Interreg - IPA CBC
Italy - Albania - Montenegro
EUROPEAN UNION
REEHUB PLUS

Manual for Energy Efficiency

"Manual on standards and qualification of energy efficiency audits"

Premise

This document is drawn up in compliance with the provisions of the application form for the "REEHUB PLUS" project - Standards and training program of Energy Efficiency Audits and also has the purpose of detailing the results achieved in a path starting from REHUB up to arrive at REHUB PLUS highlighting the technical / synergistic aspects to which each of the partners has contributed.

State of the art

The main objective of this path was and is to provide knowledge and tools to the public administration, to young professionals (construction engineers, architects, mechanical engineers, electricians), to construction companies, to design studios, to organizations and individuals. (building administrators), for an adequate assessment of the results of energy audits in order to optimize efficiency measures on public and private buildings, also providing an indication of proper energy management of the buildings.

Knowledge indicates the result of the assimilation of information through learning and is the set of facts, principles, theories and practices, relating to a field of study or work described as theoretical and practical, therefore, the tools of which a professional will be able to use for the preparation of Energy Performance Certificate (EPC) starting from knowing in advance the building system / plants under study and this is how the results obtained with literature data can be analyzed compared to those actually present in the field.
In this context, the path taken with the construction of the HUBs (REEHUBs) and the energy audits developed in them has highlighted that the data available in the literature are not always necessarily interfaceable with real cases. It has therefore been seen how the adoption of "simplified" algorithms (ENEA development) has made it possible to highlight how the knowledge of the recovery / restructuring interventions carried out over time on a property can provide that extra input for a more precise reading of the data and therefore an optimization of the proposed interventions.

The study of the building / plant system passes, in addition to the knowledge of the "previous history", also for the acquisition of instrumental data, possibly with sampling in the long and medium term, which provide those inputs as in a time frame the building has dynamically modified its behavior under indoor / outdoor climatic conditions and use of the same. This need was reflected in the continuation of the project with "REEHUB PLUS" where among the primary objectives there was precisely a measurement campaign carried out on the buildings indicated by the respective partners, which in the case of the Municipality of Agnone (MoA) were the headquarters of 'Municipal Administration and a recently built school. This choice was aimed at highlighting how technical interventions adopted on buildings of different historical / relizational conception, which confirm their heterogeneity not only in architectural terms but also in use, may not always lead to the expected values.

The installation, in each of the buildings, of adequate equipment purchased with REEHUB PLUS, made it possible to study, by collecting remote data on a proprietary server, the behavior of the building system / plants in different climatic conditions.

In fact, the results obtained have highlighted how energy efficiency interventions performed after work "(for example with the only replacement of fixtures at the Agnone municipal administration office) do not return expected project values despite the goodness of the same intervention which does not will be able to guarantee an adequate behavior of the building / systems system The results obtained on the recently built school building were of a completely different nature, where, together with the fixtures, already in the construction phase, thermal insulation interventions were carried out by means of external coatings.

All the data of the measurement campaign, with monitoring of different quantities, are collected in a certified database in order to be able to provide a valid reference for future studies of a school building in conditions of daily use set in the context of a climatic zone "E ".

Therefore it appears extremely evident that not only the knowledge and the acquisition of information / data can constitute the basis for an adequate choice of interventions to be carried out, but the correct reading and interpretation of the same data constitutes the other fundamental element in the design of a high-performance building / plant system.

In light of the above, it is clear how trained technicians in this regard can represent the cornerstone of what has been explained. In this regard, training training activities were carried out, falling within the activities envisaged in the "Training organization (A.T.2.2-WPT2)" project for professionals in the sector.

The experience, therefore, gained in situ, the result of the study of the HUB as a laboratory of the building / plant system, has emphasized the need to promote an "energy" awareness already in school age, in particular in technical schools.

In fact, more and more convinced that the energy efficiency of a building starts from a common civic sense, it is also of fundamental importance to form a conscience in the technicians of tomorrow. Starting from this certainty, the elements that characterize REEHUB and REEHUB PLUS have been promoted at the first and true "workshop of minds", the school. Projects were carried out, with the help of the equipment purchased with REEHUB, involving the graduating students of the Technical Institutes. The students were shown how field study can immediately give the first design references, making the HUB of Palazzo Bonanni a real training ground for knowledge. To date, a portion of the young people involved attend energy universities or ITS.

Therefore, the activities carried out with the active help of the HUB have already involved a large target group of technicians and students to whom to transmit knowledge and train that civic awareness on energy efficiency.

The implementation of the path briefly described above took into account all the regulations in force both in the European Community field, and in the national implementation as well as in compliance with the regulations of regional enactment.

HUB ENERGY AUDIT Palazzo Bonanni Agnone using the simplified algorithm (ENEA)

GENERAL DATA OF THE COMPLEX AND TERRITORIAL FRAMEWORK

Built in the thirteenth century, Palazzo Bonanni is an important noble building located in the oldest urban fabric of the city. Over the last few years the complex has been the subject of restoration interventions, aimed at enhancing the reuse of the building as a museum center and as a hub of the tourist, cultural and environmental network of the entire Molise area.

FUNCTIONAL AND DIMENSIONAL FEATURES

The building is structured in a single building with five floors, 4 of which are above ground and one basement. The premises intended to host the HUB are located on the second floor NORTH-WEST side.

SYSTEM CONFIGURATION OF THE COMPLEX

The complex has installed thermal systems for winter air conditioning and for the production of DHW, and electrical systems for lighting the rooms and for the operation of the electrical devices necessary for carrying out the activities. There are no summer air conditioning systems. Each of the floors is served by two methane-powered heat generators (boilers).

Each of the boilers is subservient to approximately half of the plan development of the single floor. At the time of the instrumental surveys on the floors below the one where the HUB was located, the heating systems were off with the exception of a wing on the ground floor.

