systems. The main elements handled by automation systems refer to:

- Lighting;
- Heating and cooling;
- Intrusion and safety;
- Sensor presence;
- Fire.

Some of these system, such as lighting and heating, have a direct impact on building energy consumption, and their optimal management allows you to streamline your energy consumption, as well as having a good indoor comfort for studying and working, checking temperature, humidity, air exchange and lighting.

The system consists of sensors that control the settled parameters, an electronic control unit that receives sensor data and, based on the fixed settings, sends signals to the respective systems that handle the various functions. The control unit therefore receives data on temperature, illumination level, etc. ... and then asks the boiler or electrical system to attenuate or increase the "energy flow".

These are systems that have both a hardware component (sensors) and a software component (the control unit) and which need to be "customized" to the desired parameters case-by-case.

Measure 6	Investment costs €	Energy savings kWh/year	Cost savings €/year	Return of invest years	CO_2-savings to (CO_2)/year
Install building automation system (automatic centralized control of a building's heating, ventilation and air conditioning, lighting...)	**48500**	(10%) 69.282,50	5.929	8,2	3939

Measure 6: building automation system (automatic centralized control of a building's heating, ventilation and air conditioning, lighting...)

5.7. Change end-user behaviour

Some of our behaviors and habits directly affect the energy consumption of the building, especially at home but also at school.

Acquiring awareness of how our behaviors affect or not affect on energy consumption and indirectly on the environment and climate is one of the main goals of any energy initiative, directive or research initiative.

To get a conscious behavior especially in school age helps to grow people who will mater this behavior and become a spokesman for a culture of sustainability. Specifically, it is to learn how to eliminate waste or to choose one thing rather than another one in function of the impact it generates.

What does it mean to choose to go to school by bike or on foot rather than by car? Is it true that the lights should be turned on because if I turn it off and turn it on, I use more energy? Is it true that computers consume electricity even when they are off?

Awareness helps to understand how much our daily actions affect the environment and how we can reduce our impact (ecological and environmental footprint) to preserve the environment for future generations.

Measure 7	Investment costs €	Energy savings kWh/year	Cost savings €/year	Return of invest years	CO_2-savings to (CO_2)/year
Change end-user behaviour: control devices stand-by (monitors, PCs, laboratory equipment, lights, etc.)	**0**	(5%)	2.964,5	0	1969,5

Measure 7: Change end-user behaviour: control devices stand-by (monitors, PCs, laboratory equipment, lights, etc.)

6. Timeline for implementation

The implementation of the measures must be adapted to the project duration of energy@school (from July 2016 to June 2018). In Table 3, the implementation of the measures is listed separately in times for planning or data collection and implementation or initiation.

Measure - planning / implementation		school year 16/17						vac		school year 17/18										vac		school year 18/19										vac		school year 19/20							
		1	2	3	4	5	6	7	8	9	10	11	12	1	2	3	4	5	6	7	8	9	10	11	12	1	2	3	4	5	6	7	8	9	10	11	12	1	2	3	4
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Change end-user behaviour: control devices stand-by (monitors, PCs, laboratory equipment, lights, etc.)	P																																								
	I																																								

Table 3 - timeline for implementation

ENERGY AUDIT REPORT SCUOLA ELEMENTARE LUIGI BATTAGLIA A FUSIGNANO (RA) REQUIRING DEVELOPMENT OF AN ENERGY GUARDIAN SMART SCHOOL MANAGEMENT PLAN

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Edited by Unione Bassa Romagna (Rita Ricci e Laura Dalpiaz)

In cooperation with Naxta Ltd (Federico Fileni e Giulia Righetti)

Index

1. Background

In Fusignano (RA) there are 4 schools that belongs to the "Istituto comprensivo Luigi Battaglia":

1. Scuola Secondaria di primo grado "Emaldi"
2. Scuola primaria "Luigi Battaglia" - sede
3. Scuola primaria - succursale
4. Scuola dell'infanzia

In 3 of them, a systematic inventory was carried out in the autumn of 2016, on the initiative of the European research project energy@school, on the basis of which a comprehensive report of the inventory of each city was prepared (Deliverable D.T1 .1.3, January 30, 2017, edited by CertiMaC, Italy).

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I. Optimization of energy consumption in schools,
II. Concrete and progressive increase of EE and RES use in schools not only thanks to technical application of smart solutions, but also to non-technical factors such as a better management capacity and responsible behavior toward energy use,
III. Increase of capacity of public sector to deal with increase of EE and RES use in schools thanks to strategy, action plans, tools (methods, approaches), trainings, pilot actions defined and implemented within the project,
IV. Increase in managerial and organizational competences as well as in human resources to ensure the progressive and sustainable energy efficiency and renewable energy se in public schools (trainings),
V. Creation of conditions for new job opportunities (trainings),
VI. Creation of “energy culture”, thus responsible attitude towards energy use, thanks to education and raising awareness activities, as it is demonstrated that amount of saved energy can noticeably increase if energy retrofit interventions are associated to behavioral changes.

In the research project, 12 project partners (PP) from seven Central European countries are represented:

PP 1. Union of Municipalities of Low Romagna Region , Lead Partner – Italy
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PP 8. Local Government of Town Újszilvás - Hungary
PP 9. City of Stuttgart - Germany
PP 10. Klagenfurt - Austria
PP 11. Graz Energy Agency - Austria
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From the examined schools, five schools joined up to be actively involved in energy@school.

These schools receive an individual report on the energy audit with this document. This report is intended to serve as the basis for the development of an energy action plan (Energy Guardian Smart School Management Plans - EGSMPs) to the school's managers and, in addition to inventory analysis, includes investive and non-investive measures for energy saving.

These actions help to develop individual actions in the respective school and a common strategy for smart schools (CSSS).

2. Summary

The examined school had an average energy performance indicator of electricity of 43,18 kWh/m² per year and 27.09 m3 of natural gas per year for m2. The share of renewable energies in the electricity sector is 0 % in the heating sector 0 %.

	Total consumption per year	**consumption per volume**	**consumption per heated area**	**consumption per number of students**	**total energy consumption per year**	**kg CO_2 equivalent per year**	**Tons of oil equivalent per year**
Energy carrier/fuel/power source	u.m.	u.m./m^3	u.m./m^2	u.m./student	kWh	Kg CO2 equivalent	TEP
electricity	61.531,00	7,20	43,18	221,33	61.531,00	26.655,23	11,51
naural gas	38.602,00	4,51	27,09	138,86	370.579,20	7.712,68	32,27
fuel oil/diesel							
GPL							
Biomass							
District heating							
District cooling							
Photovoltaics							
Solar thermal collectors							
Geothermal							
Other - energy produced							
Tonnes of oil equivalent	**43,78**	0,01	0,03	0,16		34.367,91	**43,78**

Table 1 - Energy performance indicators

The following measures are recommended for the order of implementation.

Measure	investment costs €	energy savings kWh/a	cost savings €/a	return of invest a	CO_2-savings to (CO_2)/a
Measure 4: Photovoltaic system for electricity productionRetrofit external walls with insulation and retrofit roof	**424.419,00**	240.876,48	15.054,78	28,19	5013,24
Fehler! Verweisquelle konnte nicht gefunden werden. Install thermostatic valves	**2.235,00**	7.411,58	463,22	4,82	203,97
Measure 3: replace light with LED	**5.200,00**	7.588,15	2.276,45	2,28	1,42
Fehler! Verweisquelle konnte nicht gefunden werden.electrical energy reduction with PV system	**32.000,00**	22.000	6.600,00	3,33	4,11

3. Generalities of the school

Figure 1 1 shows the Luigi Battaglia Primary School. School building built in 2000 and featuring two ground floors with reinforced concrete frame and full brick wall facing walls.

Fig 1 - Luigi Battaglia Primary School- main entrance

GENERALITIES

School type	Primary
Student age range	6-11

GEOGRAPHICAL LOCATION AND WEATHER CONDITIONS

Country	Italy
City	Fusignano (RA)

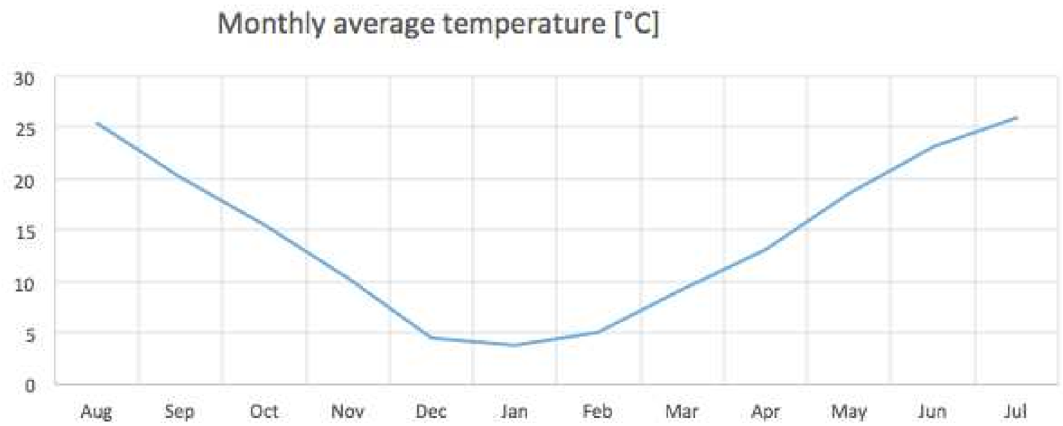
BUILDING GEOMETRY

Total floor heated area [m^2]	1425
Volume [m^3]	8550
S/V	0,50

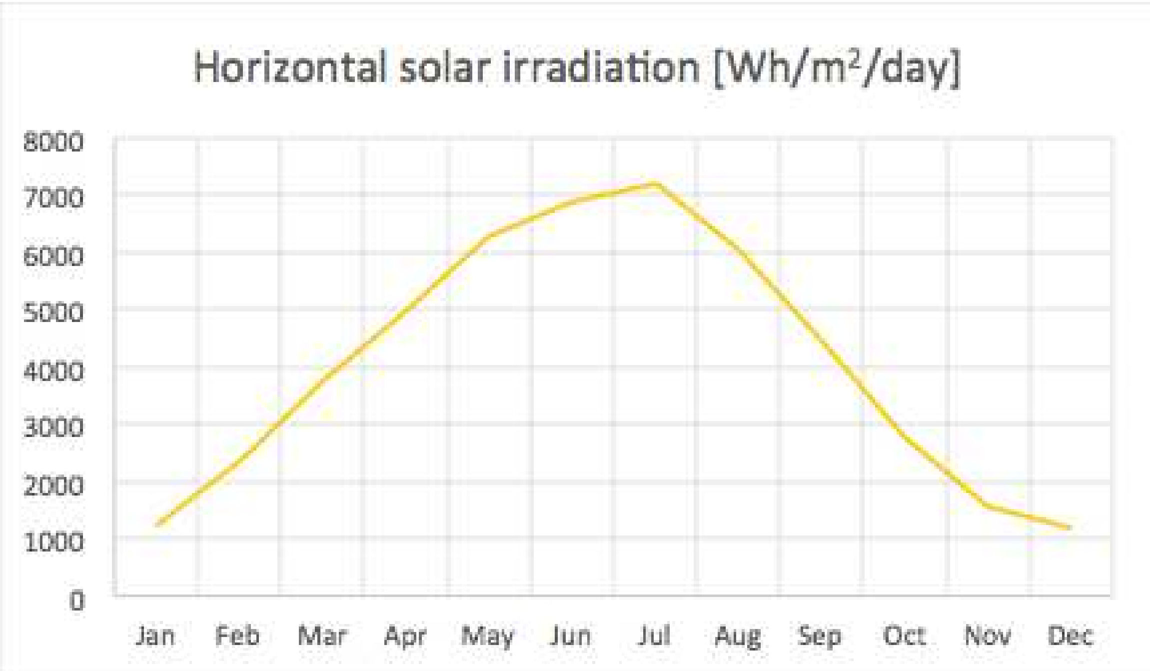
OCCUPATION AND USE OF THE BUILDING

Number of students	278
Total days of use	201
Daily hours of use	11
Total area allocated to classrooms [%]	94

General information about the climate



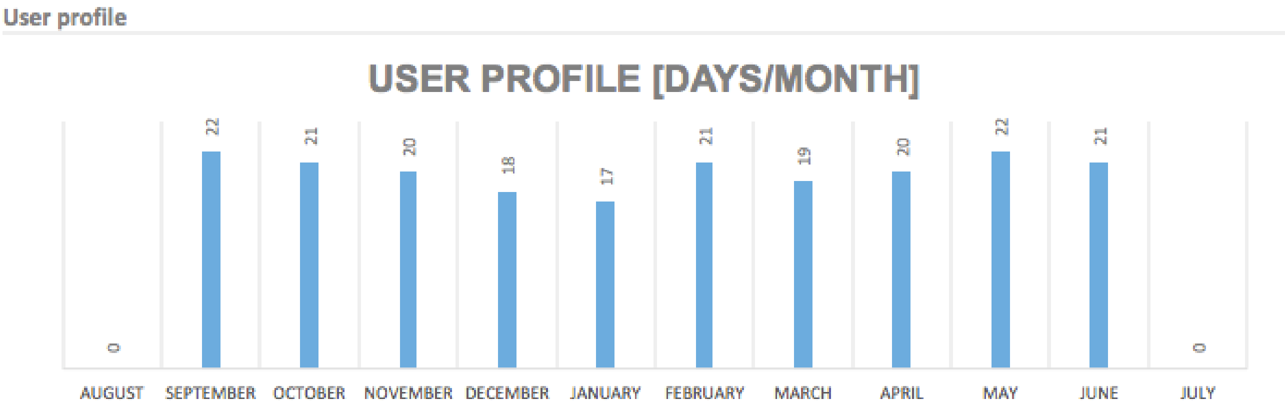
Picture 2- Graphic representation of monthly average temperature [˚C]



Picture 3 - Graphic representation of the Horizontal solar irradiation [Wh/m^2/day] per Months. This value is the monthly/yearly average of the sum of the solar radiation energy that hits one square meter in a horizontal plane in one day.

