ENGINE

ENhanced Geothermal Innovative Network for Europe

Workshop 5

Electricity generation from Enhanced Geothermal Systems

14 - 16 September 2006

HÔTEL RÉGENT - STRASBOURG - FRANCE

Workshop Abstracts

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Edited by: Martin Kaltschmitt (IE) & Laurent Le Bel (BRGM)

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Cover pictures
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Thumbnail lower top: Petite France, Strasbourg, France, by Office de Tourisme de Strasbourg, S. Hanssens.
Background: Geothermal power plant using ORC-Technology, Erdwärme-Kraftwerk Neustadt-Glewe, Germany, by T. Funke.

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ABSTRACT SUMMARY

Session 1

INTRODUCTION AND OVERVIEW OF ELECTRICITY GENERATION FROM ENHANCED GEOTHERMAL SYSTEMS

Status of geothermal electricity generation in Europe

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The use of geothermal energy has a long tradition, which – concerning electricity generation – dates back to the beginning of the 20th century. From then to these day the use of geothermal energy for power generation in Europe has reached an installed electrical capacity of 1.1 GW and an annually electricity production of 8 TWh/a. And this contribution should be increased according to the EU's Renewables Directive in the future. Therefore the European Union has granted considerable amounts for R&D-activities.

On this background the aim of this contribution is to present the current status of geothermal electricity generation in Europe. For that reason the different European countries are analysed with respect to their geothermal activities. Additionally statements are made concerning which type of reservoir (*i.e*. hydrothermal area, enhanced geothermal system) is used in connection with which conversion technology (*i.e*. dry steam plant, binary cycle). Based on this, conclusions are drawn where and what kind of newly installed geothermal power plants can be expected in the years to come.

The Organic Rankine Cycle – power production from low temperature heat

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The Organic Rankine Cycle (ORC) is a favourable process for power production from low to medium temperature heat sources. The working principle of an ORC is similar to the most widely used process for power generation, the Clausius Rankine Cycle. The main difference is the use of organic substances, like silicone oils, fluorocarbons or hydrocarbons instead of water / steam as working fluid. The boiling pressure of these substances at low temperatures is higher compared with water. Due to this favourable features the ORC is at the moment the state-of-the-art solution for electricity production from solid biomass in a power range of 400 – 1500 kW. The manufacturer Turboden (Italy) has already sold more than 60 ORCs mostly used for combined heat and power production. The temperature of the heat source is around 300 °C, the working fluid is a silicone oil.

The temperature of geothermal or waste heat is much lower, mostly in a range up to 150 °C. For this purposes mostly hydrocarbons or fluorocarbons are used as working fluids. For this purposes fewer projects have been realized.

The purpose of the presentation is to introduce the principles of the Organic Rankine Cycle, to discuss process variations, possible applications and the state of the art. Second part of the presentation will be devoted towards the development of an ORC-cycle within an EU-funded project at the TU Munich.

Low enthalpy cycles – power plant concepts

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Low-enthalpy geothermal resources are typical finite heat capacity sources, while the environment which acts as heat sink may be regarded infinite. Therefore the temperature-enthalpy curves of a low-enthalpy geothermal reservoir and its environment show a triangular shape. Applicability, advantages and disadvantages of different ideal power cycles in such a setting, like the Carnot cycle, the Lorentz cycle and a cycle with triangular shape, are discussed.

Different optimisation criteria like thermal efficiency, power output and resource utilization may be applied to improve the design of the plants. Every criterion would result in a different design.

A couple of power plant concepts were developed to get close to the ideal cycle. The most prominent like the organic Rankine cycle (ORC) and the Kalina cycle will be presented in detail, including suitable optimisation approaches. Since combined generation of heat and power, or heat, power and cooling, is expected to significantly improve the economics of a plant, promising methods of coupling of the processes will be discussed briefly.

Session 2

PRODUCER AND MANUFACTURER OF ORC-TECHNOLOGY

ORMAT: Projects and challenges

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ORMAT is a vertically integrated group of companies primarily engaged in the geothermal and recovered energy power business. ORMAT designs, develops, builds, owns and operates geothermal power plants and also designs, develops and builds and plans to own and operate recovered energy-based power plants. Additionally, the Company designs, manufactures and sells geothermal and recovered energy power units and other power generating equipment and provides related services. The ORMAT® Energy Converter (OEC) units, combined into modular power plants with a capacity of 200 kW to 130 MW, use locally available heat sources, including geothermal energy (steam and hot water), recovered energy generation, biomass and solar energy. ORMAT products and systems are covered by more than 70 patents. ORMAT currently operates the following geothermal power plants: in the United States, the Philippines, in Guatemala, in Kenya and in Nicaragua.

