**Attributes**

The attributes were selected taking into account which factors change as a result of a building renovation on a multi-family building. These range from the monetary range of costs to expected savings, from impact on the environment to comfort.

| | |
|---|---|
| **Cost of the intervention [€]** | Cost to be incurred to carry out the intervention. |
| **Reduction of CO2 emissions [kg / m2year]** | Reduction of carbon dioxide emissions produced by fossil fuels used by the building. |
| **Annual monetary savings [€ /year]** | Monetary savings achievable annually. |
| **Reduction of energy requirement from non-renewable sources [kWh /m2year]** | Reduction of the building's need from non-renewable sources. Non-renewable energies are those energies generated from sources that tend to run out over time, such as fossil fuels (coal, oil and natural gas). |
| **Comfort level achieved [0-10]** | It identifies the overall quality of an indoor environment evaluated through various factors including: indoor air quality, thermal and acoustic comfort, adequate quantity and quality of ventilation at the level of electromagnetic interference. |
| **percentage usability of the tax incentive [%]** | Percentage of tax recovery obtainable with the intervention. |
| **Sustainability achieved [0-10]** | Score between 0 and 10 aimed at assessing the sustainable aspect of the event. Higher scores identify a more sustainable intervention once the intervention in the building has been completed. |

Table 1

These attributes listed in the table were derived as follows:

-Cost of intervention: an economic analysis was carried out by means of a metric calculation as per the price lists for all interventions.

-CO2 emission reduction: derived from energy analysis for each intervention. These values are calculated as the difference to the building in the status quo situation.

-Annual monetary savings: : Calculated according to heating and ACS for the winter period by setting indoor temperature as input at 20 degrees 24/24. This calculation was done by simply taking the annual consumption data SMC and kWh from the calculation software and multiplying by the respective average prices paid by the consumer.

-Reduction in energy demand: energy from non-renewable sources needed by the building. This data, taken from energy simulations, shows that for each intervention we reduce epgl,nren (kWh/m2 per year), the value that determines the energy class of our building. This varies according to the design choices made, which at the same time reduce the use of non-renewable energy sources compared to renewable ones (solar, photovoltaic, biomass) during the useful life of the building.

-Comfort level achieved: This attribute derives from several factors. These were selected from a wider audience by choosing those considered most influential on the quality of comfort of living spaces according to the simulated interventions. The calculations performed were based on the parameters as per UNI/Pdr 13:2019. Then the individual scores were processed in order to obtain a final value for each simulated intervention.

-Tax incentive percentage: A % tax deduction has been attributed to each simulated intervention, taking into account the different incentives present today in the building sector.

-Sustainability achieved: this score has been normalised on a scale from 1 to 10. It takes into account both data deriving from numerical calculations and intangible factors to which it is not possible to associate a

numerical value, but which are linked to the feeling deriving from the perception of comfort, cost-benefit aspect and perceived sustainability strictly linked to the individual intervention.

**Results: Willingness to Pay (WtP)-Technical variables**

Data have been calculated for each planned intervention. They correspond to energy, environmental and economic calculations. The reference building taken is a condominium consisting of six building units located in Milan. This type of building was chosen because it is certainly the most suitable for carrying out renovation work, especially with today's building bonuses which aim to upgrade most of the building stock.

