XIV INTERNATIONAL CONFERENCE ON SCIENCE, ARTS AND CULTURE

WORKSHOP on GEOTHERMAL ENERGY
Status and future in the Peri - Adriatic Area

25 - 27 August 2014 • Veli Lošinj, Croatia

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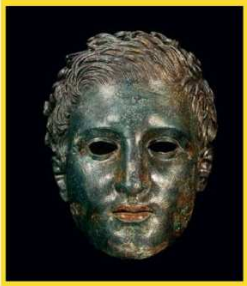

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Book of Abstracts

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WORKSHOP ON GEOTHERMAL ENERGY: Status and Future in the Peri-Adriatic Area

23/08/2014 Program

DAY	TIME	TOPICS	CHAIRMANS	SPEAKERS
MON 25/08	MORNING	REGISTRATION		08.30 Arrival and registration
		WELCOME, KEY NOTE ADDRESSES		09.00 Opening remarks by Organizers (Bradamante F., Vacchi A., Della Vedova B.) 09.35 Welcome by Cappelli G. (Mali Lošinj Major) 09.45 Key note address, Vito S. (Regional Minister of Environmental, Energy and Mountain Policies, RFVG) Key note address, Giadrossi A. (Mali Losinj Italian Community) Key note address, Graziano G. (President of Italian National Geological Council - CNG) Key note address, Fermeglia M. (Rector of the Trieste University)
		INTRODUCTION LECTURE		10.25 Lughi V. (Trieste University): *Energy as a global challenge* **10.55 COFFE BREAK**
		A Status and perspectives of geothermal technologies	Della Vedova B. (Trieste University & UGI)	11.10 Angelino L. (European Geothermal Energy Council, Bruxelles): *Geothermal energy in Europe: market development, perspectives and framework conditions* 11.40 Cociancig B. (MND Group, Czech Republic): *Geothermal energy: how does it stack up in the future energy mix?* 12.10 Ungemach P. (GPC, Paris): *Recent achievements in geothermal technology* 12.40 Conti P. (Pisa University and UGI): *How heat pumps work: criteria for heat sources evaluation*
	AFTERNOON		Ungemach P. (GPC, Paris) Buscaroli F. (HERA Group)	16.00 Pipan M. (Trieste University): *High-resolution geophysics for porosity and fracture network assessment in shallow geothermal applications* 16.30 Poletto F. (INOGS, Trieste): *Integrated geophysical characterization of geothermal reservoirs* 17.00 Antics M. (GPC IP, Paris): *Geothermal reservoir characterization and management* **17.30 COFFE BREAK** 17.45 Prestor J. (GeoZS, Ljubljana) : *Low temperature geothermal applications and projects in Slovenia* 18.15 Kurevija T. (Zagreb University): *Geothermal applications in Croatia* 18.45 Petrini R. and Della Vedova B. (Pisa and Trieste University): *Thermal springs and balneology in the Peri-Adriatic Area: geochemical status and prospects*
TUE 26/08	MORNING	**B** Resources Assessment and Geothermal Applications	Mendrinos D. (CRES, Greece) Đurić N. (Subotica University)	08.45 Wittig V. and Buescher E. (GZB, Bochum): *Down the hole hammer drilling technologies: status and future development* 09.15 Kachyna R. and Cociancig B. (MND Group, Czech Republic): *Deep geothermal project from the perspective of a drilling contractor* 09.45 Buscaroli F. and Ferraresi F. (AIRU, Milano and HERA Group): *The integrated Ferrara plant (50% geothermal)* 10.15 Della Vedova B. (Trieste University and UGI): *Geothermal heating and cooling in the FVG Region: the Grado district heating project and the Pontebba ice rink* **10.45 COFFE BREAK** 11.00 Kralj P. (Gejzir, Ljubljana): *District heating of Benedikt, 1st stage (Northeast - Slovenia)* 11.30 Floreani M. and Cozzi G. (AREA Science Park, Trieste): *Area Science Park innovative systems and* open-laboratories *for the diffusion of small size plants based on renewable energy and high efficiency technologies including geothermal applications* 12.00 Đurić N. (Subotica University) and Đjurić D.: *Ecological and economic aspects of using geothermal energy for heat supply town of Bijeljina and other areas Bosnia and Herzegovina* 12.30 Mendrinos D. (CRES, Greece): *Low temperature geothermal applications in Greece, including water desalination*
	AFTERNOON / EVENING SOCIAL EVENTS			**BOAT EXCURSION TO ILOVIK ISLAND** (from approx. 15.00 to 19.00) → **SOCIAL DINNER** (from 20.00)
WED 27/08	MORNING	**C** Integration of energy sources in the Peri - Adriatic Areas	Prestor J. (GeoZS, Ljubljana) Kurevija T. (Zagreb University)	08.45 Masella A. (Brescia University): *Heat pumps for exploitation of geothermal sources in Milano City* 09.15 Molinari F. and Tarantino P. (Cogeme SpA, Brescia): *New projects for geothermal district heating and cooling systems in the Brescia Province (Northern Italy)* 09.45 Cociancig B. (MND Group, Czech Republic): *Altheim in Upper Austria – an example of cascaded geothermal energy use* 10.15 Stefanelli S. (Friuli Venezia Giulia Region): *ALTERENERGY: energy sustainability for adriatic small communities* **10.45 COFFE BREAK** 11.00 Nardin G. (Udine University): *From healthcare buildings to a district energy system: the path to greener heating in Udine* 11.30 Jovanović D. (IRENA, Croatia): *LEGEND PROJECT mobilizing ground-source heat pumps investments in Adriatic* 12.00 Mendrinos D. (CRES, Greece): *The GROUND-MED Project - Advanced GROUND source heat pump systems for heating and cooling in MEDiterranean climate* 12.30 Zudek A. (Zudek s.r.l, Trieste): *New applications of heating and cooling using geothermal resources*
	AFTERNOON	**D** New ideas and Proposals for cooperation in the Peri - Adriatic Areas	Cociancig B. (MND Group, Czech Republic)	15.00 Stefanelli S. (Friuli Venezia Giulia Region): *The Friuli Venezia Giulia energy strategy* 15.25 Bassa Poropat M.T. (Trieste Province): *The Trieste Province Perspective for the energy efficiency* 15.35 Laureni U. (Trieste Municipality): *The Trieste PAES – Action Plan for Suistainable Energy* 16.00 Stival C.A. and Valcovich E. (Trieste University): *Methodological approach for recovery and energetic requalification of historical buildings (Trieste port)* 16.25 Manganaro A. (STEAM Srl): *M19 – A new school complex module in an historical building based on Leed Certification and Geothermal application (Trieste port)* 16.50 Pellegrini G.(STP, Torino): *Feasibility study district heating and cooling downtown Trieste by seawater heat pumps* **17.15 COFFE BREAK**
		ROUND TABLE	Della Vedova B. Vacchi A.	**NETWORKING, PROJECTS AND FUTURE PERSPECTIVES** Key note speakers invited to stimulate the round table: Cociancig B., Graziano G., Kurevija T., Mendrinos D., Prestor J., Ungemach P.

