Project co-financed by the European Regional Development Fund

REPUBLIKA SLOVENIJA
SLUŽBA VLADE REPUBLIKE SLOVENIJE ZA RAZVOJ IN EVROPSKO KOHEZIJSKO POLITIKO

D 3.2.3 Public buildings energy audits

Project co-financed by the European Regional Development Fund

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WP 3 - Testing

Activity 3.2 – Context Analysis

Deliverable 3.2.3 – Public buildings energy audits

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1. Introduction

The project’s main objective is to enhance and improve the coordination and performance of SEAPs and other Energy plans concerning achieving EU and national targets on the energy efficiency in public buildings. The project’s approach is based on belief that in order to achieve tangible effects in relation to energy efficiency in public building stock, policies and actions need to be coordinated and tailored to the territorial needs. The ENERJ project builds on the awareness that a joint approach to energy planning, especially for small local authorities, can allow achieving more effective results than an isolated one.

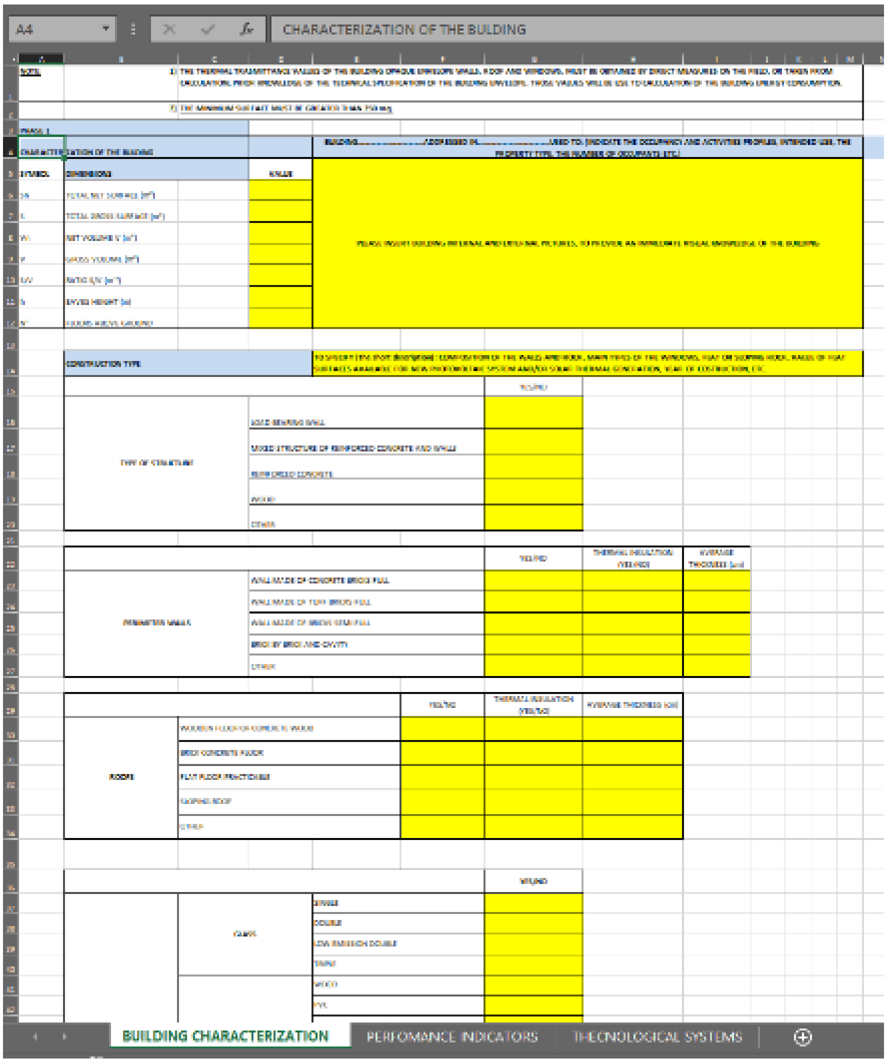
The purpose of the deliverable **3.2.3 Public buildings energy audits** is to colect existing data on selected public buildings (energy performance and EE analysis) and integration of it with new analysis and studies to be carried out in order to complete the status quo situation.

2. Data collection method

The first step in the course of elaboration of Energy audits was a definition of common methodology or method of data collection. The common methodology was developed by partner Metropolitan City of Capital Rome. Full methodology/data collection form is presented in annex I.

The data collection form was divided in three chapters:

- Building characterization
- Performance indicators
- Technological systems



Picture 1: Data collection form

The purpose of the collection form is to unify the data among partners so a common analysis is possible. Also, the data collected will be used in a ENERJ project web platform, so it has to be unified.

3. General description of the analyzed building stock

ENERJ project partners that were included in the elaboration of energy audits are:

LP1 - ANATOLIKI S.A. (Greece)

PP1 – FAMP (Spain)

PP2 – IRENA (Croatia)

PP3 – CEA (Cyprus)

PP4 – GDA (Gozo)

PP5 – CMRC - Citta Metropolitana Roma (Italy)

PP6 – GOLEA (Slovenia)

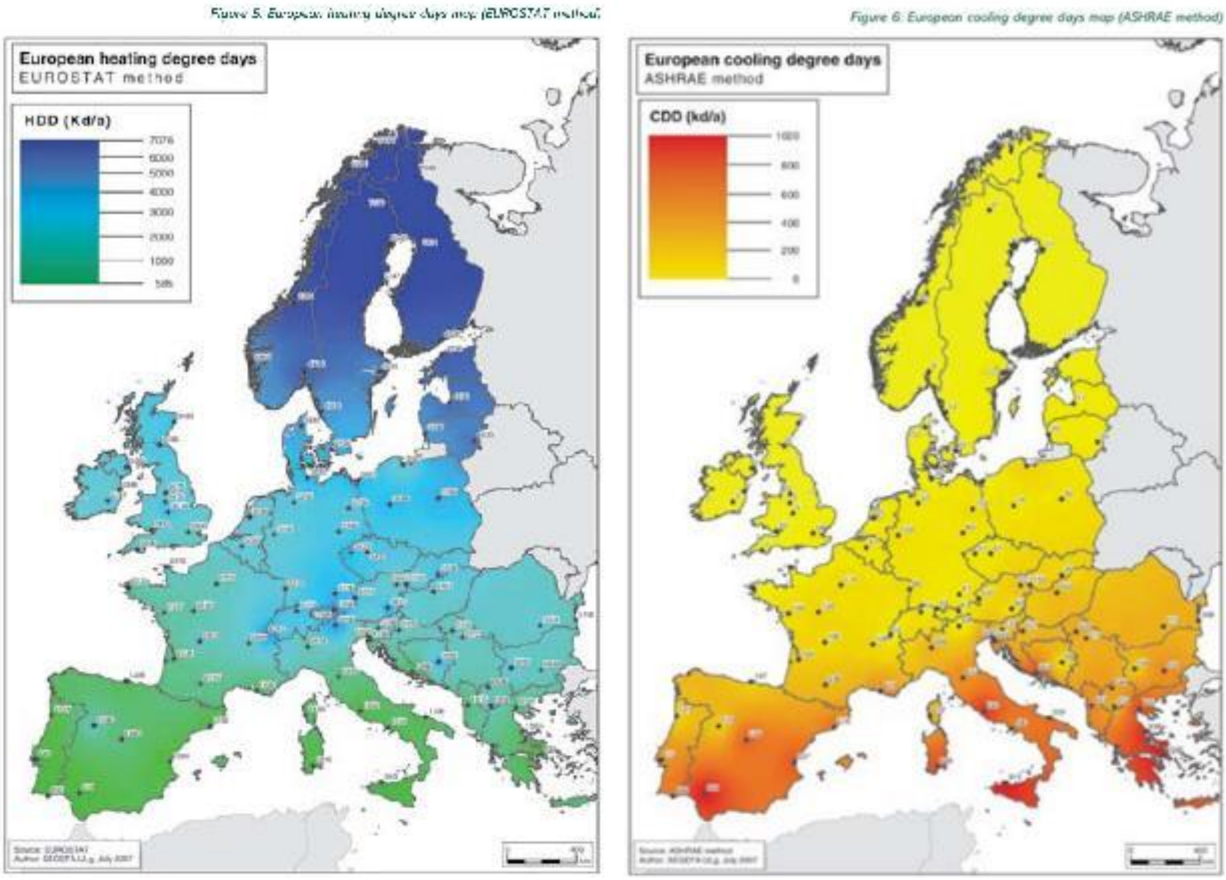
PP7 – MEI (Albania)

PP8 – AREANATejo (Portugal)

PP10 – CIMAA (Portugal)

Picture 2: Locations of buildings where an energy audit was preformed

In picture 2, the buildings locations are presented. We can see that the buildings are located all around the Mediterranean area, from Portugal and Spain on the west, to islands of Gozo in the centre and Cyprus on the easternmost part of Mediterranean Sea to northern Greece (Macedonia) and Albania, central Italy (Rome) and Slovenia and Croatia on the most northern part of the area.



Picture 3: Heating degree days (left) and cooling degree days (right) in Europe[1]

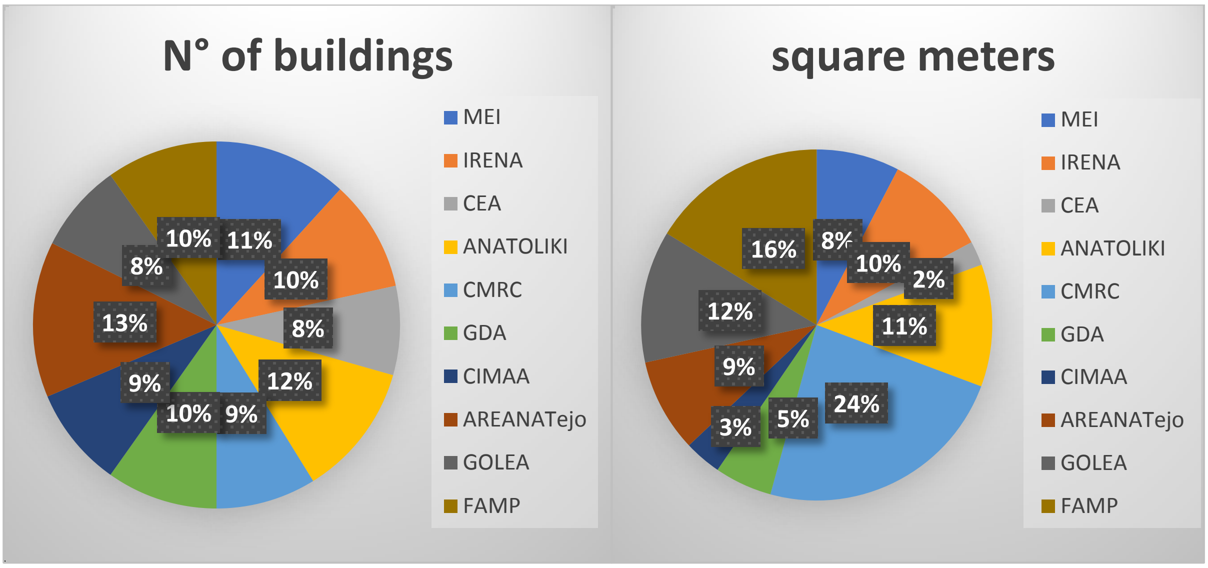
Total number of audits elaborated is 102. Total usable area of buildings audited is 190.026 m^2. The distribution of audits among partners is given in the table on page 8. The number of audits per type of building is also given.

Table 1: Energy audits per partner/type of building

Partner	MEI	IRENA	CEA	ANATOLIKI	CMRC	GDA	CIMAA	AREANATejo	GOLEA	FAMP	Total number
Country	ALBANIA	CROATIA	CYPRUS	GREECE	ITALY	MALTA	PORTUGAL	PORTUGAL	SLOVENIA	SPAIN	
Kindergarten	3								1		4
School	8	6	1	8	9		2	2	4	2	42
Administrative	1		4	4		10		3	1	4	27
Healthcare		4							1		5
Sport			1				3	4			8
Cultural							3	2		2	7
Social services										2	2
Other			2				1	3	1		7
Total number	12	10	8	12	9	10	9	14	8	10	102

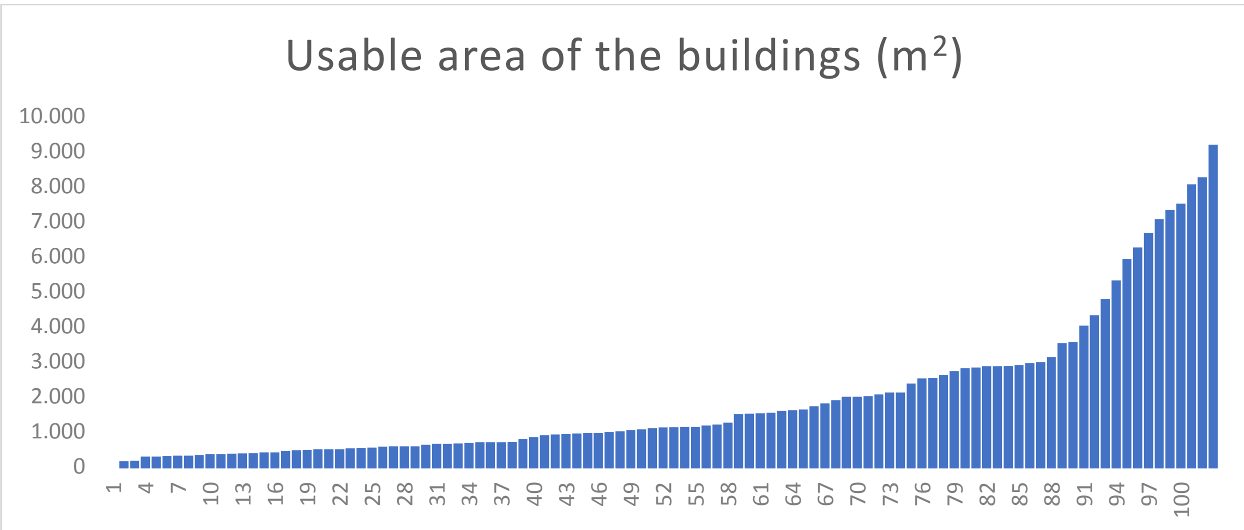
[1] Source: EURIMA - European Insulation Manufacturers Association

The average number of audits per partner is 11, the distribution of audits per partners is quite even, when looking at the number of audits. When looking at the total usable area of the buildings which were subject to energy audit the picture is quite different. The reason for this is the selection of buildings and the general difference in building stock among partners. For instance, partner PP5- CMRC has selected mostly large schools in Rome, whereas PP4 – GDA has selected mostly small community centres in island of Gozo.



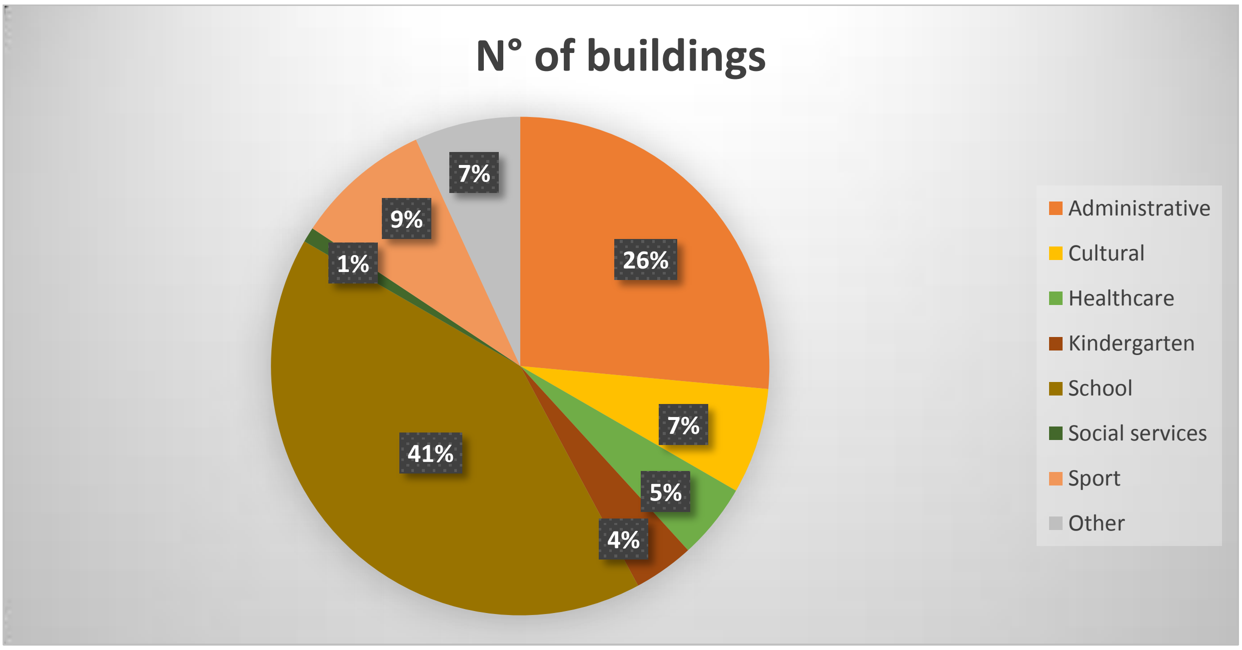
Picture 4: Distribution of energy audits among partners per number and per total usable area of audited buildings

In picture 4, a distribution of building size (usable area) is presented. We can see, that we that the building stock is quite diverse regarding the size of buildings staring from only 80 m^2 up to 9.000 m^2. Most of the buildings are less than 3.000 m^2 (85%), with one half being under 1.000 m^2. The average usable area is 1.863 m^2.