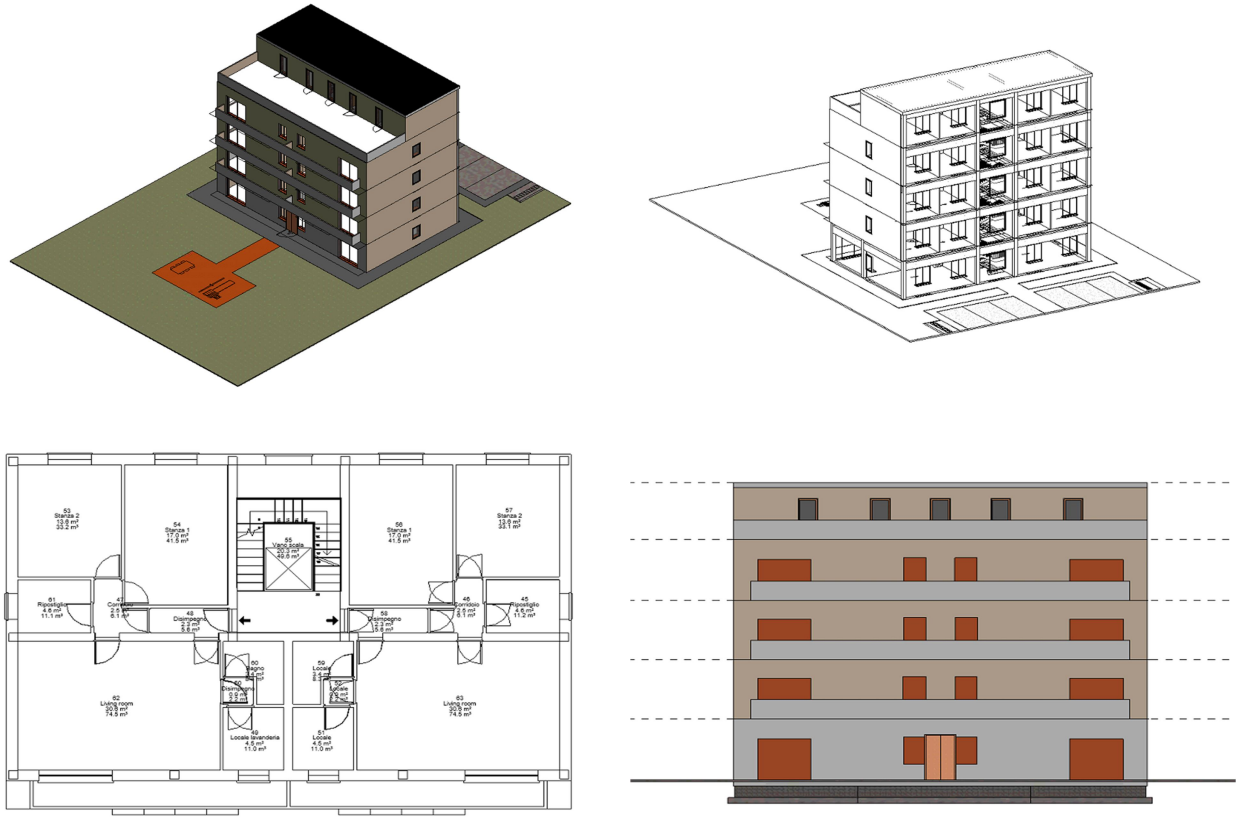


Image 1

Therefore, we started from the analysis of the Current Status building and then simulated different interventions. Replacement of windows and doors only, replacement of the generator only, installation of insulation and combined interventions that affected the entire building in a heavier way, including the renovation of the distribution system, emission and PDC generator as well as the installation of photovoltaics.

These interventions were carried out in compliance with the minimum requirements decree of 26 June 2015, as well as the technical requirements decree of 6 August 2020 including subsequent additions. In order to qualify for the various tax deductions that have been put in place in the last period.

Here the data submitted in the choice experiment.

| Attributes | LEVELS | | | | | |
|---|---|---|---|---|---|---|
| | | | LOW SUSTAINABILITY | | HIGH SUSTAINABILITY | |
| | Current Status | | Windows only | Generator only Condensing boiler | Thermal insulation only | Thermal insulation + PDC + distribution + emission + fixtures + photovoltaics |
| Cost of intervention[€] | X | Cost of intervention[€] | 70000.00 | 8000.00 | 136000.00 | 418000.00 |
| Current Co2 emission [kg/m2per year] | 38.07 | CO2 emission reduction [kg/m2 per year] | 13.59 | 15.46 | 19.87 | 35.80 |
| Actual expenditure on energy [€] | € 7376.00 | Annual monetary savings [€] | € 2,618.00 | € 2,969.00 | € 3,830.00 | € 6,859.00 |
| Current demand for non-renewable energy [KWh/m2 per year] | 192.6 | Reduction in energy demand from non-renewable sources[KWh/m2 per year] | 68.95 | 78.62 | 100.82 | 182.40 |
| Current Comfort level [0-10] | 2.7 | Comfort level achieved [ 0-10] | 7.1 | 2.7 | 2.9 | 5.6 |
| Tax incentive percentage [%] | 0 | Tax incentive percentage [%] | 50 | 65 | 110 | 110 |
| Current sustainability[0-10] | 0.0 | Sustainability achieved[0-10] | 3.0 | 3.5 | 5.0 | 8.0 |

