BSA 2017

Building Simulation Applications

IBPSA ITALY PROJECT AWARD

Freie Universität Bozen
Libera Università di Bolzano
Università Liedia de Bulsan

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VILLA CASTELLI

PROTECTING LISTED BUILDING AND ENERGY EFFICIENCY: IT CAN BE DONE!

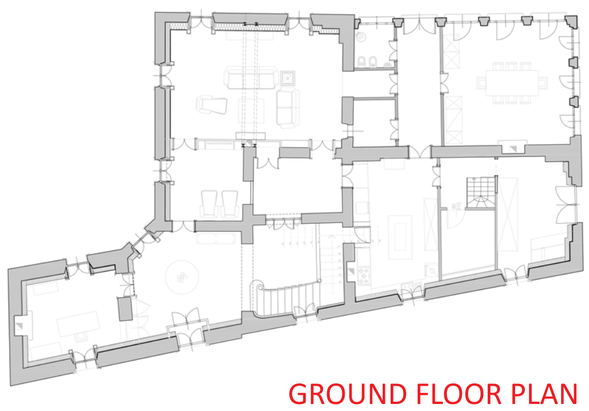
PROJECT
Reftrofitting of an hystorical Villa

PROJECT DATA
CLIENT: Alessandro Caselli
ARCHITECTURAL DESIGN: Arch. Valentina Carí
CONSERVATION DESIGN: Arch. Valentina Carí
SITE MANAGEMENT: Arch. Valentina Carí
ENERGY DESIGN: Solarraum
BUILDING SYSTEM: Solarraum
DYNAMIC SIMULATION ANALYSIS: Eurac

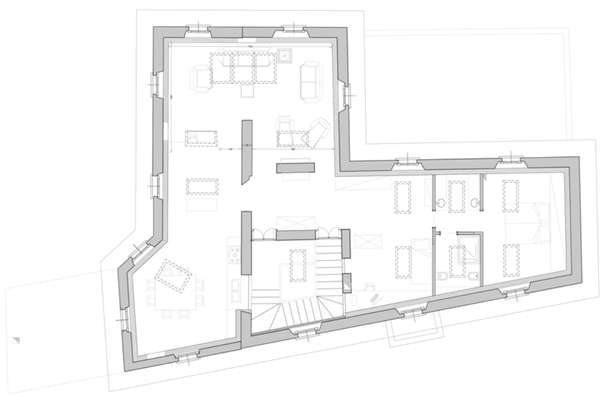
BUILDING DATA
GROSS FLOOR AREA: 680 mq
HEATING ENERGY NEEDS: 15 kWh/mq anno
ANNUAL CO2 EMISSION: 4 kg CO2/mq anno
ENERGY LABELLING: A - Casaclima certification

CLIMATIC DATA
LOCATION: Bellano (LC)
DEGREE DAY: 2220
CLIMATIC AREA: E (Italian classification)
LATITUDE: 46° 02’ 39‘ 12 N
LONGITUDE: 09° 18’ 25’’ 92 E
ALTITUDE: 202 m

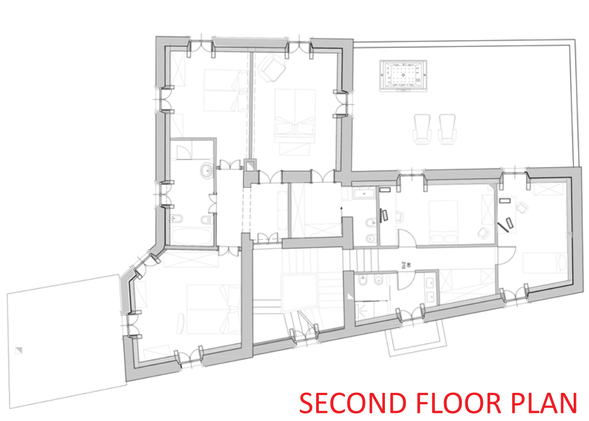
SIMULATION SOFTWARE
ENVELOPE LAYERS ANALYSIS: Wufi pro 5.3
COMPLEX CONNECTIONS ANALISYS: Delphin



