GEOKORE

Planning and implementation of Geothermal fields and cold networks

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INDICE

Geokore

- GEOKORE provides solutions for energy efficiency in buildings through the design of geothermal systems for both new and existing structures
- GEOKORE guides the client from the preliminary phase, thoroughly analysing the current situation, managing bureaucratic procedures, and carefully explaining the most efficient strategies to the client, all the way to the execution phase
- The proposed solutions consider integrated and innovative approaches, such as the adoption of multi-source heat pumps or hybrid systems (geothermal-gas), coupling with photovoltaic systems, and underground heat storage (ATES or BTES systems)

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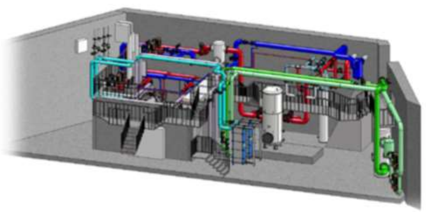
Geokore services

- Analysis of energy consumption and costs, feasibility studies, and energy simulations
- Implementation of TRT and ETRT tests with proprietary hardware GEOgert 2.0® and/or GEOsniff®
- Data interpretation of TRT and ETRT with analytical/numerical approaches
- Sizing of geothermal probe fields/wells using dedicated software recognized by Swiss standards (SIA)
- Numerical modeling of flow and heat transport in aquifers
- Verification of geothermal system performance, actual probe depth, and resolution of system issues
- Execution of flow and pressure tests
- Management of national and local authorization processes
- Preparation of technical schematics (P&I) for heating and cooling plants
- Project management

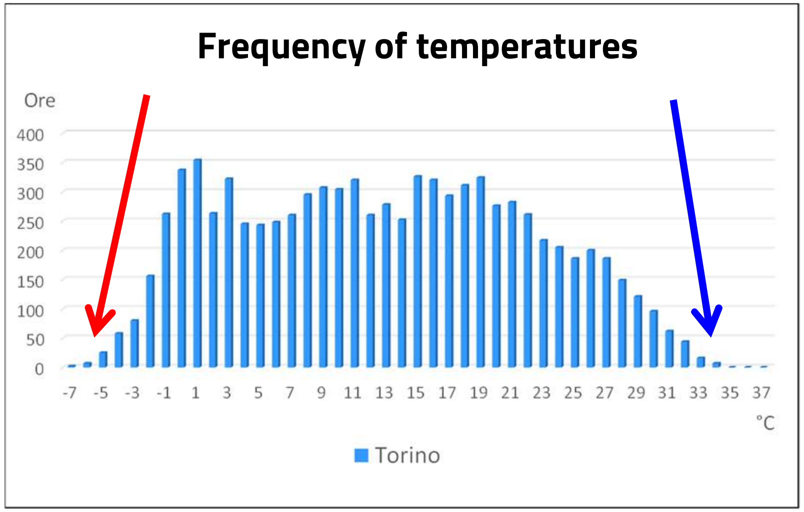


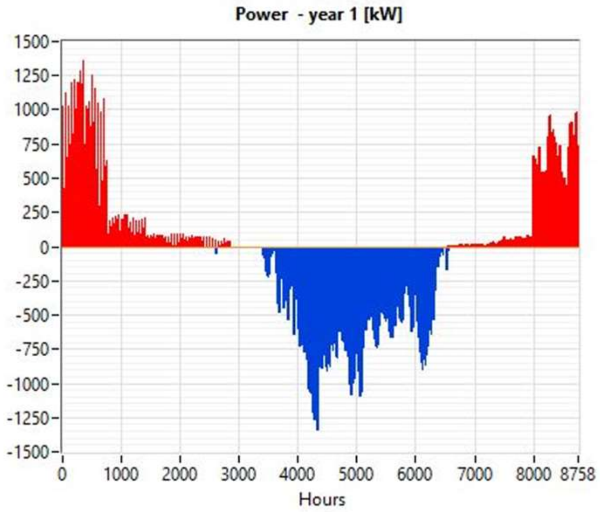


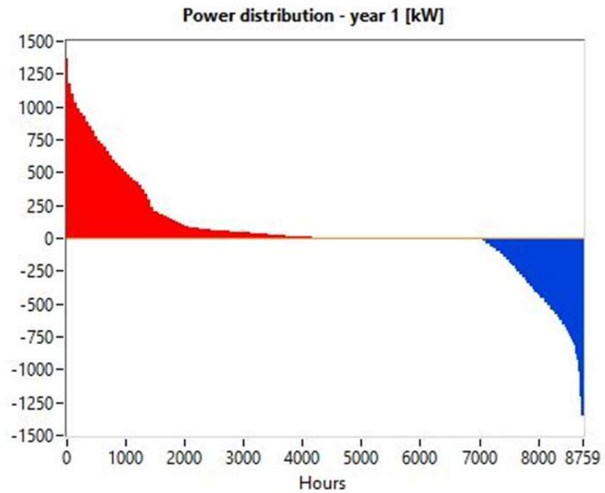
Critical issues in the GHX sizing

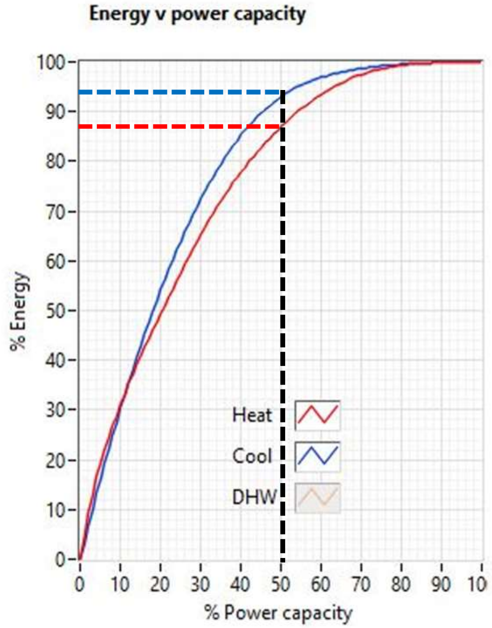
- Typical approach with poor design, rules of thumb from bibliography…. W/m…W/m²
- High capital budget CAPEX…… the project is no more viable
- Projects in urban areas or with limited space to install the System (with large powers > 100 kW – the full-size GSHP systems approach may not be the right solution
- Full size geothermal systems have no margins of error or variation related to different use or changes in the weather-climate situation
- Need to adapt to existing situations or intervention during the contruction work…very frequent!
- Underground/Geology is our system invariant ….but we can work on the system ☺
- Ensure long-term efficiency and reduce environmental impact

Energy vs Power







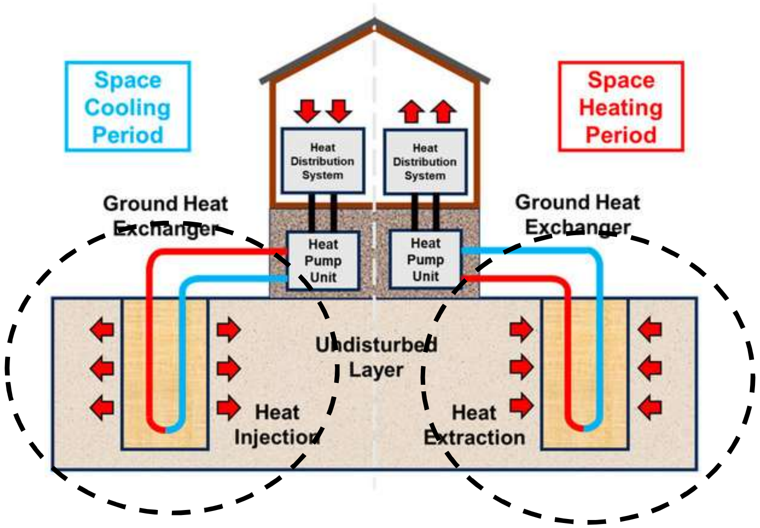


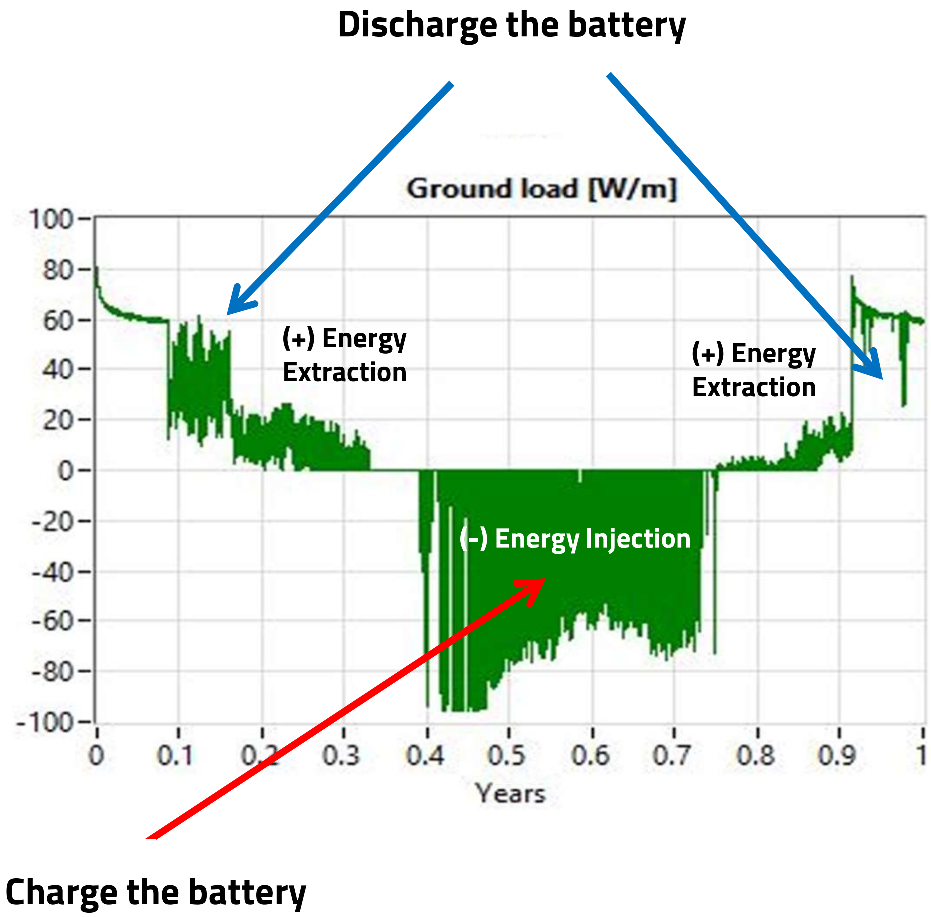
- Design conditions occur few hours per year
- Climate is changing…. fewer hours of cold and more hours of heat during the year
- Detailed energy simulation becomes very important
- **Energy vs. power analysis is fundamental**
- Sizing for peak loads with resulting significant increase in CAPEX is not useful

50% power capacity
>80% Heat & >90% Cool

GHX as a thermal battery

- Seasonal load shift and flexibility
- We've to balance the battery/ground load (charging and discharging) according to fluid temperatures constraints
- Cover the baseload
- Ensure long-term efficiency and reduce environmental impact