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Contents

1

Energy as a global challenge

Dr. LUGHI, Vanni[1]

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Appropriate matching of energy supply with energy demand is one of the most formidable challenges facing humankind today and in the near future.
On the supply side, although fossil fuels do have the potential for satisfying energy demand for at least a few decades – especially in light of the recent massive introduction of shale gas in the international market, heavily relying upon such resources does not appear to be a sustainable solution even in the medium term, as questions and doubts arise from both the economic and environmental standpoint. Renewable resources are gaining importance as alternative energy supply: they have an enormous potential and many renewable-based technologies are competitive on the market today. However, renewables face and pose major challenges (but also offer great opportunities) while entering the current very structured energy system, as a broad rethinking is needed of energy policies, market dynamics, and infrastructures.
On the demand side, there are two opposite trends at the global level. In the OECD countries there is a strong push towards the reduction of energy demand by acting along the entire energy value chain, both by considering efficient energy conversion technologies, and by promoting awareness and technology-based energy-saving solutions for the end user. Conversely, BRICS and developing countries strongly rely on energy for sustaining their economic growth, resulting in a marked increase in energy demand.
In this contribution, I will provide a critical overview on the global status and trends of energy demand and supply, outlining current strategies to improve the appropriateness and sustainability of energy supply, and to mitigate energy demand. Then, I will describe and exemplify some important indicators enabling the evaluation of the energy quality according to such strategies. Finally, I will show the high degree of complexity of the energy issue caused by the interplay with a number of other interconnected global challenges, such as a growing world population, access to food and water, human health, environmental issues, and security.

2

Geothermal energy in Europe: market development, prospective and framework conditions

Dr. ANGELINO, Luca[1]

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The first part of this presentation provides an overview of the deep and shallow geothermal market development and the prospective for the next decades.
The financial crisis has slowed down some of the development in geothermal electricity, and it is apparently a difficult time to attract the necessary investment. However, the investigation in possible projects is going on in more countries than ever. Eight new power plants became operational in 2013, increasing the installed capacity in Europe to 1848.96 MWe, producing some 11.7TWh of electric power in 2012. According to the GEOELEC resource assessment the European geothermal power economic potential is 174 TWh in 2030 and grows to more than 4000 TWh in 2050.
Regarding district heating, this is the geothermal sector with the most dynamic development and the most interesting perspective in the coming years. Eight new systems have been installed in five European countries in 2013, increasing installed capacity to ca. 4309 MWth, with 12884 GWh th/year used for heating. Furthermore, the GeoDH project has estimated that over 25% of the EU population lives in areas suitable to geothermal district heating.
However, comparing the actual geothermal production with the projections in the National Renewable Energy Action Plans, it is easy to note how we are lagging behind the expected

trajectory. Against this background support schemes remain a crucial tool of public policy for geothermal to compensate for market failures and to allow the technology to progress along its learning curve. The second part will therefore look at the support schemes in place across Europe for both geothermal electricity and heating and cooling. The situation in this field is rapidly evolving in particular following the nnewly adopted EU guidelines on public support for renewable energy projects.

3

Geothermal Energy – how does it stack up in the future energy mix?

Dr. COCIANCIG, Bernhard[1]

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When the government of Germany boldly decided in September 2010 to initiate the *Energiewende* (Energy Transition), this was only six month before the Fukushima accident.
The target of this challenging endeavor is to reduce greenhouse gases, cut down on overall energy consumption and foster renewable energy generation. Legislation to that effect was passed in 2011, which saw an expeditious and material investment in solar, wind and hydro power production. This transition was mainly facilitated by favorable electricity feed-in tariffs. Several countries around the world adopted a similar support for renewables, with different approaches - and varied success. Geothermal energy was one element in the energy mix and as such mostly confined to areas and countries where the potential exists to exploit this resource. How does geothermal compare to other energy sources, now and in the decades to come? What are the areas of potential improvement both technically and commercially? What are the elements which could make geothermal energy successful? What can governments, consumer, producers and R+D institutions contribute to such a success? And how can we define whether a geothermal project has the required makings and building blocks to thrive?

4

Recent achievements in geothermal technology

Dr. UNGEMACH, Pierre[1]

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The ambitious development goals set by the geothermal community for projected geopower and geoheat capacities in year 2050, 140 GWel (including engineered geothermal systems – EGS) and 800 GWth respectively, act as a strong stimulus for technological innovation.
In this perspective the present paper focuses on key segments aimed at (i) improving drilling success ratios, (ii) reclaiming, cogeneration eligible, medium enthalpy sources, (iii) upgrading well performance and longevities, and (iv) securing sustainable reservoir management.
Accordingly the following key issues will be addressed.
• structural geomodelling of complex reservoir • 3D seismic assisted well targeting • novel well architectures (subhorizontal, multileg, corrosion/scaling resistant wellbore designs) • high temperature/high flow/deep seated pumping equipment • downhole chemical inhibition and production control lines • high temperature steering and logging while drilling equipment
The seismic risk induced by water injection in sensitive, tectonically active, reservoir environments will be also discussed.

