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# IMPLEMENTATION COMPLETION REPORT
(CPL-40130)

ON A

LOAN

IN THE AMOUNT OF US$ 5.90 MILLION EQUIVALENT

AND A

GRANT FROM THE GLOBAL ENVIRONMENT FACILITY

IN THE AMOUNT OF SDR 4.60 MILLION (US$ 6.90 MILLION EQUIVALENT)

TO THE REPUBLIC OF

LITHUANIA

FOR A

KLAIPEDA GEOTHERMAL DEMONSTRATION PROJECT

June 11, 2003

**Environmentally and Socially Sustainable Development Sector Unit**
**Europe and Central Asia Region**

CURRENCY EQUIVALENTS

(Exchange Rate Effective November 25, 2002)

| | | |
|---|---|---|
| Currency Unit | = | Lithuania Litas (LTL) |
| LTL 1 | = | US$ 0.29 |
| US$ 1 | = | LTL 3.39 |

FISCAL YEAR

ABBREVIATIONS AND ACRONYMS

| | |
|---|---|
| BGES | Baltic Geothermal Energy Study |
| CAS | Country Assistance Strategy |
| CEM | Country Economic Memorandum |
| $CO_2$ | Carbon Dioxide |
| DEPA | Danish Environmental Protection Agency |
| DONG | Dansk Olie & Naturas A/S |
| EG | Enterprise Geoterma |
| ERR | Economic Rate of Return |
| ESR | Energy Sector Review |
| FCF | Free Cash Flow |
| FRR | Financial Rate of Return |
| GEF | Global Environment Facility |
| GHG | Greenhouse Gases |
| GOL | Government of Lithuania |
| HFO | Heavy Fuel Oil |
| IAS | International Accounting Standards |
| ICR | Implementation Completion Report |
| ICB | International Competitive Bidding |
| IRR | Internal Rate of Return |
| KGDP | Klaipeda Geothermal Demonstration Project |
| KDHE | Klaipeda District Heating Enterprise |
| KE | Klaipedos Energija |
| LPC | Lithuanian Power Company |
| MOE | Ministry of Economy |
| MOEP | Ministry of Environmental Protection |
| MOF | Ministry of Finance |
| MW | Megawatt |
| $NO_x$ | Nitrogen Oxides |
| NPV | Net Present Value |
| PER | Public Expenditure Review |
| PIP | Project Implementation Plan |
| PIU | Project Implementation Unit |
| SAR | Staff Appraisal Report |
| $SO_2$ | Sulfur Dioxide |
| TF | Trust Fund |
| TJ | Terajoules = $10^{12}$ Joules |
| TPM | Total Particulate Matter |
| ToP | Take or Pay |

| | |
|---|---|
| Vice President: | Johannes F. Linn |
| Country Manager/Director: | Roger W. Grawe |
| Sector Manager/Director: | Jane E. Holt |
| Task Team Leader/Task Manager: | Anders O. Halldin |

**LITHUANIA**
**KLAIPEDA GEOTHERMAL**

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|---|---|
| *Project ID:* P036011 | *Project Name:* KLAIPEDA GEOTHERMAL |
| *Team Leader:* Anders O. Halldin | *TL Unit:* ECSSD |
| *ICR Type: Core ICR* | *Report Date: June 19, 2003* |

## 1. Project Data

*Name:* KLAIPEDA GEOTHERMAL
*L/C/TF Number:* CPL-40130
*Country/Department:* LITHUANIA
*Region:* Europe and Central Asia Region

*Sector/subsector:* District heating and energy efficiency services (100%)
*Theme:* Other urban development (P); Pollution management and environmental health (P); Climate change (P)

KEY DATES

| | | | Original | Revised/Actual |
|---|---|---|---|---|
| *PCD:* | 01/14/1994 | *Effective:* | 09/30/1996 | 10/30/1996 |
| *Appraisal:* | 03/08/1995 | *MTR:* | 09/01/1997 | 12/13/1998 |
| *Approval:* | 05/09/1996 | *Closing:* | 04/30/2002 | 12/30/2002 |

*Borrower/Implementing Agency:* REPUBLIC OF LITHUANIA/ENTERPRISE GEOTERMA
*Other Partners:* Global Environment Facility, Danish Environmental Protection Agency

| STAFF | Current | At Appraisal |
|---|---|---|
| *Vice President:* | Johannes F. Linn | Wilfried Thalwitz |
| *Country Director:* | Roger W. Grawe | Basil G. Kavalsky |
| *Sector Manager:* | Jane Holt | Geoffrey Fox |
| *Team Leader at ICR:* | Anders Halldin | Anders Halldin |
| *ICR Primary Author(s):* | Anders O. Halldin; Kimberly Heuckroth; Da Zhu; Inesis Kiskis | |

## 2. Principal Performance Ratings

(HS=Highly Satisfactory, S=Satisfactory, U=Unsatisfactory, HL=Highly Likely, L=Likely, UN=Unlikely, HUN=Highly Unlikely, HU=Highly Unsatisfactory, H=High, SU=Substantial, M=Modest, N=Negligible)

*Outcome:* S
*Sustainability:* L
*Institutional Development Impact:* SU
*Bank Performance:* S
*Borrower Performance:* S

| | QAG (if available) | ICR |
|---|---|---|
| *Quality at Entry:* | | S |
| *Project at Risk at Any Time:* | Yes | |

From a technical perspective the Project was at risk from early stages of implementation, when the injection well turned out to have too low of an injection capacity. In view of the limited budget and the high cost for drilling a new well, the Project would most likely have been closed if the second well had also been a failure. Another technical risk occurred when the plant was first put into operation during 2001; its

injection capacity had been reduced substantially as a result of clogging with gypsum crystals, and the wells had to be cleaned. Recently, a serious problem associated with clogging of the plant's absorption heat pumps with gypsum crystals has been observed. The Project is at a considerable risk if steps are not taken to mitigate this problem. DEPA has approved further financing of US$ 0.3 million to help Enterprise Geoterma (EG) resolve this problem, which is possible to fix from a technical perspective.