PROJECT VALUES

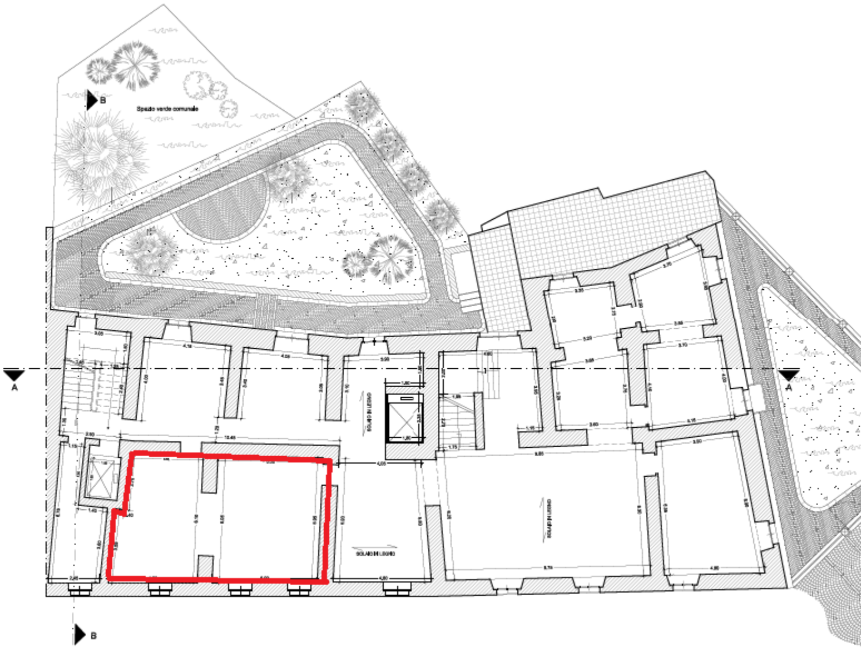
The data used for the development of the energy AUDIT, of the HUB located inside Palazzo Bonanni located in the historic part of Agnone, are the result of a careful and analytical comparison between the data collected in the measurement campaign, from those hypothesized through the current literature and finally the feedback reported by the technicians who over time have carried out maintenance, conservation and renovation works on the building.

It should be noted that the comparison with the instrumental measurements, with particular relevance in the conductivity coefficient, carried out during the audit campaign envisaged in the project, allowed an evaluation of the transmittance making sure that the values obtained from the calculation are closer to the real one. structural situation compared to an evaluation carried out with theoretical values from the literature that would have underestimated a possible redevelopment intervention. As regards the measurements of consumption deducted from the billing made available by the MoA, both for electricity and methane consumption, it should be noted that at present the entire property is equipped with a single metering unit for electricity and two methane consumption metering groups (one of these is connected to the side of the ground floor intended to house the Municipal Police offices, while the other is dedicated to the rest of the structure).

Therefore, the available data refer to the total consumption of GAS for the entire building (6 boilers) and a POD relating to the entire use of the building (net of the premises intended for the Municipal Police).

1 - STRUCTURE ANALYSIS

Locali HUB	Reference plane	Side of the floor	Medium length (m)	Medium width (m)	Surface HUB (m^2)	Height (m)	Total area floor (m^2)
Rooms	SECOND FLOOR	Nord-Ovest	10	6,1	61	3,20	390



1.1 Stratigraphy of opaque vertical walls

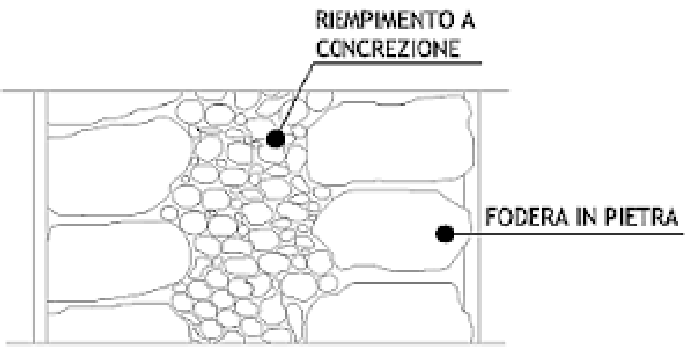
The structure is characterized by vertical surfaces with the classic sack conformation, which is detailed below. Starting from inside the premises and moving from the inside to the outside of the wall, the building components are divided as follows:

1. Internal plaster: they are taken as references given by the current literature in particular for the thermal conductivity (EN1745) it is equal to 0,7 $W/m{*}°C$.

2. stone wall and air chamber, thickness 0.80 m (35 + 15 + 30)

3. External plaster: same characteristics used for the internal layer.

Table 2 shows the data used for the calculation of the quantities that will be expressed in subsequent paragraphs.



Layer	Thickness (m)	Coeff. Conductivity ($W/m*°C$)	Density (kg/m^3)
Internal plaster	0,02	0,7	1500
Stone+C.A.+ Stone	0,80	2,2	2000
External plaster	0,02	0,7	1500

1.2 Slab stratigraphy (floor)

Proceeding, as above, from the basement upwards, we obtain the following layers:

1. Lime plaster: from the reliefs made the thickness is 2 cm and the thermal conductivity considered is ***0,7*** $W/m*°C$.

2. Slab with brick blocks and joists: the thickness considered for this layer is equal to 30 centimeters while as regards the conductivity coefficient this has been taken equal to ***0,7*** **$W/m*°C$**.

Layer	Thickness (m)	Coeff. Conductivity ($W/m*°C$)	Density (kg/m^3)
Plaster	0,02	0,7	1500
Insole	0,3	0,8	1600
Flooring	0,05	1,2	2000

1.3 Slab stratigraphy (ceiling)

Also in this case we proceed upwards from inside the structure.

The subdivision of the layers will be as follows:

1. Wooden cladding
2. Plaster: same characteristics used up to now.
3. with brick blocks and joists: as in the previous case.

Layer	Thickness (m)	Coeff. Conductivity ($W/m*°C$)	Density (kg/m^3)
Riv. Wood	0,04	0,22	850
Plaster	0,02	0,7	1500
Insole	0,3	0,8	1600

1.4 Partition stratigraphy

The partition consists of a full-height vertical wall with the function of internally dividing the various rooms. It is structured like the one that attests to the outside, that is to bag

Layer	Thickness (m)	Coeff. Conductivity ($W/m*°C$)	Density (kg/m^3)
Internal plaster	0,02	0,7	1500
Stone + C.A. + Stone	0,80	2,2	2000

1.5 Doors and windows

The frames used include double-glazed windows (double glazing) characterized by a layer of simple glass with a thickness of 4 mm followed by a vacuum chamber, containing air with a thickness of 12 mm, and a final layer of simple glass of the same thickness as the first. .
The whole is enclosed by a wooden frame with the same conductivity of double glazing equal to $\mathbf{3}\ W/m\mathbf{2} *°C$.

