Feasibility studies for Coastal Energy projects in pilot areas UNIUD

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Contents

1. Description of the deliverable

This deliverable regard feasibility studies for Coastal Energy projects in pilot areas. Specifically, feasibility studies for the realization of Blue Economy systems in the pilot coastal areas (with special focus on systems that are integrated in coastal infrastructure/built environment), that could be financed through European, national or private funds. Developed within the Local Coastal Energy Hubs, the participatory process leading to their preparation will serve to test tailored design activities and business services, that, properly systematized within WP5, will be transferable to other contexts.

1.2 The low wave energy potential in Friuli Venezia Region

The wave energy potential of the northern Adriatic Sea is very low, especially in Friuli Venezia Giulia Region as shown in Figure 1. More in detail, the sea in the Region has low wave power and wave height. In order to have high performance or at least a significant level of profitability, it is necessary a wave power between 8 and 15 kW/m, a wave height of at least 1.2 m, and a wave period of at least 4 s. Conversely, the northern Adriatic Sea is characterized by a wave power between 0.04 and 1.31 kW/m, a wave height between 0.328 and 0.488 m, and a wave period of 2.85 –3.20 m/s. The results are summarized in Table 1.

The low wave energy potential of the of the northern Adriatic Sea is confirmed by the analysis of the blue potential carried out within Maestrale project – Interrreg Med.

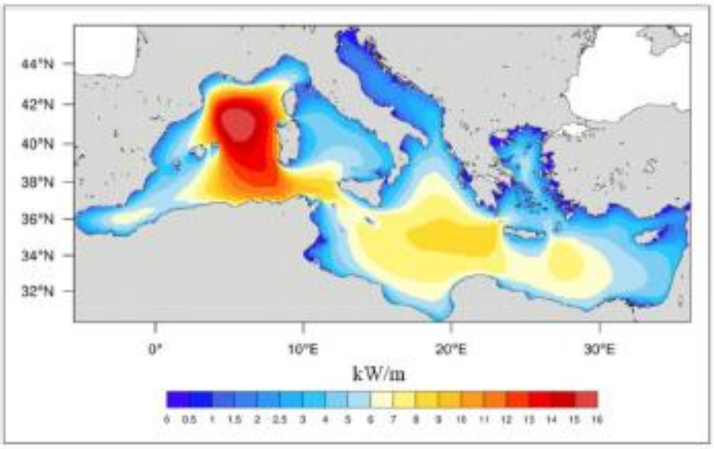


FIGURE 1 - MAP OF AVERAGE POTENTIAL ENERGY IN THE MEDITERRANEAN

TABLE 1 - DATA ON BLUE ENERGY SOURCE OF THE NORTHERN ADRIATIC SEA

Blue energy source	Data	Minimun requirements for profitability
Wave power	0.04 –1.31 kW/m	8 –15 kW/m
Wave height	0.328 –0.488 m	1.2 m
Wave period	2.85 –3.20 m/s	4 s

1.3 The geothermal and sea thermal resource in Friuli Venezia Giulia Region

As stated before, the wave energy potential of the northern Adriatic Sea is low. Therefore, other sources of blue energy are considered, particularly the geothermal one.
In the Region there are several historical and current evidences of geothermal sources that are listed below:

- the Roman Baths of Monfalcone, fed by a singular source that flows spontaneously from the limestones with a T of 38-40 ° C;
- the waters coming from the artesian aquifers at 340 m of depth in the Grado Lagoon (Val Noghera-Isola di Morgo) with a T of 42 ° C;
- the waters that flow from the artesian aquifers at 560 m depth in the area of the mouth of the Tagliamento (Fourth Basin and Isola Picchi) with T up to 52 ° C;
- the Cesarolo 1 well, drilled by AGIP for oil exploration (located in Veneto, 8 km west of Lignano), which met the Friulian Mesozoic platform at a depth of 727 m, where a temperature of 60-65 ° was measured C.

More in detail, the geothermal system affecting the Veneto-Friuli coast is characterized by two main types of thermal aquifers:

1. soft thermal aquifers, within the plio-quaternary and myocene cover soils (maximum depth up to about 600 m), with temperatures up to over 40 ° C (maximum 52 ° C);
2. brackish or deep salty aquifers, housed in the buried limestone structure (depth between 750 and 1000 m from the countryside), with a temperature of about 60 ° C. This system is generally isolated from the overlying sweet aquifers by a septum of interposed impermeable formations (marl or flysch).

1.4 Geothermal and see thermal projects carried out in the Region

Several geothermal and see thermal projects were carried out in the Region. The most significant are summarized below.

Grado geothermal Project

In the Veneto-Friuli coast area an explorative project was carried out. This project was the first initiative on the territory of the Friuli Venezia Giulia Region, for the evaluation and rational exploitation of the geothermal waters contained in the limestone buried at about 600-700 m depth. The project consisted of two phases.

The Grado geothermal Project - Phase 1 was completed in 2008 by the Regione Friuli Venezia Giulia and it was mostly supported by European Union funding. This phase resulted in the feasibility of a geothermal district heating pilot-plant on Grado Island, in the north-eastern Adriatic Sea (Italy). The reservoir characterization and the preliminary geothermal potential assessment rely on the geophysical prospect and on an exploration, borehole drilled down to 1110 m. These investigations confirmed the existence of an untapped low-enthalpy geothermal reservoir within the Mesozoic carbonate platform buried beneath about 1 km of Paleogene and Neogene sediments, in correspondence of the structural highs along the coastal areas.

In 2012, as part of the Grado geothermal Project - Phase 2, an integrated gravity and seismic geophysical prospecting, including multi-offset VSPs, was conducted in downtown Grado and in its surrounding lagoon. The target was to extend the investigation of the geothermal reservoir and to provide adequate information on the faults/fracture systems interesting the buried external Dinaric thrust front. The results of the second phase allowed operators to locate the second well of the geothermal doublet, planned to feed the district heating system of public buildings on the island.