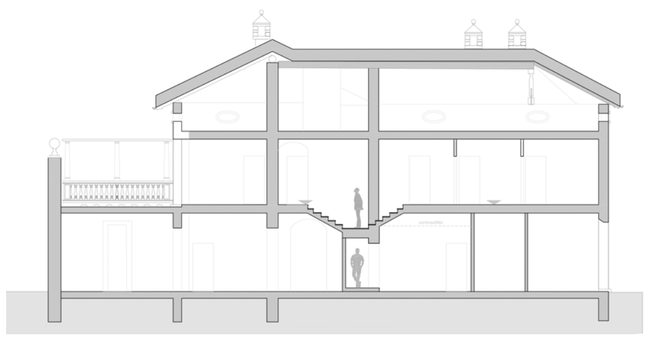
GROUND FLOOR PLAN



FIRST FLOOR PLAN



SECOND FLOOR PLAN



CROSS SECTION

BUILDING DESCRIPTION
Villa Castelli is an historical listed building owned by the Castelli family for more than 170 years. The building has been transformed many times and several extensions were made, giving as results a non-uniform structure composed by different construction technologies.

AIMS OF THE CLIENTS
The owner wants an overall refurbishment focused on energy efficiency, the exploitation of renewable energy sources based on-site production and a fixed budget.

ROLE OF DYNAMIC SIMULATION
The development of certain design solutions was only possible because of the use of dynamic simulation. In particular, the installation of 20 cm of perlite as internal insulation and the optimization of the most complex building connections were developed by means of Wufi pro 5.3 and Delphin.

RESULTS
The great synergy among building envelope retrofitting, innovative technological solutions, dynamic simulation and the employment of renewable energy sources, shows that also a protecting listed building can be turn into a nZEB.

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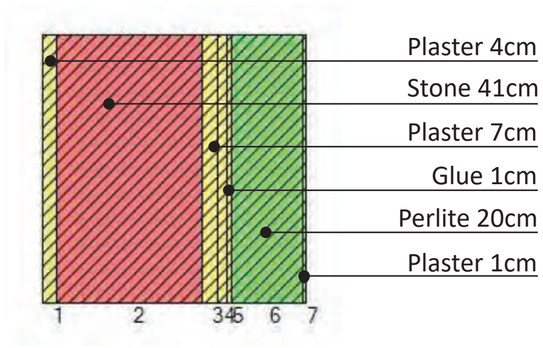
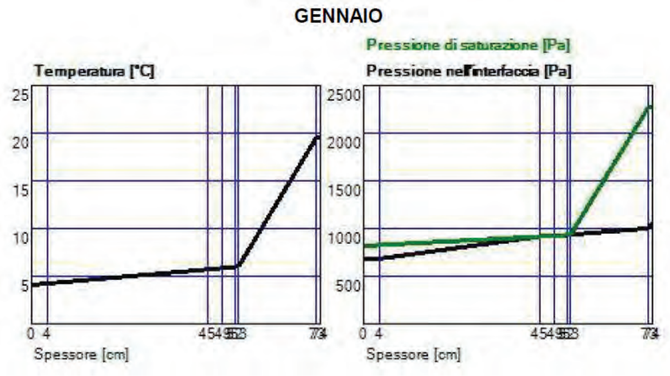
ANALYSIS OF HYGROTERMAL BEHAVIOR OF THE BUILDING STRUCTURE

