FONDÓN DISTRICT HEATING SYSTEM (ASTURIAS, SPAIN)

HULLERAS DEL NORTE S.A., S.M.E. (HUNOSA)

GLOBAL DISTRICT ENERGY CLIMATE AWARDS

ABSTRACT

The state-owned **HUNOSA** (HULLERAS DEL NORTE S.A., S.M.E.) is making progress with its own energy transition, from coal mining to renewable energies, upcycling resources and heritage that would otherwise only be the footprints of mining. Thus, Fondón DH System is an energy project with a significant environmental, cultural and economic impact, which also includes technical and social innovation in its development and offers a replicable solution for other cities.

HUNOSA has developed **Fondón DH network** around the facilities of Fondón Colliery (Asturias, Spain), harnessing the mine water pumped from an old mine and hybridising this solution with biomass boilers to provide heating and domestic hot water to a total of 13 buildings of different types in the town of La Felguera. All the equipment has been installed in the old terrains of Fondón Colliery, and the main technical parameters are:

- Average water available: 1.7 Hm^3/year
- Water temperature: 23ºC
- Thermal power: 3 MWt (1.5 MWt geothermal and 1.5 MWt biomass)
- Serving around 2,000 people/day
- Substitution of natural gas consumption: 2.84 GWh/year
- Renewable electricity consumption of 0.36 GWh/year (100% renewable with guarantees of origin) and 1.42 GWh/year of biomass.
- Reduction of primary energy consumption: 37.3%
- Emission reductions: 517,6 tCO_2/year

Hybridisation ensures energy supply to all customers, stabilises dependence on mine water, optimises the performance of the geothermal installation (by COP improvement) and optimises the cost of production through the implementation of an intelligent tool.

With a total budget of approximately €4,5M, it has boosted economic activity in the municipality and has witnessed the participation of local SMEs in the engineering and execution phase, the relocation of miners after specific training and the contracting of local biomass supply. Moreover, tools are provided to combat energy poverty, offering guaranteed savings compared to conventional supply.

HUNOSA has collaborated in R&D European projects to seek **innovative** technical solutions to increase and improve the use of geothermal resources (H2020 REWARDHeat). In the field of social innovation, it facilitates the regeneration of disadvantaged neighbourhoods (Horizon GINNGER).

The Fondón DH system represents an example of **replicability** linked to mine water, but also to geothermal or aerothermal systems. The future development of DH networks in the region of Asturias has been established in HUNOSA's "General Plan for the Development of DH Networks."

1. INTRODUCTION

In Spain, and particularly in our region Asturias, the mining sector played a pivotal role in industrial development for over two centuries. The closure of coal mines in recent decades has led to an economic decline in many mining towns, prompting the need for sustainable and socially inclusive energy alternatives.

HUNOSA, originally dedicated to coal mining, has undertaken a strategic transformation to become a key player in the energy transition. One of its main lines of activity is the recovery of mine water, which maintains a constant temperature throughout the year, as a geothermal energy source. HUNOSA had already demonstrated the feasibility of this approach with the earlier Barredo geothermal facilities, operational since 2014.

With Fondón DH System, important technical improvements have been achieved and the thermal resource has been significantly increased thanks to the hybridisation of the system.

2. TECHNICAL DESCRIPTION OF THE DH POZO FONDON

Fondon DH system is built upon the reuse of existing mining infrastructure in Langreo (Asturias, Spain). The mine shaft, with a depth of 450 m, is connected to other mines in the Nalón basin through a hydrogeological system with a total volume of 8 Hm^3 of flooded voids. Fondón is the lowest point in the system and serves as the central extraction point for mine water. Each year, approximately 1,7 Hm^3 of mine water is pumped to the surface at a stable temperature of 23°C.

Water extraction is performed using four submersible pumps (30 kW each), and the geothermal energy is recovered via shell-and-tube heat exchangers. The thermal energy is transferred to a primary circuit, which feeds the evaporator side of two water-to-water heat pumps installed in series and counterflow configuration. These units provide a combined output of 1.5 MWt (1,020 kWt and 513 kWt respectively).

The geothermal system reduces the temperature of the mine water from 23°C to 18°C before it is discarded. The generation plant is housed in the former compressor room of the mine, now repurposed as a modern energy facility. The heating circuit (condenser side) operates with modulating temperatures, reaching up to 85°C depending on demand and ambient conditions.

In response to increasing demand and the need to reduce stress on the geothermal source, the system has been hybridised with two biomass boilers, each rated 750 kWt, adding another 1.5 MWt of thermal capacity.

The integration is supported by two stratified thermal storage tanks (12,000 L each), which receive energy from both the geothermal and biomass systems. These tanks operate as independent thermal layers, allowing flexible energy dispatch based on demand profiles.

An intelligent control system determines the most efficient energy source based on real-time parameters such as external temperatures, expected heat demand, energy prices (electricity and

woodchip), and equipment's Coefficient of Performance (COP). This decision matrix supports three operational modes:

- Low demand (<750 kWt): selection between geothermal or biomass.
- Medium demand (750–1500 kWt): use of either source or combined operation.
- High demand (>1500 kWt): simultaneous operation in hybrid mode.

This smart hybridization strategy was conceptually developed during HUNOSA's participation in the Horizon 2020 REWARDHeat project.

The development of the DH Pozo Fondón network was carried out in successive phases, progressively connecting buildings of different uses. In total, 13 buildings will be connected, including a health centre, public housing units, an educational centre, a sports facility, and the HUNOSA Historical Archive. The current installed capacity of the substations is 3.95 MWt with 9 buildings (phase I + phase II), with plans to reach 5.73 MWt in the third phase.

