REEHUB

# Program Interreg IPA CBC Italy–Albania–Montenegro

## "REEHUB – Simplified methodology of the energy audit" – Deliverable WPT1

REGIONE PUGLIA

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REEHUB – Simplified methodology of the energy audit

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REEHUB Project

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Priority Axis III: Environmental Protection, Risk Management and Carbon Reduction Strategy
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Leading partner of the project: Ministry of Infrastructure and Energy

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*CONTENT*



***ANNEX:***

***INTRODUCTION***

The construction sector is fundamental to achieve the energetic and environmental objectives of the EU, and for this reason, all the efforts that aim the decarbonization of building stock encourage. The most successful buildings for an energetic perspective, improve the quality of life of citizens bringing further benefits for the economy and society.
For this reason, the European Union updated the directive 2012/27/ of European Union with **directive 2018/844** with the object to promote the widespread of the energy efficiency and renewable energies in buildings, to ensure that long-term restructuring strategies provide the progress needed to transform existing buildings into near-zero energy buildings by 2050.
**Energetic Audit** is a fundamental step to improve the efficiency of energy in the public buildings, to reduce energy consumption and to bring benefits for the environment. Also, special attention was paid, in updating the Directive, to build control and automation systems, to be able to assess better energy efficiency measures, comparing their costs and benefits, and sensibilize owners to real savings from newly improved building functions. REEHUB project has set as the main objective, the establishment of competence centers, in the four regions, on energy efficiency and sustainable construction in general. Also, before all, each partner has identified a place in Tirana, Podgorica, Brindisi, and Agnone to establish a HUB. ENEA has considered the methodology important to transfer the best practices for the energy audit, not only conducting training on this topic, for the staff assigned by each project partner but above all to allow the trained staff to experiment in this area the notions learned, conducting energy audits in HUBs, using tools purchased from the project.
The methodology of energy audit – REEHUB is a simple procedure for energetic diagnosis and applied in 4 regional HUBs.
These guidelines aim to become a manual for local public administration dealing with energy, technical, and executive actions. In the following pages, the fundamental steps are shown to make an accurate diagnosis of energy, starting from the manners on how the specific data are secured, how to use the technical tools, and how to perform a measurement campaign, how to monitor the consumption of energy, how to interpret the collected results, and how to evaluate the most appropriate energetic intervention comparing the costs.
These guidelines will be available for all the interested stakeholders, such as universities, constructors, engineers, architects, financial institutions and developers of real estates, hoping that they will be the moving force for a wide and efficient spread of the practices of the energetic qualifications for the buildings, in a way to give a contribution for the achievement of the carbon neutrality until 2050.

# 1. INTRODUCTION OF REEHUB GUIDELINE FOR ENERGETIC DIAGNOSIS

Simplified procedure for energetic diagnosis, illustrated in REEHUB guidelines, allows us to define easily the value of Primary Energy and other energy indicators, without using calculator software and/or articulated and complex algorithms.
It is an immediate procedure “construction site” and for this reason it is always applicable, especially in those cases where the use of programs and very detailed investigation is expensive, both in terms of time but also cost. For example, when you want to work in only a few rooms, inside an apartment, when you need energy efficiency measures.
These guidelines for Energetic Audit are based on the method used in EN 16247.

UNI CEI EN 16247-1 defines the requirements, usual methodology, and products of energetic diagnosis. It’s is useful for all the companies and organizations, for all the kind of energy and its usage, except the individual units of residential real estate. It defines the general requirements for all the energetic diagnosis.

UNI CEI EN 16247-2 is applicable for specific energetic diagnosis for buildings. It defines the requirements, methodology, and reporting of an energetic diagnosis related to a building or a building block, except the private individual residencies.

UNI CEI EN 16247-3 defines the requirements, methodology, and reporting of an energetic diagnosis within a process, related to a) organizing and performing an energetic diagnosis; b) analyzing the collected data with the energy diagnosis; c) reporting and documenting the results of energy diagnosis. The rule applies to places where energy use is due to the process.

In the end, UNI CEI EN 16247-4 defines the specific requirements, methodology and reporting for energetic diagnosis in the transportation sector and addresses any situation in which a move is made, regardless of who the operator is (public or private company or whether the operator is exclusively dedicated to transporting or not). The procedures described here apply to different modes of transport (road, rail, sea, air), as well as to different areas (local, long-distance) and the transported facility (mainly goods and people).

The simplified procedure essentially requires defining data that are easily accessible by manual calculations or achievable from tables, graphs provided, or described by the sector literature and technical standards.
Final results that the simplified procedure provides an order according to the size, in absolute value, not bigger than the one that is defined by the use of a software calculator that is in the

market. Everything depends on quality, in terms of accuracy and authenticity of input data namely more accurate the input data about reality, the smaller the difference between the result obtained from the simplified procedure and the one obtained from the software calculation.

The difference between the simplified procedure and the one predicted in the directives (defined in the sector's software) consists on achieving the required results, in a simple immediate way and with minimal economical expenses for the users, without neglecting the physical concept of the building –implant system and all the parameters that are used for primary energy calculation. It is a very efficient procedure, so all those who are deal with these concepts without having considerable work experience in the sector of engineering of thermos-technical implants.

In this way, the application of the simplified procedure is appropriately borrowed in the analysis of cases that are not very complex, such as those directed to some premises/rooms of an object that are subject to energy efficiency measures, or for all those cases in which there is no need to intervene throughout the building.

The obtained result with the application of the simplified procedure is different with that taken by applying the algorithms used from the software of calculation (regarding the absolute value) or it could be on a more approximate scale, but this is possible depending on how accurate the input data in the procedure are, which can achieve the intended results, in terms of energy savings and amortization time of investments for energy efficiency interventions, with deviations as low as possible about the congruence index used for the validity of the physical-mathematical model which we refer to both in the software calculations and in the case in which the simplified procedure is used (never more than 15%).

As a conclusion, the user who judge as appropriate to choose the simplified procedure to analyze "building-plant" system, for the reasons that justified its use, or in any case because he is the user, should care to define the input parameters with extreme accuracy, close to reality, by the requirements of literature and technical norms, aiming to achieve results that differ a little of the most accurate ones obtained with computing software, but, at the same time, with the advantage of instant computing, less economic cost for the users to whom it is addressed and even more with the main advantage of step-by-step tracking and concretely, from the physical point of view, the individual parameters used as input data such as: (thermal powers, transmissions, working hours, day degrees, yield, temperature changes, exposure coefficients, coefficients due to system downtime, etc. ).