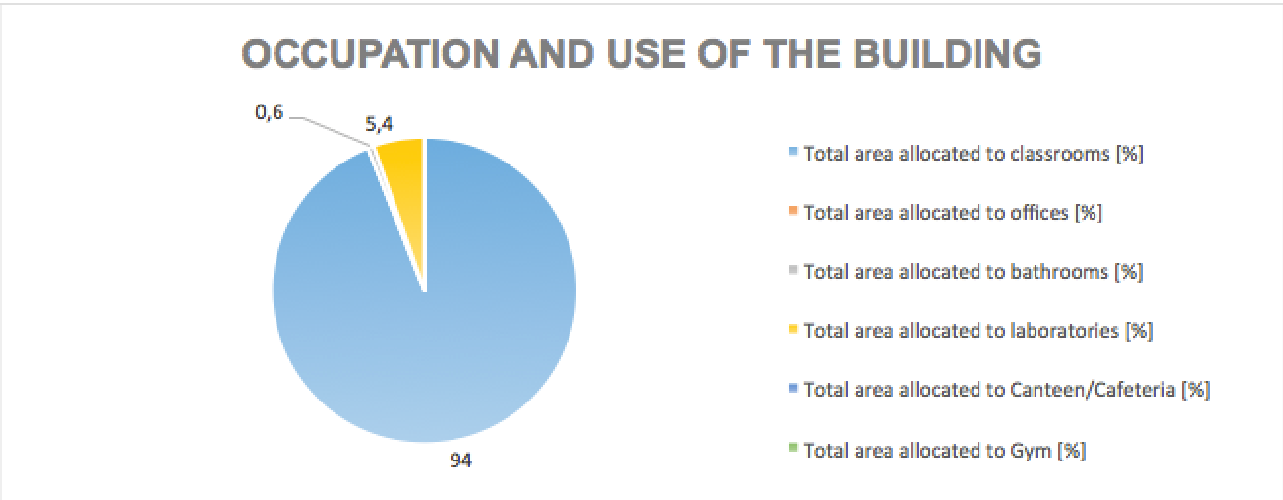
General information about the use of the school

Picture 4 shows the school's use profile and the holiday's period. In total the school comes on 201 days of operation.



Picture 4 - Graphic representation of the user profile during school period [working days/month]

Picture 5 shows the different uses in the school building. 94% of the area is allocated to classrooms. 5,4% of the area is laboratory space for e.g. physics or chemistry.

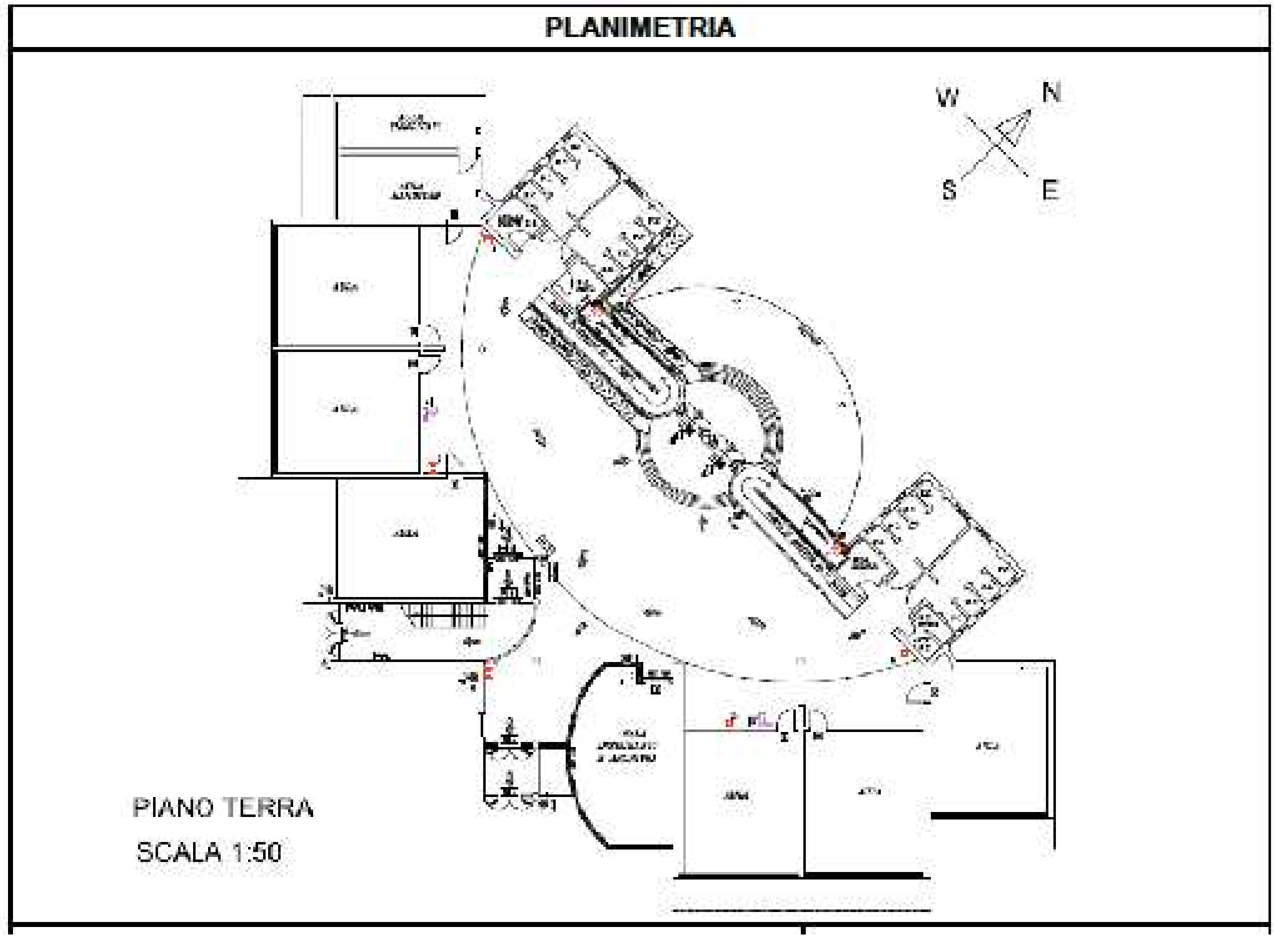


Picture 5 - Division of the School areas for intended use [%]

4. Description of the current state

General information about the current state

The building is entirely used as a school plexus and energy consumption is due to heating, lighting and power supplies.



4.1. Building

Current state of the building

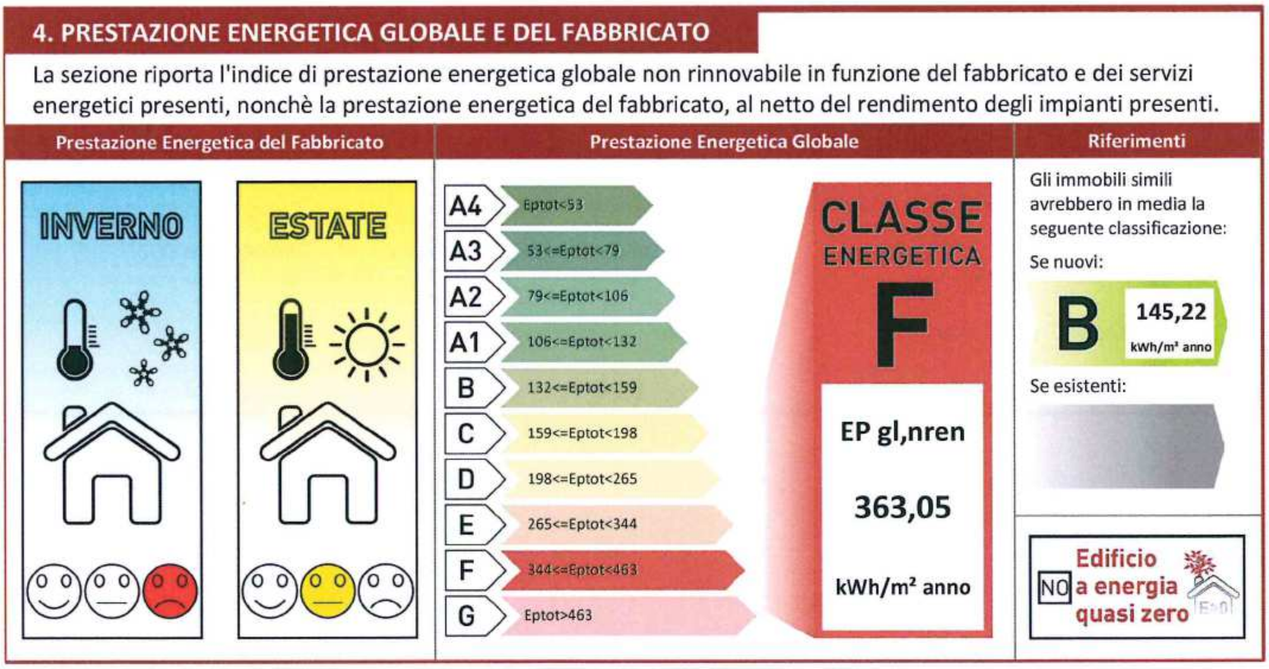
School building built in 2000 and featured on two ground floors with reinforced concrete frame and full-topped brick walls.

The classrooms are located on two floors and are all exposed to SUD, the building has an irregular shape that gives it a high S / V value.

At the center of the structure there is a very large, semi-cylindrical atrium, extending throughout the height of the property.

The main entrance is on the flat surface of the semi-cylinder, exposed to NORD and it is characterized by a large glazed surface.

The building is equipped with an Energy Performance Certificate drawn up on 25/05/2016 which certifies a building energy requirement of 363.05 kWh / m^3 / year



BUILDING ENVELOPE

Year of construction	2000
Type of structure	Armored frame and solid brick wall to face
External wall insulation	No insulation

4.2. Water and energy supply

Current state of the energy suply

The heating system of the school, together with two other school buildings, is provided by a district heating system whose thermal plant is located in a specially built exterior building.

In the latter there are 4 boilers (cascading) that are connected to 3 branch units, characterized by pumps that circulate the hot water in the building to which they are responsible.

HVAC AND RES SYSTEMS

Heat generation system	Natural gas boiler

RES systems	None

4.3. Builiding automation system

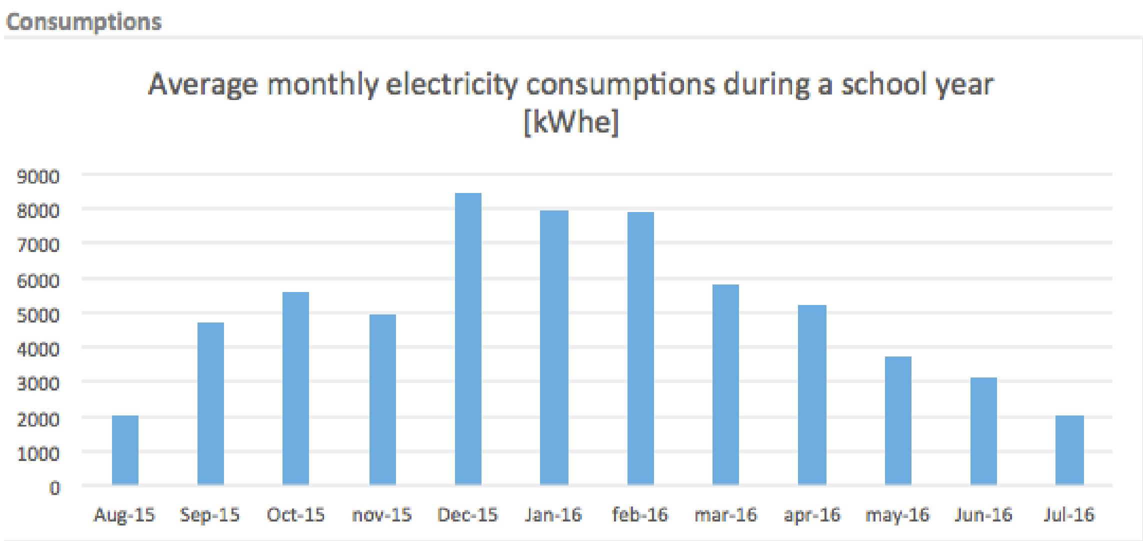
General information about the builging automation system

There is a temperature control thermostat. There are no separate heat accounting systems or other building automation or home automation systems.

