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Overview of nGEL Thermal Energy Storage for Flexible Power Generation at Kızıldere-2 GPP

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INTRODUCTION

The Horizon Europe–funded nGEL Project aims to enhance the flexibility of geothermal power plants by integrating Thermal Energy Storage (TES) into the existing system at Kızıldere-2 GPP. TES enables storing excess thermal energy during low-demand periods and releasing it during peaks, improving load balancing, efficiency, and grid participation.

This study focuses on the technical integration of TES and its economic feasibility, demonstrating its potential to make geothermal power generation more flexible, sustainable, and market-responsive.

METHODS

To achieve flexible heating, cooling, and power generation, the nGEL system integrates key components for energy storage and conversion:

Heat Source: Separator outlet from the power plant.

TES & HX01: Stores excess heat during low demand.

Secondary ORC: Converts stored heat into electricity during peak demand.

Absorption Chiller: Provides cooling when needed, bypassing storage.

HX02: Supplies heat directly to district heating or greenhouses.

CTES: Stores cold energy to increase system flexibility.

Control System & EMS: Directs flow between TES, ORC, chiller, and district heating based on grid requirements. (Fig. 1)

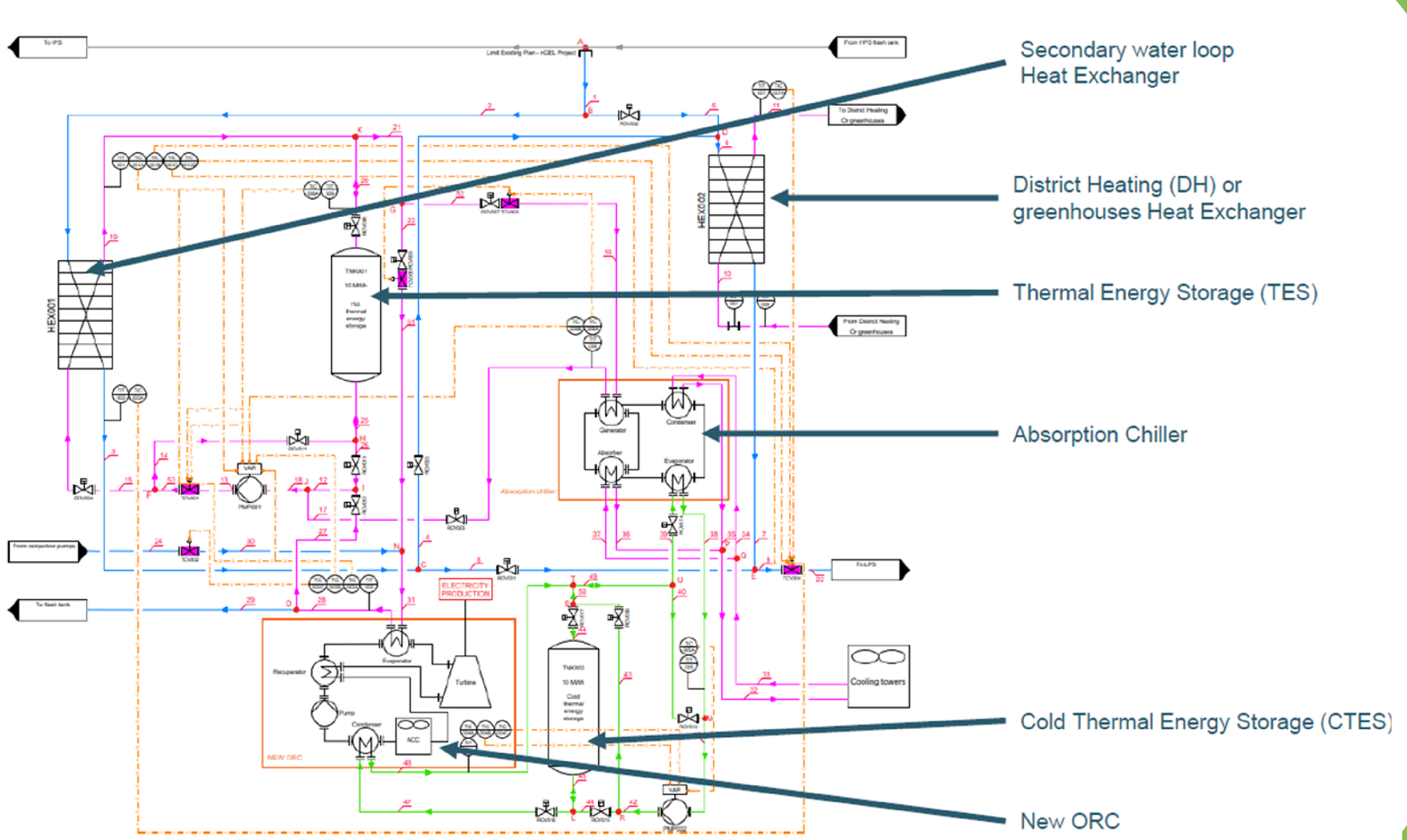


Figure 1. Preliminary P&ID for the nGEL system

EXPECTED RESULTS

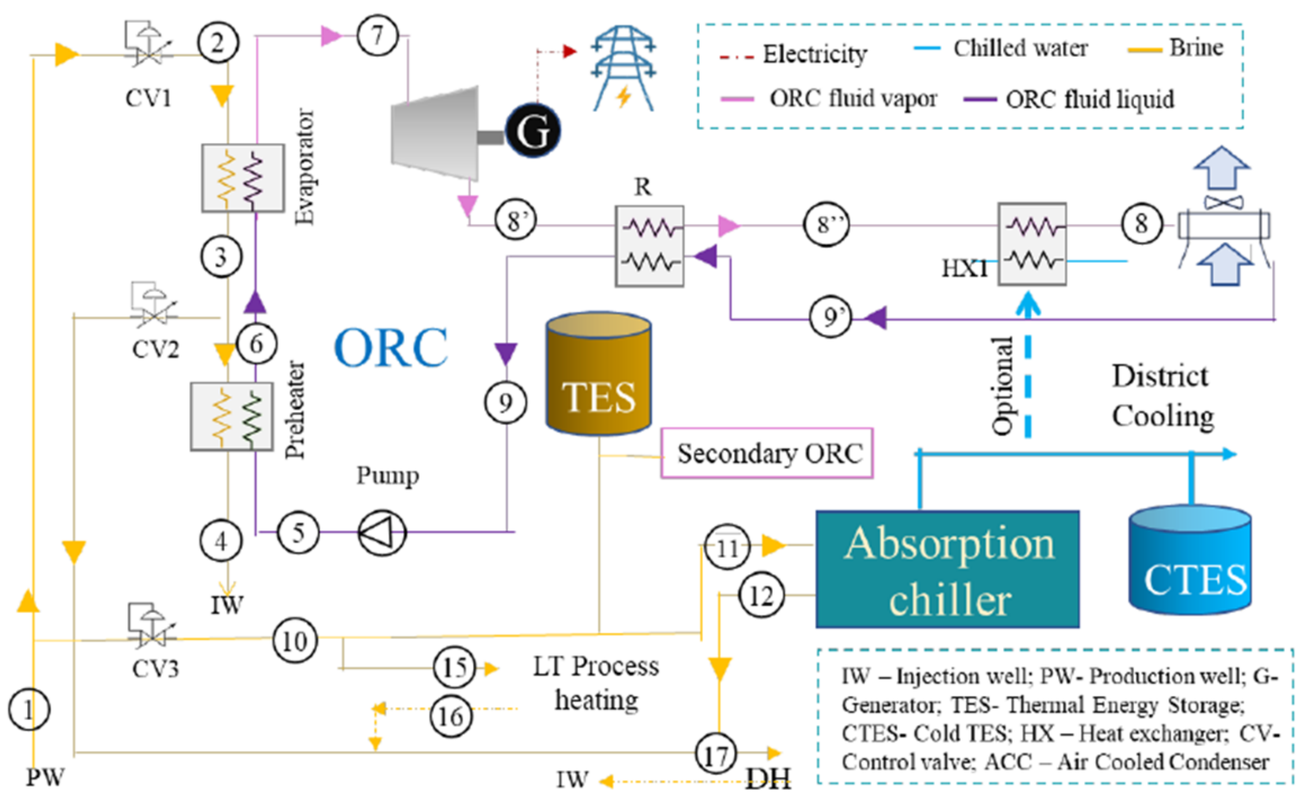


Figure 2. nGEL Consept Design

The nGEL system is designed to demonstrate flexible tri-generation by efficiently managing electricity, heating, and cooling. In Figure 2, Thermal Energy Storage (TES) serves as the central hub, storing excess heat for later use by the secondary ORC during peak hours. The secondary ORC converts TES heat into electricity, while the absorption chiller provides cooling on demand. Heat can also be delivered directly to