

Developing an Interactive Scientific Installation to Promote and Discover Geothermal Energy

Monia Procesi¹, Corrado Castellano¹, Gregorio Comandini², Saverio Villirillo², Federico Varazi³

¹ Istituto Nazionale di Geofisica e Vulcanologia (INGV), Roma, Italy

² LIMINAL STATE, Via G. Libetta 21, Roma, Italy

³ Geolab Scienze della Terra, Italy

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ABSTRACT

Public understanding and acceptance are critical for the development of geothermal energy, particularly for power generation, and in some countries such as Italy. A lack of knowledge and awareness about geothermal energy often limits public support to this resource. Communities can be more receptive to geothermal projects and recognise them as ecologically friendly and sustainable solutions by raising knowledge and understanding. Scientific-interactive exhibitions and/or installation offer an effective tool to bridge this gap of knowledge by making complex geological and physical processes accessible to the general public. This paper presents PULSE (Power Under Land Source of Energy), an innovative scientific-art installation developed by the *Istituto Nazionale di Geofisica e Vulcanologia* (INGV) and the art collective LIMINAL STATE, as part of the IRGIE project (Inventario delle Risorse Geotermiche delle Isole Eolie). Located at INGV Rome, PULSE combines visual, sensory, and audio elements to create an immersive journey into the Earth's interior, illustrating geothermal processes and phenomena such as heat sources, thermal gradients, and fumaroles. The installation features an external digital sculpture and an inner part constituted by both an interactive multimedia totem equipped with a digital platform that offers educational materials on geothermal science, and exhibition of core samples from the Larderello geothermal field, enabling visitors to observe the texture and composition of deep rocks. Integrated into educational tours for schools, PULSE exemplifies how art and science can work together to enhance public awareness and understanding of geothermal energy as a sustainable resource.

INTRODUCTION

Geothermal energy, despite its benefits, suffers from misconceptions and limited visibility in mainstream energy debates. By designing interactive installations, institutions like INGV aim to bridge the gap between

scientific complexity and public understanding. Through engaging narratives and sensory experiences, scientific-art installation can transform complex scientific concepts into tangible experiences, thereby fostering environmental awareness and support for renewable energy initiatives. The European emphasis on transparency in science communication underscores the need for projects that not only inform but also inspire. Furthermore, it is often challenging for the general people to comprehend the geological and physical processes involved in geothermal systems, which consequently affects their comprehension of geothermal energy generation. This framework introduces the scientific art installation PULSE dedicated to geothermal energy. The installation employs visual, sensory and audio components to facilitate the scientific knowledge and stimulate emotional connection with the natural phenomenon of Earth's heat. The goal is to allow visitors to understand the power and potential of geothermal energy in a direct, intuitive, and engaging way. PULSE represents an art-scientific installation where science and art work together to encourage the scientific education. Art can be a tool to bring people closer to science and phenomena that sometimes appear very complex. In the last years, the synergy between art and science has emerged as a powerful tool for science communication and public engagement. Collaborations between artists and scientists offer new ways to visualise, understand and internalise complex scientific concepts (Wilson, 2010). The interdisciplinary approach makes it possible to transcend the traditional boundaries of popularisation, bringing the public closer to environmental and scientific topics that would otherwise remain complex or inaccessible. In particular, geoscience and environmental disciplines lend themselves to being told through art, thanks to the ability of works to evoke emotions, stimulate curiosity and encourage critical reflection. The literature highlights how art installations and immersive experiences can facilitate scientific literacy by making invisible natural phenomena, such as geothermal or volcanic processes, visible (Curtis, 2009). The combination of narrative, aesthetics and interactivity enables active visitor participation, transforming the visitor from a mere spectator to a co-explorer of the

scientific phenomenon (Wright et al., 2022). This approach is particularly relevant in the context of geothermal energy, a strategic and sustainable natural resource that, however, often suffers from a lack of public knowledge and acceptance. Here, we present PULSE and a detailed description is proposed below, presenting the concept and design of the installation, and focusing also on the target audience and expected impact.

2. CONCEPT AND DESIGN OF THE PULSE EXHIBIT

The installation was conceived with a dual purpose: to inform and to inspire. It addresses a wide spectrum of visitors, ranging from school groups (primary, secondary, and high schools) to university students, educators, researchers, and the general public. Special attention has been given to making the scientific content accessible without compromising accuracy, thus promoting inclusivity and universal engagement. PULSE consists of two interconnected components: the outdoor digital sculpture and the inner information area (Fig. 1).