## 3. Assessment of Development Objective and Design, and of Quality at Entry

### *3.1 Original Objective:*

The objectives of the Klaipeda Geothermal Demonstration Project were as follows:

(i) to demonstrate the feasibility and value of using low temperature geothermal water as a renewable, indigenous energy resource in district heating systems;
(ii) to reduce emissions of greenhouse gases (GHG) and sulfur dioxide ($SO_2$) by replacing gas and heavy oil (mazut with an S-content of 3.5%); and
(iii) to promote sustainable management and the development of environmentally sound and non-polluting geothermal resources both in a national and regional perspective.

The project was expected to have considerable local and global benefits by reducing carbon dioxide ($CO_2$), sulfur dioxide ($SO_2$), total particulate matter (TPM) and nitrogen oxides ($NO_x$) emissions. It was estimated that the Project would reduce annual emissions of $CO_2$ and $NO_x$ by 47,800 tons and 1 ton respectively if natural gas were replaced, and 51,940 and 11 tons respectively if heavy fuel oil (HFO) were replaced. HFO substitution would also result in an estimated reduction of 1,160 tons per year of $SO_2$. Other project benefits included demonstrating the cost effectiveness of developing indigenous geothermal energy resources on a larger scale (as recommend in the Lithuanian Energy Development Program) and achieving savings in foreign currency exchange used to import fossil fuels for heating purposes.

*The Project objectives were clear and realistic.*
The Project objectives were in line with national priorities and the Bank's 1994 Public Expenditure Review (PER), Energy Sector Review (ESR) and at Country Assistance Strategy (CAS), which, inter alia, recommended developing indigenous, geothermal energy resources for application in district heating systems. These recommendations were supported by the findings of extensive field visits by Lithuanian and Bank specialists. The Project was undertaken on a pilot, demonstration basis in order to determine whether the use of geothermal resources could be expanded across Lithuania. The Project was not overly complex since it was in a well defined and small geographic area, did not try to undertake a large range of policy/institutional improvements, and did not involve a large number of institutions. The competence of the implementing agency, Enterprise Geoterma (EG), which had already been involved during the preparation of the Baltic Geothermal Energy Study (BGES), was evaluated as strong enough to manage the project as designed.

After the collapse of the Former Soviet Union, Lithuania faced a number of problems in its energy sector specifically related to heating: high energy intensity and the need for energy efficiency and conservation; limited domestic energy resources, which in 1996, when the Project was appraised, supplied only 2% of the country's heat demand; almost total dependence on imported fuels from Russia and thus vulnerability to serious supply disruptions; and difficulty in passing price increases on to consumers to achieve cost recovery. In 1992, the Government of Lithuania (GOL) developed a National Energy Strategy to address the issues facing the energy sector. A priority goal outlined in the strategy was the development of indigenous and renewable energy sources in order to increase Lithuania's energy independence and security of heat supply.

The BGES undertaken in the early 1990s by Petroleum Geology Investigators and financed by the Danish Environmental Protection Agency (DEPA), indicated that geothermal energy resources are the greatest in Lithuania. Compared to other indigenous energy resources such as peat and wood, geothermal energy has a much larger development potential and no environmental impact. Furthermore, accessing geothermal energy resources in the Baltic region was believed to be relatively simple given that drilling depths were limited to 800-1200 meters. The GOL requested that DEPA extend its BGES to include the preparation of a feasibility study for the construction of a geothermal demonstration plant in Klaipeda, which was identified as the most suitable location for a pilot project.

The feasibility study estimated that a geothermal demonstration plant in Klaipeda could provide approximately 10% of the city's total heat demand (5,600 Terajoules in 1994) and reduce emissions of GHGs from boiler houses in Klaipeda by 10%. If successful, from both a technical and economic perspective, the feasibility study suggested that the use of geothermal heat could be expanded to several other district heating networks in Lithuania.

In 1994, the World Bank completed a PER, ESR and CAS for Lithuania. The PER highlighted the need to support priority investments in the energy sector. The ESR recommended that limited resources be targeted at improving production efficiency, setting price incentives to promote conservation, improving the security of fuel supplies, and developing indigenous, geothermal energy resources for application in district heating systems. The 1994 CAS also emphasized the need to develop, in an environmentally sound manner, those domestic supplies of energy which could prove commercial, emphasizing the need to explore the country's for geothermal resource potential.

Given the national importance of increasing Lithuania's energy security and, the results of geothermal energy studies, the GOL requested a loan from the Bank to build a geothermal demonstration plant in Klaipeda. The Bank agreed to a loan for a portion of the project cost, while the Global Environment

Facility (GEF), and DEPA agreed to provide additional grant financing. The GOL agreed to contribute financing in the amount of 15% of the Project cost.

