



**SUSTAINABLE
PLACES 2025**

8-10 October 2025

Milano

R2M
RESEARCH TO MARKET
SOLUTION

**RENEWABLE MULTI-GENERATION FOR A
DECARBONISED EUROPE**

WORKSHOP

Valorising Renewable Thermal Energy

Innovative Renewable Multi-Generation Energy Systems for Flexibility & Sector
Coupling

REGEN² by



Smart Use of Geothermal Energy



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Next renewable multi-generation technology enabled by two-phase fluids machines

Grant agreement ID: 851541

Start date: 1

September 2020

EU Contribution: € 4,346,688.47

End date: 28 February 2026

H2020-LC-SC3-RES-1-2019-2020 - Developing the next generation of renewable energy technologies

Next generation flexible trigeneration geothermal ORC plant

Grant agreement ID: 101148170

Start date: 1

June 2024

EU Contribution: € 4,346,688.47

End date: 31 May

2028

HORIZON-CL5-2023-D3-02-06 - Smart use of geothermal electricity and heating and cooling in the energy system



Smart Use of Geothermal Energy



Smart Use of Geothermal Energy

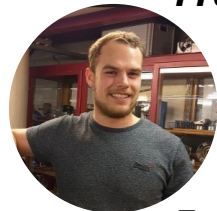


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İrem





Next renewable CCHP technology enabled by two-phase flow machines

Stefano Briola, *Tifeo*

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TIFEO

<https://tifeo.eu/>



This project has received funding from the European Union's Horizon 2020 research and innovation programme under Grant Agreement n° 851541



Two-phase flow machines

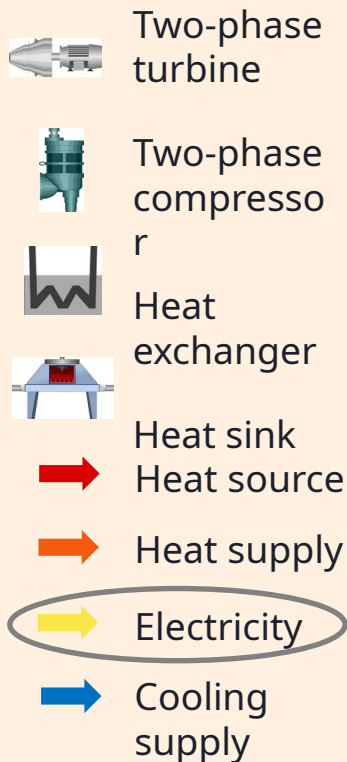
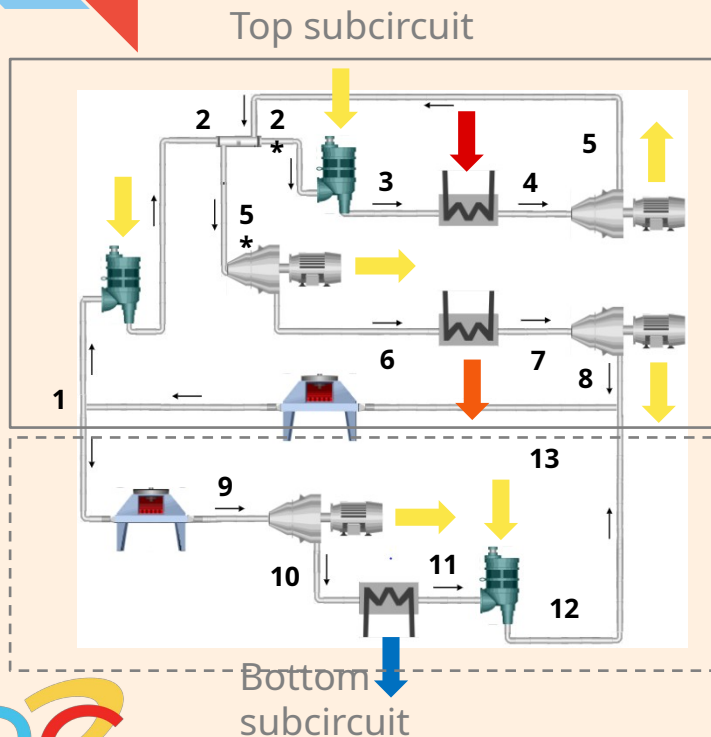
Innovative two-phase flow turbines and compressors

- Operating with both liquid and vapor phases simultaneously

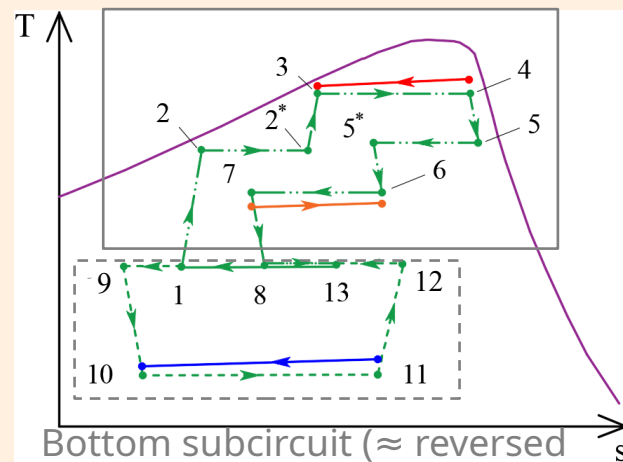
Tifeo's patented technologies based on two-phase machines

1. Combined Cooling Heating Power (CCHP) process & plant
2. High-Temperature Heat Pump (HTHP) process & plant
3. Long-term electric and thermal energy storage

Tifeo CCHP technology: Process & plant



Top subcircuit ($\approx$ direct Carnot)



Reversible process & plant

• CCHP $\longleftrightarrow$ HTHP



Tifeo CCHP technology: Advantages

- High efficiency
- High operational flexibility
- Modularity
- Scalability
- Transitioning between CCHP, CHP, CCP modes
- Capability to use multi-T heat sources simultaneously

Market opportunity: CCHP users

Industry

- Food & beverage
- Pharmaceutical, biotechnology
- Chemical, Petrochemical
- Non-metallic minerals
- Iron & steel
- Electric vehicle manufacturing
- Pulp & paper & printing

Aerospace

- Satellites, space stations

Heavy-duty transportation

- Cruise & cargo ships

AI data centers

Tertiary

- Food retails, shopping malls
- Offices
- Hotels, restaurants, resorts
- Hospitals, clinics, medical labs
- Universities, research centers
- Stadiums, gyms, swimming pools
- Airports, railway stations and bus terminals
- Amusement parks and tourist attractions

Residential

- Multi-use buildings

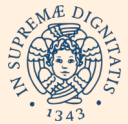
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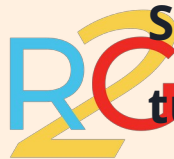
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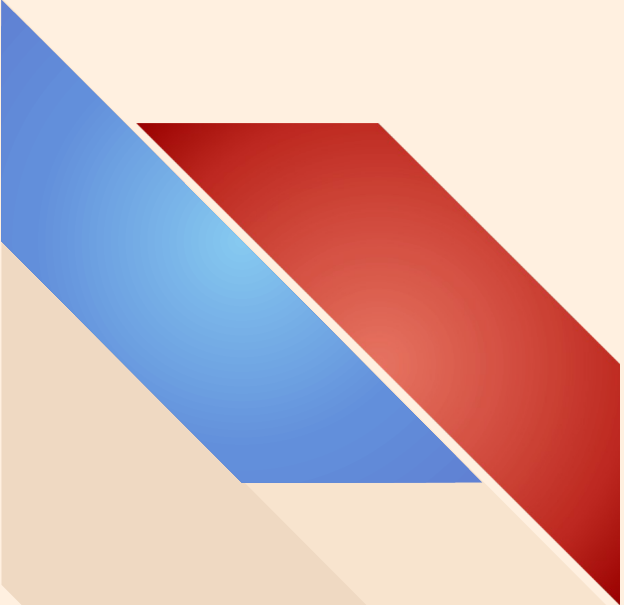
Next steps

Step 1: Deployment of two-phase turbomachinery in commercial plants

- Energy field: VCR plants, steam/ORC/geothermal power plants, ASUs, heat pumps, cryogenic (liquefaction, CO₂ capture) plants
- Hydrocarbon field: oil & gas wells, oil refineries, chemical