ANALYSIS USING UNI EN ISO 13788



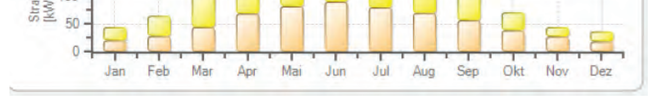


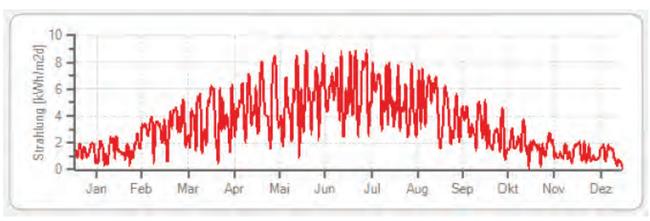
The hygrothermal behavior of the building structure has been analyzed using the steady state approach proposed by standard UNI EN 15788. The graph shows that using 20 cm of Perlite as internal insulation leads to have interstitial condensation between the stonewall and the insulation panel. This would require the installation of a vapor barrier on the hot side of the insulation layer for damp proofing.On building site the installation of this membrane is particularly delicate and complex.
The maximum insulation thickness that can be applied without risking the interstitial condensation is 8 cm. However, this would considerably reduce the thermal performance of the opaque envelope.

DYNAMIC HYGROTHERMAL SIMULATION

INPUT: hourly weather data

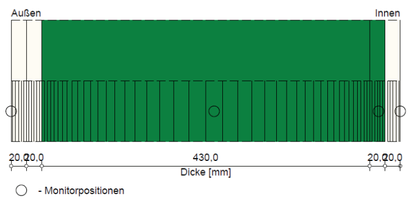
Temperature
Relative humidity
Beam radiation
Diffuse radiation



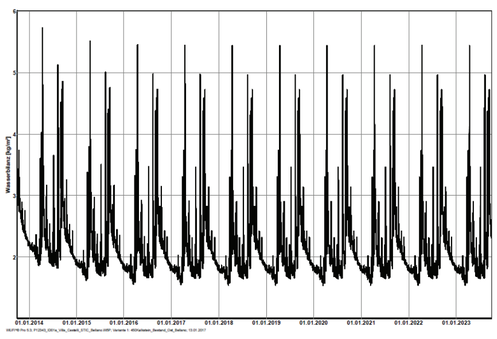


ANALYSIS OF THE WATER CONTENT STORED INTO THE BUILDING STRUCTURE OVER A PERIOD OF 10 YEARS

EXISTING BUILDING STRUCTURE

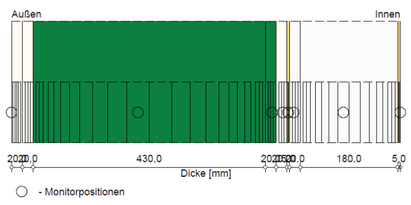


OVERALL BUILDING STRUCTURE

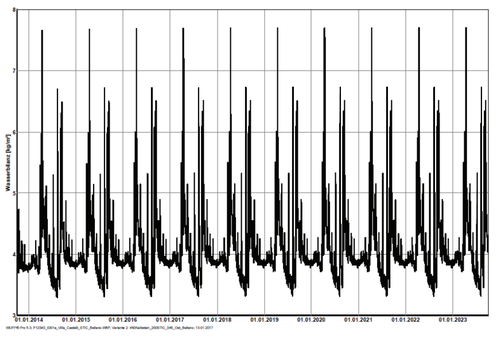


By using hygroscopic materials to insulate, it is possible to regulate naturally the internal moist air, without using any vapor barrier and making the installation phase on the building side much easier. Wufi allows realistic calculation of the transient heat and moisture transport in walls and other multi-layer building components exposed to natural weather.