Finally, it is useful to remember that energy diagnosis defined either by the use of software or by the use of the simplified procedure, is intended to provide a preliminary outcome of the situation, which allows you to assess the existence or not of the conditions, suitable for the development of energy efficiency initiatives in the building and its plants.

## 2. SIMPLIFIED PROCEDURE OF ENERGETIC DIAGNOSIS

To identify the favorable economic measurements of the efficiency of energy regarding the building – implant system, we use the ENERGETIC DIAGNOSIS.
Below are described the main points that represent the activity of energetic diagnosis, such that consist of an applicable simplified procedure even in those cases when not all the buildings should be undergone the efficiency measurements, but only some of its premises..

1. Obtaining data that interest us for energy performance (winter, summer, etc.) about the building system - plant: technical characteristics of the building enclosure, type, and operation of existing plants, fuel consumption, etc.;

2. Analysis of the energy performance behavior of the building-plant system through simplified algorithms or more generally through specific software, or the construction of a physical-mathematical model that stimulates the building-plant system for diagnosis;

3. Calculation of specific indicators that allow comparison between calculated and expected consumption (taken from the analysis mentioned in the previous point) and those derived from energy bills (real results/values);

4. Comparison between calculated and in reality (energy bills);

5. If the comparison is far from expectations (low compatibility) it is necessary to modify the parameters used as input, or it will be necessary to modify the data mentioned in point 1 (area characteristics, plant operation, etc.), so that the new indicators, defined after the changes, are as close as possible to the real ones (for example medium / high compatibility);

6. Identification of improved interventions (insulation of walls, terrace, replacement of windows, replacement of the boiler, etc.) and identification of combinations of different interventions (replacement of windows + replacement of the heater). The combination of individual interventions should be derived from what is indicated primarily by the client's wishes, as well as, from the advantage deriving from the economic analysis;

7. Analysis of the building system - plant with the application, in the physical-mathematical model, of the interventions or combinations of energy efficiency interventions identified in point 6;

8. The economic analysis aimed at determining the priority of combinations of interventions or the priority of specific interventions identified - Ease of intervention or combinations of interventions; generally considered energy and economic adequacy has given the interventions that are amortized over a period not exceeding 15 years.

The energy diagnosis does nothing else but reproduces, during the analysis of the building-implant system, the real conditions to which the system is placed

During the analysis, it is considered the real implant flow, realized by the client, and the real climatic conditions dictated by the temperatures on real.

The latter is taken from at least a three-year trend of the daily temperature of the forecast hours, for the area in question, by the public bodies that release the temperatures during the outside air hours, referring to the period that winter begins in October and ends in April.

Thus, taking into account the real and effective flow of the implant and the real trend of outdoors air temperatures, in a well-defined period, it is important to compare the defined results with the built-in physical-mathematical model (points 1. and 2. of the previous list) and current fuel or electricity consumption.

Energy diagnostics do not claim to establish accurate estimates of economic benefits but allows you to assess the existence or not of suitable conditions for the development of energy efficiency.

The more accurate the data made available by the client, the higher the level of depth of the energy diagnosis, and therefore, the more accurate the results regarding the economic and energy expectations of the interventions.

To make an accurate Energetic Diagnosis should be available:

a. Geometric data related to the room of the residential unit or the building under study (plans, facades, cuts, surveys, photographs of exposed areas such as borders, terraces, surrounding buildings, type and size of windows, identification of accurate exposure from the north, the function of the premises, etc.);

b. Use of an on-site thermofluximeter for measuring the transmission of building envelope elements (see par. 3);

c. Type of plants present, with accurate data on and off hours, both during the day and weekdays (where days with extended shutdown schedules must be taken into account);

d. Survey and typology of the plant system as a whole: production, distribution, discharge and regulation system. In particular, the technical characteristics of heat generators, heat pumps, emitting components (radiators, solar panels, multisplits, etc.) should emphasize;

e. If it exists, it is helpful to obtain all existing plant design documentation;

f. Climatic data of the area and the place where the envelope of the study building was made, for which real data should be extracted, at least for the last three years, of temperatures (within 24 hours) of the outside air. Data are available from meteorological stations in the area. This will allow you to determine important and essential data for calculating the thermal forces required by the building as well as the thermal energy required for the entire current and effective heating period. In particular, it will be necessary to determine the minimum external temperature of the project (calculation of peak thermal power) and temperature during the day (calculation of thermal energy required by the building-plant system);

g. Consumer consumption and costs (fuel/electricity) that refer to at least the last three years of operation and if possible, refer to each month;

To test an accurate simplified analysis of the Energy Hub I take into consideration, it is necessary to provide the following data and conduct an inspection to gather all the useful information:

Name of the owner
Date and place of activity
Operator data

Data of the real estate:

- Building typology
- Building year
- Town/city/country;
- Height in floors.
- Width;
- Wind speed;
- Place and description of the building /real estate unit/hub/bar/premise;
- Category/usage destination
- Gross heated volume
- Total surface lost
- Climatic area
- Degree day
- Real (monthly) duration of the warm period (days)
- Real daily on / off duration of the plant (hours)
- Minimum daily calculation temperature (winter)
- Average monthly temperature
- Projected air temperature (indoors / thermal zone)
- Construction technique used:
- Composition of perimeter walls

Visual description of the building (Ground visit):

- Photographic relief
- Constructive supporting typology
- The composition of the walls, its layers

Furthermore, the following transmission values for dark and window elements should be calculated, based on appropriate thermofluxometric analysis:

- Transmission of external walls;
- Transmission of premises in borders / unheated areas;
- Transmission of the border environment with the body of the ladder;
- Transmission of solet over garage / canteen / porch / unheated premises;
- Transmission of the floor / terrace / roof;
- Floor transmission;
- Transmission of walls to the ground;

Plant data:
- Hours of functions of the plant;
- Fuel used;
- Typology of heat generator / heat pump and determination of output efficiency value;
- Typology of the fluid distribution system and determination of the value of the distribution efficiency;
- Emission system typology and determination of emission efficiency;
- Regulation system typology and regulation efficiency determination;

In the meantime, we need to perform:

1. Calculation of thermal power lost from transmission (opaque elements and windows); Qd;

2. Calculation of thermal power lost from ventilation (natural / mechanical); Qv;

3. Calculation of the temperature difference (between the minimum indoor and outdoor air of the project); DT;

4. Calculation of real hours of operation of the plant: hg (hours);

5. Calculation of real daily temperature; GGr;

6. Calculation of Calculation of the square feet area of the hub / real estate units / building; Su;

7. Calculation of the production performance; np;

8. Calculation of distribution performance; nd;

9. Calculation of emission performance; ne;

10. Calculation of regulation performance; nr;

11. Calculation of average global seasonal performance; ng=np x nd x ne x nr;

That's why it is possible through the other values calculated before to define the value of requested Primary Energy:

**Epr = (Qd + Qv) x GGr x hg / (Su x DT° x ng); (kWh/m2 * vjet)**

Regarding the values that will attribute to the production, distribution, emission, and regulation performance, we can use or the dictated values of reference from the actual technical norms (UNI TS 11300, recommendations of CTI, etc.).

To calculate the GGR (real daily degree), it will be necessary to use the same formula given by the norm (calculation of daily degrees) but taking as the average daily air temperature, the real values (taken from weather data of control units in the area) referring to a certain period (heating period).

In this regard, to calculate the real reference period and the average daily temperature of the outside air, proceed as follows:

a. We analyze the air temperature data (data in 24 hours) for every single day starting from October to April (at least three years following the years of electricity billing referred to energy); usually elected last three years;
b. For each day, the average daily temperature will be calculated as follows:
The following values will be detected: T min, T Max, T at 6:00, T at 20:00;
With these values the arithmetic mean will be calculated;
The arithmetic average value will be considered as the value of the average daily temperature of the outdoor air.

Within the period initially considered, October-April, starting from October, we will look for the day on which the temperature is equal to 12 Celsius and which remains lower than this value for three consecutive days.

Once this day is determined, it will represent the beginning of the real warm period.

The same will be done to determine the day on which the heating period ends. That is within the period we will initially consider the day on which the average daily temperature of the outside air will be higher than 12 degrees Celsius and will remain above this value for three consecutive days.
After the determination of this day, it will represent the end of the real warm period.

It is possible to determine with the calculated data the value of the degree-day real for each year, ensuring that the same years in the study are the same referring to energy bills (natural gas, GPL, oil, energy electrical, etc.); usually analyzed at least every three years.

Based on the three GGR values, we will find the most important, and consequently, the relative energy bill will be identified.

After calculating the primary energy Epr, it is simple to determine the value of fuel consumption entering the production system (natural gas, GPL, electricity), which will be compared with the relative energy bills.

So, it will be possible to validate the structured model according to the physical-mathematical approach approved by us for performance analysis.

Validation will be as followed:

- Calculation of fuel-consuming input/output (Ccomb) determined by the calculated value of Epr (value calculated with the model structured according to the physical-mathematical approach approved by us);

- Calculation of the real fuel consumption (C. Comb.) refered to the warm period to determine the real degree-day;

- Comparison of the two calculated data before:

Ccomb. - C'comb = DCcomb (absolute value); the difference between two consumption values (input and real) to be evaluated as an absolute value;

If DCcomb. / Ccomb. <5%; it exists high compatibility between the approved model and the real one.

If DCcomb. / Ccomb. <10%; it exists average compatibility between the approved model and the real one.

If DCcomb. / Ccomb. <15%; there is low compatibility between the approved model and the real one.

If DCcomb. / Ccomb. > 15%; the approved model is not in compliance with the real one.

Therefore, in the hypothesis of low model compatibility and equally nonconformity, the input data to the model structured according to the approved physics-mathematical approach should be corrected to stimulate the performance analysis of the building-plant system, i.e. the data will have to be reviewed, and remodeled according to the relative data of the transmission, efficiency, emission, distribution and adjustment of the plant in service, the hours of operation/fixing of the plant, or everything that constitutes the input data according to the model approved for analysis.

The value of Epr will be recalculated using the new re-modulated data, so that we can repeat the comparison with real fuel consumption.

Once we have the new Epr results after reviewing the input data compared to C'comb (real consumption), they will determine at least an average compliance (<10%). It is possible to adopt final data as a model structured according to the physics-mathematical approach, and then proceed with subsequent economic analysis to evaluate interventions or a combination of energy efficiency improvement and requalification.

As a conclusion, we can say that the approved model stimulates in a congregative way the system of the building/real plant; so, we have verified the model that acquire a latter analysis (valuable model).

After validity, it will be possible to calculate the coeficient μ = C 'comb. / Ccomb.

Coeficient μ will be applied in the latter analyses regarding the intervention and/or combinations of efficiency intervention of the energy in a way that could be calculated, for any calculation, relative consumption of real fuel (methane, gpl, diesel, electricity etc.);

After the validity of the structured model according to the physical-mathematical approach, which reproduces with good adhesion therefore the building / plant system that is subject to diagnosis, it is possible to identify what will be the individual energy efficiency interventions or the combination of multiple interventions to be performed in reality; this will be possible after building a degree of priority determined by economic analysis.

In essence, priority will be given to interventions and / or a combination of interventions that will be amortized over a short period of time, which will result in payback periods of less than 10-15 years (cost-benefit analysis).

Once we have evaluated the model structured according to the physical-mathematical approach that the building system / real plant reproduces, the object that is subject to energy analysis / diagnosis, it is necessary to use this model for subsequent economic feasibility analysis (see page 4).

To sum up, this will mean that we will use this model to be able to determine, in standard conditions, even the value of Epr before the intervention, even the latter consequences in conditions after the intervention.

Standard conditions mean that in the structured model according to the adapted and evaluated physical-mathematical approach, the standard values dictated by the technical regulations in force regarding GG (day degrees) and working hours of operation of the plant will be applicable.

Whereas, the post-intervention state (future state) means the realization of a single energy efficiency intervention or in general combinations of several interventions is hypothesized; likewise, the state before the intervention means the real and current state of the building / plant system that is analyzed and studied (state of works).

Therefore, in the upstream of the economic analysis (cost-benefit analysis) it will be necessary to first determine the Epr value associated with the building / plant system in the pre-intervention state, calculated by applying, in the structured model according to the valid physico-mathematical approach, the standard values dictated by the technical regulations.