5

How heat pumps work: criteria for heat sources evaluation

Author(s): Dr. GRASSI, Walter[1]

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The presentation starts dealing with the basic thermodynamic principles of heat pumps, focusing on the main parameters describing their performances, like COP, EER etc. A brief description of compression and absorption HP is provided.
Then it describes their main components and their influence on the performance parameters. Some details about the operating fluids are also given, stressing how their properties are closely connected to the HPs use for real applications.
In addition the power sizing criteria are discussed with regard to the choice of the Balance Point and Backup generator.
A description of the different external sources follows, together with their appropriate sustainable utilization.

6

High-resolution geophysics for porosity and fracture network assessment in shallow geothermal applications

Author(s): Dr. PIPAN, Michele[1]
Co-author(s): Dr. FORTE, Emanuele [1] ; Dr. DOSSI, Matteo [1] ; Dr. DEL BEN, Anna [1] ; Dr. MOCNIK, Arianna [1] ; Dr. LASHIN, Aref [2] ; Dr. AL-[U+2010]ARIFI, Nassir S.N. [2]

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High resolution imaging and characterization of shallow rock and sediments volumes by means of reflection seismics and ground penetrating radar (GPR) are powerful tools in the evaluation of shallow geothermal systems. We exploit the sensi,vity of GPR to porosity and fluid content to study shallow limestone volumes and to detect fracture networks and sectors characterized by larger porosity. We further apply reflecion seismics to extend the depth limits of GPR, normally not larger than few tens of meters in rock, and reach depths of interest for the analysis of aquifers and geothermal systems (hundreds to thousands meters). The study is performed on a reservoir analogue in Italy and on a selected area in the western Saudi Arabia geothermal province. Both studies are based on multifold methods in data acquisition and attribute analysis in data processing. The results obtained from a 3D radar dataset show that the effects of small size fractures (below the resolution limit of the method) can be detected as a global attenuation effect in the radar image through the analysis of amplitude attributes, while large fractures are successfully imaged across the volume. Several fractures possibly connected to the surface geothermal evidences are seismically imaged up to an approximate depth of 500 m in the Arabian test-site.

7

Integrated geophysical characterization of geothermal reservois

Dr. POLETTO, Flavio[1]

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We present the results of an integrated geophysical approach for the characterization of the geothermal reservoir on the Grado Island, northeastern Adriatic Sea (Italy), where a low-enthalpy binary pilot-plant is under development for district-heating purposes. The initial geothermal potential assessment was based on the geophysical prospect and the results of the first exploration borehole of 1110 m depth, drilled during 2008. The study 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 structural highs of the coastal area. The well production potential from a fossil, seawater confined aquifer, having a temperature of about 45-50 °C, was estimated to be approximately 140 tons/h. In 2012, an integrated gravity and seismic geophysical prospecting, including borehole seismic profiles (VSP), was conducted in Grado downtown and 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, here presented, allowed operators to locate the second well of the geothermal doublet, planned and drilled to feed the district heating system of public buildings on the island. Besides these results, we present a short overwiew of other seismic methods, including seismic while drilling for medium-enthalpy reservoir characterization, and a summary of recent studies on seismic full waveform propagation in high temperature rocks and melting zones, including the brittle-ductile transition.

8

Geothermal reservoir characterisation and management

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From surface reconnaissance to reservoir management and from expectations to achievements, is an interactive process integrating the following segments and benchmarks.
• surface/subsurface exploration geology, hydrogeology, geochemistry and geophysics (MT, seismics) data processing and imaging • geostatistics, structural geomodelling and assessment of a relevant conceptual model • import into a numerical model simulating heat and mass transfers within the reservoir • well targeting by optimising drilling locations and trajectories • direct drilling assessment, well testing and reservoir engineering • planning/implementation of a sustainable heat extraction and injection strategy • heat farming development, operation, maintenance and monitoring policies • reservoir management troubleshooting (pressure/temperature depletion, corrosion/scaling shortcomings, well longevities, induced seismicity).
The foregoing will be echoed by fields examples and outputs from currently operated modelling suites.

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Low temperature geothermal applications and projects in Slovenia

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In Slovenia, production of geothermal energy from thermal water (T > 20 °C) is actually 635,9 TJ (176,6 GWht (15,19 ktoe). It increases and the potential enables achieving the objectives 2020 (20 ktoe) by the development of additional geothermal resources, better efficiency of existing wells and activation of unused existing wells.
The objective for the contribution from geothermal (ground-source) heat pumps is expected to increase more significantly where the objective is five times greater contribution in 2020 than actual. It is estimated that the actual market growth of geothermal heat pumps applications in Slovenia is in the range from 13 % to 18 %. The quick market growth, not lower than 22 %, would enable to achieve the objective 2020 (38 ktoe) for the contribution of shallow geothermal energy. To foster the market growth, larger geothermal heat pump installations (systems) are very important because they have higher ability to introduce advanced technology, to make quicker steps in the energy contribution and especially in public procurement to be attractive demonstration cases. There are several larger geothermal heat pumps units presented showing that

advanced geothermal heat collectors and heat pumps are making good use of shallow geothermal energy potential in different geological and climate conditions characteristic also for the Adriatic region (e. g. Thermal deep foundations piles for the blocks of flats of the Settlement 15. maj in Koper, Ground heat storage and borehole heat exchangers (BHEs) field in the Pipistrel research centre in Ajdovščina, Groundwater well system at the elderly home in Idrija, small BHE field at BIA Separations Co. in Ajdovščina, greater BHE field at the Olmo elderly home blocks in Koper. . .).
It is assessed that 37 - 74 bigger geothermal heat pumps systems yearly (of > 30 - 200 kW installed capacities) and 650 – 960 minor geothermal heat pump units (approx. 10 kW installed capacity) per year could lead to significant share (till 7 %) of shallow geothermal energy in the renewable energy sources for heating and cooling and to reach the objectives for 2020.