In brief the geothermal plant was designed as follows:
Geothermal water at a temperature of about 42 °C would be pumped from the Devonian aquifer at a depth of 1300 m below ground. After passing through the geothermal plant, the temperature of the water would fall to about 17 °C and then be reinjected to the same aquifer, but at a distance of more than 1.6 km from the well where the water was pumped up. The extracted energy would be transferred to the district heating system to raise the water temperature from about 44 °C to about 68 °C. The heart in the plant is the absorption heat pump, where the energy is extracted from the geothermal water and transferred to the district heating system. The heat pumps use hot water for driving energy; the energy from the hot water would also be transferred to the district heating system. The extraction of heat from the geothermal water was estimated at 16.3 MW, based on a flow of 600 $m^3$/hour. At the time of design and appraisal, it was anticipated that the driving heat would be delivered by the nearby Eastern Boiler House belonging to the Klaipeda District Heating Enterprise (KDHE), and that the extracted geothermal heat would be received by the district heating company as the base load (representing the need for hot water production) all year round.

*Certain risks were foreseen*. Technical and managerial risks were identified. The technical ones were limited to lower than expected supply of geothermal energy (amount of water and water temperature). Implementation risks included: longer implementation period due to limited institutional and administrative capacity in Lithuania for future development of geothermal resources; and delayed installation of a steam boiler at KDHE needed to provide driving energy to the geothermal plant (absorption heat pumps). These risks were to be reduced through: careful monitoring during drilling of production wells; ensuring that appropriate project management arrangements were in place in a timely manner; preparing and executing a sound Action Plan for development of Enterprise Geoterma (EG); and securing grant funding to cover the manufacturing and installation of the required steam or hot water boiler if deemed necessary. A decline in the price of HFO and natural gas to the point where geothermal energy would be uncompetitive was identified as a potential economic risk for the project but was not considered likely to occur.

In addition to these risks, efforts were taken prior to project approval to address the potential risk that KDHE would not purchase energy from EG. At the time of project appraisal, a Take-or-Pay (ToP) contract was signed between EG and KDHE (owned by the Lithuanian Power Company (LPC)). The contract provided that, over a 25 year period, KDHE would be obligated to accept a quantity of heat up to an amount equal to the base load demand over the year. The price to be paid was to be based on the actual heat production cost (border price, custom duty, transport, storage, handling in Klaipeda, environmental fees) for KDHE during the previous quarter, inclusive of fees. During project negotiations, it was agreed that LPC would take all necessary measures to ensure that KDHE complied with its obligations under the ToP contract, and that if KDHE were sold, its obligations in accordance with the ToP contract would be transferred to the new owner. The contract was to start on January 1, 1999, but was delayed to 2001 given the technical start-up difficulties that EG faced.

### *3.2 Revised Objective:*
The original objectives remained unchanged throughout the project.

### *3.3 Original Components:*
The project had two major components (see Annex 2 for more details):

(a) **Investment component** for:

- drilling of two production wells and one injection well;
- procurement and installation of above ground facilities including buildings and necessary equipment such as absorption heat pumps, heat exchangers, and auxiliary equipment for control and regulation of the plant and the transfer of heat to the district heating system; and
- installation of piping between the production wells and the geothermal plant, the geothermal plant and the injection well, and the geothermal plant and the district heating network.

(b) **Technical assistance and training component** for:

- design of the geothermal loop, including all necessary equipment for extracting heat from the geothermal water and transferring it to the district heating system;
- preparation of detailed drilling, testing and completion programs;
- provision of management support for project implementation, including support in preparing tender documents and construction supervision; and
- training of Lithuanian staff and management in the operation of a similar geothermal plant in Thisted, Denmark to optimize transfer of technology.

The components were related to achieving the project's objectives. Project activities were supported by technical and engineering support from Dansk Olie & Naturgas A/S (DONG), which managed Danish consulting groups Petroleum Geological Investigators A/S and Houe & Olsen, that provided assistance during the planning, implementation and start-up of the Project. In addition to technical support and training, the Project also provided assistance to build EG's financial management capacity at all stages of the Project. EG received training in disbursement and procurement practices several times during Project implementation, and also training in financial management during Bank supervision missions. In addition to the input during supervision, the Bank utilized the Flemish TF to provide further managerial and procurement assistance to EG during the first two years, when a number of crucial procurement activities took place.

At the time of Project preparation, Bank involvement in geothermal energy activities in Europe and Central Asia (ECA) was limited to ongoing preparation work for planned projects in Poland and Slovakia. Overall Bank experience in implementing geothermal projects was limited to power producing plants in Kenya, and a new geothermal project in the Philippines. Therefore, the Klaipeda Geothermal Demonstration Project was not only the first geothermal project in the Baltic region, but was also the first Bank loan to assist with the development of geothermal resources to be used for heating purposes. Given the pilot nature of the Project, the design of the components was based to a large extent on existing geothermal plants and experience in Scandinavia, especially Denmark. Lessons learned from this project in Klaipeda will be very useful for any future projects that might be undertaken in Lithuania, other countries in ECA, and more broadly, in different regions of the world, especially if they are made available in a hand book for technical and administrative planners and decision-makers.

### *3.4 Revised Components:*

No new components were added to the project and none were dropped. However, the scope, type and number of activities were revised a number of times in order to solve the emerging technical problems that occurred during the implementation of the project, and in order to increase the geothermal heat generation capacity of the plant, thus ensuring EG's status as a reliable heat supplier.

At different stages during project implementation, additional works and new equipment had to be procured. The inclusion of these additional items was agreed with country and sector management, and could be implemented without amending the Project's legal documents.

New injection well: Unexpected, low hydrological flow potential at the first, drilled injection well necessitated the establishment of an additional injection well. The flow rate in the new well is very high, and now provides most of the required injection capacity. Together with the first well, the injection capacity is sufficient.