Therefore, it should be taken into account as input data in the valid model, not the values of GGR (real daily degrees) and actual working hours (hg), but the standard values dictated and imposed by the current legislation for the site and for the intended use of the object being studied and analyzed.

In this way it will be possible to determine the value of Epr (before intervention) from which, depending on the type of fuel, get Ccomb (fuel consumption before intervention under standard conditions) and then determine, applying the coefficient μ, the C'comb value or the real value of fuel consumption under standard conditions that will be compared from time to time with those related to energy efficiency measures:

C'comb (real standard consumption of fuel) = μ x Ccomb (standard consumption of fuel); (the formula will be used not only before the intervention but also for the after intervention conditions)

Subsequently, the further values of Epr in relation to each energy efficiency intervention will be determined gradually and for each of them the same calculation will be performed, i.e. after calculating the relative fuel consumption (Ccomb), the final value will be multiplied by the coefficient μ thus obtaining the real value of fuel consumption C'comb = μ x Ccomb (in relation to the intervention). Therefore, for each intervention and / or for a well-defined combination of interventions, the value of C'comb will be taken which will be compared with the value determined in standard conditions and before the intervention thus obtaining R energy savings:

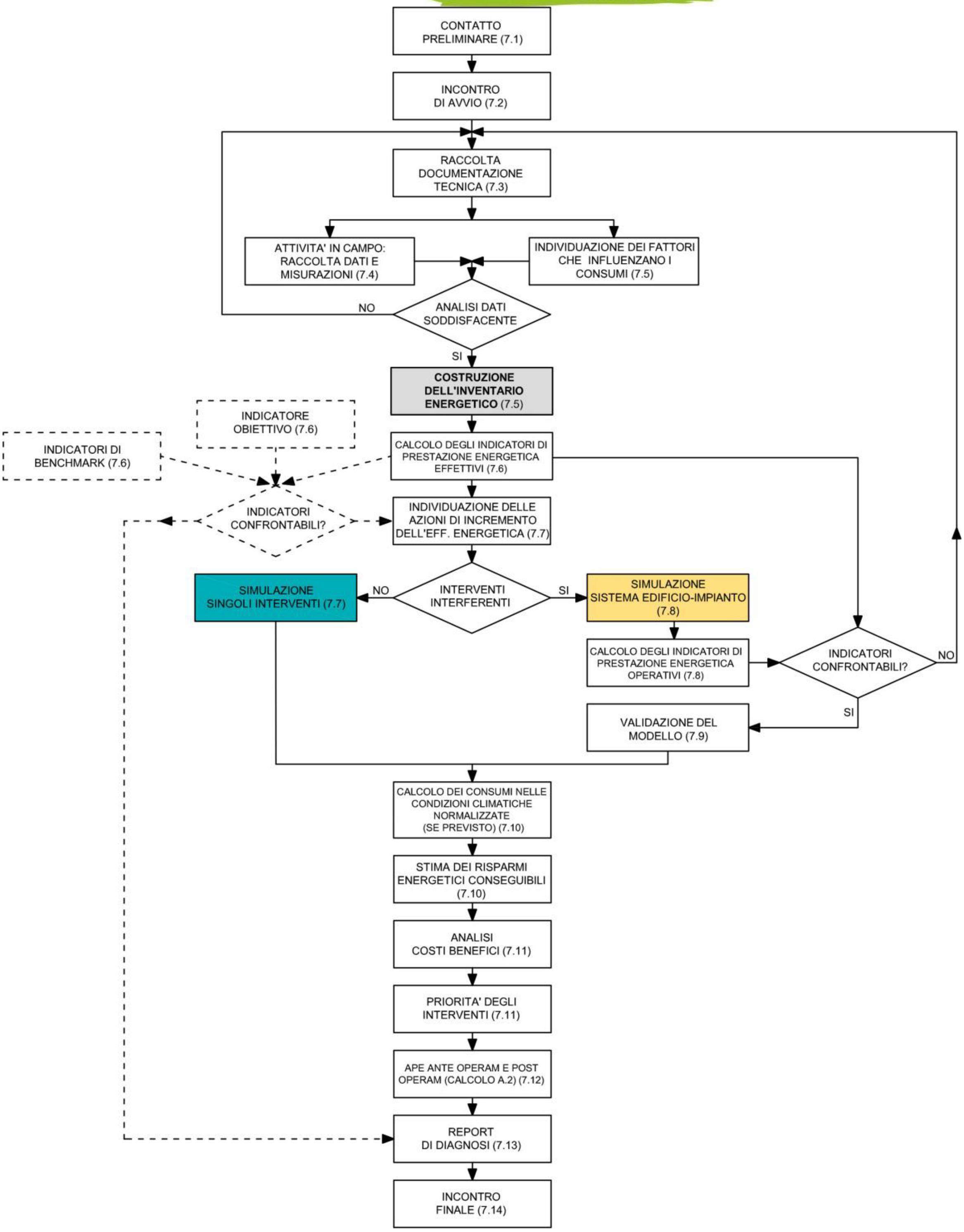
R (energy consumption) = C'comb (before intervention) - C'comb (after intervention).

The value of R will be used after in the economic analysis that aims to identify the return investment time (the cost of intervention) and after the determination of a priority degree of individual interventions or combinations of multiple energy efficiency interventions as a function of the value of each return time; minimum return time values will give the highest priority.

### *2.1 Summary of actions to be performed for energy diagnostics*

A. The construction of the structured model according to the physics-mathematics approach (plant system of the buildings) based on the dimentional technical data, real climatic data, performed instrumental measurements and plan function as it's required by the client,
B. The calculation of the main expected energy (the calculated value using the model mentioned at A.);
C. The calculation of energy indicator related to the primary expected energy (fuel consuption)
D. The calculation of the real consumption of fuel (data from the energy bills);
E. The comparison of fuel consumption in absolute numeric terms;
F. The vadility of the structured model according to the physics-mathematics with the determination of the adaptation profile (if it is not adaptable or low adaptation, the input data should be re-modulated and everything should be repeat starting from A to F.)
G. In case of a positive validity of the model (high or average adaptation), the coefficient value μ will be calculated;
H. The calculation of value of Primary Energy in conditions before the intervention and standard conditions;
I. The calculation nof the real consumption of fuel in conditions after the intervention and standard conditions;

J. The identification of individual intervention or the combined efficiency of energy (two or more interventions);
K. The calculation of main value of energy for each individual intervention or for each combination of the intervention of the energy effect; after the intervention and standard conditions;
L. The calculation of the real consumption of the fuel for all the conditions after the intervention and standard conditions;
M. The calculation of the energy consumption as a difference between the real consumption in the condition before the intervention and the real one determined for each one or combined intervention of the energy effect;
N. For each value of the R (energy saving) associated with negative value of the economic investement (the one intervention or combined costs) will be performed by an economic analysis (cost=benefit analysis);
O. The results of the economic analysis, in terms of return on investment time, will reverse the advantages of relative intervention; the minimum return time determines the highest priority of the intervention.