2- CALCULATION OF THERMAL LOADS

In the following chapter, the working data will be set out and the thermal requirements required by the building / HUB rooms in the winter period will then be calculated.

2.1 Project data

The table shows the temperature and humidity data referring to the locality of Agnone in the winter period.

Project data	Winter
Temper. int. (°C)	21
Temper. exst. (°C)	-3

Humidity int. (%)	55
Humidity exst. (%)	65

2.2 Calculation of transmittance

With the data set out so far, we can proceed with the calculation of the transmittance for the various structural components of the building. It is still necessary to consider the effect on the transmission of heat through a surface due to the convective motions of the air masses both inside and outside the building.

Therefore, the following coefficients can be introduced:

- h_i = internal liminal heat transfer coefficient expressed in $W/m2 *°C$.
- h_e = external liminal heat transfer coefficient expressed in $W/m2*°C$.
- Si = single layer thickness expressed in m.
- Ki = conductivity coefficient expressed in $W/m*°C$.

The coefficients assume, according to the UNI 7357 standard, the following values

	hi ($W/m2*°C$)	**he ($W/m2*°C$)**
Vertical walls	8	25
Horizontal walls (ascending flow)	9,3	23,2
Horizontal walls (downward flow)	5,3	16,3

The thermal transmittance of a generic wall (U), expressed in $W/m2 *°C$, is equal to:

$$U - \frac{1}{\frac{1}{h_i} + \sum_{i=1}^{n} \frac{S_i}{k_i} + \frac{1}{h_e}}$$

where n refers to the number of layers present in the wall under examination.

For opaque vertical walls, the result is as follows:

$$U = \frac{1}{\frac{1}{hi} + \sum_{i=1}^{n} \frac{si}{ki} + \frac{1}{he}} = 1{,}89\ W/m2 * °C$$

For slabs (floor), the result is as follows:

$$U = \frac{1}{\frac{1}{hi} + \sum_{i=1}^{n} \frac{si}{ki} + \frac{1}{he}} = 1{,}44\ W/m2 * °C$$

For slabs (attic), the result is as follows:

$$U = \frac{1}{\frac{1}{hi} + \sum_{i=1}^{n} \frac{si}{ki} + \frac{1}{he}} = 2{,}07 \ W/m2 * °C$$

For partitions, the result is the following:

$$U = \frac{1}{\frac{1}{hi} + \sum_{i=1}^{n} \frac{si}{ki} + \frac{1}{he}} = 1{,}89 \ W/m2 * °C$$

Wall	**U ($W/m2 * °C$)**
Vertical	1,89
Flooring	1,44
Ceiling	2,07
Partitions	1,89
Doors and windows	3

3 - CALCULATION OF LOST THERMAL LOADS

Taking into account the project data set out in chapter 2, we proceed to calculate the dispersed thermal loads and useful ventilation.

3.1 Calculation of dispersed thermal power on opaque surfaces (Qdo)

In this paragraph we proceed with the calculation of the powers dispersed by all the opaque surfaces.

The thermal power lost by an opaque surface can be expressed as:

$$Q_{do} = \sum_{i=1}^{n} \alpha_i \cdot U_i \cdot S_i \cdot \Delta t_i$$

Dove:

- α_i is the coefficient that takes into account the exposure of the wall
- U_i is the transmittance of the i-th wall $W/m2*°C$
- S_i is the internal surface of the i-th $m2$
- Δt_i is the temperature difference between inside and outside
- n represents the walls (North, South, West, East, ceiling and floor)

The value of αi is a function of the exposure of the wall (UNI 7357, par.9); this coefficient, shown in the table below, is included for vertical surfaces between 1.02 and 1.20, and is equal to 1 for horizontal surfaces;

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Esposizione	S	SO	O	NO	N	NE	E	SE
Coefficiente f	1	1,02-1,05	1,05-1,10	1,10-1,15	1,15-1,20	1,15-1,20	1,10-1,15	1,05-1,10

1Matte surface and breakdown [m2]

Matt Surface	**Nord**	**Sud**	**Ovest**	**Est**	**TOT.**
VERTICAL	19,36	17,6	29,6	33,12	99,68

Matt Surface	pavimento	solaio	**TOT.**
HORIZZONTAL	54,57	54,57	109,14

$$Q_{do} = \sum_{i=1}^{n} \alpha_i \cdot U_i \cdot S_i \cdot \Delta t_i$$

NORD

Matt Surface	α_i	**S**	**U**	Δt	Q_{do}	Q_{do} + 10 PERCENTO	Q_{do} + 10 PERCENTO kW
Partitions	1,15	19,36	1,89	4	168,32	185,14	0,18

SUD

Matt Surface	α_i	**S**	**U**	Δt	Q_{do}	Q_{do} + 10 PERCENTO	Q_{do} + 10 PERCENTO kW
Partitions	1,02	17,6	1,89	4	135,71	149,28	0,15

EST

Matt Surface	α_i	**S**	**U**	Δt	Q_{do}	Q_{do} + 10 PERCENTO	Q_{do} + 10 PERCENTO kW
Partitions	1,15	33,12	1,89	4	287,94	316,73	0,3

OVEST

Matt Surface	α_i	**S**	**U**	Δt	Q_{do}	Q_{do} + 10 PERCENTO	Q_{do} + 10 PERCENTO kW
PARETE VERSO EST	1,05	29,6	1,89	24	1409,78	1550,68	1,55

Matt Surface	α_i	**S**	**U**	Δt	Q_{do}	Q_{do} + 10 PERCENTO	Q_{do} + 10 PERCENTO kW
HORIZZONTAL FLLOR	1	54,57	2,07	21	2372,15	2609,15	2,6
FLOORING	1	54,57	1,44	21	1650,19	1815,19	1,82

Matt Surface	Q_{do}	Q_{do} + 10 PERCENTO	Q_{do} + 10 PERCENTO kW
Total	6024,09	6626,17	6,6

3.2 Calculation of dispersed thermal power on glass surfaces (Qdv)

$Q_{dv} = S \cdot U \cdot \Delta t.$

The data used refer to the tables in the previous paragraphs. Also in this case the calculation was subject to a separation based on the orientation of the surfaces with respect to the cardinal points.