Pontebba Ice Rink Plants

The existing cooling system of the ice rink of Pontebba town (UD), located close to the Austrian border, was totally renovated in late summer 2012: an open loop heat pump system using groundwater thermal energy was realized and functions both for the ice production and maintenance, and for the heating and hot water needs of the ice stadium. Two ammonia heat pumps (350 kW each) were installed, supported by two production water wells (32 m deep) and one re - injection water well (30 m deep), drilled into the alluvial deposits of the Fella River. A total production rate of up to 200 t/h could be achieved from the shallow unconfined aquifer, with an average temperature of about 8.5 - 9.0 °C. Numerical modelling of groundwater flow supported the assessment of the production and re - injection rates, as well as the evaluation and the minimization of the impacts on the groundwater resource during the plant management in various hydraulic regimes. Over the first two years of operation, cost reductions of the order of 45% have been achieved.

Thermal energy from the sea for the city of Trieste: proposal for sustainable use

In 2014 the Trieste International Foundation and University of Trieste, in agreement with the Municipal Administration of Trieste, proposed to evaluate the construction of plants for the exploitation and distribution of hydrothermal energy derived from the Gulf of Trieste, on one or more buildings in the historic centre of the city, in particular in the "Rive" area. This solution should have been achieved through a primary mini-district heating network, equipped with pipes positioned at adequate depth in the road section, without insulation, to allow each building to connect to the water supply and return sea water (in open circuit), or to connect to an intermediate technical water network (in closed circuit), which network requires a common exchanger with the sea resource. In the case of a solution with an open seawater circuit, the second section of the system consists of a heat exchanger connected to the open circuit ring and connected, on the other side, to a closed loop ring, in which a fluid flows, which transfers heat to the heat pump serving the buildings connected to the network.

Portopiccolo Seawater air conditioning system

The former limestone quarry of Sistiana, in the province of Trieste, was the subject of an important environmental restoration intervention. "Portopiccolo Sistiana" is a complex that includes 460 housing units, public and private beaches, green areas, bars and restaurants, hotels, 124 berths and a large spa. This is an entire village with energy efficiency class A. The centralized air conditioning system run with seawater and it is based on the water ring technology. Moreover, the plant is set up for the exploitation of groundwater, thanks to the contribution of the Timavo river. Seawater exchanges heat with the technical water circuit, which in turn brings the energy carrier to the 25 electric pumps located in the 18 sub-stations spread throughout the village, covering the heating, cooling and hot water needs of all utilities. After the construction of the infrastructures, the laying of the networks and the construction of the buildings, the small port was excavated and opened, allowing the start-up of the air conditioning system in April 2014.
Given the successful projects carried out in the Friuli Venezia Region, the focus is on the implementation of a sea thermal energy system.

2. Possibile need for downscaling

2.1 Low and high enthalpy sea thermal energy

Having considered the low wave energy potential as a disadvantage and the high sea thermal energy potential as an advantage of the northern Adriatic Sea, the focus is on the implementation of a sea thermal energy system. It is important to keep in mind the most common classification parameter of geothermal resources which is based on the enthalpy of fluids, which transfer heat from deep hot rocks to the surface. Enthalpy is used to express the thermal content (thermal energy) of fluids and gives an approximate idea of their "value". Resources are divided into low, medium and high enthalpy (or temperature) resources. Low temperature or “low enthalpy” geothermal energy is a renewable thermal energy resource that uses heat below 90°C as its energy source. In particular, geothermal heat pump systems exploit the thermal energy naturally available in the surface portion of the subsoil (within 200 m). Medium and high enthalpy resources are those that instead use heat as energy source, respectively, at a temperature between 90°C-150°C and above 150°C. The high enthalpy geothermal fields are located in the pre-Apennine belt (between Tuscany, Lazio and Campania), in Sicily and Sardinia, as well as in the volcanic islands of the Tyrrhenian Sea. The territory of the Friuli-Venezia Giulia Region does not offer great possibilities for large plants at high temperatures, while it has an interesting installation capacity for those at low temperatures. By carrying out a more in-depth analysis of the resource in the area, it has been discovered that the resource is partially low enthalpy. However, this resource could guarantee substantial energy benefits through heat pumps. The areas with the highest temperature in the subsoil are those with numbers 1, 2 and 3, shown in Figure 2.

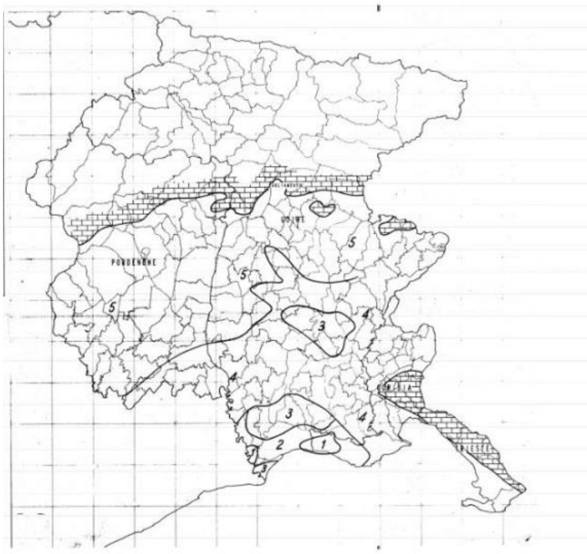


FIGURE 2 - GEOTHERMAL POTENTIAL AREAS IN FRIULI-VENEZIA GIULIA

In the next section the operating principle of the most successful technologies is analysed. Also, the following devices is identified as the most suitable to be implemented in the area. However, expert advice was needed to get more details about downscaling.

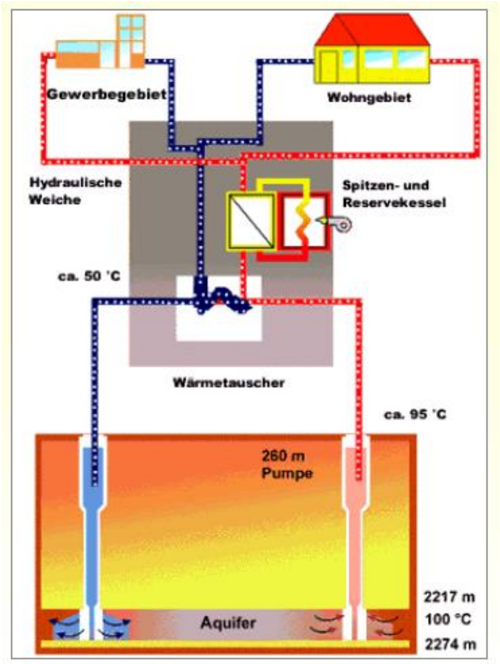
2.2 Process description of the Geothermal District Heating Project

A first successful system in the is a district heating plant (Figure 3) made by an extraction well and a re-injection well. The system guarantees heating to public buildings. In the first phase of the project the characterization and quantification of the available geothermal resource were carried out. The first phase ended with the following main activities: geological and geophysical investigations aimed at the location and design of the first exploratory well, tender for its construction, drilling, flow tests and well logs. The next phase included the second well drilling and surface systems building (i.e., heat exchangers, insulated pipes and connections to the heating network).