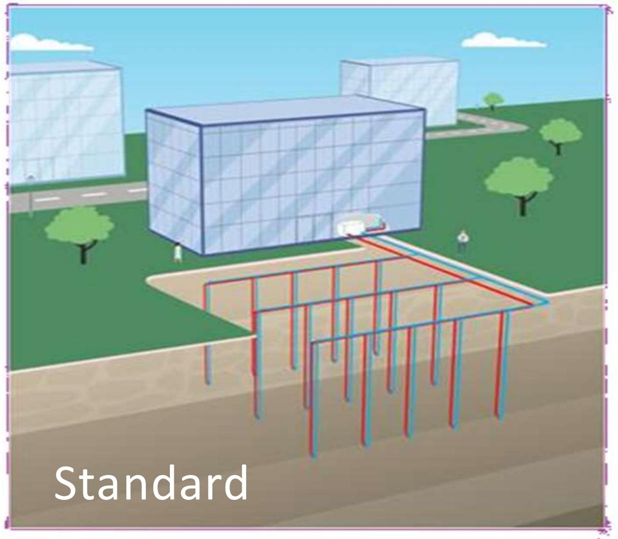


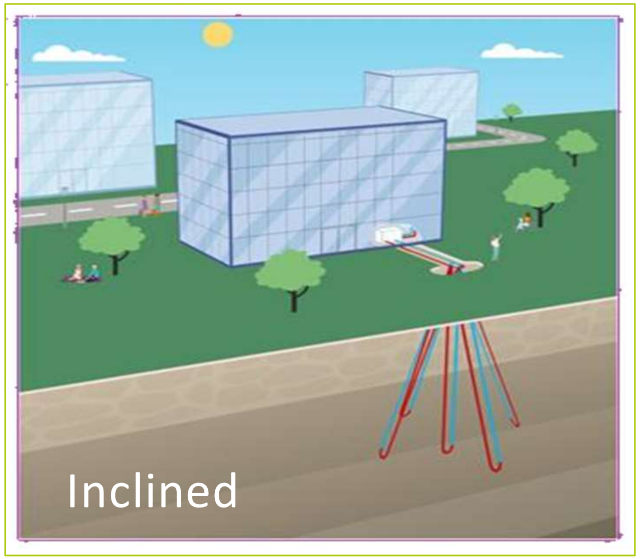


Optimized GHX

Vertical vs. slanted wells/GHX for big plants

- More than 90% footprint/site impact
- Up to 70% less horizontal piping
- Up to 30% fewer less GHX (in unbalanced system)
- Opening new opportunities in renovation
- Increasing flexibility in construction planning
- Possible combination of vertical and inclined GHX

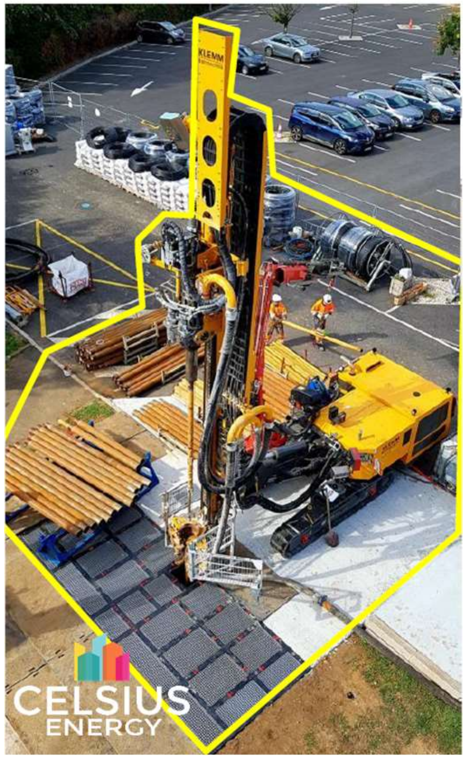




Inclined drilling technology

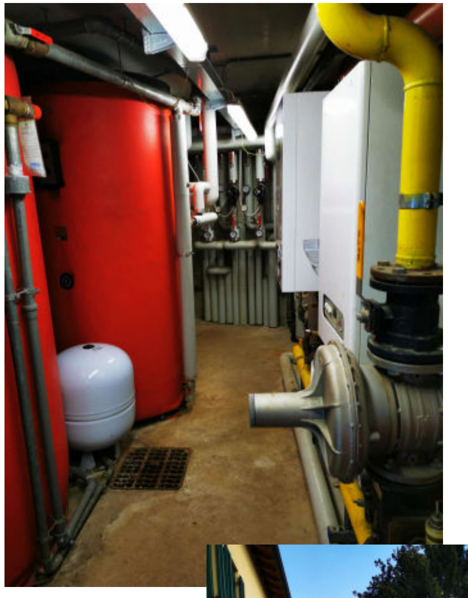
Benefits:

- Footprint wellpad 6500X2500X750mm
- Up to 21 GHX per wellpad (4200 ml)
- Horizontal connection≈0
- Excavation reduction
- Reduced interference with underground structures



Data source: *Celsius Energy*

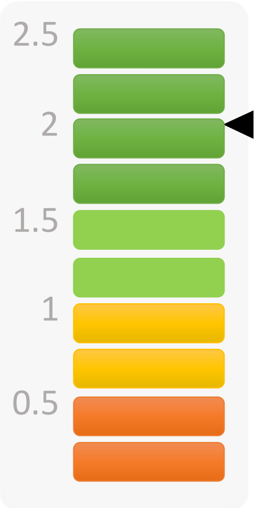
Example 1: Residential Houses in Milan



Site characteristics

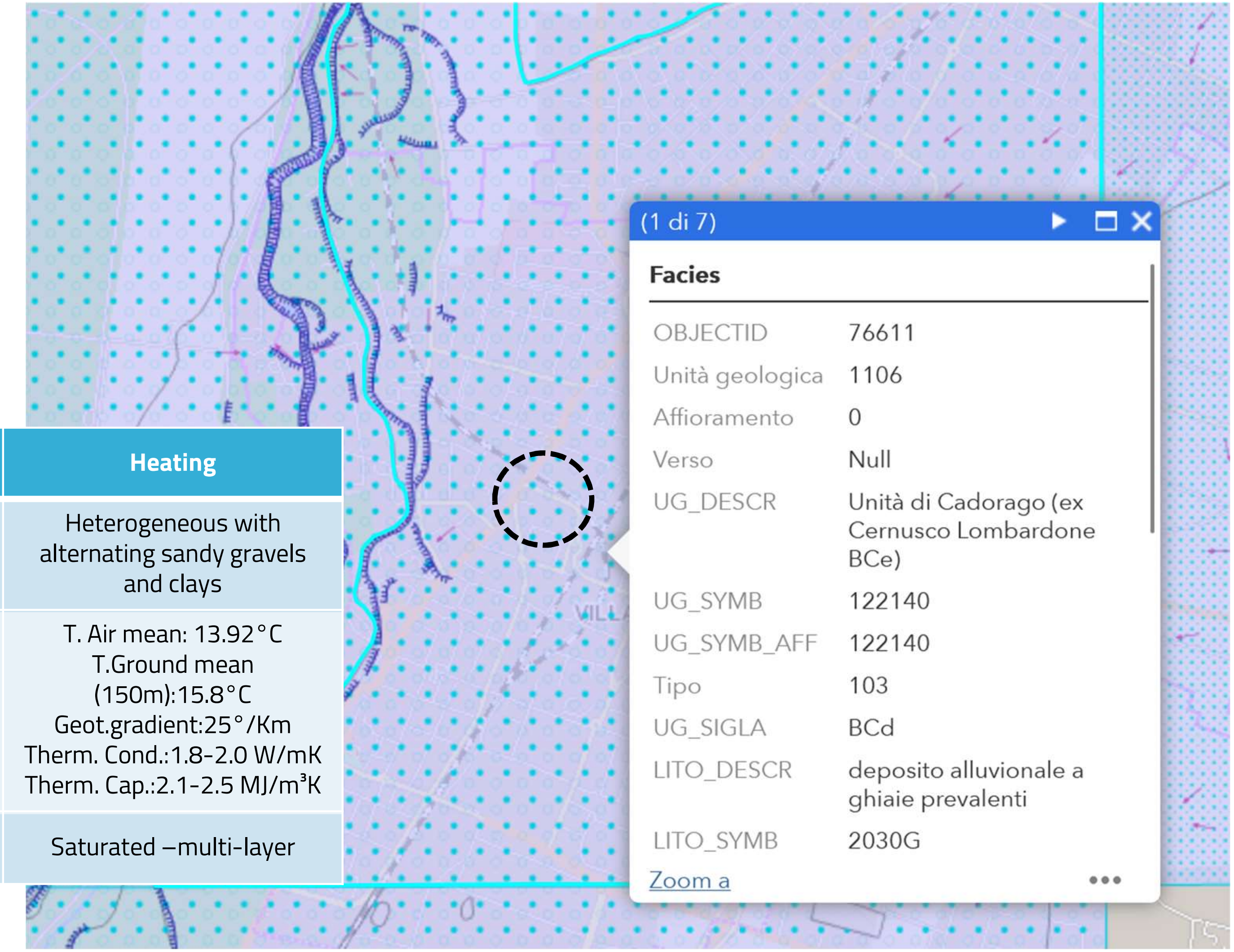
Address	**Lat: 45°36'25.16"N** **Lon: 9°18'0.08"E** **Via Grazia Deledda –20852 Villasanta (MB)**
Project type	Retrofit generation system
Use	Residential
Dimensions	27 apartments (2010) - 1300 m^2
Actual plant	Gas Boiler (70+114 kW) + Solar th (25 m²) Floor radiant system
Project status	Realization

Geoenergy potential



1,8 – 2,0 W/mK

	Heating
Geology	Heterogeneous with alternating sandy gravels and clays
T.Physical Param	T. Air mean: 13.92°C T.Ground mean (150m):15.8°C Geot.gradient:25°/Km Therm. Cond.:1.8-2.0 W/mK Therm. Cap.:2.1-2.5 MJ/m³K
Ground water	Saturated –multi-layer



Data source: *ISPRA & Regione Lombardia*

Energy demands

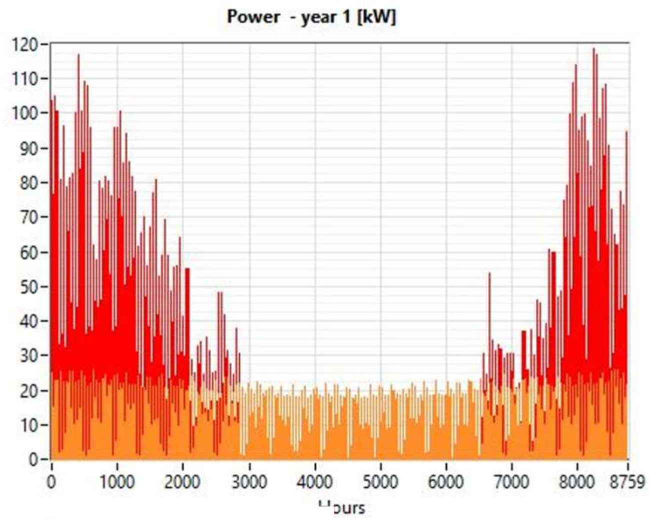
	Heating	DHW
Energy demand [MWh/year]	131	93
Peak Power [kW]	97	48

