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Economical Assessment for Liepaja Geothermal Pilot Project

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ABSTRACT

The highest geothermal potential in Latvia is located in the western part of the country. There is located the third biggest city of Latvia – Liepaja. Geothermal aquifer zone characteristics suggest that this energy source would be suitable for space heating using geothermal heat pumps.

The use of an absorption heat pump nearly eliminates energy consumption and operational costs for the heat pump, and the design has made it possible to avoid corrosion problems and to reinject millions of cubic metres of saline geothermal water into a sandstone reservoir.

Based on the Feasibility Study and supplementary material previously discussed with Latvian authorities it is proposed to launch the Liepaja Geothermal Pilot Project providing an annual heat supply into the Liepaja district heating network corresponding to 300 TJ/y. Project implementation should be preceded by appraisal activities financed by the Latvian Government and the Liepaja City Council at a total cost amounting to LVL 1.24 million*. The total cost for the subsequent project implementation is assessed at LVL 5.5 million. Financing of the implementation of the project is recommended pursuant to assembling a satisfactory financial package comprising local contribution, bilateral support, international grant(s) and an international bank loan.

1. INTRODUCTION

Liepaja is located in the most prospective geothermal region of the country. It is the third largest city in Latvia with its population of 87058 (4% of the total in Latvia).

Recent technological and geo-political development trends have introduced a dynamic factor that will alter the future of geothermal energy. This factor will change conventional economic comparisons between different energy technologies and cause a reversal in their order. Along with the fact that variability is great for geothermal energy due to local conditions (including well drilling and well productivity), this means that economic analysis and economic forecasting of geothermal energy investments is both complex and challenging. Nevertheless, the basic approach to analyzing geothermal energy investments is a matter of estimating the amount of energy to be produced by a system over its technical lifetime relative to the capital and operational costs (Tallbacka, 2000).

The economics of geothermal energy plants are characterized by high initial investment costs and very low operating costs. As far as the latter is concerned, some plants are known to have run for decades with only minor servicing.

An increasingly important economic factor in calculating the economic feasibility of geothermal energy is the extent to which a market exists for CO_2 emissions in the country of operation. With the Kyoto Protocol and Berlin agreement, the motivation for investors in highly industrialized countries effectively to buy CO_2 quotas by investing in geothermal energy is increasing rapidly. This parameter is of a magnitude that will significantly influence the cost-benefit calculations of a geothermal energy investment.

In the terminology of development banks, this means that geothermal energy projects may be seen as "bankable". Supporting this perspective, the concern “Energy Carbon Facility” in Russia represents a pioneering approach in striving to translate the concept of carbon credits and joint implementation into reality on Russian ground, applying the concepts to geothermal energy development. In addition, the UNEP-GEF "Technology Transfer Network" is working on turning emission benefits into a real competitive advantage for geothermal energy.

Currently, it is broadly considered that the economic value of geothermal energy is highly underestimated. Geothermal energy is often compared to other sources of energy, where externalities are excluded. To the extent that such externalities will be internalised, through green taxes and new regulation, geothermal energy will become more competitive. According to some studies, external costs of conventional energy systems may be up to ten times greater than those of renewables.

2. GENERAL CONCEPTS

2.1 Characteristics of Liepaja, as Potential Geothermal Energy Consumer

During the last years the economy of the town has grown very fast. The most significant investments in the economy of Liepaja were made by entrepreneurs in processing industries (69%), which is a reasonable guarantee for increased competitive capacity and development.

Until recently the processing industry was a leading sector in the structure of the Liepaja economy. However, in 2001 the ratio of the services sector reached 53% in the overall structure of the economy. The amount of accrued foreign investments in fixed assets of the companies registered in Liepaja reached LVL 14 million at the end of 2002. Direct foreign investments in Liepaja amount to LVL 160 per capita. The last two years brought the largest amount of non-financial investments in Liepaja in the last seven year period: LVL 28.7 million in 2001, or twice as much as in 2000, and LVL 32.7 million or 14.6% more than in 2001.

Liepaja City municipality organizes all the communal services (water supply and sewage; heating; household

* *1 LVL ≈ US$1.84*

waste management; collection, drainage and treatment of waste water) regardless of who is the owner of dwelling stock..

