Environmental monitoring for sustainable redevelopment: the case of Rocca Sant'Apollinare

Geothermal, monitoring and historical heritage:

the Perugia pilot project

In the heart of Umbria, central Italy, among the hills surrounding Perugia, lies a medieval complex of great historical value: the **Rocca Sant'Apollinare**. Once the stables of the Benedictine monastery, it is now a cutting-edge research center. This site is the focus of an ambitious **sustainable redevelopment** and **environmental monitoring** project that combines cutting-edge technologies, heritage protection, and citizen well-being. Furthermore, the stables have obtained the first GBC Historic Building certificate in Italy and the Ecomondo award for sustainable construction, confirming the quality and innovation of the project.

GEOFIT: an innovative approach to geothermal refurbishment

The European **GEOFIT** project, funded by the EU's **Horizon 2020** program, aims to revolutionize the energy renovation of buildings through a **holistic and innovative** approach based on the use of geothermal energy. The goal is to develop systems that are **cost-competitive**, **easy to install**, and capable of ensuring **efficient low-temperature heating** and **effective high-temperature cooling**, using the most advanced technologies and methods available.

To test and validate these solutions, GEOFIT has been successfully implemented at **five pilot sites across Europe**, including Ireland, Italy, France, and Spain. The selected sites represent a broad spectrum of climate conditions, building types, and geological characteristics, making the project a true open-air laboratory for energy refurbishment in real-world settings.

Rocca Sant'Apollinare: a pilot site of excellence

Rocca Sant'Apollinare (PG) is one of five pilot sites chosen to test these innovative technologies. In the case of Perugia, the objective was challenging: to apply a **cutting-edge hybrid geothermal system** to a building dating back to the 10th and 11th centuries, with significant cultural value and located in a seismic zone. Here, the University of Perugia, project leader for this site, collaborated with several industrial and technological partners to integrate a **hybrid heat pump** and an **unconventional horizontal heat exchanger**, all supported by digital modelling and advanced simulations.

Finally, the entire system is monitored and managed by an intelligent **Building Energy Management System (BEMS)** that optimizes energy efficiency while maintaining a high level of environmental comfort for residents.

Invisible technology for heritage protection

The project addressed several critical issues:

- How to **reduce consumption** and **emissions** without invasive interventions?
- How to **integrate geothermal systems** and monitoring systems into a heritage building?
- How to **ensure environmental comfort** for users?

The answer came from an innovative design approach, combining efficiency and respect for the historical context. The interventions were carried out with excavations limited to a depth of 2.5 meters, through five parallel trenches and underground heat exchange rings, **minimizing** the **visual and structural impact**.

Why environmental monitoring is essential

To ensure accurate control of comfort and energy efficiency, the **continuous monitoring system** implemented at Rocca Sant'Apollinare uses two types of LSI LASTEM stations:

- **Outdoor weather station:** measures temperature, humidity, atmospheric pressure, wind speed and direction, solar radiation, and precipitation;
- **Indoor microclimate station:** measures indoor temperature and humidity, black globe temperature, wet bulb temperature, and air velocity.

Jointly monitoring **indoor and outdoor conditions** is essential for assessing **thermohygrometric comfort**, analyzing **building-environment energy balances** and optimizing **plant management** through predictive strategies. This approach allows for objective correlation of environmental data with consumption, improving efficiency and well-being.

How the data is used: analysis, optimization, and research

The collected data is then processed through digital platforms and used to:

- Optimize system operation and reduce waste;
- Evaluate environmental quality and **microclimatic comfort**;
- Support **scientific research and educational activities**;
- Share best practices with European institutions and stakeholders.

Concrete impacts: efficiency, well-being, and enhancement

The Rocca Sant'Apollinare project has generated tangible benefits:

- **Reduction in energy consumption** and CO_2 emissions;
- **Improved air quality** and comfort for students and researchers;
- **Protection of historical heritage**, thanks to a non-invasive approach;
- **Training and innovation**, with a participatory laboratory available to the University and scientific partners.

A model replicable for other buildings

The project looks to the future with the intention of **extending the sensor network** to other urban and historic contexts, integrating smart technologies to optimize energy management and microclimate control. The collaboration between LSI LASTEM and the University of Perugia has created a virtuous model of cooperation, replicable nationally and internationally. The long-term goal is to make the Rocca **Sant'Apollinare a European benchmark** for the sustainable redevelopment of historic heritage.

A new direction for sustainable redevelopment

The Rocca Sant'Apollinare project demonstrates that it is possible to combine historical heritage protection and ecological transition through advanced technological solutions. LSI LASTEM, with its **environmental monitoring** systems, contributed to defining an **operational model** capable of **enhancing complex architectural contexts** and promoting **more informed energy management**. An approach based on accurate and reliable data, interdisciplinary cooperation, and strategic vision that paves the way for new opportunities for the future of sustainable redevelopment.