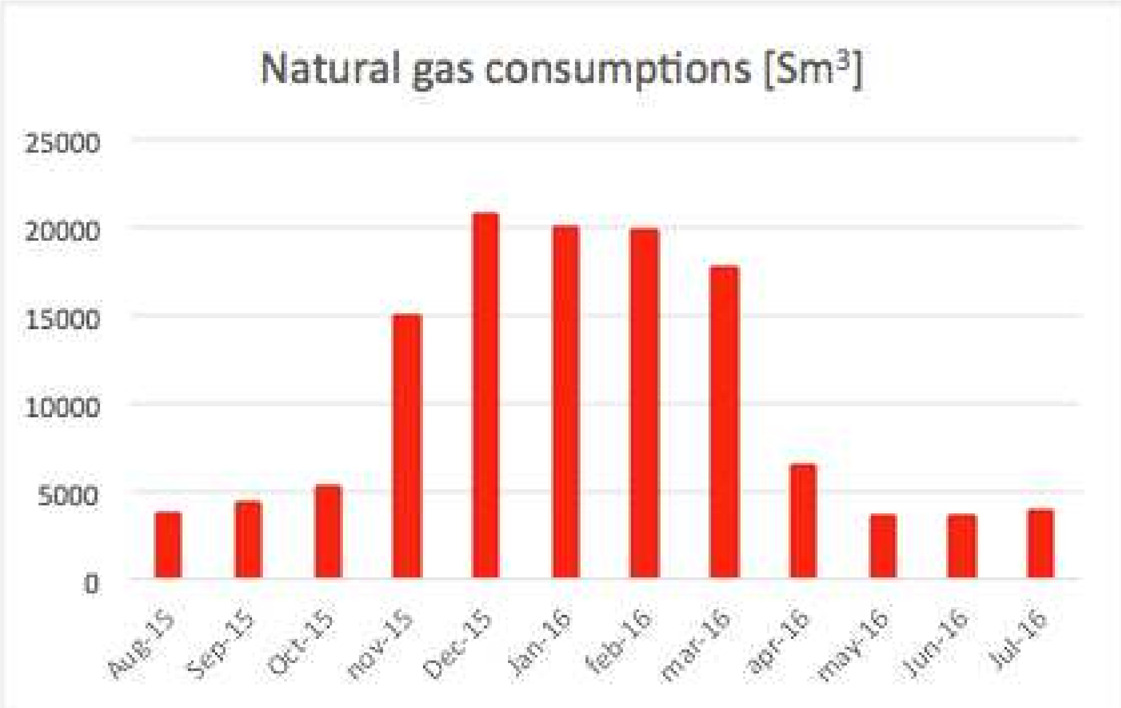
4.4. Recording Energy Consumption

There is no Energy consumption monitoring in the building. The energy and costs have been elaborated from the energy invoices.

There is no solar generated electricity. (Picture 6, Picture 7) show the monthly consumption values.



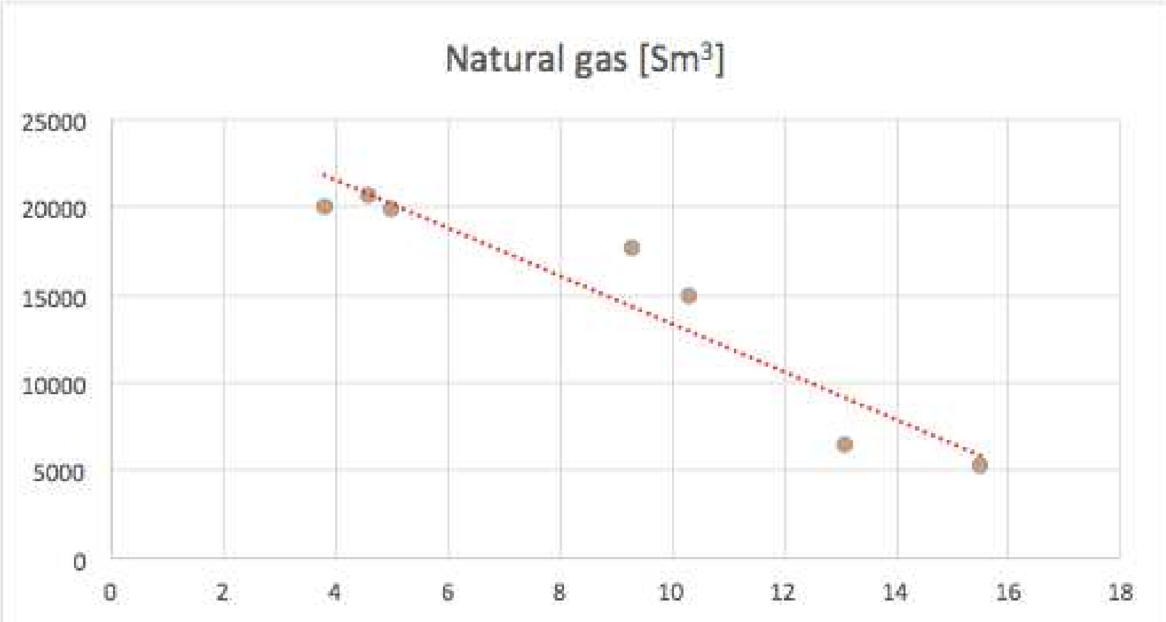
Picture 6 - Average monthly electricity consumptions during a school year [kWhe]



Picture 7 - Natural gas consumptions during a school year [Sm^3]

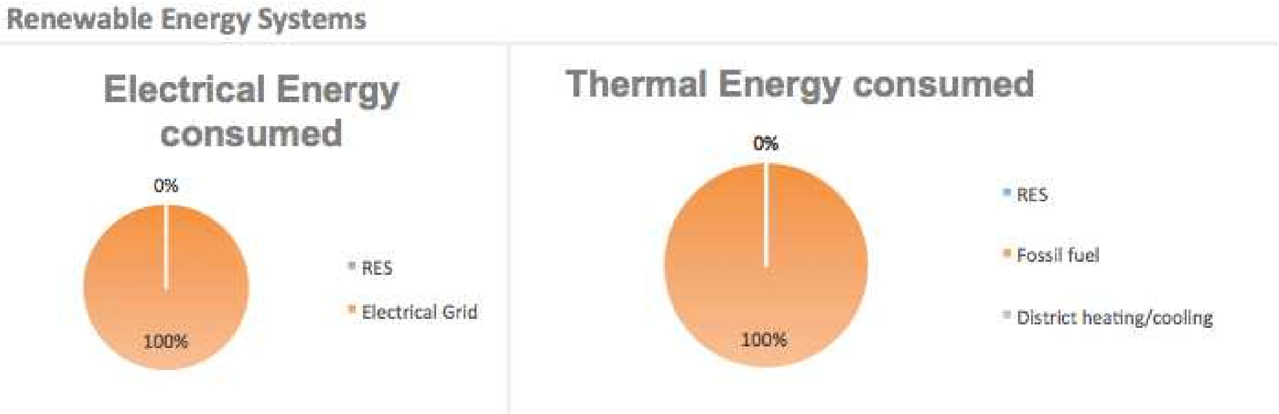
The higher demand of both types of energy is clearly visible in winter. While the higher demand of electricity is influenced in particular by the longer lighting time in winter, the heating energy demand depends on the weather and/or on the outside temperature.

The following figure (Picture 8) shows the relationship between the average outside temperature and the monthly gas requirement.



Picture 8 - Energy signature representation: Natural gas consumptions [Sm³] vs External Temperature [°C]

The share of renewable energies (see Picture 9) is 0 % in the electricity sector. In the heating system the RES contribute is 0 %.



Picture 9 - Pie Graph of Electrical and Thermal energy consumptions, related to the different energy carriers/fuels or systems [%] in use into the school.

4.5. Energy Performance Indicators

General information about energy performance indicators

Energy performance indicators are necessary for comparability with other schools. There are constant reference values, such as, e.g. the heated area or the volume, or slightly fluctuating reference variables such as the number of pupils or the working days.

A very important reference is the heating degree-days. Over the past few years, these have seen a deviation of approx. +/- 12%.

The heating performance indicator in relation to the area and the heating degree-days therefore allows a consideration of the consumption figures irrespective of the weather. Table 2 shows the indicators of the examined school.

Energy Performance Indicators

		Total consumption per year	Consumption per volume	Consumption per heated area	Consumption per number of students	Consumption per number of days	Total energy consumption per year	kg CO2 equivalent per year	Tonnes of oil equivalent per year
Energy carrier/Fuel/ Power source	u.m.	u.m.	u.m./m³	u.m./m²	u.m./student	u.m./day	kWh	kg CO_2 equiv	tep
Electricity	kWh_{el}	61531	7,20	43,18	221,33	306,12	61531	26655	12
Natural gas	Sm3	38602	4,51	27,09	138,86	192,05	370579	7713	32
Fuel oil/Diesel	t	0					0		0
GPL	t	0					0		0
Biomass	t	0					0		0
District heating	kWh_{t}	0					0		0
District cooling	kWh_{t}	0					0		0
Photovoltaics	kWh_{el}	0					0		0
Solar thermal collectors	kWh_{t}	0					0		0
Geothermal	kWh_{t}	0					0		0
Other - energy produced	0	0					0		0
Tonne of oil equivalent	tep	43,78	0,01	0,03	0,16	0,22		34368	44

Table 2 - Energy performance indicators

4.6. Energy consumers

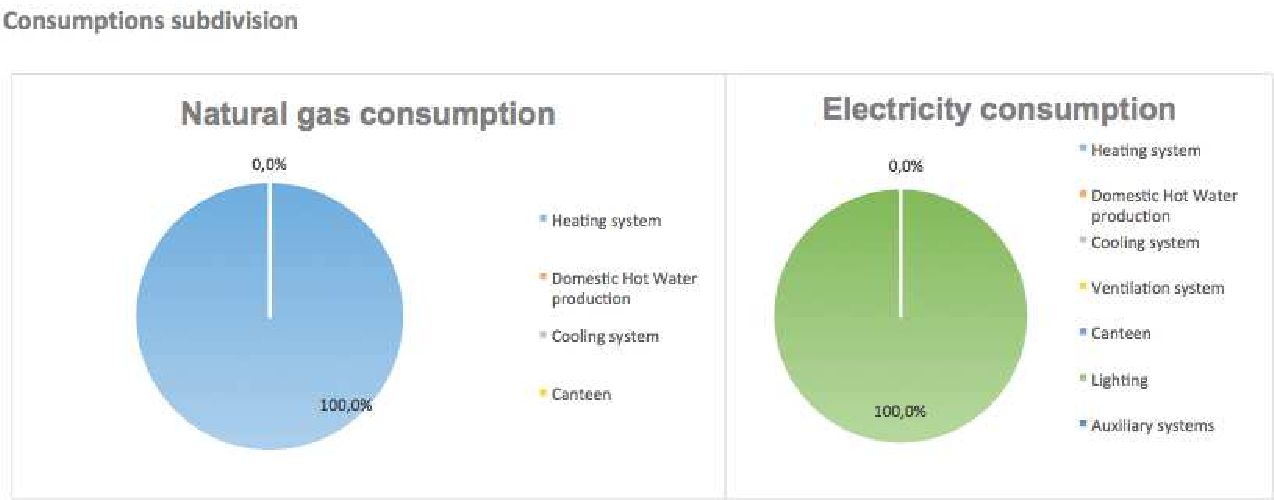
The analysis of the energy consumers is intended to show the most important consumption points with the highest potential.

In the case of heat supply, the heat requirement for the domestic hot water supply and the heat demand play a role.

The heat demand for space heating is the sum of the heat loss caused by the transmission of heat through the walls and windows and the heat loss due to the ventilation of the windows minus the solar gains over the window surfaces.

Simplified, the heat required for the shower water is very low (we are in a primary school). In the school building, the fresh air demand is only realized with window ventilation.

The underlying value is therefore based on a fresh air requirement of 30 m³ / h per person. The share of end users for electricity and heat demand is shown in Picture 10.