At the end of 2003, the tariff for heating energy provided to legal entities on the administrative territory was 23.16 LVL/MWh

2.2 Geothermal Aquifer Zone Characteristics

The Liepaja geothermal project could have good characteristics of viability because of:

- high transmissivity in the aquifer;
- the possibility of supplying heat to the district heating system throughout the whole year;
- the good performance of the absorption heat pumps.

Figures 1 and 2 shows available temperatures on the surfaces of the Cambrian and Pernavas-Kemeru aquifers.

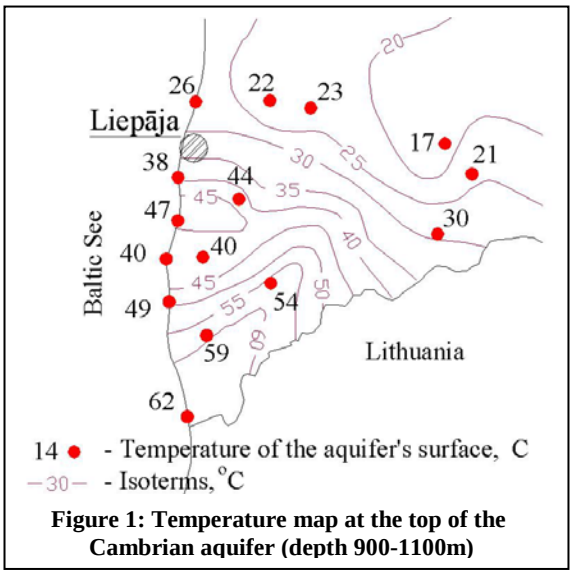


Figure 1: Temperature map at the top of the Cambrian aquifer (depth 900-1100m)

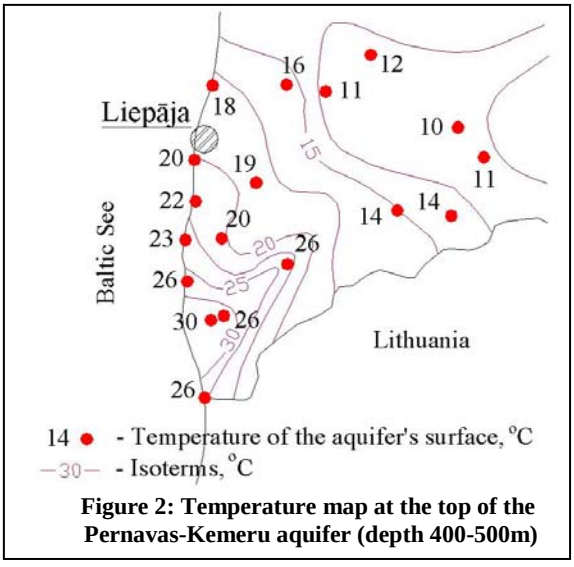


Figure 2: Temperature map at the top of the Pernavas-Kemeru aquifer (depth 400-500m)

Table 1: Relevant aquifer zone characteristics

Aquifer zone stratigraphy	Cambrian
Formation	Cm2dm-Cml
Top aquifer depth, m (GL)	1.500
Gross aquifer thickness, m	235
Net aquifer thickness, m	146
Permeability, mD	550
Static water level, m(GL)	13
Transmissivity, Dm	80
Aquifer pressure, bar	170 @ 1,610 m (GL)
Aquifer temperature, °C	48 @ 1,610m (GL)
Water mineralization, g/1	125
Production index, m^3/hr/bar	25-30 (est.)

The most relevant for the proposed project could be the Cambrian aquifer, the zone characteristics of which are summarized in Table 1 above. These are based on seismic and well data previously acquired within the southern Liepaja area. The closest well in this context is located approximately four kilometres north of the planned project area, i.e. Liepaja Sanatory-1 drilled in 1974; well Liepaja-P46 drilled in 1980 and located at a similar distance south of the planned project area comprises a second point of well control . Seismic control consists of one seismic line, acquired back in the 1970s, extending north-south approximately two kilometres west of the project area.

