

**THE "GEOTHERMAL QUADRI-GENERATION" POWER PLANT:
PRODUCTION OF ELECTRICITY, H & C, GREEN HYDROGEN AND AMMONIA,
CLINICAL-THERMAL WATERS IN THE APRILIA SITE (Udine – ITALY)**

1- THE PRODUCTION POWER PLANT AND THE "GEOTHERMAL QUADRI-GENERATION"

AGA 4.0 s.r.l. geothermal-electric plant will produce in the APRILIA-LIGNANO SABBIADORO site (Udine, ITALY North-Est – Fig. 1) a "**geothermal quadri-generation**" plant producing electricity, Heating & Cooling, green hydrogen, green ammonia and clinic-medical water for thermae in local rehabilitation center.

In fact in APRILIA area, an **important geothermal aquifer has been known since the 60's, and confirmed** by several deep geophysical prospections (ENI, OGS) and 5-6 oil exploration wells (AGIP, ENI) in this hydrogeological zone, dozens of geothermal wells pumping in the shallow aquifers up to 700m. These investigations allowed the hydrogeological parameterisation of a large fractured saturated carbonate reservoir existing between 1,200-5,000m deep.

Therefore AGA obtained the geothermal research permit from the authority of the FRIULI VENEZIA GIULIA (Fig. 2), and the **hydro-geothermal Model** predicting that the warmer area is the APRILIA zone (Fig. 3) and, for one well, the following **hydrogeological data estimated conservatively** (Fig. 4):

- flow rate $Q = 120 \text{ l/s}$;
- temperature $T = 130\text{-}140^\circ\text{C}$;
- water pressure $P = +2.6 \text{ Atm}$ (at g.l.);
- time exploitation $t = 8,500 \text{ h/year}$.

The **main features of the numerical Model** are the following:

- Finite Difference numerical Model;
- production reservoir = fractured limestone rocks in huge regional acquifer, thickness c.a 4,000m;
- dimension of computing domain = 10Km x 10Km;
- 5 layers A-B-C-D-E, bottom 4,500m deep;
- Plume definition = horizontal and vertical (thermal plume) = thermal interferences calculation between the exploited deep acquifer (c.a 4,500m) and the artesian multilayer acquifers (c.a 600m deep).

The project of **AGA's geothermal plant** is made up of the following main elements:

- PUMPING WELL 4,500m deep (Figg. 5, 6);
- ORC system for electric production, connection and delivery to the national grid in MT (Fig. 7);
- ELECTROLYSER for the GREEN HYDROGEN production and CATALYST for the production of supercritical water/steam for energy production. Production of GREEN AMMONIA for ECOFUELS;
- H&C distribution with a local pipeline network (radius zone = 1.5 Km);
- clinic-medical water supply for THERMAE in a rehabilitation center;
- REINJECTION WELL to return water in the same extraction acquifer.

This system will provide energy demand in the **tourist area of APRILIA-LIGNANO SABBIADORO** that is the most important yacht port area of the MEDITERRANEAN Sea (c.a 3.500 berths for yachts).

Here, in a 1,5Km radius zone, we will produce with a single production deep well and applying a **geothermal quadrigeneration production strategy** based on the modulation of the exploitation of the electricity, the following **4 type of green energies and ressources** for the local and regional users:

1. **ELECTRICITY** = 3,3 MWel net, 8.500 h/year for alimentation of the national electric grid;
2. **H & C** up to 5 MWt ("thermal waste" after the electric production) for the tourist-residential-port use, in the District Heating for exisisting residential and tourist activities listed below:
 - 2.000 apartments and villas;
 - 17 swimming pools;
 - 2.400 yachts berths < 24m;
 - with this geothermal plant the APRILIA's Marina will become the only turistic port in Europe with H&C & hot water to the boats, all year, from 100% green energy 24 h/day;
3. **GREEN HYDROGEN and/or GREEN AMMONIA** for ECO-FUELS will be produced by the ORC plant when economic conditions make it profitable;
4. **CLINIC-MEDICAL WATER** for THERMAE and the existing "RESORT CLINIC & WELLNESS CENTER".



Fig. 1 – Turistic zone of LIGNANO SABBIAADORO-APRILIA (Italy) and the geothermal vocated sites in the permit area.