Step 2: Development of Tifeo's tech based on two-phase turbomachinery



REGEN²by

Two-phase scroll machines

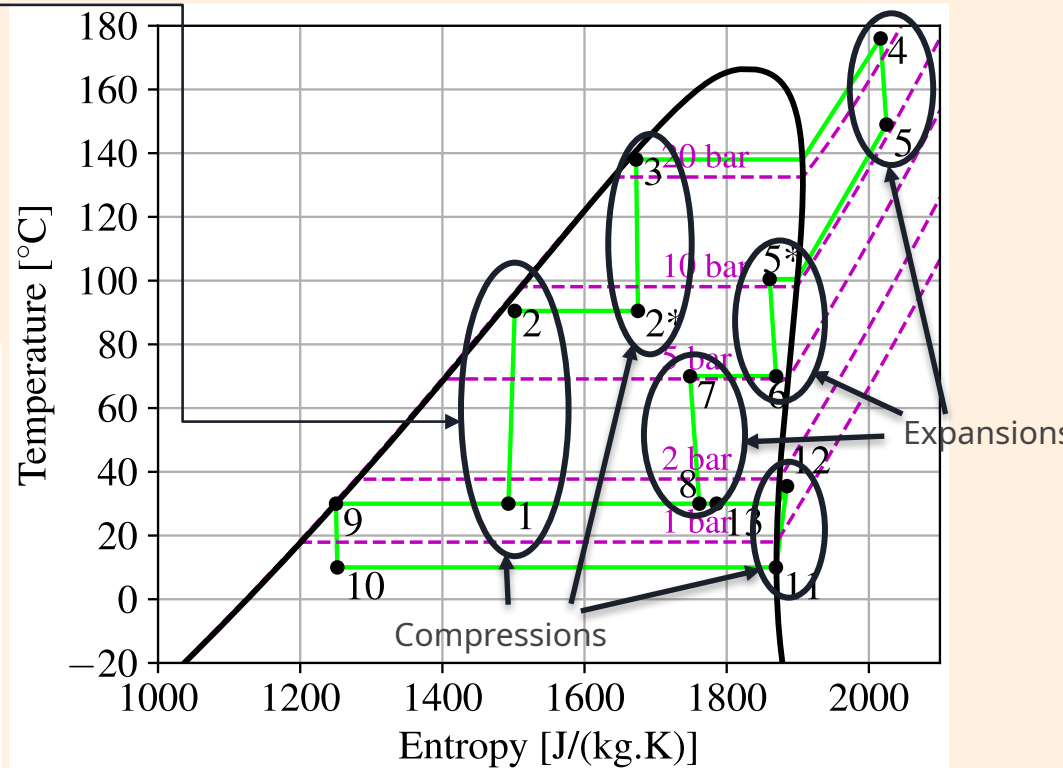
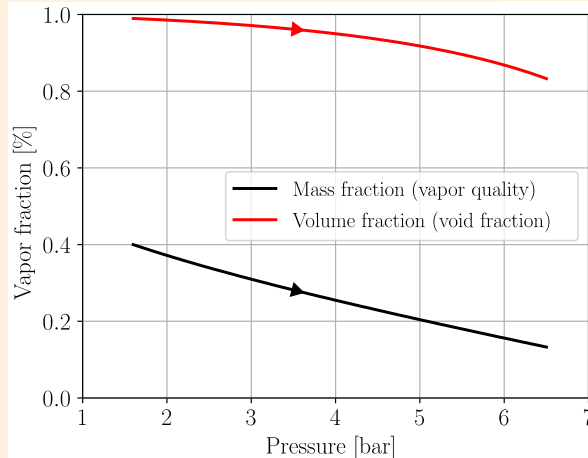
Nicolas Leclercq, *ULiège*



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Scroll machines designed for the plant

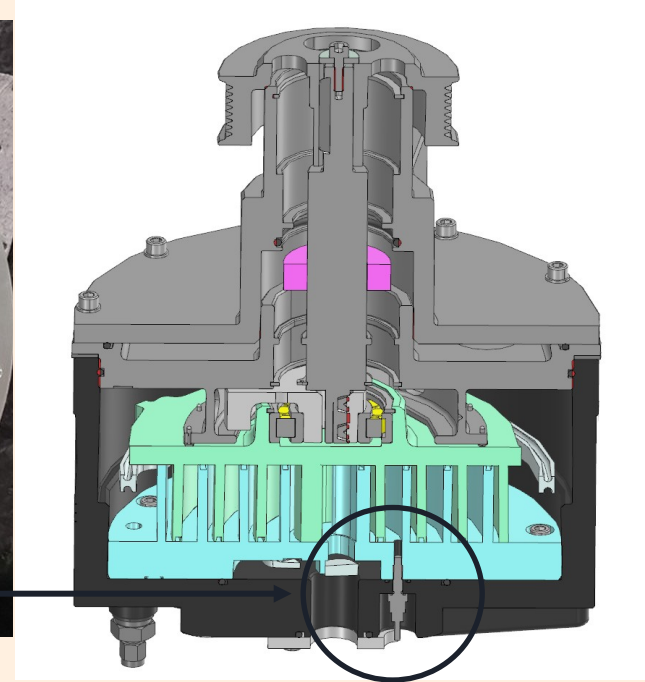
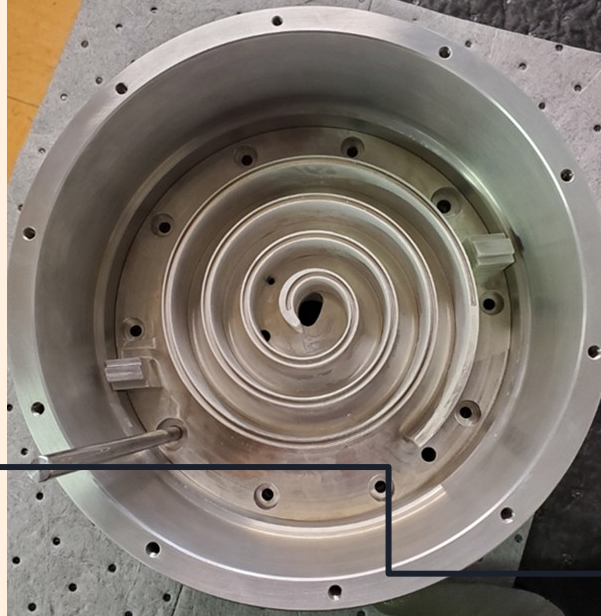
	Comp (1-2)
Inlet temperature T [K]	303
Inlet pressure P [bar]	1.6
Inlet quality Q [-]	0.39
Pressure ratio r_p [-]	5.5
Inlet average density [kg/m^3]	21
Speed [RPM]	3100
Fluid mass flow rate [kg/s]	0.208
Displacement volume [cm^3]	200
Compressor power [W]	2400



Scroll compressor prototype

Characteristics:

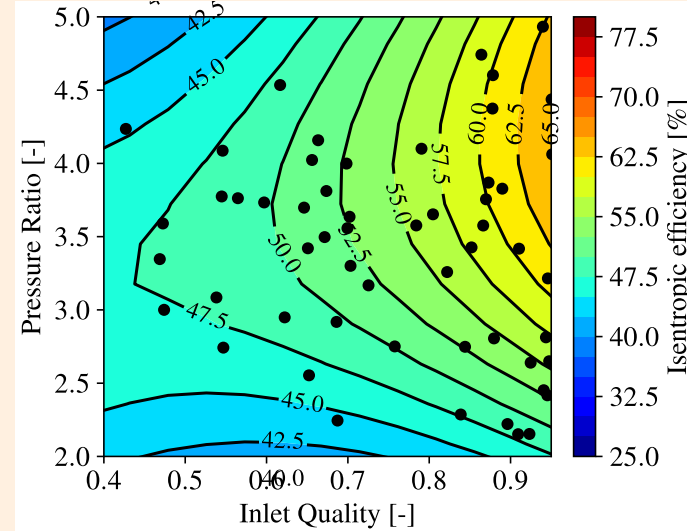
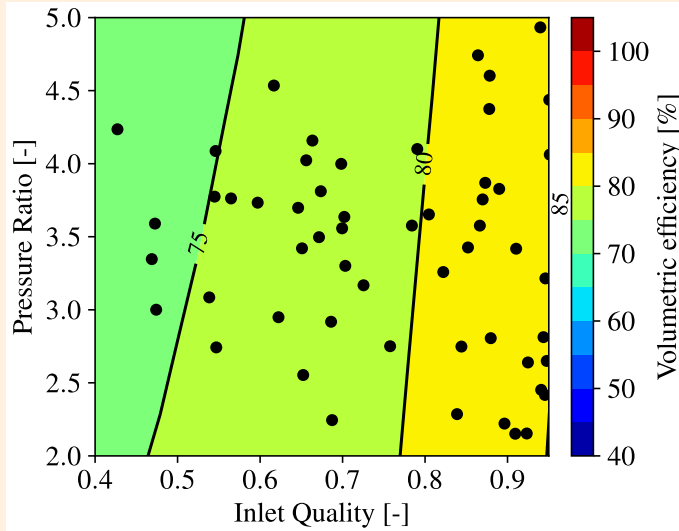
- High displacement volume $\rightarrow 200 \text{ cm}^3$
- High built-in volume ratio $\rightarrow 3$
- Radial compliance
- Embedded pressure sensor



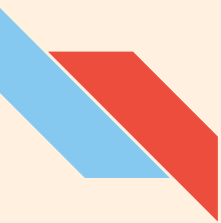
Prototype performance

$$\varepsilon_v = \frac{\dot{m}_{tot}}{N \cdot V_{disp} \cdot \rho_{su}}$$

$$\varepsilon_{is} = \frac{\dot{m}_{tot} w_{is}}{\dot{W}_{shaft,cp}}$$



Pressure of 1.5 bar, OCR of 5% and compressor speed of 2500 RPM



What has been learned?