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Prospects of geothermal energy exploitation in Croatia

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Over the last few years in Croatia several international companies and local developers have worked on the potential of high enthalpy geothermal fields. They have managed to get several new exploration licenses for power generation from deep geothermal energy. The object interest is fractured carbonate geothermal water aquifers, able to produce temperatures much higher than 100°C. Currently, investors are faced with cutting investment costs for drilling, testing and producing at the depths of more than 2000 m. First privately invested deep well for direct utilization of geothermal energy was drilled several years ago to 1300 m where sandy geothermal water reservoir was found, with water temperatures near 100°C. All phases of exploration, drilling and final production had been carried out in agreement with legal, regional and environmental considerations and despite high initial cost of drilling and construction of deep well, has proven itself as a reliable and favorable, in the long-term, than other locally available energy sources. Such production can also yield unconventional hydrocarbon productions from dissolved gas in regional aquifers, or enhance production in conventionally exhausted hydrocarbon fields, increasing profit and net production. Several projects using abandoned oil exploration and production wells are in the process of legalization and utilization, also for direct heat consumption.
Exploitation of shallow geothermal resources via heat pump system has also seen significant rise in last 5 years. Although there is no central monitoring system which could track amount of thermal power installed, there is good indication of how many borehole heat exchangers and water wells have been drilled to exploit shallow heat from the ground. There is also subsidiary system established for ground source heat pumps financed trough local municipalities to improve energy efficiency of family homes. It is expected that shallow geothermal resource exploitation will strongly dominate over the deep geothermal in the near future.

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Thermal balneology in the Peri-Adriatic area: geochemical status and prospects

Dr. PETRINI, Riccardo[1]

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The demand for low-enthalpy thermal waters to be used in balneology, as natural curative resources in Spa treatments, is rapidly increasing across Europe. However, long-term abstractions of thermal resources should be carefully planned to avoid waters overexploitation and contamination, which may cause changes in the hydrodynamic pressure of the thermal aquifers and in the chemical composition of the abstracted waters. Hence, for a sustainable water management and quality preservation, it is fundamental to enhance the knowledge about the aquifers, in particular when

natural springs are replaced by boreholes. In the characterization of thermal water reservoirs, geochemistry is becoming an expanding discipline, providing useful information on the origin of the fluids, the occurrence of mixing processes among different components, the role of water-rock and water-gas interactions, and the flow regimes at depth. The geothermal manifestations in the Peri-Adriatic Region belong to different hydrofacies, reflecting the different origin and nature of the aquifers in the complex geodynamic and lithological settings that include the Eastern Alps, Southern Alps, Dinarides, Panonian basin and Adriatic – Apulia foreland. These include: (i) thermal waters in Mesozoic carbonate-rock aquifers; (ii) thermal waters in aquifers within the metamorphic basement; (iii) thermal waters in porous media in sedimentary basins and (iv) thermal waters of marine origin in coastal environments. In the work here described, the geochemistry of thermal waters in the Peri-Adriatic region is summarized, and the application of a multiple geochemical approach to a thermal spring site is reported.

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Down the hole hammer drilling technologies: status and future development

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Geothermal resources tend to be found in deeper and harder geologic formations than typical hydrocarbon reservoirs. Therefore, drilling technologies from the oil & gas field need to be improved constantly to make for more efficient, economic drilling. Yet today drilling cost are the largest factor in any geothermal project.
One innovation over the past ten plus years has been the development of downhole fluid hammer systems at GZB in Bochum and elsewhere worldwide for geothermal, hydrocarbon, and mining applications. These tools, commonly powered with compressed air for shallow (< 400 m) drilling, have shown and proven to increase ROP in the order of tenfold over conventional drilling methods based on tricone or PDC bits.
However, several disadvantages of these hydraulic, DTH water hammer systems do hold back their widespread use so far. Main hindrances are e.g. the required water quality of almost clean tap water, missing recirculation systems and thus, no possibility of using drill mud additives for borehole control and improved flushing capabilities. With new hydraulic hammer systems being developed in Bochum and gradually coming onto the market, some of these problems have been addressed or even solved by now, also pushing their drilling applications further down to 5.000 m.
Drilling methods for shallow and deep geothermal applications will be discussed, with the focus on DTH water hammers including case studies, recirculation and recycling systems, DTH mud hammers. Furthermore, DTH fluid hammers do make for an excellent logging tool, being used as a good noise source for seismic-while-drilling (SWD) logs and measurements. These greatly help predict and find good geothermal reservoirs as well as reducing drilling risks.
Thus, the DTH mud hammer drilling technology will greatly help the geothermal industry to make their drilling efforts far more economic, especially but not exclusively in deep, hard rock drilling situations.

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Deep Geothermal Project from the perspective of a Drilling Contractor

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MND Drilling and Services (MND D+S) is a wholly owned subsidiary of the Czech domiciled MND Group. The company owns and operates a broad range of drilling and workover rigs,

ranging from 50 to 450 tons hook load. MND D+S is involved internationally as contractor for oil and gas well drilling for large petroleum firms such as ExxonMobil, ConocoPhilips, OMV and others.
The drilling rig used to drill and complete the geothermal well Geretsried 1 in Bavaria (Germany) has a horsepower rating of 2,000 BHP. The geothermal project was planned and developed by ENEX Power of Germany, whereby the source well was supposed to provide 145°C hot water energy for a 5 MW(el) power generation and a cascaded 40 MW(therm) district heating system. The well was spud in Dec-2013 and successfully drilled to a total depth of 6,034 m which made it the deepest geothermal well in Europe.
The presentation provides some insight into the achieved results and the technical and commercial challenges encountered during the construction of the well.

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The integrated Ferrara plant (50% geothermal)

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Ferrara “District Heating Plant”, managed by HERA group, is one of the best applications in Italy and in Europe of “Integrated Energy System”, based on geothermal source: the geothermal resource was developed as the primary source for the urban heating system, but just from the beginning it was integrated with other resource: the “Waste–To–Energy” plant and back - up boilers.
The geothermal fluid is pumped to the surface from a depth of 1.000 m through two extraction wells (14 MW powered) and, after transferring the thermal energy to the network, it is re-introduced in the ground through an intake well, in order to ensure the geotechnical stability.
In the existing plant, the amount of energy from renewable sources is equal to 83%, compared to the total production of thermalm energy, and allows to heat about 5.400.000 mc of users.
As the system is now hydraulically satured, and thanks to geo - structural and geothermal investigation that confirmed the presence of geothermal reservoirs, suitable for a district heating exploitation, it was decided to develop the existing scheme with a new plant ("Polo Energie Rinnovabili"), design that represent the first italian example of several new technologies applied to District Heating.
The development project, in addition to geothermal source (14 MW), shows other innovative solutions, such as a Solar thermal Plant (1Mw) and an ORC (Organic Rankine Cycle) turbine.
With “Polo Energie Rinnovabili” operating at full capacity, the amount of energy from renewable sources will be equal to 91%, and allows to heat about 8.500.000 mc of users. At the present time, the applications of authorizations are in stand - by, in order to wait the definitive conclusions on the studies of International “Commission on Hidrocarbon Exploration And Seismicity in the Emilia Region” (ICHESE).