Picture.1 Diagram for diagnosification of the energy buildings
Source: ENEA, ES-PA Project – Energy and Stability for Public Adminstration - https://www.espa.enea.it

## *1. INSTRUMENTAL DIAGNOSIS (with tools or with the help of suitable tools)*

Energy diagnostics requires the use of some non-destructive controls in the procedure, in order to be reliable and complete, in particular, for the evaluation of pre-intervention transmission measurement to improve efficiency in the absence of stratigraphy of dark vertical and horizontal structures, as reported in the simplified procedure paragraph 2.2.

### *3.1 Measurement for on-site thermal transmission*

The protocols adopted for diagnosis with the help of appropriate instrumental tools refer to the following rules:

UNI EN ISO 6946: 2018 Components and building elements - Thermal resistance and thermal transmission - Calculation methods

UNI ISO 9869-1: 2015: Thermal insulation - Building elements - On-site measurement of thermal resistance and thermal transmission - Part 1: Thermal flow method (thermofluximeter).

UNI EN 13187: 2000: Thermal performance of buildings - Qualitative detection of thermal irregularities in building envelopes - Infrared radiation method.

ISO 18434-2: 2019 Machinery diagnostic monitoring monitoring conditions, thermogram interpretation.

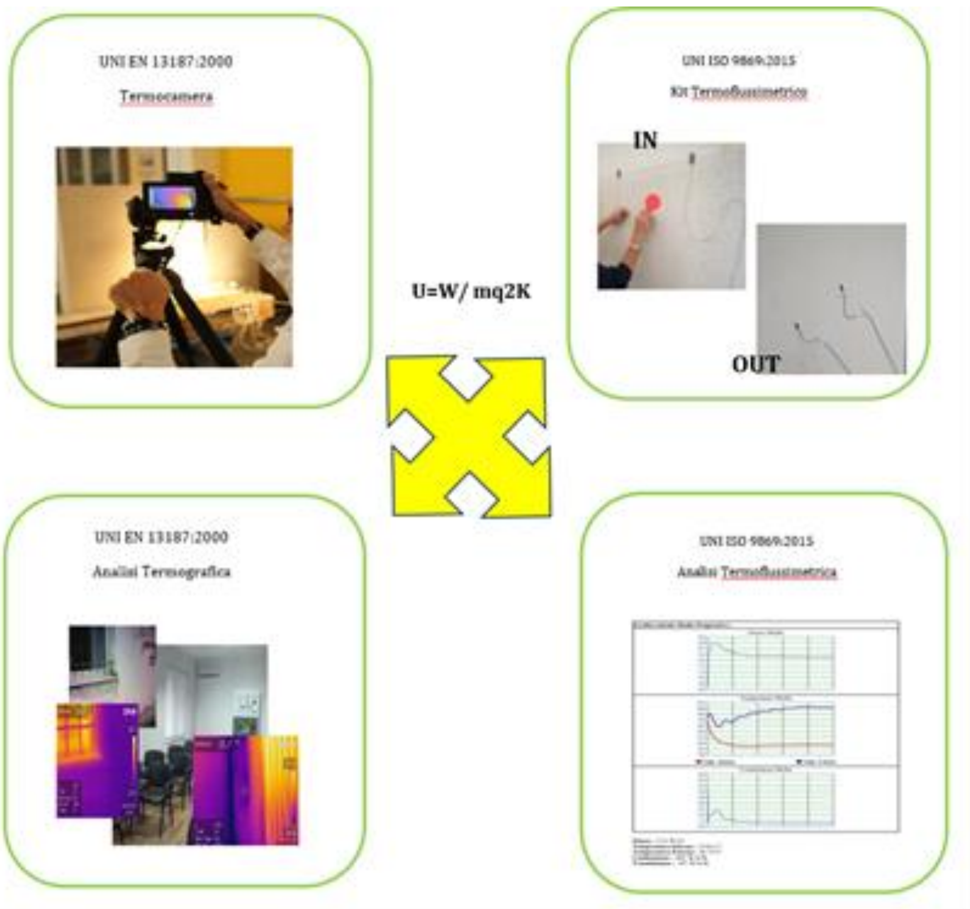
Terms and definitions of non-destructive testing infrared radiation thermography UNI 10824: 2000

The standards describe the method for measuring the transmission of dark components in buildings using the heat flow meter and thermal imaging camera.

The transmission measurement instrument consists of a KIT that includes basic data for receiving and managing the data, a sensor for measuring thermal flow, and four thermo-elements for measuring the surface temperatures of internal and external walls. The configuration envisages the positioning of the sensor for measuring the thermal flow on the inner surface of the wall, and at least two temperature sensors on the inner surface and two on the outer surface of the wall, which is not directly irradiated by the sun. It is the best practice to carry out measurements to assess transmission over a period characterized by temperature changes between indoor and outdoor environments with $\Delta T$ ° C equal to or greater than about 10 ° C. The duration of the test should be at least 72 hours assuming that the final value of the resistance does not differ by more than 5% from the values obtained in the previous 24 hours.

Diagnosis of thermo-thermal leakage in the absence of adequate training for the correct installation of the instrument can produce an error in the transmission estimation of up to 30% compared to the assumed value. Because of this, before making the measurement, we proceed with a thermographic investigation to verify the textiles/wall layer under the plaster, the lack of homogeneity of materials, thermal bridges.