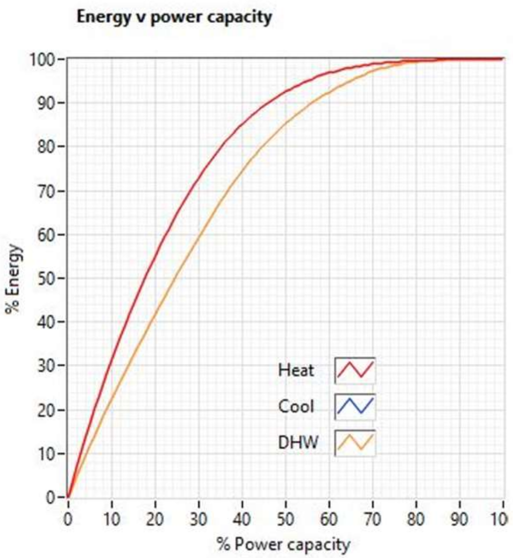
Hourly energy demand were calculated on an hourly basis starting from:

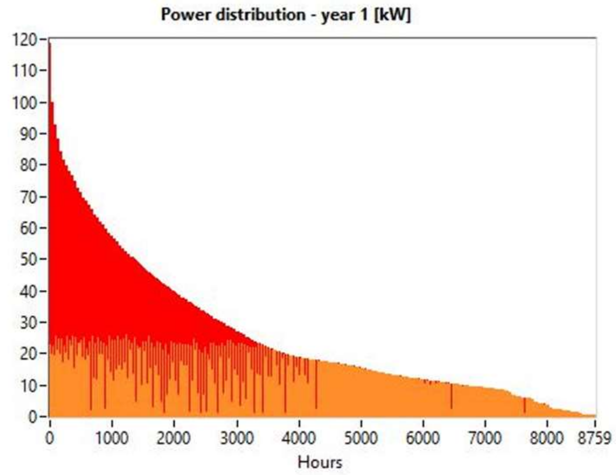
- Energy check from the client
- GAS consumption (boiler efficiency 90%)
- DHW consumption verification
- Last 5 yrs Hourly ext.air temperatures (https://re.jrc.ec.europa.eu/pvg_tools/en/tools.html)

Production temperatures - primary:

- Heating : >55°C (ΔT = 10 K)
- DHW : >55°C







HY-GSHP scenario

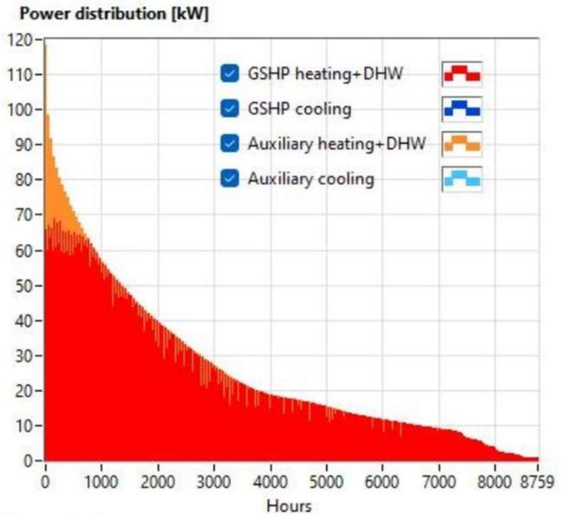
	Heating	Domestic Water
Enery demand [MWh/year]	131	93
Geoexchange system [MWh/year]	**126 (96%)**	**69 (74%)**
Geoexchange system [kW]	≈65	≈25
Ausiliary system [kW]	≈42	≈25

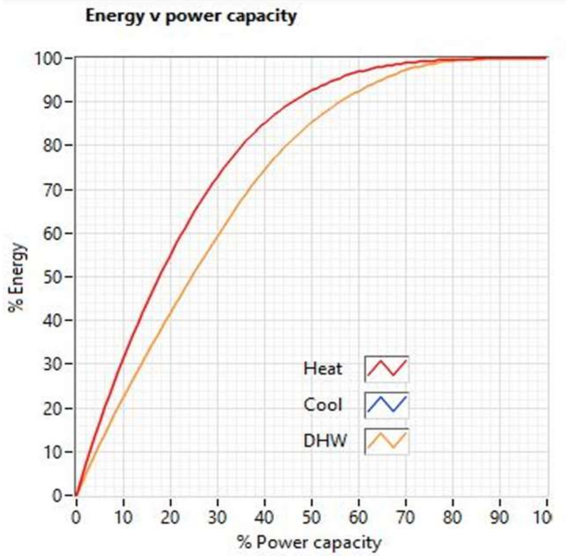
The GSHP system:

- Tmin-max fluid: -3.0° C – 35° C
- ΔT : 3K (source side)
- Prop. Glycol: 25% (antifreeze -10,4° C)

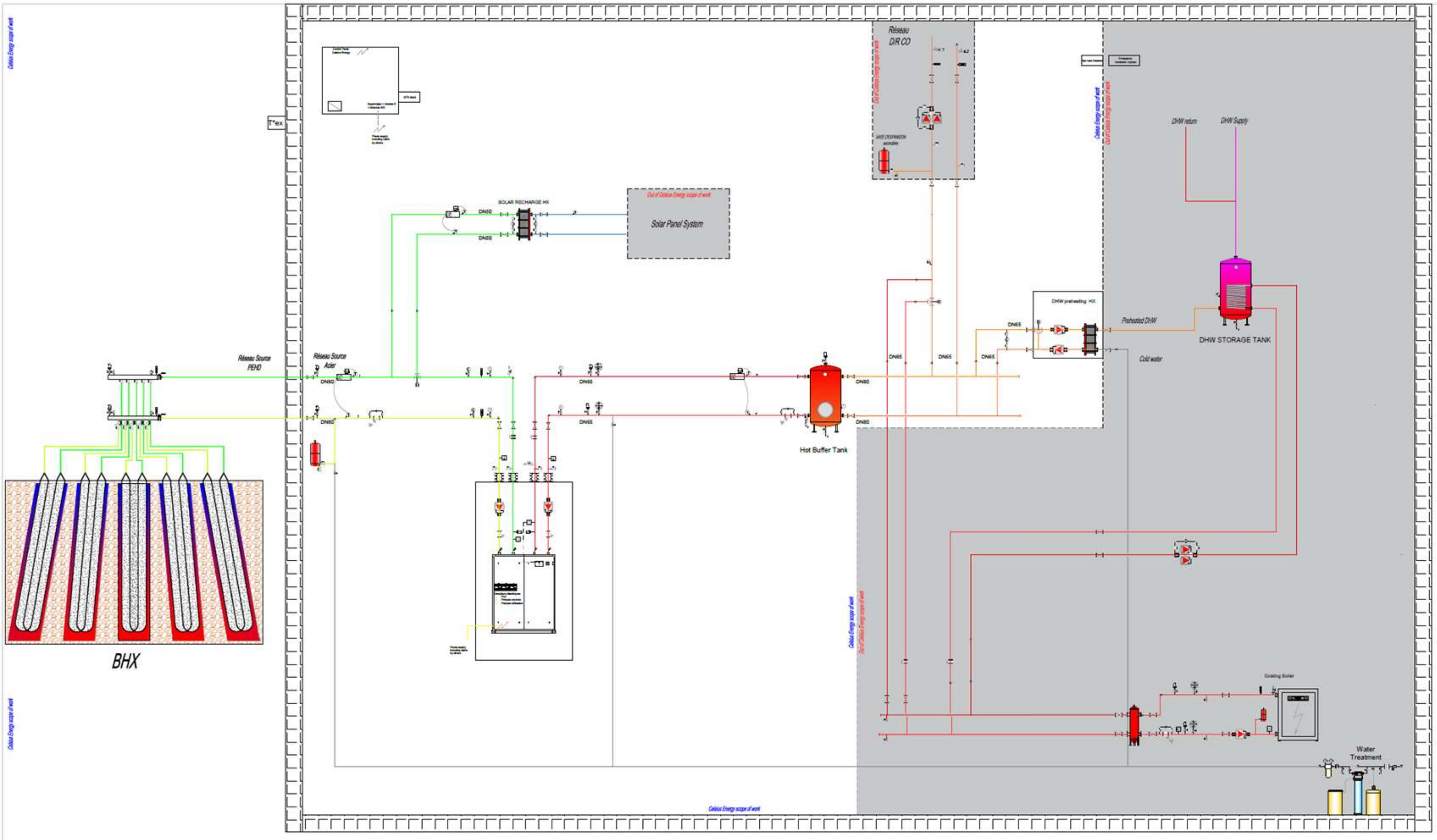
The simulation shows that with the geothermal system it is possible to cover 90% of the heating and DHW production energy on an annual basis.

The auxiliary system is represented by a GAS generator (existing) whose installed power (114 kW) is higher than the calculated necessary max power



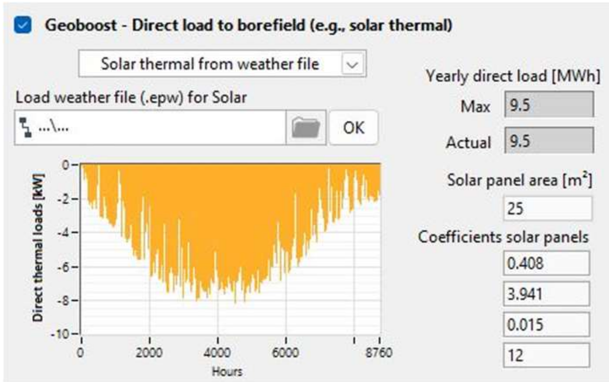


Conceptual scheme

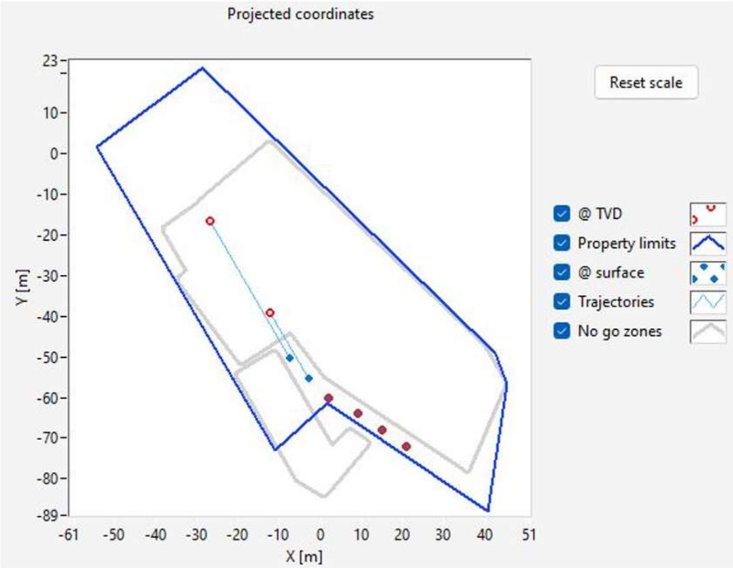


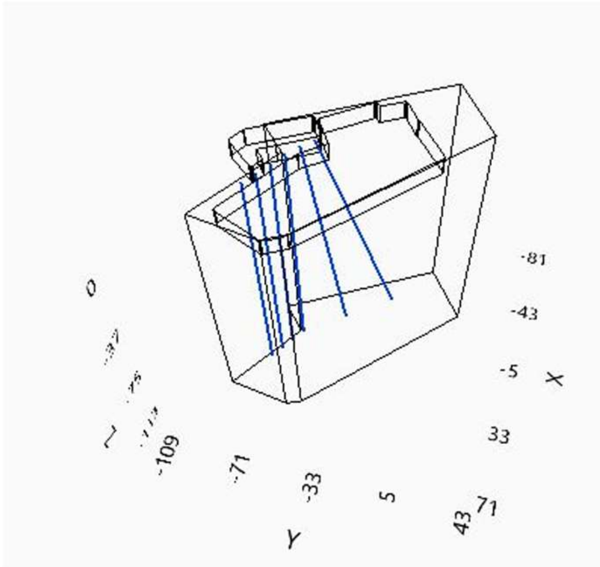
HY-GSHP system concept

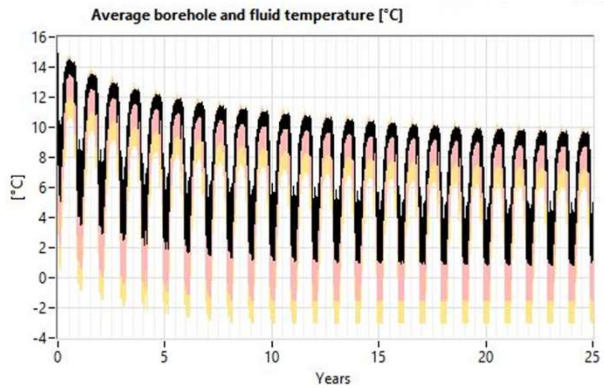
- HT (High temperature) Heat Pump
- Heating up to 65° C
- DHW up to 65° C
- Boiler as auxiliary /backup (system redundancy)
- Geoboost – Solar regeneration with existing solar panels to balance the ground load (25 m² -9-10 MWh/yr)