Table 2

Sustainability Scores Criteria - ITACA - Example of a case study

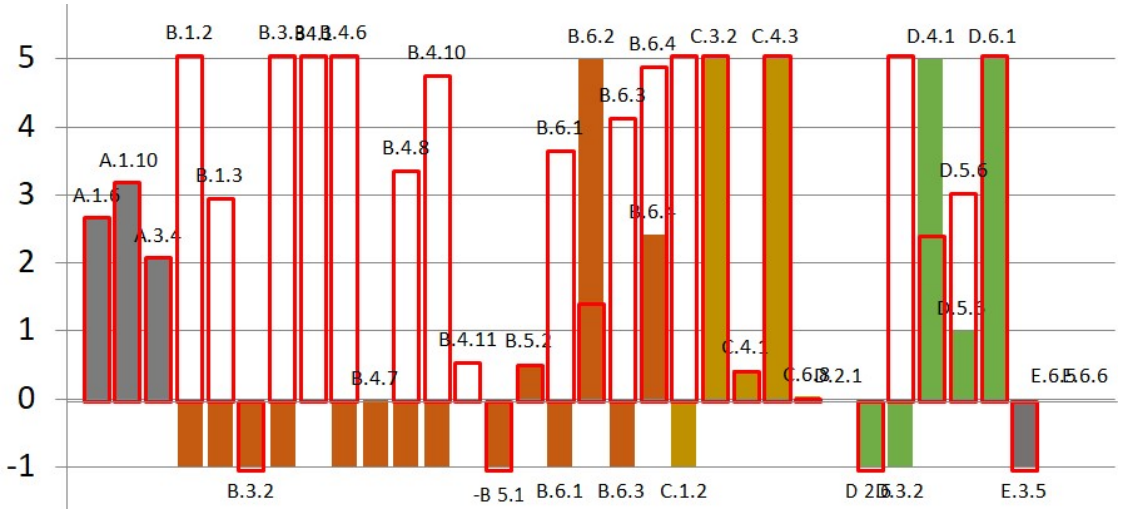
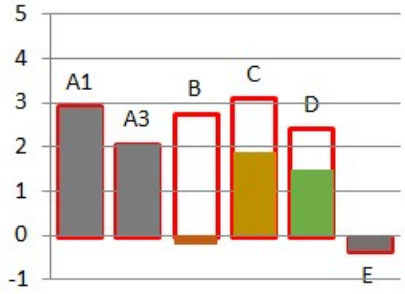



Chart 1

After surgery




Areas

In the graph we see all the criteria taken into account in this single-case analysis. Here we can see how each criterion undergoes variations before the intervention and after. In this case the variation of parameters is consistent, due to the fact that the intervention compared is a global renovation of the building. Otherwise in more limited interventions we will obtain that many criteria will not undergo variations and consequently also the score. The graphicisation of the criteria allows an immediate overview of the starting and project situation. The use of more sustainable, recyclable, local, disassemblable materials, rainwater recovery, both for irrigation and indoor use, operating temperature, indoor comfort, soil permeability, materials with SRI limiting the heat island effect, ventilation and magnetic fields are the aspects to be taken into account during the intervention, considering that sustainability is much broader than the fields that tax breaks encourage and promote.