This presentation will discuss some technical and operational details of the latest developed plants such as Mokai II and Wairakei.

The Wairakei binary power plant located at the Wairakei power station near Taupo, in New Zealand, was inaugurated in summer 2005. The binary plant adds approximately 10% of additional power to the initial base load capacity of the power station.

Geothermal power generation by GEOCAL®

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The geothermal power generation will make a growing contribution to energy supply in the future. Very important is the kind of the cycle, which is used for energy supply. When the hot thermal water is directly relaxed from a temperature of circa 200 °C in the turbines, the secondary loop is used under this limit. For this purpose the two technologies Kalina Cycle and Organic Rankine Cycle are available. For the ORC there is more operational experience, but a higher efficiency of Kalina cycle is assumed. Because the choice of the plant for power generation influences the economies of geothermal projects, a clarification of the question, which type of plant is advantageous for the energy recovery, has an immense importance. GEOCAL® is one solution of ORC power plant with various possibilities. Every power plant has its own boundary conditions, like temperature of geothermal water, cooling conditions and utilization of heat. The most economic is not always the most efficient geothermal power plant.

The presentation won't solve all problems but will give some background information and will show some possibilities for a better understanding in ORC technology.

Turboden ORC systems

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Turboden has been established in 1980 for the development of ORC systems for renewable energy and for industrial heat recovery. Besides a few applications in the geothermal field, most Turboden ORC systems have exploited the combustion of biomass. The volume of the company business in supplying ORC systems in 2005 exceeded 15 million Euros. By the end of 2006 more then 50 plants will be in operation in Europe for a total installed power of some 50 MW.

The activity of Turboden was started as a spin-off of research on ORC concepts and fluid-dynamic design at Politecnico di Milano, during more than 10 years. Until now, Turboden focussed mainly on biomass combustion applications, as well as heat recovery of industrial heat, following the growth of renewable distributed CHP demand in Europe. As a consequence Turboden developed a number of standard ORC modules, which were applied with growing success, mostly in Central European countries. In particular Turboden developed proprietary advanced design turbines, for high efficiency, reliability and ease of maintenance. The same objectives are obtained in lower temperature systems, like geothermal applications, with different working fluids. As most geothermal cases presently exploit a liquid brine, particular care has to be given to the working fluid selection and cycle characteristics, in order to obtain the best overall performance, from a variable temperature heat source. Turboden, in collaboration with the fluid manufacturer, selected, tested and successfully proved in commercial operation, in its own ORC System supplied to the Commune of Altheim (Austria), a new working fluid. This fluid is particularly promising for applications in densely populated sites, as it has the following characteristics:

- the fluid is not flammable;
- the required peripheral speed of the turbine is quite low, yielding low rpm turbines;
- the heat receiving curve from the brine is quite favourable, yielding high performance.

The performance in a specific case is presented and discussed.

Enex binary plant

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Enex is a conglomerate of the Icelandic energy sector, owned by a group of Icelandic companies and organizations that have over 70 years of experience, spanning a wide range of application, in the development of geothermal energy. Installed capacity of the geothermal power plants of the owner group in operation is over 420 MWe and 840 MWth. Enex is an active participant in geothermal projects, offering, engineering, design and construction of geothermal power plants, both ORC power plants and steam power plants, as well as offering geoscientific research and consulting in connection with provided geothermal solutions. Enex offers expert knowledge in district heating systems and its owner currently operates the largest, most modern geothermal district heating system in the world and Iceland's largest geothermal combined heat & power plant (120 MWe). Enex provides full or partial financing and participates in project development offering joint venture partnership, part ownership or acts as an operator.

Enex's presentation in the category of Producers and Manufacturer of ORC Technology will cover:

- Overview of Enex;
- Operational experience and experience in handling geothermal fluids;
- Projects and activities in the ORC power plant market;
  . Use of abandoned oil wells for electrical generation in ORC power plants;
  . 8 MW ORC bottoming plant in Berlin, El Salvador;
- Technical specifications, construction and challenges;
- Progress to date.