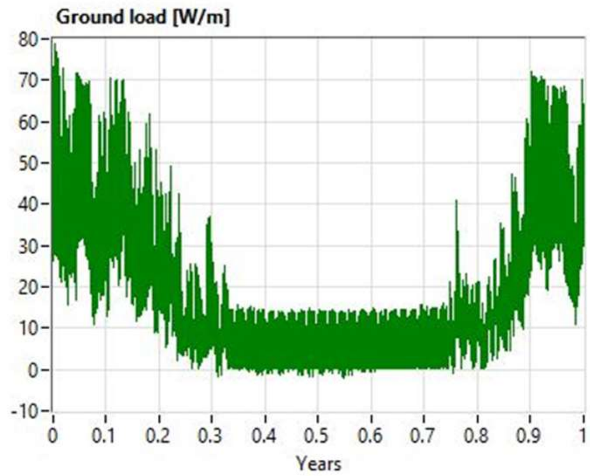


GHX configuration









Suggested layout **with 4 vertical GHX at 150m and 2 inclined GHX at 150m** (inclination from 5° to 20° from vertical) The scenario allows working within the boundaries of the property.

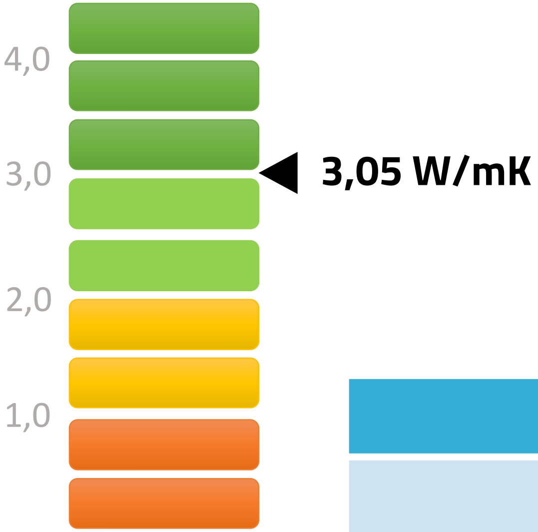
<u>GHX length = 900 ml (50% GHX reduction with respect to full geo approach)</u>
GSHP SCOP = 3.2 (Heating) – 3.1 (DHW)
SPF (with Boiler) = 3.1 (Heating) – 2,54 (DHW)
LCOE = 0.118 €/kWh (-34%)
CO_2 = -80% - % - renewable energy 57%
Budget cost = 313 k€ - Payback time = 9 yrs (*with 50% tax deduction)

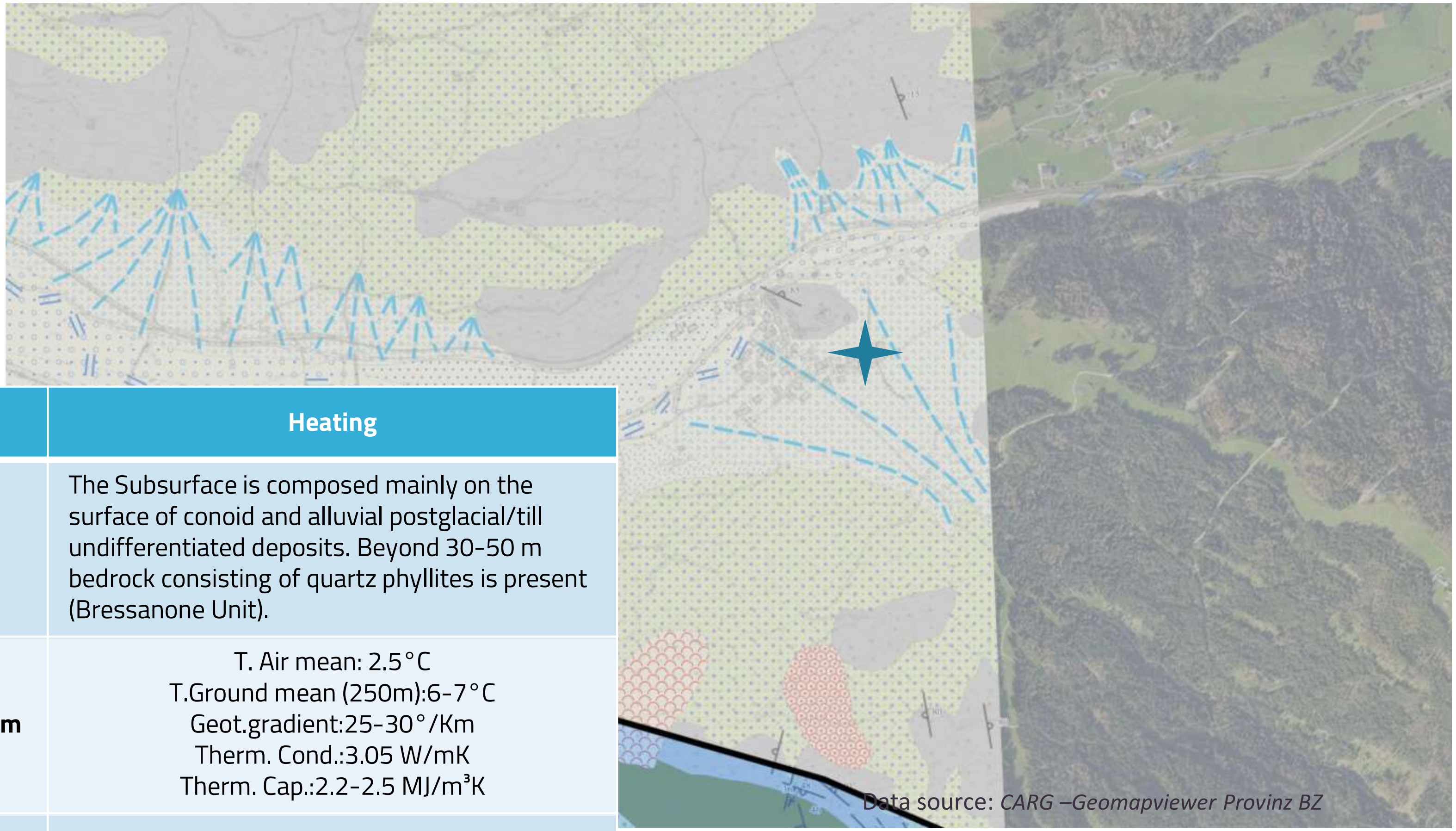
Example 2: Hotel Post Alpina

Site characteristics

Address	**Lat: 46°43'46.53"N** **Lon: 12°19'39.52"E** **Via Ombrosa – 39038 San Candido (BZ)**
Project type	Renovation
Use	Hotel + Restaurant
Dimensions	65 rooms/ap. > 5000 m^2 Pools (int + ext)
Actual plant	District Heating >700 kWt (2 substations) Fan coils + Floor radiant syst + AHU
Project status	Planning

Geoenergy potential





Data source: *CARG –Geomapviewer Provinz BZ*

	Heating
Geology	The Subsurface is composed mainly on the surface of conoid and alluvial postglacial/till undifferentiated deposits. Beyond 30-50 m bedrock consisting of quartz phyllites is present (Bressanone Unit).
T.Physical Param	T. Air mean: 2.5°C T.Ground mean (250m):6-7°C Geot.gradient:25-30°/Km Therm. Cond.:3.05 W/mK Therm. Cap.:2.2-2.5 MJ/m³K
Ground water	Contact bedrock

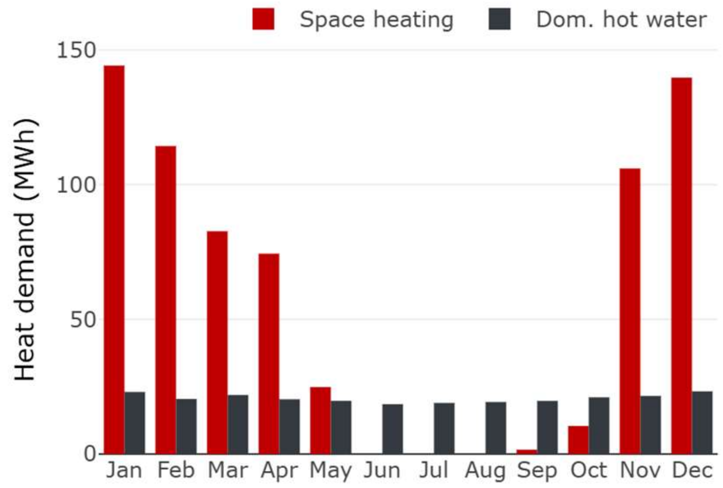
Energy demands

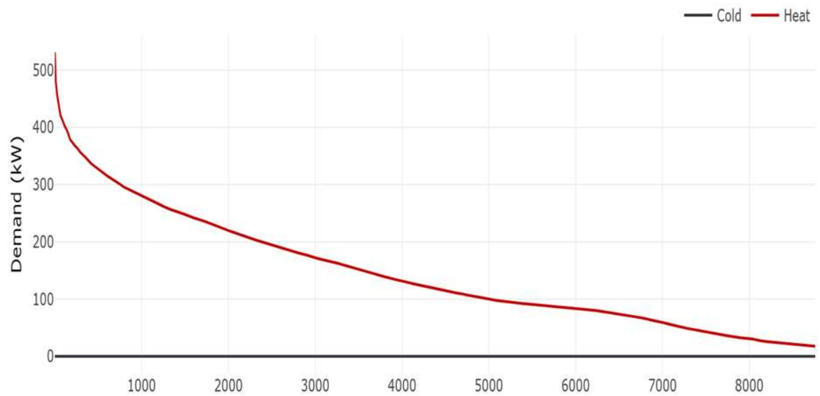
	Heating	Domestic Water	Pools
Energy demand [MWh/year]	698	576	81 (int)+247(ext)
Peak Power [kW]	448	164	93

Maximum calculated peak heat capacity: 531 kW

Hourly energy needs were calculated from:
- District heating energy consumption
- Indoor and outdoor swimming pool consumption simulation
- Domestic hot water consumption simulation (11.700 l/d)
- Hourly average outdoor temperatures last 5 (https://re.jrc.ec.europa.eu/pvg_tools/en/tools.html)
- Year-round continuous use simulation (future customer perspective)