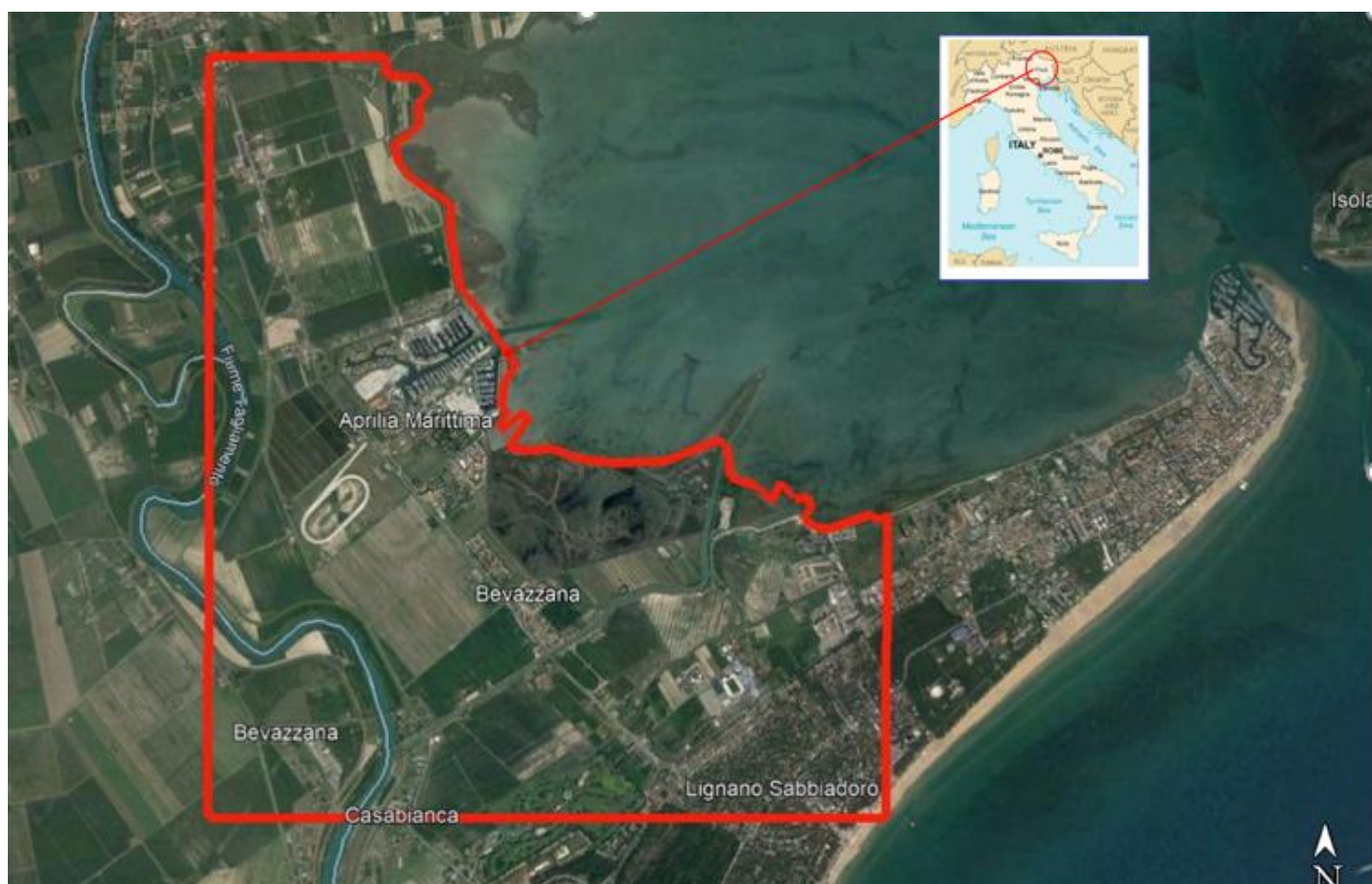


Fig. 2 – The AGA – APRILIA-LIGNANO SABBIAADORO geothermal research permit, issued by authority of the FRIULI VENEZIA GIULIA Region.



Fig. 3 – The marine port of APRILIA MARITTIMA and the geothermal site (c.a 7.200m²).