1. Glazed area and distribution [m2]

Glass surface	Nord	Sud	Ovest	Est	TOT.
Windows	/	/	6,21	/	6,21

Glass surface	S	U	Δt	Q_{dv}	Q_{dv} + 10 PERCENTO	Q_{dv} + 10 PERCENTO kW
Rooms	6,21	3	24	447,12	491,82	0,49

3.3 Calculation of total thermal power dispersed by opaque and glazed surfaces

Surface	total kW
Matt surface	6,6
Glass surface	0,49
TOTAL	7,09

Qdov = Qdo + Qdv = 7,09 kW.

3.4 Calculation of dispersed power for ventilation (Qvent)

A certain amount of external renewal air enters all rooms due to infiltration through cracks or occasional opening of doors and windows.

The thermal power required to bring the aforementioned external air to the temperature of the heated environment (Qvent thermal power dispersed by ventilation, also called ventilation thermal load) is equal to:

$$\dot{Q}_{vent} = \dot{V}_a \cdot c_{pv} \cdot (t_i - t_e) = V \cdot n \cdot c_{pv} \cdot (t_i - t_e) = V \cdot n \cdot c_p \cdot \rho \cdot (t_i - t_e)$$

where is it

- $\dot{Q}_{vent}$ = thermal power dispersed by ventilation, W (kcal/h);
- Va = flow of incoming external air, m3/s (m3/h);
- V = net volume of the heated zone, m3;
- n =number of volumes of fresh external air, s-1 (h-1);
- c_p = mass heat capacity (specific heat) at constant air pressure, post equal to 1.000 J/kgK (0,24 kcal/kg°C);
- ρ = air density, set equal to 1,2 kg/m3;
- c_{pv} = volumic unit heat capacity (specific heat referred to the unit of volume) at constant air pressure, set equal to 1.200 J/m3K ≅ 0,29 kcal/m3°C.

Moving on to the calculation

$$\dot{Q}_{vent} = \dot{V}_a \cdot c_{pv} \cdot (t_i - t_e) = V \cdot n \cdot c_{pv} \cdot (t_i - t_e) = V \cdot n \cdot c_p \cdot \rho \cdot (t_i - t_e)$$

design characteristics and conditions:
- site: **Agnone (IS)**
- (t_e = -3 °C)
- (t_i = 21 °C)

The room volume: 174,62 m3

- External replacement air: n = 0,5 h^{-1} (usual avarage value)

From the assigned data it appears that the external air flow entering the room is:

V = n · Volume = 0,5 x 174,62 = 87,312 m3/h = 87,312/3600 m3/s = 0.024 m3/s

Therefore, the thermal power lost by ventilation is equal to:

Qvent = 174,62 x (0.5/3.600) x 1000 x 1.2 x (21 - (-3) · = 698,48 W ≅ 0,7kW

Ventilation dispersions Qvent		
Room	**Volume m3**	**Q vent (kW)**
HUB	174,62	0,7

Qvent = 0,7 kW.

3.5 Calculation of latent thermal power (Qlat)

For the calculation of the Qlat, an endogenous contribution due to the presence of people in the premises is assumed equal to $60W\ /\ persona$, thus obtaining for the latent thermal power for the HUB with an average number of people present equal to 4

$$Q_{lat} = 60W/persona \cdot 4\,persone = 240\ W = 0{,}24\ kW$$

Qlat = 0,24 kW.

3.6 Thermal load

In light of the above, it is possible to conclude that the thermal load that the system will have to restore in the face of the dispersions is given by the algebraic sum of the thermal power dispersed through the surfaces (Qdv + Qdo = Qdov), the power dispersed by ventilation and the endogenous contributions.

Thermal power dispersed opaque and transparent components	Qdov (kW)	7,09
Thermal power dispersed by ventilation	Qvent (kW)	0,7
Latent thermal power	Qlat (kW)	- 0,24
Total dispersed thermal power	**Qdov+Qvent-Qlat**	**7,55 kW**

Performance analysis of the installed heating unit

As regards the measurements of consumption deducted from the billing made available by the MoA, both for electricity and methane consumption, it should be noted that at present the entire property is equipped with a single metering unit for electricity and two methane consumption metering groups (one of these is connected to the side of the ground floor intended to house the Municipal Police offices, while the other is dedicated to the rest of the structure).

Therefore, the available data, provided by the MoA, refer to the total consumption of GAS for the entire property and a POD relating to the entire use of the property (net of the premises intended for the Municipal Police). Therefore, in order to analyze the performance of the HUB, we will refer to the data determined for the structure and the existing heat production plants.

Technological systems

List of technological systems installed in the complex, with the relative typological characteristics and the power produced or absorbed.

Condensing boiler for space heating and production of ACS **Site HUB**	**Pot. foc. [kW]**	**Rend. utile nom.**	**Comb.**	**Terminal type**	**Served area (m^2)**
	30	0.93	Metano	Radiatori	195

To check if the boiler installed meets the calculation parameters, we proceed with the analysis of the existing system with respect to the thermal load to be reintegrated and the efficiency of the system itself:

- To supply 7.55kW to the HUB premises, an emission system (radiators) is in place with an efficiency: 95%.
- Hot water passes through pipes that disperse a certain amount of heat and for these it can be assumed efficiency: 96%.
- The water is accumulated in a tank that disperses and for this reason it can be assumed that the efficiency is 98%.
- The regulation system does not control the peaks perfectly, yielding at times too much and at others too little and for this reason it can be assumed efficiency: 97%.
- Finally, the boiler is of the condensing type with thermal efficiency: 93%.