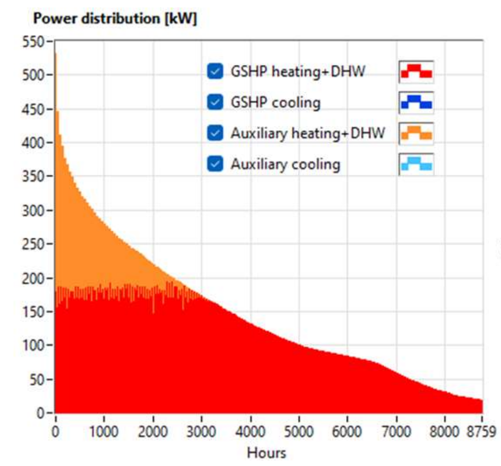
Expected mimimimum/maximum production:
- Heating : 40-55° C(ΔT = 5 K)
- DHW : >55°C

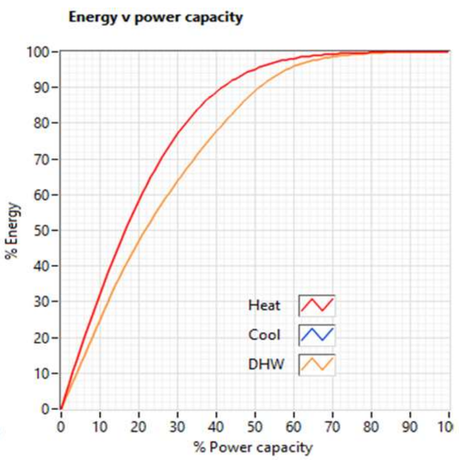




HY-GSHP scenario

	Heating	DHW
Energy demand [MWh/year]	698	576
Geoexchange system [MWh/year]	**580 (83%)**	**389 (67%)**
Geoexchange system [kW]	190-200	140-150
Ausiliary system [kW]	331	307



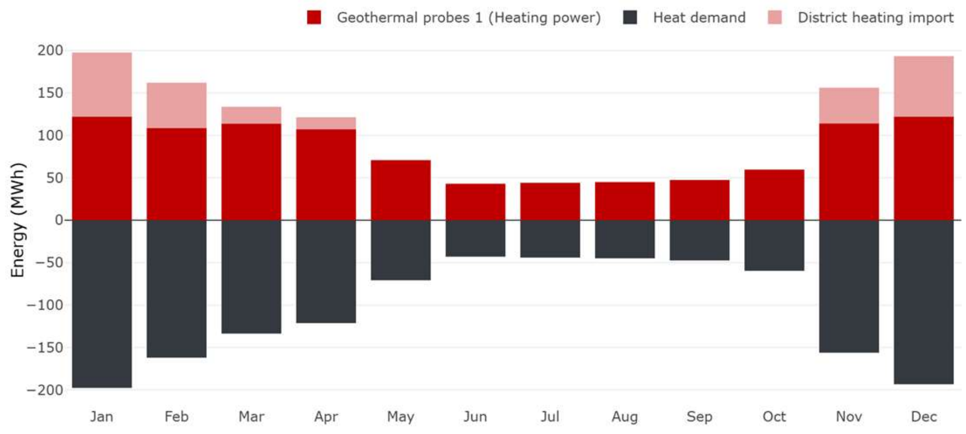


Teh geoexchange system is optimized to cover 76% of the annual energy need (83% Heating e 67% DHW):

- Tmin-max fluid vector: -3.0° C – 40° C
- ΔT : 3K (heating source)
- Propylene glycol : 25% on weight (antifreeze -10,4° C)

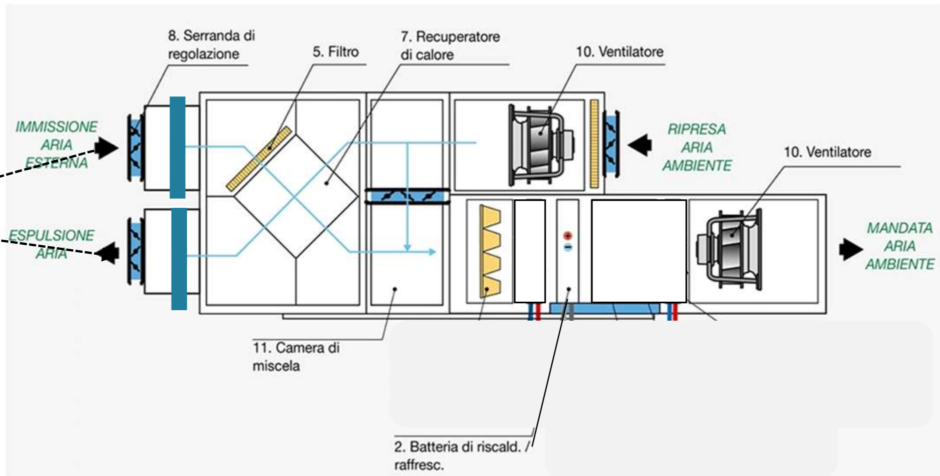
The remaining share is covered by an auxiliary system according to two possible scenarios:

- Use of the existing district heating (a perfect fit as it is already present)
- Heat pump A/W + district heating



Residual energy recovery - Ventilation system

Heat Recovery A/W batteries



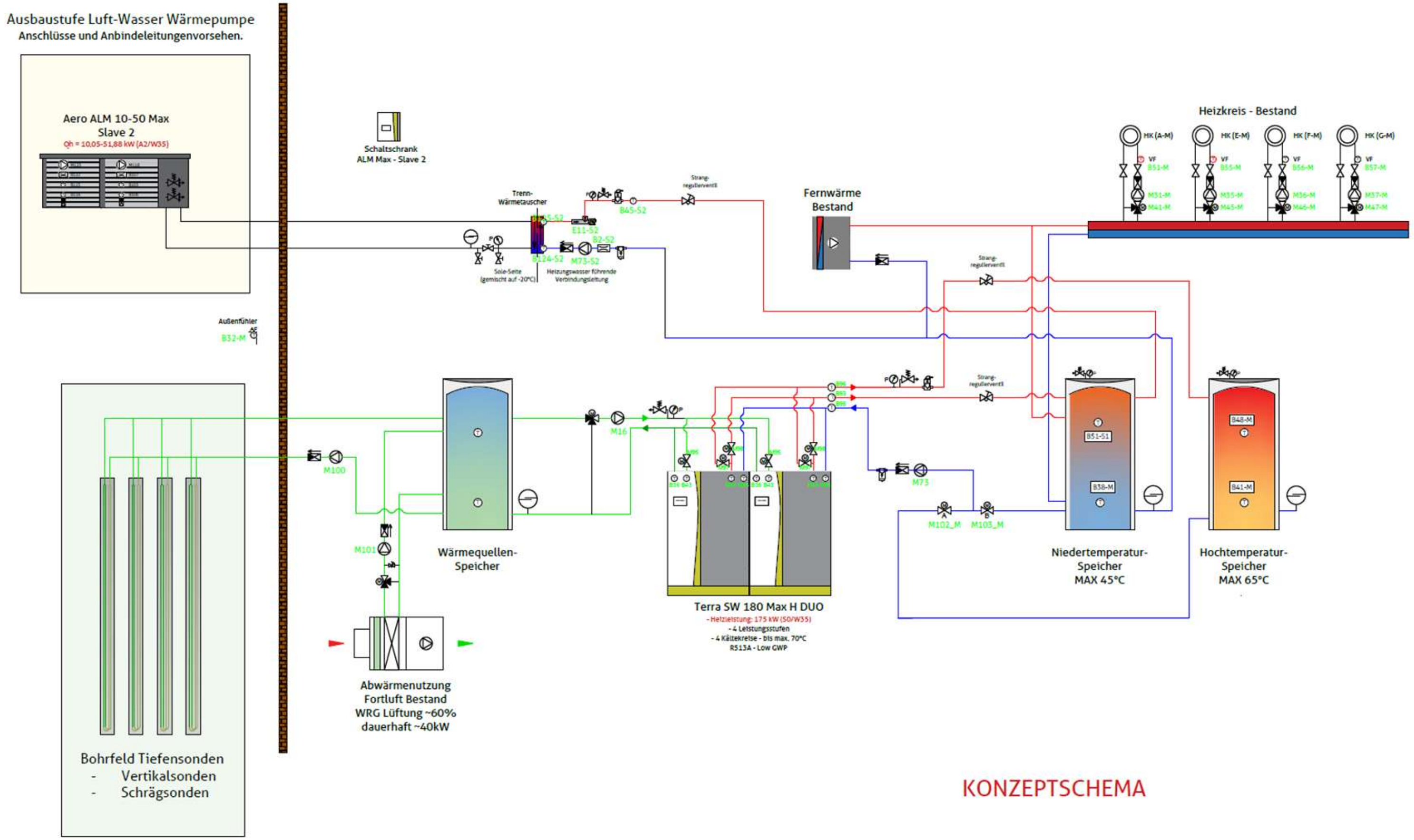
Two batteries/heat exchangers(A/W) for energy recover:

- **In the exhaust air discharge (main)**
- **In the outside air intake (with favorable outside temperatures)**

Proprietary smart system to store energy through waste air in the GHX field

Assumptions with recovery from air at T. of 19° C and considering heat recovery exchanger present in AHU 50%.