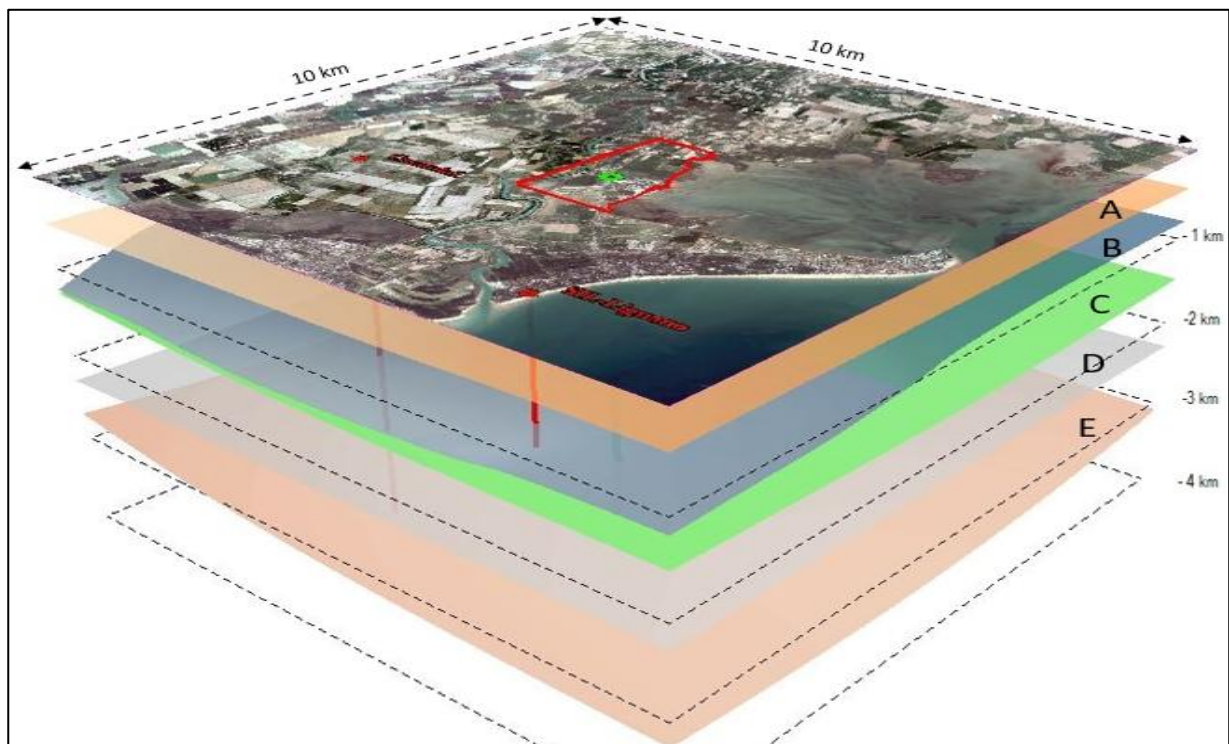


Fig. 4 - The hydro-geothermal numerical Model predicted for an exploitation well drilled in the APRILIA site at 4.500m deep in the fractured limestone rocks regional acquifer, the conservatively estimated geothermal exploitation data: $Q = 120 \text{ l/s}$, $T = 130\text{-}140^\circ\text{C}$, $P = 2,1 \text{ Atm}$, dimension of computing domain = 10Km x 10Km, computing layers A-B-C-D-E, from 0m to 4.500m deep, deep monitoring existing wells in the domein.