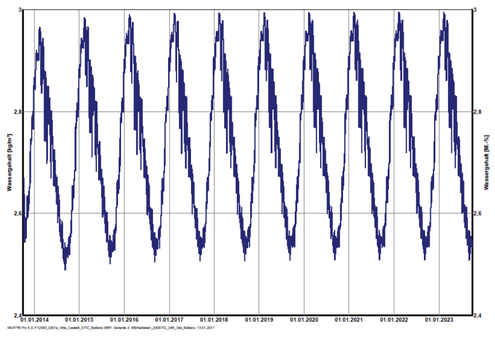
RETROFITTED BUILDING STRUCTURE (20 cm PERLITE)

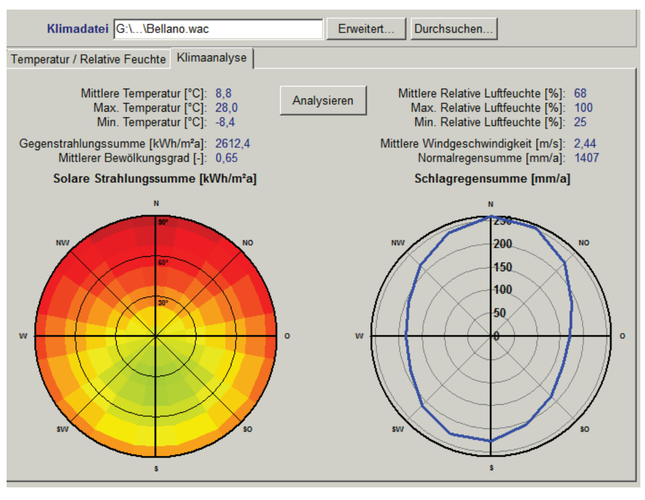


OVERALL BUILDING STRUCTURE

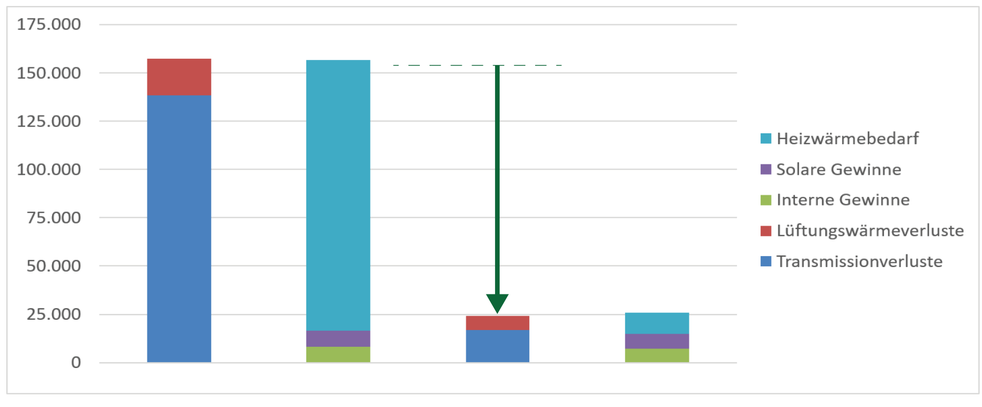


PERLITE INSULATION LAYER





RESULTS



PICTURES FROM THE BUILDING SITE

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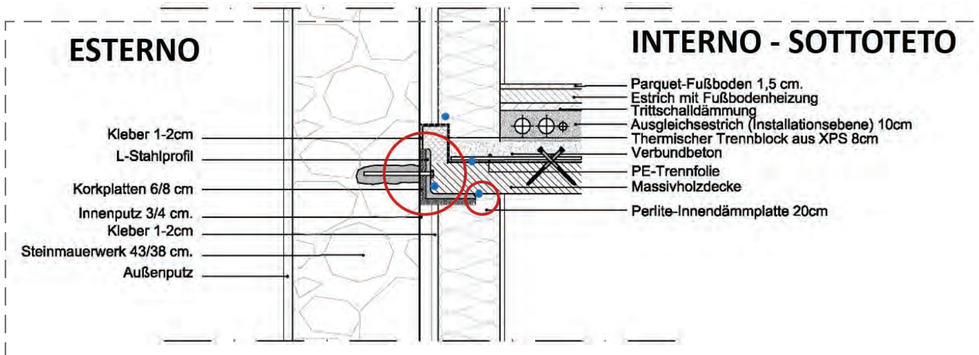
DYNAMIC SIMULATION OF COMPLEX CONNECTIONS