Session 3

PRODUCER AND MANUFACTURER OF KALINA-TECHNOLOGY

Geothermal turnkey power generation solutions by Siemens

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Siemens is a multi-business electrical engineering and electronics company, active in the areas of Power, Automation and Control, Transportation, Information and Communications, Medical, and Lighting. In 2005, Siemens had approx. 75 billion EUR in sales, 460.000 employees and served customers in 190 countries. The power generation and distribution business area of Siemens continues to be one of the largest players worldwide. About one-fifth of the world's total installed capacity is generated using Siemens equipment. The Industrial Solutions and Services group provides turnkey power generation solutions in specific application areas like geothermal and industrial waste heat recovery. Siemens has delivered key components for several geothermal projects in the past. As a turnkey provider of geothermal power plants, Siemens was awarded contracts for two projects in Germany last year. The construction phase for one of them (Unterhaching/Munich) has already commenced.

Depending on the characteristics of the geothermal or industrial heat source, essentially the temperature, Siemens heat recovery solutions employ either the conventional water-steam cycle or the Kalina cycle.

In addition to the delivery of turnkey projects, Siemens also provides comprehensive solutions and services for financing and insurance, project development and permitting. With its widespread service network, Siemens offers a large variety of customized maintenance packages and life-cycle services to ensure highest levels of availability and performance throughout the plants' life.

Siemens, through its various businesses, is committed to developing and deploying efficient technologies in the area of regenerative energies.

Exorka

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Exorka ehf. (Ltd.) designs, builds and sells Kalina power plants for waste heat and geothermal utilization and holds the official license to use the Kalina technology which grants access to markets in all of geographical Europe. Exorka headquarters are located in Húsavik, Northern Iceland, close to our reference Kalina plant, producing 2,1 MWe from geothermal heat. The plant has been running constantly since 2000 and is Exorka's main source of experience and knowledge. Therefore, Exorka is the only company in the world having real practical experience in designing, building and operating a geothermal Kalina plant. Moreover, some waste heat plants will soon be added to the scope.

At the ENGINE workshop in Strasbourg, Exorka will be introduced by Magnús Gehringer, CEO.

Kalina and Organic Rankine cycles: how to choose the best expansion turbine?

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Cryostar has been a world leader in radial inflow turbine technology for more than 30 years and our superior product quality is recognised across the globe. Since 1986, we have used our expertise to provide energy recovery solutions, ensuring optimum recovery through highly efficient and economical operations.

Our installed base of generator loaded turbines comprises over 130 units and more than 60MW installed, including 20 machines on natural gas distribution networks. The natural gas installations have so far provided our customers with more than 1000 GWhs of recovered electricity.

Cryostar is the selected supplier of expanders for two on-going projects based on Kalina Technology.

For historical reasons axial turbines derivate from steam turbine technology are chosen for energy recovery from geothermal or waste heat sources. Nevertheless radial inflow turbines technology perfectly matches the need of binary cycles with higher isentropic efficiency from 85 to 90%.

The presentation outlines some criteria and limitations for selecting the best turbine design. We show that, for most of the process data issued from binary cycle, the turbine can run at the best efficiency.

The second part of the presentation is mainly focused on basics of expander technology. It is shown that expanders for binary cycle does not required special developments and that standard products can be used with minor modifications. Those special requirements are described in more details.

The last part deals with the choice of the best combination of expander size and binary cycle fluid for Organic Rankine cycle. It is shown that choosing an optimised fluids mixture leads to increase the total cycle efficiency and decrease at the same time the size and cost of the expansion turbine. Some examples are given.

The new generation Kalina cycle

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M+W Zander is a global acting engineering corporation offering complete packages for high-efficiency facilities for power systems and high-tech manufacturing installations. We are singular provider of services - from consulting, design, construction to operation and facility management.

The present contribution to the workshop "The New Generation Kalina Cycle" will cover the topics:

- Introduction to combined cycles for geothermal power applications;
- Impact of efficiency in geothermal power plants;
- Comparison of system effectiveness;
- Consequences for geothermal projects.

The effects of the difference of several power generation approaches will be discussed in regards to low temperature geothermal electrification applications.

Session 4

POSSIBILITIES AND RESTRICTIONS OF COOLING SYSTEMS

Geothermal binary plants: water or air cooled?