Picture 5: Distribution of usable area among the building stock

When looking at the distribution of audits regarding the purpose of the building, the largest part is represented by schools (41%), followed by administrative buildings (26%). Sports, Cultural, and buildings classified as other are quite evenly distributed (7 to 9%), and at the lower part we find healthcare (5%), Kindergartens (4%) and Social services (1%).



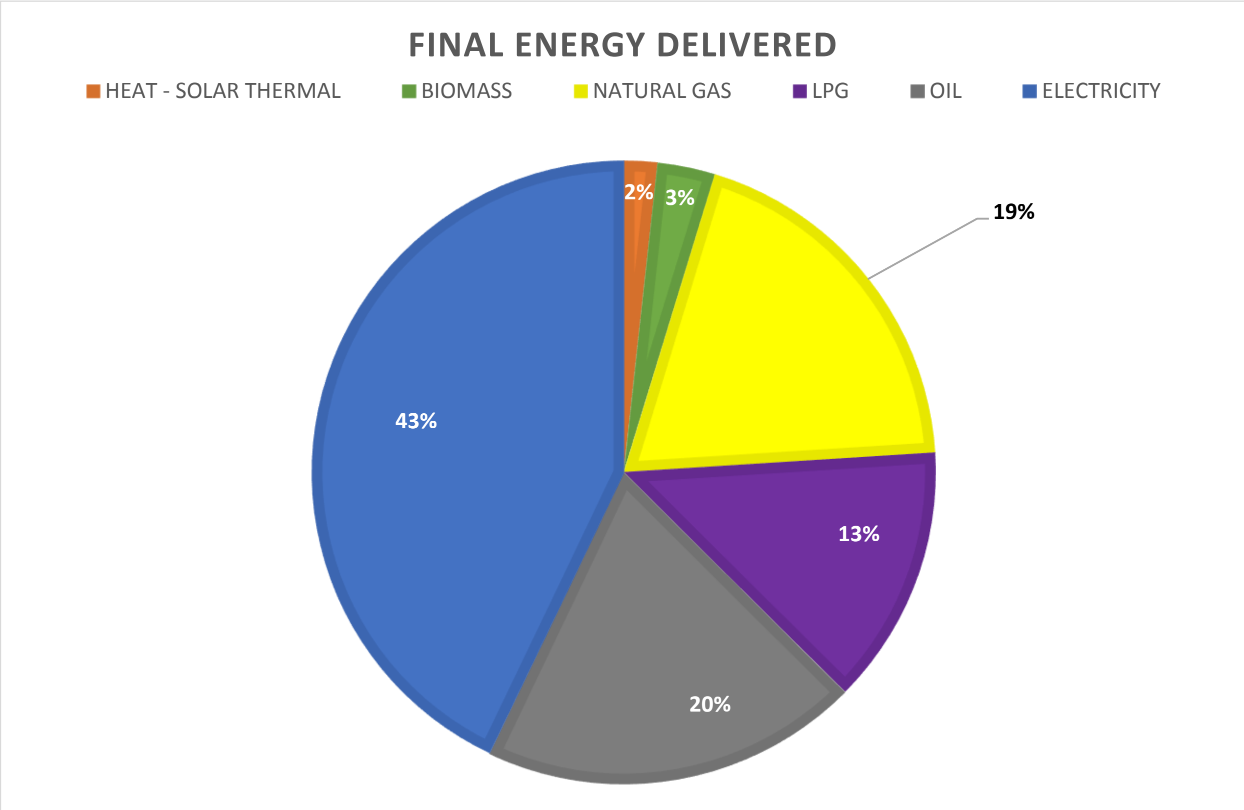
Picture 6: Distribution of audits per general type of building

4. Energy sources and energy use indicators

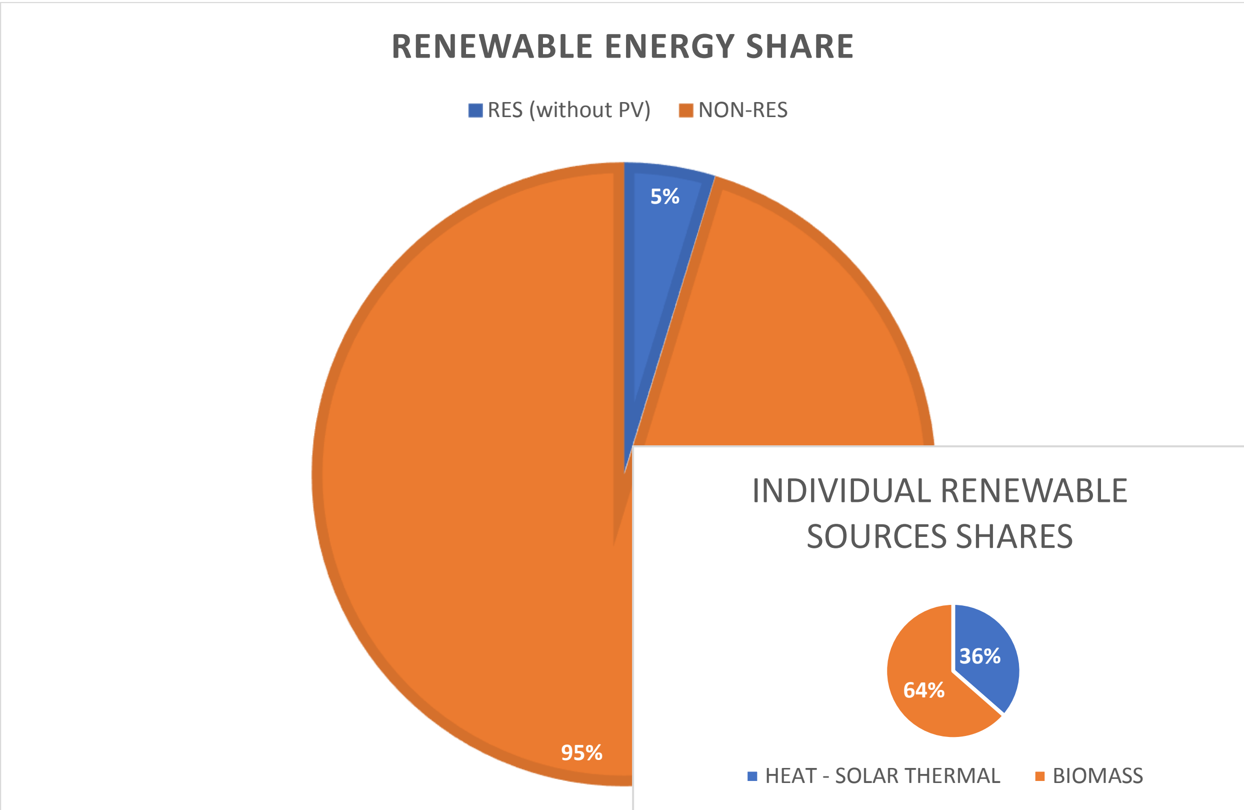
Buildings are supplied with different energy sources. In this chapter, an overview is given for the whole analysed buildings stock.

Every building has grid electricity supply. Electricity has the largest share - 43% among energy sources. Some buildings have solar PV power plants installed, but as the electricity is exported to electricity grid the electricity production by PV is not taken into account. Extra light heating oil and natural gas have similar shares - 20 and 19% respectively. Furth largest share is provided by LPG with 13%. The smallest share is provided by two renewable energy sources, biomass with 3% and solar thermal heat with 2%.

In picture 8, renewable energy share is shown in relation to final energy delivered. Altogether, renewable energy represents only 5% of total energy delivered to buildings (PV excluded). Two thirds of renewable energy is provided by biomass and one third by solar thermal heat.



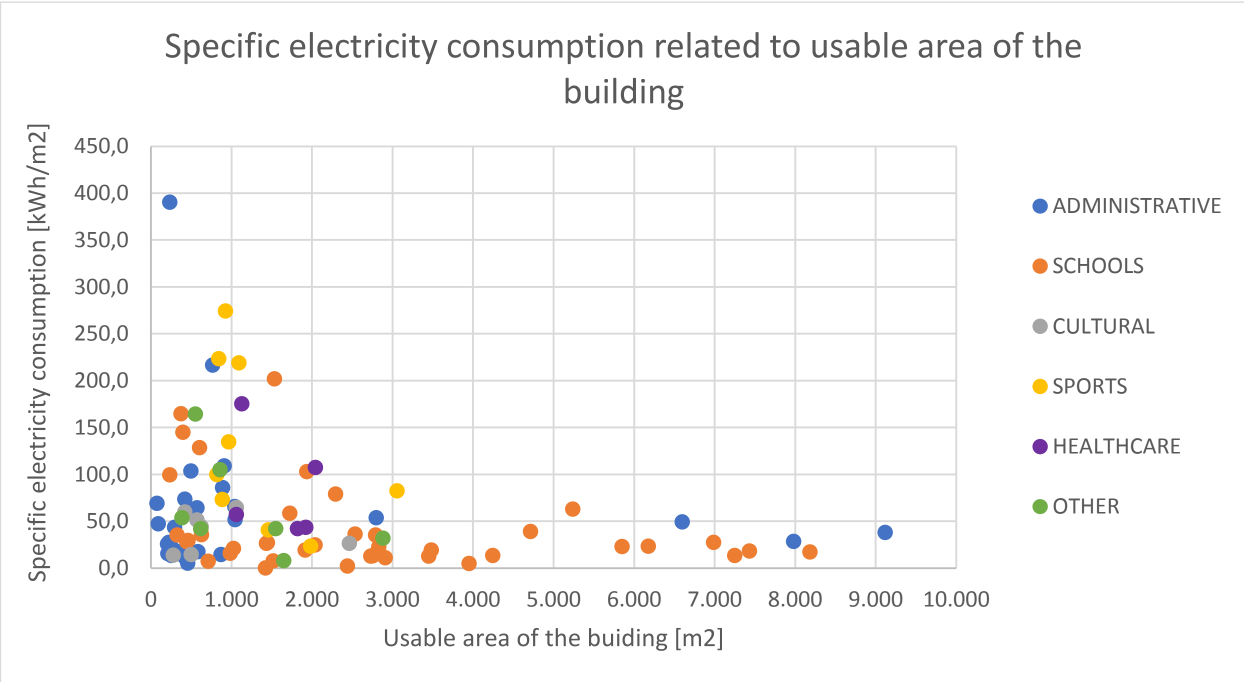
Picture 7: Final energy supply by source



Picture 8: RES (renewable energy sources) share in final energy supply

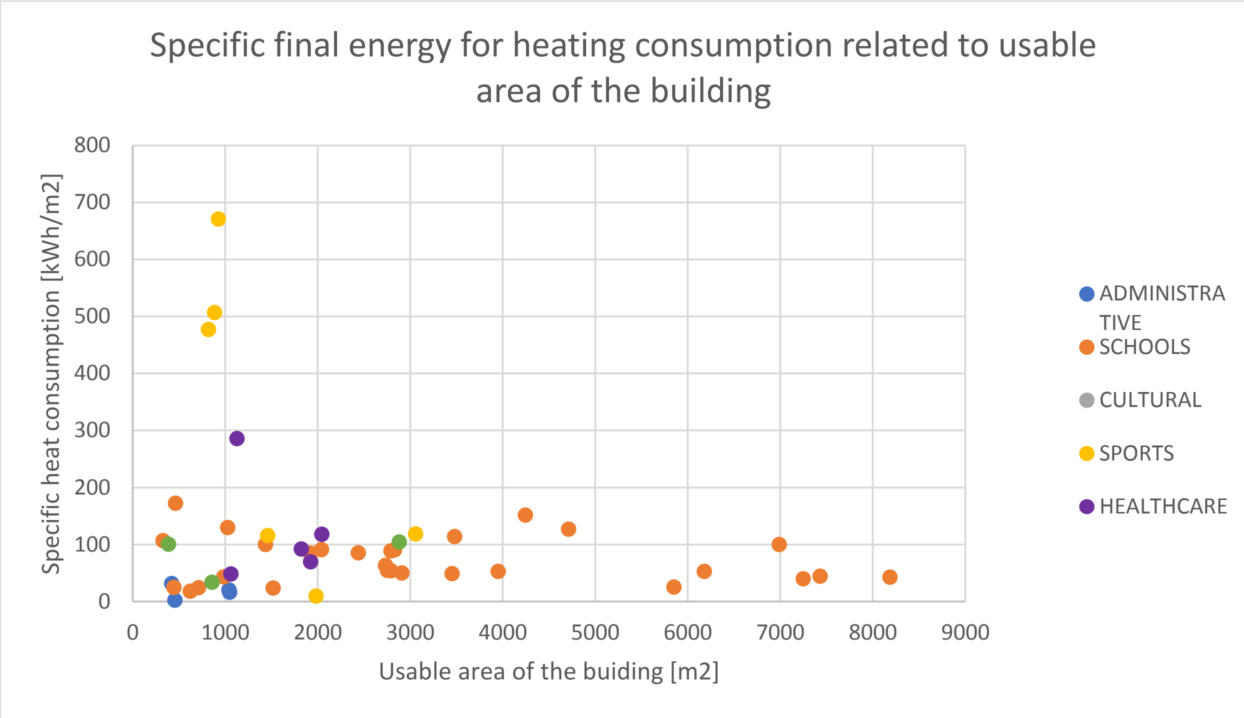
In order to compare the intensity of energy use in different buildings, a specific yearly energy use pre-square meter of usable area of the building is used. This indicator is used to assess the overall energy efficiency of the building. However, when comparing buildings with different purposes and different sizers etc. it is important to know, what is the expected value for this kind of building. For example, an indoor swimming pool is much more energy intensive than an elementary school.

In picture 9, specific electricity consumption is shown in relation to usable area of the buildings. Different types of buildings are shown in different colours so the difference between buildings of different usage types can be seen. The usual and expected distribution can be seen, where smaller buildings show larger specific consumption (the group of dots on the left side of the chart). Many of the buildings analysed use electricity also for space and sanitary hot water heating (heat pumps or direct electro heating).



Picture 9: Specific electricity consumption in relation to usable area of the building

For the buildings that don't use electricity as primary heat source. An analysis of specific final energy for heating consumption related to usable (heated) area of the building is shown on picture 10. The majority of this buildings are schools, sports facilities and healthcare institutions. It can be seen that the large schools (above 5.000 m^2) all have specific consumption under 100 kWh/m^2, under 5.000 m2 the specific for schools can also reach values up to 170 kWh/m^2, but substantial number of buildings is also under 50 kWh/m^2, meaning that their specific consumption is already pretty low. The highest values are seen in some of the sport facilities, namely indoor swimming pools reaching values of final energy for heating up to 670 kWh/m^2/year.



Picture 10: Specific final energy for heating consumption in relation to usable area of the building

5. Overview of results by country

4.1 Albania

Nine primary schools and three kindergartens were analysed in four different municipalities in Albania. Two of the municipalities are located in coastal area (Vlore and Sarande) and two inlands (Permet and Gjirokastër).

Picture 11: Elementary School Adem Sheme, Saranda (Albania)

All the buildings were constructed in the period between 1960 and 1990. The typology of buildings is pretty simple, usually with rectangular flor plan, spanning 2 to 3 floors in height. Buildings are constructed from massive walls and floor slabs, mainly from brick and reinforced concrete, some buildings have load bearing walls made form stone. The buildings in coastal area have flat roofs, others have pitched roofs. Average total net surface is 1.211,1 m^2.

Table 2: Buildings dimensions overview - Albania

	TOTAL NET SURFACE (m²)	TOTAL GROSS SURFACE (m²)	NET VOLUME V (m³)	GROSS VOLUME (m³)	RATIO S/V (m⁻¹)	EAVES HEIGHT (m)	FLOORS ABOVE GROUND
SUM	14.533	18.662	96.165	141.248			

AVERAGE	1.211,1	1.555,2	8.013,7	11.770,7	0,2	9,1	2,6

Building envelope characteristics

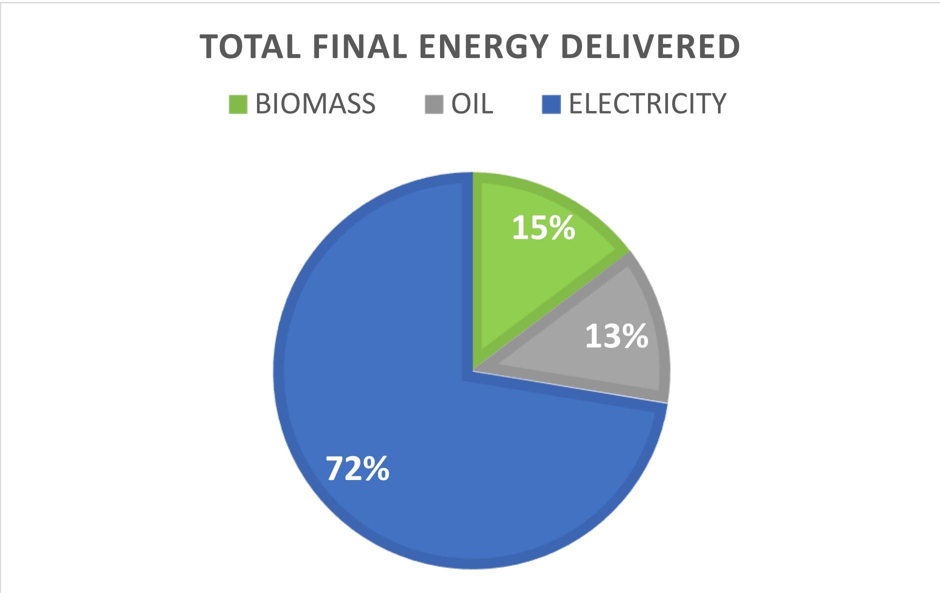
The envelope of buildings is very poorly insulated, only few buildings have some thermal insulation (5 to 15 cm) on roof. The U values for perimeter walls are in the range of 1 – 2,5 W/m^2K. All windows have single glazing and aluminium frames, with U value for the whole window U=4,8 W/m^2K.
The regulation limits are between 0,36 and 0,6 W/m_2K for roofs, around 0,5 W/m2K for perimeter walls and 1,2 W/m^2K for windows.