Therefore the minimum heat output of the boiler must be: 7.55 / (0.95 * 0.96 * 0.98 * 0.97 * 0.93) = 9.36 kW which compared to the square meters of the HUB 9.36 / 61 ~ = 0.15kW / m2 In the case in question, the installed boiler has a thermal power of 30kW which must satisfy the part of the floor where the 195m2 HUB is located therefore the thermal power 30/195 = 0.15kW / m2 In light of the above, the nominal heat output of the boiler is suitably sized with respect to the needs of the

HUB.

Therefore the minimum heat output of the boiler must be:
7,55/(0,95*0,96*0,98*0,97*0,93)=**9,36 kW** which compared to the square meters of the HUB **9,36/61 ~ = 0,15kW/m^2**

In the case in question, the installed boiler has a thermal power of 30kW which must satisfy the part of the floor where the 195m2 HUB is located
therefore the thermal power 30/195= **0,15kW/m^2**

In light of the above, the nominal heat output of the boiler is suitably sized with respect to the needs of the HUB.

Determination of the Primary Energy Required

In order to determine the Primary Energy Required, reference will be made to:

Epr [kWh/mq * anno]= (Qd + Qv) x GGr x hg / (Su x DT° x ηg)

With reference to the HUB in question, this is located in Agnone (IS) falling within the "E" climate zone. As regards GGr = 2.457.

- Su = 61mq;
- Pn = 28 kW;
- GGr=2.457
- Qd+Qv= 7,55 kW
- hg = (576)
- DT°= 24 °C

ηg = np x nd x ne x nr = 0,8066 in linea con i valori limiti

ηg = (75 + 3 log Pn) / 100 = (75 + 3 log 28) / 100= 0,7934

Epr = (7,55 * 2457*384) / (61*24*80,66) = **60,32 kWh/mq * anno**

Performance analysis of the building / plant system

Referring to the available data, provided by the MoA, which refer to the total consumption of GAS for the entire property and a POD relating to the entire use of the property (net of the premises intended for the Municipal Police). Let's start from these by proportioning them to the surface of the HUB.

The plants belonging to the GAS supply measurement group are 6 in number, meaning that each of the three floors on which the property is developed is served by two boilers, all of the same type and power. Each of the portions of the floor served by the single boiler is equal to 195mq.

From what has been reported, the plants of the six present, which were actually used, served an area of 390mq, while the POD of the electricity carrier served 195mq.

Electric energy

Electricity consumption

Electric Energy	**Consumption** *(kWh_e) year (three-year average 2017/2018/2019)*
	5680,84 kWh/anno

Methane gas

Methane gas consumption

Methane gas	**Consumption** *(m^3) year (three-year average 2017/2018/2019)*
	2358,77 m^3/anno

Let's start by transforming the m3 of methane consumed on average in a year into kWh:

2358,77 m^3 * 9,5= 22408,315 kWht → 22408,315 /390 = 57,46 kWh/mq * year**C'comb.** = 57,46 kWh/mq * year

DCcomb = Ccomb. – C'comb. = 60,32 – 57,46 → 2,86 kWh/mq * year

DCcomb / Ccomb. = 2,86 / 60,32 = 0,0474 **4,74%**

There is high congruity between the adopted model and the real one.

Calculation of the global consumption of primary energy

Let's start by transforming the m3 of methane consumed on average in a year into kWh:

2358,77 m^3 * 9,5= 22408,315 kWht → 22408,315 /390 = 57,46 kWh/mq * anno

Similarly, we transform electricity into primary energy

5680,84 Kwhe * 2,174 = 12350,15 kWht → 12350,15/195 = 63,33 kWh/mq * anno

Eprgl = 57,46 + 63,33 = 120,79 kWh/mq*anno

4. INTERVENTIONS

In order to analyze any improvement interventions and evaluate the return times of any costs to be incurred, it is necessary to highlight that the structure of Palazzo Bonanni where the HUB is located is of historical and cultural interest, therefore this aspect excludes a whole series of redevelopment interventions, both in correspondence with the external walls and on the internal perimeter walls, the same applies to the horizontal ones (in correspondence with the wooden cladding roof slab, see photo).

THE MEASUREMENT CAMPAIGN

Wp T1 - Energy Performance Diagnoses of Public Buildings

As part of the activities envisaged in the project, a measurement campaign was carried out on the two buildings under study. definition of good practices to be adopted in the field of energy efficiency in order to create a tool that can be easily transferred to other public entities both on a regional and national scale in a cross-border cooperation perspective;

As part of the cooperation between the various partners in the context of measurements and surveys, the technical methodological aspects to be implemented for the specificity of the places, have been studied and implemented in synergy with ENEA technicians.

The data collected in the measurement campaign were promptly transmitted to the National Energy Technology District (DiTNE) through a final report which, in addition to the data collected by the other project partners, constitute a valid tool aimed at identifying the best solutions to be adopted. for local public bodies in order to optimize the energy performance of public buildings.

METHODOLOGICAL ANALYSIS

In accordance with the provisions of the project, the monitoring activities of the performance parameters necessary for the energy study of the buildings identified as part of WP T1 - Pilot action Identification of public buildings for energy performance diagnosis were carried out:

- The "School Complex "G.N. D'Agnillo", Piazza del Popolo, 31/A - 86081 Agnone (IS);
- Town Hall Municipal Administration, Salita G. Verdi, 9 - 86081 Agnone (IS);

The technical / design choice fell on the WiFi type instrumentation and dedicated software purchased with the project.
Specifically, devices were purchased that guarantee, in addition to the technical characteristics of the case, also a bidirectional management solution of the same, by interfacing with a single control unit and remote control of the data detected to a system on a platform accessible remotely, which offers, in addition to the storage of the data themselves (database) such as to be able to be consulted at any time remotely, also and

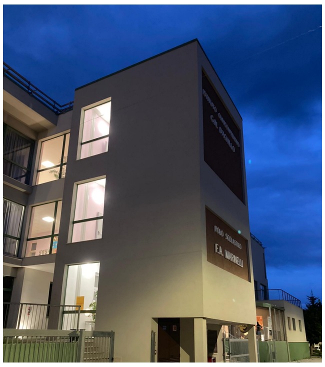
above all the possibility of interacting with the devices in the field in order to be able to configure the individual data loggers, for example by modifying, according to the needs of the period, the frequencies of the measurements.