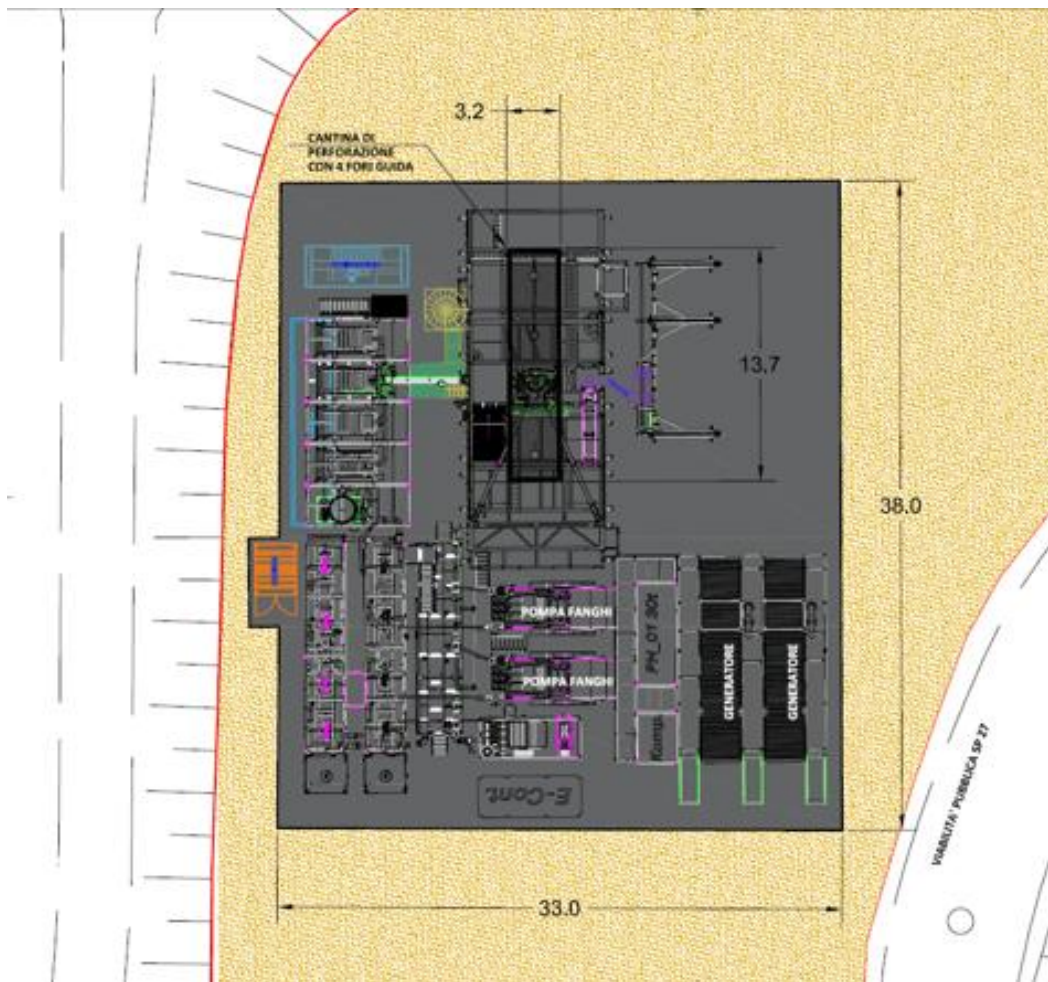


Fig. 5 – Project of the drilling working area and (x, y) dimensions in APRILIA site.



Fig. 6 – Rendering of the drilling plant (exemple).