The modeling and the experimental works carried out on the two-phase compression machines has taught us the following:

- Scroll compressors are robust machines to work in two-phase regime
- Working with two-phase refrigerant flows reduces the pressure ratio for a given volume ratio → high built-in volume ratio needed when working at high compression ratios
- Two-phase compression creates irreversibilities due to temperatures difference between the two phases
- Due to the liquid, the leakage gaps of the machine can be increased, leading to higher leakages and lower volumetric efficiencies
- On the contrary to screw compressors where mechanical losses caused by the liquid are important, they are negligible in scroll compressors due to the low speeds involved

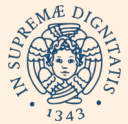
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Analysis of users and thermal demands on trigeneration units

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energy
research

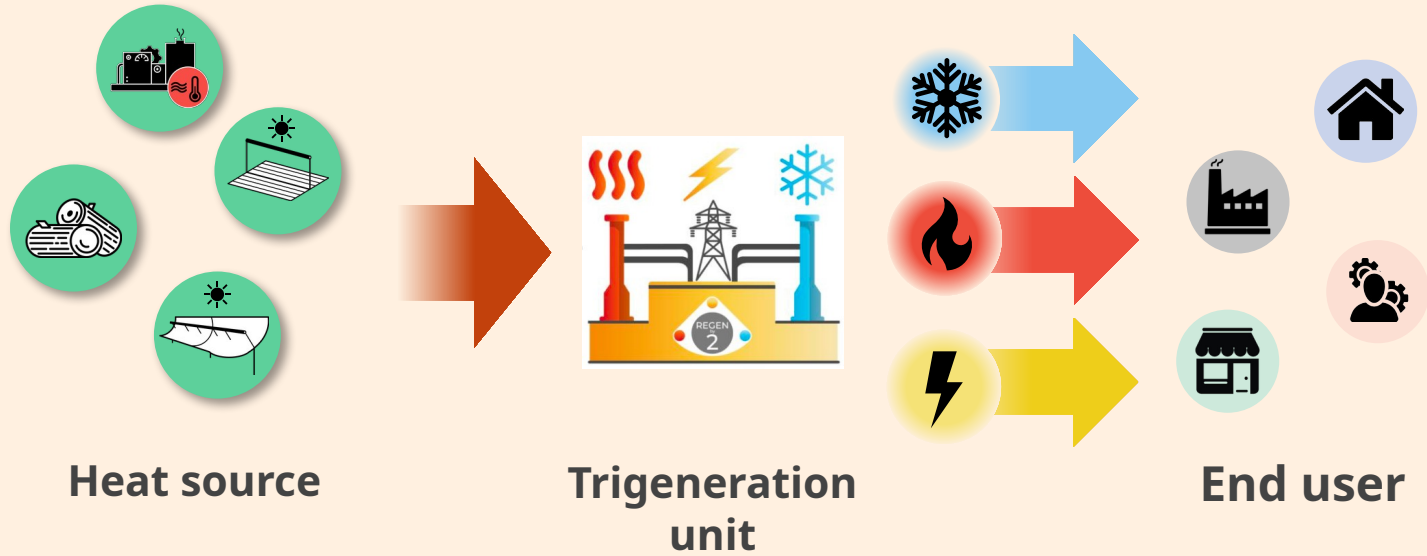


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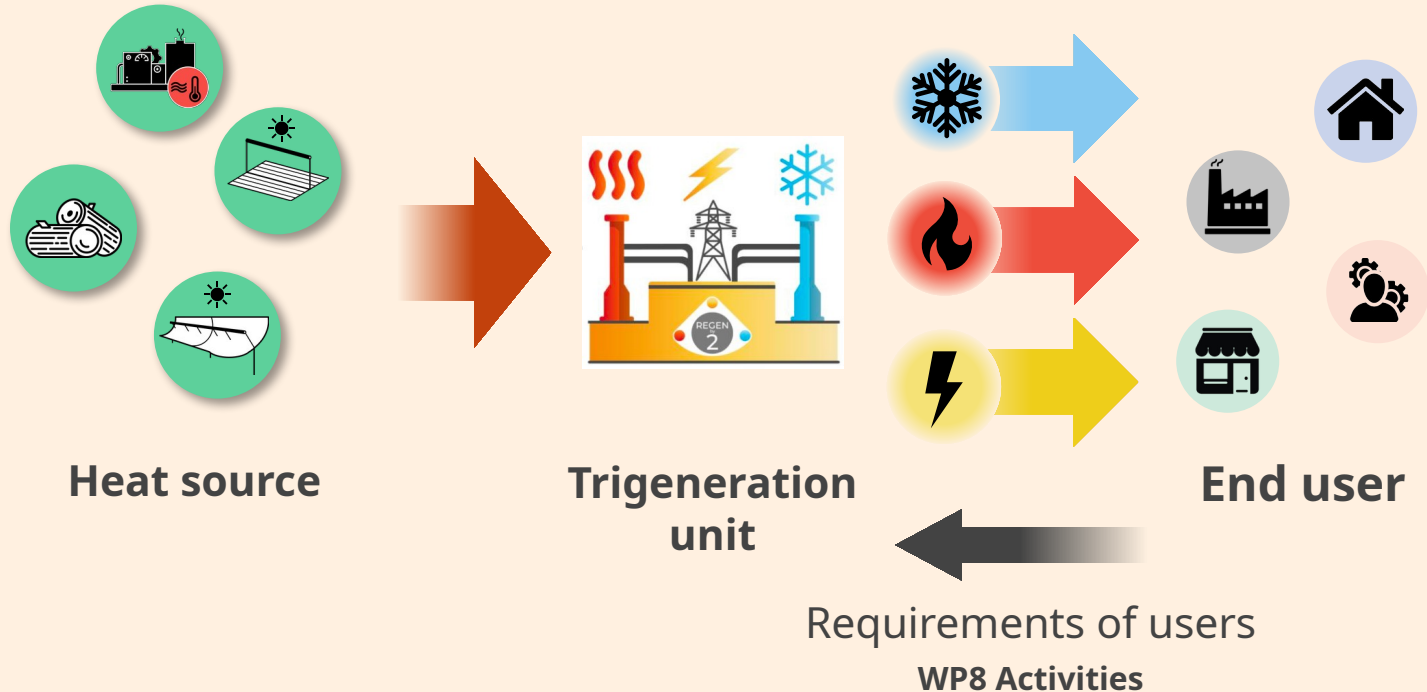


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REGEN-by-2 system



REGEN-by-2 system – investigation



Investigated user types

Industry

- Large consumer of heat & cold
- No changes in season
- Potentially high temperature in heat demand
- Waste heat as source



Residential

- Individual users
- Seasonal energy demands
- Demand by climate
- Heat & cold temperature well in line with project unit



Retail

- Mainly heating demand
- Cold covered by refrigerators & freezers
- No changes in season



Office

- Individual users
- Seasonal energy demands
- Demand by climate
- Heat & cold temperature well in line with project unit



Combination of user types

Reality

User types are not isolated. They are in close distance



Google Maps: Weinstadt, Germany

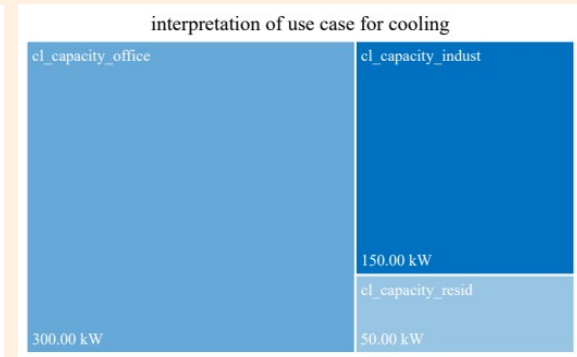
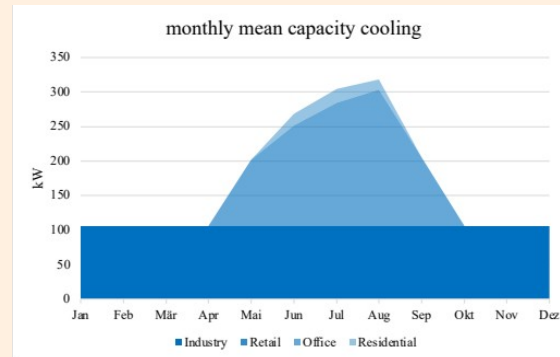
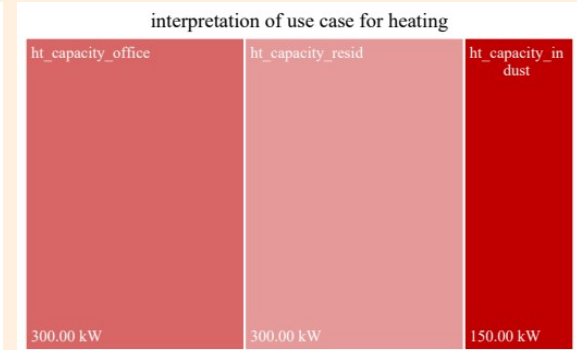
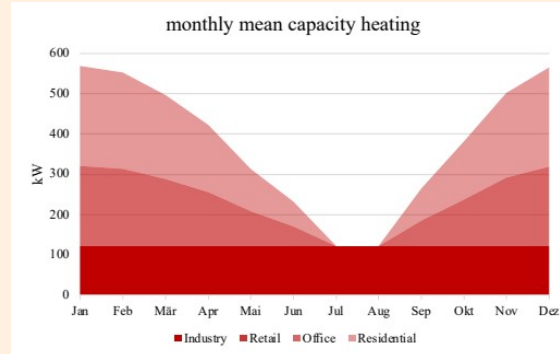
Demand of mixed users

'Berlin Mix'