The Fondón DH System project was co-financed through a combination of public and European funding mechanisms:

- FEDER grants: 1,651,675.00 € (EIX4 - Urban Development) (Phase I+ Phase II)
- IDAE (Spanish Institute for Energy Diversification and Saving): 158,972.35 € for the next phase III.
- EU Horizon 2020 - REWARDHeat Project: 114,445.24 €
- EU Horizon Europe - GINNGER Project: 141,375.00 €

These complementary funds supported infrastructure works, equipment installation and innovation pilot testing across the different implementation stages.

3. INNOVATIVE APPROACHES

From its inception, the Fondón DH project was designed to go beyond conventional geothermal installations by integrating innovation in both technical and social dimensions. The hybridisation of a mine-water-based geothermal system with a biomass backup source is, to the best of our knowledge, the first of its kind implemented in Europe.

This innovative configuration allows for enhanced operational flexibility, maximising the efficiency of the geothermal system while ensuring continuity of service even during peak demand periods. The smart control system that governs the hybrid installation was developed as part of the Horizon 2020 REWARDHeat project, where HUNOSA played an active role in modelling and conceptualising such hybrid networks.

The use of stratified storage tanks is another key technical innovation. These tanks act as modular energy buffers, enabling the system to layer thermal energy from both sources, geothermal and biomass, into temperature-dependent zones. This approach not only improves energy efficiency but also reduces wear on generation equipment by avoiding frequent start-stops.

From a social innovation perspective, the project was conceived within the framework of the Horizon Europe GINNGER project, which promotes the regeneration of disadvantaged neighbourhoods through co-creation processes with stakeholders, local authorities and citizens. In this context, HUNOSA facilitated the connection of social housing units and public service buildings to the network, targeting energy poverty mitigation.

Moreover, the business model adopted ensures a minimum 10% energy cost saving compared to conventional natural gas systems, as well as long-term price stability due to the use of renewable resources. The service model is built around Energy Service Contracts (ESCOs), which reinforce user confidence and facilitate broader adoption.

Lastly, the integration of the HUNOSA Historical Archive into the network is a symbolic and functional innovation. By providing a stable and sustainable indoor climate, it supports the conservation of thousands of historical documents while reinforcing the project's connection with the mining heritage of the region.

4. ENVIRONMENTAL AND SOCIO-ECONOMIC IMPACTS

Fondón DH system delivers significant environmental and socio-economic benefits, both locally and in alignment with broader climate goals such as reducing greenhouse gas emissions and improving energy efficiency.

Environmentally, the project replaces 2.84 GWh/year of natural gas consumption with 0.36 GWh/year of certified renewable electricity and 1.42 GWh/year of biomass. This transition results in a 37,3% reduction in primary energy consumption and avoids an estimated 517,6 tons of CO_2 emissions annually. Moreover, by eliminating the use of natural gas boilers in connected buildings, it contributes to the improvement of urban air quality and reduces the urban heat island effect.

The use of biomass, sourced locally from forestry residues, promotes responsible forest management practices and fosters a regional bioenergy supply chain. The recovered geothermal energy is now valorised as a renewable asset, enhancing circular economy principles.

From a socio-economic perspective, the project is located in Langreo, a municipality in economic decline due to the deindustrialization of the coal sector. The implementation of the Fondon DH Network has stimulated the local economy through, the participation of local SMEs in engineering and construction phases, the retraining and employment of former miners for operation and maintenance roles, and the creation of indirect jobs linked to biomass supply and logistics.

In terms of energy equity, the system prioritizes connection to public buildings, schools, and social housing. Residents benefit from guaranteed cost savings compared to conventional heating systems. This is especially relevant in a region where unemployment has historically ranged between 19% and 28%, and energy poverty remains a pressing concern.

The project has also strengthened cultural and community identity by restoring heritage assets, such as the old coal treatment pavilions and the HUNOSA Historical Archive. These restored buildings now play active roles in the energy transition, serving functional and symbolic purposes.

5. REPLICABILITY AND FUTURE PLANS

The success of the Fondon DH project establishes a replicable model for other post-mining regions seeking to transition to renewable heating. The technical approach—based on the hybridization of geothermal mine water energy with biomass, supported by smart controls and stratified storage—is modular and scalable.

HUNOSA has already demonstrated replicability through its earlier experience with the DH Pozo Barredo project in Mieres, currently the largest geothermal heating installation in Spain. Lessons learned from Barredo and Fondon are now being integrated into a broader roadmap, the "General Plan for the Development of Heat Networks," which aims to implement similar networks across the Asturian mining basin.

The approach is especially well-suited for regions with a) abandoned or flooded mine infrastructure, b) high levels of energy poverty, c) degraded industrial heritage assets suitable for reuse., d) access to biomass resources and forested areas.

Through its involvement in EU research programmes and alignment with national decarbonisation policies, HUNOSA is positioning itself as a leader in geothermal-based district heating. In future phases, it is expected that the model will be expanded not only regionally but also internationally through knowledge transfer, participation in European consortia and cooperation with other coal regions in transition.

6. SUMMARY

The Fondón DH System stands as a benchmark in the transformation of former coal mining infrastructures into renewable energy systems. It demonstrates the technical feasibility and socio-economic benefits of hybridizing geothermal mine water with biomass in district heating networks.

This initiative goes beyond energy generation, embracing innovation, equity, sustainability and heritage preservation. It contributes to climate targets while revitalizing a territory afflicted by deindustrialization. Its replicable model offers a valuable reference for other regions undergoing similar transitions.