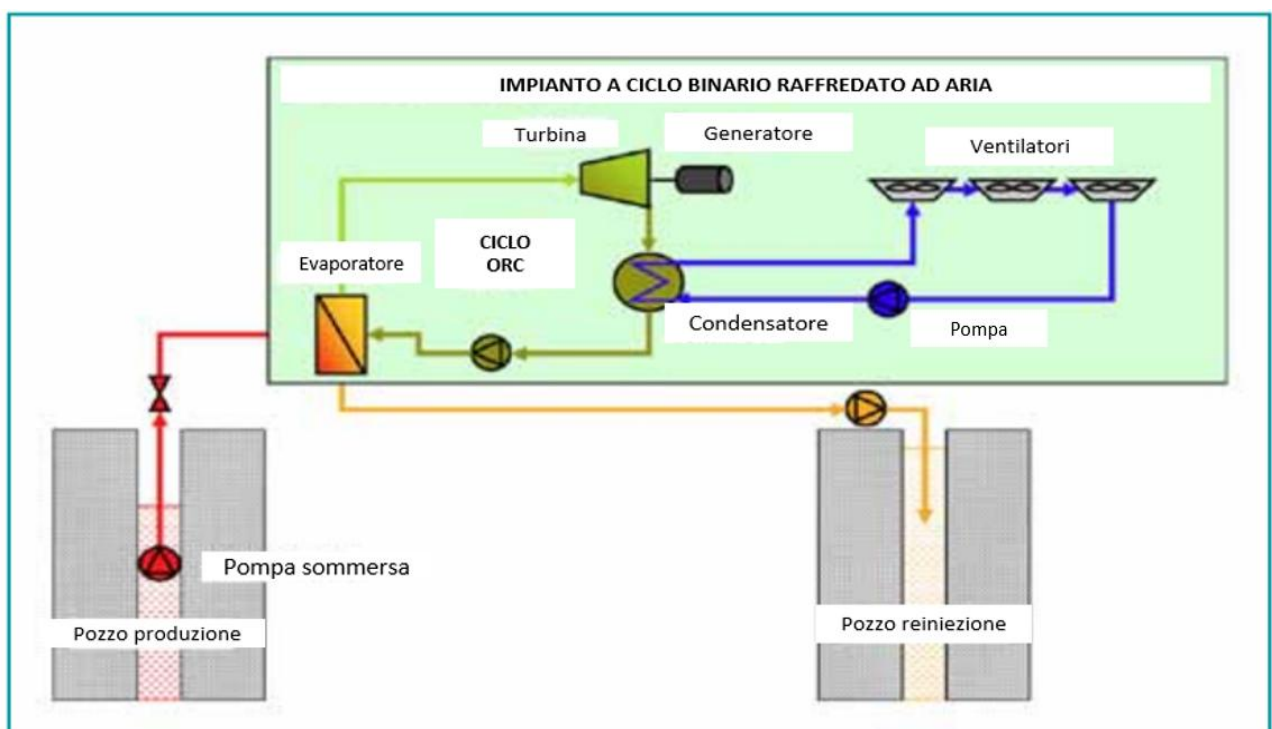
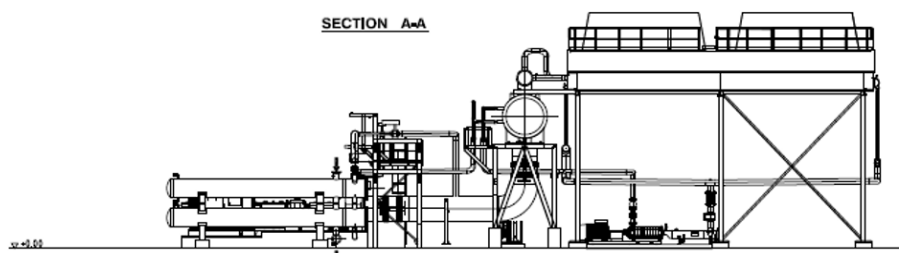
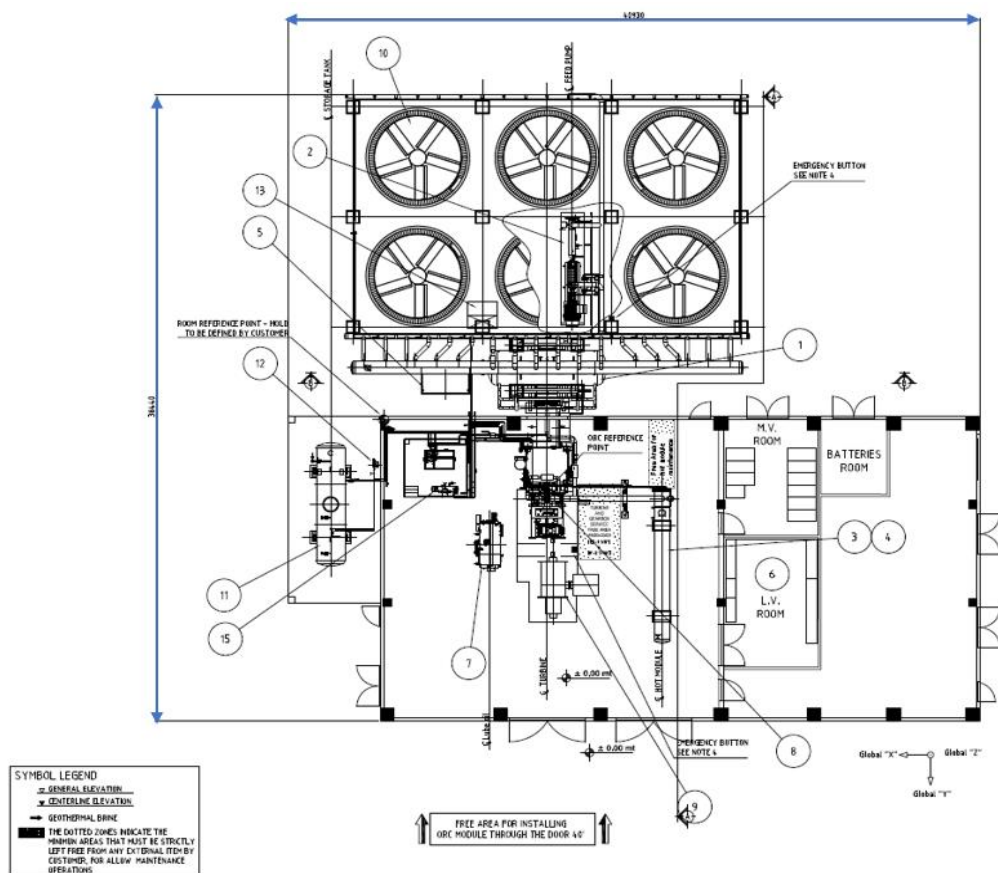