Industrial waste heat
serves as heat source

Centralised approach,
District Heating/
Cooling Networks
required

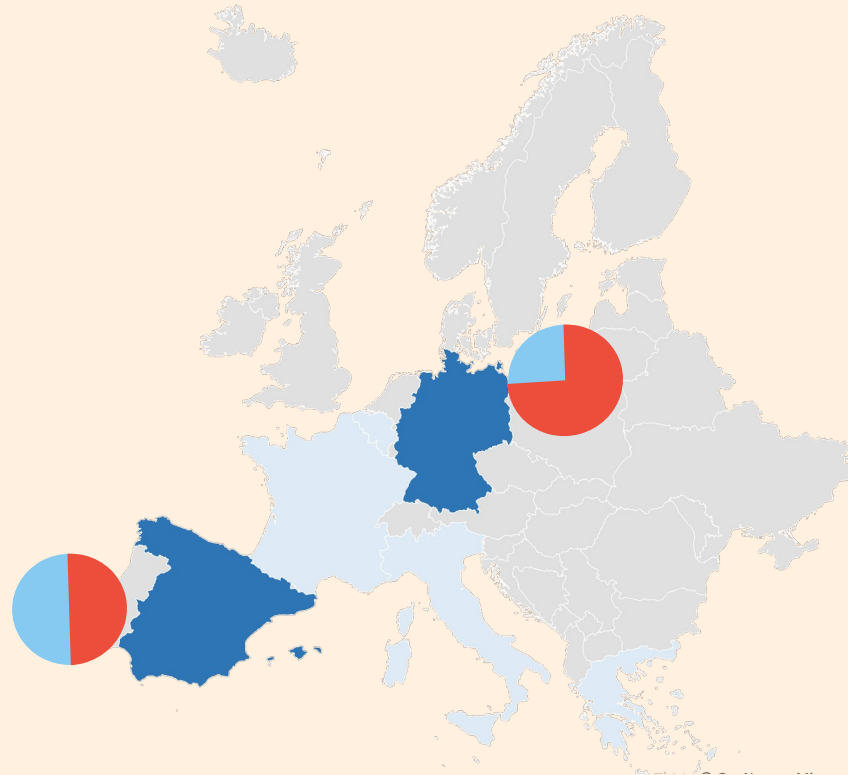


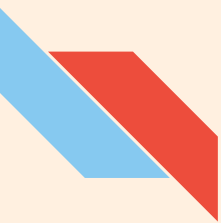
Impact of climate

'Berlin Mix'



Total demand of heat and cold still depends on the local climate.





Learnings & requirements on operation

- **Heat source relevance**

- Industrial sites have highest potential in heat source
- Timely availability of heat source

- **TES & System**

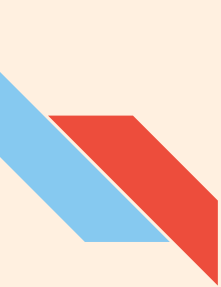
- Relevant for coverage demand
- Crucial for sizing of system/ plant (large variation in here)
- Potential for back-up/ peak load boiler

- **Temperatures**

- Heat Input: Waste heat as promising source of heat
- Heat Output: One supply temperature for all users (?)
- Cold Output: Industrial users may require cooler temperatures than residential or office

- **Power generation**

- Electricity is always required, may increase payback period



Conclusion and next steps

- **User types and climate are fundamental for the unit operation**
- **Adaption of REGEN-by-2 plant/unit to use-case**
- **Detailed dynamic analysis of plant/unit performance**
- **Investitgation on flexible heat supply**
(e.g. fluctuation of heat supply from concentrating solar thermal collectors)

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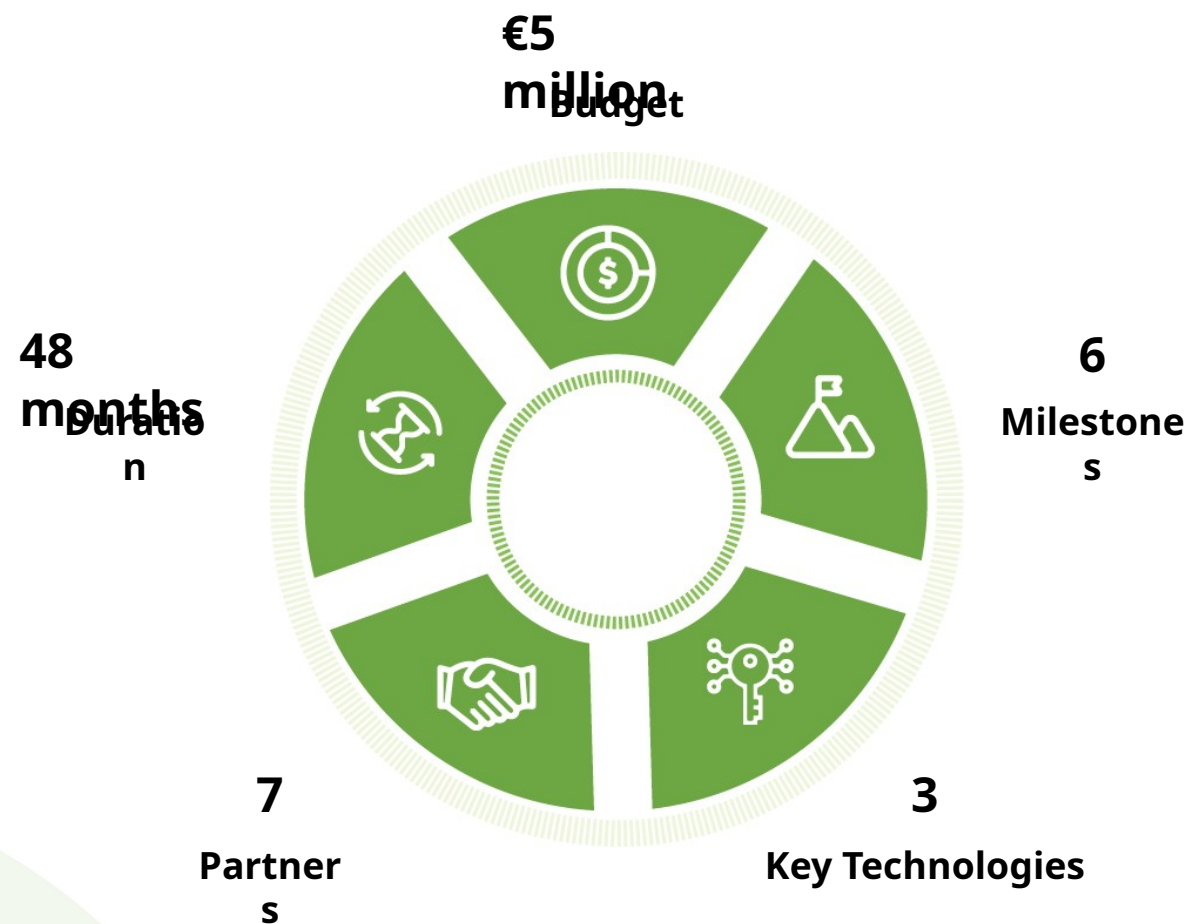
Next Generation Flexible Trigeneration Geothermal ORC Plant

Innovating Geothermal Energy for
a Carbon-Neutral Europe



This project has received funding from the Horizon Europe Framework Programme (HORIZON) Research and Innovation Actions under grant agreement No 101148170.

Project Overview



Consortium



Missio



Core Mission

To transform geothermal Organic Rankine Cycle (ORC) plants into flexible tri-generation systems that produce electricity, heating, and cooling, using an AI-integrated Energy Management System (EMS).



Energy Demand Focus

Heating and cooling account for 46% of EU energy consumption, with only 18% met by renewables. nGEL targets the untapped potential of low-to-medium temperature geothermal resources to balance energy demands.



Scalability Potential

If applied across the EU, nGEL could meet about 4% of the EU's current annual heat demand, equivalent to an economic saving of €9.6 billion annually through reduced natural gas imports.

The



Energy Consumption Gaps: Heating and cooling represent 46% of the EU's energy use, but renewables only cover a fraction of this demand.



Reliance on Fossil Fuels: Natural gas is a primary source, creating economic and environmental vulnerabilities.



Grid Instability: Current renewables (e.g., solar, wind) are intermittent, challenging grid stability.



Low-Temperature Resources: Europe has abundant low-enthalpy geothermal fields, but they are underutilised, especially in binary ORC plants.

What is



Flexible and Scalable Renewable Energy:

nGEL's tri-generation system provides flexibility for various energy demands.