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Geothermal heating and cooling in the FVG Region: the Grado district heating project and the Pontebba ice rink

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Over the last few years, the Regione Friuli Venezia Giulia (RFVG) launched 5 calls for the geothermal energy direct uses, including borehole heat exchangers, shallow aquifers and deep geothermal resources beyond 700 m depth. About 20 projects for heating and cooling of public

buildings funded, with a substantial contribution of 77% of the admissible costs, supported by EU funding. This contribution deals with the Grado Geothermal Pilot Project (GGPP) and with the heating and cooling of the Pontebba Ice Rink.

The feasibility of a geothermal district heating pilot-plant on Grado Island, northeastern Italy, was the result of the GGPP, Phase 1, completed in 2008. The reservoir characterization and the preliminary geothermal potential assessment rely on the geophysical prospect and on the exploration borehole Gado-1, 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 terrigenous sediments, in correspondence of the platform structural highs along the coastal areas. The well production potential from a fossil, seawater confined aquifer, having a temperature of about 42-44 °C, was estimated to be about 100 tons/h.

In 2012, as part of the GGPP, Phase 2, an integrated gravity and seismic geophysical prospecting was conducted in downtown Grado and in its surrounding lagoon, to extend the investigation of the reservoir and to locate the 2nd borehole of the geothermal doublet. The Grado-2 well is located at one km distance from the other borehole. Grado-2 was drilled down to 1200 m, into the faulted reservoir: fluids and pressure at wellhead (250 kPa) are similar to Grado-1 ones, but the measured temperature of 47 °C is about 5 °C higher; the artesian flow is of about 44 tons/h, whereas the preliminary pumping tests show a production capacity of at least 74 tons/h. The interference pumping tests indicate that there is hydraulic connection between wells. Well logs, acidizing of the deeper section of the borehole and production tests are due by September 2014. The deployment of the main distribution network is currently in progress. 3-D thermo-fluid dynamic numerical modeling will optimize the production and fluid re-injection and manage the sustainability of the geothermal plant.

The Pontebba Ice Rink is located close to the Austrian border. The energy requalification of the old cooling system was completed in late summer 2012, by means of a groundwater open loop geothermal system for the ice production and maintenance, and for the heating and hot water needs of the ice stadium. Two new ammonia heat pumps (2 x 350 kW) were installed and supported by two production water wells upstream (32 m deep) and one re-injection water well downstream (30 m deep), all drilled in alluvial deposits. A total production rate of up to 200 tons/h could be achieved from the shallow unconfined aquifer, with an average temperature of about 8,5 - 9.0 °C. Over the first two years of operation, cost reductions of the order of 45% have been achieved.

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District Heating of Benedikt, I. stage (Nordeast - Slovenia)

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In spring 2004, a 1857 m deep geothermal well Be-2/03 was drilled in the Benedikt place, north-eastern Slovenia. The temperature of thermal water exceeds 100 °C. The water belongs to the Na-HCO3 hydrogeochemical facies and has been classified as a CO2-rich healing mineral water suitable for drinking, bottling and balneology. Free degassing gas is almost pure CO2 (99.9 volume %). Major ion composition is dominated by sodium (1750 ppm) and bicarbonate (4700 ppm). The well testing would be an expensive and difficult operation owing to the high water temperature. For that reason, the Municipality of Benedikt, as the well owner decided to construct a part of the planned district heating project, and in this way, usefully lowered the waste water temperature. Owing to very high investment costs that could not be carried by the Municipality itself, and very poor engagement of the responsible governmental institutions, the Municipality council decided to make a contract with the company Gejzir Consulting from Ljubljana in the beginning of the year 2006. The Municipality of Benedikt is the well owner and ensured an uptake of 5L/sec of thermal water to Gejzir Consulting for construction of the first stage of district heating. District heating encompasses public dwellings – the Municipality building, gymnasium, primary school and kindergarten that consume altogether 20 % of total Municipality consumption. Heat station has the power of 600 kW and annually produces 2.000 MWh of heat. Gas separator

and heat exchanger are located at the production well in order to simplify the system operation. Energetically used thermal water is cooled in a nearby pool.
The inflow of thermal water from the production well is regulated automatically with respect to the outflow temperature from the heat exchanger which is constant and amounts to 40 °C. The water undergoes further cooling in the pool and is less than 30 °C when disposed into a small creek. After the enlargement of the district heating network, construction of a small power plant and a spa centre, energetically used thermal water will be reinjected into the primary aquifer. The cooling pool will not be needed any more.
The whole project of district heating is characterised by 3,3 MW of power and annual production of 4.000 MWh.

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Area Science Park innovative systems and open-laboratories for the diffusion of small size plants based on renewable energy and high efficiency technologies including geothermal applications

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Since 2008, Area Science Park has been building innovative small size plants in the fields of internal combustion engines cogeneration , gas turbine cogeneration, low enthalpy geothermal climatization, photovoltaics, LED public lighting and solar cooling.
These plants, based on the best technologies currently available on the market, are not just meant to cut energy costs and reduce green-house gases.
As a matter of facts, they are designed to operate as full-size working demonstrators and "open labs" where universities and primary schools, research institutes, enterprises and public administrations can learn about innovative solutions and compare different technologies in terms of technical, environmental and economic effects.