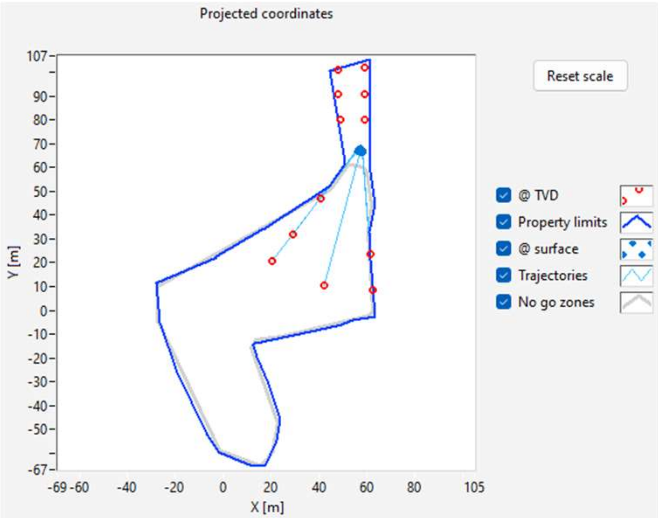
Conceptual scheme

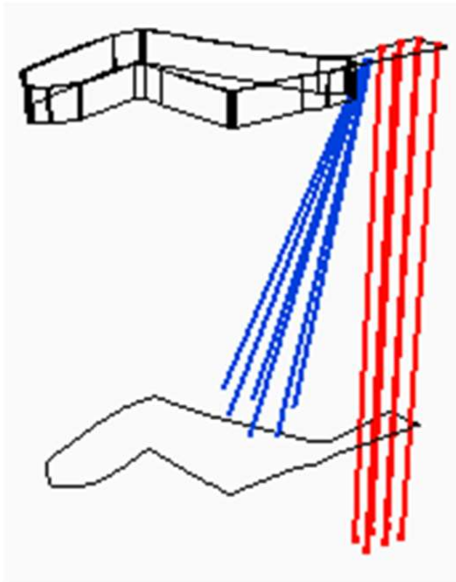


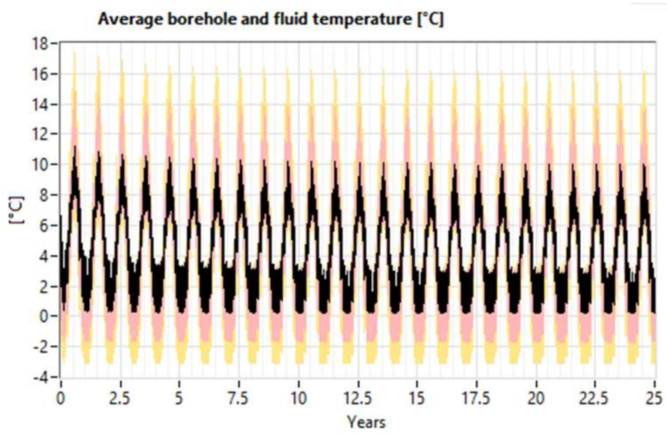
HY-GSHP system concept

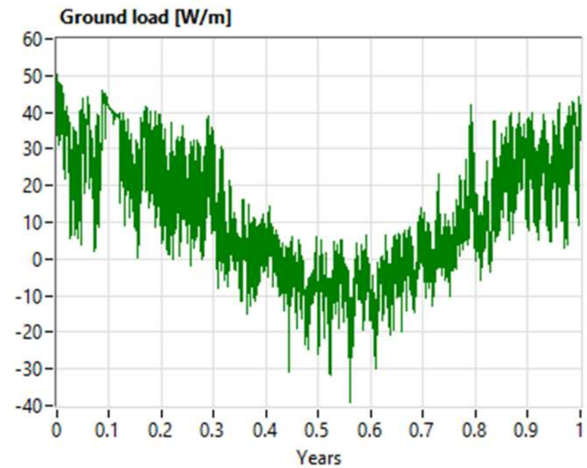
- Heat pump iDM TERRA SW Max H DUO 180 (S0W35) 174,7 kW
- Recovery from exhausted air AHU
- Distric heating integration
- Buffer medium temperature
- Existing high temperature DHW boilers
- ASHP integration in the future (50 kW partial – 300 kW full with no District Heating

GHX configuration









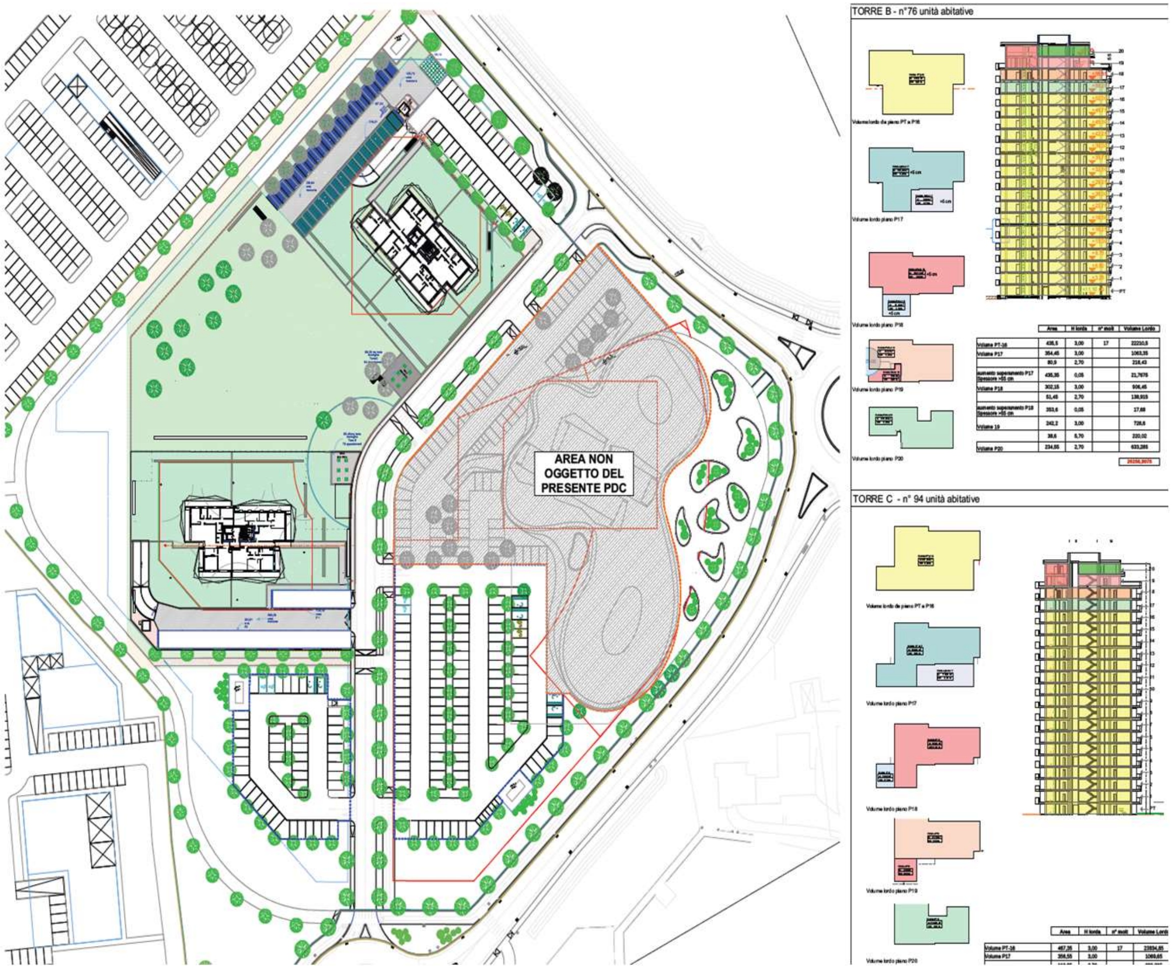
6 vertical GHX at 250m and 6 inclined GHX at 170m (inclination from 5° to 20 ° from vertical). The scenario allows working within the boundaries of the property.

<u>GHX length = 2520 ml (66% GHX reduction with respect to full geo approach without Heat Recovery)</u>
GSHP SCOP = 3.41 (Heating+DHW)
SPF (with DH) = 2.98 (Heating) -2,58 (DHW)
LCOE = 0.079 €/kWh (-36%)
CO_2 = -22% - renewable energy 56%
Budget cost = 650 – 800 k€ - Payback time = 8-9 yrs (with Conto Termico 2.0 contribution)

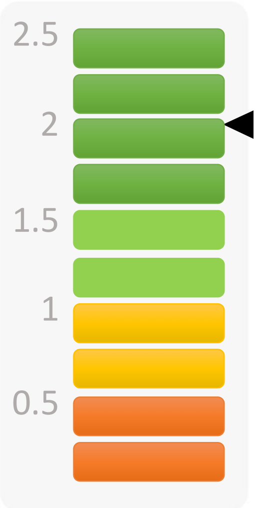
Example 3: Towers in Padova

Site characteristics

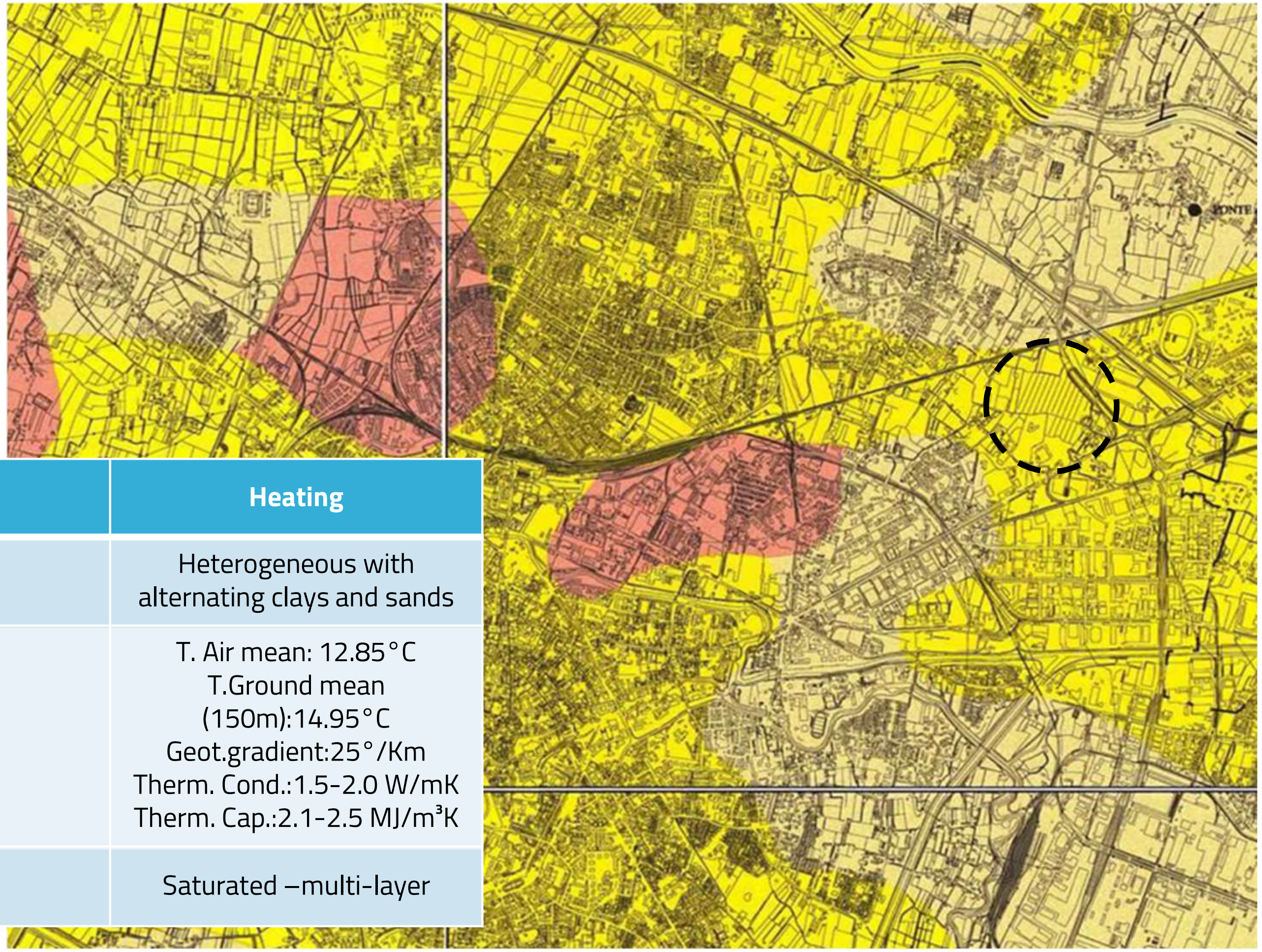
Address	Lat: 45°25'16.12"N Lon: 11°54'56.16"E Padova (PD)
Project type	New Buildings/Towers
Use	Residential + Commercial
Dimensions	>200 apartments ≈ 24.000 m²
First concept	Indipendent ASHP or GWHP
Project status	Feasibility



