A spatial-based approach for enhancing the energy renovation of historical settlements

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Energy retrofit actions at urban level play a strategic role in promoting the renovation of existing towns. An evaluation of the building stock's energy demand baseline is vital in defining the most appropriate energy retrofit strategies, as well as to support the elaboration of more sustainable urban plans while, at the same time, also considering energy issues.
The present study defines an operative method for quantitatively determining the annual heating energy demand of a historic building stock, while considering its heritage value, conservation state, geometry, and constructive features. This approach has been applied to Calavino, a historical town in the Province of Trento (Italy) which has an altitude of about 400 m. About 220 buildings, partly isolated, partly aggregated in original compositions and partly attached to each other flank the central street, creating a beautiful historical area with Renaissance origins [2].

The historical town of Calavino

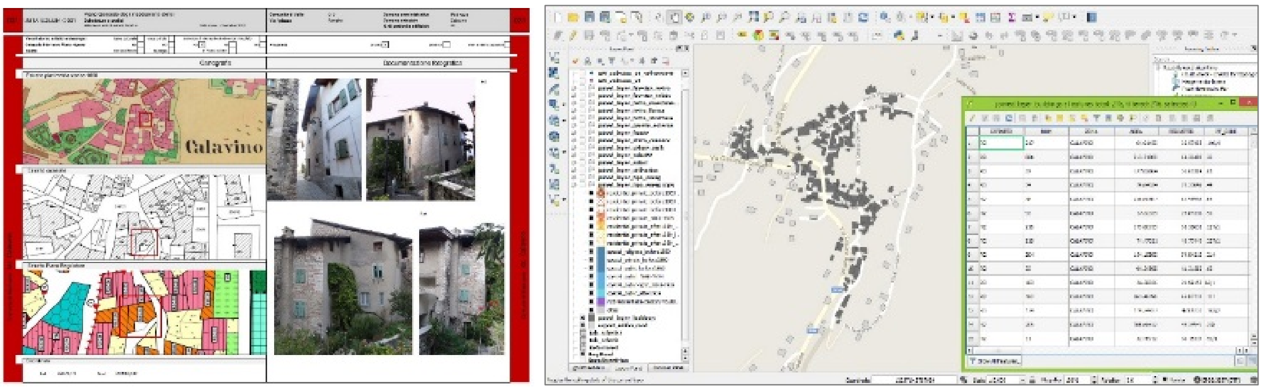
The town is becoming depopulated and only a quarter of the apartments are inhabited, as demonstrated both by statistical data and infrared thermography. Moreover, the entire municipal area - which in the past few years has seen the merging of two municipalities - has no more than 3000 inhabitants.

Utilization level of the building stock: (a) infrared thermography; (b) GIS map

To solve this huge problem, increasingly common in several alpine towns, the administration first commissioned an architectural firm to generate an accurate record of the georeferenced location, functions, architectural features, constructive materials, heritage values and constrains, conservation states, construction year classes, and utilization levels for each building. This resulted in 220 datasheets with detailed descriptions of each building.

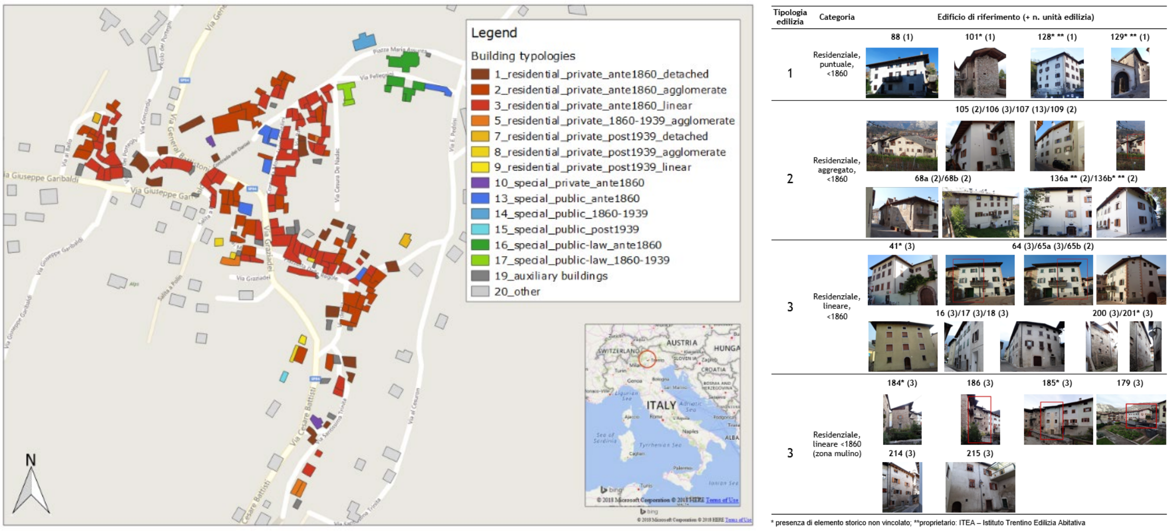
Then, departing from this data, the administration commissioned EURAC Research with a survey campaign to ascertain the potential for the restoration of the entire scenario stock. This work was structured in two main phases:

- Analysis of the building stock status quo
- Building energy modeling.