The devices used for the measurement campaign with the widest possible spectrum of information detected are listed below: thermofluximetric Wi-Fi data loggers, microclimatic and CO2 Wi-Fi data loggers, Wi-Fi data loggers for punctual energy consumption, interfaced and manageable through the aforementioned characteristics.
This instrumentation made it possible to detect data which, when properly treated, give information on the transmittance of the vertical opaque walls and the microclimate in the school complex located in the municipality of Agnone and the transmittance of the vertical opaque walls of the headquarters of the Municipality of Agnone.

THE LOGISTICS OF THE SURVEYS

The "School Complex "

According to a detailed chrono-program, starting from the school building, we proceeded, also following the indications suggested by the ENEA technician Aversa Patrizia, with the installation of a system of plates and sensors suitable for the evaluation of thermal conductance, together with the installation of a sensor network for the assessment of indoor air quality in 4 of the classrooms chosen according to a criterion of maximum expected crowding.



In correspondence with a dedicated technical room, the installation company has installed the control unit which takes care of the telemetry of the detected data.
An accurate interfacing action as well as the experience of the technicians involved allowed us to be immediately operational, the remote monitoring immediately demonstrated the efficiency of the installed system.

Municipal Administration headquarters building of Agnone

As regards the Municipal headquarters, monitoring takes place at a room located on the second floor of the building where plates and sensors dedicated to the detection of the parameters of the thermal conductance of the opaque walls are installed.

It is important to point out that the technical choice of identifying WI-FI devices has allowed greater freedom of action in terms of installation logistics, as well as ample flexibility in the context of the monitoring technique. In fact, while the data collected by the aforementioned system, installed in the school building, have seen the interface to a local control unit that constantly communicates with the data loggers, in the case of the Municipality the data are downloaded locally using the appropriate software.

INSTRUMENTAL SURVEYS AND DATA ANALYSIS

The "School Complex"

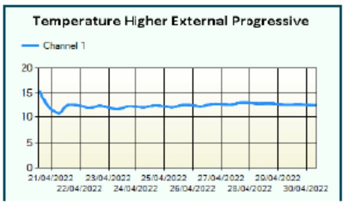
Sampling with data transmission in real time 24h / 24 of the detected data supported by an installation action that took into account all the surrounding conditions of the building-plant system, made it possible to store a considerable amount of data whose processing led to the calculation of the transmittance of the opaque walls.

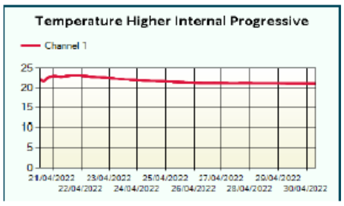
REPORT DELLA MISURA IN OPERA DELLA TRASMITTANZA TERMICA

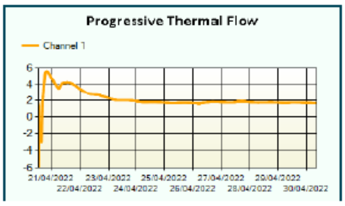
Luogo: Città di Agnone (IS) Data: 30/04/2022 10:56:29

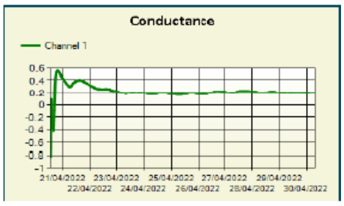
Strumentazione Impiegata
Termoflussimetro: MACADD 0000C1A5
Misura temperature superficiale esterna: MACADD 0000C1AB
Misura temperature superficiale interna: MACADD 0000C1AC

Misura a cura di : Città di Agnone DS
Tipologia di edificio : Edificio scolastico "G.N. D'Agnillo"
Inizio misure : 20/04/2022 Fine misure : 30/04/2022 N.Campionamenti : 1411









FINAL CONDUCTANCE: **0.190** $\frac{W}{m^2K}$

FINAL TRANSMITTANCE: **0.184** $\frac{W}{m^2K}$

The determined value of the thermal transmittance of opaque walls is characteristic of an environment in which there are masonry works of thermal insulation (external coat).

Municipal Administration headquarters building of Agnone

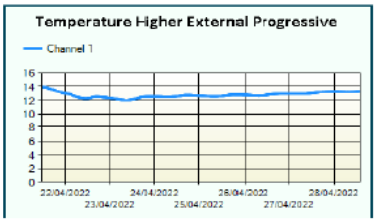
The 24h / 24 sampling of the data collected with the method of downloading the data locally, supported by an installation action that took into account all the surrounding conditions of the building-plant system, made it possible to store a considerable amount of data whose processing led to the calculation of the transmittance of the opaque walls of the building.

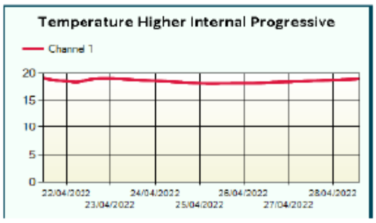
REPORT DELLA MISURA IN OPERA DELLA TRASMITTANZA TERMICA

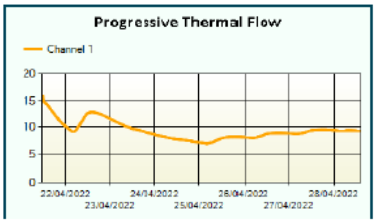
Luogo: Città di Agnone (IS) Data: 30/04/2022 11:08:39

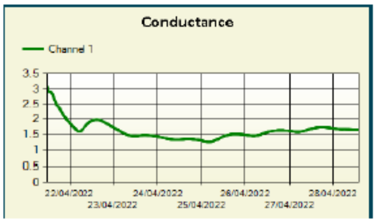
Strumentazione Impiegata
Termoflussimetro: MACADD 0000C1A6
Misura temperature superficiale esterna: MACADD 0000C1AD
Misura temperature superficiale interna: MACADD 0000C1AA