Real-Time Demand Response:

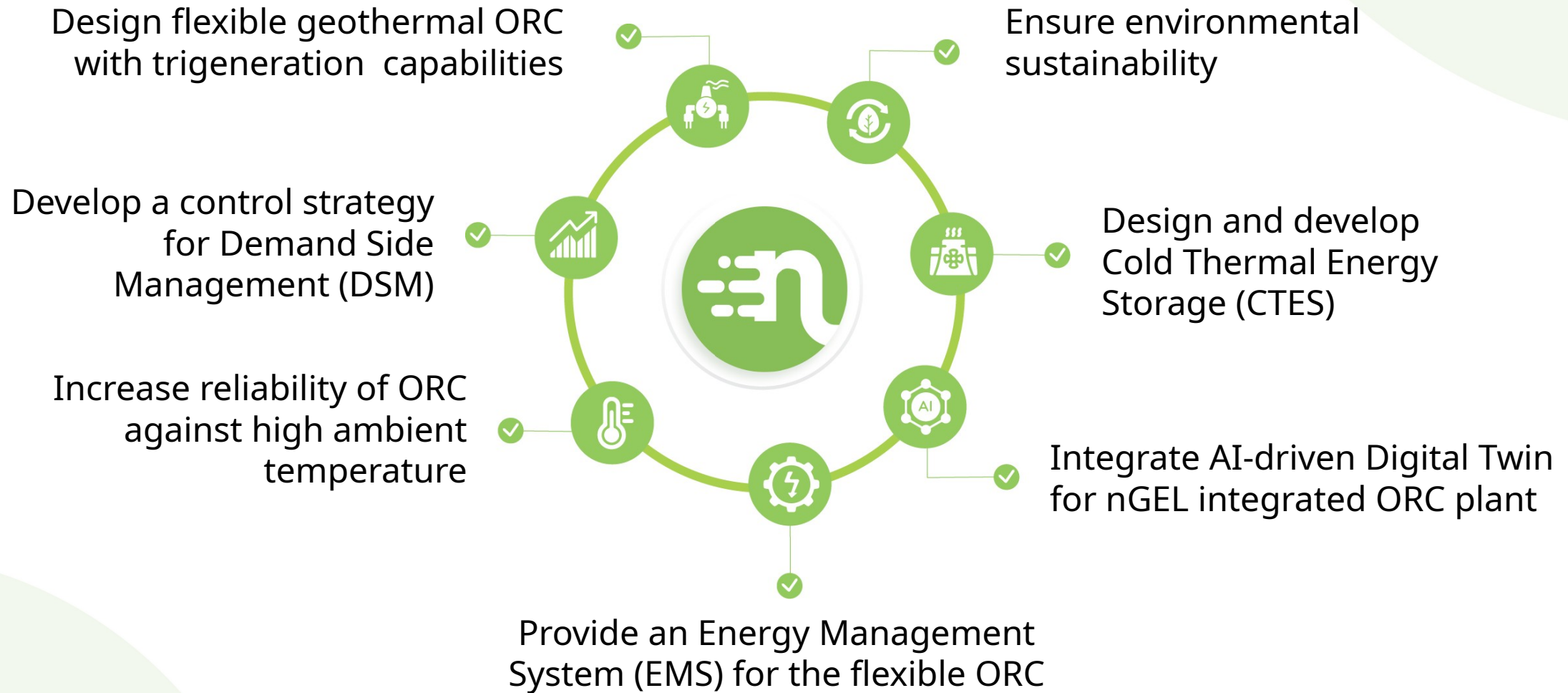
An AI-driven EMS, integrated with cold and thermal energy storage, enhances grid compatibility and supports the day-ahead energy market.



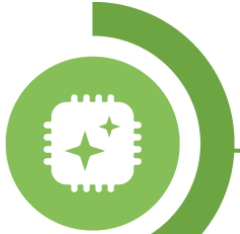
Scalability Across the EU:

The technology targets sedimentary formations (e.g. Pannonian Basin and Upper Rhine Graben) and can be implemented widely with existing and new ORC infrastructure.

Project Objectives



nGEL Project



AI-Driven EMS

Schedules power, heat, and cooling output in real-time



Cold Thermal Energy Storage (CTES) and Hot Thermal Energy Storage (HTES)

Based on market and demand forecasts.

Storage solutions ensure energy availability during peak demand.



Absorption Chiller and Heat Exchangers

Enable cooling alongside power and heating, enhancing multi-functional use.

Expected Outcomes

Meets dynamic energy needs and contributes 4% to the EU's heating demand, with substantial reductions in reliance on imported natural gas.

Key



Digital Twin of ORC Plant

AI-driven digital twin to monitor, predict, and optimise plant operations, ensuring peak performance.

Demand Side Management (DSM)

Adaptive control strategies to handle fluctuations in demand and grid needs.

Enhanced Resilience

Ensures operational reliability even in high ambient temperatures, essential for summer demandspikes.

Smart Control Integration

Optimises tri-generation flexibility by balancing output across power, heating, and cooling.

Concept and Methodology



Methodology



Design Philosophy

Digital Twin Integration

Uses AI-based simulation models to optimise ORC system performance.

Cold Thermal Energy Storage and Thermal Energy Storage Development

Designs and implements CTES and TES for enhanced grid resilience.

Demand Side Management

Creates a responsive energy solution by optimising energy output to match grid requirements.

Demand Side Management

Flexibility and environmental sustainability are at the core, with scalable solutions adaptable to various European regions.

Expected Outcomes



Cost Efficiency

Reduces capital, operational, and maintenance costs, making geothermal energy more competitive.



Environmental & Societal Benefits

Lower CO2 emissions and significant contributions to the EU's climate neutrality goals.



Increased ORC Competitiveness

Enhances geothermal ORC technology's role in Europe's renewable energy landscape.



Energy Security & Grid Resilience

Provides a reliable renewable energy source to stabilise grids, especially during intermittent renewable peaks.

Contact

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Jamali**

**Organisation: Fraunhofer
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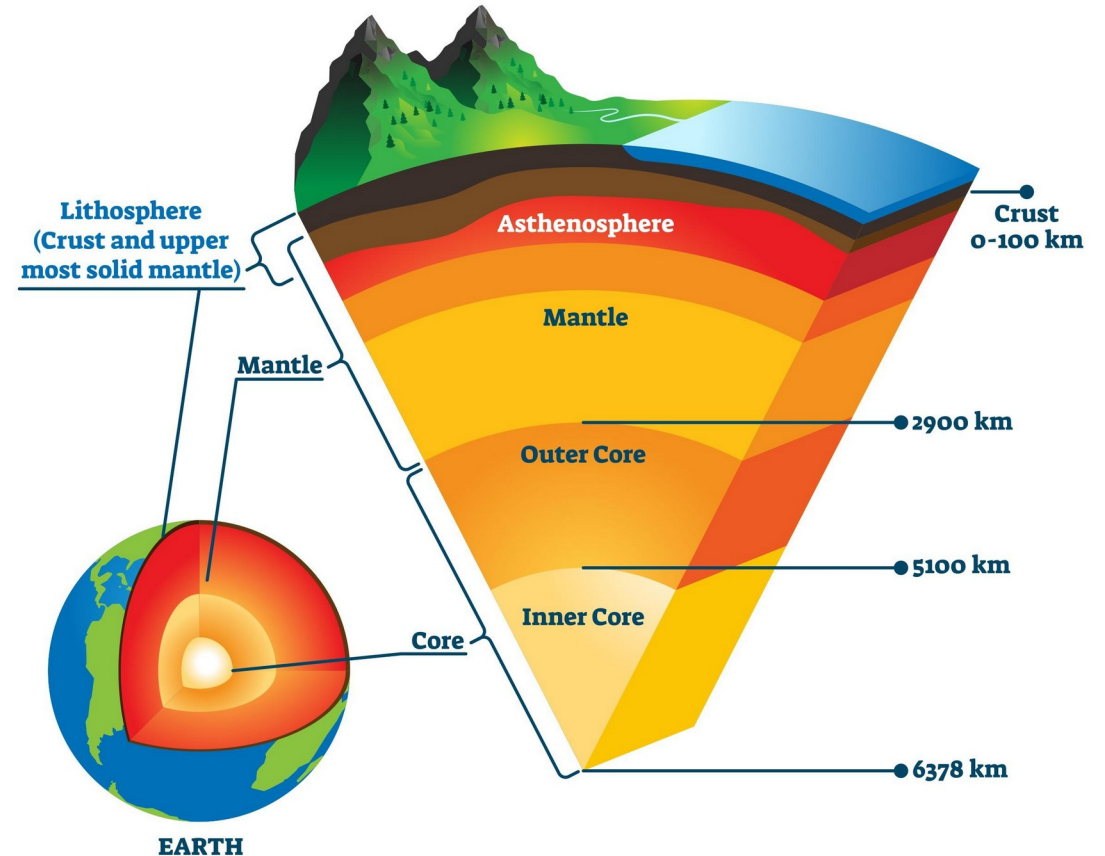
Next generation flexible trigeneration geothermal ORC plant