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Ecological and economic aspects of using geothermal energy for heat supply town of Bijeljina and other areas Bosnia and Herzegovina

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The geothermal potentiality the area is related to Semberia, which represents with Macva big deposits of thermal waters. This deposits is most likely extends below the Srem region in the north and the Sava valley to the west.
Semberija and Posavina belong to the northeastern and northern regions of the Republic of Srpska - Bosnia and Herzegovina, Srem and Macva belong to Serbia. Space deposits thermal waters in the area and Macve Semberia is about 2000 km2, and geothermal potential in terms of energy as heat equivalent to about 40 million tons of oil.
So far, the use of geothermal energy deposits in Semberije is in Dvorovi for heating buildings, spa treatment, sports and recreation, then Slobomir city for heating buildings Slobomir P. Universities and Ava Park.
For the period include the use of geothermal energy for heating the town of Bijeljina, which has about 70,000 inhabitants. Utilization of energy will be in several stages, from 800C to 160C, when the chilled water through injection wells to return back into an underground the collector.

By using of geothermal of energy, will improve the quality of the environment, and especially winter period when the air pollution is much higher, due to the use of coal for heating residential and industrial buildings. Observation of air quality the last five (5) years shows which are critical periods are during the year and at which locations in the city.
Analysis of the economic effects have shown that the use of of geothermal energy only for heating the town of Bijeljina, the investment pay off for a period of 9 - 10 years. Including the possibility of utilization of of geothermal of energy for other purposes, during the of repayment of investment is significantly reduced.
This paper will give a few examples of possibilities of using geothermal energy in other areas of Bosnia and Herzegovina.

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Low temperature geothermal applications in Greece, including water desalination

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Greece is favoured by geothermal resources encountered in regions of Quaternary or Miocene volcanism and in continental basins of high heat flow.
Although the high enthalpy (>300 C) geothermal potential identified by deep drilling in Milos and Nisyros islands still remains unused, the low enthalpy geothermal resources (T<90C) identified by shallow wells in the vicinity of thermal springs are utilized mainly for spas, agricultural cultivations, aquaculture of algae and fish farming, corresponding to ˜100 MWth of installed capacity in 2013.
To these applications another 100 MWth should be added corresponding to ground source heat pumps exploiting shallow geothermal energy all over the country.
Two European projects implemented by CRES and other partners proved the technical and economic feasibility of using low enthalpy geothermal energy (T<90C) for sea water desalination.

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Heat pumps for exploitation of geothermal sources in Milano City

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The employ of geothermal heat pumps to supply large heating systems is a technology which has been developed in the last decade in Italy, in particular using shallow geothermal sources thanks to following technical, environmental and economical advantages in comparison with deep resources: · shallow resources are easier to be found · no mining risk or at least reduced mining risk · strong reduction of drilling costs · simpler authorization procedures · lower problems for the chemical composition of the geothermal fluid · need in any case for the use of a heat pump system · possible compensation of the reduced temperature drop with a higher available flow.
For this reasons, the lecture will describe the following application cases of ground water heat pumps in Milano city: · the geothermal heat stations feeding the A2A Company district heating systems of Milano Canavese and Milano Famagosta, each with a 15,5 MW ground water heat pump · the complex named “Palazzo Lombardia” in Milano, the new headquarters of Region Lombardia: the largest building in the world fully heated by means only of geothermal sources.

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New projects for geothermal district heating and cooling systems in the Brescia Province (Northern Italy)

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Direct and indirect use of geothermal energy in the Brescia Province; an area with major superficial aquifers and geological irregularity which allow the exploitation, also direct, of a geothermal source.
Analysis of the results achieved by Cogeme SpA in the research of deep geothermal fluids and in the prototyping of "cold district heating" network systems allowing a rational use of groundwater for energy purposes.
"Cold District heating" allows the transfer of a geothermal resource from the area of pumping and storage, toward revamping thermal plants which supply existing buildings, thus solving the typical issues concerning the use of renewable energy sources in old town centres, in areas with few common spaces, in contexts subject to an environmental, historical and architectural constraint of protection or to strict acoustic zoning "Cold District Heating" can represent a simple, rapid, noninvasive and "renewable" way to revamp heat production plants.
It is a valid answer to the energy needs of those small urban centers which are interested in reaching the energy efficiency of their buildings but, which cannot find a valid solution in the conventional District Heating, because of the limited dimension of their catchment area.

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Altheim in Upper Austria – an example of cascaded geothermal energy use

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The community of Altheim in Upper Austria has embarked on the implementation of a geothermally sourced district heating system in early 1990, serving about 700 households which represent some 40% of the population.
Shortly afterwards, the project was expanded upstream by the installation of a hot water source and disposal well, utilized for powering a ORC turbine for electricity generation.
The 1 MWel turbine and the cascaded heating infrastructure is now in operation since well over 20 years and was one of the first facilities which operated from a medium enthalpy source.
Information on the technical setup, facilities, and the operating system is provided along with data on capital and operating costs.
Finally, options for financing are discussed.

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ALTERENERGY- Energy sustainability for Adriatic Small Communities

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The Strategic Project "Alterenergy" within the IPA ADRIATIC Programme involves eight countries (Albania, Italy, Croatia, Greece, Montenegro, Serbia, Bosnia-Herzegovina, Slovenia) and 17 partners.
It aims at enhancing energy sustainability in the Adriatic Area through an integrated approach to the efficient use of energy and support to renewable energy generation. Target beneficiaries of the project are small communities with less than 10.000 inhabitants. The project shares and supports actions on energy balances, energy sustainability actions plans, feasibility studies and capacity building at local level. It aims also at strengthening business partnership and investment support between SMEs, private investors ad banks in the Adriatic area on energy services and infrastructures.
Two demonstrative actions of energy sustainable communities will be implemented in Albania where schools of the Lushnje e Lezha regions will benefit technical and financial support, as well as in the Municipality of Sant'Agata in Puglia (Italy).
Finally the example of two sustainable communities will be analysed in details: Forni di Sopra, a best practice example of energy sustainable community for district heating and bioenergy sustainable short supply chain implementation and Brda (Slovenia), where there is a plan to implement a district heating network fed by geothermal sources.