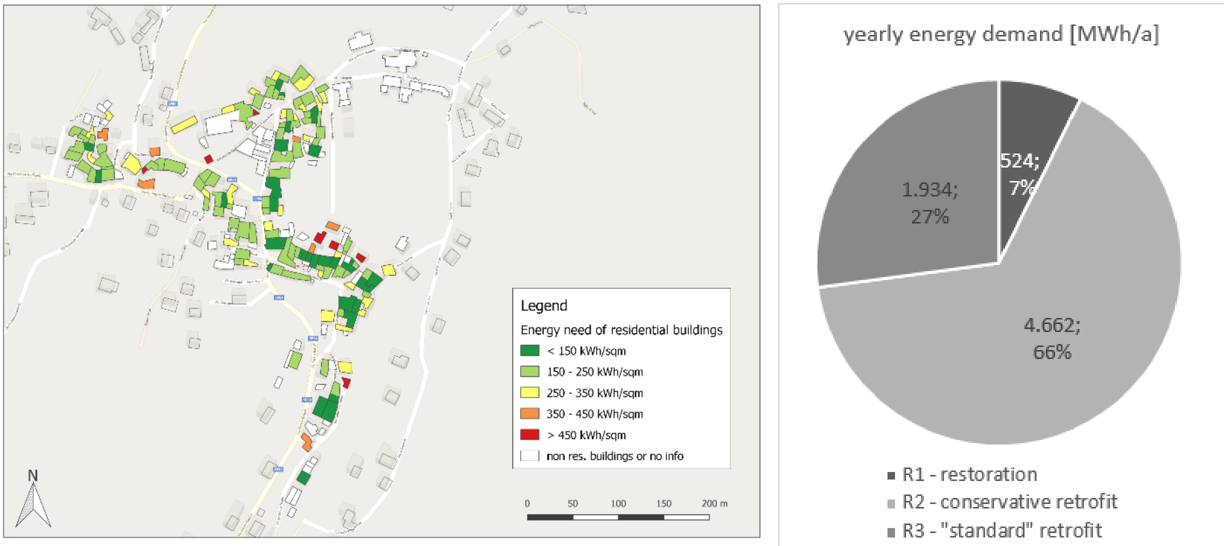
Analysis of the building stock status quo: (a) building datasheet; (b) construction of the GIS model from building data

A spatial-based analysis was created with GIS software. Furthermore, the data was statistically analyzed in order to classify the types of buildings and calculate the actual consumption for heating the inhabited houses. The goal is to estimate how much would have to be invested in order to redevelop the historical center.



Definition of the building typologies: (a) GIS map; (b) on site survey of building typologies

Thanks in part to the survey and in part to the GIS evaluation, a considerable amount of information at "single building" level was available – it was therefore decided in this case, not to proceed with the pure "building type approach" we had previously used in two other cases in the same region [2]. Since the dominating typology (70% of the buildings are residential buildings dating from before 1860) is widely characterized by stone walls with presumably similar U-values, we concentrated on these buildings, determined the typical U-value and used this together with the information on wall, roof and window surfaces from GIS, as well as information on single/double windows and used spaces (needed e.g. to understand the heated volume) from the survey in order to estimate the energy demand. Linking the xls-based PHPP tool [ref] to the GIS and survey tables enabled the automation of the process for the 154 buildings studied. The calculated energy demand varies over a wide range: from 80 to more than 553 kWh/m²a, with an average around 230 kWh/m²a. In 20% of the examples, the demand exceeds 300 kWh/m²a. The wide distribution of energy demands within a category shows the benefits of an approach which can account for physical parameters, such as the actual surface-to-volume ratios, window types, building size and shape.



Energy need of the residential buildings studied (a) GIS map; and (b) aggregation of the demand by possible category of intervention

Furthermore, aggregating the energy demand by the category of possible intervention – ranging from *R1-restoration* over *R2-conservative retrofit* to *R3-standard retrofit* and also available from the survey – shows that only a small amount fall into the most restrictive category, while the major part of the demand could effectively be reduced with a conservative retrofit. This again underlines how important it is to develop truly tailored, retrofit proposals in accordance with such a building value centered approach and also demonstrates the high potential of safeguarding our cultural heritage.

This activity would save valuable heritage and traditional buildings, with arcades and decorations of great historical interest. It is early to make evaluations on the beneficial costs of an energy retrofit, but the old owners who moved could find more comfortable and less expensive houses, to return to or either rent them out to new tenants.

Reference:

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2. Exner D., D'Alonzo V., Paoletti G., Pascual R., Pernetti R. (2017), Building Stock Analysis for the Definition of an Energy Renovation Scenario at the Urban Scale. In: Smart and Sustainable Planning for Cities and Regions. Results of SSPCR 2015, Book published by Springer, pp.33–54.