The typology of this plant for the exploitation of terrestrial heat is known as "geothermal doublet" therefore based on a two-well system and on a surface heat exchanger that works in a binary cycle. In this way, the only net extraction from the subsoil is the heat exchanged on the surface (heat mining) between the primary fluid from the well and the secondary fluid consisting of the fresh water of the city aqueduct.

The project develops approximately between the Costa Azzurra beach, where you can find the exploration well and Piazza Carpaccio where the second well was built, both located within the perimeter of the mining concession obtained by the Municipality and extending over almost 6 km^2.

The fluid extracted from the first well is re-injected in depth through a second well after being circulated in a district heating network in turn connected to heat exchangers. The district heating network is connected to two wells of 1110 and 1200 m depth, located in the city and about a kilometre away. The derivation well supplies geothermal water at 45-47°C which, circulating in the distribution network, transfers heat to the exchangers that heats the connected buildings. The water returning from the exchangers is collected and channelled to the re-injection well, into the same deep tank.



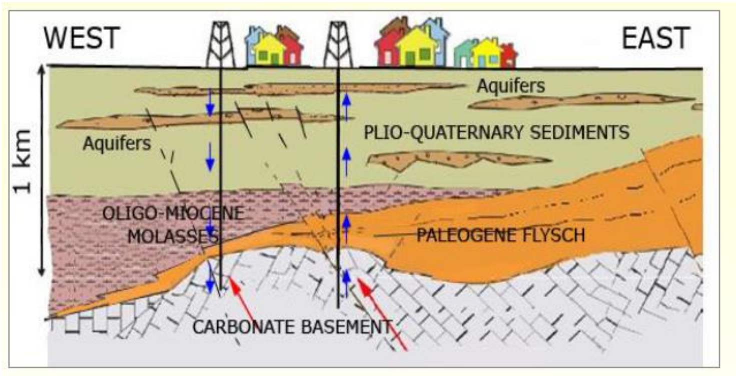


FIGURE 3 - GEOTHERMAL DISTRICT HEATING PILOT PROJECT

2.3 Technical description of the air conditioning system

A second successful system in the Region is an air conditioning system shown in Figure 4. The sea water exchanges the heat with a technical water circuit which takes the energy to the electric heat pumps located in the sub-plants. The technical water circuit forms a ring that extends for about 2 km and, thanks to the operating temperatures always below 35 ° C. The circuit was entirely made with polyethylene pipes also used in the seawater network. The innovative part of the system is power station powered by a medium voltage (20 kV) electrical substation. The power station is made by four heat exchangers of seawater and technical water (1 of which designed for reserve only) each with a nominal power of 1.45 MW. These are plate exchangers, made of titanium and insulated to avoid condensation during the winter. The control system continuously detects their pressure drops and allows the operator to evaluate when maintenance is required (usually annual). The maintenance foresees disassembly and cleaning of the plates to remove the deposits. There is also the possibility of carrying out a chemical descaling of the exchangers without disassembling, through a special circuit and with recovery of the fluid used for the operation.

Each exchanger is equipped upstream with a self-cleaning filter for the removal of algae: the control system automatically plans the flow inversions with by-pass of the dirty water towards the exhaust manifold. The maximum heat output that can be extracted from sea water is around 4.5 MW (with 3

circuits out of 4, the other is reserve). To date, the request has never gone beyond half of this value: not all users are still active.
The sea water treatment system injects ClO_2 according to its volumetric flow rate and its temperature. Before discharging, the presence of chlorine is monitored in order to comply with legislative constraints and, if necessary, dechlorinators are also added. The use of chlorinators and dechlorinators is significant in the summer, when the number of algae increases and at the same time the demand for air conditioning increases and therefore a greater flow of water is needed.
The circulation of sea water is guaranteed by 4 centrifugal pumps powered by stainless steel inverters, with a nominal flow rate of 183 m^3/h each. The result is ΔT maximum sea water of about 4-5 °C). The water of the technical water distribution ring is instead handled in the central sea by 4 centrifugal pumps: 2 large (274 m^3/h each), a medium and a small one, used according to the needs of the user. The result is a ΔT technical water of about 3 °C).
In the plant there are also two well-water-cooled fan coils for cooling the environment. The fan coils allow to dispose the thermal load to the outside, without having to use fans for guarantee a high air exchange. To ensure the exchange of heat with the environment, the seawater intake was placed at a depth of 3.8 m, and the system could alternatively be supplied with water from two wells at a depth of 80 m or from the municipal aqueduct.
The analysis of the data recorded in over 2 years of constant monitoring of the plant shows that the system has performed well so far, showing excellent efficiencies and without approaching the constraints imposed by environmental protection. The sea water temperature reached a maximum summer peak of about 28 °C and a minimum of 9 °C, during a persistent Bora wind. The most critical conditions for the operation of the plant, initially assumed for the summer, were unexpectedly encountered in the winter. In the middle of winter, the operating temperatures of the technical water circuit are actually around 10-5 °C (flow/return), while the production of water for heating at about 40 °C must be guaranteed.