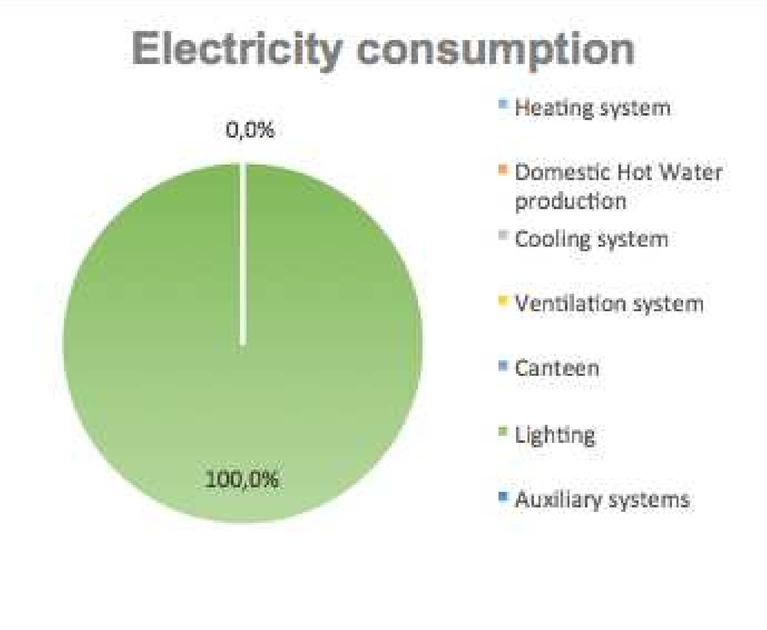
Picture 10 - Natural gas and electricity consumptions subdivision [%] for each final intended use

The lighting mainly influences the electricity consumption. The electricity requirement of the electric water heaters on the hand-washing basins is based on the fact that each user needs an average of about one liter of hot water. The current requirement for the equipment is set according to the values in Table 3 over the operating days.

Equipment and machineries			
	[number]	Typical power [W]	Average daily hours of use [h/day]
a. PCs	12		11
b. Projectors/Light boards	7		3
c. Printers/copiers	1		11
d. Vending machines	2		11
e. Coolers (in canteen, cafeteria)	1		11
f. Elevators	0		
g. Laboratories	*(Brief description of equipment installed with power, time of use...)*		
h. Other			

Table 3 - power and operating time of equipment and machines

Picture 11 shows that a share of 99% is used for lighting.



Picture 11 - Electrical consumptions subdivision [%] for each final intended use

5. Ways to improve energy efficient

The following section is concerned to ways to improve energy efficiency.

5.1. Building

General information about the improvement at the buildingside

The exterior walls of the existing buildings correspond to the constructional insulation standard of the builted year. Subsequent insulation of the walls, together with roof insulation, reduces heat losses by 65%.

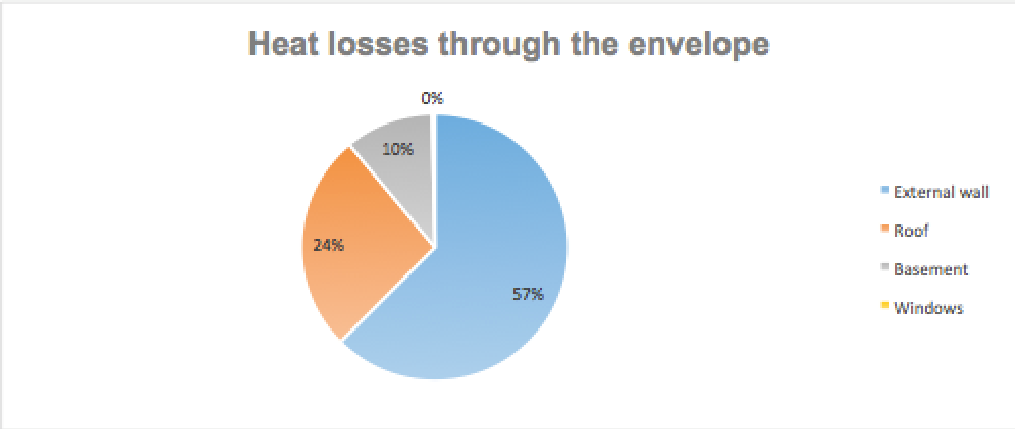
Windows replacement have not been considered because of the total amount of the costs, referred to the energy saving.

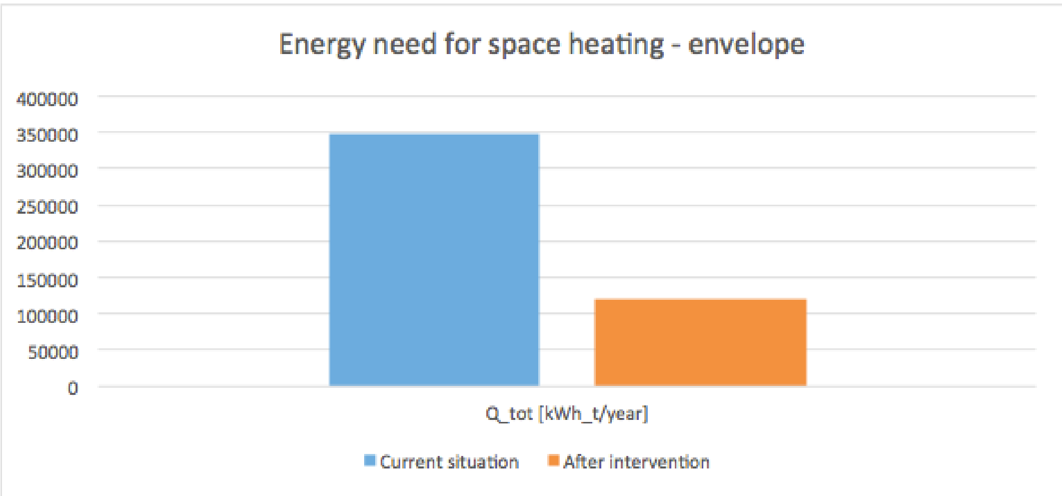
Measure 1: Retrofit the external walls and roof with insulation

The building envelope also offers opportunities for the user to actively contribute to energy saving. For example, sun protection can be used specifically to influence the solar gains: in winter they can reduce heating requirements and counteract heat build-up in the summer. Furthermore, the energy consumption can also be reduced to the necessary extent by means of a demand-oriented window ventilation.

Measure	investment costs €	energy savings kWh/a	cost savings €/a	return of invest a	CO_2-savings kg (CO_2)/a
Retrofit external walls with insulation and retrofit roof	424.419,00	240.876,48	15.054,78	28,19	5.013,24

Heat losses through the envelope





5.2. Install thermostatic valves

Thermostatic valves on radiators allow you to adjust the temperature on each radiator but especially in each classroom separately.

By this way, you can have the ideal temperature, avoiding waste and taking advantage of free energy supplies such as solar radiation, the presence of many people, and so on. It has been estimated 2% of energy savings on heat demand (natural gas consumption) but in addition to the energy savings the thermostatic valves allow to improve the climate inside the classrooms.

Thermal regulation should be a task of the JEGs (Junior Energy Guardians).

Measure	Investment costs €	Energy savings kWh/a	Cost savings €/a	Return of invest a	CO_2-savings to (CO_2)/a
Fehler! Verweisquelle konnte nicht gefunden werden. Install thermostatic valves	2.235	7.411,58	463,22	4,82	203,97

Measure 2: install thermostatic valves

5.3. Replace light with LED

Replacing current lamps with new LED lamps gives an estimated 57% energy saving as regards electricity consumption. In the case of school, lighting is the almost exclusive cause of electricity consumption.

Even though LEDs reduce power consumption, JEGs can always check that energy is not wasted by illuminating classrooms when they are not used (recreation or lunch time, etc.).

Measure	Investment costs €	Energy savings kWh/a	Cost savings €/a	Return of invest a	CO_2-savings to (CO_2)/a
Measure 3: replace light with LED	5.200,00	7.588,15	2.276,45	2,28	1,42

Measure 3: replace existing light with LED

5.4. Electrical energy reduction with PV system

The electricity used by the school is totally taken from the national electricity grid. A photovoltaic installation calculated on the possible 100% self-consumption will reduce the energy demand by self-production (when the school is open) and to avoid CO2 emissions because it should be Renewable Energy Source.

Measure	Investment costs €	Energy savings kWh/a	Cost savings €/a	Return of invest a	CO_2-savings to (CO_2)/a
Fehler! Verweisquelle konnte nicht gefunden werden.electrical energy reduction with PV system	32.000	22.000	6.600,00	3,33	4,11

Measure 4: Photovoltaic system for electricity production

6. Timeline for implementation

The implementation of the measures must be adapted to the project duration of energy@school (from July 2016 to June 2018). In Table 4, the implementation of the measures is listed separately in times for planning or data collection and implementation or initiation.

Timeline of the measures																																									
Measure planning / implementation		school year 16/17						vac		school year 17/18										vac		school year 18/19										vac		school year 19/20							
		1	2	3	4	5	6	7	8	9	10	11	12	1	2	3	4	5	6	7	8	9	10	11	12	1	2	3	4	5	6	7	8	9	10	11	12	1	2	3	4
Measure 1: Retrofit the external walls and roof with insulation	P																																								
	I																																								
Measure 2: install thermostatic valves	P																																								
	I																																								
Measure 3: replace existing light with LED	P																																								
	I																																								
Measure 4: Photovoltaic system for electricity production	P																																								
	I																																								
Install smart metering/on line data access	P																																								
	I																																								

Table 4 - timeline for implementation

7. Appendix

7.1. Economic efficiency calculation *Measure 1: Retrofit the external walls and roof with insulation*

calculation of the energy savings							
Scuole Elementari Luigi Battaglia a Fusignano (RA)							
Masure:	Retrofit external walls with insulation						
Building specifications							
Energy carrier:		naural gas				Area	
Energy prize:		60,3	€/MWh$_{(Hs)}$	external wall type 1		2.298	m²
				external wall type 2		0	m²
Overall efficiency		65%		Windows		1.920	m²
				Roof		973	m²
period of use:		30	years	others		0	m²
State old							
		EW T1	EW T2	WINDOW	ROOF	OTHERS	
	U value$_{old}$:	1,3		2,4			W/m²K
State new							
		EW T1	EW T2	WINDOW	ROOF	OTHERS	
	U value$_{new}$:	0,2		0,9			W/m²K
Energy saving							
		EW T1	EW T2	WINDOW	ROOF	OTHERS	
	U value$_{old}$:	1,10	0,00	1,50	0,00	0,00	W/m²K
	Factor:	1,00	1,00	1,00	1,00	0,60	-
	Ux F x A	2.528	0	2.880	0	0	W/K
	intermediate result				5.408		W/K
	Factor local climate		0,066	Kh/1000			
	Heating energy saving		549	MWh/a	energycosts	33.113	€/a
	incl. efficiency					33.114	€/a
Cost of intervention							
external wall			100	€/m²		229.840	€
window			450	€/m²		0	€
roof			200	€/m²		194.580	€
others			100	€/m²		0	€
Planning costs and fees				included		0	€
						424.420	€
					incl. VAT	**505.060**	**€**
Economics							
return on capital (static)			**15,3**	**years**			
CO_2-savings			**110**	**to/a**	Subsidy	**164.579**	**€**
return on capital (static)			**10,3**	**years**	incl. Subsidy		

7.2. Fehler! Verweisquelle konnte nicht gefunden werden.

Scuole Luigi Battaglia - Fusignano						
Masure:	new lighting with LED					
Building specifications						
Energy carrier:	electrical power					
Energy prize:		301,0	€/MWh	(incl. VAT)		
period of use:		15	years			
State old						
	power per lamp	70	Watt	lifespan lamp	12.000	h
	number of lamp	208		time of use	1.200	h/a
	period of use from	15	years	Cost of the lamp	1,50	€incl.VAT
	number of replacements	1		installation costs	1,00	€incl.VAT
State new						
	power per lamp	34	Watt	lifespan lamp	30.000	h
	number of lamp	208		time of use	1.200	h/a
	period of use from	15	years	Cost of the lamp	20,00	€incl.VAT
	number of replacements	0		installation costs	5,00	€incl.VAT
Energy saving and maintenance saving						
	Power consumption					
	state old	17.472	KWh/a			
	state new	-8.486	KWh/a			
	electricity energy saving	8.986	KWh/a	energycosts	2.705	€/a
	maintenance					
	state old				35	€/a
	state new				0	€/a
	maintenance saving				35	
	intermediate result				2.739	€/a
Cost of intervention						
	Installation LED lighting		25	€/lamp	5.200	€
					5.200	€
				incl. VAT	**6.188**	**€**
Economics						
return on capital (static)		**2,3**	**years**			
CO_2-savings		**3,89**	**to/a**	Subsidy	**2.475**	**€**
return on capital (static)		**1,4**	**years**	incl. Subsidy		

Interreg
CENTRAL EUROPE
ENERGY@SCHOOL
European Union
European Regional Development Fund

ENERGY AUDIT REPORT PRIMARY SCHOOL "IL CERCHIO" (BRANCH) FUSIGNANO (RA) REQUIRING DEVELOPMENT OF AN ENERGY GUARDIAN SMART SCHOOL MANAGEMENT PLAN

N. DELIVERABLE D.T2.1.1 — *Version 01* — *06 07 2017*

http://www.interreg-central.eu/Content.Node/ENERGYATSCHOOL.html

Edited by Unione Bassa Romagna (Rita Ricci and Laura Delpiaz)

In cooperation with Naxta Ltd (Federico Fileni and Giulia Righetti)

Index

1. Background

In Fusignano (RAVENNA - Italy) there are 4 municipal schools belonging to the "Istituto comprensivo Luigi Battaglia":

1. Scuola Secondaria di primo grado "Emaldi"
2. Scuola primaria "Luigi Battaglia" - sede
3. Scuola primaria - succursale
4. Scuola dell'infanzia

In 3 of them, a systematic inventory was carried out in the autumn of 2016, on the initiative of the European research project energy@school, on the basis of which a comprehensive report of the inventory of each city was prepared (Deliverable D.T1 .1.3, January 30, 2017, edited by CertiMaC, Italy).