F. İrem Eren
R&D Specialist, Zorlu Enerji



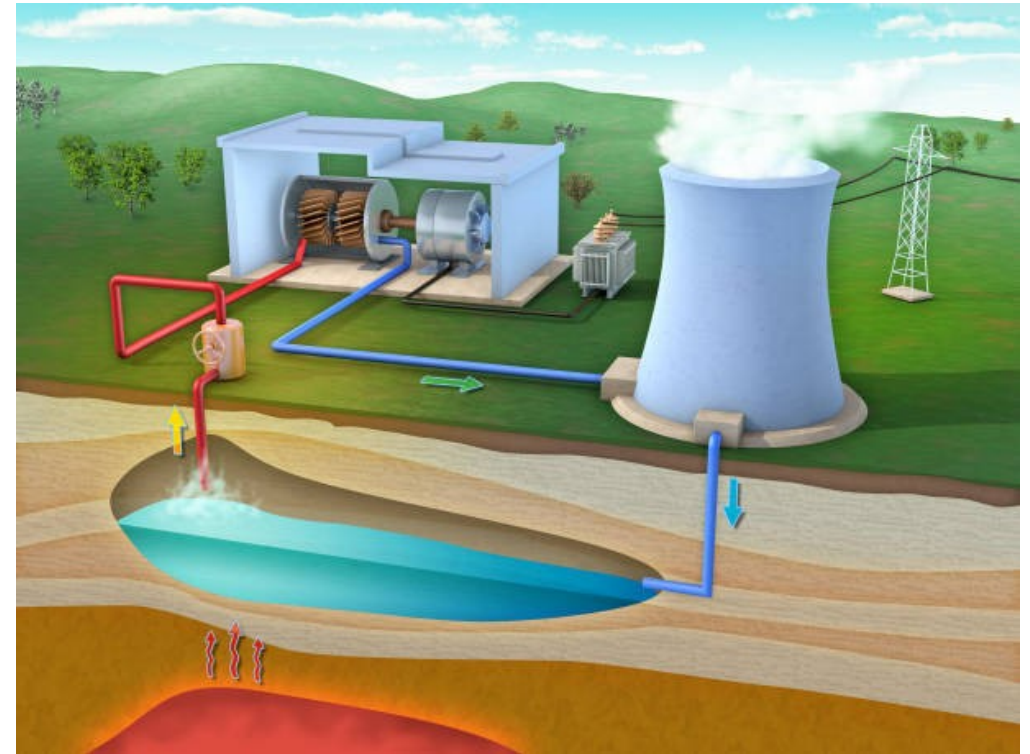
Geothermal Energy

- Geothermal energy is the heat energy of the earth itself.
- Core of the planet is the main heat source, which is transferred to mantle and then to upper surfaces.
- Geothermal energy is used for many purposes utilizing this heat.



Geothermal Energy in Power Generation

- Geothermal Power Plants (GPPs) use the heat that makes its way upwards into the crust.
- The power plant type depends on the reservoir characteristics and environmental conditions.
- In addition to these conditions, economical factors play a huge role.

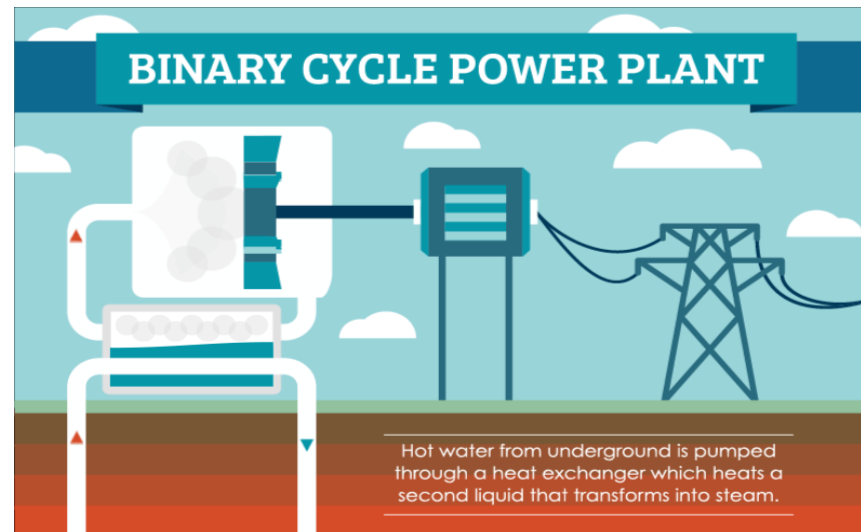
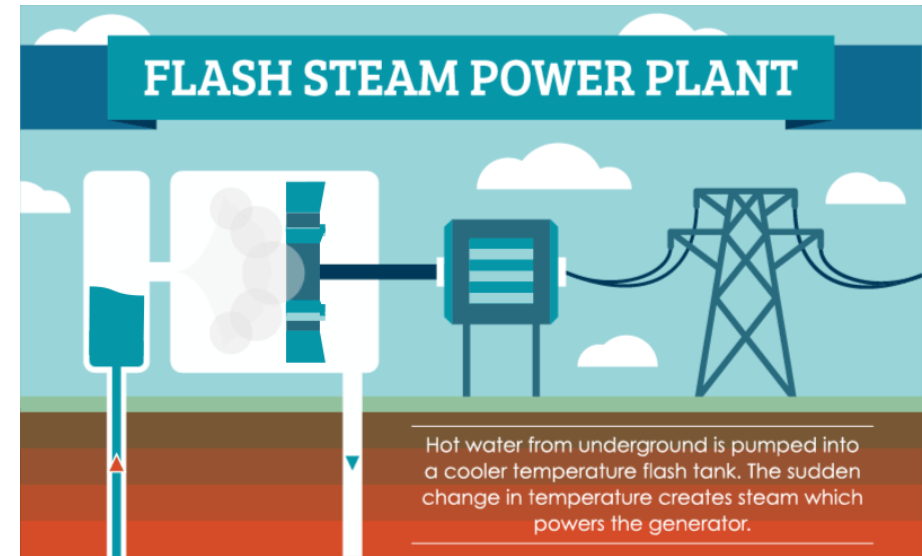
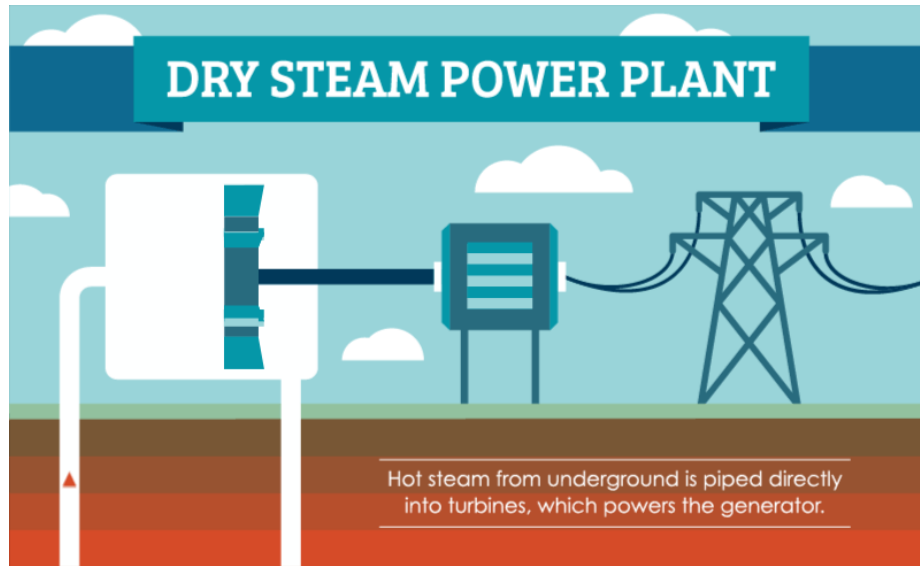


Geothermal Power Plant Types

- Temperature is the dictating parameter, while pressure also indicates what the mass flow would be.
- There needs to be seismic and magneto-telluric studies to be held to understand reservoir volume.
- Fluid type –while depends on the temperature- is also another element that helps decide the power plant type.

Reservoir Temperature	Fluid Type	Technology
High Temperature (>150°C)	Water-Steam	Dry Steam / Flash Cycle / Combined Cycle
Medium Temperature (90°C-150°C)	Water	Binary Organic Rankine Cycle
Low Temperature (<90°C)	Water	Heat Pump / Direct Use

Geothermal Power Plants



Illustrations are from
saveonenergy.com

Frequency Reserve

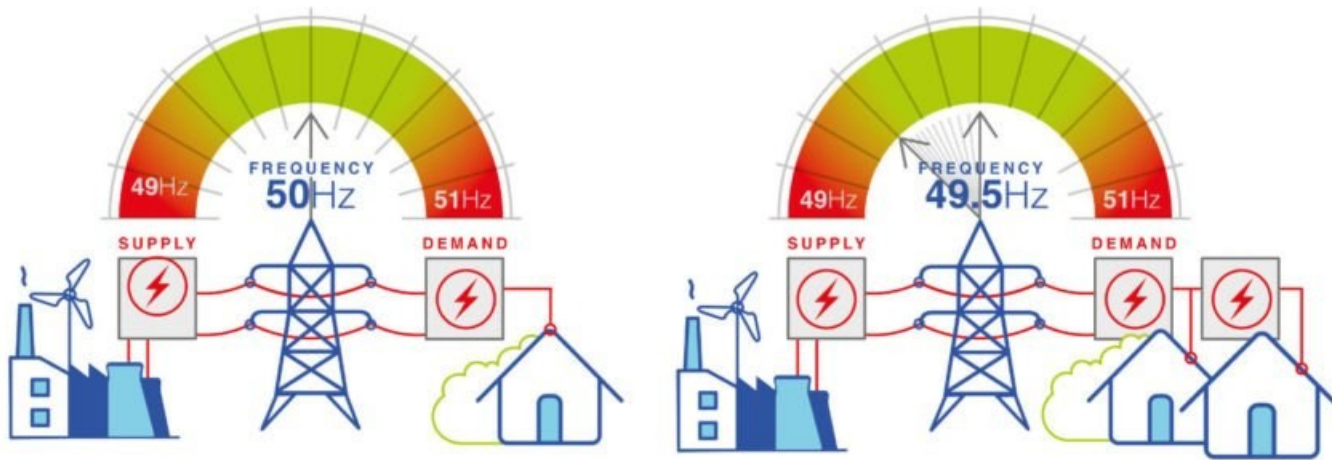


Illustration acquired from inhabitat.com

- Frequency is the changes in direction in AC per second.
- The frequency in different regions can be different (EU, North America etc.).
- Purpose is to have a standardization so the transformers and relevant electrical equipment can work in harmony.
- Grid frequency can change due to supply and demand fluctuations.
- Frequency reserve is there to stabilize the grid and return it to the normal levels.