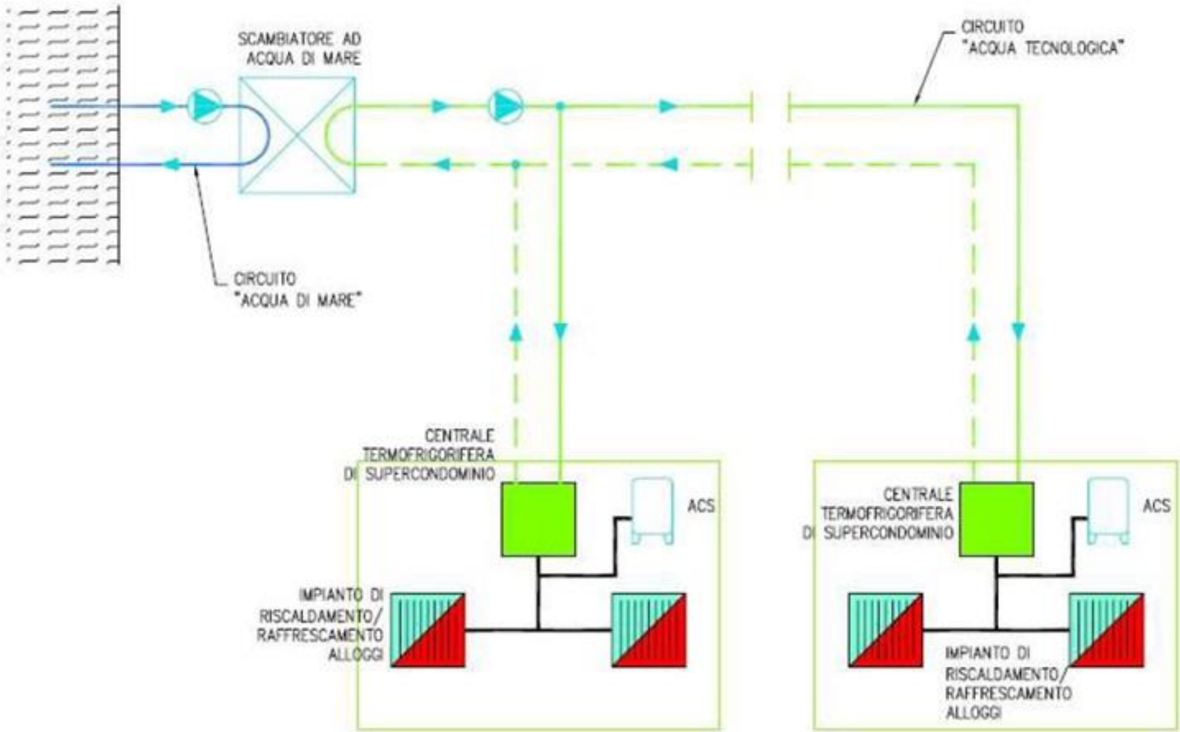


FIGURE 4 - OPERATING DIAGRAM OF THE SEAWATER AIR CONDITIONING SYSTEM

3. Possible barriers to implementation

A first assessment of the potential exploitation of the geothermal resource at regional level was conducted. The result is that the territory of Friuli Venezia Giulia Region does not offer great possibilities for large high-temperature systems, while it has interesting installation capacity for low-temperature ones.

3.1 Physical requirements for installation

As regards physical requirements, the installation of a geothermal plant needs the availability of a sufficient amount of soil, in relation to the type of plant you want to build, for drilling or for laying. For instance, in the case of installation of horizontal probes, the necessary external surface must correspond to a percentage between 100% and 150% of the surface to be heated. Moreover, to evaluate the convenience of the system, it is important to know the characteristics of the subsoil that you intend to use as a heat source, both to check the technical feasibility and any hydrogeological constraints, and to verify, based on the type of soil, the performance of the subsoil. Actually, the thermal conductivity of the soil (in other words its ability to transmit heat) varies according to the type of subsoil.

3.2 Authorizations and regulation for installation

A provincial authorization should be asked to the Region, in the case of small geothermal uses that exchange heat directly with the subsoil or with the aquifers without carrying out the withdrawal of fluids. This authorization is provided through the Water Protection Plan which aims to protect the groundwater. As regards the installation of vertical geothermal probes, the authorizations are regulated by local authorities, generally by the Regions and in some cases directly by the Provinces or Municipalities. While in the case of a system with horizontal probes, the maximum excavation depth does not normally exceed two meters and therefore no authorization is required.

As for geothermal installations that use groundwater as a thermal source, the legislation that regulates the sector in Italy takes as reference the national law on water and protection of the subsoil (single environmental text Legislative Decree 152/2006). The province of Trieste together with ARPA (Regional Agency for Environmental Protection), has established the respect of the national constraints and the obligation to install a monitoring system able to guarantee constantly:

- a threshold on the maximum discharge temperature of 35 °C;
- an increase in sea temperature 1 km from the discharge below 33 °C;
- a limit to the presence of residual chlorine at the discharge of less than 0.2 parts mg/l.

During the drilling and recombination operations, all the safety measures must be taken to avoid:

- to penetrate waterproof layers by connecting several aquifers;

- the contamination and pollution of the subsoil and/or groundwater caused from the use of additives, from leaks or from other operating irregularities of the plant;
- negative consequences for soil and subsoil due to oil, fuel, additives or other products of the drilling machines (the soil under the drilling machines must be protected by waterproof sheets and collection tanks).

The holes for the vertical geothermal probes must respect the legal distances from the property borders and a minimum distance of 4 meters in any case. The drilling cannot be carried out near existing water utilities and 100 meters from public drinking water supply wells in any case. During the drilling and before commissioning the plant, a report must be drawn up with:

- punctual data relating to drilling with indication of the stratigraphy of the subsoil, inflows of groundwater, losses of drilling water, technical data on the type of drilling and recombination, materials and additives used, particular situations and events
- technical data and results of the tightness tests of the geothermal probe.

3.3 Economic and financial impacts

Portopiccolo Seawater air conditioning system

Concerning Portopiccolo Seawater air conditioning system, the technology taken as a reference is characterized by the fact that it can be present anywhere in the soil, it also has a low energy and environmental impact. The cost of the system (mechanical, electrical and sanitary installations) is approximately about 25 million euros. The air conditioning system is about 2.5-3 million euros, of which 1.6 million euros only for the sea power plant and technical water ring. It is a system that has a high initial investment, linked to the total area to be supplied. Actually, the theoretical cost estimation would result in a cost for the probes starting from 8/10 thousand euros, the average cost of the company carrying out the survey would be approximately 900 euros while the cost for the survey would be around 40-80 euros per meter, depending on the type of soil. Taking as reference an apartment of 80 square meters, the hypothetical investment would be equal to 15-20 thousand euros, the more the area, the more the cost.

Grado geothermal Project

In the geothermal project of Grado completed in 2014, a network was created to connect six public buildings such as gym, hotel, auditorium, library, middle school, former school. The total cost is approximately about 5 million euros: 2.5 million euros in phase one of assessment of the geothermal resource and further 2.5 million euros in phase two of design and realize the geothermal doublet. In detail, the costs of the two geophysical surveys, logs, coring, production tests were 0.8 million euros, the design and field supervision amounted to around 0.2 million euros, one production and one re-injection wells of approximately 2 million euros and the district heating network, circulation pumps and heat exchangers for a cost of 2 million euros.