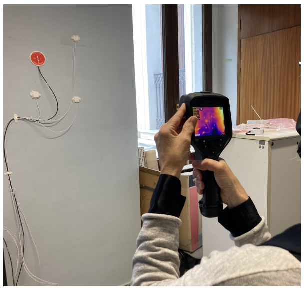
Misura a cura di : Città di Agnone DS
Tipologia di edificio : Edificio Sede Comune di Agnone
Inizio misure : 21/04/2022 Fine misure : 30/04/2022 N.Campionamenti : 1023

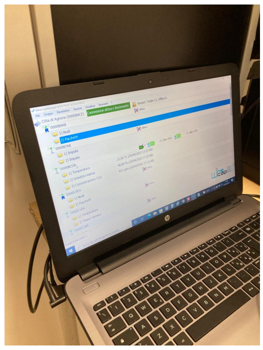












FINAL CONDUCTANCE: **1.653** $\frac{W}{m^2K}$

FINAL TRANSMITTANCE: **1.293** $\frac{W}{m^2K}$

The determined value of the thermal transmittance of opaque walls is characteristic of an environment in which there are no masonry works for thermal insulation.

The technical / design choice of using equipment such as to offer a high installation dynamism together with the fact that they are reusable for other measurement campaigns, all combined with a 24h / 24 sampling of the data collected, has allowed us to provide a high amount of information about the behavior of opaque walls of buildings which are substantially different due to construction technique and construction period.

This measurement campaign made it possible to instrumentally identify the value of the thermal transmittance of a wall and the comparison of the two values determined by the data collected, clearly highlights how the thermal insulation of a wall can clearly determine savings in terms of energy consumption.

The contribution provided by the MoA to the Reehub + project, as part of a field monitoring of the telemetry data detected, using a 24h / 24 measurement methodology on substantially different buildings, has certainly highlighted how the instrumental approach to audit energy can unequivocally return useful and necessary information for the choice of technical interventions aimed at energy efficiency of buildings.

Seminar "The tools to support the energy requalification of buildings and the Green Public Procurement" - Training Organization

The results obtained during the measurement campaign were illustrated during the seminar of May 13, 2022 organized by the MoA. During the work of the seminar the relevant points were also touched upon:

- the good practices implemented by the REEHUB PLUS cooperation project in the field of energy requalification and energy auditing of buildings.
- The issue of Green Public Procurement (GPP), an important topic both for public bodies and for professionals and companies that work closely with the Public Administration.

- The issue of green procurement was dealt with from a regulatory and jurisprudential point of view, in a national and European context, with the presentation of good practices, advice and practical suggestions.

Last but not least, it should be noted that the partnership, which was created starting with Reehub, between the institutions, the project and the school has traced the path towards new horizons in the field of training and preparation of the technicians of tomorrow.

Training Organization

The target group for this event were the technicians belonging to the various professional orders. The official nature and technical validity have been sanctioned by the recognition by the National Council of Engineers (CNI) of valid training credits for the completion of the free profession.

Synergy between partners

The synergistic aspect previously mentioned, has determined the birth of new issues in the field of energy efficiency, this is what was dealt with in the "Project meeting & Project ideas preparation Brindisi" held in Brindisi on 12 May 2022 by of the DITNE.

The study of the building-plant system through the interpretation of the data collected in the measurement campaign fits perfectly into the future perspective of what was dealt with in the meeting in Brindisi where on axis 2 GREENER EU - S.O. 2.3 Energy ACTIONS FOCUSED ON ENERGY EFFICIENCY, the following points have been dealt with:

- raising awareness of CO2 emissions
- energy efficiency measures aimed at specific sectors (eg culture / tourism, construction, public buildings, etc.)
- security of cross-border energy networks
- digital tools / processes for energy efficiency
- energy efficiency plans integrated into RES strategies
- adoption of EU energy rules
- Transform HUBs into One Stop Shops and further promote the adoption of European legislation (EPBD Energy Performance of Buildings Directive) on the energy efficiency of buildings

Regulatory references

Energy Efficiency Directive (EED) - EU Level

Directive 2012/27/EU of the European Parliament and of the Council of 25 October 2012 on energy efficiency amending Directives 2009/125/EC and 2010/30/EU and repealing Directives 2004/8/EC and 2006/32/EC

Council Directive 2013/12/EU of 13 May 2013 adapting Directive 2012/27/EU of the European Parliament and of the Council on energy efficiency, by reason of the accession of the Republic of Croatia

Directive (EU) 2018/844 of the European Parliament and of the Council of 30 May 2018 amending Directive 2010/31/EU on the energy performance of buildings and Directive 2012/27/EU on energy efficiency

Directive (EU) 2018/2002 of the European Parliament and of the Council of 11 December 2018 amending Directive 2012/27/EU on energy efficiency

Regulation (EU) 2018/1999 of the European Parliament and of the Council of 11 December 2018 on the Governance of the Energy Union and Climate Action, amending Regulations (EC) No 663/2009 and (EC) No 715/2009 of the European Parliament and of the Council, Directives 94/22/EC, 98/70/EC, 2009/31/EC, 2009/73/EC, 2010/31/EU, 2012/27/EU and 2013/30/EU of the European Parliament and of the Council, Council Directives 2009/119/EC and (EU) 2015/652 and repealing Regulation (EU) No 525/2013 of the European Parliament and of the Council

Decision (EU) 2019/504 of the European Parliament and of the Council of 19 March 2019 on amending Directive 2012/27/EU on energy efficiency and Regulation (EU) 2018/1999 on the Governance of the Energy Union and Climate Action, by reason of the withdrawal of the United Kingdom of Great Britain and Northern Ireland from the Union

Commission Delegated Regulation (EU) 2019/826 of 4 March 2019 amending Annexes VIII and IX to Directive 2012/27/EU of the European Parliament and of the Council on the contents of comprehensive assessments of the potential for efficient heating and cooling

Directive (EU) 2019/944 of the European Parliament and of the Council of 5 June 2019 on common rules for the internal market for electricity and amending Directive 2012/27/EU