Geoenergy potential



1,8 – 2,0 W/mK

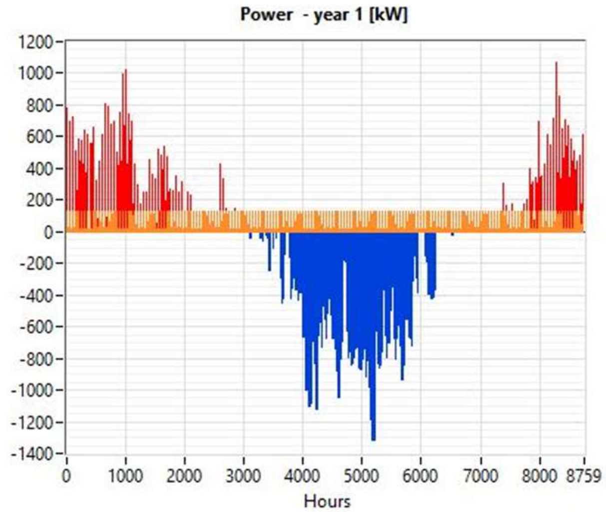


	Heating
Geology	Heterogeneous with alternating clays and sands
T.Physical Param	T. Air mean: 12.85°C T.Ground mean (150m):14.95°C Geot.gradient:25°/Km Therm. Cond.:1.5-2.0 W/mK Therm. Cap.:2.1-2.5 MJ/m³K
Ground water	Saturated –multi-layer

Data source: *ISPRA & Servizio Geologico Nazionale*

Energy demands

	Heating	Cooling	DHW
Energy demand [MWh/year]	434	442	422
Peak Power [kW]	970	1317	128

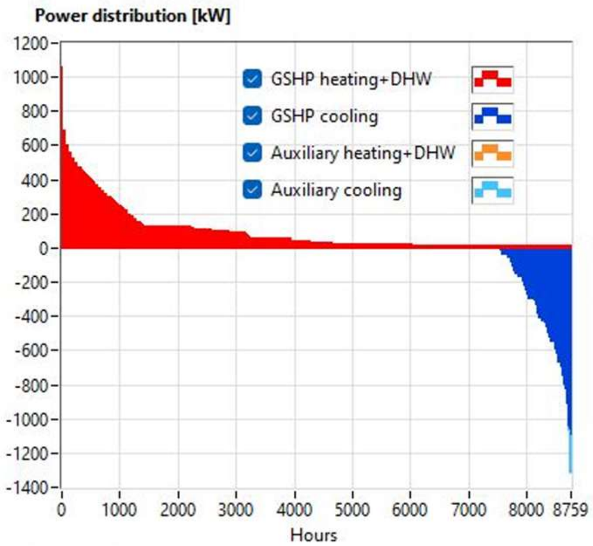


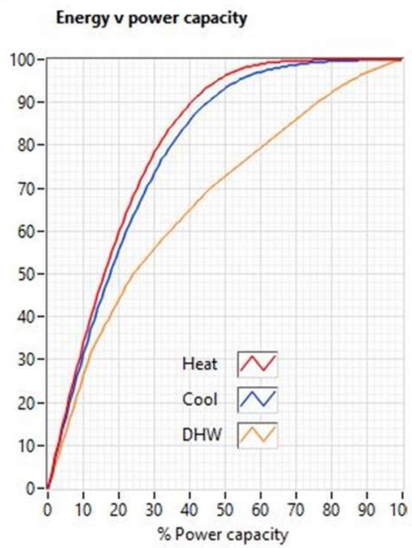
Hourly energy needs were calculated from:

- Monthly energy profiles
- Domestic hot water consumption simulation (UNI EN 11300)
- Hourly average outdoor temperatures last 5 (https://re.jrc.ec.europa.eu/pvg_tools/en/tools.html)

Expected mimimimum/maximum production:

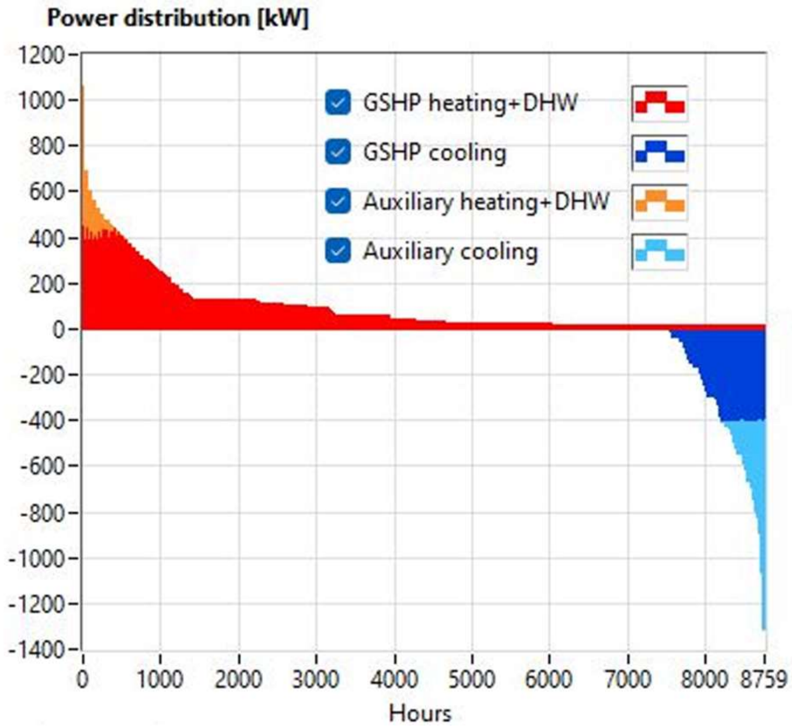
- Heating : 40° C (ΔT = 5 K) – floor radiant system
- Cooling: 7°C (ΔT = 5 K) – Fan coils
- DHW : >50°C





HY-GSHP scenario

	Heating	Cooling	DHW
Energy demand [MWh/year]	434	442	422
Geoexchange system [MWh/year]	**384 (88%)**	**324 (73%)**	**398 (94%)**
Geoexchange system [kW]	448	398	128
Ausiliary system [kW]	597	942	128



Teh geoexchange system is optimized to cover 85% of the annual energy demands

- Tmin-max fluid vector: -3.0° C – 35° C
- ΔT : 3K (heating source)
- Propylene glycol : 25% on weight (antifreeze -10,4° C)

Two possible energy solutions:

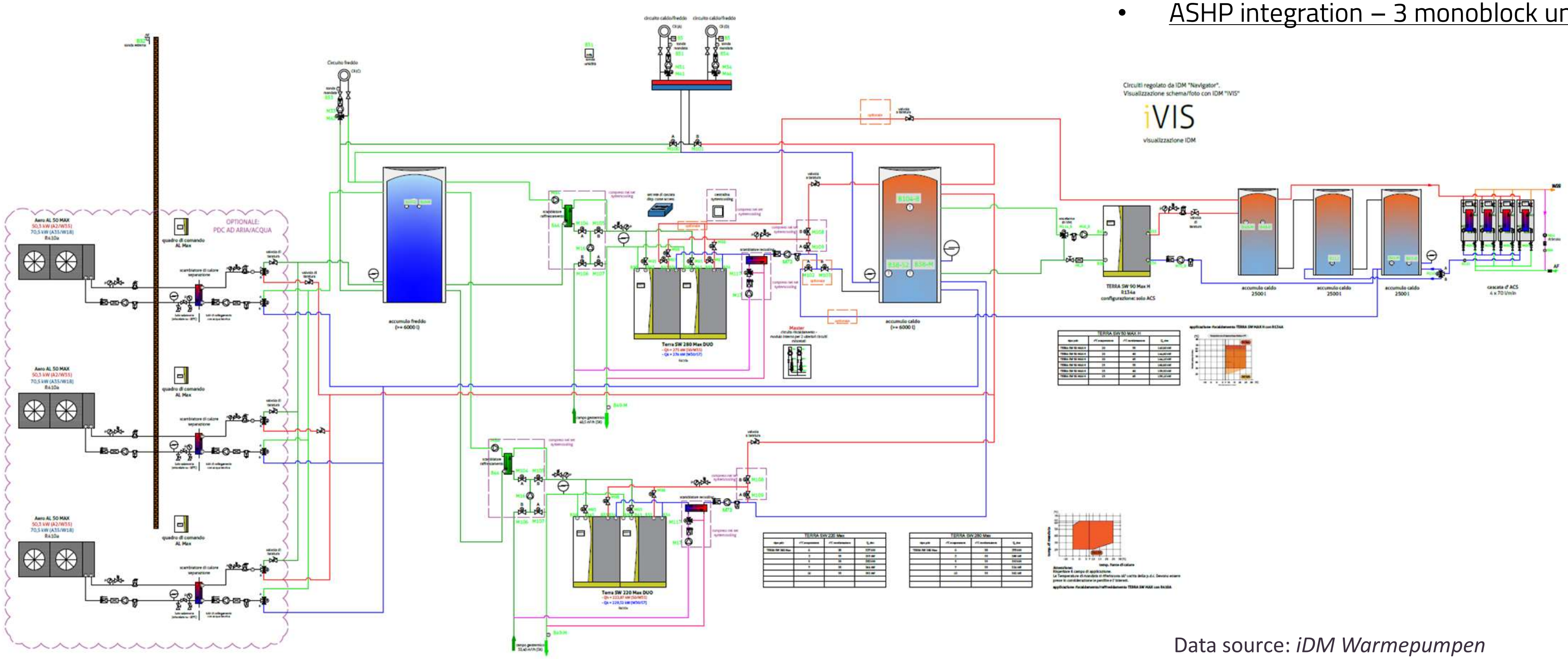
I. **Centralized energy production GSHP + ASHP**