3.4 Preliminary summary

The analysis carried out underlines that geothermal and hydrothermal energy is currently an underdeveloped sector, it is difficult to take it off. In order to promote a plan for the conservation and development of the use of geothermal energy, the Region has financed various studies and research reported below:

- "Preliminary study of deep aquifers" which allowed to reconstruct the geometry and characterization of the aquifers deep in the Friuli plain;
- "Creation of the geological-technical map of the regional geothermal resource and definition of the guidelines for its use";
- "Geothermal Project" including the "Construction of an exploratory well and the quantification and parameterization of the geothermal resource in the Municipality of Grado".

As regards geothermal installations exploiting groundwater as a thermal source, the legislation that regulates the sector in Italy refers to the national law on water and protection of the subsoil, therefore not providing a specific regional regulation.
In addition, from a first analysis of the costs of these systems, it can also be deduced that these are plants with a high initial investment, however their useful life can extend to several generations. Risk and capital expenditure are concentrated in the initial phases of a project, only when the initial drilling has been completed the quality of geothermal resource can be demonstrated.

4. Heat pump feasibility study in Piazza Unità d'Italia in Trieste (Italy)

4.1 Macro geographical area

The pilot area chosen in terms of energy efficiency is the Gulf of Trieste. From a functional point of view, the area is convenient because it has water flows, water pulling, and it is possible to take advantage of fresh water.

Furthermore, there is a good depth in the Gulf of Trieste, as it reaches and exceeds 20/25 m. This because any temperature source serving heat pumps must attempt to provide fluids or resource at constant temperature, because otherwise it is impossible to design the machine. The constant temperature of the sea generally lies at the bottom where there is the densest water and changes in water characteristics (temperature and salinity) are little.

Therefore, both in the Adriatic and the Gulf of Trieste (Figure 5) the sea currents are counter clockwise in the deepest layers and clockwise in the surface layer, and in particular, the Isonzo triggers a clockwise current, whereas the bottom current in the other way. Since the undercurrent flows in the other way permits to continually stir the bottom water and keep the temperature at almost constant values.

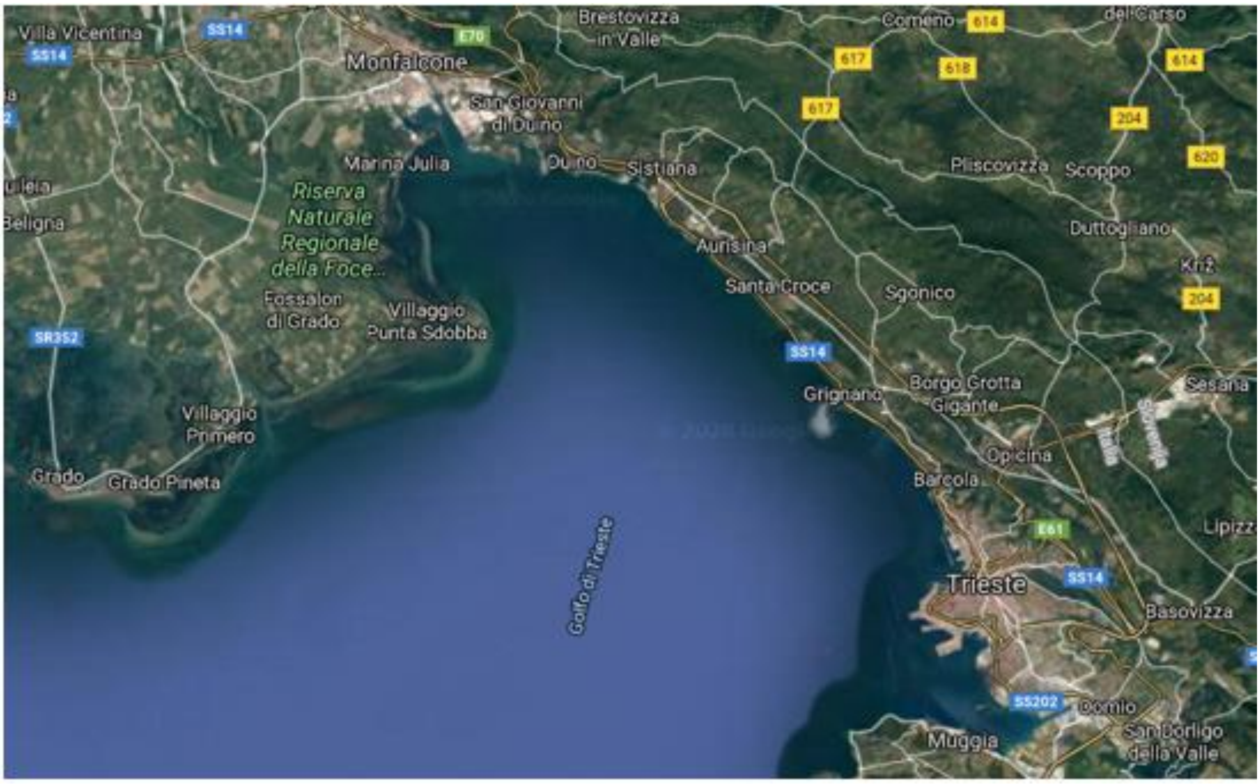


FIGURE 5: MACRO - LOCATION OF THE PROJECT

4.2 Micro geographical area

Our pilot project is located in Piazza Unità d'Italia (Trieste, Italy), circled in the Figure 6.

FIGURE 6: MICRO LOCATION OF THE PROJECT: PIAZZA UNITÀ D'ITALIA (TRIESTE, ITALY)

The historic center of Trieste is characterized by the proximity of the sea, a basin with a depth of about ten meters and a variations temperature limited throughout the year (14-16 ° C in summer and 9-11 ° C in winter). The square has a rectangular plan with a total area of 12,280 m². The square opens on one side into the Gulf of Trieste and is surrounded by numerous palaces and public buildings, headquarters of various entities.

In detail (Figure 7), starting from the left, in clockwise, the following public and private building can be identified: the Palace of the Prefecture, Stratti Palace, the Trieste town hall, Pitteri Palace, the Lloyd Triestino Palace, all potential end users of the analysed system.