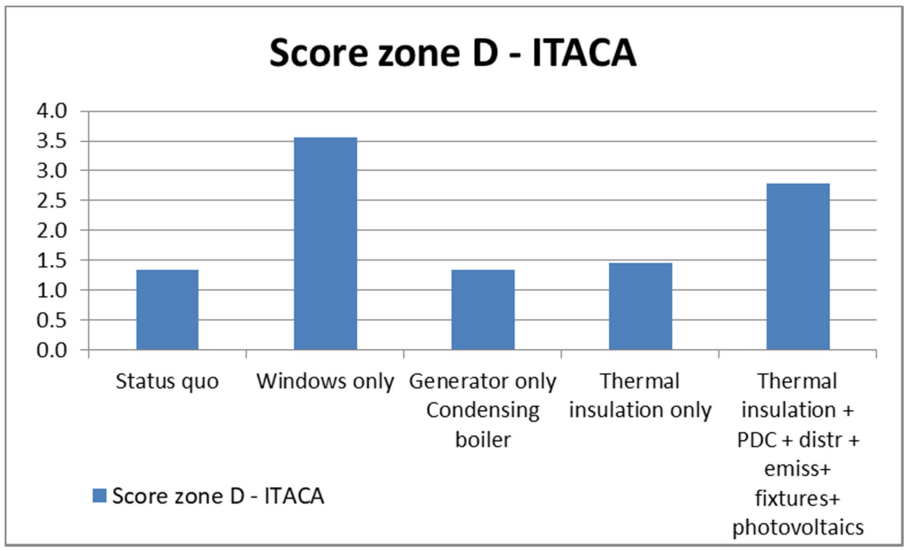



Chart 2

In assessing the criteria for determining the score (Chart 2), which is then correlated with the comfort attribute, the following aspects were analysed: effectiveness of natural ventilation, radon, operating temperature in summer, natural lighting, acoustic quality of the building, industrial frequency magnetic fields. We can see how the replacement of windows and doors and the most massive intervention have a greater influence on the score for area D than the status quo.

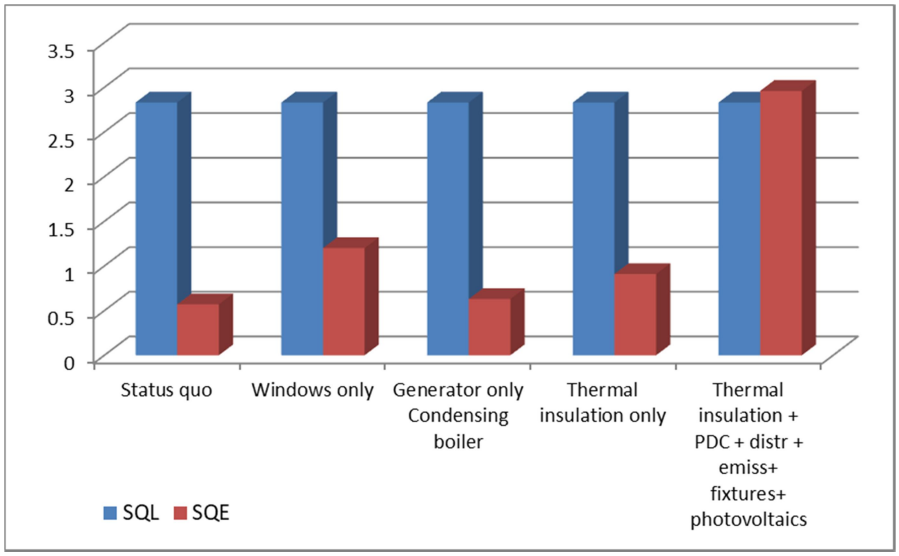



Chart 3

Here we show the graph (Chart 3) that separates the two macro areas, i.e. SQL and SQE, comparing the score achieved for each simulated case. The SQL index indicates the score relative to the location, in fact this remains unchanged given the fact that the case study has not moved from its initial location. Therefore, we can focus only on the SQE parameter or the one related to the building, to make our considerations of the simulated cases.