Heating, ventilation, air conditioning and lightning system

Only 2 buildings have central heating systems installed. In one case heating source is fuel oil boiler, one other school has a central biomass boiler, 4 other buildings have local biomass stoves installed, other 6 buildings have local electrical heaters or heat pumps (split type air/air) which can also be used for heating (in the coastal area). There are no mechanical ventilation systems installed. Air conditioning is provided in 8 buildings via local split type air conditioners (heat pumps).
Lightning is provided by fluorescent lamps.

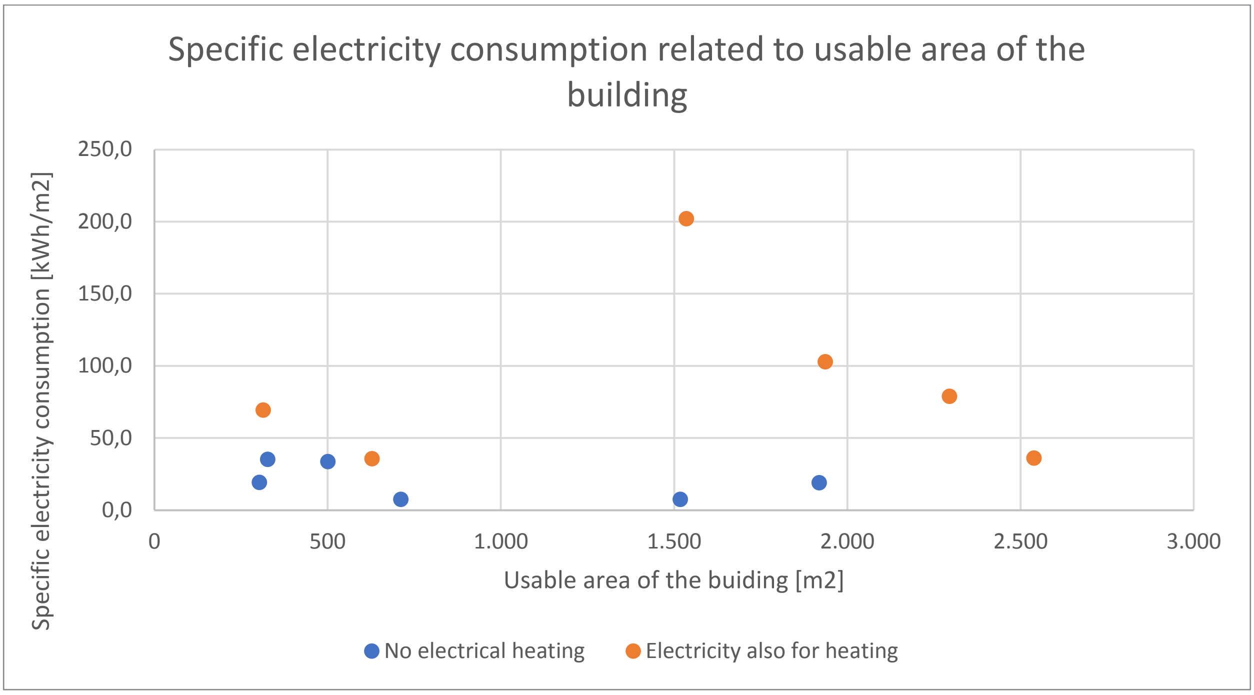
Energy supply

Almost three quarters of final energy delivered is provided by electricity from grid, biomass has second largest share – 15% and 13% is provided by oil.



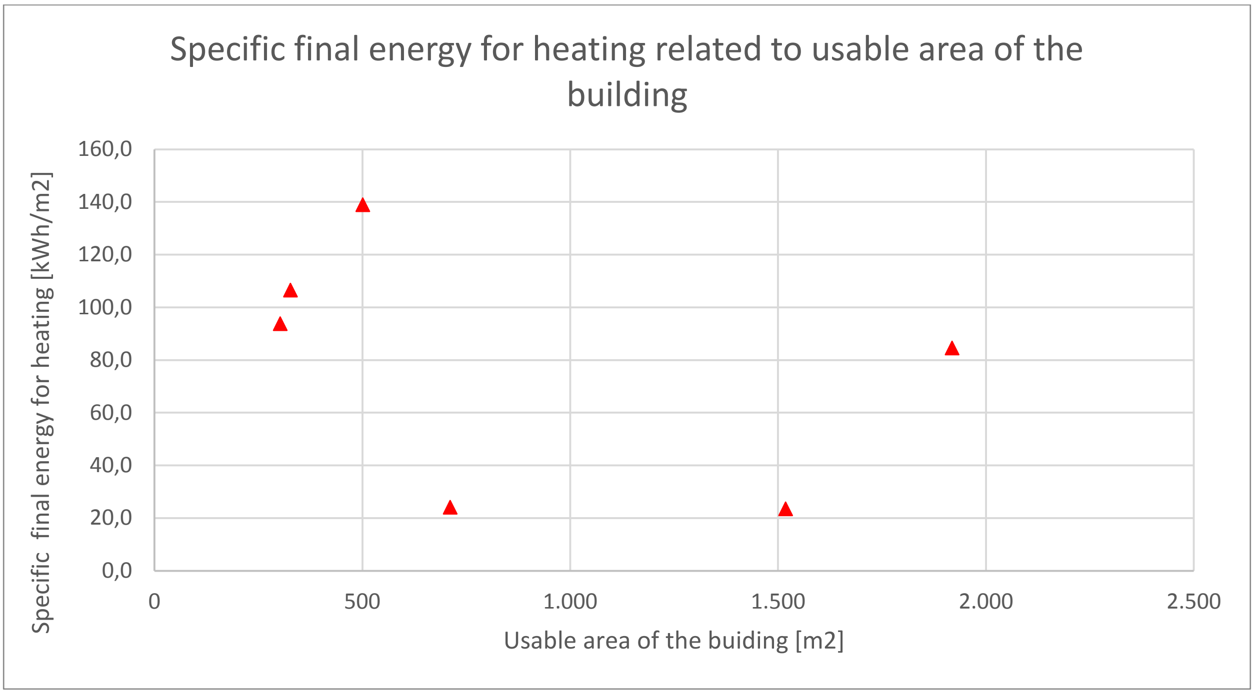
Picture 12: Final energy delivered – Albania

Specific electricity consumption varies a lot and depends very much if the buildings also uses electrical appliances for space heating. Graph on picture 13 shows electricity per square meter use related to building usable area. It can be seen that regardless the size of the building, specific consumption can be twice as high if electrical heating is used. If no electrical heating is used, average specific consumption is 20,3 kWh/m^2 per year in buildings where heating is provided by electricity, average specific electricity consumption is 87,4 kWh/m^2.



Picture 13: Specific electricity consumption related to usable area of the building (Albania)

For the buildings where heating is provided by biomass or oil, we can also analyse specific final energy for heating. Specific indicators are quite low for two buildings (both high schools) with under 25 kWh/m^2 all other are in the range of 80 to 140 kWh/m^2.



Picture 14: Specific final energy for heating related to usable area of the building (Albania)

4.2 Croatia

Six schools and four healthcare institutions were analysed in 7 different municipalities in Istria County.

Picture 15: Left: Istrian Health Centre Rovinj, Right: High school in Pazin (Croatia)

Two of the buildings were built in 1911, one in 1936 and one in 1992, all the others were built in 50s, 60s and 70s. Older buildings are constructed from massive walls made of stone, newer buildings are built mainly from reinforced concrete and different kind of brick. Majority of buildings have pitched roofs. Average total net surface is 1.813 m^2.

Table 3: Buildings dimensions overview - Croatia

	TOTAL NET SURFACE (m^2)	TOTAL GROSS SURFACE (m^2)	NET VOLUME V (m^3)	GROSS VOLUME (m^3)	RATIO S/V (m^{-1})	EAVES HEIGHT (m)	FLOORS ABOVE GROUND
SUM	18.130	34.197	62.492	80.446			
AVERAGE	1.813,0	3.419,7	6.249,2	8.044,6	0,5	11,3	3,3

Building envelope characteristics

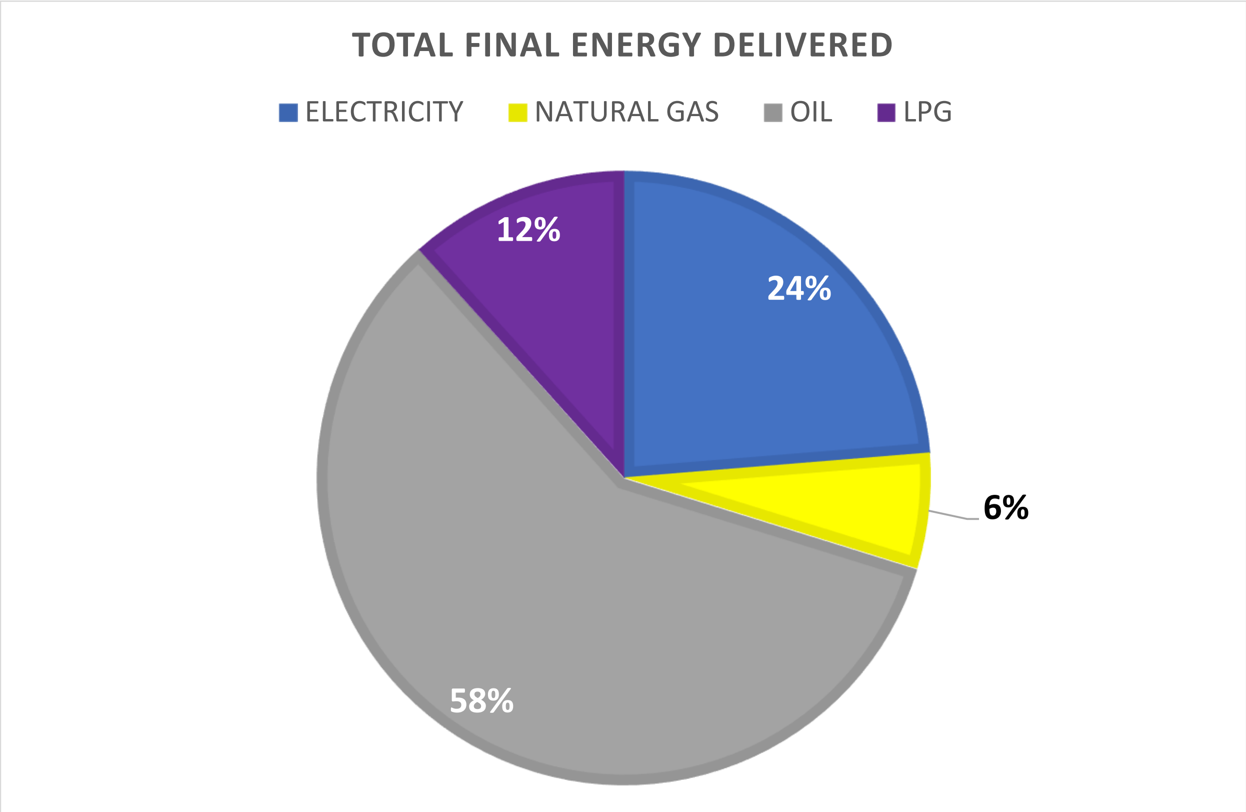
The envelope of buildings is poorly insulated, only 5 out of 10 buildings has some insulation (4 to 10 cm) on perimeter walls, 6 buildings have thermal insulation (5 to 15 cm) on the roof. The U values for perimeter walls are in the range of 0,3 – 3 W/m^2K, average is around 1,4 W/m^2K. There are many different types of windows installed, the best U values are obtained in PVC windows with double glazing (1,4 W/m^2K) but more than half of the buildings have much higher U values (between 2 and 4 W/m^2K).
The regulation limits are between 0,25 and 0,4 W/m^2K for roofs, between 0,3 and 0,6 W/m^2K for perimeter walls and 1,8 W/m^2K for windows.

Heating, ventilation, air conditioning and lightning systems

All the buildings have central heating systems installed. In one case heating source is natural gas boiler, one other school has a LPG boiler, 8 other buildings have extra light fuel oil boilers installed. There are no mechanical ventilation systems installed. Air conditioning is provided in all four healthcare buildings via local split type air conditioners (heat pumps). Schools have only marginal share of rooms (mainly offices) equipped with air conditioning. All the buildings are ventilated naturally.
Lightning is provided mainly by fluorescent lamps.

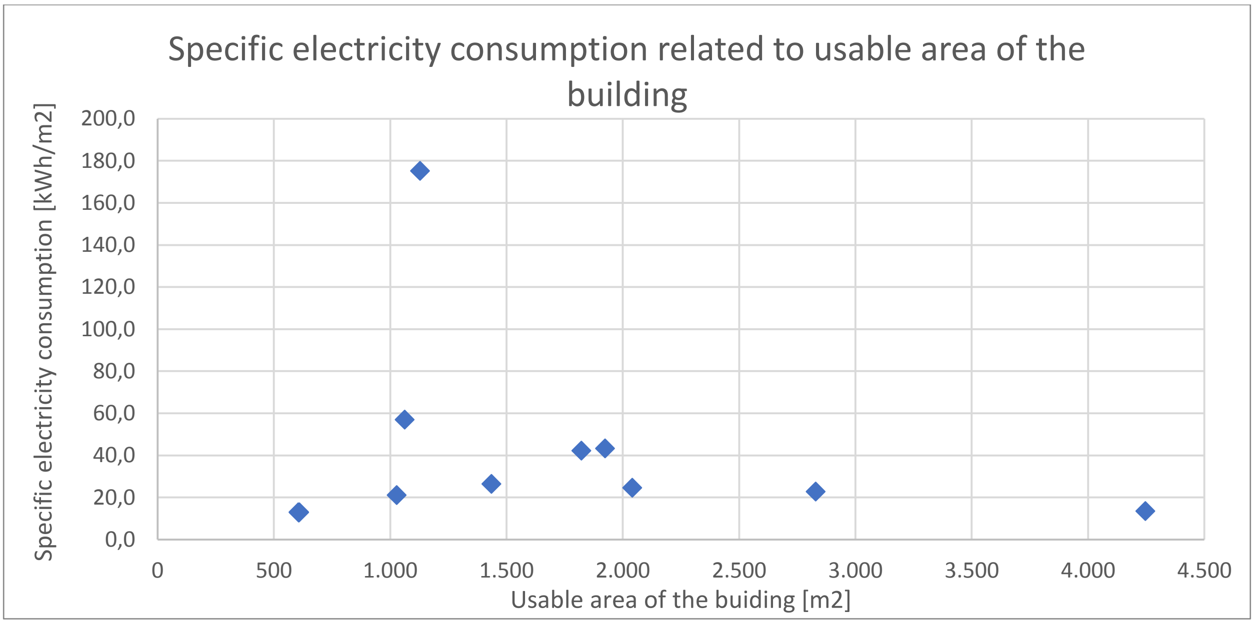
Energy use

Almost 60% of final energy delivered is provided by oil, electricity has second largest share – 24%, and 12% is provided by LPG and 6% by natural gas.



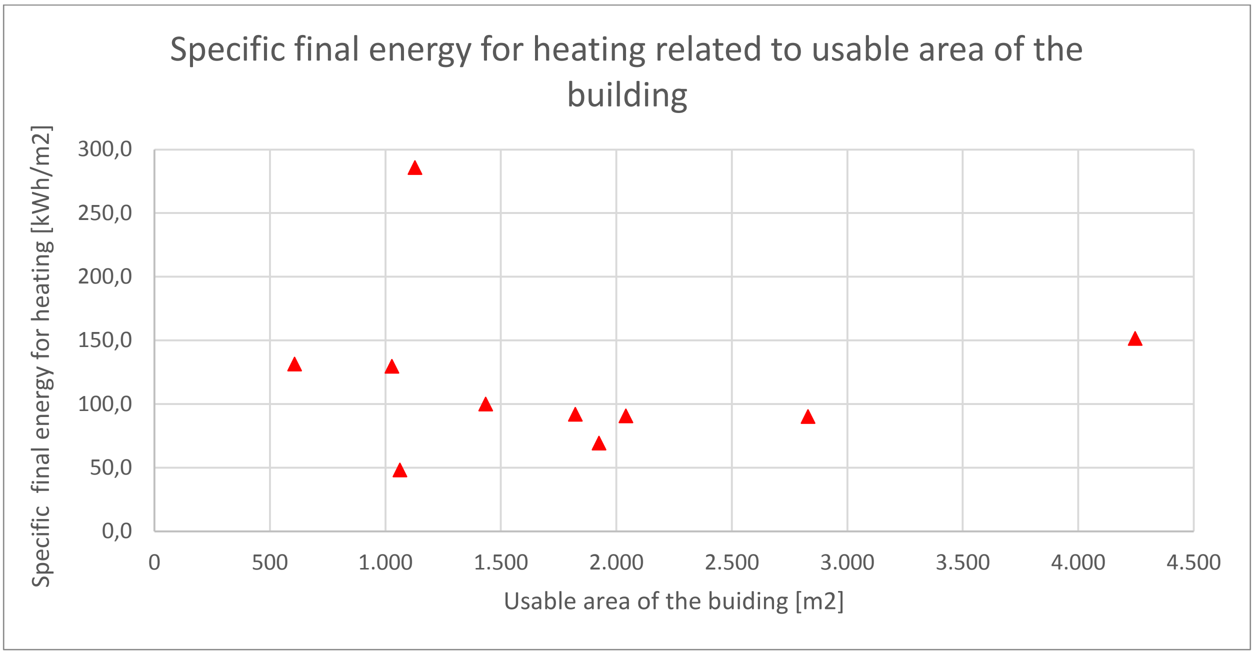
Picture 16: Final energy delivered - Croatia

Graph on picture 17 shows electricity per square meter use related to building usable area. Most of the buildings have specific consumption in the range between 15 and 60 kWh/m^2/year. One building (healthcare) deviates from the average with specific consumption of 175 kWh/m^2/year. Schools tend to have lower specific electricity consumption (20,3 kWh/m^2 per year) compared to healthcare institutions (87,4 kWh/m^2).