II. **Low temperature network with SGLA – Decentralized single apartments GSHP – Dry Coolers to balance the network**

Conceptual scheme - Centralized

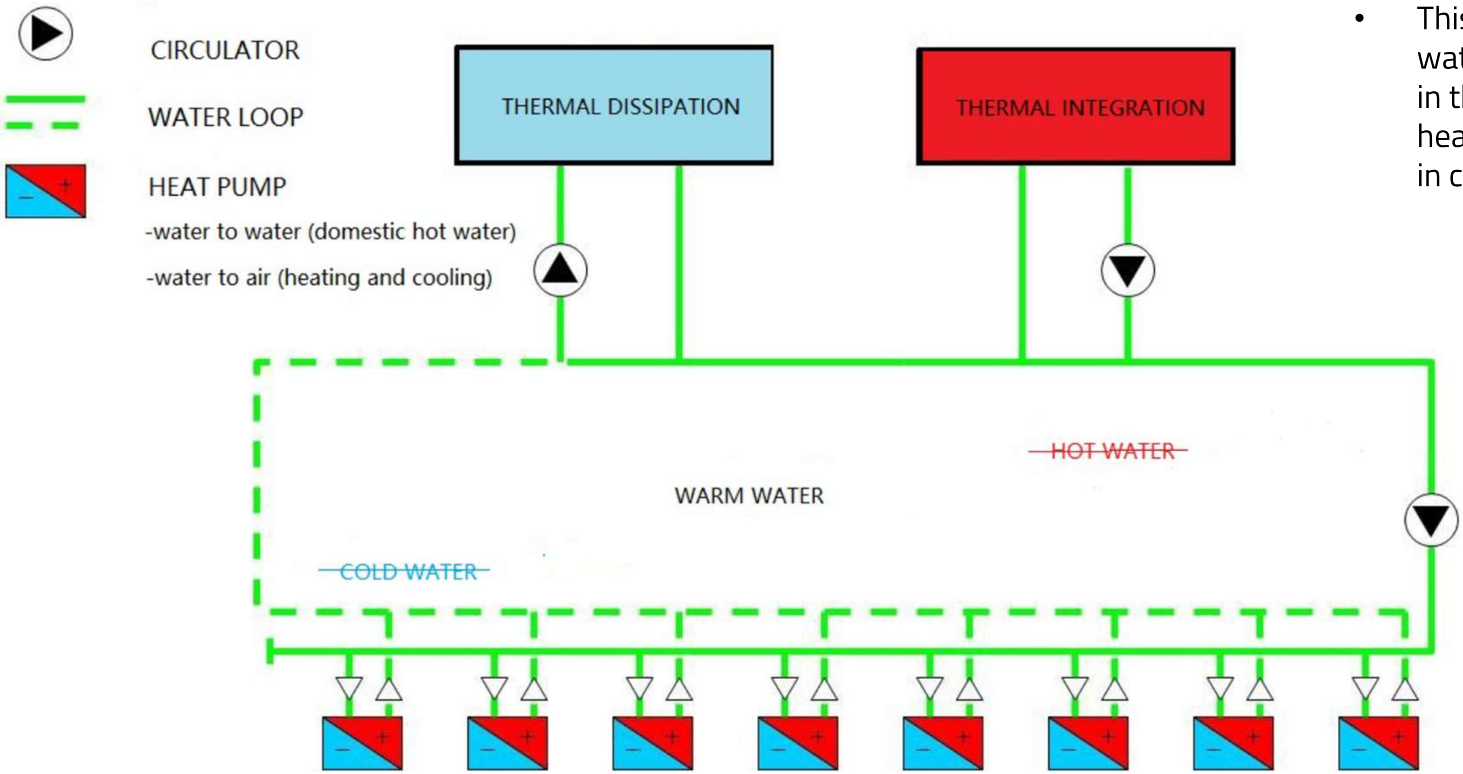
HY-GSHP system concept

- Heat pump iDM TERRA SW Max DUO 280 (S0W35) 450 kW
- Heat pumps iDM TERRA SW Max H Booster for DHW
- iDM System Cooling
- ASHP integration – 3 monoblock units



Data source: *iDM Warmepumpen*

Conceptual scheme – Decentralized (Water loop system)



HY-GSHP + ANETWORK

- The water loop system is made up of a closed two-pipe hydraulic circuit maintained at a neutral temperature thanks to thermal dissipation or integration systems.
- This acts as a source for decentralized water/water heat pumps - WLHP - positioned in the apartments to be air-conditioned: in heating they extract heat from the loop while in cooling they inject it in the loop.

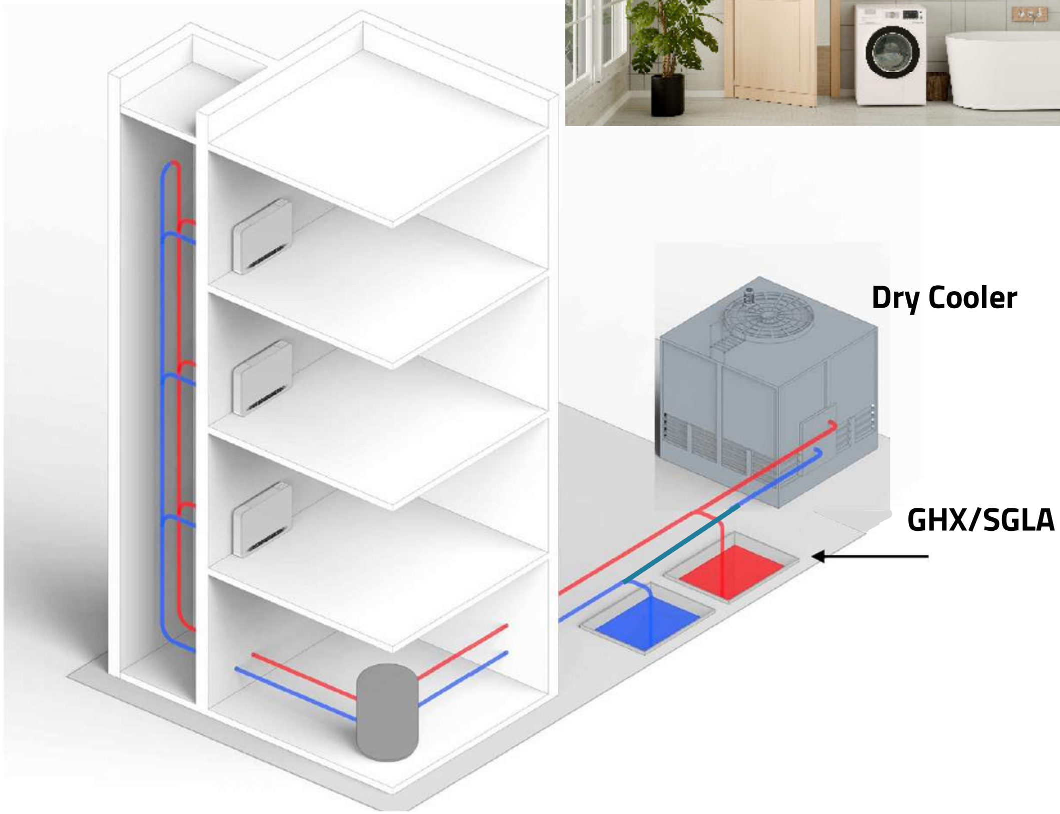
Conceptual scheme – Decentralized (Water loop system)

HY-GSHP + ANETWORK

In each apartment, a water/water heat pump with DHW storage can be placed for heating/cooling and DHW.

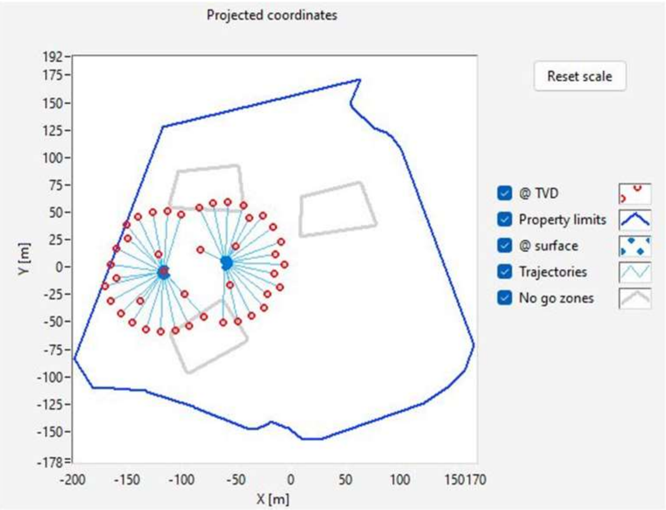
ADVANTAGES:

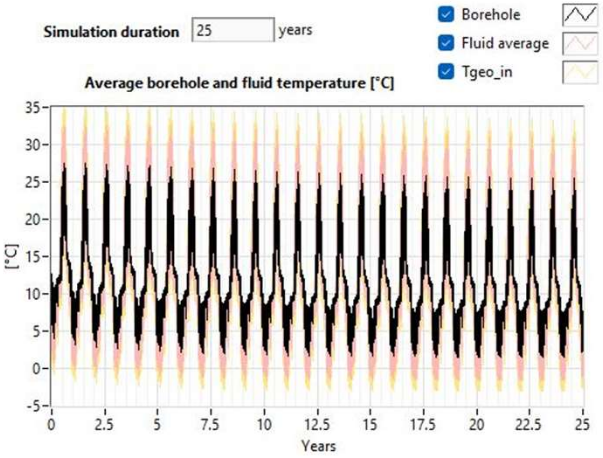
- Decommissioning of the standard rise. columns and related consumption due to the significant heat losses.
- The DHW produced locally can be maintained at a lower temperature with a reduction in energy consumption.
- In the summer, the heat removed from the rooms is recovered for the production of DHW, through the system loop.
- No accounting of the heating/cooling thermal energy is necessary due to the connection of the pumps to the apartment's electrical user.



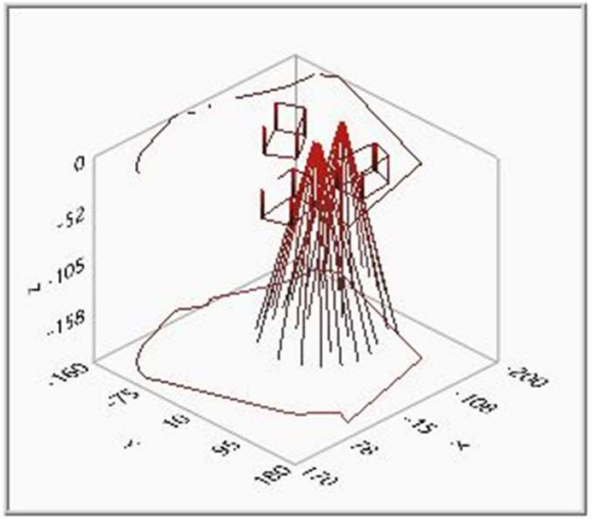
GHX configuration

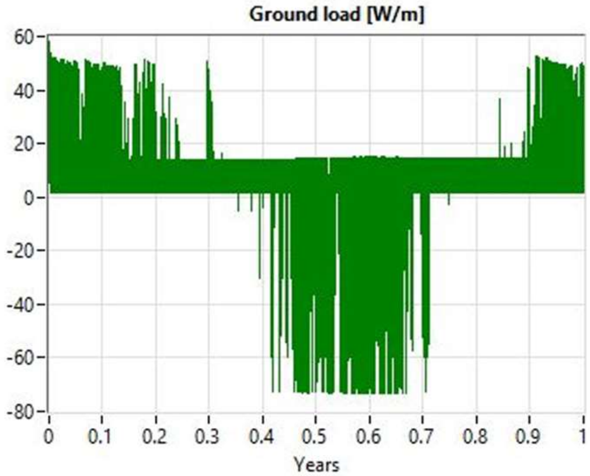
42 inclined GHX at 150m (inclination from 5° to 20 ° from vertical). The scenario allows working within the boundaries of the property.





<u>GHX length = 6300 ml</u>
SCOP GSHP = 4.45 (Heating) - 2,81 (DHW) – 5.25 (Cooling)
SPF= 4.18 (Heating+DHW+Cooling)
LCOE = -13% (reference ASHP)
CO_2 = -78% - renewable energy 63%
Plant budget cost = 2 – 2.4 MIO €
Payback time = 8.5 yrs (reference ASHP)





GHX scenarios comparison

Total Cost for a Full size vertical GHX = 1.0 – 1.2 MIO €

Solution	Length GHX (m)	Footprint (m²)	N° Probe	Footprint reduction (%)	GHX Cost reduction (%)
Full GEO vertical	12.300	5.248	82	0	0
Full GEO inclined	12.000	587	80	88	16
Hybrid vertical	8.400	3.548	56	71	29
Hybrid inclined	**6.300**	**293**	**42**	**94**	**54**

Conclusions

- Rhule of thumbs are killing the majority of the GSHP project!
- Energy vs Power analysis is fundamental for a correct HP system design
- GSHP systems are an ideal solution to cover the «baseload»
- It is important to balance the «ground battery»
- A multisource/hybrid approach can strongly reduce the CAPEX of the project and allows a long term operation of the GHX field/GSHP system
- An optimized GHX geometrical configuration can improve the solution (for medium-big installations > 100-200 kW) and/or can reduce the GHX field footprint (important expecially in the renovation/retrofit)
- Further system real-time robust monitoring after the start up phase is important to ensure that the system is working properly/as intended!

GEOKORE

Thank you for the attention!

Planning and implementation of Geothermal fields and cold networks

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