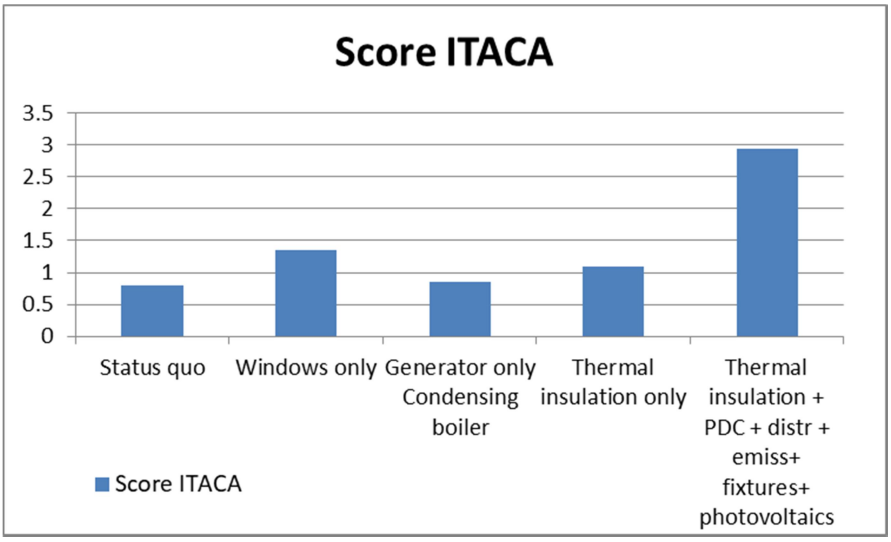



Chart 4

This other graph (Chart 4) shows the total score obtained. This shows how applying UNI/PdR undergoes an increase for the intervention only fixtures due to the fact of the improvement of the summer operating temperature that goes to affect substantially the score. While for the case of only generator there are no obvious changes or at least appreciable as this intervention affects only the part of heating consumption and Co2 emissions not bringing appreciable improvements on the final score. The intervention only coat goes to improve the energy part, even if the jump compared to the previous ones is not so high since it also affects only a few criteria in the totals.Finally, the intervention coat + PDC + emission + distribution + PV achieves a much higher score due to the fact that the intervention is almost global, such as in the renewable energy part, and not localized as in the previous ones. Both in this graph and in the previous ones, we can see that the intervention only in the area D weighs considerably for the final score, but it is not to be understood that it brings significant benefits in the winter phase and in all the other criteria, especially in those that aim to reduce emissions and energy consumption.