Picture 17: Specific electricity consumption related to usable area of the building (Croatia)

Specific final energy for heating is the range of 48 to 286 kWh/m^2/year, average is 119 kWh/m^2/year. The lowest consumption was recorded in a healthcare institution, where most of the façade and roof was renovated (additional insulation), and also a part of joinery (windows) were already replaced in 2013.



Picture 18: Specific final energy for heating related to usable area of the building (Croatia)

4.3 Cyprus

Four city hall's, a primary school, football stadium, park and restaurant and a multipurpose building was analysed in 6 different municipalities in Cyprus.

Picture 19: Left: Neo Chorio Community city hall, Right: Pegeia Football stadium (Cyprus)

The oldest building was built in 1930. One building was built in 1996. Four buildings were built in the period between 2004 and 2005, and two buildings have had a major reconstruction in 2007 and 2014 respectively.

A lot of the buildings are built of massive stone walls, newer buildings are built mainly from reinforced concrete and different kind of brick. Average total net surface is 531 m^2.

Table 4: Buildings dimensions overview - Cyprus

	TOTAL NET SURFACE (m^2)	TOTAL GROSS SURFACE (m^2)	NET VOLUME V (m^3)	GROSS VOLUME (m^3)	RATIO S/V (m^{-1})	EAVES HEIGHT (m)	FLOORS ABOVE GROUND
SUM	4.255	4.534	15.065	17.127			
AVERAGE	531,9	566,8	1.883,1	2.140,9	0,3	2,7	1,1

Building envelope characteristics

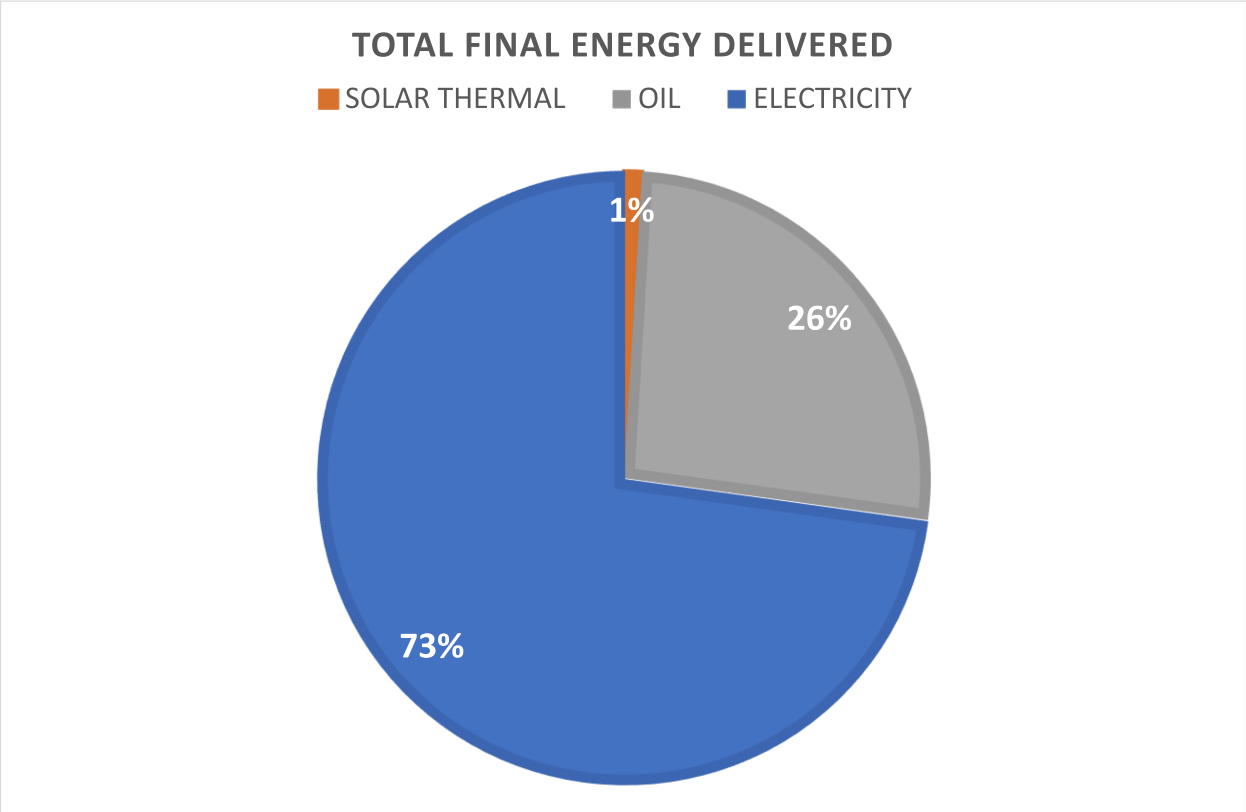
None of the buildings has any insulation on perimeter walls, roof or flor slab. The U values for perimeter walls are in the range of 1,1– 2,9 W/m^2K, average is 1,7 W/m^2K. The U values for roofs are in the range of 1,25– 3,3 W/m^2K, average is 2,4 W/m^2K. Most of the windows have aluminium or wooden frames and single or double glazing (without gas filing). U values for windows are in the range of 3,4 do 5 W/m^2K, average is 4,3 W/m^2K.
The regulation limits are 0,4 W/m^2K for roofs and perimeter walls and 2,9 W/m^2K for windows.

Heating, ventilation, air conditioning and lightning systems

Only 3 buildings have central heating systems with oil boiler as a heat source. Other five buildings are heated via different electrical heaters or spilt and heat pumps or VRF systems. In five buildings this split VRF type heat pumps are also used for air conditioning in the summer. There are no mechanical ventilation systems installed. All the buildings are ventilated naturally.
Lightning is provided by fluorescent lamps.

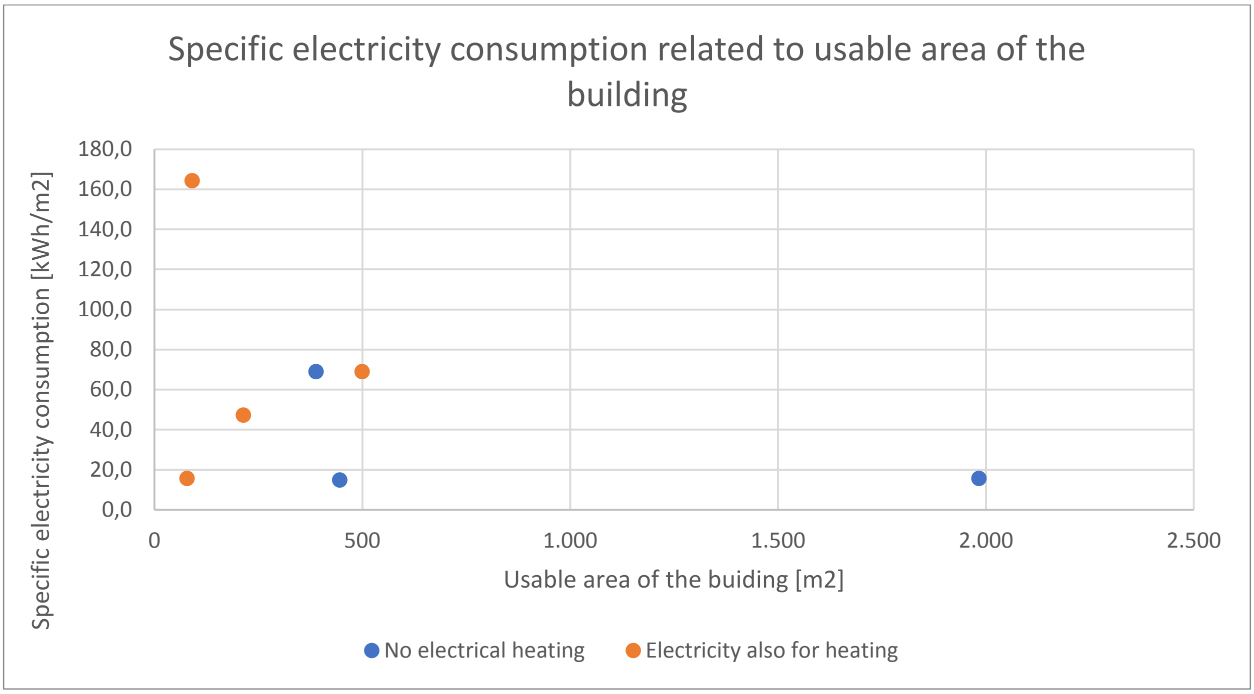
Energy use

Almost 73% of final energy delivered is provided by electricity, second largest share is provided by oil - 24%, and 1% is provided by solar thermal collectors. One building is also equipped with PV system, but the electricity produced is exported to electrical grid, so it is not considered in total final energy delivered.



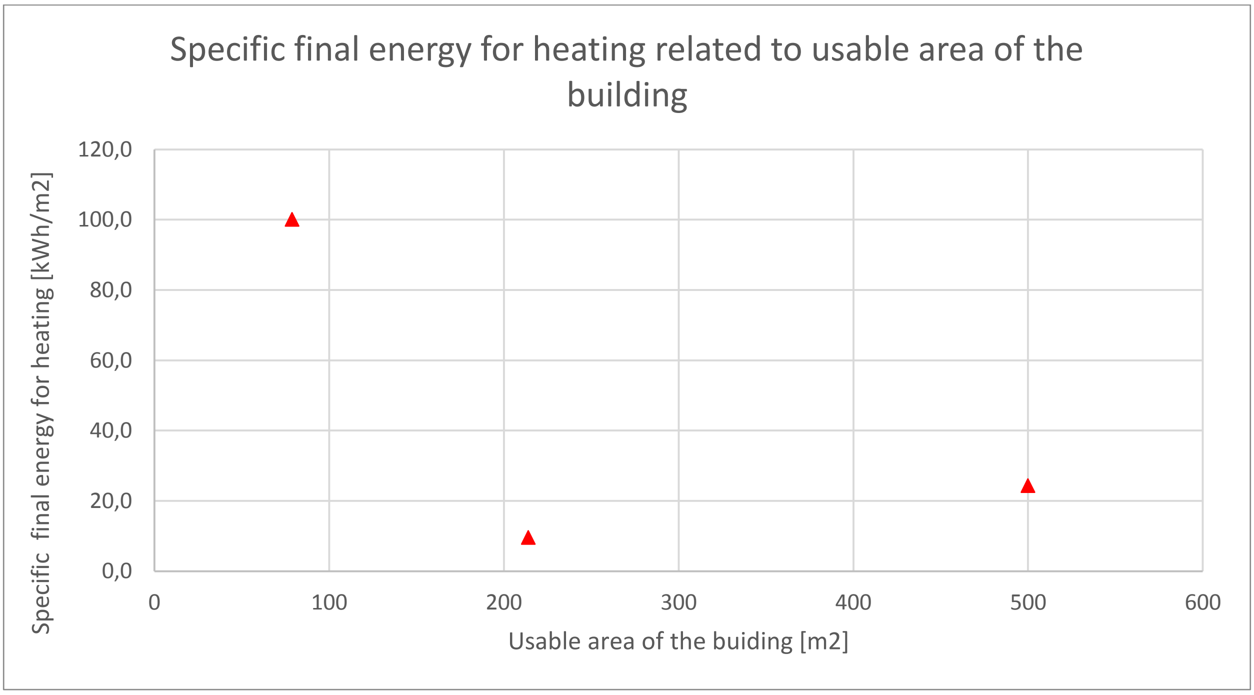
Picture 20: Final energy delivered - Cyprus

Graph on picture 21 shows electricity per square meter use related to building usable area. Most of the buildings have specific consumption in the range between 15 and 70 kWh/m^2/year. One building (park and a restaurant) deviates from the average with specific consumption of 165 kWh/m^2/year.



Picture 21: Specific electricity consumption related to usable area of the building (Cyprus)

Specific final energy for heating is the range of 10 to 100 kWh/m^2/year. The lowest consumption was recorded in a football stadium and the highest in multipurpose building.



Picture 22: Specific final energy for heating related to usable area of the building (Cyprus)

4.4 Greece

Five elementary and three high schools, one town hall, and three different administrative buildings were analysed in 3 different municipalities in Greece.

Picture 23: Left: City Hall of Thermi, Right: 3rd High School of Kalamaria (Greece)

Two oldest buildings were built in 1950. Two buildings were built in the 80's, and seven buildings in the 90's. The newest building was built in 2004.
A lot of the buildings are built of massive stone walls, newer buildings are built mainly from reinforced concrete and different kind of brick. Average total net surface is 531 m^2.

Table 5: Buildings dimensions overview - Greece

	TOTAL NET SURFACE (m^2)	TOTAL GROSS SURFACE (m^2)	NET VOLUME V (m^3)	GROSS VOLUME (m^3)	RATIO S/V (m^{-1})	EAVES HEIGHT (m)	FLOORS ABOVE GROUND
SUM	21.393	25.276	72.262	85.443			
AVERAGE	1.782,7	2.106,3	6.021,9	7.120,3	0,3	3,4	3,8

Building envelope characteristics

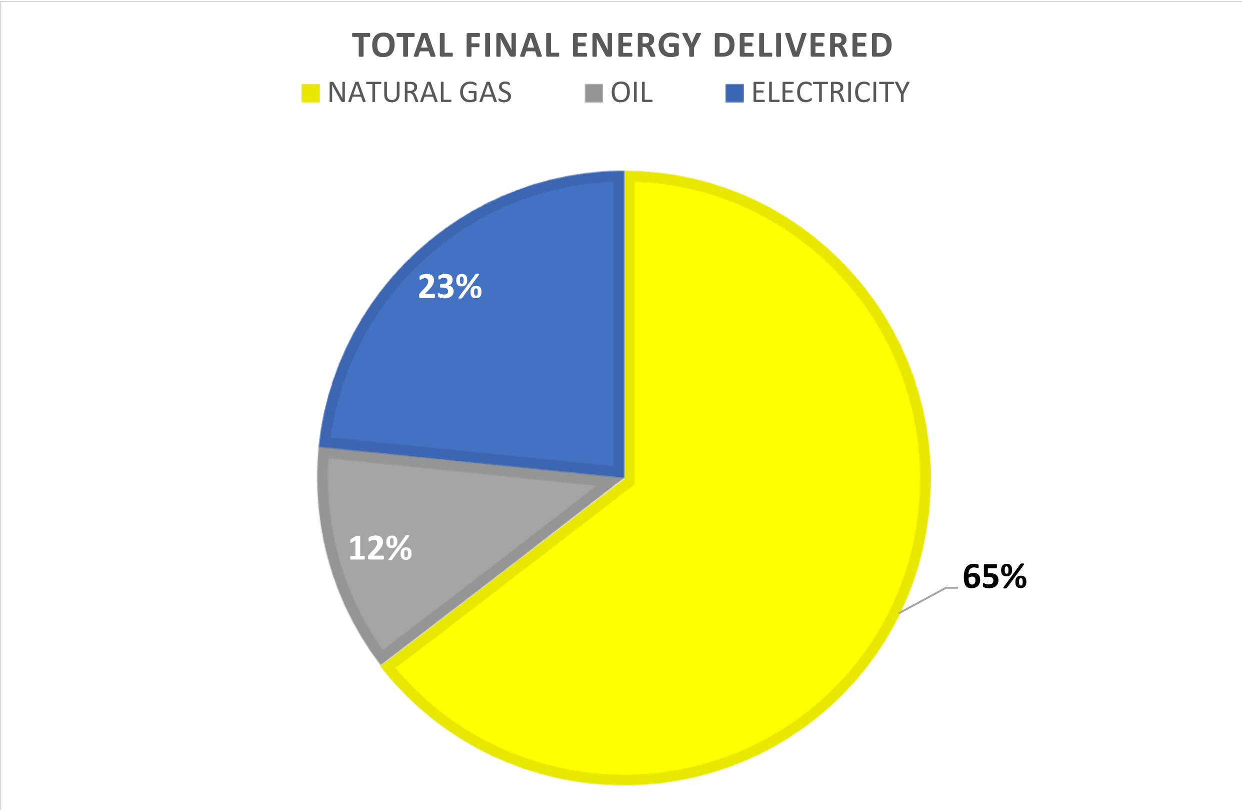
All the buildings are poorly insulated. The average U value for perimeter walls is 0,83 W/m^2K. The average U value for the roofs is 0,71 W/m^2K. Most of the windows have aluminium or and single glazing. Average U value for windows is 4,18 W/m^2K.
The regulation limits are 0,4 W/m^2K for roofs and perimeter walls and 2,8 W/m^2K for windows.

Heating, ventilation, air conditioning and lightning systems

All buildings have central heating systems with oil or natural gas boiler as a heat source. Air conditioning is provided by split type heat pumps in all the analysed buildings. There are no mechanical ventilation systems installed. All the buildings are ventilated naturally.
Lightning is provided by fluorescent lamps.