Both the seismic and well data suggest the presence of a major east-west trending fault intersecting southern Liepaja, downthrown to the south by some 200 metres. It is of paramount importance that the underground geothermal development takes place on the downthrown side of this fault. The planned project site should be located as close as possible to the existing boiler house at Tukuma Street in the southernmost town of Liepaja.

The time and distance between available well control and the planned project area as well as the limited seismic control present the project with certain stratigraphic and structural risks. The preparatory activity and actual works required in order to remove these risks are collectively referred to as project appraisal in the following.

The corrosion properties of geothermal water are expected to be similar to those in Klaipeda (Lithuania). The corrosion rate of carbon steel has been measured to be 0.1-0.2mm per year in the geothermal water there. The conclusion was that normal steel can be used with 5mm corrosion allowance and the moving parts such as balls in ball valves can be AISI 316. The carbon steel, however, should not contain more than 0.02% sulphur. Special consideration must be given to welds which can be corroded by the carbon dioxide. Precipitation problems are not expected. The water has a high mineral content (125 g/l), more than 96% NaCl and CaCl. The pH value is up to 6.3. One litre of geothermal water contains 160ml of dissolved gas. Approximately 94% of this gas is N_2. (Zinevicius, 2002)

2.3 Technical Remarks

Low temperature levels for the district heating networks are important for geothermal heat production. A method to reduce the temperature levels has been suggested: exchange of ejector pumps with circulation pumps and new control valves. The changes can be more than paid for by reduced heat loses on the network, but lack of capital may delay such changes. A winter/summer supply temperature becomes then 110/70°C and winter/summer return temperatures become then 50/40°C.

Liepaja has an annual heat demand of approx. 902.7 GWh and a base load of approx. 30 MW. Electricity prices are expected to increase. This will lead to higher heat production costs for electric heat pumps than for absorption heat pumps (though the plant actually reduces boiler capacity demands). The future outdoor temperature and heat demands, including their variation through a normal year, have been estimated based on monthly fuel consumption, types of consumers and temperature levels on the district heating networks. The distance between production and injection wells is calculated to give constant production temperature for 30 years and a moderate decline in the succeeding years. Like district heating networks the plant can operate for more then 30 years but maintenance costs are assumed to increase by then. New production wells after 30 years of operation can prolong the plant operation period (Mahler, 1994).

Heat production from direct heat exchange and absorption heat pumps can be obtained by lowering the temperature of the district heating network (the return temperature is the most important) or by heating water supplied to the network to compensate for water losses by cheap direct heat exchange. For example, a lowering of the winter/summer supply temperatures to 95/65°C and winter/summer return temperatures to 40/35°C will lower heat production costs. The present main obstacle for continuation of the investigation into the possibility of building a geothermal plant in Liepaja is the plan to erect a big heating and power plant in Liepaja.

3. PROJECT APPRAISAL

The project appraisal programme can be subdivided into three phases of activity, comprising

a) preparations, programming and procurement for the acquisition of approximately 12 kilometres of seismic data and the construction of one geothermal well in southern Liepaja,
b) acquisition, processing and interpretation of the seismic data
c) the drilling, construction and testing of one geothermal well, i.e. well LGPP-1,
d) evaluation of well and test results, the reporting and the submittal of recommendations for further geothermal development as applicable.

The total cost for the project appraisal activities is estimated at LVL 1.24 million allocated as follows: .

Table 2: Project appraisal

Preparatory work, programming, procurement	LVL 250,000
Seismic survey, 12 km	LVL 60,000
Well construction	LVL 780,000
Well test & evaluation, reporting	LVL 150,000
Total project appraisal	**LVL 1,240,000**

It is recommended that the financial means required for the performance and completion of the project appraisal works are provided as a mixed grant by the Latvian Government and the Liepaja City Council. Administration and supervision of the project appraisal activities could be assumed by e.g. A/S Liepajas Siltums in cooperation with PGI (Petroleum Geology Investigators). The cost for Petroleum Geology Investigators' involvement in the project appraisal is included under points "a" and "d" in the above cost allocation.