Geothermal flow line to new injection well. The flow line for used geothermal water had to be extended to include the new injection well.

Hot water boilers. At the time of project preparation, it was agreed that driving heat needed to run EG's absorption heat pumps would come from the district heating system's Eastern Boiler House. During project implementation however, KE decided to stop running the Eastern Boiler House during the summer given the low demand for heat. In order to ensure that EG would be able to operate during the summer, a steam boiler was installed.

Later on during project implementation, the decision was taken to oversize the geothermal plant's boiler capacity to ensure that EG would always be able to produce the full amount of heat (using natural gas) should technical problems arise with the extraction of geothermal heat. As such, three hot water boilers were installed at EG. The decision to oversize the boilers was prudent in retrospect, since KE closed down the Eastern Boiler House in 2002 given over capacity of heat supply in the city of around 230 MW per year (approximately 40% over capacity). The Eastern Boiler House's pumps and pipes are still operational. Instead of using the boilers only in the summer, EG now uses them throughout the year to provide the required driving heat for the absorption pumps. The oversized boilers are not being run to their full capacity given the cost of natural gas, but have the potential to produce more heat if necessary in order to guarantee EG's role as a primarily supplier of heat.

Heat exchangers and economizers for boilers. Heat exchangers were installed in the event that the geothermal part of the plant would not be able to function and the majority or all of the heat would have to be provided by the boilers using natural gas. Economizers were also installed to collect waste heat from the boilers in order to improve the efficiency of the hot water boilers by extracting about 2 to 4.5 MW from exhaust gases, thus increasing the overall heating capacity of the geothermal plant.

Sewage pipes and storage tanks. While the geothermal plant operates as a closed system, water must be discharged after temporary plant stoppages (testing, power cuts) to flush out the system. During project implementation, a new environmental law came into force in Lithuania, limiting discharges of highly saline waters. To comply with the rate of flow discharge specified in the law, two storage tanks were built (one at the first production well and one at the second injection well). Water in these tanks is tested for quality and then if it cannot be injected to the aquifer, it is discharged via sewage pipelines that have been constructed.

Heat accumulation tank. In order to increase the geothermal heat capacity of the plant, an accumulation tank was added to the project. It was installed to compensate for daily variations in heat and hot water demand and enable full use of geothermal energy during summer months. EG operates approximately 6 months of the year on a summer schedule, providing 25 MW of heat to the district heating system, of which about 9 MW is geothermal heat.

Clean-up of injection well filters. Gradually reduced geothermal water injection capacity was experienced in both injection wells at the time of start-up of the plant in 2000/2001. Inspections using video camera in late 2001 revealed seriously clogged screens at the bottom of the injection wells, requiring clean-up. The

formation of gypsum crystals was finally cited as being responsible for the clogging of the wells. The clean-up was conducted to full satisfaction during March-April 2002.

Pressure expansion tanks, nitrogen buffers and an inhibitor substance: To be financed by DEPA ($0.3 million) and aimed at solving, by August 2003, the remaining technical problems related to gypsum crystallization in the geothermal plant and flowline. The funding will also be used to add nitrogen buffers to prevent oxygen entering the system should a power outage occur. An inhibitor will also be introduced into the geothermal loop to prevent crystallization in the circulation system. The inhibitor substance has been reviewed and approved by both the Ministry of Environment and DEPA, and will not have any impacts on the environment.

The final cost of the Project, including interest during construction and the still pending clean up of the gypsum crystals currently clogging the geothermal plant's pipelines and absorption heat pumps is US$ 17.55 million. (See Annex 2 for more details)

### *3.5 Quality at Entry:*

Quality at entry is rated as "satisfactory". The Quality Assurance Group (QAG) did not exist at the time the project was being prepared. Every effort was made however, to use the best available information on geothermal resources, knowledge gained from site visits, and the advice of geothermal energy experts, to ensure the highest level of project design possible. The Project was prepared by an interdisciplinary team of professionals that included representatives from the GOL, the Government of Denmark, the World Bank, EG, a Danish consultant group, Klaipedos Energija (KE), and LPC.

The SAR documented the project and its background particularly well and included an assessment of potential risks. The Project Implementation Plan (PIP) included a list of monitoring and evaluation indicators to guide the project.

In accordance with OD 4.01, the Project was screened and rated as category B. An environmental analysis was undertaken, which concluded that the Project would not have any significant adverse impact on the environment. The environmental review provided guidance on the best way to dispose of debris from the drilling process and safe practices for geothermal water discharge to the sewer system. The suggestions provided in the environmental analysis were carefully considered during the design and implementation of the Project.

Some unforeseen risks arose during the course of the project, for example: the need to drill an additional injection well because of insufficient capacity in the first well and the unwillingness of the Klaipeda district heating company, after it was placed under the control of the municipality, to pay EG the price stipulated in the ToP contract agreed with the LPC at the time of the signing of the Loan Agreement.

## 4. Achievement of Objective and Outputs

### *4.1 Outcome/achievement of objective:*

The overall outcome of the project is marginally satisfactory. Despite significant delays in project completion, the project achieved all the relevant objectives specified at the time of project appraisal and achieved satisfactory development results.

Despite the fact that actual geothermal water temperatures are lower than originally expected (38-39°C compared to 40-42°C), the project has still been successful in extracting a sustainable level of heat and thus has demonstrated that using low temperature geothermal water as a renewable, indigenous energy

resource is feasible. However, the plant still has to prove that it can extract heat on continuously, without being hampered by technical problems.