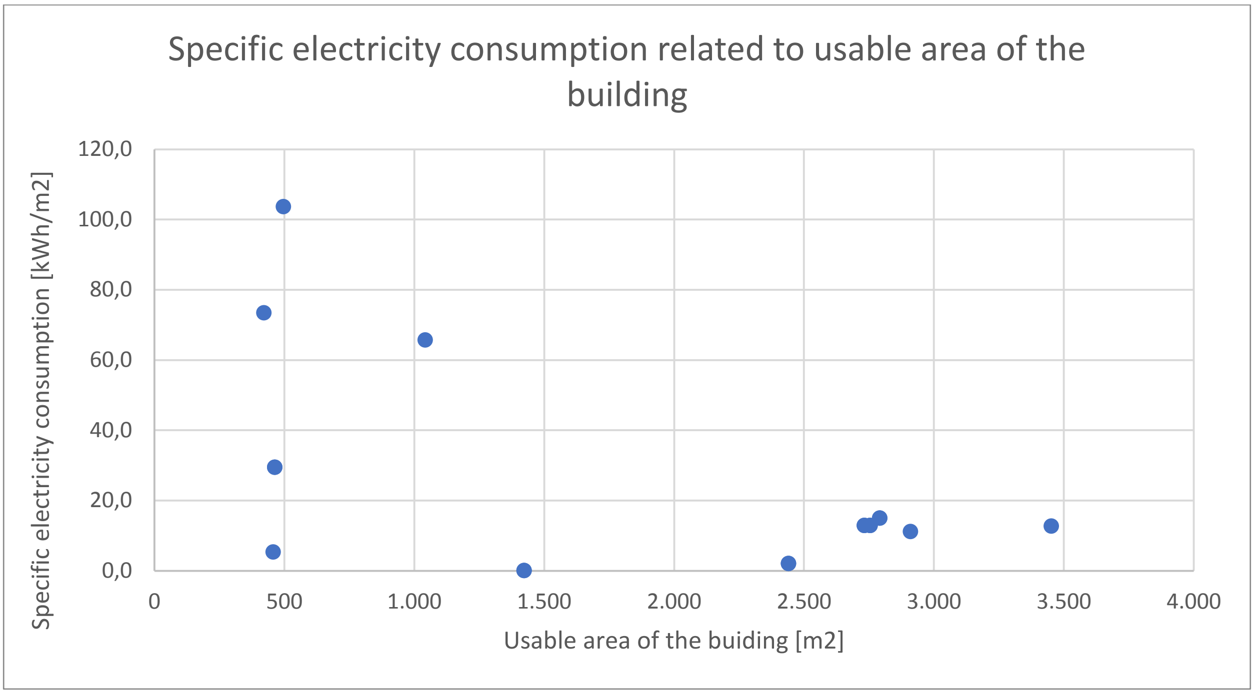
Energy use

The most - 65% of final energy delivered is provided by natural gas, approximately one quarter (23%) is covered by electricity and 12% by oil.



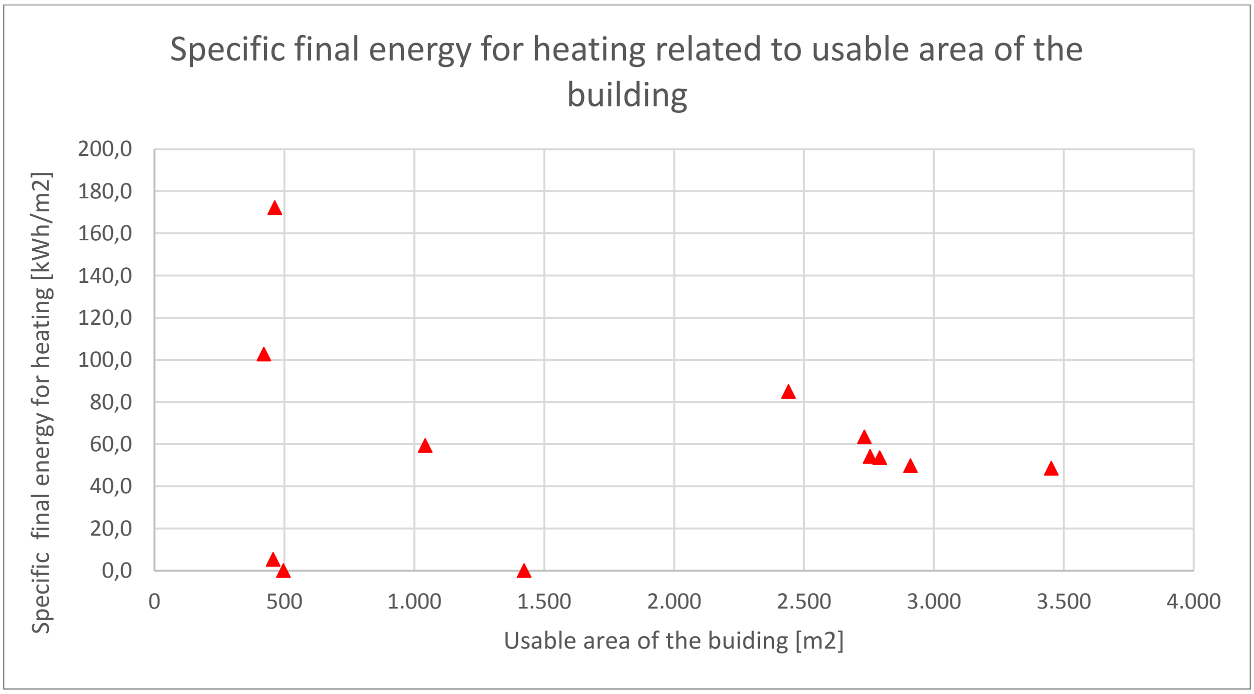
Picture 25: Final energy delivered - Greece

Graph on picture 24 shows electricity per square meter use related to building usable area. Most of the schools have specific consumption below 20 kWh/m^2/year (the group on the right side of the graph). The group of dots on the left side of the graph represents smaller administrative buildings average specific electricity consumption is higher 60 kWh/m^2/kWh. For one building, the data on actual electricity consumption was not available.



Picture 24: Specific electricity consumption related to usable area of the building (Greece)

Specific final energy for heating is the range of 50 to 170 kWh/m^2/year. As expected, larger buildings tend to have lower consumption, measured per square meter. For two buildings, the data on actual energy consumption was not available.



Picture 25: Specific final energy for heating related to usable area of the building (Greece)

4.5 Italy

Nine high schools were analysed in Metropolitan area of Rome.

Picture 26: Left: Heinrich Herz High School, Right: Antonio Labriola High School (Italy)

Two oldest buildings were built in the 50's. Two buildings were built in the 60's, and three buildings in the 70's. The newest building was built in 1980.
Most buildings are built from reinforced concrete. Average total net surface is 4.974,7 m^2.

Table 6: Buildings dimensions overview - Italy

	TOTAL NET SURFACE (m²)	TOTAL GROSS SURFACE (m²)	NET VOLUME V (m³)	GROSS VOLUME (m³)	RATIO S/V (m⁻¹)	EAVES HEIGHT (m)	FLOORS ABOVE GROUND
SUM	44.772	51.242	158.292	192.082			
AVERAGE	4.974,7	5.693,6	17.588,0	21.342,4	0,3	7,4	4,0

Building envelope characteristics

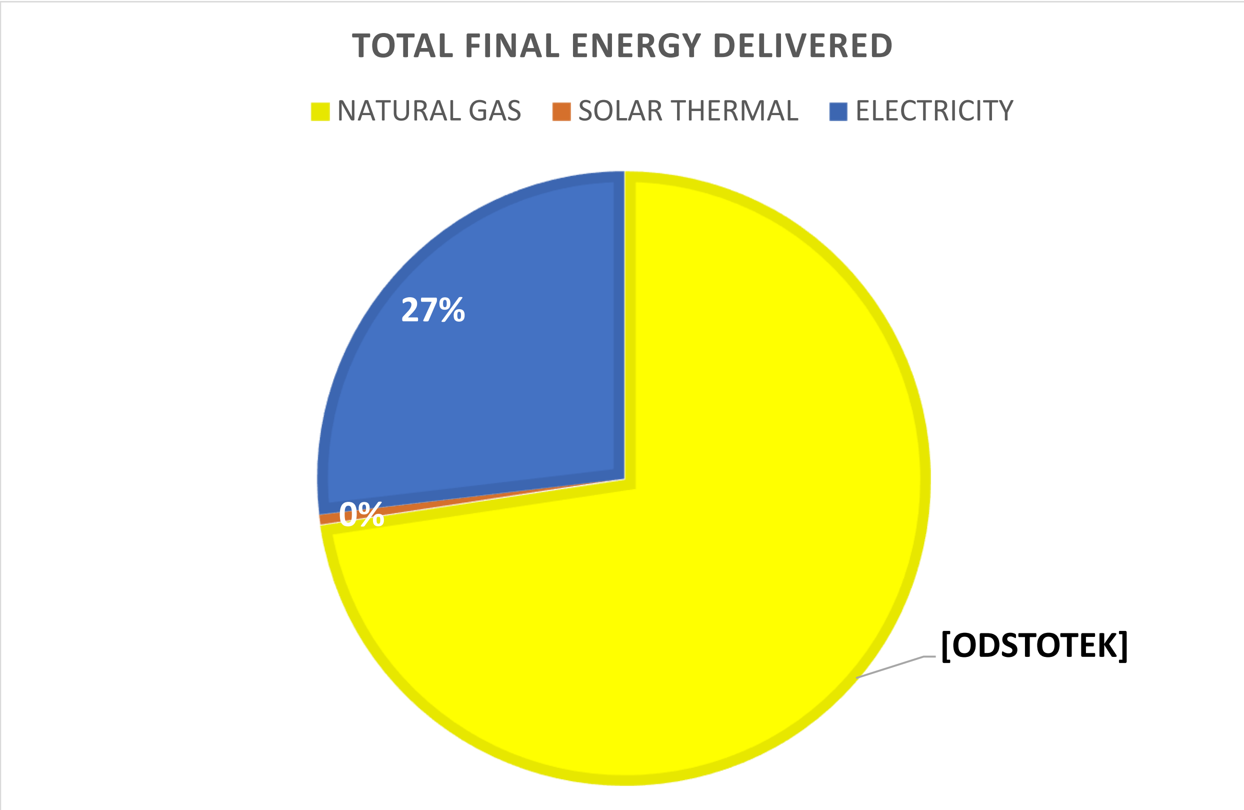
All the buildings are poorly insulated. The average U value for perimeter walls is 1,56 W/m^{2}K. The average U value for the roofs is 1,65 W/m^{2}K. Most of the windows have aluminium frames and double or single glazing. Average U value for windows is 4,7 W/m^{2}K.
The regulation limits are 0,26 W/m^{2}K for roofs, 0,29 W/m^{2}K and perimeter walls and 1,8 W/m^{2}K for windows.

Heating, ventilation, air conditioning and lightning systems

All buildings have central heating systems with natural gas boiler as a heat source. Air conditioning is provided by split type heat pumps in 2/3 of the analysed buildings, but only for a smaller part of the building. There are no mechanical ventilation systems installed. All the buildings are ventilated naturally.
Lightning is provided by fluorescent lamps.

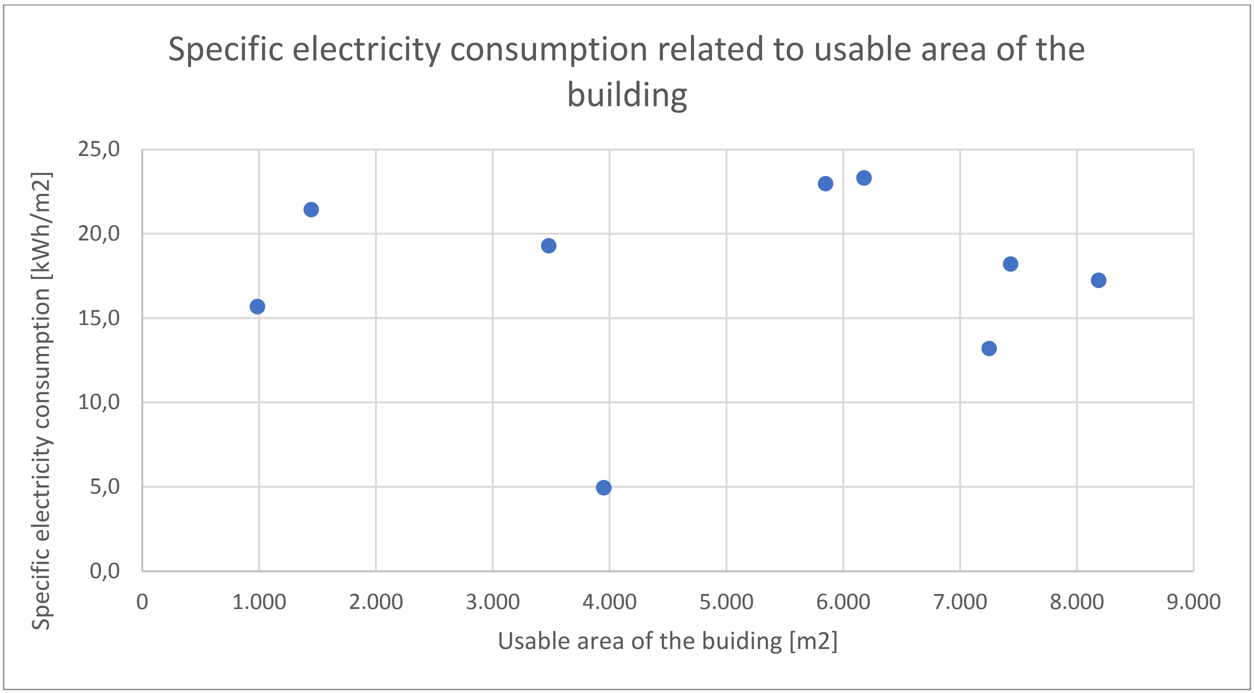
Energy use

The most - 73% of final energy delivered is provided by natural gas, approximately one quarter (27%) is covered by electricity and less than 1% by solar thermal heat.



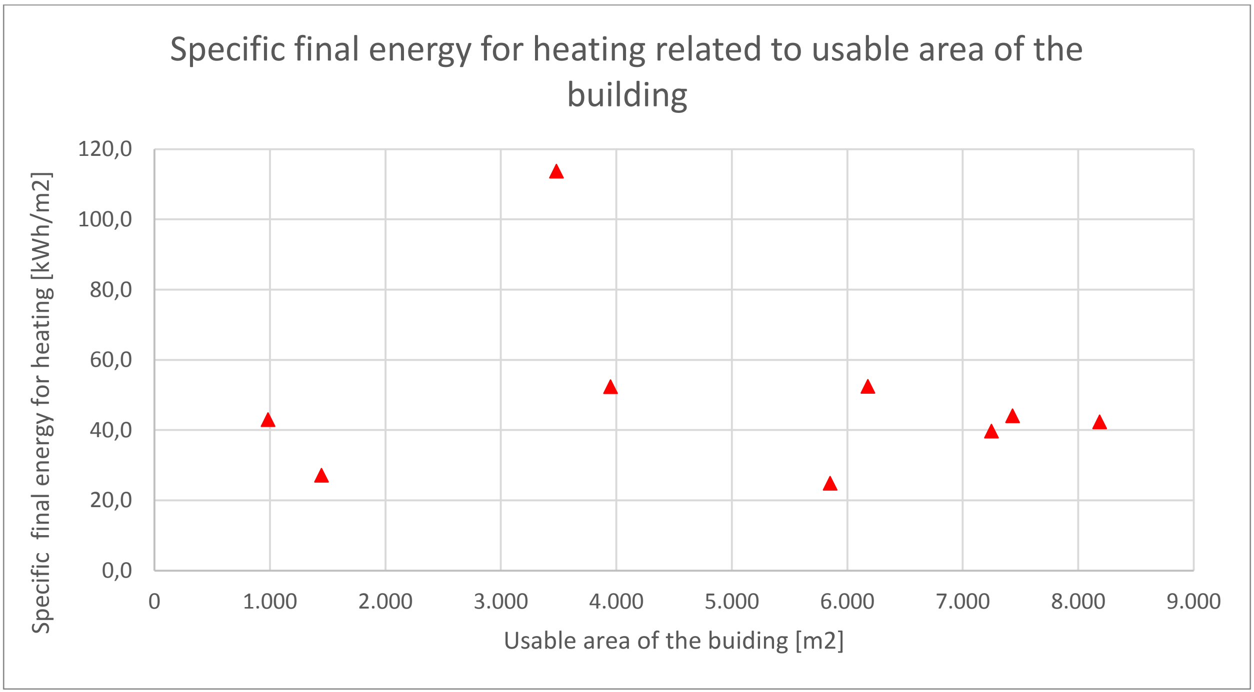
Picture 27: Final energy delivered - Italy

Graph on picture 28 shows electricity per square meter use related to building usable area. Most of the schools have specific consumption below 20 kWh/m^2/year. The average specific electricity consumption is 17,3 kWh/m^2/year which is quite low.



Picture 28: Specific electricity consumption related to usable area of the building (Italy)

Specific final energy for heating is the range of 25 to 114 kWh/m^2/year, the average is 47,5 kWh/m^2/year.



Picture 29: Specific final energy for heating related to usable area of the building (Italy)

4.5 Malta (Island of Gozo)

Ten public buildings were analysed on the island of Gozo. Three buildings are local council buildings, six buildings are a multipurpose building hosting different public services and one building (by far the largest) is the Ministry of Gozo building.


Picture 30: Left Public complex in Gharb, Right: Fontana Local council (Gozo)

The oldest building (Ministry for Gozo) was built in 1729 and 1860. One building was built in the 50's, two in the 60's and two in the 70's. other five buildings are built in period 2006 – 2015.

All the buildings are built from massive (local) stone load bearing walls. Average total net surface is 1.007,6 m^2, without the Ministry for Gozo, the average net surface is only 397 m^2.