Challenges and Opportunities

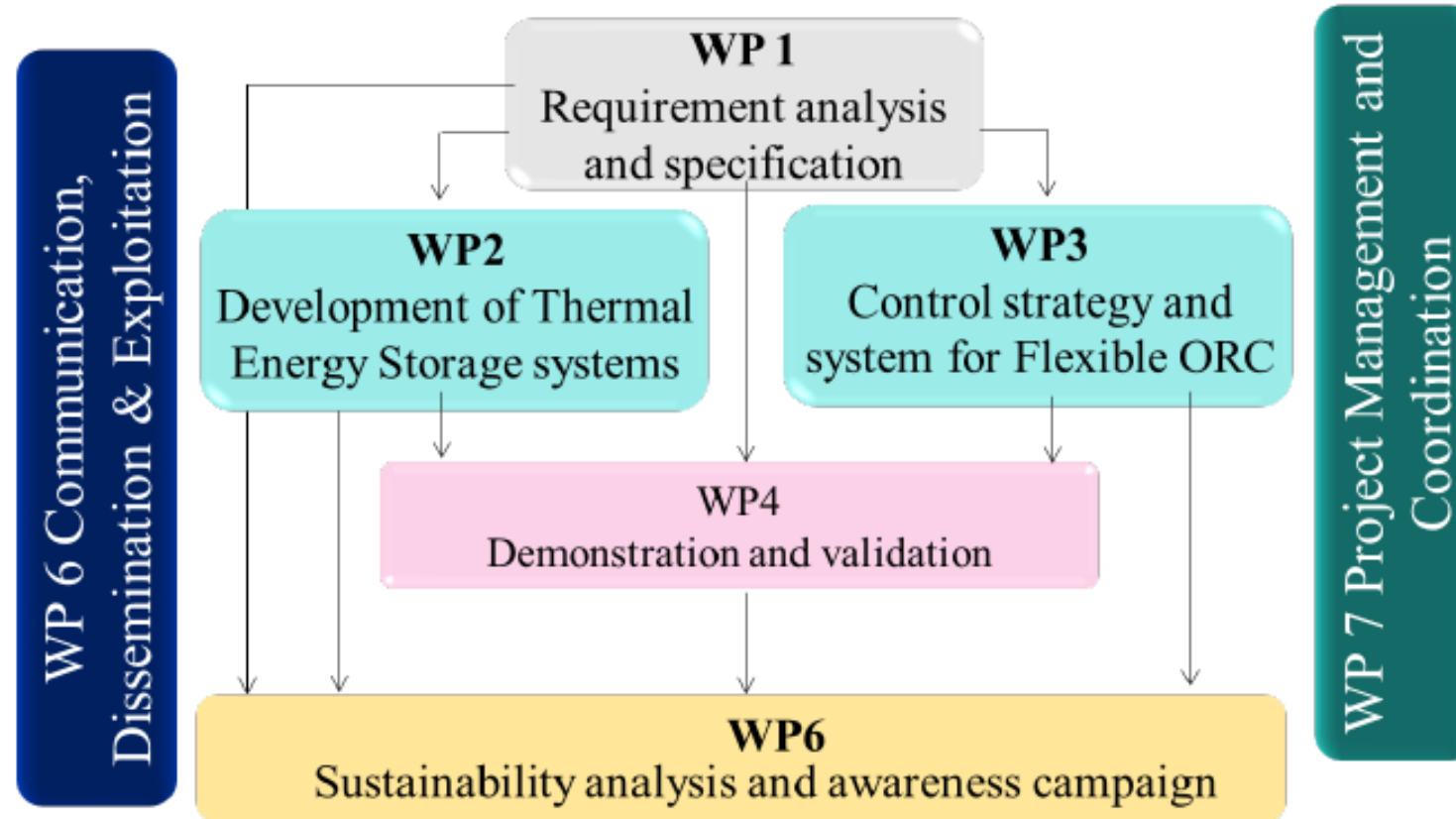
- EU has a well established frequency reserve system, however the renewable energy dominance in the market (wind, solar etc.) causes fluctuations and decreases viability.
- Transition into renewable energy will require more baseload providers for balancing.
- Geothermal energy has a '*always on*' system that requires continuous running and cannot be used as conventional fossil powered thermal power plants.
- EU has mostly low enthalpy geothermal, which fits ORC or district heating/cooling options.
- ORC efficiency changes drastically over the year due to ambient temperature conditions.

nGEL Project

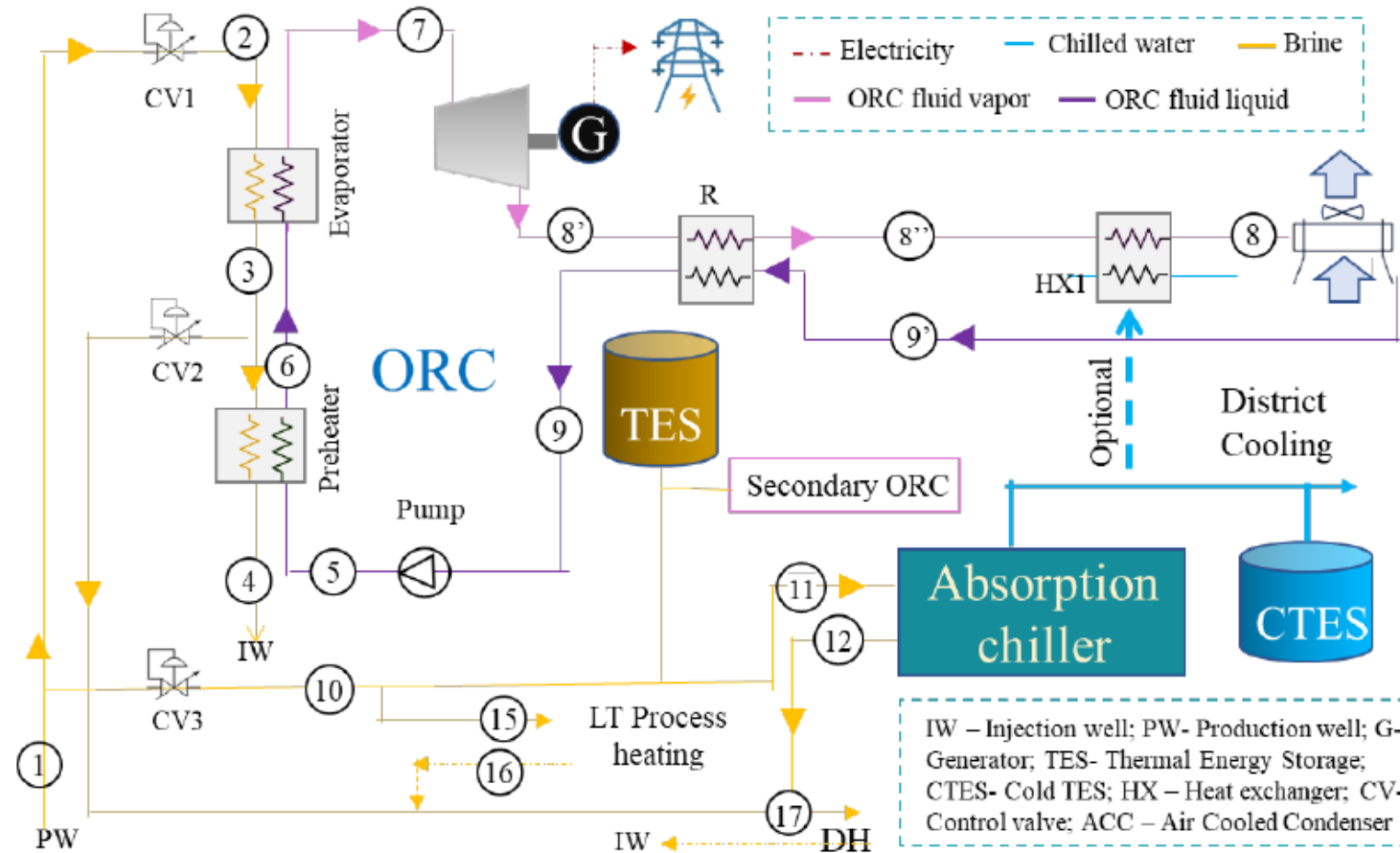
- As the name of the Project suggests, main goal is to create 'Next generation, flexible trigeneration geothermal ORC plants'.
- Additionally, a separate cooling method will be applied to demonstrate the capabilities of ORC under different ambient conditions.
- System will work aligned with heating grid supply/demand conditions with help from STORM controller integrated Energy Management System.