With a view to a time- and cost-effective execution of the project appraisal it is further recommended to negotiate a single source fixed price contract with the Lithuanian contractor AB Geonafta, Gargzdai for the required seismic and drilling activities. Separate purchase contracts should be executed for tubular goods, diesel fuel etc., and separate works contracts to comprise the construction of the well site as well as the provision of required well services (cementing, drilling fluids and wireline logging). In this context it is suggested to consider the construction of a deviated rather than a vertical geothermal appraisal well. Although this would increase the well construction cost the potential later construction of the second (and eventually a third) well from a common site carries considerable savings in the project implementation budget (injection site, flow line). The project appraisal cost above assumes the construction of a deviated well. It is estimated that it would take one year from the date of execution of the required financial grant to complete the project appraisal activity as summarized in the above.

4. GEOTHERMAL HEAT GENERATION AND UTILISATION

The Cambrian aquifer zone pressure and temperature within the southern Liepaja area were assessed at 170 bars and 48°C, respectively. The petrophysical indicators (Ref. TABLE 1) suggest an aquifer zone production index between 25-30 m^3/hr/bar. This would imply that at a drawdown between 10-12 bars a sustained production/ injection rate could be maintained at 300 m^3/hr. At a geothermal water withdrawal rate of 300 m^3/hr an annual geothermal heat production rate of 300 TJ has been calculated, corresponding to approximately 20% of Liepaja's heat demand. A preliminary assessment of the duration curve and schematic configuration of the Liepaja Geothermal Pilot Project are shown in Figures 3 and 4 respectively.

Pending the conclusive establishment of the aquifer zone transmissivity under the project appraisal activities, the extension of the project to comprise two geothermal water production wells should be considered. The increased water production rate from 300 to 600 m^3/hr would in principal double the geothermal heat generation.

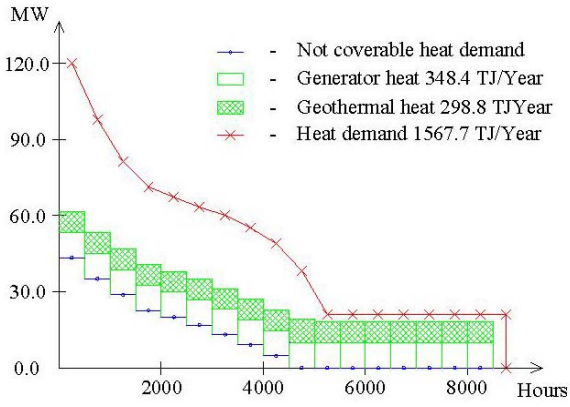


Figure 3: Liepaja Geothermal Pilot project, duration curve

Eventual surplus geothermal heat could be utilized for auxiliary heating purposes, such as fish farming, green houses and/or bathing. Liepaja has a long tradition as a health and recreation resort in Latvia.

5. GEOTHERMAL DEVELOPMENT PROGRAMME

Assuming a successful result of the project appraisal, a second geothermal well can be constructed followed by the implementation and hook up of the geothermal heat plant, preceded however by a) thorough financial and economical analyses, b) the establishment of necessary institutional arrangements and c) the establishment of a financial package. The collective activities under points "a", "b" and "c" in the foregoing are referred to as the "upfront engineering assessment" in the following

5.1 Upfront Engineering Assessment

The upfront engineering assessment should primarily focus on the institutional and financial issues related to the final implementation of the project. Institutional arrangements have already been discussed with relevant Latvian government and local authorities as well as with A/S Liepajas Siltums. Requirements for additional institutional arrangements are to a large extent related to the eventual international content in the financing for the project implementation.

5.2 Financial Package

The financial package could involve: a) local financial support through the Latvian Government, b) local project investment (e.g. A/S Liepajas Siltums), c) bilateral international financial support (e.g. Denmark), d) international grant (e.g. GEF, EU), e) international bank loan (e.g. IBRD, EBRD) and f) local bank loan.