Table 7: Buildings dimensions overview – Malta (Island of Gozo)

	TOTAL NET SURFACE (m^2)	TOTAL GROSS SURFACE (m^2)	NET VOLUME V (m^3)	GROSS VOLUME (m^3)	RATIO S/V (m^{-1})	EAVES HEIGHT (m)	FLOORS ABOVE GROUND
SUM	10.076	11.367	36.668	44.863			
AVERAGE	1.007,6	1.136,7	3.666,8	4.486,3	0,3	6,1	1,8

Building envelope characteristics

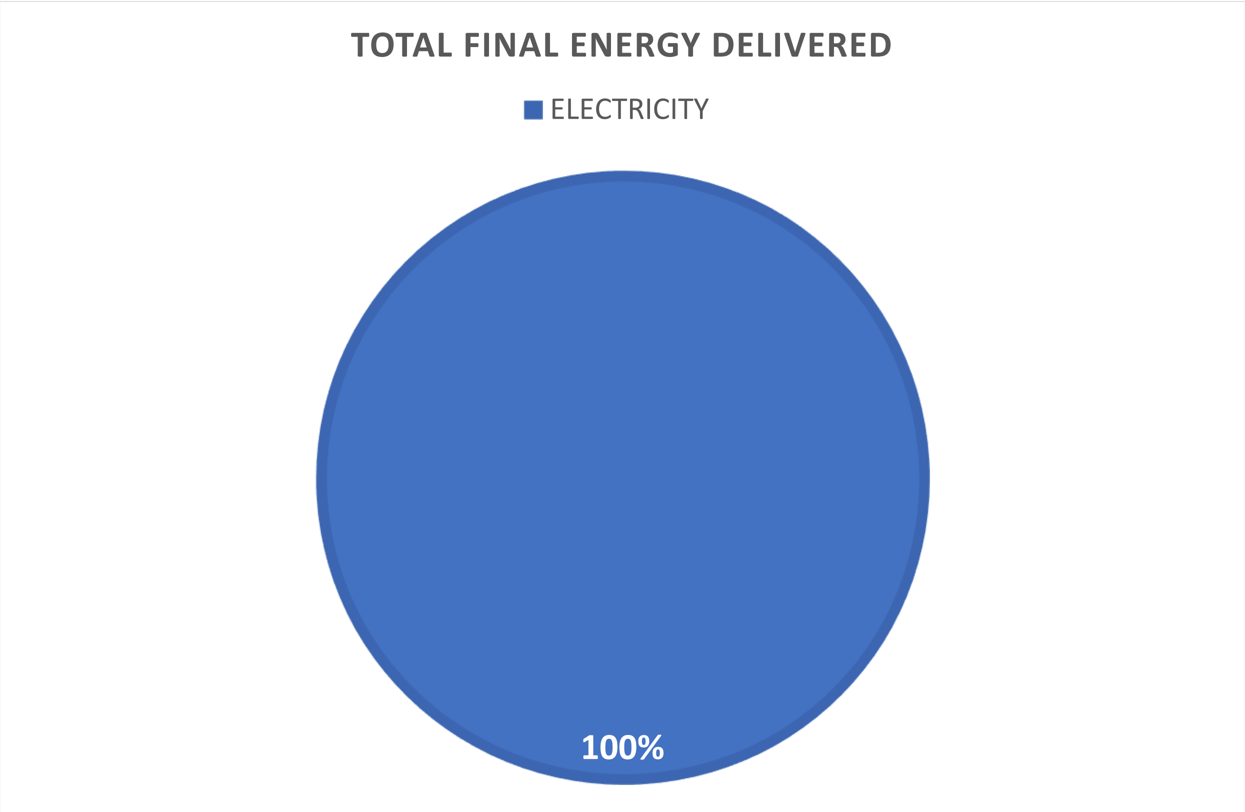
All the buildings are poorly insulated. The average U value for perimeter walls is 1,14 W/m^{2}K. The average U value for the roofs is 1,36 W/m^{2}K. Windows have aluminium or wooden frame and single or double glazing (without gas). Average U value for windows is 4,3 W/m^{2}K.
The regulation limits are 0,59 W/m^{2}K for roofs and 1,57 W/m^{2}K for perimeter walls. There are no regulation limits for windows.

Heating, ventilation, air conditioning and lightning systems

All buildings use split type heat pumps for both, heating and air-conditioning. There are no mechanical ventilation systems installed. All the buildings are ventilated naturally.
Lightning is provided in majority by fluorescent lamps.

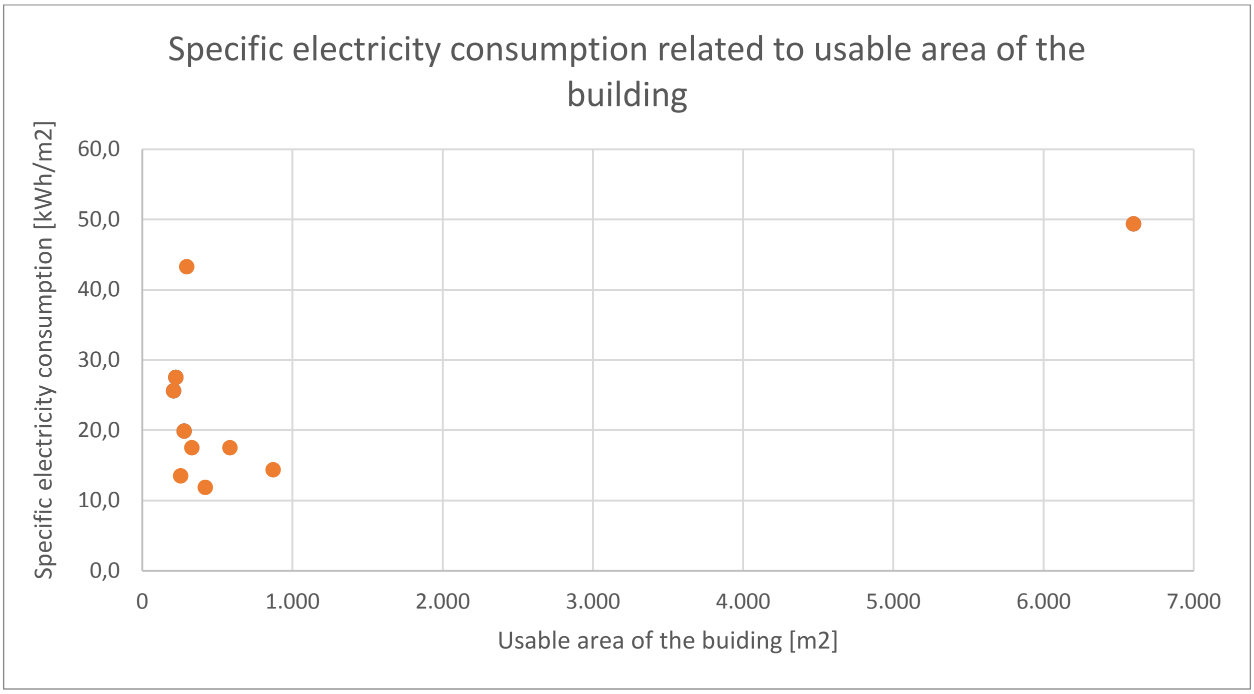
Energy use

The only energy source in the analysed buildings is electricity.



Picture 31: Final energy delivered – Malta (Island of Gozo)

Graph on picture 32 shows electricity per square meter use related to building usable area. Average specific electricity consumption is 24,0 kWh/m^2/year.



Picture 32: Specific electricity consumption related to usable area of the building (Malta – Island of Gozo).

4.6 Portugal

Twenty-three buildings were analysed in Alto Alentejo intermunicipal community in Portugal. Eight sports buildings (4 indoor swimming pools), five cultural buildings, three schools, three administrative and four other buildings were subject to energy audit.


Picture 33: Left: Municipal Swimming Pool in Arronches, Right: Municipal Town Hall in Arronches (Portugal)

The oldest four buildings which were built in previous centuries (1600-1800) were reconstructed in past 20 years, there are three buildings in the period 1950-1980, three buildings from 90's, seven buildings form 00's and the newest building built in 2014.

Majority of buildings are built from brick and reinforced concrete. Average total net surface is 4.975 m^2.

Table 8: Buildings dimensions overview - Malta

	TOTAL NET SURFACE (m^2)	TOTAL GROSS SURFACE (m^2)	NET VOLUME V (m^3)	GROSS VOLUME (m^3)	RATIO S/V (m^{-1})	EAVES HEIGHT (m)	FLOORS ABOVE GROUND
SUM	22.840	18.363	75.559	75.351			
AVERAGE	993,0	1.224,2	3.778,0	5.023,4	0,3	5,5	1,6

Building envelope characteristics

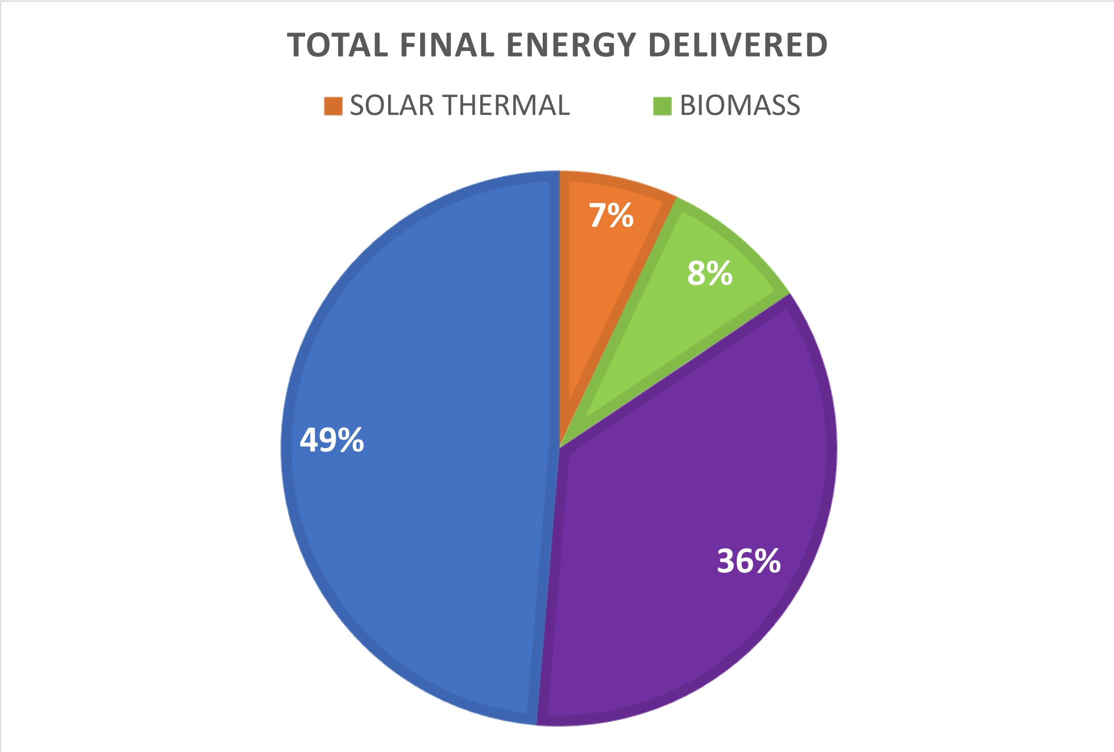
All the buildings are poorly insulated. Exact thermal characteristics were obtained only for 12 out of 23 buildings. Average U value for perimeter walls is 1,17 W/m^2K. The average U value for the roofs is 1,5 W/m^2K. Average U value for windows is 5,3 W/m^2K.
The regulation limits are 0,5 W/m^2K for roofs, 0,7 W/m^2K for perimeter walls and 4,3 W/m^2K for windows.

Heating, ventilation, air conditioning and lightning systems

Buildings use different types of heating. Manny buildings has just split type heat pumps. Among the buildings with classical boilers, the main type of fuel is LPG. Only one of the swimming pools is using biomass as the heat source. Large number of solar-thermal systems is installed.
Air conditioning is provided by split type heat pumps or VRF systems in 75% of the buildings. Mechanical ventilation systems installed are only present in some of the municipal indoor swimming pools. Other buildings are ventilated naturally.
Lightning is provided in majority by fluorescent lamps.

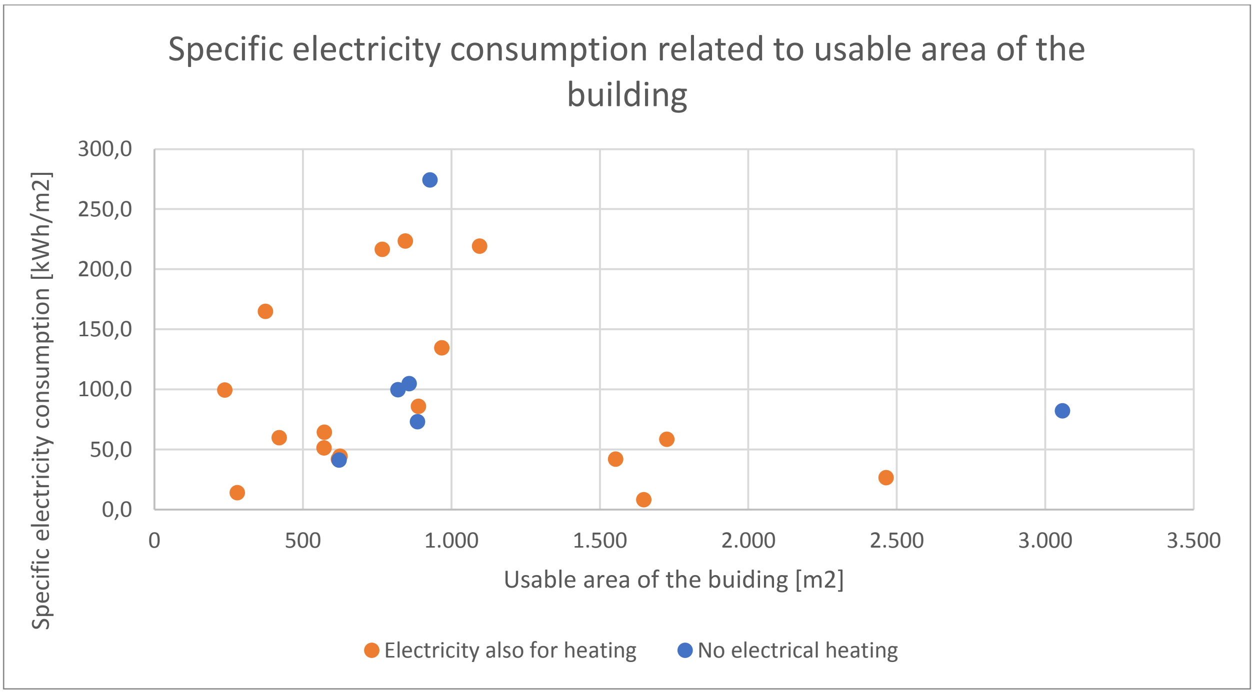
Energy use

The largest part – 49% of final energy delivered is provided by electricity, 36% is covered by LPG, 8% by biomass and 7 by solar thermal energy.



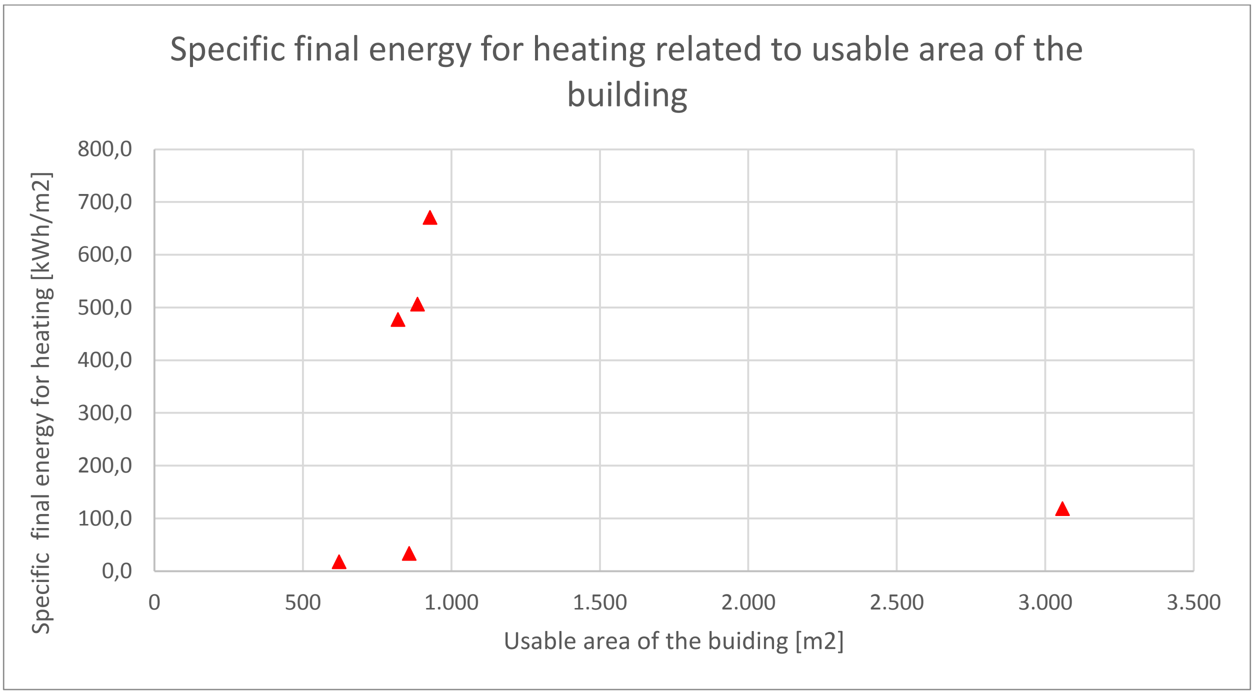
Picture 34: Final energy delivered - Portugal

Graph on picture 35 shows electricity per square meter use related to building usable area. Average specific electricity consumption is 96,9 kWh/m^2/year. Buildings up to 1.000 m^2 show higher average specific consumption than larger buildings.



Picture 35: Specific electricity consumption related to usable area of the building (Portugal)

Specific final energy for heating for buildings where heating is provided with LPG or biomass systems is the range of 18 to 670 kWh/m^2/year. All three buildings with specific consumption above 400 kWh/m2 are indoor swimming pools where high heat consumption is expected.