The goal of ENERGY @ SCHOOL is to simplify the introduction of smart energy schools. With an integrated approach, teachers and students are trained as Senior and Junior Energy Guardians (EGs).

They are committed to a sustainable increase in the energy efficiency of buildings and an understanding of the appropriate energy consumption ("energy culture") of a school building.

ENERGY @ SCHOOL aims to achieve the following results:

I. Optimization of energy consumption in schools,
II. Concrete and progressive increase of EE and RES use in schools not only thanks to technical application of smart solutions, but also to non-technical factors such as a better management capacity and responsible behavior toward energy use,
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These schools receive an individual report on the energy audit with this document. This report is intended to serve as the basis for the development of an energy action plan (Energy Guardian Smart School Management Plans - EGSMPs) to the school's managers and, in addition to inventory analysis, includes investive and non-investive measures for energy saving.

These actions help to develop individual actions in the respective school and a common strategy for smart schools (CSSS).

Further information are available at the following link **http://www.interreg-central.eu/Content.Node/ENERGYATSCHOOL.html**

2. Summary

The examined school had an average energy performance indicator of electricity of 37,74 kWh/m² per year and 27.09 m³ of natural gas per year for m². The share of renewable energies in the electricity sector is 0 % in the heating sector 0 %.

Energy Performance Indicators

		Total consumption per year	Consumption per volume	Consumption per heated area	Consumption per number of students	Consumption per number of days	Total energy consumption per year	kg CO2 equivalent per year	Tonnes of oil equivalent per year
Energy carrier/Fuel/ Power source	u.m.	u.m.	u.m./m³	u.m./m²	u.m./student	u.m./day	kWh	kg CO_2 equiv	tep
Electricity	kWh_{el}	46085	6,29	37,74	415,18	190,43	46085	19964	9
Natural gas	Sm3	33076	4,51	27,09	297,98	136,68	317528	6609	28
Fuel oil/Diesel	t	0					0		0
GPL	t	0					0		0
Biomass	t	0					0		0
District heating	kWh_t	0					0		0
District cooling	kWh_f	0					0		0
Photovoltaics	kWh_{el}	0					0		0
Solar thermal collectors	kWh_t	0					0		0
Geothermal	kWh_t	0					0		0
Other - energy produced	0	0					0		0
Tonnes of oil equivalent	tep	36,27	0,00	0,03	0,33	0,15		26573	36

Table 1 - Energy performance indicators

The following measures are recommended for the order of implementation.

Measure	Investment costs €	energy savings kWh/year	cost savings €/year	return of invest years	Kg CO_2-savings to (CO_2)/year
Measure 1: Retrofit external walls with insulation	**411.806**	(66%) 241.842	17.452	23,6	48.320
Measure 2: install thermostatic valves	**932**	(2%) 7.320	534	1,7	1.462
Measure 3: Replace lights with LED	**4.050**	4.204 (-57%)	1.009	4	1821
Measure 4: Install Energy Saving Switch and Presence Sensors	**8.500**	(-10%) 740	180	45	320
Measure 5: Install a photovoltaic system	**32.000,00**	(-48%) 22.000	5.280	6	9.530
Measure 6: Install a solar thermal system	**2.400**	1.600	120	20	33
Measure 7: Install building automation system (automatic centralized control of a building's heating, ventilation and air conditioning, lighting...)	**30525**	(10%) 36361	3421	8,8	8340
Measure 8: Change end-user behaviour: control devices stand-by (monitors, PCs, laboratory equipment, lights, etc.)	**0**	(5%) 18.180	1710	0	8340

3. Generalities of the school

Figure 1 shows the Primary School "Il Cerchio" in Fusignano (RA). The school building was built in two different steps, the U-shaped central body was built in 1900 and has an accessible basement, while the two lateral wings, subsequently constructed, have the accessible basement. In 1960, the building, which was characterized by a brick-filled masonry, was subjected to several renovation works that mainly affected the floors.

The classrooms (9 in total) are located only on the first floor and are exposed to SUD, while on the ground floor there is a canteen and some spaces dedicated to the polyvalent center that are used as art workshops.

Fig 1 - Primary School "Il Cerchio"

GENERALITIES

School type	Primary
Student age range	6-11

GEOGRAPHICAL LOCATION AND WEATHER CONDITIONS

Country	Italy
City	Fusignano (RA)

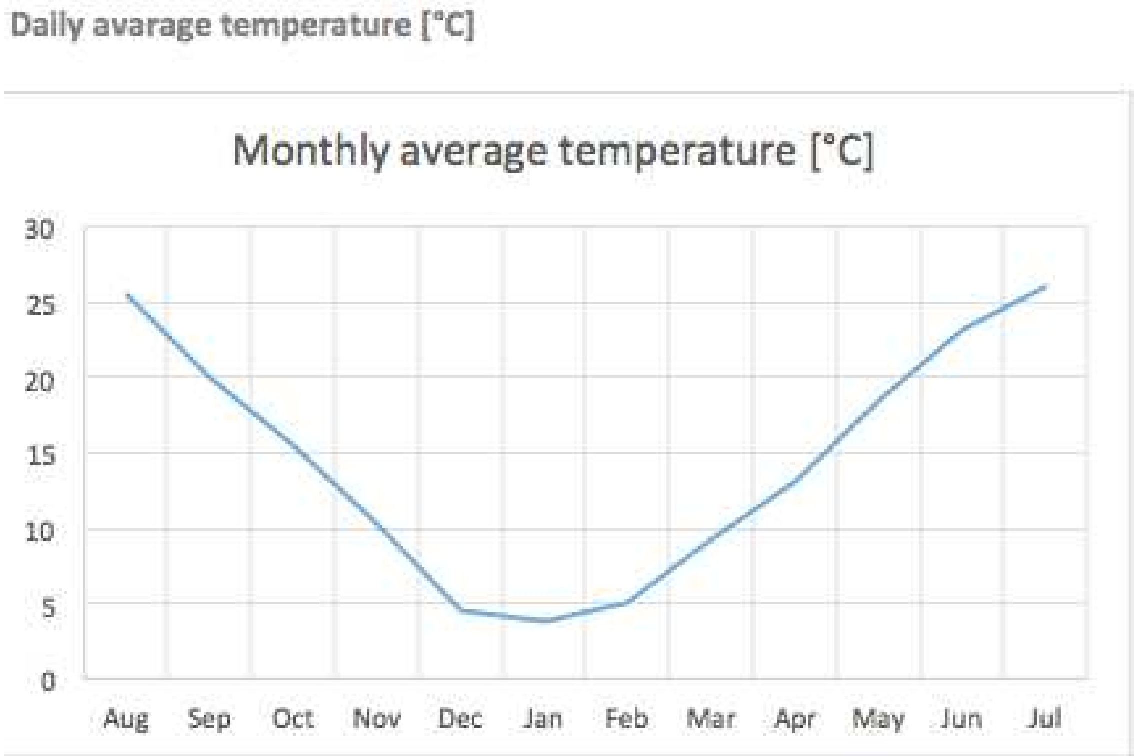
BUILDING GEOMETRY

OCCUPATION AND USE OF THE BUILDING

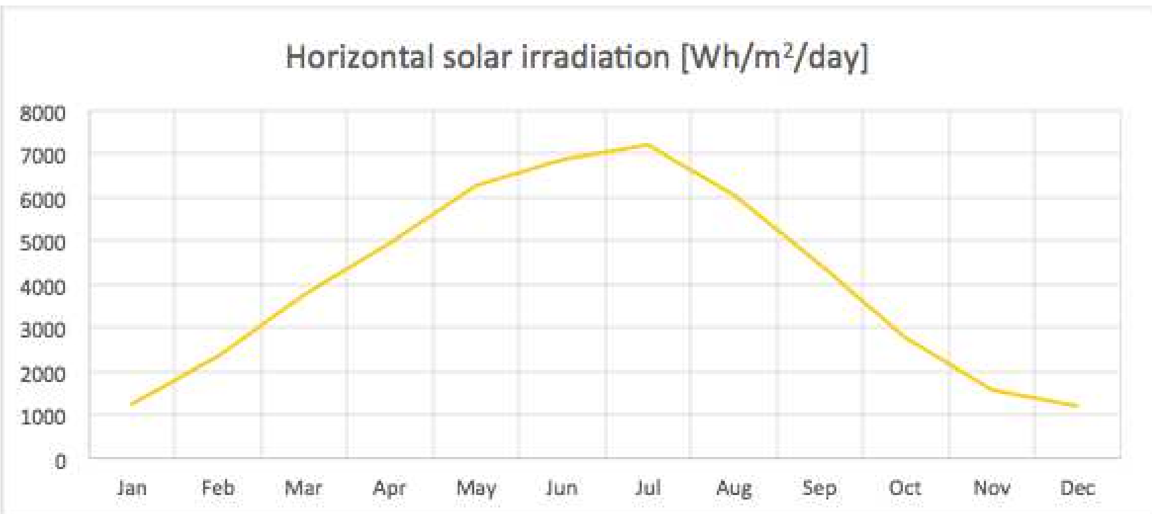
Total floor heated area [m^2]	1221
Volume [m^3]	7326
S/V	0,56

Number of students	111
Total days of use	242
Daily hours of use	7
Total area allocated to classrooms [%]	72%

General information about the climate



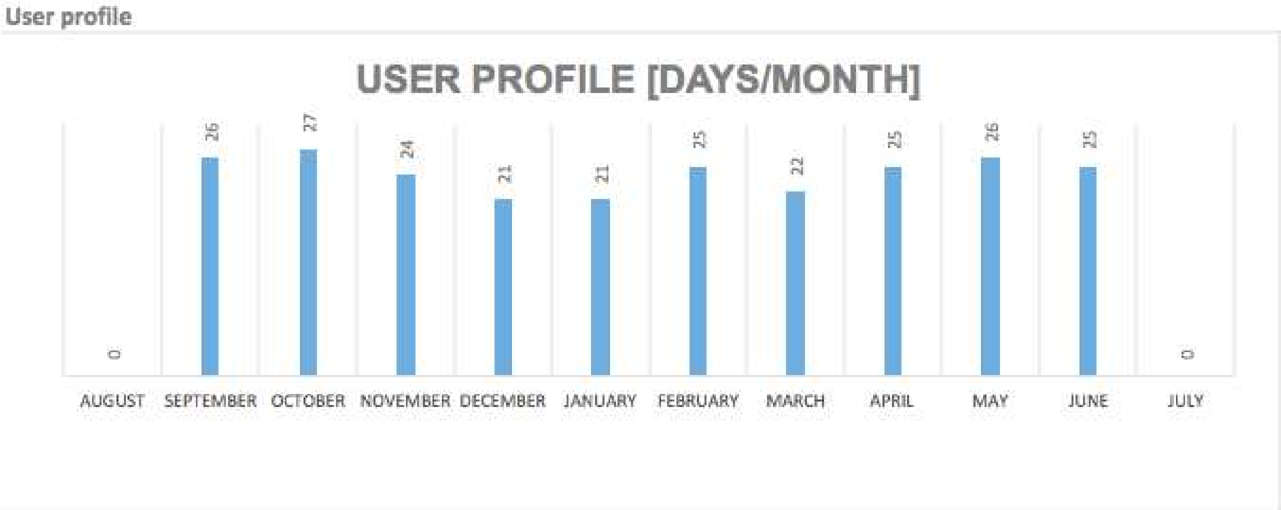
Picture 2- Graphic representation of monthly average temperature [°C]



Picture 3 - Graphic representation of the Horizontal solar irradiation [Wh/m^2/day] per Months. This value is the monthly/yearly average of the sum of the solar radiation energy that hits one square meter in a horizontal plane in one day.