- The outer part offers a journey into the Earth providing, on two large LED walls, video, sounds and flash messages, to information about the: i) rheological behaviours of the terrestrial interior; ii) heat sources; iii) thermal gradient, iv) depths of main components of the Earth such as inner and outer core,

mantle, crust, magmatic chamber, geothermal reservoir; v) main component of geothermal fluids (Fig. 2). The journey finishes with a spectacular simulation of a fumarole, a surficial manifestation of the heat of the Earth (Fig. 3). Infrared heating lamps (IR-A short-wave) simulates the warmth of geothermal systems, while soundscapes linked to visual cues amplify emotional resonance. This approach translates technical concepts into intuitive experiences, fostering deeper cognitive and emotional understanding.

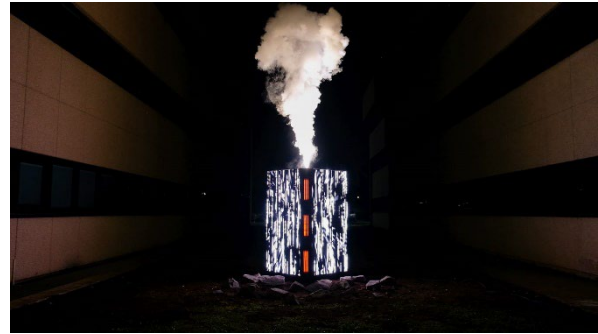


Figure 3: PULSE – External component of the installation featuring a dynamic simulation of a fumarole, combining visual animation and ambient sound. The central section of the sculpture incorporates infrared pulsating heating lamps to enhance the sensory experience and provide the perception of the Earth's heat.

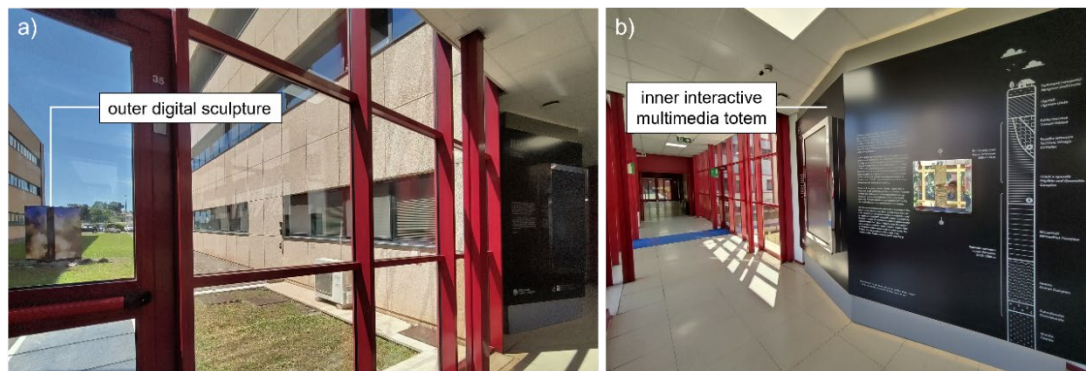


Figure 1: Scientific-art installation PULSE composed by two interconnected components: a) the outdoor digital sculpture where the two led walls (1 x 2m) are shown; b) the inner information area, constituted by a 65-inch touchscreen to access to simple scientific information on geothermal energy and exhibition of the core samples from the Larderello geothermal field.

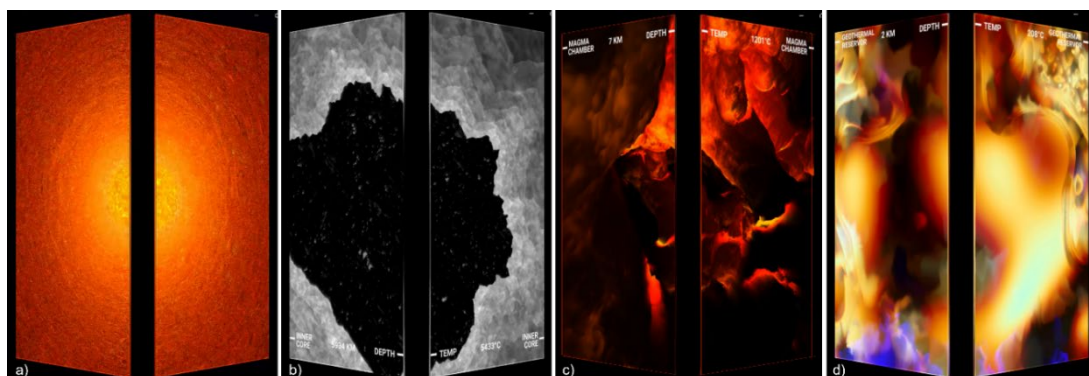


Figure 2: Selected frames projected onto the led walls of PULSE outdoor sculpture. (a) representation of early Earth formations and connection with the primordial heat generation; (b) depiction of the solid metallic inner core; (c) visualization of a magmatic chamber; (d) illustration of a geothermal reservoir. Depths and temperature ranges are indicated for each component.