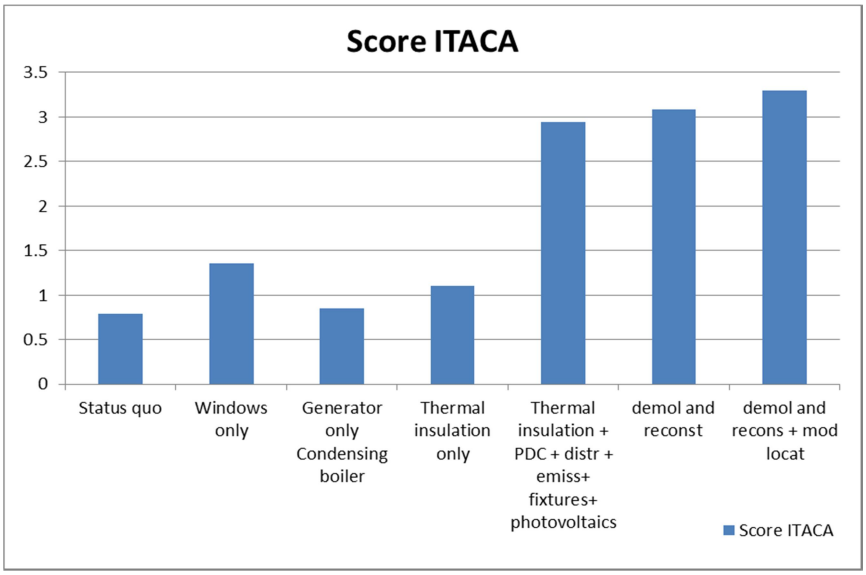


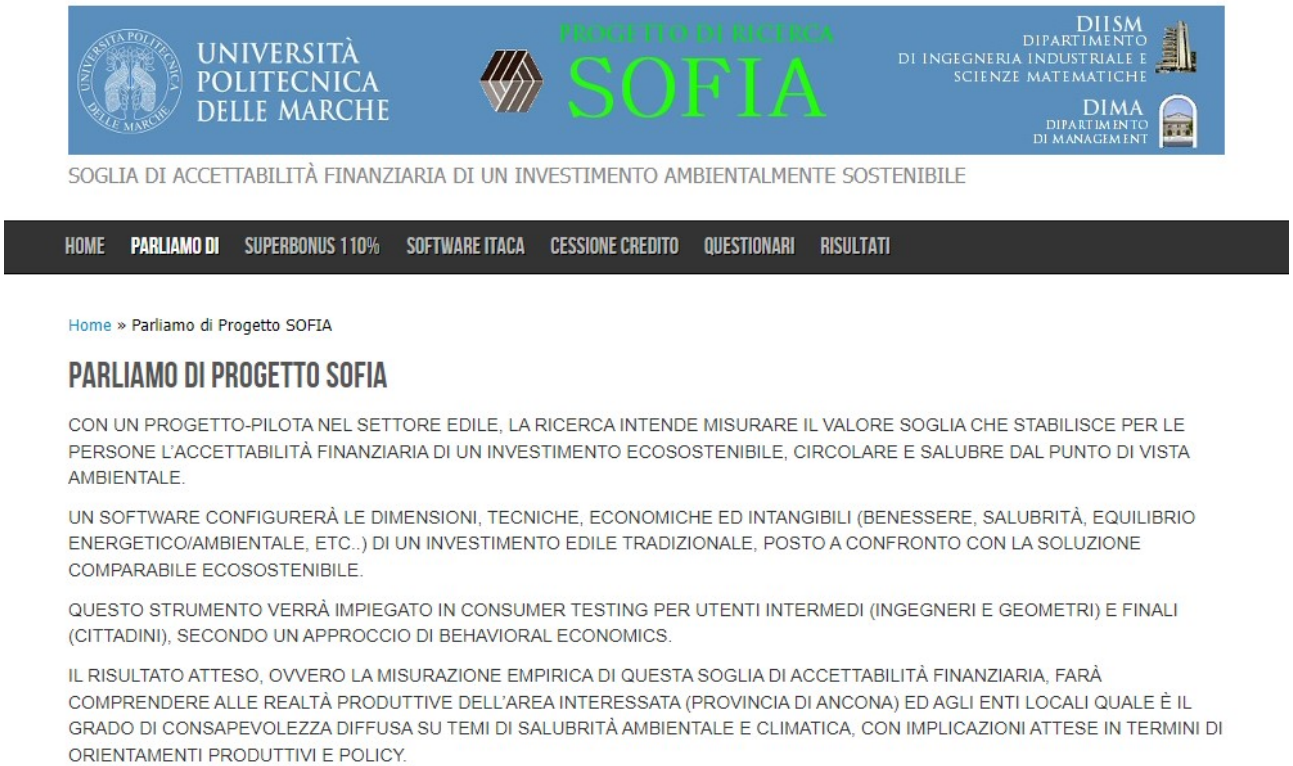

Chart 5

In the graph above we also put the data, obtained from the simulations, which were not used in the choice experiment, but which constitute case studies and research. They are both demolition and reconstruction interventions, but with the difference that in the second case the building was also moved to a location that improves the SQL parameter or the quality of the location. These interventions are undoubtedly the best in all respects, making it possible to have totally new and updated buildings in all aspects of energy, structural and domotics, etc., guaranteeing a longer useful life for the building than any renovation. These simulations were carried out by placing the building in two different locations, Milan and Ancona, obtaining all the relevant data. It was found that there are no appreciable differences due to the different locations.

**Web Site SOFIA**

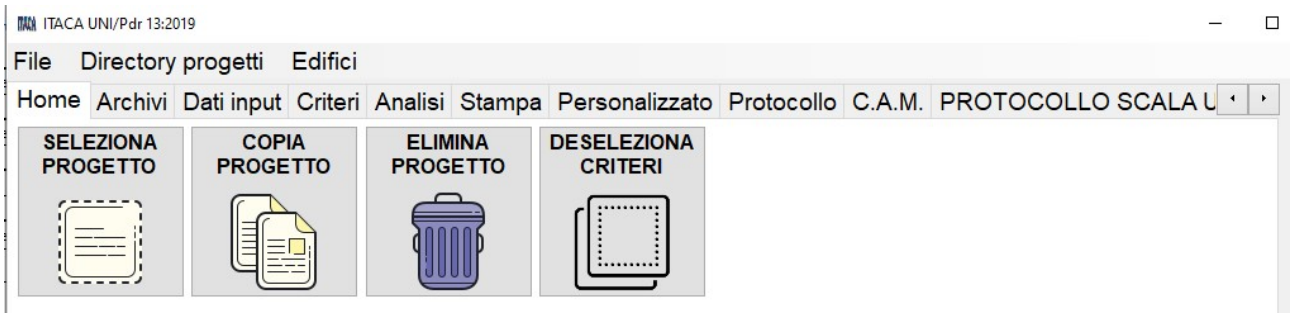
SOFIA – Soglia di accettabilità Finanziaria di un Investimento Ambientalmente sostenibile