FIGURE 7: POTENTIAL END USERS OF THE PROJECT

4.3 Feasibility study

The Feasibility study was articulated as listed below (Figure 8):

- *Technical feasibility:* evaluating the technical resources needed and available to implement the project.
- *Economic feasibility:* estimating the financial aspects of the project, evaluating costs and return of investments.
- *Legal feasibility:* identifying whether the proposed project conflicts with national or international laws.
- *Operational feasibility:* identifying the barriers in order to overcome possible solutions to ensure the feasibility.
- *Task planning:* assessing the sequencing of activities according to their criticality and priority.

In the next section, all these perspectives will be discussed.

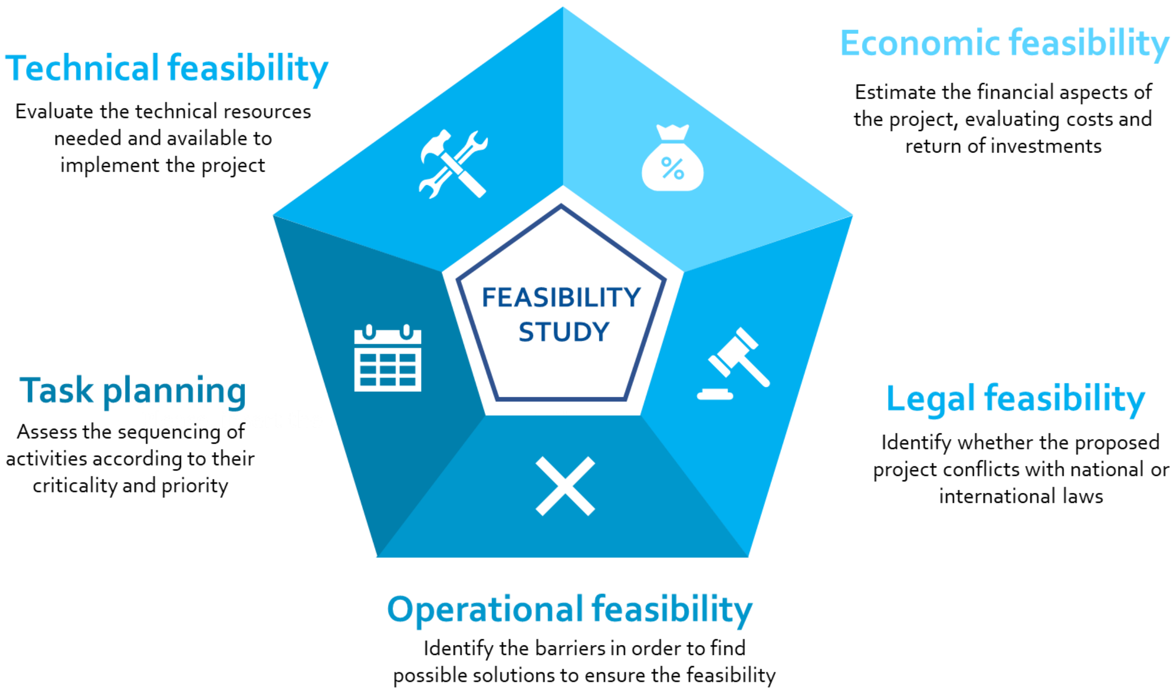


FIGURE 8: FEASIBILITY STUDY ARCHITECTURE

4.3.1 Technical feasibility

It is estimated that the resources needed for our plant are: heat pump, heat exchangers, ring circuit with pipes that connect all the buildings (see Figure 9), water intake filter, coupling maritime works of the intake pipe to the seabed, service plant where there is the heat exchanger at sea (temperature, pressure, salinity) flow rate monitoring sensors etc.), cleaning system, heating/cooling system connected to the buildings, thermal power plant, monitoring sensors in buildings, source fluid (sea water), technical fluid (transporter of energy from the sea side to the machine side) and cooling fluid.