The latest, and only remaining problem, which must be resolved quickly to avoid the failure of the plant is related to gypsum crystallization, which has led to serious clogging of equipment and the flow line for reinjection of geothermal water. At the moment, one of the absorption heat pumps has been taken out of operation, while the other heat pumps are operating at about 50% of their capacity. If this problem is not resolved, the plant will no longer be sustainable, and would be regarded as a failure.

During a short period in November 2002, EG was able to operate at its full capacity, and demonstrate in principle that it is able to extract heat at the expected level from the geothermal water. The delay in rectifying the gypsum crystallization problem, however, has now caused serious operational problems, which if left unmitigated will shut down the plant completely. An action plan has been presented by the Danish consultant (DONG) to rectify the problem. The plant includes clean-up of the whole system (geothermal plant and flow line) and installation of an inhibitor system to prevent future gypsum crystallization.

Although the plant has operated satisfactorily for a relatively short period, the plant has proven its capacity to provide 41 MW of heat (41% from geothermal heat and 59% from boilers running on natural gas) to the district heating system, representing about 12% of Klaipeda's current heat demand (350 MW). It was expected at the time of project appraisal that the geothermal plant would provide 530 TJ, equal to 10% of the city's heat demand. However, a reduction in demand for heat (was 5600 TJ per year in 1994), combined with network efficiency improvements and a higher than expected heat output from the geothermal plant, have increased the percentage of Klaipeda's heat demand that EG is able to supply. If the installed boilers were operated at their maximum capacity during the winter season, EG's total capacity would be 68 MW, consisting of 17 MW geothermal energy, 48 MW from natural gas and 3 MW from economizers extracting energy from the stack gases.

While not all the heat produced by EG is from geothermal energy, its natural gas boilers are more efficient than KE's (96.5% compared to 85%). Overall, the heat supplied from the geothermal plant has reduced the amount of natural gas and heavy fuel oil used for heating. Based on a supply of 270,000 MWh, the reduction in fuel consumption at KE is about 14.5 M $m^3$ of natural gas or about 13,170 tons of mazut. This decline in the use of fossil fuels corresponds to a reduction of 46,000 tons $CO_2$, 2,100 tons of $SO_2$, and 75 tons of $NO_x$ emissions if mazut is replaced, and 33,500 tons $CO_2$ and 94 tons of $NO_x$ if natural gas is replaced, with associated, positive benefits to the local, regional and global environments. It should be noted that the use of natural gas at the geothermal plant in order to generate the driving heat to the heat pumps actually reduces the $CO_2$ emission at the boiler house due to a higher efficiency at the geothermal plant's boilers. These figures are slightly below expected output, but the difference is actually less than would have been expected as the plant is now only operating at 50% during the summer season, due to lower heat demand as a result of KE's planning. The project has also demonstrated sustainable management principles and showed that it is possible to develop environmentally sound renewable and non-polluting sources of energy.

During project preparation, there was a discussion of including a component in the project to help improve the efficiency of the district heating system. While this component was not included in the project, discussions about the financial benefits of improving heat efficiency have influenced KE to use its own resources to improve the efficiency its operations. As of the end of 2002, about 11% of KE's sub-stations had been modified, and the temperature of outgoing district heating water reduced from 130 to 120°C.

These actions have resulted in lower temperatures of return water to EG, which are now below 40°C, approximately 5 degrees less than assumed at appraisal. Continued improvements in the district heating system will result in a further reduction of the return temperature, enabling EG to extract even higher amounts of geothermal energy.

*4.2 Outputs by components:*

Overall the project has established a framework for the:

· Long-term sustainable operation of the Klaipeda geothermal plant, which is providing heat to Klaipeda and the Free Economic Zone (FEZ) that has
been recently established near EG;

· Gradual improvement of air quality in Klaipeda and reduction of GHG emissions, which contribute to global climate change; and

· Demonstration of the potential for adopting environmentally friendly methods of supplying energy in Lithuania.

**Investment Component**

*Underground system*

- 2 production and 2 injection wells drilled
- Submersible brine pumps for the production wells and 4 brine pumps at the surface level (2 per well) for the injection wells installed - flow capacity of injection wells is 600 $m^3$/h as was foreseen at the time of project appraisal

*Above ground system*

- Buried geothermal heat and water loop flowlines (4 kilometers long in total) built connecting production and injection wells to plant and plant to KE district heating system
- Geothermal plant building, office, housing for injection facilities and pump station
- Sewage tanks and sewage pipeline
- Heat accumulation tank
- Circulation pumps (district loop and accumulator)

*Plant equipment*

- Absorption heat pumps (four with 41 MW combined capacity at flow rate of 600 $m^3$/h and temperature of 38°C)
- Boilers (3 with combined capacity of 48 MW)
- Heat exchangers and economizers for boilers
- Equipment for control and regulation of the plant including: SCADA computerized system (power and optical cable installation connecting plant to wells), heat pumps, external boilers, electrical installations and filters, valves and internal piping

*Other equipment to be provided and financed under an additional grant from DEPA*

- Pressure expansion tanks and nitrogen buffers
- Inhibitor dosage equipment to prevent gypsum crystallization

In addition to installation of equipment, the investment component of the project also financed the clean-up of gypsum crystals responsible for clogging the injection wells.