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Cooling geothermal power plants is necessary in order to condense the vapour feeding the turbine, lower the heat rejection temperature, raise power output and increase heat to power conversion efficiency. Three main cooling options are used: a) surface water (once-through systems), b) wet type cooling towers, and c) dry type cooling towers. Cooling with surface water yields the lowest condensing pressure and temperature and the highest conversion efficiency, followed by wet cooling towers, and then by dry cooling towers. Regarding the need for cold water supply, the order is reversed. Typical values are 970 t/h, 30 t/h and zero t/h respectively per MWe of installed power. In terms of costs, once through cooling may require both high capital costs and electricity consumption for transporting water. Dry cooling is the most expensive option due to the much higher heat capacity and heat transfer coefficient of water compared with ambient air. A dry cooling tower for a binary power plant of high conversion efficiency may cost 10 times more than its wet counterpart, which may result in raising overall power plant costs by 50%. In flash plants, where there is plenty of steam condensate to use as make up water, the standard technology adopted almost exclusively is cost effective direct contact condensers coupled with wet cooling towers. In binary plants, where the more expensive shell-and-tube or plate heat exchangers are used as surface condensers, the selection of the cooling system type is governed by water availability, local water use regulations and economics.

CRES profile

The Centre for Renewable Energy Sources (CRES) is the Greek National Centre for Renewable Energy Sources (RES) and Rational Use of Energy (RUE) (Law 2244/94 and Law 2702/99). CRES is a public entity, supervised by the Ministry of Development, General Secretariat of Research, and Technology. CRES has participated in more than 500 European, national and international projects including applied research and development, demonstration, commercial applications, energy policy, energy information and modelling systems, feasibility studies, environmental impact assessment, market research and promotion. CRES has a notable experience in all aspects of geothermal energy, including research, design, financing, works supervision, construction, testing and monitoring of innovative geothermal applications, geothermal resource assessment, geothermal exploration, policy making, legislation and others.

Experience in running geothermal power plants in severe climate conditions in Russia

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Intergeotherm JSC was established specially to develop geothermal projects in Russia and Latin America (Nicaragua, Mexico and Salvador). Over the last years Intergeotherm JSC works in close cooperation with Nauka SC (www.naukasc.ru), Geotherm-M SC, and the Russian Association of Geothermal Energy Society (www.gesa.ru) on implementation of geothermal projects in Kamchatka, Kuril Islands, North Caucasia and Kaliningrad region.

Geothermal resources in Russia are available over a wide territory from Kaliningrad region in the west to Kuril Islands in the east. Such reserves could cover 100% demand of several regions in Russia (Kamchatka, Kuril Islands, Chukotka, part of Siberia, Krasnodarsky Krai, etc.) for heat and electricity. However being rich in geothermal resources, some of such regions are located in severe climate conditions, where snow depth in winter could reach 6-10 meters, and wind speed could come up to 60 m/s.

In several remote regions lacking local fossil fuel reserves a price for electricity usually exceeds 15 cents (ranging from 12 to 30 cents) per 1 kWh, while 1 Gkal could cost US$60 - US$70. Therefore geothermal energy is a way out for such regions, offering valid benefits through reduction of heat and electricity cost, and providing environmentally friendly electricity generation technology.

As early as in 1995 in the USSR were developed and published basic principles of water-ammonia cycle (L.M. Rosenfeld, A.G. Tkachev. Cooling machines and devices. Moscow: Gosorgizdat, 1955. 584 p.) for electricity generation from low enthalpy geothermal resources (hot water with temperature over 90 °C). In our days this technology is widely applied.

In 1967 the first world Paratunsky binary cycle power plant utilizing F-112 working fluid was constructed in Kamchatka and has been in continuous operation since that time.

Presently in Russia with participation of Intergeotherm JSC, the Association of Geothermal Energy Society, Nauka SC several binary cycle power plant projects are under development or implementation, among which: Verkhne-Mutnovskaya binary cycle power plant, Pauzhetsky binary cycle power plant, binary cycle power plants on Kuril Islands and in Krasnodar region. Such binary cycle power plants are supplied with different types of a condenser (air- or water-cooled condensers) depending on climate conditions and availability of water sources.