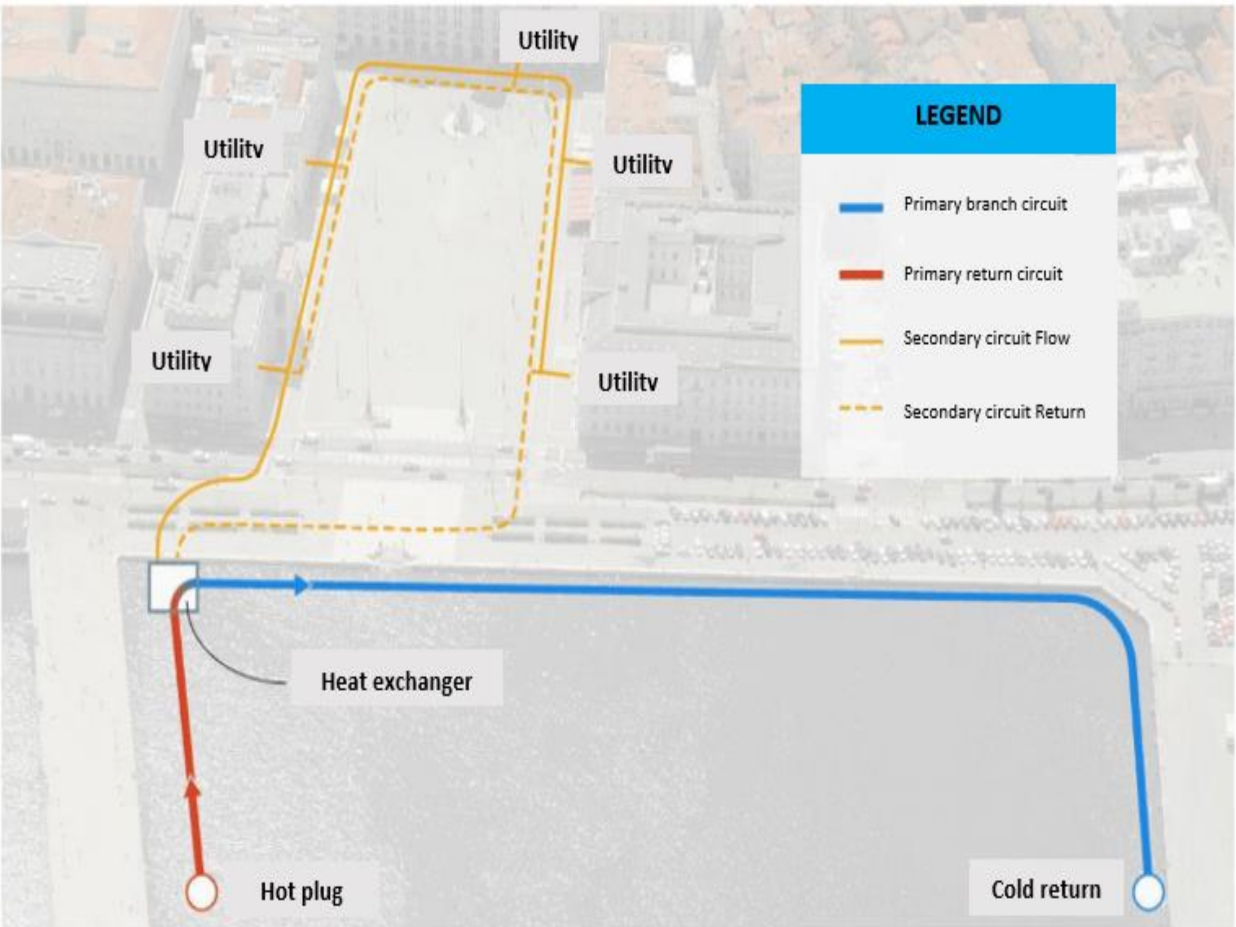


FIGURE 9: RING CIRCUIT WITH PIPES THAT CONNECT ALL THE BUILDINGS

4.3.2 Economic feasibility

Given the complexity of the project, it is not possible to have a precise estimate. In general, since the technology is innovative, it requires high initial investment and a long pay-back period (about 15 years), compared to other technologies. Thus, the realization of the prototype could take about 5 years (TRL 5) and further 10 years for scale-up activities (TRL 7/8) and installation. For these reasons, economic feasibility is strictly subordinated to partnerships with financially solid companies and national incentives.

4.3.3 Legal feasibility

Authorisations to be applied for and regulation to be respected are identified to evaluate the legal perspective. In particular, authorisations must be requested by maritime property, harbourmaster's office, Fvg Region and Municipality of Trieste. Simultaneously, it is necessary to respect regulations:

- for the withdrawal and use of water

and

- for the use of the site (Master Plan), in which it is verified that the site is not archaeological or naturalistic, that it is not frequented by boats, that there are no black water discharges or purifier discharges.

Moreover, Environmental Code 152/2006 (Legislative Decree No. 152 of 3 April 2006) must be observed. In particular, for the analysed plant, it is necessary to check the amount of free chlorine release, because the seawater system must have a treatment against the proliferation of microorganisms.

4.3.4 Operational feasibility

The aim of this analysis is to identify the barriers that could potentially prevent the project from being implemented, in order to find possible solutions to ensure its feasibility. Starting from the question "*Which are the problems that could be related to our potential investment?*", it was possible to identify the following barriers:

- Bureaucratic barriers
- Legislative barriers
- Plant implementation
- Environmental barriers

- Stakeholder engagement and alignment

Advantages and disadvantages were defined in order to evaluate whether the advantages go beyond the disadvantages. This is to assess whether it is worth trying to overcome the barriers. In the table 2, it is showed that advantages are greater than disadvantages. In the next section, the activities are planned in order to exploit all the advantages, to overcome the barriers and proceed with the realization of the project. In particular, the overview of a potential task planning is provided in order to exploit advantages and face barriers.

TABLE 2: ADVANTAGES VS DISADVANTAGES

ADVANTAGES	DISADVANTAGES
Provide more energy	Noise
CO_2 reduction	Maintenance (cost and time)
Energy from renewable energy sources	High installation costs
High yield compared to other plants	Availability of an adequate site where to install the system and a suitable place in the buildings
Modular technology	
Possibility of being hot and cold	
Possibility to create hybrid systems	

4.3.5 Task planning

For this type of project, it is difficult to estimate specifically the duration. Therefore, the activities are divided into two main parts: preliminary activities as critical success factors and activities to consider for executive planning.

Preliminary activities as critical success factors are:

- Request for partnerships to financially solid companies
- Request for government incentives and grants
- Request for permissions
- Project compliance analysis with current and updated regulations
- Verification of environmental regulations
- Stakeholder engagement to ensure the feasibility

In addition, these activities have been ordered and scheduled as highlighted in Figure 10:

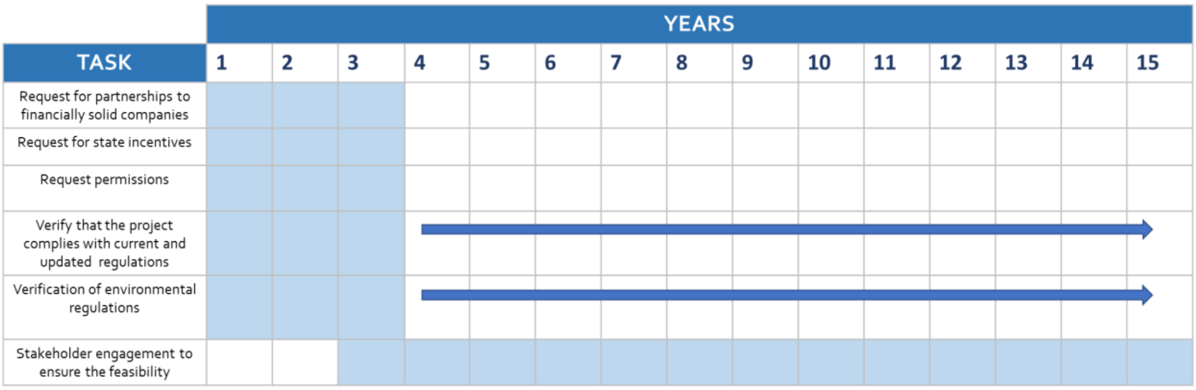


FIGURE 10: PRELIMINARY ACTIVITIES AS CRITICAL SUCCESS FACTORS (TIME SCHEDULE)

As Figure 10 shows, the first five activities (request for partnerships to financially solid companies, request for incentive, request permissions, verify that the project complies with current and updated regulations, verification of environmental regulations) should start the first year in parallel and should last about 3 years. In detail, two tasks (verify that the project complies with current and updated regulation and verification of environmental regulations) should require a continuous commitment over time. Stakeholder engagement should require more time to align and gain the support of the different stakeholders.