Energy Performance Buildings Directive (EPBD) - EU Level

Directive 2010/31/EU of the European Parliament and of the Council of 19 May 2010 on the energy performance of buildings (recast)
Directive (EU) 2018/844 of the European Parliament and of the Council of 30 May 2018 amending Directive 2010/31/EU on the energy performance of buildings and Directive 2012/27/EU on energy efficiency
Regulation (EU) 2018/1999 of the European Parliament and of the Council of 11 December 2018 on the Governance of the Energy Union and Climate Action, amending Regulations (EC) No 663/2009 and (EC) No 715/2009 of the European Parliament and of the Council, Directives 94/22/EC, 98/70/EC, 2009/31/EC, 2009/73/EC, 2010/31/EU, 2012/27/EU and 2013/30/EU of the European Parliament and of the Council, Council Directives 2009/119/EC and (EU) 2015/652 and repealing Regulation (EU) No 525/2013 of the European Parliament and of the Council

Technical regulations

The EU directives are the basis for the implementation of technical regulations, which are the real tools allowing the designer to develop the new building architectures compliant to the best practise.
There are several technical standards in effect about the energy efficiency in buildings. Here, the most important ones are listed with a short description of their content.

1. **<u>EN 16247-1:2012 Energy audits - Part 1: General requirements</u>**

Summary: The European standard specifies the requirements, common methodology and deliverables for energy audits. It applies to all forms of establishments and organizations, all forms of energy and uses of energy, excluding individual private dwellings.
It covers the general requirements common to all energy audits. Specific energy audit requirements will complete the general requirements in separate parts dedicated to energy audits for buildings, industrial processes, and transportation.

2. **<u>EN 16247-2:2014 Energy audits - Part 2: Buildings;</u>**

Summary: This European Standard is applicable to specific energy audit requirements in buildings. It specifies the requirements, methodology and deliverables of an energy audit in a building or group of buildings, excluding individual private dwellings. It shall be applied in conjunction with, and is supplementary to, EN 16247-1, Energy audits — Part 1: General requirements. It provides additional requirements to EN 16247-1 and shall be applied simultaneously.

3. **EN 16247-5:2015 Energy audits - Part 5: Competence of energy auditors**

Summary: This European Standard specifies the competence requirements of the energy auditor. This European Standard can be used to specify energy auditor qualification schemes at a national level; used by organizations undertaking energy audits to appoint a suitably competent energy auditor and used by organizations, in conjunction with EN 16247-1, EN 16247-2, EN 16247-3 and EN 16247-4, to ensure a good level of quality of the energy audits. This European Standard also recognizes that all the competence required can reside in the energy auditor or a team of energy auditors.

4. **UNI/TS 11300-1:2014 Energy performance of buildings - Part 1: Evaluation of energy need for space heating and cooling**

Summary: The technical specification provides data and methods for evaluating of energy need for space heating and cooling.
The technical specification defines the procedures for the national application of UNI EN ISO 13790:2008 according to monthly method for evaluating of energy need for space heating and cooling.
The technical specification is aimed at all the possible applications provided by the UNIEN ISO 13790:2008: evaluation of the project (design rating), energy assessment of buildings through the calculation under standard conditions (asset rating) or a specific climatic and operating conditions (tailored rating).

5. **UNI/TS 11300-2:2019 Energy performance of buildings - Part 2: Evaluation of primary energy need and of system efficiencies for space heating, domestic hot water production, ventilation and lighting for non-residential buildings**

Summary: The technical specification provides data and methods for evaluating: the energy need for hot water production, systems efficiencies and primary energy need for space heating and hot water production, primary energy need for ventilation, primary energy need for lighting of non-residential buildings. The technical specification applies to newly design systems, retrofitting or to existing systems - for heating only - mixed or combined heating and domestic hot water - for producing only hot water, for ventilation only systems, for combined ventilation and space heating systems, for lighting systems in non-residential buildings.

6. **UNI/TS 11300-3:2010 Energy performance of buildings - Part 3: Evaluation of primary energy and system efficiencies for space cooling**

Summary: This standard specifies data and procedures for the calculation of the energy performance of buildings relating to space heating and cooling and domestic hot water production.This standard is a national guideline for immediate and univocal application of technical specifications elaborated by CEN to support the Diretive 2002/91/EC "Energy Performance of Buildings"This standard is divided into 3 parts:Part 1 - Determination of building energy need for space heating and cooling Part 2 - Determination of primary energy and system efficiencies for space heating and domestic hot water production.This Part 3 provides data and methods for the determination of: - seasonal average efficiency of the conditioning system- annual specific need of primary energy for space cooling.

7. **UNI/TS 11300-4:2016 Energy performance of buildings - Part 4: Renewable energy and other generation systems for space heating and domestic hot water production**

Summary: The technical specification calculates the energy demand for space heating and domestic hot water production if there are subsystems that provide useful thermal energy generation from renewable energy or generation methods other than the flame combustion of fossil fuels treated in UNI / TS 11300-2.
The following subsystems for production of heat and / or electricity are considered:
- Solar thermal systems;
- Combustion biomass generators;
- Heat pumps;
- Photovoltaic systems;
- Cogenerators.

They are also considered the district heating substations.

UNI/TS 11300-6:2016 Energy performance of buildings - Part 6: Evaluation of energy need for lifts, escalators and moving walkways

Summary : This technical specification provides data and methods for the determination of the electricity needs for the operation of equipment intended for lifting and transportation of persons or persons accompanied by things in a building, on the basis of the characteristics of the building and plant.
These calculation methods take into account only the electrical energy needs during periods of movement and stop of the operational phase of the life cycle.

8. EN 15232-1:2017 Energy performance of buildings - Part 1: Impact of Building Automation, Controls and Building Management

Summary : This European Standard specifies:
- a structured list of control, building automation and technical building management functions which contribute to the energy performance of buildings; functions have been categorized and structured according to building disciplines and so called Building automation and control (BAC);
- a method to define minimum requirements or any specification regarding the control, building automation and technical building management functions contributing to energy efficiency of a building to be implemented in building of different complexities;
- a factor based method to get a first estimation of the effect of these functions on typical buildings types and use profiles;
- detailed methods to assess the effect of these functions on a given building.

Agnone, 07 novembre 2022

Il Tecnico Incaricato
Ing. Diego Vincenzo SALZANO