Fig. 7 - ORC binary system for electric production, aircooling plant, production and reinjection wells.

2- **ENVIRONMENTAL, SOCIAL BENEFITS: FOR THE LOCAL & REGIONAL COMMUNITY**

1. **Phase 2025 (current):** the Authority of FRIULI VENEZIA GIULIA Region issued to AGA 4.0 the **GEOTHERMAL RESEARCH PERMIT «AGA 4.0 – APRILIA MARITTIMA» Decree April/30/2025 RAFVG - Environment Direction**. The PdR is valid for 4+2 years and contains the **approval of the V.I.A./PAUR 1 work program** for the on-site execution of:
 - Geophysical investigations (reflection seismic, passive seismic, gravimetry, magnetotelluric), the approval of the V.I.A. (Environmental Impact Evaluation);
 - Drafting Executive Project of Well 1: for water extraction;
 - Drilling Well 1: for water extraction according to the Executive Project.
2. **Phase 2026-1: ON SITE WORKS and VIA/PAUR 2**
 - Geophysical investigations;
 - Drilling WELL 1;
 - Draft of the V.I.A./PAUR 2, unifies / includes all PERMITS: V.I.A. and all Permits for: Well 2 for reinjection (reinjection in the same aquifer), ORC plant for geothermal production of 3.3 MWe, 8,500 h/y, 28.000 MWh el/y);
 - Permit of geothermal water use, and energy production for 30 years.
3. **Phase 2026-2: ON SITE WORKS:**
 - Installation ORC plant;
 - Drilling Well 2 (for water reinjection in the same extraction reservoir or aquifer);
 - Installation ORC plant;
 - Start of the electric production (28.000 MWh el/y approximatively).
4. **TARIFF REGULATION in ITALY: the Ministerial Update June/28/2024 sets the tariff at €200/MWh for 25 years.**

A **new next FER** forecasted regulation is in the plans of the Italian Environment/Energy MINISTER that provides for a rate of €200/MWh indexed = €240/MWh (like current rates of France and Germany), contributions to the electricity grid limited to 500 MW in 10 years from 2025-35, the risk of 1st drilling well provides compensation for a maximum of 60% of drilling costs.
5. **«QUASI-ZERO» ENVIRONMENTAL IMPACT:** the **construction phases** have a high impact for the 6 months of drilling work due to the drilling rig having 34m height.

The plant in the **production phase** has an almost **irrelevant environmental impact** as follows:

 - The geothermal production plant and the ORC will have a height of 5-10m and its impact will be addressed in PAUR 2 in which the aesthetic solutions to reduce it will be presented.
 - At the end of the energy use, the geothermal water will be reintroduced into the aquifer with the reinjection Well 2.
 - Zero emissions + total reinjection.
 - Zero odors, steam emissions, chimneys.
 - 1,5 km radius H&C users.

"Geothermal quadrigenation" = 100% water utilization from 1 pumping well.

 1. Electricity;
 2. H & C;
 3. Green Hydrogen, Green Ammonia;
 4. Medical water for Thermae/rehabilitation use.

Opportunity for **different-scalable plans for energy production: Plan A, Plan B, Plan C.**
6. **AESTHETIC and FUNCTIONAL BENEFITS for Public Authorities in LATISANA community:**
 - the Plant will be **masked with aesthetic solutions** useful both to make it visually pleasing.
 - **TOTEM-large screen for the public advertisings of LATISANA territory**, its tourist activities, public events, municipal activities, describe the **Municipality of Latisana** as a "Green Energy City" and other uses decided by the administration, associations, population, etc.
 - The solutions will be **agreed with the Municipality and local stakeholders** in PAUR 2, in aesthetic and architectural coherence with the landscape, the surrounding buildings, the port-marina, the environment, economic activities.