A thermal camera, a device capable of displaying contact energy with infrared rays, is used to investigate the situation. It is recommended to set the parameters accurately and perform indoor and outdoor temperature gradient measurements equal to or greater than 10 ° C.

| Thermographic valuation | Trasmission measurement |
|---|---|
|  | |



PIC.2 Synthetic diagram for thermic on-site transmission

### *3.2 Measurement of indoor microclimate*

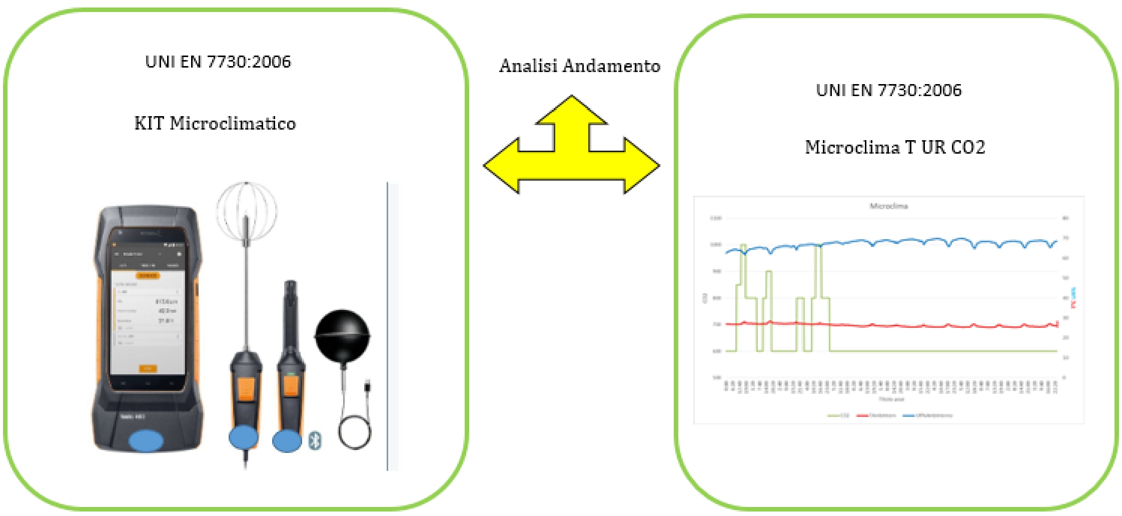
Finally, the following guidelines suggest the use of control units or completed indoor temperature, humidity, and CO2 monitoring according to the regulations already in force to comply with those indicated in European Directive 844/2018.

The directive, the objective of which is sustainable development, suggests that it is necessary to carry out an assessment or diagnosis, in terms of well-being and comfort in indoor environments about energy control interventions in buildings.

Welfare defined by the European Commission Observatory for Health systems and policies as a state of emotional, mental, physical, social, and spiritual well-being that allows people to achieve and maintain their potential in society.

UNI EN 7730: 2006 Ergonomics (Scientific discipline that deals with problems related to human labor concerning the design of machines and work environments, to identify the most appropriate solutions to the psycho-physical needs of workers and at the same time those of production) of thermal environments.

- Analytical definition and interpretation of thermal well-being by calculating PMV and PPD indices and local thermal well-being criteria.




PIC.3 Synthetic scheme of indoor microclimate

### 3.3 Operator qualification

The complexity of on-site measurement methodologies and the execution of measurements are not sufficient for the interpretation and evaluation of performed data according to the standard that requires the necessary skills and specialized personnel with knowledge of relevant techniques and technologies. The reference regulations require for assigned staff to instrument measurement diagnosis and preparation of measurement reports are reported below.

UNI EN ISO 9712: 2012 qualification and certification of personnel involved in non-destructive / destructive tests.

CND License - Level 1 - A Level 1 certified person in a non-destructive test method is qualified to perform operations in the certified method based on written instructions and under the control of Level 2 or Level 3 personnel. He/she must be able to: a) adjust PND equipment; b) perform the tests; c) record and classify the results to the written criteria; d) compile a report of results.

CND License - Level 2 - A Level 2 certified person in a specific PND method, is qualified to perform tests in the certified method according to established procedures. Must be able to: a) choose the technique for the test method to be used; b) determine the limits of application of the test method; c) translates PND codes, standards, specifications, and procedures into PND instructions adapted to current working conditions; d) adjust and control the device settings; e) perform and supervise the tests; f) interpret and evaluate the results according to the standards, codes, specifications, and procedures in force; g) draft test instructions for level 1; h) perform and supervise all specific tasks of a level 1; i) training or leader of level 1 staff; j) draft PND reports.

CND License - Level 3 - A Level 3 certified person in a specific PND method, is qualified to perform and direct the PND activities for which he/she is certified. Must be able to: a) take full responsibility for a testing laboratory or examination center and relevant staff; b) establish and certify testing techniques and procedures; c) interpret rules, codes, specifications, and procedures; d) establish the specific test methods, procedures, and instructions to be used; e) perform and supervise all offices at all levels; f) provide assistance to PND staff at all levels.

### 3.4 Report preparation

The report generally reports information on performed methods, measurement, and instrumental conditions, encountered problems, results, and, if required, suggestions for solutions. The report should draft in such a way that it is understood not only by technicians and should contain the following elements.

Applied methodology

Normative requirements

Functioning conditions

Instrumental conditions

Encountered problem

Results

Photographic documents, thermogram

Conclusion and/or suggestions if asked

### 3.5 Operator safety requirements

Mandatory training certification of DLGs. 81/08

Hard hat

Visible phosphorescent jacket

Leather gloves

Glasses and FFPP1 CE mask for dusts, if it's necessary

Construction site shoes/safety shoes

**Security of the construction site is responsible of the client**

## 4. Economic values of the intervention

After identifying energy reclamation interventions, advisable in a given structure, taking into account the whole building-plant system, and after verifying the technical feasibility, a cost-benefit analysis should be found for the economic comfort of the interventions identified.

For this purpose, the NPV methodology is proposed. This is an accurate, simple, but very effective method of determining the goodness of an investment. The question is whether the investment produces more or less money than can be obtained by leaving an identical amount in the bank for a certain period at a specific rate.

Starting from the net present value, it is possible to develop a series of economic indicators capable of highlighting the key characteristics of the investment that we are considering.

This methodology is not reserve for energy saving. It has a width validity and can be applied whenever the decision can benefit from the information made available by the cost-benefit analysis.

## 4.1 Net Present Value

The net present value is calculated by comparing the investment cost with the economic benefits that are created.

**NPV = Economic benefits – Investment**

So, if the NPV is positive, the investment is suitable, and if the NPV is negative, it is not advised for the intervention.

However, it is not accurate that only by comparing the economic benefits with the investment because the terms of this comparison have a diachronic evolution.