- The inner part of PULSE, is constituted by an interactive multimedia totem equipped with a digital platform (<https://pulse.ingv.it>) that offers educational materials and interactive resources to foster awareness of geothermal science and its applications, both on-site visitors and remote users (Fig. 4). The web platform of PULSE is organized into seven main sections, each section combines educational texts, images, and multimedia materials to facilitate understanding of geothermal concepts:

1. Pulse :General introduction to the installation and its educational goals.
2. Heat :Explanation of the origin and distribution of Earth's internal heat, focusing on thermal gradients and deep heat sources.
3. Geothermal Energy: Description of geothermal systems, distribution worldwide, and processes of heat transfer within the subsurface.
4. Applications: Overview of geothermal energy uses, both for electricity production and direct thermal applications.
5. Sustainability: Insights into the role of geothermal energy in the energy transition and in combating climate change.

6. IRGIE: Information about the IRGIE project, from which the installation originated.

7. Survey: Interactive section to collect feedback from visitors.

Moreover, in the inner section of the installation, visitors can view core samples from the geothermal reservoirs of the Larderello, located in Tuscany (Italy) and kindly provided by Enel Green Power. The cores are displayed within a $50 \times 50 \times 50$ cm box, designed as a small-scale quadrisfera, both to preserve the samples and to offer a 360-degree view of them (Fig. 5). A quadrisfera is an immersive artistic device designed to fully engage viewers with a phenomenon, in this case, the core samples. The box consists of a cubic structure equipped with five mirrors, which reflect the surfaces and create the illusion of an expanded, continuous visual narrative that envelops the observer. Exhibiting rock samples taken from thousands of metres deep allows the public to imagine and understand concretely what lies beneath our feet. These samples, taken from active geothermal systems, offer a rare opportunity to directly observe the structure, colour and composition of deep rocks, making a normally inaccessible world tangible and visible, and thus fostering a better contextualisation of geological processes related to geothermal energy.