**Technical Assistance and Training Component**
- Geothermal loop designed, including all equipment necessary for heat extraction and transfer
- Detailed drilling, testing and completion programs prepared
- Staff and management of KE trained in Lithuania
- Project implementation support - bidding and tender documents, construction supervision
- Training manual produced

The training component of the Project helped to develop the technical and management skills of EG's employees. The plant staff now have the knowledge and skills required to operate the plant and provide heat to KE and the FEZ. EG also now has the experience needed to implement its business plan, which includes providing reliable and environmentally friendly heat supply to Klaipeda's district heating system and to businesses in the city's new FEZ. One heat supply contract has already been signed with the FEZ and it is expected that business will expand as more companies are established in the FEZ in the future. EG can also now draw on its experience with the demonstration plant in Klaipeda to focus on future aspects of its business plan, including the expansion of geothermal energy activities in Lithuania where this is economically and financially feasible. The MOE has recently expressed a strong interest for further geothermal plants in Lithuania, and EG's experience would be of great value. In addition, EG has plans to use geothermal water for medicinal purposes by possibly establishing a spa adjacent to the already drilled Vidmantai wells, which it owns, near Palanga.

### *4.3 Net Present Value/Economic rate of return:*

#### *4.3.1 Project Benefit*

The benefit to the environment in this project is significant because it reduces $CO_2$, $SO_2$, $NO_x$ and TPM emissions by replacing natural gas and mazut with an alternative and renewable source of energy. The annual benefit from reduced emissions would be US$ 1.6 million if mazut were replaced, and US$ 0.3 million if natural gas were replaced, assuming that EG reaches its full operational capacity. (see Table 3)

**Table 3 Annual emission reductions and benefits from lower mazut and natural gas use**

| | Annual emission reduction (ton) | | | | Annual benefits (million US$) | |
|---|---|---|---|---|---|---|
| Scenario | CO2 | SO2 | NOx | TPM | Emission reduction | Energy efficiency |
| Mazut | 45,956 | 2,101 | 75 | 30 | 1.6 | 1.6 |
| Natural gas | 33,469 | | 94 | | 0.3 | 1.1 |

Cost savings because of higher energy efficiency can also contribute to the benefit. Both mazut and natural gas are used in the heating system in Klaipeda, and their prices determined by the free market. The efficiency of KE's mazut boilers is around 80%, and the efficiency of its natural gas boilers is about 85%. The efficiency of EG's boilers is 97-98%. The annual benefit in terms of cost savings from higher energy efficiency associated with using geothermal heat is US$ 1.6 million if mazut is replaced, and US$ 1.1 million if natural gas is replaced. These benefits will be positive when the mazut price is higher than US$ 86/ton and natural gas prices are higher than US$78/1000 $m^3$. Given that the current mazut price is about US$ 140/ton and natural gas is US$ 115/1000 $m^3$, the project is very beneficial from an economic standpoint.

Assuming that the future development of geothermal energy resources in Lithuania would be undertaken

without the need for driving heat from natural gas, the benefit would be even higher because geothermal heat can contribute more to both emissions reduction and energy efficiency.

In both the ICR and SAR, it is assumed that the environmental benefits from reducing pollutants (or the pollution costs) are: US $600/ton for $SO_2$; US $250/ton for $NO_x$; US $1000/ton for particulate matter; and US $7/ton for $CO_2$ (US $25.7/ton for carbon). It is also assumed that the current difficulties with the plant will be resolved in 2003 and that the plant at the start of the heating season in October 2003 will reach its full heat generation capacity.

*4.3.2 NPV and ERR*

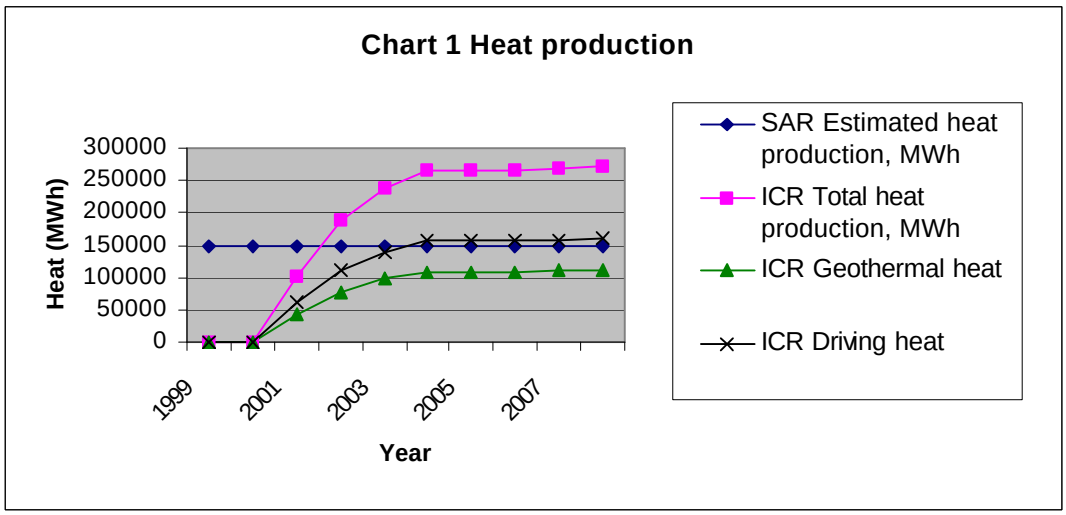
In comparison with mazut, the project NPV is US$ 6.4 million and the ERR is 14.8%. In comparison with natural gas, the project NPV is negative US$ 5.2 million and ERR is 4.7%. The economic NPV (at 10% discount rate) and the ERR are calculated with 1996 as the base year, which is the year the SAR was approved and the year the project started. The exchange rates between the US dollar and Lithuania Lita are taken as the average annual rates. Details are shown in Table 4.