In this context the financial package underlying the Klaipeda Geothermal Demonstration Project consisted of 19% local contribution (Lithuanian Government), 15% bilateral financial support (Danish Environmental Protection Agency), 34% international grant (GEF) and 32% international bank loan (IBRD). The establishment of the financial package for the Klaipeda Geothermal Demonstration Project was made in Lithuania by Petroleum Geology Investigators and required one year of work at a total cost of approximately LVL 62,000. Assuming Petroleum Geology Investigators' involvement in the Liepaja Geothermal Pilot Project it is believed that the time and cost for the soliciting of a financial package could be reduced to around 50% of those for the Klaipeda Geothermal Demonstration Project, i.e. implying six months of work at a total cost of LVL 31,000.

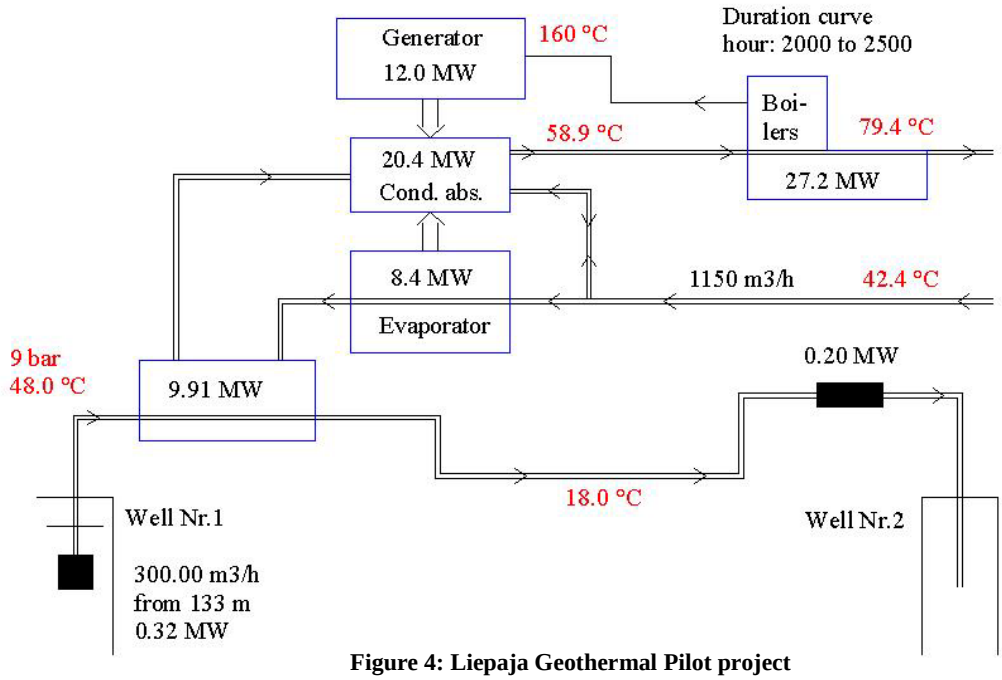


Figure 4: Liepaja Geothermal Pilot project

5.3 Implementation

The project implementation can be subdivided into two phases, i.e. Phase 1 development comprising the construction of the first geothermal well (including submersible production/injection pumps, filters, switchboard etc) and required building(s), the installation of heat pump equipment, the provision of power supply, sewer connections, etc., and the supply and installation of required power and control systems. A Phase 2 development could comprise the construction of a second geothermal production well (with submersible pump) and a related expansion of the absorption heat pump capacity. The financial package discussed above is solely related to the Phase 1 development.

6. PROJECT COSTS

6.1 Phase 1: Underground Development

The total cost for the construction of the second well, i.e. well LGPP-2, is estimated at LVL 929,000 allocated as follows:

Table 3: Total cost (Phase 1)

Drilling rig including mob/demob	LVL 255,000
Well services (cementing, fluids, deviation etc.,)	LVL 414,000
Tubulars	LVL 90,000
Diesel & lubricants	LVL 20,000
Testing, evaluation & reporting	LVL 150,000
Total cost, underground development	**LVL 929,000**

As for the appraisal well, the cost assumes the construction of a deviated well, i.e. drilled side by side with the appraisal well LGPP-1.