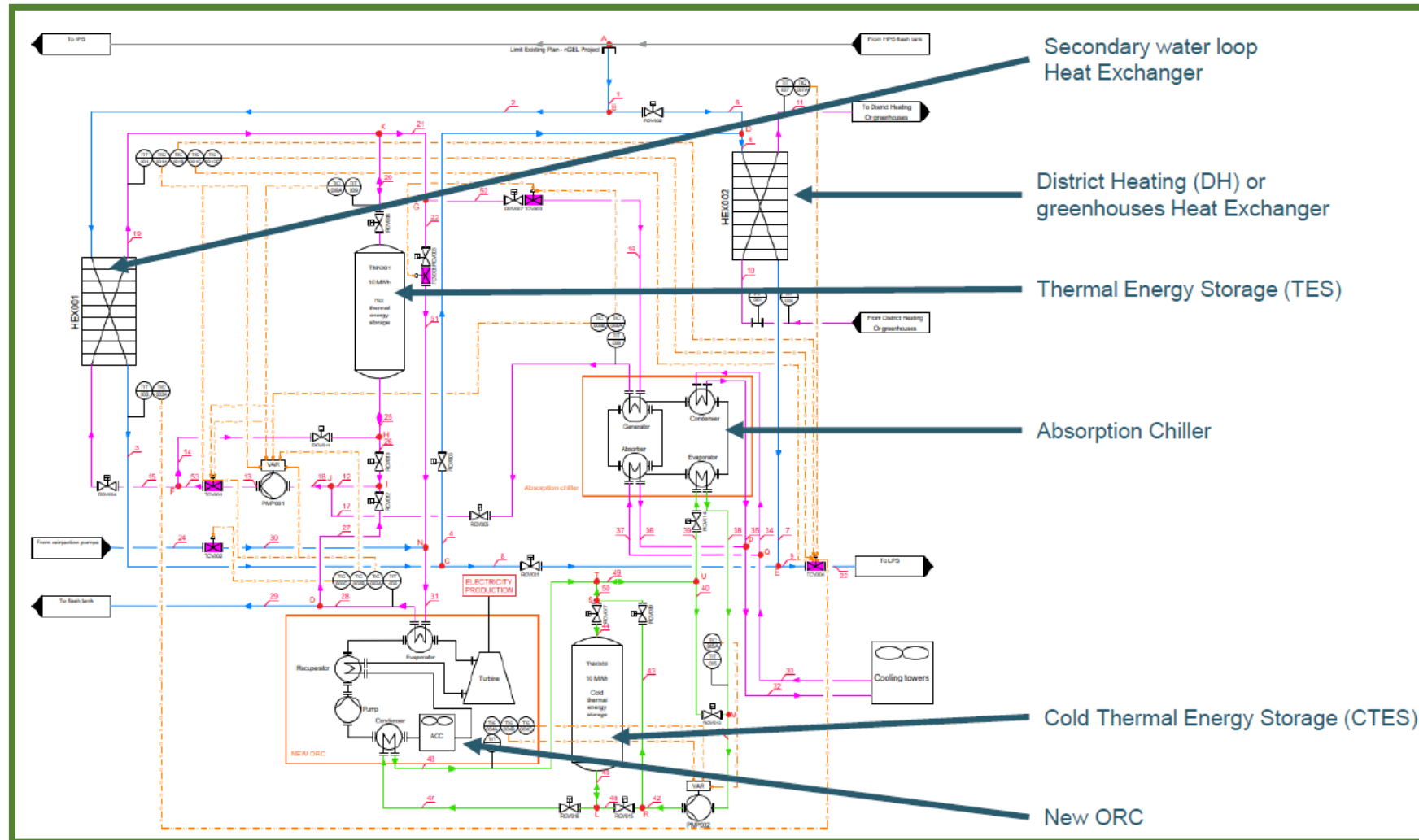
nGEL Project Work Packages



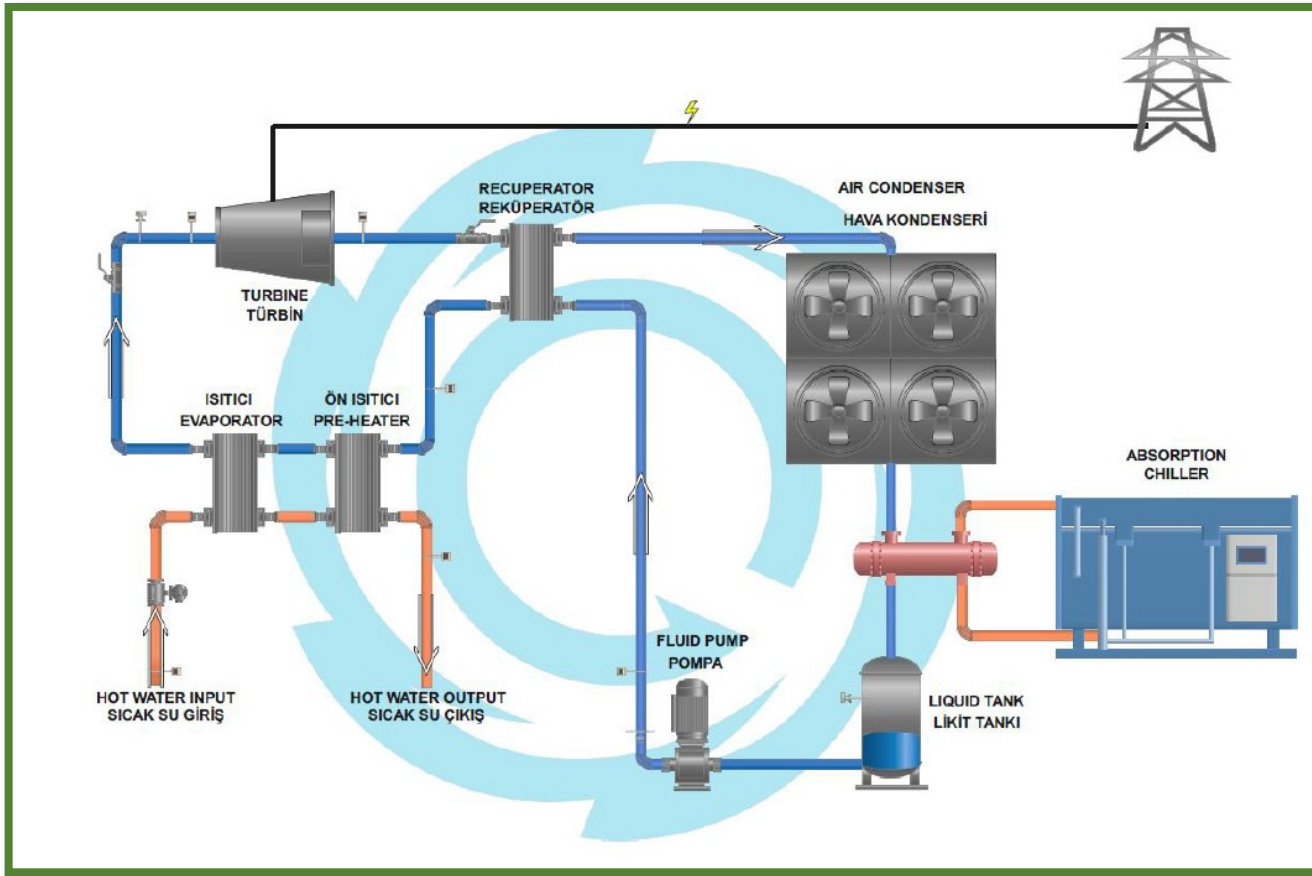
nGEL Project Demonstration Case 1



nGEL Project Demonstration Case 1



nGEL Project Demonstration Case 2



- Figure on the left shows the ORC module that is being planned to be implemented for the Project.
- Cooling will be applied in two stages, with ACC unit and the absorption chiller, via a heat exchanger. The configuration will be adapted to see which is more beneficial. Overall ORC efficiency is expected to be increased.
- Depending on the variation, CTES and TES can be used during case 2 as well.

THANK YOU FOR YOUR TIME!



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RENEWABLE MULTI-GENERATION FOR A DECARBONISED EUROPE

Valorising Renewable Thermal Energy
Innovative Renewable Multi-Generation Energy Systems for Flexibility & Sector
Coupling

Why increasing efficiency of RE Sources is Important

Presenter: Kevin Mallin, Geolorn Ireland Ltd.

9th October 2025





Wind Turbines – Pro and Cons

- Low Carbon is a plus, although their carbon footprint can be quite high!
- At best < 60% efficient (Betz Limit)
- Typically, 25%-45%
- Offshore arrays complex to construct
- Detrimental environmental impacts
- Limited to electrical power production

Solar PV – Pros and Cons

- Low Carbon is a plus, although their carbon footprint can be quite high!
- At best < 50% Efficient
- Typically, 15% - 25%
- Require large amounts of space, although this is improving in terms of array designs and domestic panels.
- They get HOT
- Large usage of CRM's, although recycling is reducing this.



Hydro Power

- Low Carbon is a plus, although their carbon footprint is very high!
- Major geohazard risks
- Geopolitical issues on major cross-border rivers
- Require large amounts of space, with associated environmental impacts
- Limited to power production
- High maintenance

ORC

- You have heard the arguments!



Sustainability

- Increased efficiencies, mean longer life-cycles.
- Our research and innovations have wide-reaching implications for other Renewable Energy technologies.



If the nGEL technology can be implemented in all of the existing ORC plants in the EU, around 215 TWh heat can be delivered to the thermal grid, which is approximately 4% of the EU current annual heat demand, which corresponds to annual economic saving (on NG import) of € 9.6 billion/year.



nGEL Project Consortium

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