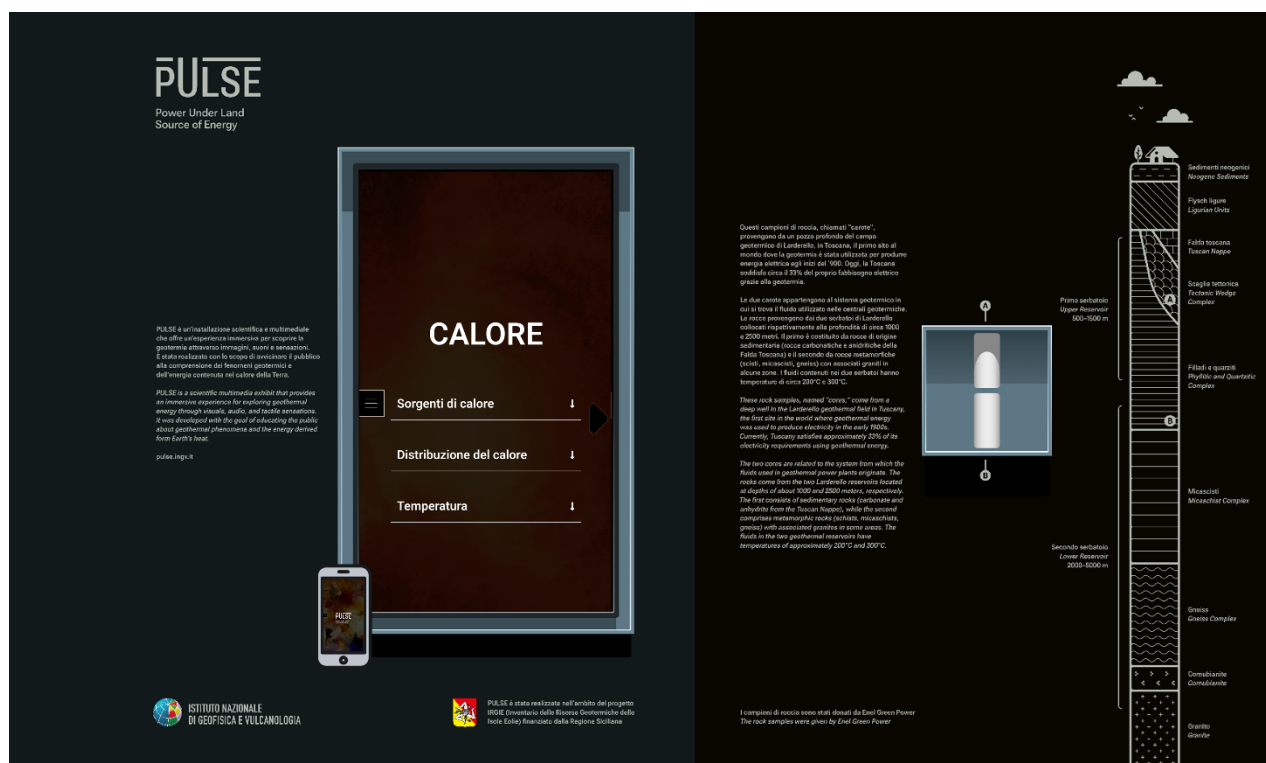


Figure 4: Schematic view of the internal section of the PULSE. On the left, the 65-inch touchscreen display provides access to multimedia educational content (pulse.ingv.it), both on-site and remotely. On the right, the illuminated display box contains rock core samples from the Larderello geothermal field (Tuscany, Italy), recognisable in the simplified stratigraphic column illustrating the geological units of the Larderello area, highlighting the position of the upper and lower geothermal reservoirs within the subsurface.



Figure 5: Detail of the box containing rock core samples
The box is designed as a small-scale quadrifera, with mirrored surfaces enhancing the perception of the rock textures and structures.

2.3 Target Audience and Expected Impact

PULSE aims to engage a wide range of visitors through its accessible and interactive format:

Young students and educators: The interactive nature of the exhibition makes it an ideal educational tool for schoolchildren and university students. By presenting scientific concepts in an intuitive and engaging way, the installation seeks to create informed and aware young citizens towards renewable energy and geothermal energy in particular (Fig. 6).

Families and the General Public: For families and casual visitors, the multisensory experience offers a unique opportunity to explore and understand the environmental benefits of geothermal energy together. The clear and engaging presentation helps demystify complex principles, making them accessible and enjoyable for audiences of all ages.

Professionals in the industry and environmentalists: The technical simulations and detailed information available through the interactive totem provide valuable insights for professionals working in the fields of energy, environment, and engineering. The installation also serves as a platform for sharing best practices and technological advancements in geothermal energy.

Local Communities and Public Administrators: Raising public awareness and understanding is essential for the social acceptance of geothermal projects. By

emphasizing the safety, efficiency, and sustainability of geothermal energy, PULSE aims to foster trust and support among local communities and policymakers.

The expected outcomes of the installation include a deeper public understanding of geothermal processes, increased social acceptance of geothermal projects, and a strengthened role for INGV in science communication. By fostering dialogue between scientific experts and the broader community, PULSE sets the stage for informed discussions on renewable energy and sustainability.



Figure 6: Middle school students observing the external component of the PULSE installation at INGV Rome.

3. CONCLUSIONS

The development and implementation of PULSE represents a pioneering effort to integrate scientific knowledge and artistic expression for the communication of geothermal energy. Through an immersive, multisensory experience that combines an outdoor digital sculpture with an indoor interactive totem, PULSE has succeeded in transforming complex geothermal concepts into accessible and engaging narratives for a broad audience. By providing an intuitive and experiential approach, the installation effectively addresses the knowledge gap that often limits public understanding and acceptance of geothermal energy, particularly in countries like Italy where geothermal resources are abundant but underutilised due to misconceptions and lack of awareness. The exhibit not only serves as an educational tool for students and the general public, but also offers valuable insights for industry professionals,

environmental advocates, and policymakers, fostering dialogue and collaboration across different sectors. PULSE serves as a compelling example of what can be achieved when artistic and scientific disciplines converge, setting a benchmark for future initiatives that are likely to yield even more impactful outcomes. PULSE is currently integrated into the educational itinerary at the INGV Rome, where it complements ongoing outreach activities focused on earthquakes, volcanic eruptions, and other natural phenomena. With the addition of geothermal energy to this programme, the installation continues to expand the institute's role in promoting public understanding of Earth sciences.

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