The investment is made in cash, while the benefits it creates will only be converted into cash later. It is, therefore, necessary to use correlation coefficients that make the value of money available in different comparable periods.

Therefore, the future cash flows that make up the economic benefits that will flow from the investment should be multiplied by an annual factor that makes these benefits homogeneous and comparable to the amount invested. Therefore we have:

**NPV = (CF) (AF) - I**

NPV = Net Present Value

CF = Cash Flow

AF = Annual Factor

I = Net Investment

## 4.2 Cash Flow

It represents the economic benefits generated by the investment during all its life.

With good approximation, we can estimate the money supply equal to the economic value of the energy saved.

### 4.3 Annual Factor

To analyze the correlation coefficients, which allow us to equalize the value of money available in different periods, we need to introduce the concepts of capitalization and deduction.

*A. Capitalization and deduction*

If we have 1 Euro and we use it at interest rate “I” after a year, it pays interest equal to:

$$1 \times i = i$$

so at the end of the year we will have the initial capital of 1 Euro plus the calculated interest, in total:

$$1 + i \text{ (euro)}$$

it follows that 1 Euro available within a year at the present time has a value equal to:

$$1/\ (1+i) \text{ or } (1+i)^{-1}$$

If we use our Euro at the "i" interest rate for two years, at the end of the first year we will have, as seen above, capital 1 + i. At the end of the second year, we will have the following total capital:

$$(1+i)(1+i) \text{ or } (1+i)^{2}$$

It follows that 1 Euro available in two years at present time has a value equal to:

$$1/\ (1+i)^{2} \text{ or } (1+i)^{-2}$$

In general, we can say that one Euro today in n years will be worth:

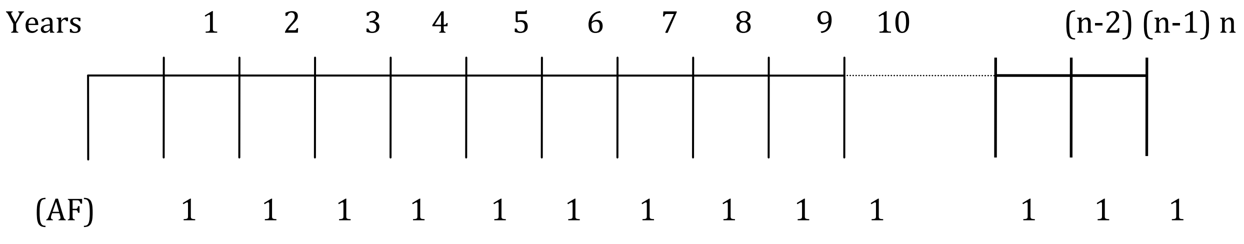
$$\mathbf{(1+i)^{n}} \quad \textbf{Capitalization Factor}$$

And that one Euro available in n year is worth today

$$\mathbf{1/(1+i)^{n} \text{ or } (1+i)^{-n}} \quad \textbf{Deduction Factor}$$

*B. Annual Factor Formula*

Annual Factor is given by the Present Value of a continuous deferred year for one Euro:




That is equal to the sum of future Euro deducted until now.

So, we have:

$$AF = \sum_{J=1}^{n} (1 + i)^{-J}$$

the Annual Factor value can be found in the double-entry tables compiled based on "n" and "i". It represents the equal life of the investment, which takes into account the discount effect. Therefore the FA will be less than n, the greater the interest.

*C. Investment life*

Represents the period during which the investment will continue to produce the expected economic benefits. It is given by the smallest of the following:

**- Physic life** (due to the pants coating)

- **Technical life** (due to technical evolution of plant, the age of the plant)

**- Commercial life** (due to sustainability of demains for goods or services produced by the plant in the market)

**- Political life** (defined by unclearness regarding the general political and economical situation: legal requirements, confiscations risk, wars, etc.).

*D. Interest rate*

Calculation interest or capital cost depends from the origin of financial means. They can be supplied using credit or owned by the entrepreneur. Therefore there are the following two cases:

- **Investment with credit capital** (highest level of interest of financial means that the entrepreneur really is withdrawing.

- **With capital owned by the entrepreneur** (lowest level of interest among the activities available to the entrepreneur for any diversion with which the necessary funds can be supplied).

*E. Inflation and differential increase of the prices*

Finally, we need to consider the worrying effect of inflation and differentiated price increases. With a good approximation we can consider the real interest equal to the net nominal interest of the average estimated inflation rate for the years of investment life. Moreover, if we assume that the price of goods produced by our plants will change differently from the inflation trend, it is necessary to consider the extent of this diversification. Therefore we have the following formula:

$$\mathbf{i = r - f - f'}$$

i = real interest rate
r = nominal interest rate
f = inflation rate
f ’ = the rate of shift of the price of goods produced against inflation

### 4.4 Net Investment

Once the present value of the future economic benefits of the investment has been calculated with the criteria we have seen, we can compare it to the total cost of the intervention. The following articles contribute to its definition:
1) Net price of the production system (machinery, factory, building, etc.);
2) Installation cost (modeling, assembly, arrangement, etc.);
3) The relative cost of transportation (taxes included);
4) Initial cost (additional cost for necessary operations at the beginning, every fee for not production, interest expenses for fixed activities until the beginning of production, etc.);
5) Immobilized working capital (spare parts, stored lubricants, etc.).

The number of items from 1) to 5) should be deducted from the recovery value of the existing plant, which is withdrawn due to the new investment.

### 4.5 Economic indicator

We now present some of the most common economic indicators that summarize the characteristics of the investment and allow greater speed in the decision-making process, especially in a comparative key.
*A. Return Time (RT)*
Return time, which the Americans called the "payback" is the most popular economic indicator and in many cases is sufficient to determine the benefit of the agreement identified. However, it is advisable to use it with caution, as its exclusive and indistinguishable use may, in some cases, provide the wrong answers. It does not take into account investment life, interest, inflation, and the cost rate of the product produced.

$$RT = I / CF$$

RT = Return time
I = Investment
CF = Cash Flow
*B. Profit index (PI)*

The profit index tells us how much a Euro invested in the activity in question produces. This index is very useful when you do not have enough capital to make all the investments identified as suitable. In this case, this indicator helps us make the best use of the little money available.