CONNECTION BETWEEN LAMINATED WOODEN CEILING AND EXTERNAL WALL

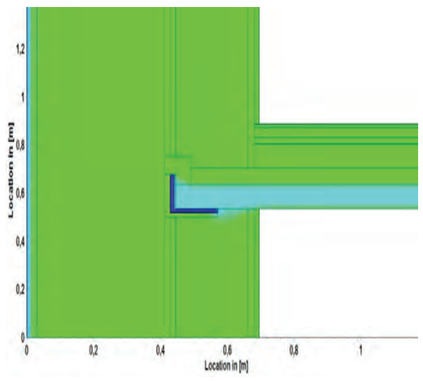
DETAIL OF THE JUNCTION



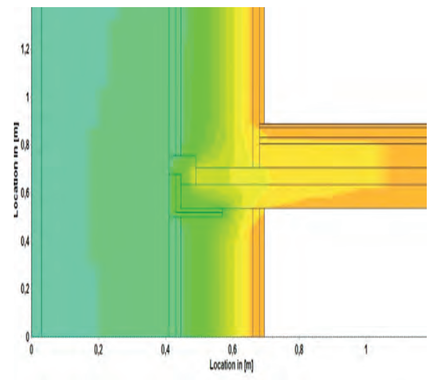
Static simulations (at outside temperature of -10°C and of 0°C; inside temperature 20°C) showed that the critical areas are the bearing of the ceiling on steel angle (underside of the ceiling) and the layer behind the interior insulation (glue), these two points are the areas with the highest accumulation of humidity.

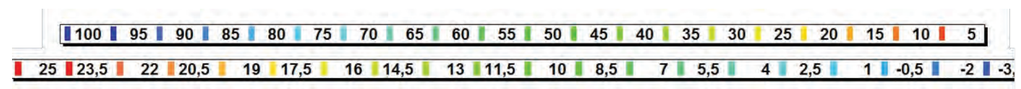
At the steel angel, simulation show that not the area at the bend of the L-profile is the point with the highest humidity. The reason is, that because of the thermal bridge in the area of the ceiling bearing the temperatures of the profile in the area of the stone wall is still quite high, therefore it becomes like a "heater" for the surrounding zone, the temperature rises and the humidity does no condensate at this point. Stationary simulations showed 7 – 7,5%Vol. of humidity in the critical point of the wooden ceiling. This is however below the critical range for mould grow, which is >10% over a certain period of time. While the dynamic simulation shows max. 6%Vol. in winter and min. 4%Vol. in summer. The simulations confirmed therefor that there is no serious risk of mould grow in the area of the wooden ceiling, the detail connection can therefore be executed as planned.