Based on the current fossil fuel prices, future, successor geothermal projects producing 146, 880 MWh of geothermal heat annually without driving heat from natural gas could result in an ERR of 17% compared with projects using mazut, or 10% compared with projects using natural gas. The investment cost of a future geothermal plant is assumed to be 75% of the investment cost of the Klaipeda demonstration plant.

**Table 4 Economic NPV(million US$) and ERR**

| | ICR | SAR | Differences between ICR and SAR | Future plant |
|---|---|---|---|---|
| Comparing with projects using Mazut | | | | |
| NPV | 6.4 | 2.2 | 4.2 | |
| ERR | 14.8% | 11.6% | 3.2% | 17% |
| Comparing with projects using Natural Gas | | | | |
| NPV | (5.2) | (4.1) | (1.1) | |
| ERR | 4.7% | 6.6% | -1.9% | 10% |

Most of the differences between the NPV and ERR calculations in the ICR and SAR can be explained by changes made to the Project's components during implementation. One of the most significant changes was the addition of natural gas boilers to provide the driving heat needed to run the plant's absorption heat pumps. As a result, the total annual heat production increased to 270,800 MWh, estimated at only 147,234 MWh (530,000 GJ) in the SAR. Forty-one percent of the total heat generated by the plant is from the geothermal water, while the rest (59%) is from natural gas (see Chart 1).




The difference between the expected and actual amounts of heat extracted from the geothermal water (lower in the ICR), is due to the fact that KE decided during the implementation phase to reduce demand from its Eastern Boiler House during the summer time, which was not anticipated at appraisal.

When considering environmental benefits from the geothermal project versus a plant using mazut for its energy supply, both the NPV and ERR are higher at the time of the ICR than in the SAR. The reason is that both geothermal energy and natural gas contribute benefits in terms of lower emissions, more so than mazut. However, when the geothermal plant is compared to a plant using natural gas, only 41% of the heat is provided from geothermal energy, resulting in an environmental benefit by reducing $CO_2$ and $NO_x$ emissions. The NPV and ERR are both lower than estimated in the SAR.

The detailed economic analysis for the Project is shown in Annex 3.

*4.3.3 Sensitivity analysis*

Table 5 shows a sensitivity analysis based on varying levels of mazut and natural gas prices. The prices for mazut and natural gas are positively correlated with the ERR and NPV. The higher the price, the higher the ERR and NPV. In comparison with a scenario where the plant uses mazut, NPVs are positive throughout all the possible range of mazut prices, and ERRs are very likely higher than 15%.

In comparison with plants using natural gas, the NPVs, on the other hand, are negative. The current natural gas price (April 2003) is about US$ 110-120/1000 $m^3$. If the price is lower than US$ 100, the project cannot break even. All natural gas in Klaipeda is imported from Russia, but Russia is decreasing its exports to Klaipeda. For this reason, the natural gas price may not go down in the short run unless Klaipeda can find other, lower priced sources for its natural gas imports. It is worthwhile mentioning that natural gas used at another Bank financed geothermal project in Poland costs about US$ 200/1000 $m^3$.

**Table 5 Sensitivity analysis**

| In comparison with mazut | | | In comparison with natural gas | | |
|---|---|---|---|---|---|
| **Price of Mazut($/ton)** | **NPV (000US$)** | **ERR** | **NG Price ($/000M3)** | **NPV (000US$)** | **ERR** |
| 110 | 981 | 11% | 80 | (11,175) | - |
| 120 | 2,785 | 12% | 90 | (9,183) | -2% |
| 130 | 4,588 | 14% | 100 | (7,191) | 2% |
| 140 | 6,392 | 15% | 110 | (5,200) | 5% |
| 150 | 8,195 | 16% | 120 | (3,208) | 7% |
| 160 | 9,999 | 17% | 130 | (1,216) | 9% |

*4.4 Financial rate of return:*

No attempt was made at project appraisal to calculate either a financial internal rate of return (FIRR), or a net present value (NPV) on the free cash flow (FCF) from 2000 onwards; a re-constitution of these calculations has now been carried out.

On the basis of the project's investments and the operating forecasts for the enterprise (both contained in the appraisal report) the calculation of the FIRR and the NPV for the project give the following results:

FIRR over 25 years, positive 0.49% (over 20 years the value is –0.55%)
NPV of the FCF at 10% is positive at US$ 8.38M (LTL 33.52 M) over 25 years, and positive at US$ 8.04M (LTL 32.16M) over 20 years.

The FIRR and NPV calculations for the completed project are based, on the cost side, on the realized investments, capitalized interest and commitment fee payments, and capitalized administrative expenses as per the audited accounts. The operating and overhead costs are as calculated in the most recent financial projection. On the benefit side are the sales of heat, as per the financial projection, and a terminal value of the investment of 10%.

The results of the calculations are as follows:

FIRR positive 3.46% over 25 years (+1.44% over 20 years)
NPV of the FCF at 10% is positive at US$ 7.7M (LTL 30.8M) over 25 years, and positive at US$ 6.7M (LTL 26.8M) over 20 years

The comparison of the two sets of calculations shows that the realized project, assuming it will operate successfully from 2003 onwards, has a higher FIRR compared to the appraised project, while the NPV indicators are somewhat lower, but still largely positive.

A further FIRR and NPV calculation has been carried out on the cost/benefit streams by eliminating the GEF grant financing. The resulting FIRR increases from 3.46% in the base case to 7.76% without the GEF financing over 25 years; calculated over 20 years the figures are 1.44% and 6.18% respectively. The NPV indicators remain identical, as they are measured from the year 2000 onwards, after the GEF grant had been entirely disbursed.