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From healthcare buildings to a district energy system: the path to greener heating in Udine

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Barriers to energy efficiency have been amply discussed in literature: even when incentives or savings remove some economic obstacles, a number of financial, organizational, socio-technical and human aspects often prevent green energy concepts from becoming reality.
It is therefore of interest to investigate and reflect on which barriers arose and how they have been overcome when such projects are successfully developed and put into practice.
This is the case of the new district heating system inaugurated in Udine in 2013, a unique example of energy systems integration in that an hospital energy station has become a waste heat source to feed a municipal district heating network, enabling approximately 12% primary energy savings, compared with the previous system configuration.
The path from the district heating concept to its current operation and future prospects is reviewed here, disclosing the actual and potential role of hospitals as large heat consumers, making energy efficiency and renewable energy investments mostly profitable, but also as project developers and energy innovators in a position to originate energy and environmental benefits for districts and whole regions, if a systemic approach is favoured.

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LEGEND PROJECT mobilizing ground-source heat pumps investments in Adriatic

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The Adriatic Area shows optimal climatic and geological conditions for fully exploit the potentialities of low temperature geothermal energy with Ground-Source Heat Pumps (GSHP) due to presence of medium temperature sedimentary basin across the Western Adriatic shore and the shallow geothermal conditions which characterize the entire Eastern Adriatic Countries. However, in this area the technical expertise and the presence of successful cases are polarized mainly in

the north Adriatic and along the Italian shore, whilst the awareness over the benefits of heat pumps, the legislations and - finally - the maturity of the market are still in the early stage.
With around 3 million of budget, LEGEND “Low Enthalpy Geothermal ENergy Demonstration cases for Energy Efficient building in Adriatic area” is the largest geothermal energy investment project ever financed by the European Union in the Adriatic and Balkan area, through the financial assistance of the IPA CBC Adriatic Programme.
The purpose of the project, coordinated by the Province of Ferrara (IT) and implemented in 11 Adriatic regions of Italy, Croatia, Montenegro, Albania, Serbia, Slovenia and Bosnia Herzegovina, is to promote the use of shallow geothermal energy, in particular the GSHP technologies, through the conversion of 10 publically owned buildings to use GSHP as the primary energy source for heating and cooling.
The project represents an outstanding example of a cross-border initiative to meet the EU climate and energy targets to 2020 and it is based on a very concrete approach: LEGEND has immediate effects in terms of energy generated by renewables and CO2 reduction, it encourages green-market, technological development and deployment, and public & private investments.
The project runs from October 2012 to December 2014.
More information at: www.legend-geothermalenergy.eu

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The GROUND-MED Project - Advanced GROUND source heat pump systems for heating and cooling in MEDiterranean climate

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Ground-Med project (2009-2014), supported by the European Commission through the FP7 programme, developed a new generation of ground source heat pump systems providing heating, cooling and sanitary hot water, characterised by improved energy efficiency.
These systems have been installed and are being monitored in 8 buildings of South Europe.
The project proved that the technological advantage of high efficiency heat pumps can be utilized in its full potential by adequate borehole heat exchangers, internal system design and advanced operation control synchronizing pumps and fans with the compressor and optimising the heating/cooling water temperature.
Monitoring results indicate system seasonal performance factors SPF2 (considering electricity consumption at the compressors and external pump) up to 5.91for heating, 6.76 for active cooling and 39.93 for free cooling directly from the borehole heat exchanger, well above the project objective of 5.0 and the average ground source heat pump performance of 3.5.

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New applications of heating and cooling using geothermal resources

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This paper shows application for methods and solutions for innovative heating and cooling for applications with the use of geothermal resources.
The main core of the system is the heat pump with ammonia as refrigerant for combined heating and cooling using geothermal energy as resource for the cycle. Ammonia is the refrigerant which offers the best advantages in terms of efficiency and environmental impact with zero GWP and zero ODP.

The presentation will show real cases of installed plants with ammonia heat pumps with the use of geothermic energy across Europe and their benefits in terms of energy savings, environment respect and reduction of costs during operation.

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The Friuli Venezia Giulia energy strategy

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The Friuli Venezia Giulia Autonomous Region will face several energy challenges over the next years that include meeting the burden Sharing target of 12,7% of renewable energy in final energy consumption, shifting from a centralized to a decentralized energy system and improving energy efficiency in a wide range of economic sectors.
Despite the steady growth of RES- Electricity in the last years driven by the increase of solar PV and biomass and biogas, several constraints hinder the full deployment of renewables from the integration in the conventional electricity grids to stronger support of RES-Heat. An outlook of current RES share will also be discussed.
The ongoing regional energy plan addresses some of the key challenges. Some of the most strategic energy measures of the plan will include: 1) Support energy efficiency in public buildings, transport and industry 2) Overhaul the energy distribution system defining the main energy corridors and implementing smart grids 3) Support energy audits 4) Enhancing sustainable transport and in particular electric mobility and intelligent charging stations 5) Define the optimal energy RES and not RES mix and the use of local energy sources like biomass from sustainable short supply chains, hydropower and geothermal sources 6) Contribute to reducing regional GHG emissions.

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The Sustainable Energy Action Plan (SEAP) of the Municipality of Trieste

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A reduction of over 20% of CO2 emissions by 2020 is the challenge for all cities that have signed the Covenant of Mayors.
This challenge is particularly demanding for Trieste, a city that is adressing other issues in connection with its economic and industrial development and which has limited renewable energy sources on its territory.
Trieste is willing to take on these challenges and with its SEAP aims to become a model for energy efficiency, sustainable development and environmental quality.
The development and implementation of this long-term vision focuses on three strategic lines: greater efficiency and energy savings in buildings, generation of energy from renewable sources and reduction of emissions from transport. This requires a continuous effort, which must be organized with flexibility and creativity, and will be pursued over the next decade, through appropriate organizational and financial structures that allow for their implementation.
The City of Trieste takes on the challenge to achieve these results, knowing that a larger commitment is required from local stakeholders, including citizens, who need to change their habits moving towards new modes of transportation and energy consumption.
After a brief presentation of the PAES, the fundamental role of the research particularly in the field of geothermal energy is discussed.