On the other hand, activities for executive planning are:

- Realization of the first scale prototype (first phase TRL5 and then TRL7)
- Preparation of the site
- Machine Realization
- Preliminary and pilot tests, and the installation
- Verification and standardization of use with consequent monitoring

Moreover, also execution activities have been ordered and scheduled as identified in the Figure 11:

	YEARS																			
TASK	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20
Realization of the first scale prototype (TRL5)																				
Realization of the first scale prototype (TRL7)																				
Preparation of the site																				
Machine realization																				
Preliminary test, and installation																				
Verification and standardization of use with consequent monitoring																				

FIGURE 11: ACTIVITIES TO CONSIDER FOR EXECUTIVE PLANNING (TIME SCHEDULE)

Figure 11 shows that the activities are strictly connected. In particular, the first activity (realization of the first scale prototype TRL5) should start in the fourth year and complete the activities by the end of the eighth.

Consequently, the TRL7 prototype implementation should last five years. Moreover, three main activities (preparation of the site, machine realization, preliminary and pilot tests, and the installation) should be performed simultaneously to guarantee a proper installation of the scaled-up plant (iterative process). Thus, the verification and standardization of use with consequent monitoring should require a continuous commitment over time to guarantee a sound functioning of the technology.

5. A model for stakeholder engagement

The stakeholder value flow model Figure 12 could be useful to overcome the barrier of stakeholder engagement. The stakeholder value flow model could support the mapping process of stakeholders in the development of a business model, oriented to the creation of a sustainable value and it could be applied also in the context of the blue economy.

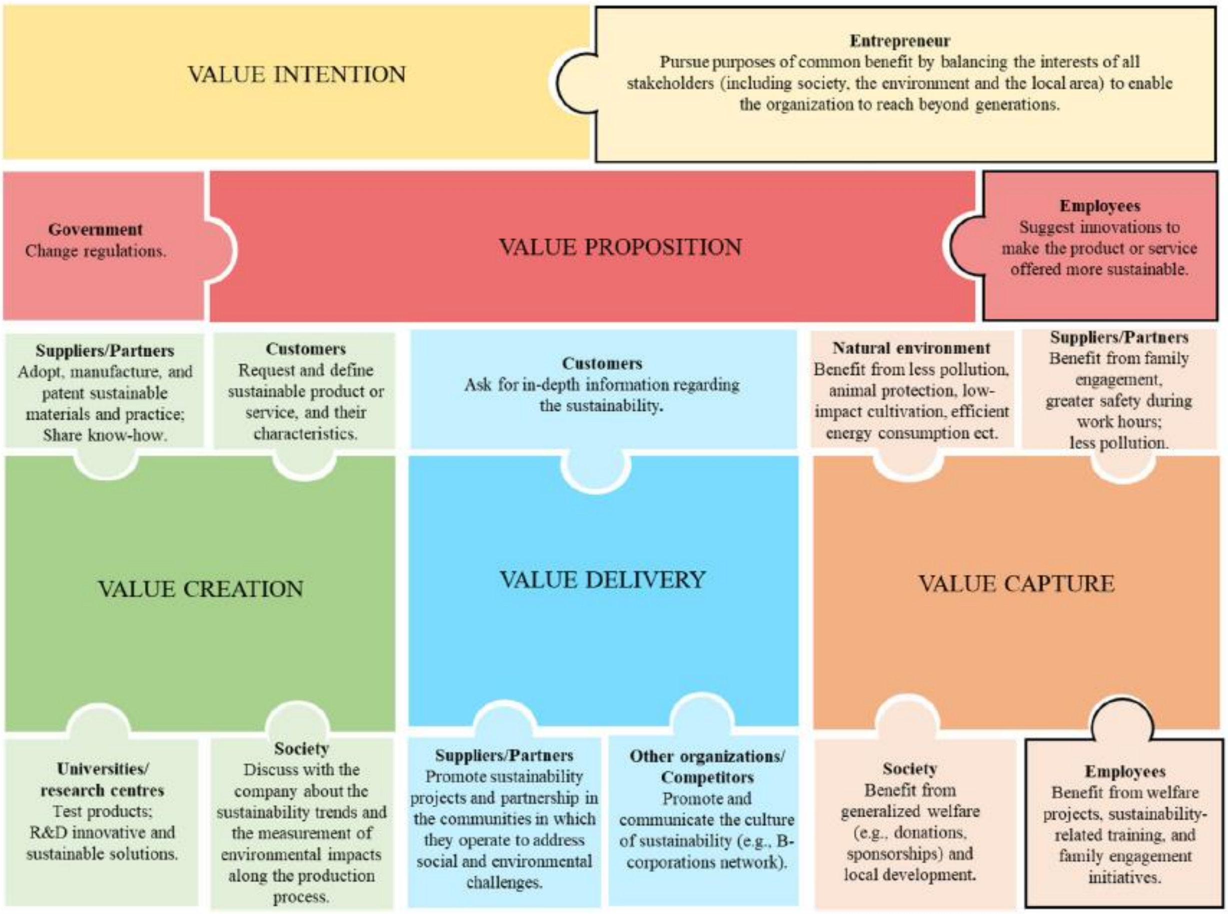


FIGURE 12: THE STAKEHOLDER VALUE FLOW MODEL. NOTE: INTERNAL STAKEHOLDERS ARE MARKED WITH BLACK BORDERS

(ATTANASIO, G., PREGHENELLA, N., DE TONI, A. F., & BATTISTELLA, C. (2021). STAKEHOLDER ENGAGEMENT IN BUSINESS MODELS FOR SUSTAINABILITY: THE STAKEHOLDER VALUE FLOW MODEL FOR SUSTAINABLE DEVELOPMENT. BUSINESS STRATEGY AND THE ENVIRONMENT, 1–15. HTTPS://DOI.ORG/10.1002/BSE.2922)

5. Conclusions

The feasibility study of this technology should be assessed by considering the five aspects shown. Therefore, a multidisciplinary project team is required. The feasibility study shows that the project is technically feasible, but high investments are required. Long payback periods require partnerships and national incentives. Barriers can be overcome by firstly scheduling and planning activities critical to the success of the project. Year by year, from the beginning, the following points should be addressed:

- Identification of the energy needs of the end users;
- Detailed economic assessment;
- Environmental impact analysis.