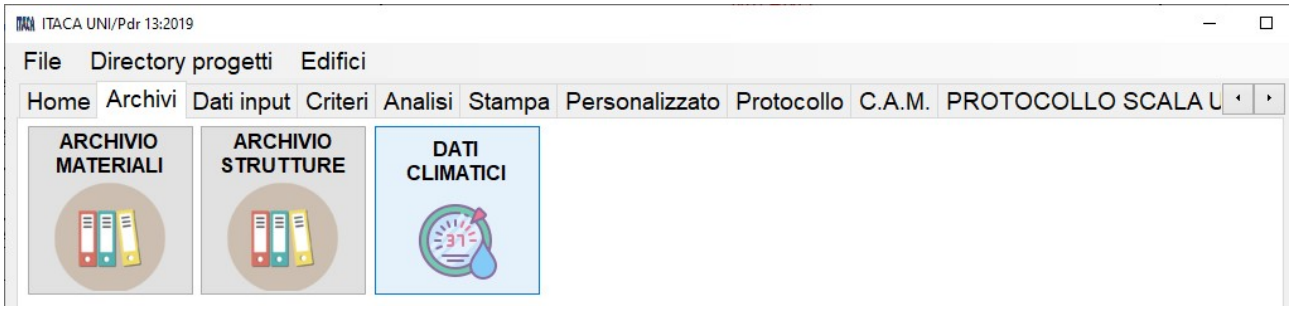
Financial Acceptability Threshold of an Environmentally Sustainable Investment



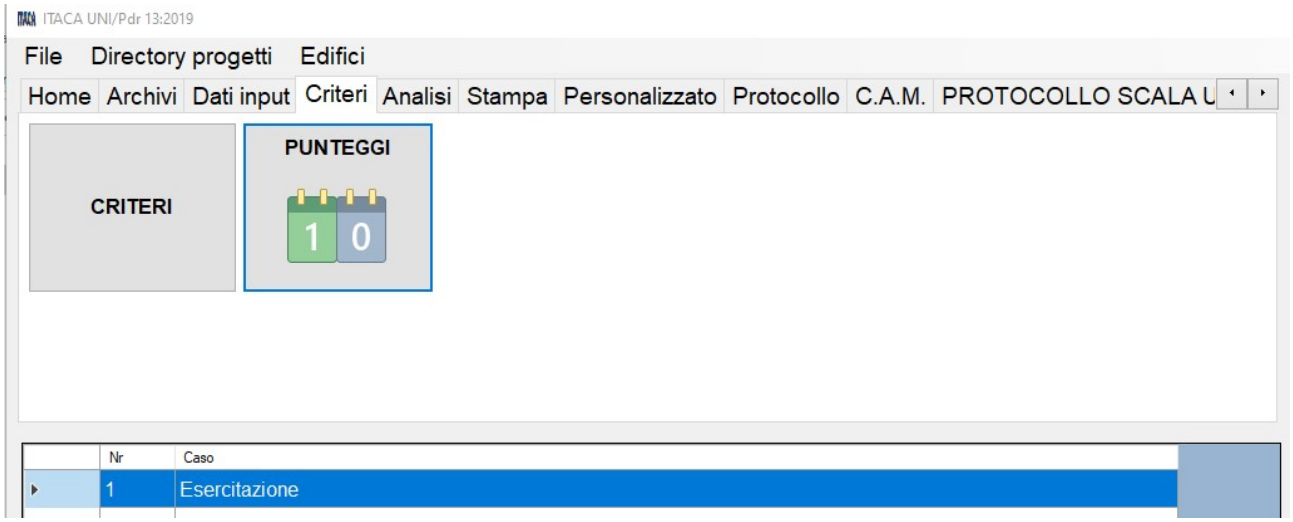

The objective of creating a dedicated website stems from the need and desire to disseminate research data and collect information by filling in questionnaires submitted to various user profiles on the sensitivity of those involved in sustainability issues. This tool was not created as an end in itself, but with the idea of being developed over time by implementing it with further data collected, thus ensuring a support base on the web for disseminating information on the subject. It also offers a valuable opportunity for communication between universities, organisations, professionals and companies, guaranteeing long-term collaboration and development.