Picture 36: Specific final energy for heating related to usable area of the building (Portugal)

4.7 Slovenia

Eight buildings were analysed in primorska region of Slovenia. Three elementary schools, one kindergarten, a sports hall, healthcare centre, a dormitory and a town hall were analysed.

Picture 37: Left: Livade elementary school in Izola, Right: Healthcare centre in Ajdovščina (Slovenia)

The oldest two buildings which were built in the 50's, two buildings were built in 70's, two buildings were built in 80's and two in 90's.

Majority of buildings are built from different kind of brick and reinforced concrete. Average total net surface is 2.889,0 m^2.

Table 9: Buildings dimensions overview - Slovenia

	TOTAL NET SURFACE (m²)	**TOTAL GROSS SURFACE (m²)**	**NET VOLUME V (m³)**	**GROSS VOLUME (m³)**	**RATIO S/V (m⁻¹)**	**EAVES HEIGHT (m)**	**FLOORS ABOVE GROUND**
SUM	23.112	23.627	93.366	109.108			
AVERAGE	2.889,0	3.375,2	11.670,7	13.638,5	0,4	11,7	2,5

Building envelope characteristics

Some buildings from 80's and 90's already have some insulation on the facades or parts of the roof. On some parts of the buildings an energy efficient windows were already installed. Average U value for perimeter walls is 0,87 W/m^{2}K. The average U value for the roofs is 0,74 W/m^{2}K. Average U value for windows is 2,0 W/m^{2}K.
The regulation limits are 0,20 W/m^{2}K for roofs, 0,28 W/m^{2}K for perimeter walls and 1,3 W/m^{2}K in case of wooden or PVC and 1,6 W/m^{2}K for windows with aluminium frames.

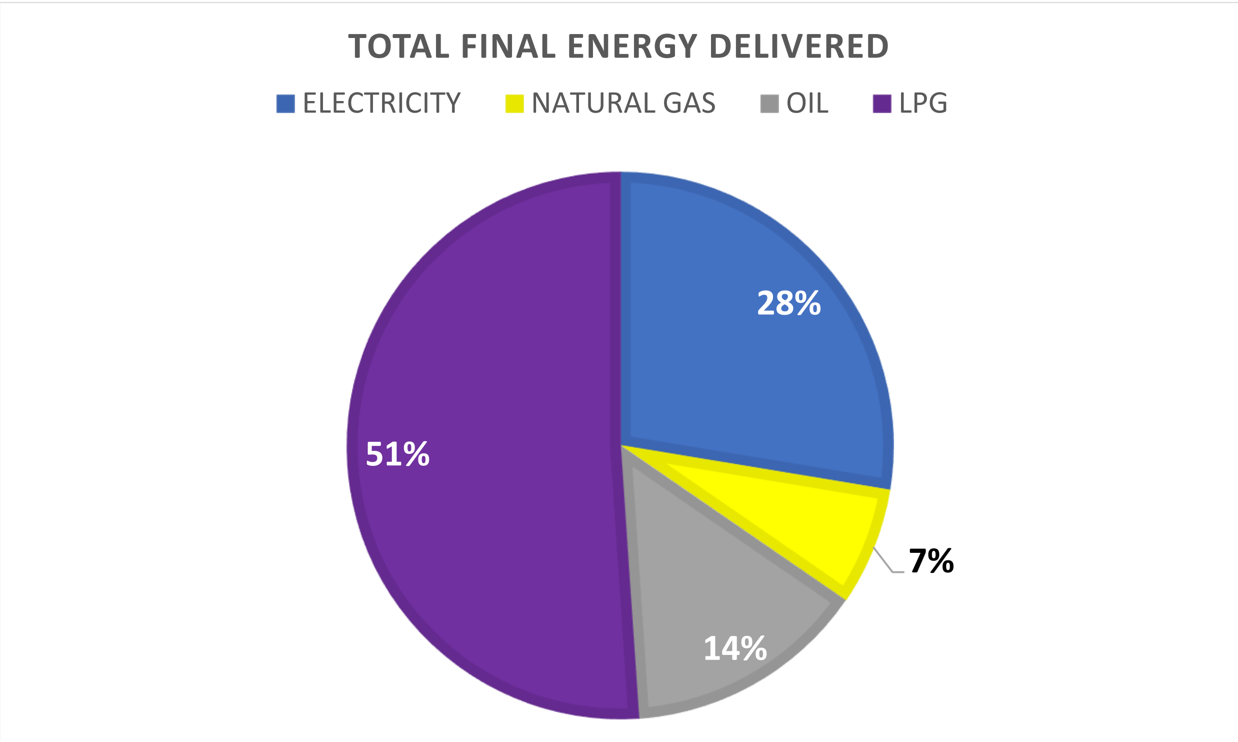
Heating, ventilation, air conditioning and lightning systems

Buildings use different types of heating. All buildings have central heating system installed. The heating sources are natural gas, LPG and oil.
Five buildings have some kind of Air conditioning, some with central VRF systems or split systems. Mechanical ventilation systems are installed in parts of 4 buildings. Other parts of this buildings and other buildings are ventilated naturally.

Lightning is provided in majority by fluorescent lamps.

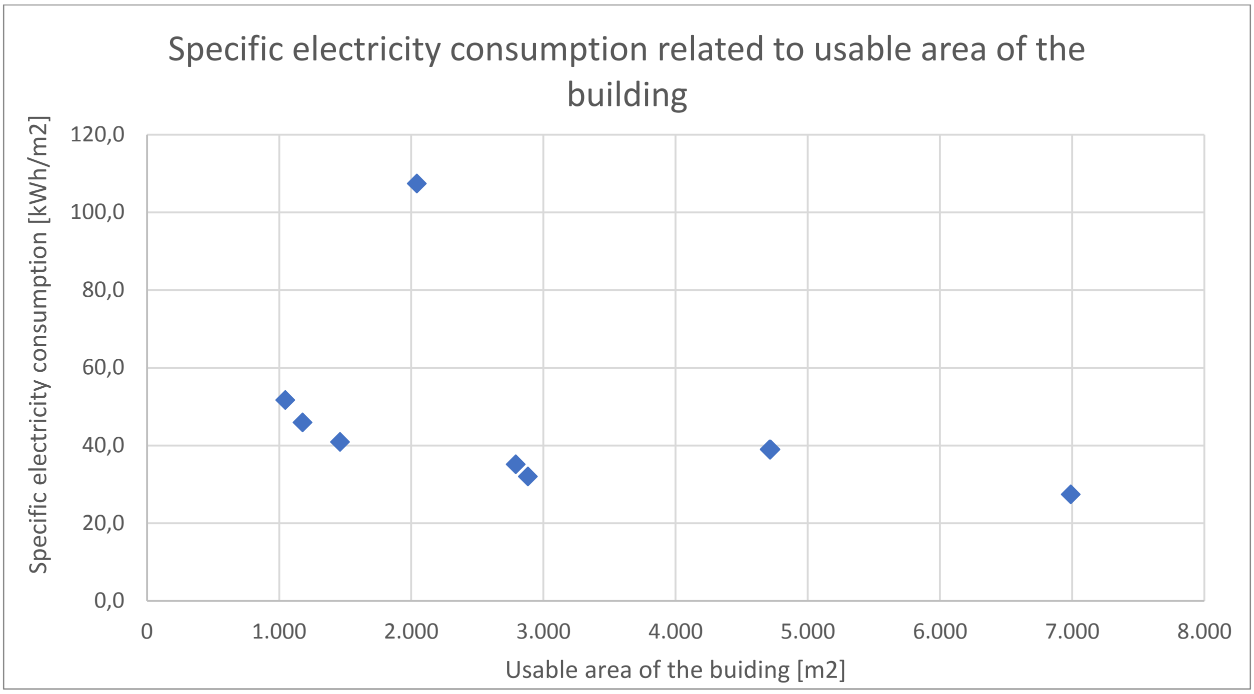
Energy use

The largest part – 51% of final energy delivered is provided by LPG, 28% is covered by electricity, 14 % by oil and 7 by natural gas.



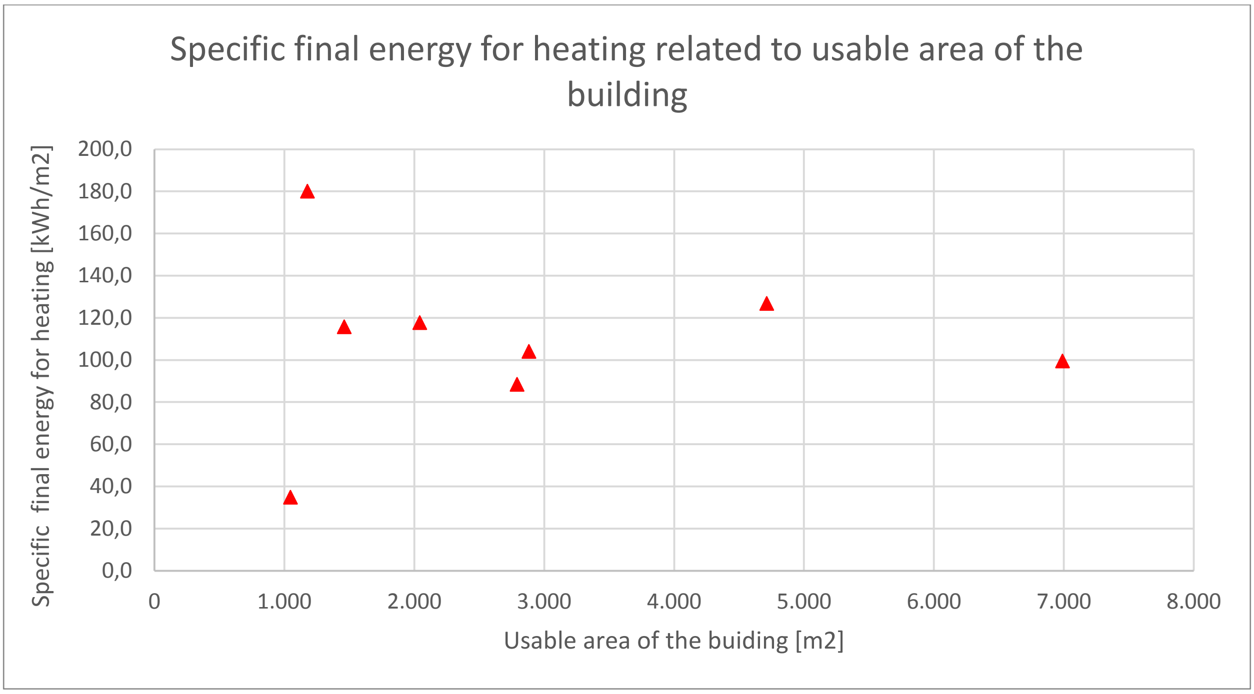
Picture 38: Final energy delivered - Slovenia

Graph on picture 39 shows electricity per square meter use related to building usable area. Average specific electricity consumption is 47,4 kWh/m^2/year. The highest consumption - 107,4 kWh/m^2/year can be seen in a healthcare centre.



Picture 39: Specific electricity consumption related to usable area of the building (Slovenia)

Specific final energy for heating is 134,1 kWh/m^2/year. The highest consumption - 179,9 kWh/m^2/year is seen in a kindergarten; the lowest - 34,8 kWh/m^2/year is seen in a Town hall.



Picture 40: Specific final energy for heating related to usable area of the building (Slovenia)

4.8 Spain

Ten public buildings were analysed in the Andalusia in southern Spain. Five buildings are town or city councils, two cultural buildings, one social services (nursery) building, one elementary school and one university campus building.

Picture 41:Left: City Hall Alcalá la Real, Jaén, Right: EUSA campus in Seville (Spain)

The oldest three buildings were built in 17th century, one in 18th century, one building is form 40's and one from 50's. The newest two buildings are form 90's. For two buildings, the year of construction is unknown.

Majority of the buildings are built from load bearing walls, made of different kind of brick. Average total net surface is 3.091,5 m^2.

Table 10: Buildings dimensions overview - Spain

	TOTAL NET SURFACE (m^2)	TOTAL GROSS SURFACE (m^2)	NET VOLUME V (m^3)	GROSS VOLUME (m^3)	RATIO S/V (m^{-1})	EAVES HEIGHT (m)	FLOORS ABOVE GROUND
SUM	30.915	37.688	294.262	293.101			
AVERAGE	3.091,5	3.768,8	29.426,2	29.310,1	4,8	10,2	2,1

Building envelope characteristics

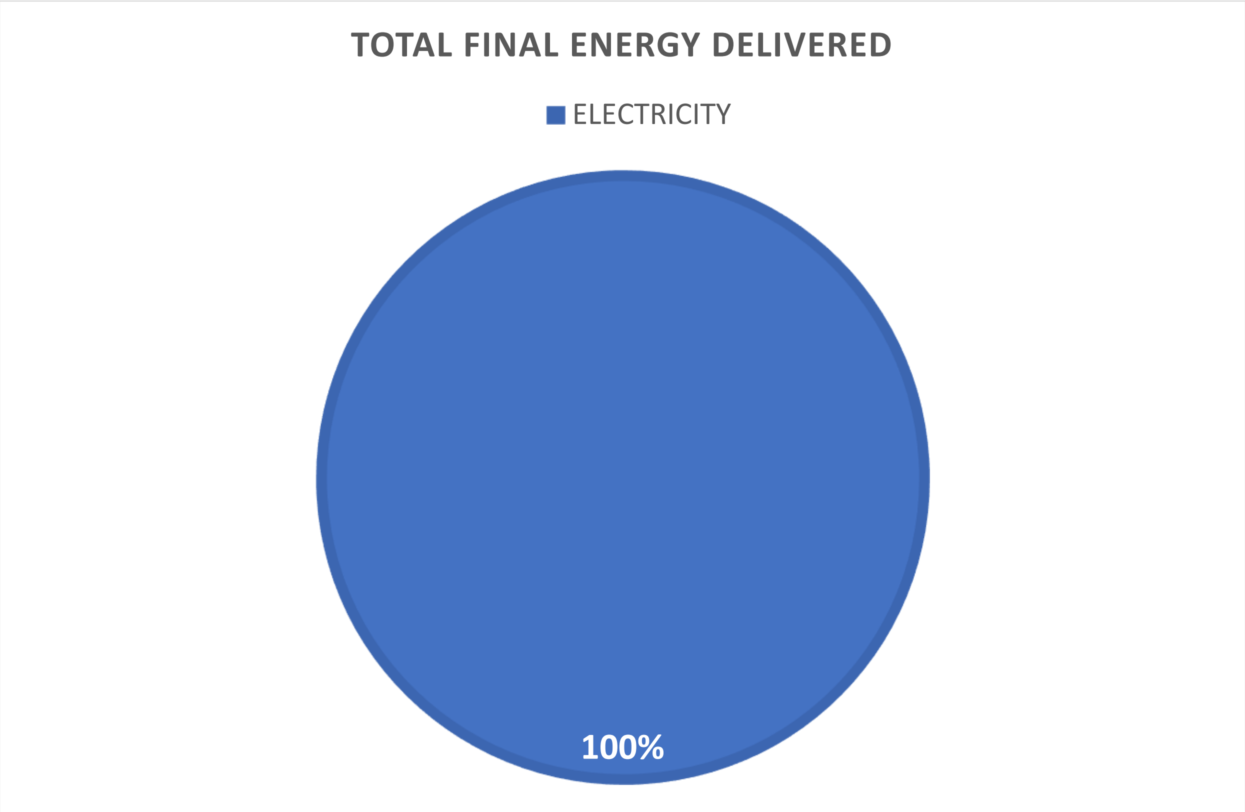
All the buildings are poorly insulated. The average U value for perimeter walls is 1,65 W/m^2K. The average U value for the roofs is 1,66 W/m^2K. Windows have pretty diverse frame materials and single or double glazing (without gas filling). Average U value for windows is 4,8 W/m^2K.
The regulation limits are 0,5 W/m^2K for roofs, 0,94 W/m^2K for perimeter walls and 4,1 – 5,7 W/m^2K for windows.

Heating, ventilation, air conditioning and lightning systems

All buildings use some type of heat pumps for both, heating and air-conditioning. Only two buildings also have a natural gas boiler, but the use of this source is practically negligible. There are no mechanical ventilation systems installed. All the buildings are ventilated naturally.
Lightning is provided in majority by fluorescent lamps, there is also some LED lightning present (around 5%).