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Methodological approach for recovery and energetic requalification of historical buildings

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Among Renewable Energy Sources (RES) defined in European Directive 2009/28/CE, as coming from renewable non-fossil sources„ are included hydrothermal energy – referring to surface water – and oceanic energy. The extension of this definition to energy contained in seas should be taken into account: in specific boundary conditions, sea hydrothermal energy, mainly deriving from solar radiation, is a valuable resource for possible exploitation, occurring through heat pumps that withdraw heat from the sea transferring it to the cold sink, a heat transfer fluid.
A possible application in the city of Trieste refers to exploit this energy source to serve buildings characterized by high historical and architectural values. The plant provided for this goal consists of three main parts: an open-loop system that picks up seawater through main heat exchanger and then restores it to sea; a closed-loop ring in which a heat transfer fluid brings sea-recovered energy to final users' derivations; installations inside buildings, consisting in water-to-water heat pumps in order to meet the energy needs of those buildings.
Particular attention has to be paid to the positioning of heat pumps in historical buildings: complying rules on safety during operation, there should be considered settings for exclusive use, suitably located and partitioned form remaining part of the asset. Similar importance is due to replacements and integration of technical distribution facilities in historical buildings. The proposed system must then interface with architectural features, distribution network and plant of each building. Intervention design, therefore, must firstly identify technical elements contemporary with the construction of the building, distinguishing them from those, following, of lesser value. Based on this analysis, identifies the most suitable positions for insertion of new distribution network, realized by minimizing the invasiveness of operations in accordance with the operating principles of the restoration.

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M19 – A new school complex module in an historical building based on Leed Certification and Geothermal application (Trieste port)

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Starting from "Provincia di Trieste"'s expression of interest during recent Concession Procedure for areas and buildings in Trieste port, the M19 design started from the need to relocate the Naval College in that area, developed a modern school complex module to be settled in the historical buildings and his guidelines to reduce consistently working costs from management and energy consumption point of view. The suggested module is suitable for a 700 students unit and it should be applicable to building "Magazzino 19" as well as many other similar buildings present in the port area, in order to create an "Educational Pole".
The management costs should be lesser sharing support facilities between modules, while the exploitation of environmental local resources (Geothermal energy) and the application of Leed Certification should decrease the energy cost.
The approach used by the design team was the LEED certification program based on defined efficiency standards regarding energy and water use, CO2 emissions, the quality of the interior environment and environmentally resource management practices. LEED recognizes the unique nature of design of schools that are healthy for students, comfortable for teachers, and costeffective addressing issues such as classroom acoustics, master planning, mold prevention, and environmental site assessment. The use of a local resource as sea water in a heat pump to produce hot/cold water for HVAC systems together to an integrated design approach involving

all disciplines allow to get a certified green building. Optimization of building insulation and solar shading devices, selection of materials, use of low temperature heating terminal unit and study of photovoltaic panels integration are other analysis included in the design.

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Feasibility study district heating and cooling downtown Trieste by seawater heat pumps

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This study concerns the application of water to water heat pumps at high temperature (Tm≥80°C) (hereinafter referred HT HP) to a new concept district heating plant called "Cold District Heating - CDH" where HT HP use, as the low temperature heat source, water distributed with networks, similar to the classic district heating ones, where, however, instead of using pre-insulated pipes, much less invasive and much cheaper PEAD not insulated pipes are laid. These networks supply water to a series of HT HP to be installed in various buildings to replace existing centralized boilers.

With SMAT of Turin we are monitoring a pilot site with a first CDH where it will subsequently be possible to connect other buildings until reaching the maximum flow compatible with said source.

The purpose of this study is to demonstrate the technical feasibility of initially exploit all existing urban infrastructures in "Piazza Unità d'Italia – Trieste" capable of providing sea water and then suggest to build new infrastructures to distribute water drawn from remote centralized sources (groundwater, irrigation ditches, rivers, lakes, sea, etc..). They are therefore systems which allow the use of heat pumps at high temperature in a diffuse manner in urban contexts.

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PELLEGRINI, Gianfranco (Stp Srl, Torino)
- Feasibility study district heating and cooling downtown Trieste by seawater heat pumps

PESTOTNIK, Simona (Geological Survey of Slovenia)
- Low temperature geothermal applications and projects in Slovenia

PETRINI, Riccardo (University of Pisa, Italy)
- Thermal balneology in the Peri-Adriatic area: geochemical status and prospects

PIEMONTE, Carlo (Studio Associato di Ingegneria)
- Heat pumps for exploitation of geothermal sources in Milano City

PIPAN, Michele (University of Trieste)
- High-resolution geophysics for porosity and fracture network assessment in shallow geothermal applications

POLETTO, Flavio (OGS - National Institute of Oceanography and Experimental Geophysics)
- Integrated geophysical characterization of geothermal reservois

PRESTOR, Joerg (Geological Survey of Slovenia)
- Low temperature geothermal applications and projects in Slovenia

RAJVER, Dušan (Geological Survey of Slovenia)
- Low temperature geothermal applications and projects in Slovenia

ROMANO, Giuseppe (STEAM Srl, Padova)
- M19 – A new school complex module in an historical building based on Leed Certification and Geothermal application (Trieste port)

STEFANELLI, Silvia (Regione Autonoma Friuli Venezia Giulia)
- ALTERENERGY- Energy sustainability for Adriatic Small Communities
- The Friuli Venezia Giulia energy strategy

STIVAL, Carlo Antonio (University of Trieste)
- Methodological approach for recovery and energetic requalification of historical buildings

STRADA, Mauro (STEAM Srl, Padova)
- M19 – A new school complex module in an historical building based on Leed Certification and Geothermal application (Trieste port)

TARANTINO, Paolo (Technical Director - Cogeme SpA)
- New projects for geothermal district heating and cooling systems in the Brescia Province (Northern Italy)

UNGEMACH, Pierre (Chief executive, GPC INSTRUMENTATION PROCESS (GPC IP))
- Recent achievements in geothermal technology
- Geothermal reservoir characterisation and management

VALCOVICH, Edino (University of Trieste)
- Methodological approach for recovery and energetic requalification of historical buildings

WITTIG, Volker (Head of Drilling Technologies, International Geothermal Centre)
- Down the hole hammer drilling technologies: status and future development

ZUDEK, Alfredo (ZUDEK srl)
- New applications of heating and cooling using geothermal resources

SUPPORTING INSTITUTIONS:

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- AREA Science Park
- Consorzio per la Fisica
- Fondazione Internazionale di Trieste
- Friuli Venezia Giulia Region
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- Italian Institute of Culture of Zagreb
- OGS National Institute of Oceanography and Experimental Geophysics
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