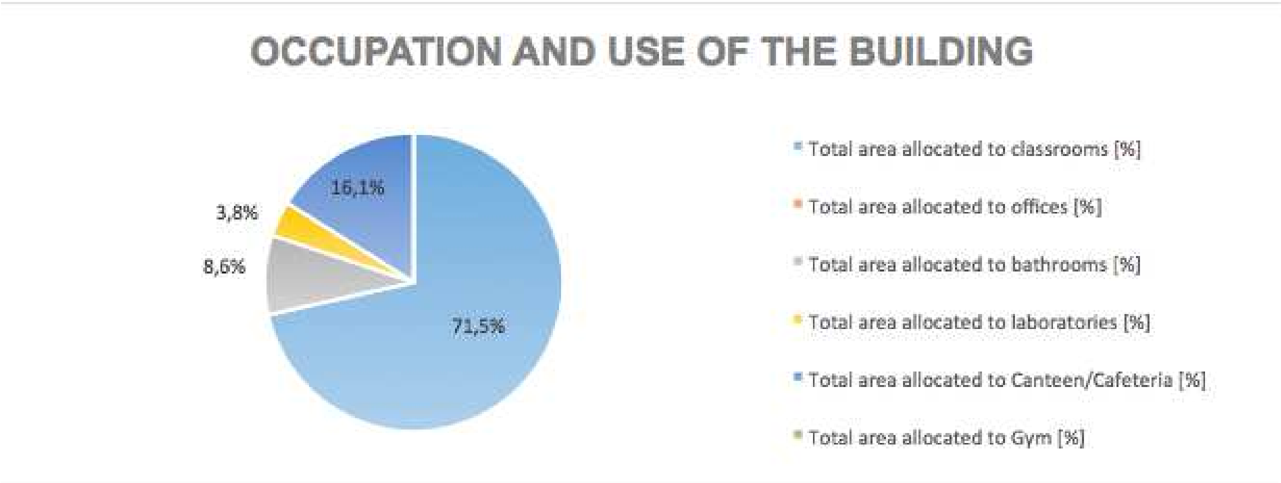
General information about the use of the school

Picture 4 shows the school's use profile and the holiday's period. In total the school comes on 242 days of operation.



Picture 4 - Graphic representation of the user profile during school period [working days/month]

Picture 5 shows the different uses in the school building. 71,5% of the area is allocated to classrooms. 16,1 % of the area is canteen, 8,6 to bathrooms and 3,8 to laboratories-

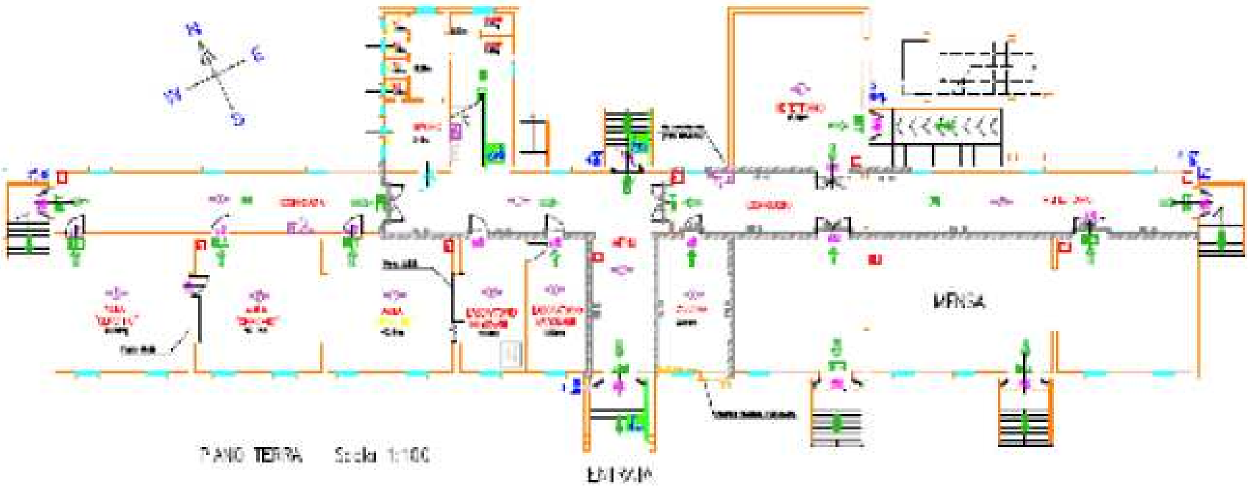


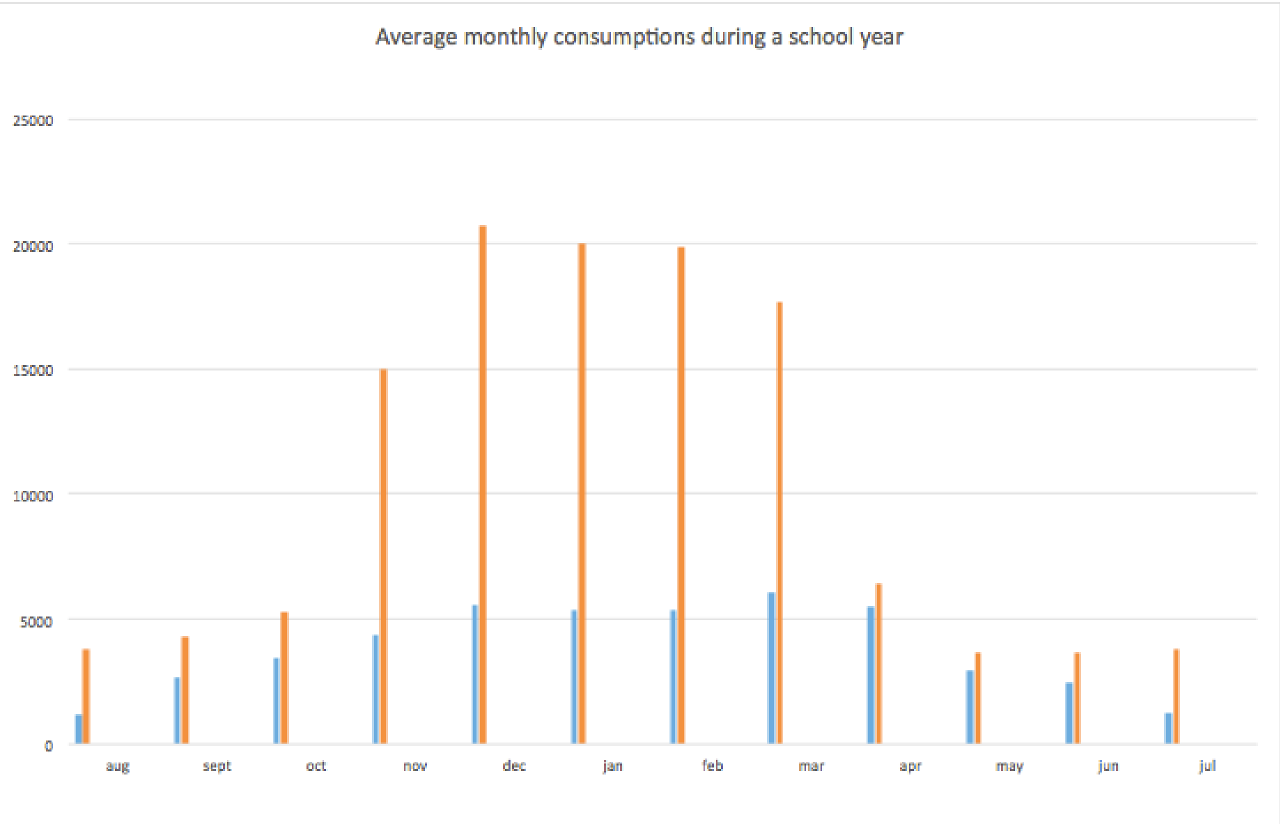
Picture 5 - Division of the School areas for intended use [%]

4. Description of the current state

General information about the current state

The building is entirely used as a school plexus and energy consumption is due to heating, lighting and power supplies.





Picture 6: average monthly consumption (electricity and gas) during a school year

4.1. Building

Current state of the building

The school building was built in two different steps, the U-shaped central body was built in 1900 and in 1960, the building was subjected to several renovation works that mainly affected the floors.

The masonry structure is a full brick walls without hollow Insulated space (30 cm thick).

The building is equipped with an Energy Performance Certificate drawn up on 25/05/2016 which certifies a building energy requirement of 372,11 kWh/m^2/year (E Class).

BUILDING ENVELOPE

Year of construction	1900 - 1960
Type of structure	masonry structure is a full brick walls without hollow Insulated space
External wall insulation	No insulation

4.2. Water and energy supply

Current state of the energy suply

The heating system of the schools is provided by a district heating system whose thermal plant is located in a specially built exterior building.

In the latter there are 4 boilers (cascading) that are connected to 3 branch units, characterized by pumps that circulate the hot water in the building to which they are responsible.

HVAC AND RES SYSTEMS

Heat generation system	Natural gas boiler
RES systems	None

4.3. Builiding automation system

General information about the builging automation system

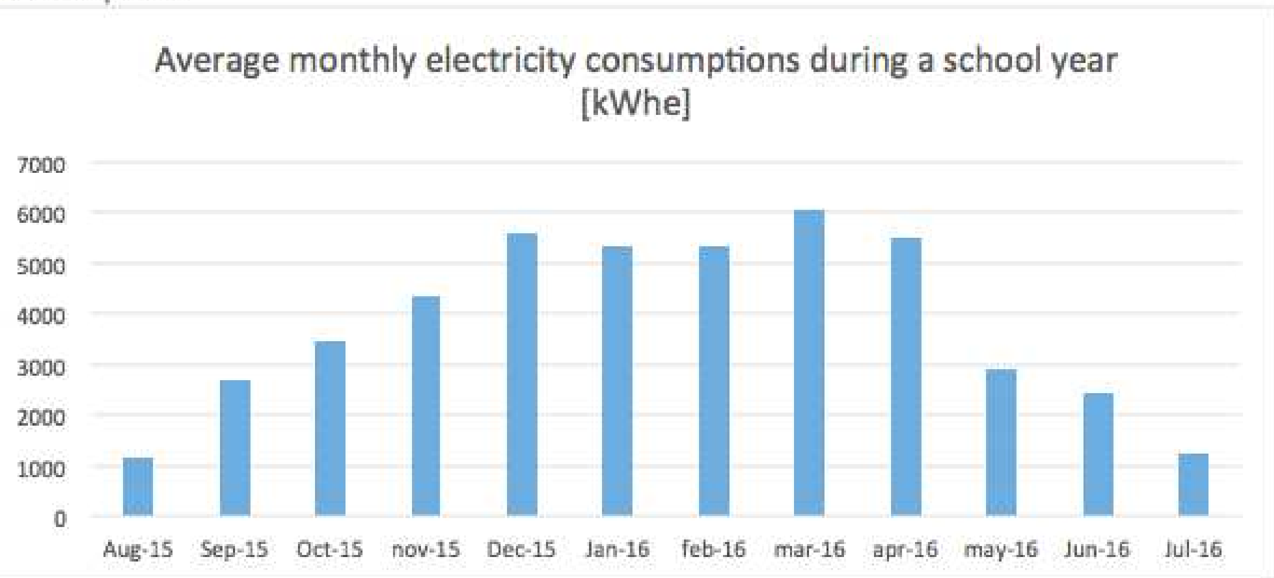
There is a temperature control thermostat. There are no separate heat accounting systems or other building automation or home automation systems.