3- **ECONOMIC BENEFITS: FOR THE LOCAL COMMUNITY & ECO-SUSTAINABLE DEVELOPMENT**

1. **BENEFITS for the REGIONAL ENERGY-ECONOMY:**

- CO2 emissions reduction and METHANE/TEP avoided;
- Reduction ENERGY BILL COSTS FOR THE POPULATION;
- Green H2 and Green NH3 production;
- Economic benefit for the local people, users, PRODUCTIVE ACTIVITIES.

The production of energy for 3.3 MWel and H&C thermal energy from programmable RES, for 365 d/y or 8,500 h/y = 28,050 MWh of electricity/year with "zero emissions", **allows FVG to contribute to complying with EU regulations that impose certainly a "Zero CO2 emissions" by 2035.**

This production of clean energy will allow both the achievement of the targets imposed by the regulations and the elimination of additional costs in energy bills for the Authorities, regional economic-industrial-agricultural activities, and normal users of the regional population.

This **clean and programmable energy 24 h/d or 365d/y** will also be used for the production of Green H2 and Green NH3 currently foreseen in the FVG Regional Energy Plan.

2. **BUSINESS BENEFITS 365 gg/y FOR THE LOCAL tourism high-level, accommodations, commercial, clinic-thermal center, School of FER-WATER SCIENCES:** alongside geothermal production, an INTERNATIONAL CENTER OF HIGH HYDROGEOLOGICAL SPECIALIZATION, innovative FER, industrial patents on FER will be built in APRILIA.

They **will produce 12 months/y:**

- high-level scientific tourism: specialists, university teachers/students, school groups, researchers and fans in water sciences-FER solutions;
- research – innovation activities in new forms of clean energy, patents, international projects;
- scientific activities, specialized teaching and training for ecological transition and CO2 reduction;
- a local influx of approximately 25 people/day, for 5 days/week, for 10 months/y is estimated;
- the geothermal well will supply clinical-thermal waters of the highest quality rehabilitation and SPA center being designed/iter in APRILIA (Municipality of LATISANA).

3. **CO2 and METHANE savings:** 3.3MWel net allows:

- reduction of METHANE = - 2,800,000 m3/y;
- reduction of CO2 = - 12,000 tons/y.

4. **LOCAL ECONOMIC BENEFITS for population and economic activities thanks to THERMAL INDIPENDENCE in a NEW DISTRICT H & C:** a preliminary study by the University of UDINE predicts savings for citizens on energy-thermal costs (heating, cooling, domestic hot water) thanks to the energy that will be supplied at **advantageous costs in APRILIA and BEVAZZANA villages:**

- 2.000 apartments and villas;
- 17 swimming pools;
- 2.400 yachts berths < 24m;
- The APRILIA's Marina will become the only turistic port in Europe with H&C & hot water to the boats, all year, from 100% green energy 24 h/day;
- PRILIA 2000 Marina will offer users heating for boats during the winter: the company APRILIA 2000 Marina predicts a strong increase of clients during 12 months/y.

5. **LONG TERM BENEFITS: Economic-business development, new activities 12 months/y:** The supply of low-cost thermal energy in D.H. for boats, apartments and structures present in APRILIA will produce an increase in attendance for 12 months/year not only to the advantage of APRILIA but also of LATISANA and LIGNANO territory (see the official communications issued by Marina «APRILIA 2000», Municipality of LIGNANO, Building Administrators in APRILIA, University of UDINE, etc.).

6. **THE ECONOMIC-FINANCIAL PARAMETERS** (budgetary estimation):

- Electric production: 3,3 MWel net, 8,500 h/y, for 25 years, tariff = 200 €/MWel;
- Thermal H&C production: > 3,3 MWt for use in DH for 5,040 h/y;
- Flexibility: Alternative PLANS A, B, C;
- Gross Pay-back = 8,6 y;
- IRR or TIR on equity = 18%.
- DSCR = 2.