The formula is as follows:

$$PI = NPV / I$$

PI = Profit Index

NPV = net present value

I = Investment

To better illustrate this, let us take as an example two investments:

Case 1):

CF = 15.000 € of the deducted profits;
I = 10.000 €;

NPV = 15.000 – 10.000 = 5.000 €.

Case 2):
CF = 10.000 € të përfitimeve të zbritura;
I = 5.000 €;

NPV = 10.000 – 5.000 = 5.000 €.

Both cases offer the same NPV, but it is clear that the latter is preferable, requiring a lower initial cost for the same achievable profit.
Using the profit index we have:

PI = NPV / I

Case 1):

PI = 5.000 / 10.000 = 0, 5

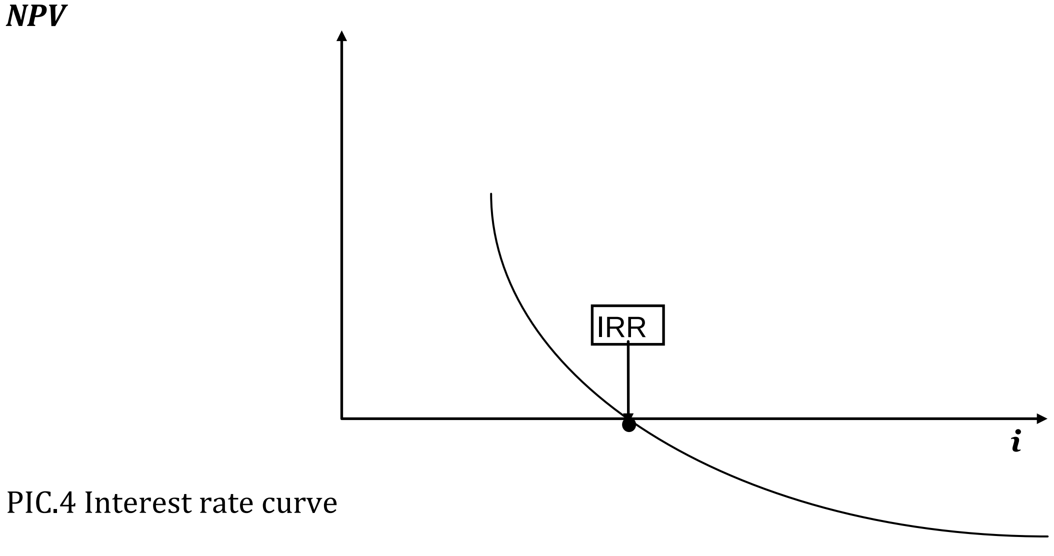
Case 2):

PI = 5.000 / 5.000 = 1

The preference for the second solution is justified by the fact that one euro invested in this activity produces 1 profit, while in the first case the same euro produces 0.5.

*C. Internal rate of return (IRR)*

If we place the NPV value on a Cartesian axis system and the interest rate on the horizontal axis, we obtain a curve like the one shown in the following figure.

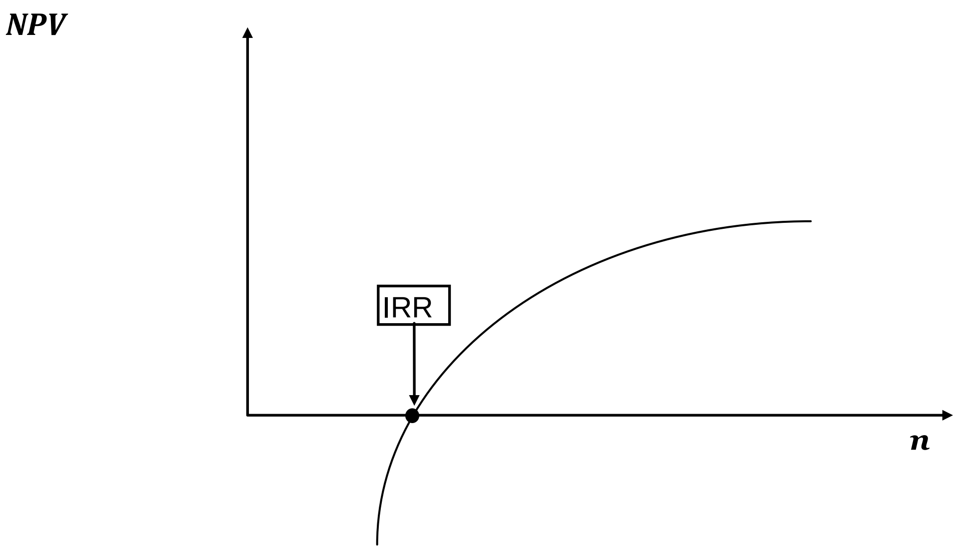



PIC.4 Interest rate curve

The value of ***i*** for which the NPV is canceled is a special value, which is called the "Internal Rate of Return". This indicator tells us at what rate we are using our money to perform the intervention.

D. Return Time (RT)

Similar to what is seen for IRR, we place the NPV in the vertical axis and the expected life n on the horizontal axis. The number of years for which the NPV is canceled identifies the return time (RT).




PIC.5 Return time curve

## 5. CONCLUSION

The REEHUB project established regional energy distribution in each country of the geographical area included in the IPA INTERREG Program Montenegro, Albania, Molise and Puglia, reference centers for public administration on issues of energy-saving and efficiency. HUBs are physical meeting places, exchange with community and professionals to spread the culture of environmental and energy sustainability, and transfer good practices on this topic through training and capacity building courses. A specialized technician manages each HUB. He has attended a training course on the methodology described in the guidelines and has become the "Protector" of good practices, as well as the HUB's technical equipment.

Each HUB has its construction specificity, and this has allowed us to share problems and solutions for different types of buildings. During the implementation of the project, HUBs were field laboratories equipped with instruments to perform measurements on-site, and technicians were able to experiment and apply the REEHUB ENERGY AUDIT methodology shared by all partners.

The methodology described in the previous pages highlights the basic technical notions that every professional should know and what are the procedures you should follow according to International Standards and Community Policies in progress.

These guidelines have in two sections, a descriptive one explaining the methodological approach of an energy audit of a building and the second section with examples of "Best Practice" which describe how the audit is used within the regional centers established under the project.

The purpose of these guidelines is to provide practical guidance for public administration technicians and professionals and emphasizes that before any energy efficiency intervention, it is necessary to know the building in all its construction aspects and the plant located in it and the measurement of the interventions with a cost-benefit analysis.