4.4. Recording Energy Consumption

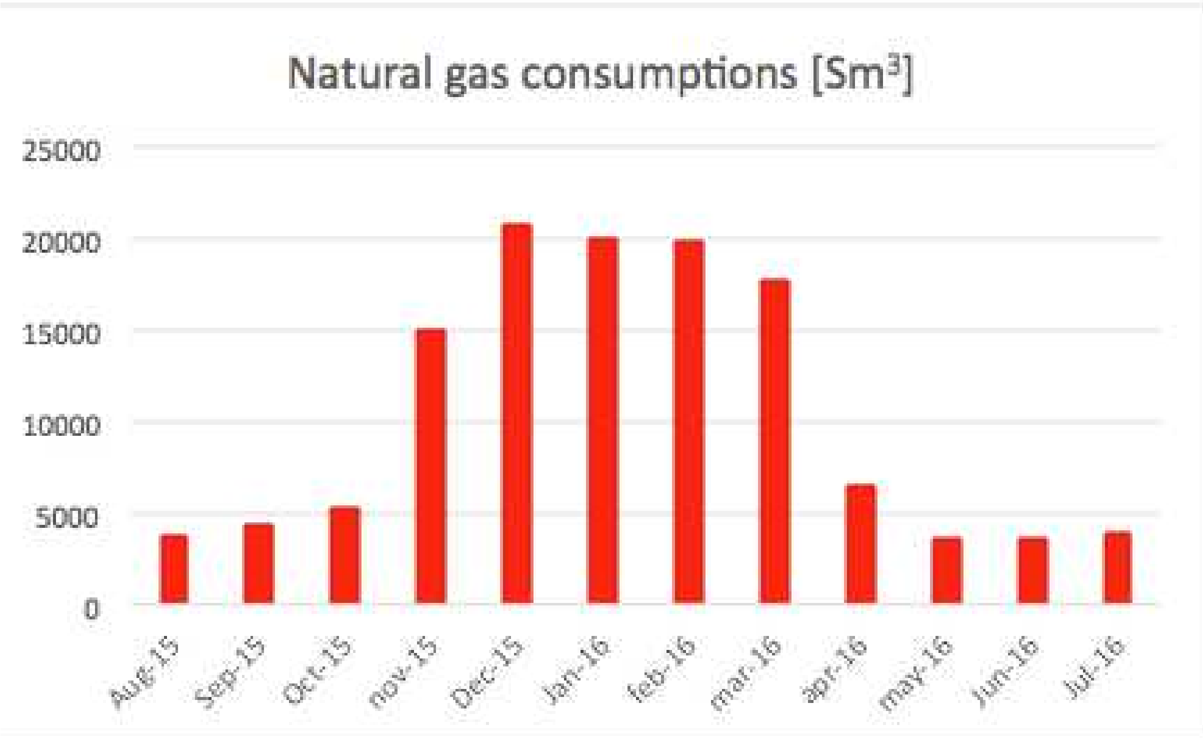
There is monitor Energy consumption for lighting but no monitoring for other energy uses. The energy and costs have been elaborated from the energy invoices.

There is no solar generated electricity. (Picture 6, Picture 7) show the monthly consumption values.

Consumptions



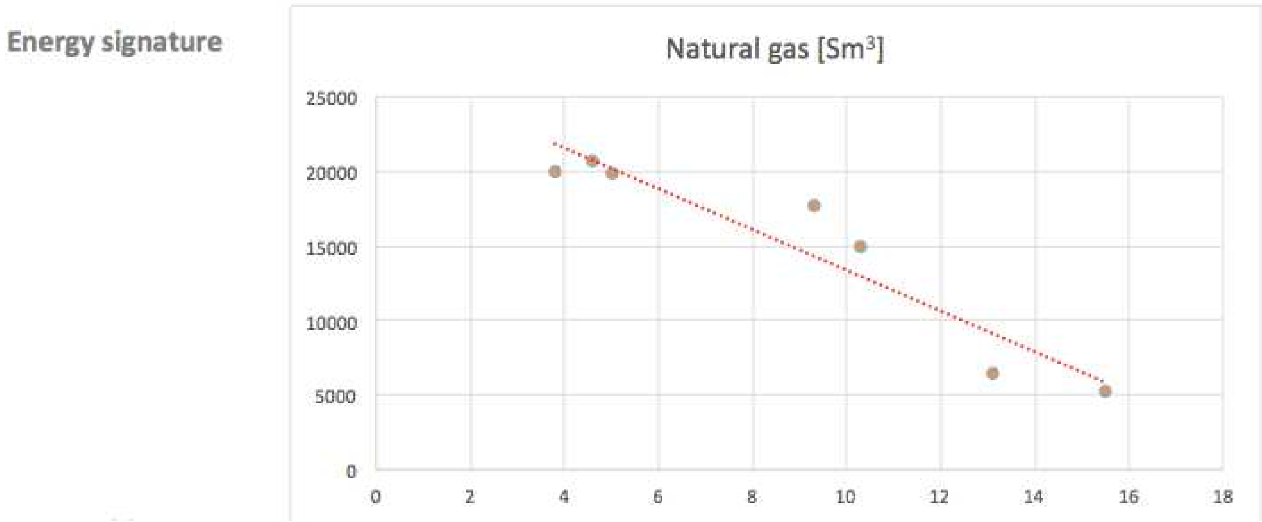
Picture 6 - Average monthly electricity consumptions during a school year [kWhe]



Picture 7 - Natural gas consumptions during a school year [Sm^3]

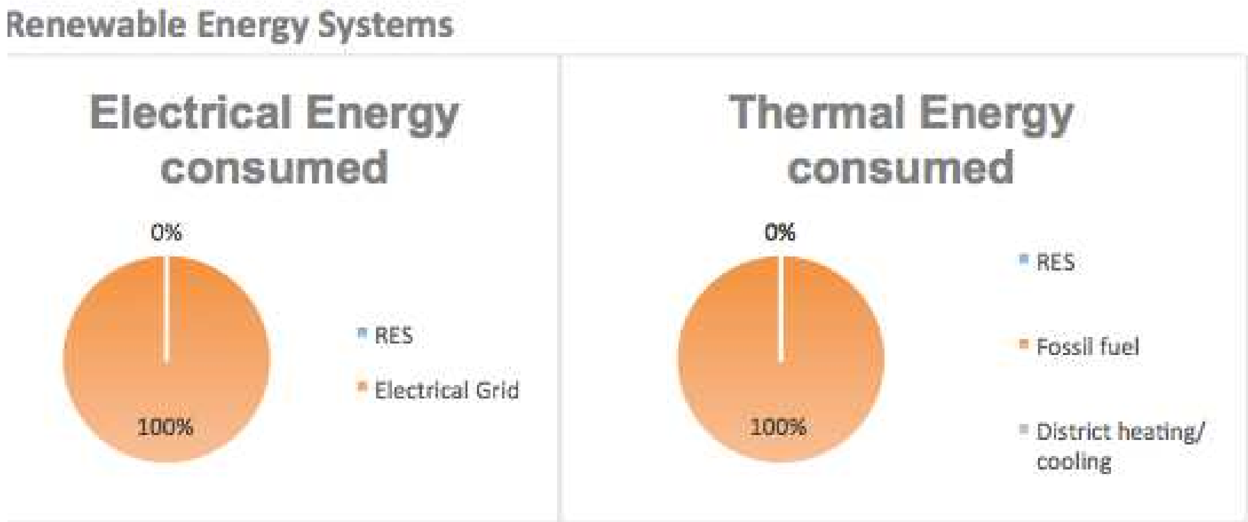
The higher demand of both types of energy is clearly visible in winter. While the higher demand of electricity is influenced in particular by the longer lighting time in winter, the heating energy demand depends on the weather and/or on the outside temperature.

The following figure (Picture 8) shows the relationship between the average outside temperature and the monthly gas requirement.



Picture 8 - Energy signature representation: Natural gas consumptions [Sm^3] vs External Temperature [°C]

The share of renewable energies (see Picture 9) is 0 % in the electricity sector. In the heating system the RES contribute is 0 %.



Picture 9 - Pie Graph of Electrical and Thermal energy consumptions, related to the different energy carriers/fuels or systems [%] in use into the school.

4.5. Energy Performance Indicators

General information about energy performance indicators

Energy performance indicators are necessary for comparability with other schools. There are constant reference values, such as, e.g. the heated area or the volume, or slightly fluctuating reference variables such as the number of pupils or the working days.

A very important reference is the heating degree-days. Over the past few years, these have seen a deviation of approx. +/- 12%.

The heating performance indicator in relation to the area and the heating degree-days therefore allows a consideration of the consumption figures irrespective of the weather.

		Total consumption per year	Consumption per volume	Consumption per heated area	Consumption per number of students	Consumption per number of days	Total energy consumption per year	kg CO2 equivalent per year	Tonnes of oil equivalent per year
Energy carrier/Fuel/ Power source	u.m.	u.m.	u.m./m³	u.m./m²	u.m./student	u.m./day	kWh	kg CO_2 equiv	tep
Electricity	kWh_{el}	46085	6,29	37,74	415,18	190,43	46085	19964	9
Natural gas	Sm3	33076	4,51	27,09	297,98	136,68	317528	6609	28
Fuel oil/Diesel	t	0					0		0
GPL	t	0					0		0
Biomass	t	0					0		0
District heating	kWh_t	0					0		0
District cooling	kWh_f	0					0		0
Photovoltaics	kWh_{el}	0					0		0
Solar thermal collectors	kWh_t	0					0		0
Geothermal	kWh_t	0					0		0
Other - energy produced	0	0					0		0
Tonnes of oil equivalent	tep	36,27	0,00	0,03	0,33	0,15		26573	36

Table 2 - Energy performance indicators

4.6. Energy consumers

The analysis of the energy consumers is intended to show the most important consumption points with the highest potential.

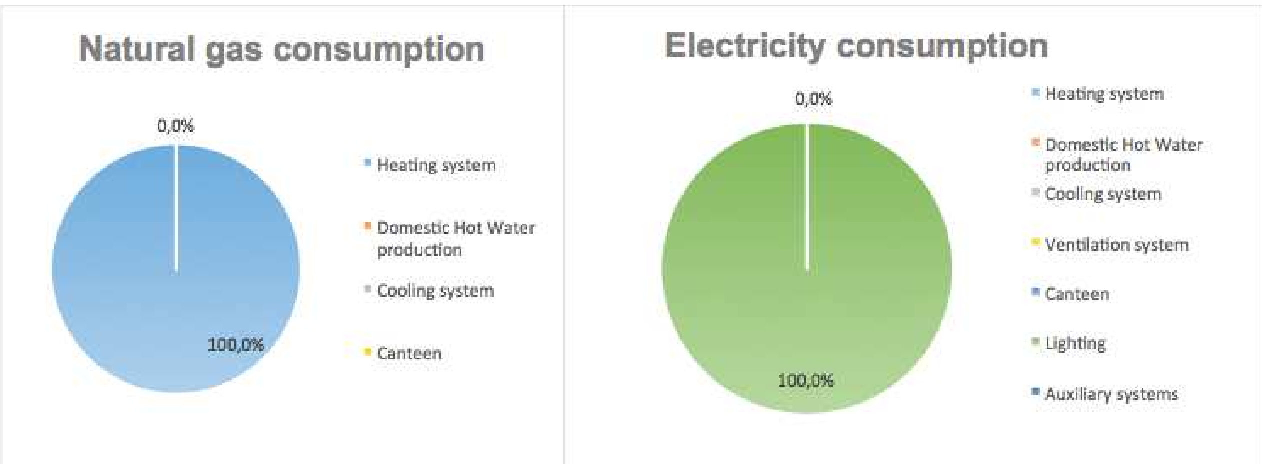
In the case of heat supply, the heat requirement for the domestic hot water supply and the heat demand play a role.

The heat demand for space heating is the sum of the heat loss caused by the transmission of heat through the walls and windows and the heat loss due to the ventilation of the windows minus the solar gains over the window surfaces.

Simplified, the heat required for the shower water is very low (we are in a primary school). In the school building, the fresh air demand is only realized with window ventilation.

The underlying value is therefore based on a fresh air requirement of 30 m³ / h per person. The share of end users for electricity and heat demand is shown in Picture 10.

Consumptions subdivision

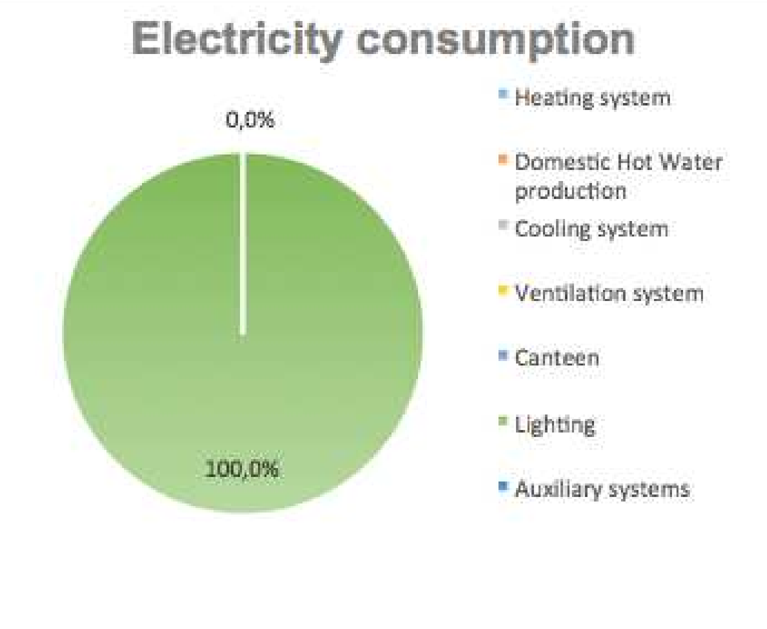


Picture 10 - Natural gas and electricity consumptions subdivision [%] for each final intended use

The lighting mainly influences the electricity consumption. The electricity requirement of the electric water heaters on the hand-washing basins is based on the fact that each user needs an average of about one liter of hot water.

Currently there is no known electrical consumption due to the kitchen appliances and kitchen utensils. To simplify, total electrical consumption has been attributed to lighting, but the development of the project will allow you to measure (by smart meter) the consumption of the canteen and kitchen separately.