Since 1999 the 12 (3x4) MW Verkhne-Mutnovskaya geothermal power plant with an air-cooled condenser has been in successful operation in Kamchatka. Air-cooled condensers proved themselves to be reliable in severe climate conditions of Kamchatka with no water resources available. In winter, when temperature could drop below 25 °C, the Verkhne-Mutnovskaya geothermal power plant can generate up to 12,8 MW(e). The Verkhne-Mutnovskaya geothermal direct cycle power plant is in fact the first experience of successful operation of a geothermal power plant with an air-cooled condenser generating environmentally friendly heat and electricity. Combined heat and electricity production from geothermal resources could solve the problem of electricity and heat deficit in remote regions with severe climate conditions.

Session 5

RUNNING AND FORTHCOMING ORC-PROJECTS

ORC power plant Neustadt-Glewe operational experience since 2004

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The first geothermal power plant of Germany in Neustadt-Glewe with 200 kW gross electrical power started up on 12. November 2003. The beginning of normal operation was in August 2004.

Two specific features of the plant require high technology solutions for engineering and operation:

- the lowest brine temperature (95 - 97 °C) for electrical power station;
- combined heat and power station.

The plant is water cooled, using cooling towers. A part of geothermal heat is always used in the local district heating system.

From the beginning the plant was not able to operate with maximum load.

During the second year we had to face three brakedowns because of damage of the generator bearing, leaky valves with a loss of fluid and a failure of the brine pump.

Investigations are started to analyse the malfunction of the whole system.

ORC plant Altheim - a progress report

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Altheim is a city with about 5 000 inhabitants in the province of Upper Austria. It is located about 60 km north of Salzburg and about 15 km from the German border (Bavaria). Geothermal energy for district heating has been used since 1990. The capacity is more than 11 MWth. The ORC project started in 1996 (proposal to the European Commission). District heating and power production is operated by the city itself within the city's budget.

ORC project:

- Commissioned end of 2000
- Design data/nominal conditions:
  Hot water flow rate: 81,7 kg/s
  Hot water temperature in/out: 106 °C/70 °C
  Cooling water flow rate: 340 kg/s
  Cooling water temperature in/out: 10 °C/18 °C
  Electric net output: 1 MW
- Experiencies:
  In general: There is a big difference between nominal conditions and the real world.
  The earth is reliable. No problems concerning hot water temperature and hot water pressure.
- Main problems:
  Control system:
  District heating has priority - hence only the quantity of hot water which is not needed for that is available for electricity generation

Cooling water side:

That means cooling water quantity, cooling water purity, cooling water temperature

Working fluid side:
In 2005 the working fluid had to be replaced and the plants efficiency increased

The availability of the plant is very high up to more than 7 500 hours/y.

ORMAT ORC-units for industry and Geothermics

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The FirstGeoTherm GmbH is a company that develops and realises turn-key geothermal-projects in the Upper Rhine graben in Germany. Together with powerful partners in drilling and power plant-design, FirstGeoTherm is able to realise geothermal projects from the first idea to the acceptance-test of the installed and tested power plant.

ORC-power plants are able to use low-temperature-sources to generate electricity. To show the variability and reliability of ORMAT-OEC-Units the presentation compares two power plants, one using Clinker Cooler exhaust air with rapidly changing temperatures and one using water from a geothermal well.

Power production in HFR Soultz project

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After the completion of the 3 wells system in the previous years of the European HFR Soultz project, improvement of the brine circulation to be established through the underground heat-exchanger is under way, mainly by innovative chemical and hydraulic stimulation of the crystalline rocks. In the mean time, the design of the future power plant was investigated by integration of numeric modelling of the different components. This power unit will include the brine circulation system consisting of two extraction pumps, one long shaft and one electro-submersible pump, and one re-injection pump at ground level.

The energy consumption for brine extraction and re-injection was computed from the combination of the thermo-hydraulic Geowatt well model and well pumping modules. As for the electric power production, Organic Rankine Cycle system with hydrocarbon working fluid shows better efficiency than other conversion systems in connection with the hot temperature expected at the inlet of the plant (175-185 °C) and with the cold source available on site.

The expected energy balance of a demonstrative 1,5 MWelec ORC to be installed on site will be presented in regard with different wells management hypothesis. Final figures of real heat extraction will be fixed at the end of the long duration thermal test of the heat-exchanger to start in the coming months.