6.2 Phase 2: Surface Development

Apart from the cost related to construction of well LGPP-2, major items of capital expenditure for the Phase 1 project implementation comprise a) the establishment of the geothermal heat generation facility (building and civil works), b) the purchase and installation of submersible geothermal water production pumps as well as injection pump(s), c) the purchase and installation of required absorption heat pump capacity, d) the required internal piping and connection works including tie-in to the final boiler house and e) the installation of required power and control systems. The Phase 1 investment is allocated as follows:

Table 4: Total cost (Phase 2)

Production plant and facilities	LVL 960,000
Water production/injection pumps	LVL 600,000
Piping/connections and tie-in	LVL 720,000
Power & control systems	LVL 600,000
Total cost, surface plant development	**LVL 2,880,000**

A Phase 2 development is currently considered tentative only. Major items of further investment would comprise the construction of a second geothermal water production well (well LGPP-3) and the expansion of the heat pumps' capacity in order to generate 600 TJ of geothermal heat per year. Based on the above this would indicate an additional capital expenditure between LVL 2.0-2.5 million. Time will show whether this investment can be justified.

6.3 Total Project Cost

The compilations shown above reveal a total project base cost at approximately LVL 5 million. Adding construction interest and price contingency would indicate a total project implementation cost, hence a financial requirement, to the tune of LVL 5.5 million. Adding the cost attributed to the project appraisal brings the total capital outlay for the Phase 1 implementation of the LGPP to LVL 6.74 million. The corresponding capital outlay for the Klaipeda Geothermal Demonstration Project amounted to approximately LVL 11 million.

7. GEOTHERMAL HEAT PRODUCTION COST

Assuming a bank loan of LVL 5 million over 20 years at five percent real interest and an annual operating cost (including power) of LVL 256,000 would imply an initial heat production cost of LVL 2.2/GJ. After repayment of the loan this cost would drop to approximately LVL 0.9/GJ. Continued development (Phase 2) as mentioned in the above would tend to improve this situation. The same would apply pending a reduction of the loan amount due to the eventual soliciting of bilateral financial support and international grant(s).

8. PROJECT PROPOSAL

Geothermal energy is a clean, proven and reliable resource for supplying the needs of a sustainable society and helping to improve the global environment. The environmental impact of geothermal energy is small as compared to that of hydrocarbons (especially CO_2 emission). Energy prices and environmental impacts are the two parameters that will have the largest influence on the competitive status of geothermal energy in the 21st century. New possibilities for geothermal energy development in new Member countries of the European Union are given by the European Commission in the Sixth Framework Programme (FP6) (www.fp6.com, 2004).

The aim of this element of FP6 is to pave the way for the introduction into the market of innovative and cost competitive renewable and energy efficiency technologies. Projects should focus on: "geothermal energy for heating and cooling employing innovative environmentally sustainable and cost competitive technologies, including ground coupled heat pumps". Support is also offered for "Geothermal energy for electricity generation, combined heat and power (CHP), innovative research into exploration, resource assessment and management techniques, cheaper and more advanced drilling and simulation technologies, and more efficient power cycles".

New technologies, standardization and new grid management tools should facilitate the access of small self-producers to the grid; fuel flexibility ensures increased security in the decentralized energy market.

Based on the foregoing and in consideration of the indigenous domestic geothermal energy resource and the environmental benefits attributed to geothermal heat generation it is proposed to consider seriously the launching of the Liepaja Geothermal Pilot Project pursuant to the description and development and financing scenario as discussed above. An early initiation of the project would provide the opportunity to benefit from the experience and know-how acquired in connection with the implementation of the Geothermal Demonstration Project in Lithuania.

The terms of reference and action plan together with estimated capital expenditures and operating costs for the implementation of the Liepaja Geothermal Pilot Project were initially presented by Petroleum Geology Investigators pursuant to the results of the Baltic Geothermal Energy Project. The Baltic Geothermal Energy Project was performed and executed through *inter alia* Latvijas Geoterma in cooperation with a Danish group of consultants headed by Petroleum Geology Investigators. Financial support for the Baltic Geothermal Energy project had been provided through the Danish Environmental Protection Agency.

In consideration of the interest expressed by the Latvian Government and the Liepaja Oty Council an application for financial support was forwarded by DONG E&P A/S to the Danish Environmental Protection Agency for the purpose to cover the costs related to the preparatory phase of the Liepaja Geothermal Pilot Project.

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