district heating networks or greenhouses via HX02, and Cold Thermal Energy Storage (CTES) complements TES by storing and releasing cold energy. The integrated control system and EMS optimize flow paths among TES, CTES, ORC, absorption chiller, and district heating to ensure efficient, reliable operation. By coordinating energy storage and conversion, the system enhances responsiveness to grid demand, improves operational flexibility, and reduces reliance on external energy sources. Overall, the nGEL system is expected to provide valuable technical insights and demonstrate economic potential for future scaling in flexible geothermal power generation.

DISCUSSION

The nGEL TES and CTES system will enable flexible tri-generation, allowing the plant to respond efficiently to electricity, heating, and cooling demands. By storing excess heat and cold energy, the system can optimize electricity generation during peak hours and provide heating or cooling without relying on fossil fuels, reducing carbon emissions. Integration of the absorption chiller and secondary ORC poses technical challenges in flow control and responsiveness, which are addressed through the EMS. Successful nGEL demonstration at Kızıldere-2 GPP will provide valuable insights for scaling up, enhancing grid support, and evaluating economic benefits, highlighting the potential of energy storage to improve both operational flexibility and environmental performance.

CONCLUSION

The nGEL TES and CTES integration in nGEL demonstration system at Kızıldere-2 GPP is expected to demonstrate the feasibility of flexible tri-generation. By dynamically managing electricity, heating, and cooling, the system enhances operational flexibility, supports grid responsiveness, and promotes environmental sustainability. The demonstration will provide critical insights for scaling the system, improving economic performance, and advancing the adoption of flexible geothermal solutions.

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