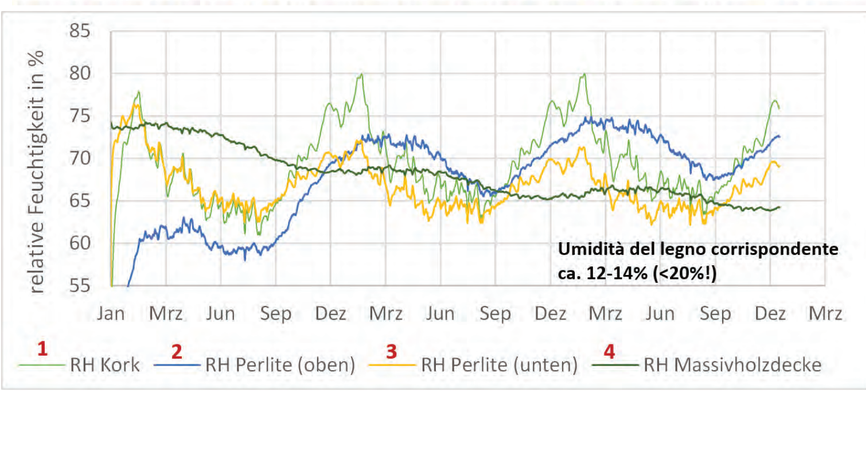
RELATIVE HUMIDITY

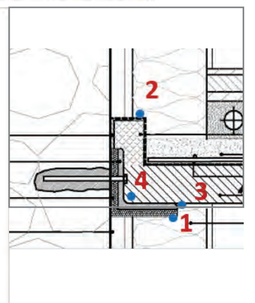


TEMPERATURE



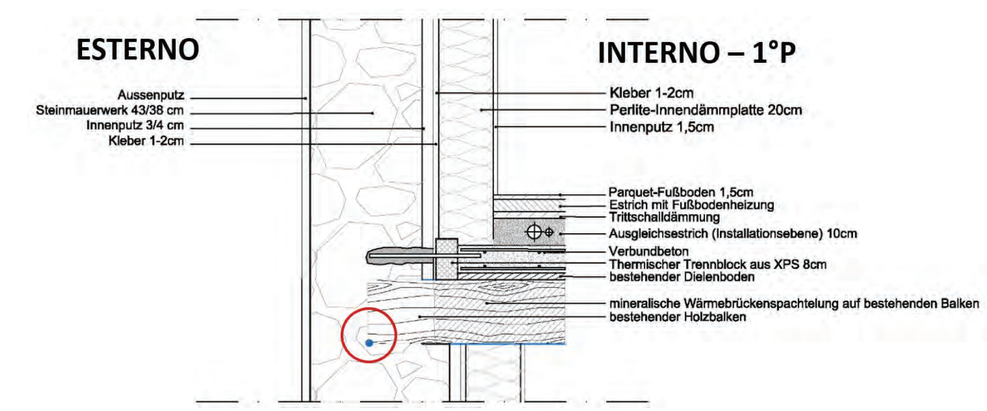






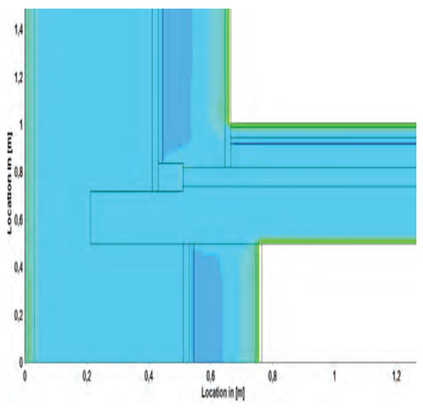
CONNECTION BETWEEN LAMINATED WOODEN CEILING AND EXTERNAL WALL

DETAIL OF THE JUNCTION

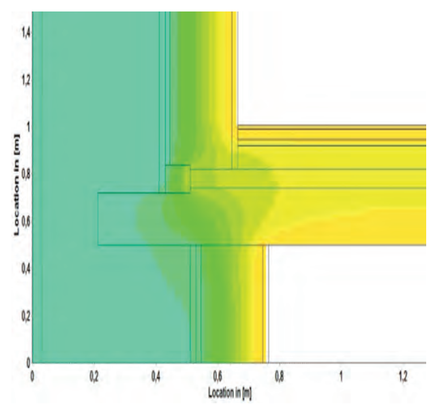


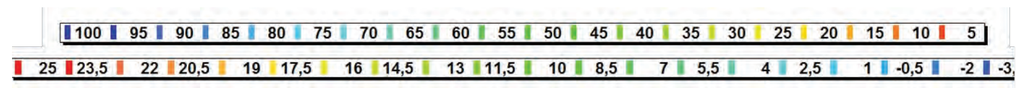
In the area of the veranda because of architectonical and conservation reasons it is important to keep the proportions of the façade (rhythm and dimensions of columns and glazing area). It is therefore not possible to apply the same concept for the interior insulation also in the area of the veranda as proposed for the stone walls. This would change considerably the appearance of the columns. At the same time, the concrete has a low thermal resistance. To avoid a thermal bridge and the risk of condensation, it is therefore important to use a high performing material. The solution developed here is to apply 2 cm thick vacuum panels on the inner side of the columns, while in the reveals between vacuum panel and the blind frame of the window a layer of XPS is installed.