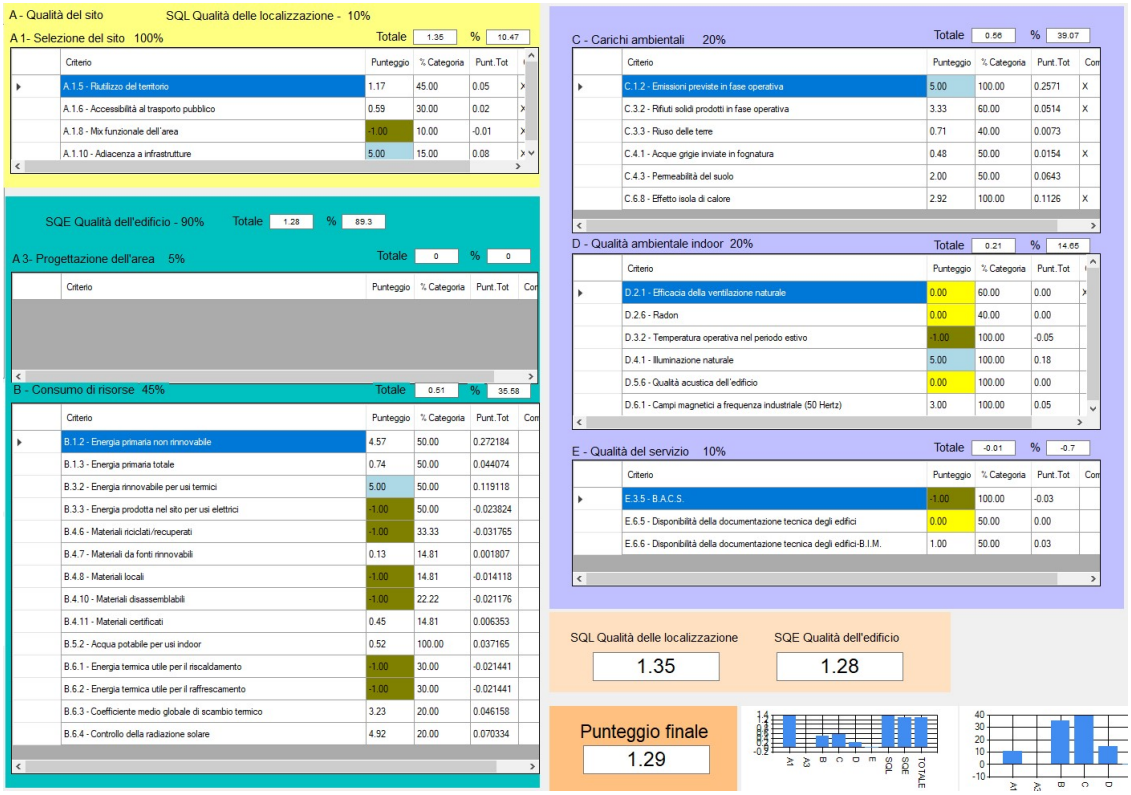
**The software**










During the period under review, a calculation software was developed based on the application of UNI/Pdr 13:2019, which allows to derive the sustainability score. This was made available by Univpm through the download option from the SOFIA website - Financial Acceptability Threshold of an Environmentally Sustainable Investment - http://www.sofia.univpm.it/software_itaca . It allows professionals to calculate the sustainability score of the building interventions to be carried out, allowing them to intuitively identify the individual aspect and act by making changes to the project to obtain the desired level. It is easy for professionals to compile, allowing a pre- and post-intervention analysis by placing renovation and new construction interventions on a scale from -1 to 5 as required by UNI/Pdr 13:2019.