Picture 11 shows that a share of 99% is used for lighting.



Picture 11 - Electrical consumptions subdivision [%] for each final intended use

5. Ways to improve energy efficient

The following section is concerned to ways to improve energy efficiency.

5.1. Building envelope

General information about the improvement at the buildingside

The exterior walls of the existing buildings correspond to the constructional "non" insulation standard of the builted year. Subsequent insulation of the walls, together with roof insulation, reduces heat losses by 66%.

Windows replacement have not been considered because of the total amount of the costs, referred to the energy saving.

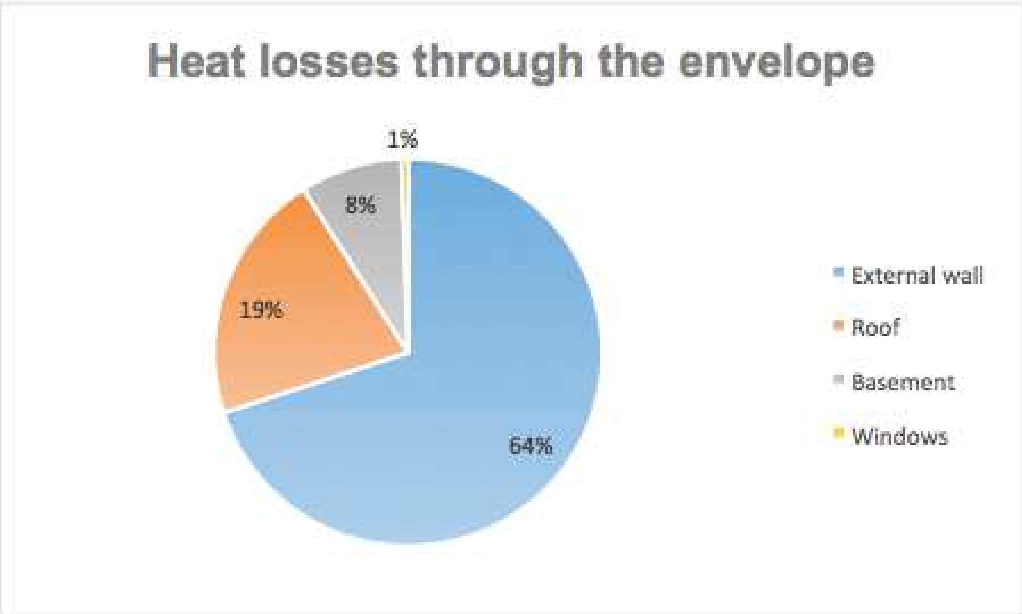
Measure 1: Retrofit the external walls and roof with insulation

The building envelope also offers opportunities for the user to actively contribute to energy saving. For example, sun protection can be used specifically to influence the solar gains: in winter they can reduce heating requirements and counteract heat build-up in the summer time. Furthermore, the energy consumption can also be reduced to the necessary extent by means of a demand-oriented window ventilation.

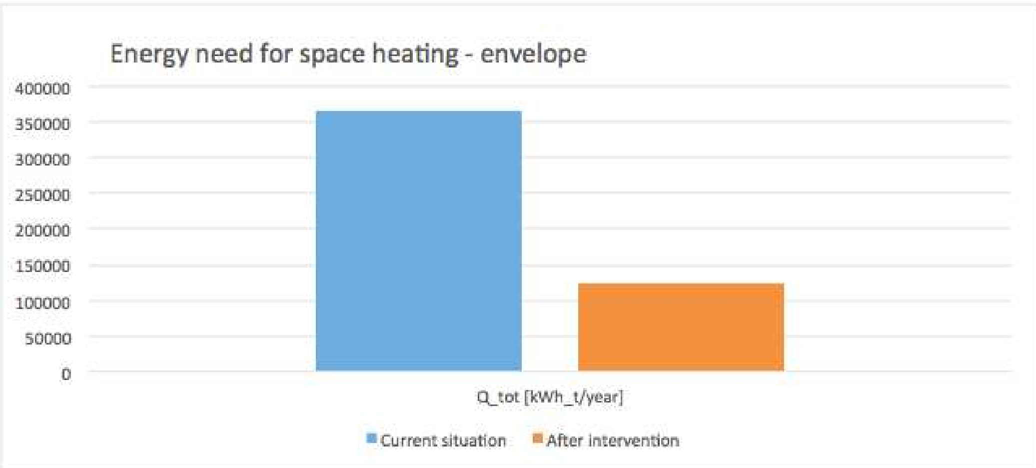
Measure	Investment costs €	Energy savings kWh/a	Cost savings €/a	Return of invest years	CO_2-savings kg (CO_2)/a
Retrofit external walls with insulation and retrofit roof	**411.806**	**(66%) 241.842**	**17.452**	**23,6**	**48.320**

Note: the evaluation of the investment doesn't take care of incentives. In affirmative case, the incentves is 40% of the total costs of the investment.

Heat losses through the envelope



The graph shows the energy losses through the different components of the building



The graph shows the current energy needs and what would result from the implementation of the energy efficiency intervention on the envelope.

5.2. Install thermostatic valves

Thermostatic valves on radiators allow you to adjust the temperature on each radiator but especially in each classroom separately.

By this way, you can have the ideal temperature, avoiding waste and taking advantage of free energy supplies such as solar radiation, the presence of many people, and so on. It has been estimated 2% of energy savings on heat demand (natural gas consumption) but in addition to the energy savings the thermostatic valves allow to improve the climate inside the classrooms.

Thermal regulation should be a task of the JEGs (Junior Energy Guardians).

Measure 2	Investment costs €	Energy savings kWh/year	Cost savings €/year	Return of invest year	CO_2-savings to (CO_2)/year
Install thermostatic valves	**932**	(2%) 7.320	534	1,7	1.462

Measure 2: Installation of thermostatic valves

5.3. Replace light with LED

Replacing current lamps with new LED lamps gives an estimated 57% energy saving as regards electricity consumption. In the case of school, lighting is the almost exclusive cause of electricity consumption.

Even though LEDs reduce power consumption, Junior Energy Guardians can always check that energy is not wasted by illuminating the classrooms when they are not busy (recreation or lunch time, ecc.).

Measure 3	Investment costs €	Energy savings kWh/year	Cost savings €/year	Return of invest year	CO_2-savings to (CO_2)/year
Replace lights with LED	**4.050**	4.204 (-57%)	1.009	4	1821

Measure 3: replacement of the light with LED

5.4. Install Energy Saving Switch and Presence Sensors

The luminous flux regulators affect the amount of light to be delivered. The adjustment process, called "dimming", adjusts the amount of artificial light according to the amount of light set. A brightness sensor allows you to estimate the amount of light present in the compartment and to reduce the amount of artificial light depending on the presence of natural light, ensuring both an energy-efficient system, but above all a properly illuminated indoor environment depending on the activities that It takes place (studyng, working, ecc.).

The presence sensors, on the other hand, eliminate artificial light delivery if nobody is in the room, bathroom, ecc. This device is really useful for rooms that are used in a non-continuous manner such as bathrooms and storage rooms.

In the school it could also be useful for the classrooms to prevent the lights from turning on when students and teachers go away. This last activity, before the installation of presence sensors, may be carried out by the Junior Energy Guardian.

Measure 4	investment costs €	energy savings kWh/a	cost savings €/a	return of invest a	CO2-savings to (CO2)/a
Install Energy Saving Switch and Presence Sensors	**8.500**	(-10%) 740	180	45	320

Measure 4: Install Energy Saving Switch and Presence Sensors

5.5. Electrical energy reduction with PV system

The electricity used by the school is totally taken from the national electricity grid. A photovoltaic installation calculated on the possible 100% self-consumption will reduce the energy demand by self-production (when the school is open) and to avoid CO_2 emissions because it should be Renewable Energy Source. The cost saving has been calculated with a 0,24 € per kWh of the actual costs, referred to the invoices.

Measure 5	Investment costs €	Energy savings kWh/year	Cost savings €/year	Return of invest year	CO_2-savings to (CO_2)/year
Install a photovoltaic system	**32.000,00**	(-48%) 22.000	5.280	6	9.530

Measure 5: Photovoltaic system for electricity production

5.6. Install a solar thermal system

Solar collectors are devices installed outside the building (usually on the roof). These are elongated tanks that contain water that, thanks to solar radiation, warms up. Heated water is accumulated in a tank and can be used as sanitary hot water without any needing of "energy" to heat it.

In summer time, the use of hot water from the exhaled collector allows the boiler not to activate (avoiding gas consumption) or not to use the electric boilers in the bathrooms (avoiding electricity consumption).

Some built-in systems allow you to use the collector's hot water in synergy with the heating system because, especially in the autumn, during sunny days the collector allows to heat the water thus "working" less the boiler.

As the collector water is heated (for free) from the sun, the produced energy is considered to be produced from a completely renewable source. In addition, sunbathing is completely free.

Measure 6	Investment costs €	Energy savings kWh/year	Cost savings €/year	Return of invest year	CO_2-savings to (CO_2)/year
Install a solar thermal system	**2.400**	1.600	120	20	33

Measure 6: solar thermal system for thermal production (hot water)

5.7. Install building automation system

Building Automation systems allow you to monitor and manage integrated building systems. The main elements handled by automation systems refer to:

- Lighting;
- Heating and cooling;
- Intrusion and safety;
- Sensor presence;
- Fire.

Some of these system, such as lighting and heating, have a direct impact on building energy consumption, and their optimal management allows you to streamline your energy consumption, as well as having a good indoor comfort for studying and working, checking temperature, humidity, air exchange and lighting.

The system consists of sensors that control the settled parameters, an electronic control unit that receives sensor data and, based on the fixed settings, sends signals to the respective systems that handle the various functions. The control unit therefore receives data on temperature, illumination level, etc. ... and then asks the boiler or electrical system to attenuate or increase the "energy flow".

These are systems that have both a hardware component (sensors) and a software component (the control unit) and which need to be "customized" to the desired parameters case-by-case.

Measure 7	Investment costs €	Energy savings kWh/year	Cost savings €/year	Return of invest years	kg CO_2-savings to (CO_2)/year
Install building automation system (automatic centralized control of a building's heating, ventilation and air conditioning, lighting…)	**30525**	(10%) 36361	3421	8,8	8340

Measure 7: building automation system (automatic centralized control of a building's heating, ventilation and air conditioning, lighting…)

5.8. Change end-user behaviour

Some of our behaviors and habits directly affect the energy consumption of the building, especially at home but also at school.

Acquiring awareness of how our behaviors affect or not affect on energy consumption and indirectly on the environment and climate is one of the main goals of any energy initiative, directive or research initiative.

To get a conscious behavior especially in school age helps to grow people who will mater this behavior and become a spokesman for a culture of sustainability. Specifically, it is to learn how to eliminate waste or to choose one thing rather than another one in function of the impact it generates.

What does it mean to choose to go to school by bike or on foot rather than by car? Is it true that the lights should be turned on because if I turn it off and turn it on, I use more energy? Is it true that computers consume electricity even when they are off?

Awareness helps to understand how much our daily actions affect the environment and how we can reduce our impact (ecological and environmental footprint) to preserve the environment for future generations.

Measure 8	Investme nt costs €	Energy savings kWh/year	Cost savings €/year	Return of invest years	CO_2-savings to (CO_2)/year
Change end-user behaviour: control devices stand-by (monitors, PCs, laboratory equipment, lights, etc.)	**0**	(5%) 18.180	1710	0	8340

Measure 8: Change end-user behaviour: control devices stand-by (monitors, PCs, laboratory equipment, lights, etc.)

6. Timeline for implementation

The implementation of the measures must be adapted to the project duration of energy@school (from July 2016 to June 2018). In Table 3, the implementation of the measures is listed separately in times for planning or data collection and implementation or initiation.

Measure - planning / implementation		school year 16/17						vac		school year 17/18										vac		school year 18/19										vac		school year 19/20							
		1	2	3	4	5	6	7	8	9	10	11	12	1	2	3	4	5	6	7	8	9	10	11	12	1	2	3	4	5	6	7	8	9	10	11	12	1	2	3	4
Retrofit external walls with insulation	P										■	■	■	■																											
	I																															■	■	■	■						
Thermostatic valves									■																																
										■	■																														
Replace lights with LED	P						■	■	■																																
	I								■	■																															
Install Energy Saving Switch and Presence Sensors	P									■	■																														
	I											■	■	■	■	■																									
Install a photovoltaic system	P										■	■	■																												
	I																															■	■								
Install a solar thermal system	P										■	■	■																												
	I																															■	■								
Install building automation system	P																■	■																							
	I																		■	■	■	■	■																		
Change end-user behaviour: control devices stand-by (monitors, PCs, laboratory equipment, lights, etc.)	P											■	■	■																											
	I													■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■

Table 3 - timeline for implementation