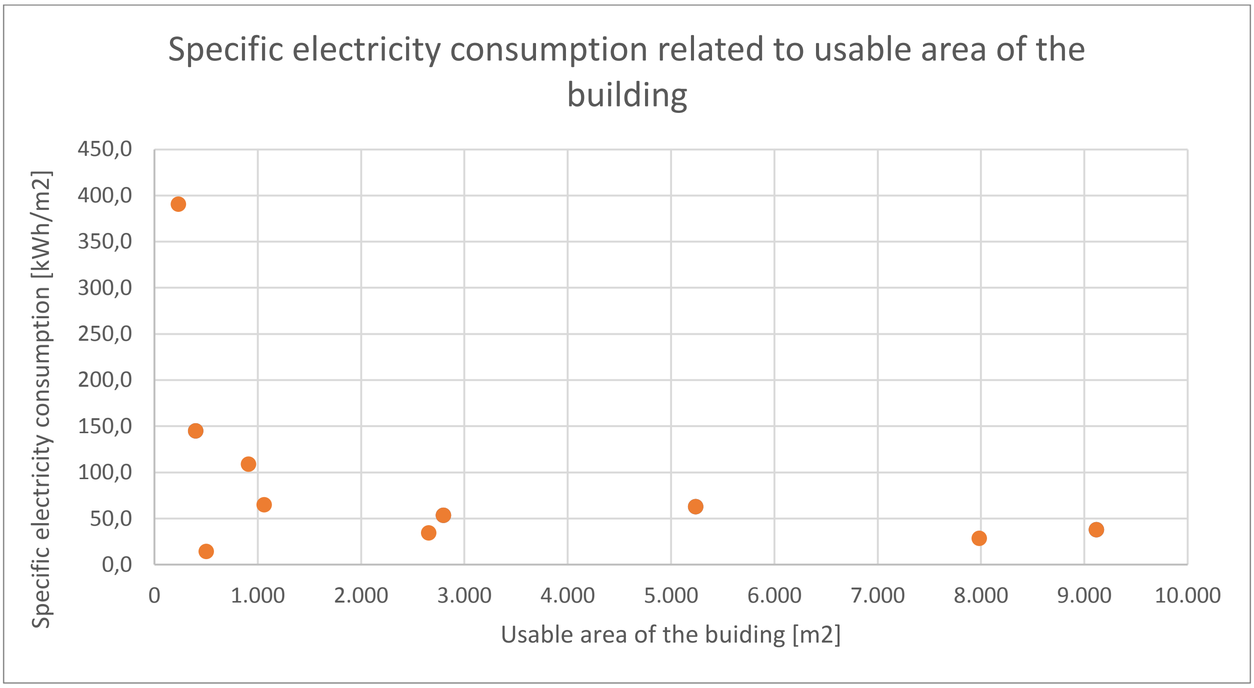
Energy use

The predominant energy source in the analysed buildings is electricity. Natural gas is also present, but is share is negligible.



Picture 42: Final energy delivered - Spain

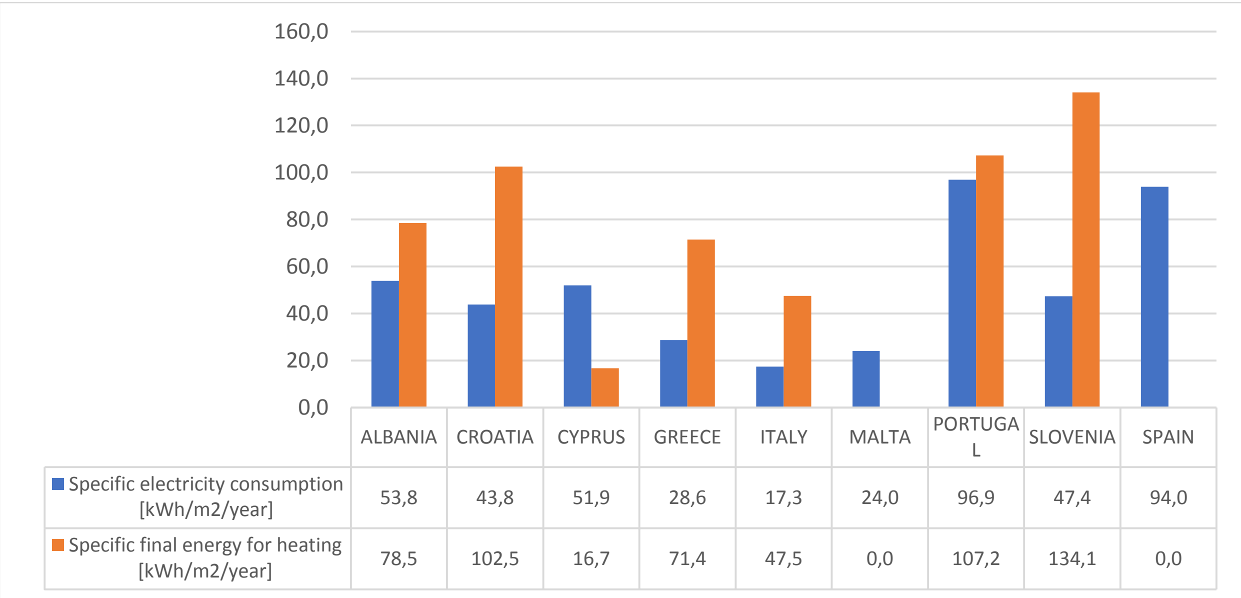
Graph on picture 43 shows electricity per square meter use related to building usable area. Average specific electricity consumption is 94,0 kWh/m^2/year. The highest specific consumption of 380 kWh/m^2/year can be seen in the smallest town hall.



Picture 43: Specific electricity consumption related to usable area of the building (Spain).

6. Conclusion

With the exception of island of Gozo (Malta), the building construction techniques and materials used are pretty similar in buildings which were built in same period in different countries. Most of the analysed buildings have poor insulation properties of thermal envelope. The regulation limits for thermal transmittance (U value) are stricter in countries with colder climate. Energy use indicators and different energy sources shares differ a lot among different countries (picture 44). Final energy use for heating is higher in highest in northern most countries (Croatia and Slovenia), but also in Portugal, largely because a lot of indoor swimming pools were in the analysed building stock. In southernmost countries like Spain and Malta Gozo) and partly also Cyprus, buildings aren’t equipped with classic central heating systems with a boiler and hot water as heat transfer medium. In these cases, different type of electricity driven systems are used for heating (split type air conditioners, VRF systems, thermal resistance heaters etc.).



Picture 44:Average specific energy consumption related to usable area of the building

Large number of buildings, especially in hotter climate countries are equipped with some kind of air conditioning system. Forced (mechanical) ventilation is present only in very few buildings.

The coverage of energy needs with renewable energy sources is pretty low. Only 5% of final energy delivered to buildings is covered with renewable energy sources, mostly by biomass boilers or solar thermal systems.

Considering current energy prices in MED countries and the fact of relatively low specific energy consumption in the studied building stock, the payback time, especially for complex energy efficiency measures (i.e. facades insulation, joinery replacement) is expected to be long. Therefore, a joint action approach is favourable, as it expected to have a positive impact on the investment costs due to economy of scale effect.

7. Anex I: Data collection form

NOTE:	1)	THE THERMAL TRASMITTANCE VALUES OF THE BUILDING OPAQUE ENVELOPE WALLS, ROOF AND WINDOWS, MUST BE OBTAINED BY DIRECT MEASURES ON THE FIELD, OR TAKEN FROM CALCULATION, PRIOR KNOWLEDGE OF THE TECHNICAL SPECIFICATION OF THE BUILDING ENVELOPE. THOSE VALUES WILL BE USE TO CALCULATION OF THE BUILDING ENERGY CONSUMPTION.
	2)	THE MINIMUM SURFACE MUST BE GREATER THAN 250 mq.

PHASE 1

CHARACTERIZATION OF THE BULDING

SYMBOL	DIMENSIONS	VALUE	BUILDING……………………….ADDRESSED IN…………………………..USED TO: (INDICATE THE OCCUPANCY AND ACTIVITIES PROFILES, INTENDED USE, THE PROPERTY TYPE, THE NUMBER OF OCCUPANTS ETC.)
Sn	TOTAL NET SURFACE (m²)		PLEASE INSERT BUILDING INTERNAL AND EXTERNAL PICTURES, TO PROVIDE AN IMMEDIATE VISUAL KNOWLEDGE OF THE BUILDING
S	TOTAL GROSS SURFACE (m²)		
Vn	NET VOLUME V (m³)		
V	GROSS VOLUME (m³)		
S/V	RATIO S/V (m⁻¹)		
h	EAVES HEIGHT (m)		
N°	FLOORS ABOVE GROUND		

CONSTRUCTION TYPE	TO SPECIFY (the short description): COMPOSITION OF THE WALLS AND ROOF, MAIN TYPES OF THE WINDOWS, FLAT OR SLOPING ROOF, VALUE OF FLAT SURFACES AVAILABLE FOR NEW PHOTOVOLTAIC SYSTEM AND/OR SOLAR THERMAL GENERATION, YEAR OF COSTRUCTION, ETC.

		YES/NO
TYPE OF STRUCTURE	LOAD-BEARING WALL	
	MIXED STRUCTURE OF REINFORCED CONCRETE AND WALLS	
	REINFORCED CONCRETE	
	WOOD	
	OTHER	

		YES/NO	THERMAL INSULATION (YES/NO)	AVERAGE THICKNESS (cm)
PERIMETER WALLS	WALL MADE OF CONCRETE BRICKS FULL			
	WALL MADE OF TUFF BRICKS FULL			
	WALL MADE OF BRICKS SEMI-FULL			
	BRICK BY BRICK AND CAVITY			
	OTHER			

		YES/NO	THERMAL INSULATION (YES/NO)	AVERAGE THICKNESS (cm)
ROOFS	WOODEN FLOOR OR CONCRETE-WOOD			
	BRICK-CONCRETE FLOOR			
	FLAT FLOOR PRACTICABLE			
	SLOPING ROOF			
	OTHER			

			YES/NO
WINDOWS	GLASS	SINGLE	
		DOUBLE	
		LOW EMISSION DOUBLE	
		TRIPLE	
	FRAME	WOOD	
		PVC	
		ALUMINUM OPEN JOINT	
		ALUMINUM THERMAL BREAK	
		WOOD/ALUMINUM	
		OTHER	
	TYPE OF ROLLER BLIND OR OTHER	NOT PRESENT	
		ALUMINUM	
		WOOD	
		INSULATED	
		NOT INSULATED	
SHADING SYSTEMS		PRESENT	
		NOT PRESENT	
		TYPOLOGY	

	CLIMATE DATA OF THE PLACE	
Tmm	MONTHLY AVERAGE TEMPERATURES (°C)	to Attach table
Igmm	IRRADIANCE SOLAR GLOBAL AVERAGE MONTHLY (W/m²)	to Attach table
PVr	VAPOR PRESSURE RELATIVE (kPa) FOR CALCULATION OF THE RELATIVE HUMIDITY	to Attach table
Vv	AVERAGE WIND SPEED (m/s)	

	INDOOR CLIMATE DATA	
Tri	WINTER HEATING TEMPERATURE (°C)	
Tci	TEMPERATURE COOLING (°C)	
Np	AVERAGE NUMBER OF PEOPLE PER SQUARE METER (Np/mq)	
	OCCUPANCY AND ACTIVITIES PROFILE: TIME OF USE, SLOTS TIME AND TIME PERIOD OF INACTIVITY	description of occupancy profile
Qli (W/m³)	CONTRIBUTION OF INTERNAL HEAT, ROOM FOR ROOM AND TOTAL VALUE	to Specify or Attach table
N° VOL/h	RENEWAL FRESH AIR	

THERMOPHISICAL SPECIFICATIONS OF THE BUILDING ENVELOPE				
	DIMENSION (m²)	THERMAL TRASMITTANCE U (W/m²·K)	THERMAL TRASMITTANCE - REGULATION LIMIT UL (W/m²·K)	AVERAGE THICKNESS (cm)
ROOF				
GROUND FLOOR				
PERIMETER WALLS NORTHERN EXPOSURE				
PERIMETER WALLS EXPOSURE EST				
PERIMETER WALLS SOUTHERN EXPOSURE				
PERIMETER WALLS EXPOSURE WEST				
WINDOWS NORTHERN EXPOSURE				
WINDOWS EXPOSURE EST				
WINDOWS SOUTHERN EXPOSURE				
WINDOWS EXPOSURE WEST				

THERMAL BRIDGES	SHORT DESCRIPTION OF THE THERMAL BRIDGES TYPOLOGY	
	INSULATED (YES/NO)	

NOTES:	①	FOR WHAT CONCERN THERMAL AND ELECTRIC ENERGY CONSUMPTION, ATTACH:
		• DAILY MEDIUM PROFILE OF THE ENERGY CONSUMPTION OF THE DAY TYPE, WITH MAXIMUM SAMPLING INTERVAL OF 30 MINUTES
		• ANNUAL TREND OF THE TOTAL AVERAGE MONTHLY CONSUMPTION (LOAD HISTOGRAM MONTH BY MONTH, FOR A TYPICAL YEAR OR FOR THE LAST 2 YEARS)
	②	IN ADDITION, SPECIFY :
		• OPERATING MODE OF THE HEATING GENERATORS: CONTINOUS HEATING, INTERMITTENT HEATING AND NUMBER OF HOURS OF DAILY WORKING, AS WELL AS HEATING WORKING PERIOD OF THE YEAR.
	③	FOR WHAT CONCERN THE CALCULATION OF THE ENERGY CONSUMPTION:
		• THE CALCULATION OF CONSUMPTIONS MUST BE OBTAINED BY CERTIFIED SOFTWARE, STARTING FROM KNOWLEDGE OF THE REAL DATA OF THE ENVELOPE BUILDING AND OF THE THECNOLOGICAL PLANTS , OR, ALTERNATIVELY, OBTAINED FROM ENERGY VECTOR BILLING, CONSIDERING THE GRID ENERGY LOSSES.

ENERGY PERFORMANCE INDICATORS

INDICATOR	U.M.	SYMBOL	VALUE
SPECIFIC ENERGY CONSUMPTION OF THE **BUILDING ENVELOPE**, FOR **WINTER HEATING**	kWh/m³·year	EH	
SPECIFIC ENERGY CONSUMPTION OF THE **BUILDING ENVELOPE**, FOR **COOLING**	kWh/m³·year	EC	
SPECIFIC **PRIMARY ENERGY** CONSUMPTION FOR **WINTER HEATING PLUS DHW** (domestic heat water)	kWh/m³·year	EPH	

ENERGY PERFORMANCE INDICATORS

INDICATOR	U.M.	SYMBOL	VALUE
SPECIFIC ENERGY PRODUCED BY RENEWABLES - **SOLAR THERMAL GENERATOR**	kWh/m³·year	EFERSOL	
SPECIFIC ENERGY PRODUCED BY RENEWABLES - **PHOTOVOLTAIC SYSTEMS**	kWh/m³·year	EFERFOT	
SPECIFIC ENERGY PRODUCED BY RENEWABLES - **BIOMASS**	kWh/m³·year	EFERB	
SPECIFIC ENERGY PRODUCED BY RENEWABLES - **GEOTHERMAL**	kWh/m³·year	EFERG	
TOTAL SPECIFIC ENERGY PRODUCED BY RENEWABLES - **(SOLAR THERMAL GENERATOR, PHOTOVOLTAIC SYSTEM, GEOTHERMAL, BIOMASS)**	kWh/m³·year	EFERT	
BUILDING ENERGY PERFORMANCE CLASS, IN ACCORDING TO NATIONAL LAWS BASED ON EU DIRECTIVES			

REAL DATA ABOUT ENERGY CONSUMPTION PER YEAR, CONCERNING LAST 2 YEARS, FOR ALL ENERGY VECTORS

ENERGY VECTOR	U.M.	CONVERSION FACTOR		LOWER CALORIFIC VALUE LCV		TOTAL ANNUAL CONSUMPTION		
TYPOLOGY		VALUE	U.M.	VALUE	U.M.	VALUE	kWh	TEP
ELECTRIC ENERGY	kWh	0,000187	TEP/kWh	1	kWh/kWh			
NATURAL GAS	SMC	0,00082	TEP/SMC	9,59	kWh/SMC			
OIL	liter	0,00093	TEP/liter	10,85	kWh/liter			
LPG	kg	0,001099	TEP/kg	12,76	kWh/kg			
WOOD	kg	0,00045	TEP/kg	5,13	kWh/kg			

DESCRIPTION OF THE MAIN THECNOLOGICAL SYSTEMS					

HEATING AND DHW THERMAL					
HEAT GENERATION AND INTENDED USE (HEATING AND/OR DHW) (describe number of boilers and their working type: single way or cascade way)		TOTAL POWER INSTALLED (KW)	PRESENCE OF CLIMATE CONTROL MODULE ON THE HEAT GENERATORS (YES/NO) (describe kind of technology adopted)	GENERATOR TYPOLOGY (CONDENSING BOILER, HEAT PUMPS, 3 STARS, TRADITIONAL BOILERS, ETC.)	PRESENCE OF REGAIN HEAT SYSTEMS FROM EXHAUST FUMES (YES/NO) (describe typology and efficiency %)
1					
2					
3					
4					
5					

HEATING TERMINAL TYPOLOGY AND DISTRIBUTION GRID	TOTAL NUMBER OF INSTALLED HEATING TERMINALS	PRESENCE OF THERMOSTATIC VALVES ON RADIATORS (YES/NO)	PRESENCE AND TYPOLOGY OF PIPELINE'S THERMAL INSULATION OF DISTRIBUTION GRID (description of the type and state of use)	PRESENCE OF LOCAL CLIMATE CONTROL MODULE OF THE INDOOR TEMPERATURES (YES/NO) (describe kind of technology adopted)
RADIATORS WALL				
WATER FAN-CONVECTOR TO WALL				
WATER FAN-CONVECTOR TO FLOOR				
OTHER (to specify)				

AIR CONDITIONING PLANTS AND AIR TREATMENT PLANTS (UTA)					
N° REFRIGERATED UNITS/UTA INSTALLED		TOTAL POWER INSTALLED (KW)	EFFICIENCY (%)	GENERATORS TYPOLOGY (description)	PRESENCE OF REGAIN HEAT SYSTEMS (YES/NO) (describe typology and efficiency %)
1					
2					
3					
4					
5					

ELECTRIC PLANTS						
TYPE OF USERS AND SUPPLY CONTRACTS WITH DEALER	MULTI-HOUR RATE (YES/NO) (describe typology and time slots)	TOTAL POWER INSTALLED (KW)	USED CONTEMPORARY POWER (kW)	COMMITTED OR REQUEST POWER (kW)	REACTIVE CONSUMPTION POWER (kWAR)	OPPORTUNITY OF REFORMULATION OF THE CONTRACTS (YES/NO)
TYPOLOGY OF THE CONTRACTS						
FLUORESCENT LIGHTING						
LED LIGHTING						
ELECTRICAL OUTLETS						
ELEVATORS						
SPECIAL PLANTS (NOT POWER PLANTS)						
AUXILIARY SERVICIES POWER FOR HEAT GENERATORS						
OTHER AUXILIARY SERVICES						