Possible evolution of a small double-flash geothermal unit (5 MW)

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CFG SERVICES (CFG) is an engineering company, subsidiary of BRGM, conducting high and medium enthalpy geothermal projects from the exploration phase to the field development. Its main activities are project management, borehole engineering, geological and geochemical monitoring and survey, development and implementation of test programs, corrosion and incrustation studies, technico-economic feasibility studies. CFG has en 8-years-long experience in geothermal development in Guadeloupe as owner and operator of the existing 5 MWe power plant and an extension of 11 MW commissioned by the end of 2004. CFG also developed a large know-how in the maintenance and operation of low enthalpy geothermal exploitations in the Paris Basin for district heating. CFG has been participating to previous THERMIE and 5th FP projects.

The purpose of the presentation is to provide preliminary analysis of the possible evolution of the Bouillante 5 MW double-flash steam turbine unit:

There are mainly 4 options to be analysed:

1) Revamping of the unit according to the existing status: double-flash steam turbine;

2) Idem 1 + small binary cycle on available separated water (after HP separator);

3) Single flash turbine (HP only) and larger binary cycle;

4) Actual double flash turbine totally replaced by a binary cycle.

The paper will give the results of the preliminary analysis.

These results are still to be confirmed by a detailed technico-economic study, taking into account technical, financial, economical but also environmental considerations, the unit being installed in the city of Bouillante (Guadeloupe).

Session 6

RUNNING AND FORTHCOMING KALINA-PROJECTS

The Kalina power plant in Húsavik - why Kalina and what has been learned

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The alternatives for the selection of the power production cycle for the Husavik plant (Iceland) are discussed. The role of effectiveness and efficiency in such a selection is explained, as well as the reason for selection a cycle with regeneration. A comparison is made between the best alternatives.

The Kalina power plant in Husavik is described, and the operating experience for the last six years presented.

Finally the undergoing modification of the plant is presented, a modification which will increase the power to 15% over the original target.

Presentation of geothermal project "Unterhaching", Germany

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Short Presentation of Rödl & Partner

Rödl & Partner is one of the biggest international auditing and consulting firms. Rödl & Partner engages 2.430 employees on 49 international locations and on 22 locations in Germany. Within the business unit Public Management Consulting and the department of infrastructure, the Competence Center "Renewable Energies" focuses on Renewable Energy Technologies. Project management, financing advisory, tariff models, PPP-models and emission trade are the main subjects of the consulting services. Rödl & Partner is assigned for the overall project management of the geothermal pilot project Unterhaching and provided already services in the field of renewable energies to the Worldbank, UNEP, Federal Ministry of Environment and numerous client from the private and public sector.

Summary of Presentation *Geothermal Project Unterhaching*

Geothermal Unterhaching Limited, owned by 100% by the community, implements a hydrogeothermal project with combined heat and power generation based on a geothermal doublet drilled down to depths of approx. 3,350 m. This geothermal project includes the installation of a power generation plant, district heat network, heat plant, thermal water pipeline and pump system. For the first time a power generation plant unsing the Kalina-Process will be installed in Germany. The first drilling was finished successfully in September 2004. The final pump test results are: thermal water at 122 °C and a flow rate of 150 l/s. The second drilling for reinjection of thermal water has started in June 2006 in the South-East of Unterhaching. The two drillings have a distance of about four km and are connected by a thermal water pipeline.

The geothermal energy, respectively thermal water at a temperature is pumped up by one borehole, the so-called production well. At surface it is either cooled down by the power plant (evaporating ammonium-water mixture) or during winter time providing heat energy for the district heating network. The exact flow volume is determined by the demand of district heat network ("heat-guided system"). The cooled water is pumped back to the same aquifer by the second borehole, the so-called reinjection well. The aquifer is the thermal water reservoir in the subsurface, which is located in the Molasse Basin in South Germany.

The Kalina power plant will have a capacity of 3.36 MWe. The generated power will be fed into the public network at a regulated fee (Renewable Energy Act) of 0.15 €/kWh. In Unterhaching the thermal capacity of the geothermal production well will be approx. 38 MWth. The district heating network is realized in two construction phases. The installed capacity in the first construction phase is about 28 MWth and for the second one it will reach 40 MWth.

Presently the project is in the construction phase: district heating network, reinjection drilling, thermal water pipe line, power plant are under construction. Commissioning of the district heating network is planned for 10/2006 and of the power plant for the fourth quarter of 2007. The environmental relief by the project in Unterhaching will be a considerable CO_2 reduction between 30,000 and 40,000 t per year.

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