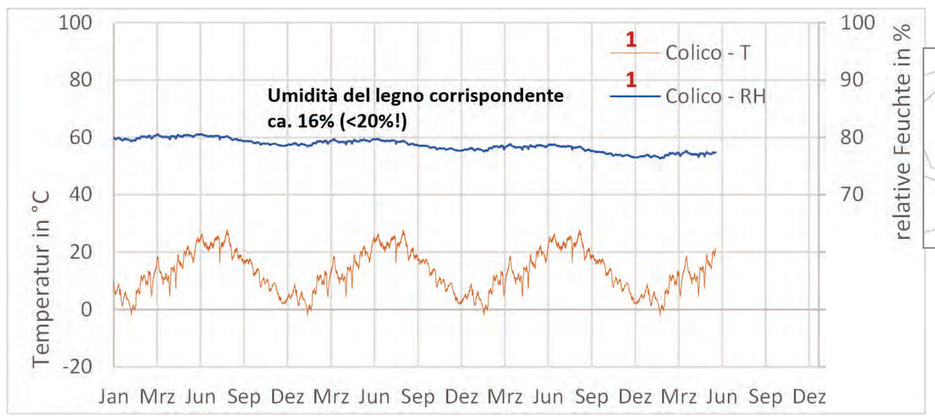
RELATIVE HUMIDITY

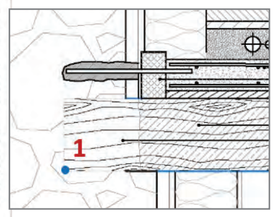


TEMPERATURE



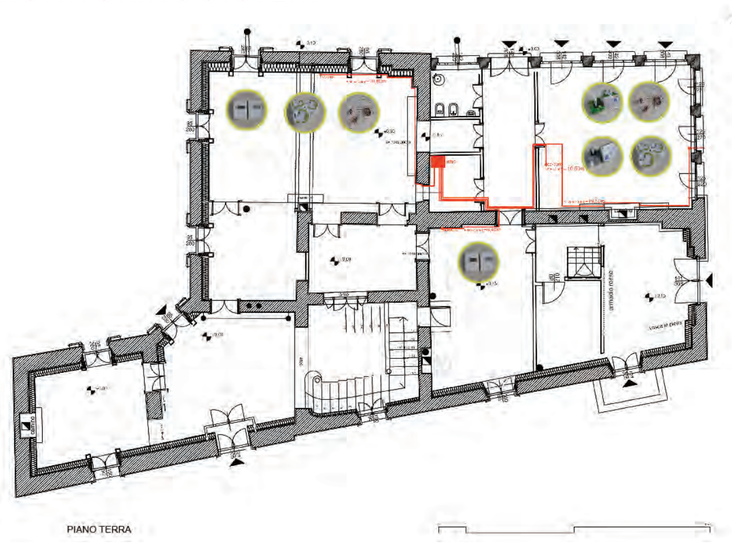






INFRARED THERMOGRAPHY SURVEY

MONITORING SYSTEM



A comprehensive monitoring system, developed by the European Academy of Research (EURAC), allows to constantly checking the indoor environmental conditions and the thermal behavior of the building structures, where the internal insulation is installed. The monitoring systems analyzes continuously: (i) indoor air temperature; (ii) indoor relative humidity; (iii) CO2 concentration levels; and (iv) light levels. The monitoring system has been inserted in the most representative rooms of the building: kitchen, dining room and living room (first floor) and in two bedrooms (second floor). According to the measurements the indoor condition shows to be really comfortable, with pretty constant thermohygrometric values (T = 20-22 °C; RH = 53-55 %) during the entire monitoring period (June-November 2016).

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