*4.4.1 Cash Flow Projections*:

The SAR for this project contained a cash flow analysis, which showed that EG would operate at a loss,

but have positive operating income; that is it would have a positive cash flow after adding back the depreciation and the debt service ratio would remain above 1.00.

The cash flow projection for the completed project, using actual figures for the years 2001 and 2002, and based on the most likely production and price parameters, shows that EG had negative net operational margins during 2001 and 2002, which are forecast to remain negative in 2003 but turn positive from 2004 onwards. When adding in financial charges, however, the operational results are negative from 2001 until the year 2008. To ease the financial strain on the company, GOL has agreed to cover loan repayment during 2001 until 2004.

Overall, cash flows (after adding back the depreciation) will be positive throughout, while the debt service ratio, after the initial years, will be well above 2.00.

#### *4.4.2 Conclusion:*

The completed project has a better financial performance than estimated at appraisal. Due to the unexpected production delays and the lower than agreed heat prices paid by KE, the company is experiencing temporary financial problems. This has resulted in operational losses for the years 2001 and 2002, as well as a projected loss for 2003. For the future it has been assumed that no further production problems will occur and that heat prices will increase to levels set by the State Commission. On that basis the company will become profitable from 2008 onwards and will be able to service the loan from the Bank without any problems. The company's cash flow after loan repayment will be positive from 2004 and onwards. If, however, the plant's gypsum crystallization problem is not resolved to allow the plant to be fully operational, the financial analysis shows that the plant is not sustainable. If the technical issues are resolved, it should also be mentioned that the plant can generate more heat than currently requested by KE. An increase in the development of new industries within the FEZ would give EG other customers to which it could sell its excess heat, thus strengthening EG's financial situation.

### *4.5 Institutional development impact:*

Institutional capacity building undertaken during project implementation primarily benefitted EG. As a result of the project, EG became an independent, closed, joint-stock company operating under commercial law. The technical assistance and training component of the project provided strong support to the management of EG throughout project implementation. Assistance was provided for the preparation of tender documents and for supervision of construction works. Staff and management received training on how to operate a similar geothermal plant in Thisted, Denmark. This training helped to simplify the transfer of geothermal technology to the Klaipeda plant. A plant operation manual was prepared for staff and management in Klaipeda to help them properly manage the plant, and identify and solve problems encountered during operation.

On a broader scale, the project transferred knowledge and skills on how to run a geothermal plant. The know how gained from the project can now be used in Lithuania by EG to expand geothermal energy operations in the future where economically feasible. The GOL will also now have resources on which to draw, should it wish to pursue the further development of geothermal resources to increase Lithuania's energy security. In fact, the Project has had a direct impact on the Draft Law on Heating, now under review by the Parliament. The Law is worded in such a way that it promotes the use and development of renewable energy resources. Furthermore, it specifically proposes that district heating companies be obliged to buy available heat produced from renewable energy sources.

## 5. Major Factors Affecting Implementation and Outcome

*5.1 Factors outside the control of government or implementing agency:*

Unexpected technical issues outside the control of the government or implementing agency. Major technical difficulties included the need to: drill a second injection well, install boilers at the plant to provide the necessary driving heat to the absorption heat pumps given the closure of the Eastern Boiler House during the summer, resolve regulator pump problems for the production wells, cleanup the injection wells due to clogging of the sand filters in the aquifer zone, and address gypsum crystallization problems in the geothermal plant system. Closures of the district heating plant for maintenance have also interrupted the operation of the geothermal plant.

The plant continues to face a serious problem with gypsum crystallization in the equipment and flow line. It could be debated whether or not this problem could have been identified at an earlier stage, when the geothermal water was analyzed, and thereby avoided. Similar problems were identified more than 25 years ago in Slovakia, and mitigated successfully. It is clear, however that without resolving this urgent problem, the plant will never be financially sustainable, and the Project will be regarded as a failure. From a technical perspective, the problem can be resolved, and DEPA recently approved US$ 0.3 million in financing to remedy the situation.

Design issues. During the procurement of heat pumps, the technical staff at EG raised the question of choice of heat pump technology, and a CIDA financed Global Environment TF was secured in 1997 to study the comparative cost effectiveness of electrical compressor heat pumps versus the planned use of absorption heat pumps. The study, completed in August 1997, concluded that absorption heat pump technology, which was proposed at appraisal, would be more cost effective than electrical heat pump technology. The cost for the heat pumps was well below that estimated at the time of project preparation, freeing up financing for other project activities, both unforeseen and added to further increase the plant's heat capacity.

Refusal of KE to honor Take or Pay Contract: In 1999, LPC sold KDHE to the Municipality of Klaipeda, changing the name of the district heating system to SPAB Klaipedos Energija (KE). Even though obliged to pay in accordance with the ToP contract, the new owner of the district heating system did not want to honor the original ToP contract, paying EG only 40 LTL/MWh (from March to October 2001) instead of the LTL 54/MWh that it should have according to the price formula included in the contract. In September 2000, the Managing Director of EG signed a temporary new contract with KE. The price paid by KE to EG only rose to LTL 46/MWh in November 2001 and will not rise further until certification for the geothermal plant as a reliable energy supplier is received from the State Commission. KE has stated that it will not pay the full LTL 54/MWh (which has also now been confirmed as fair by a Presidential price commission controlling all sales prices of power, heat and water) until the geothermal plant has received certification as a reliable heat supplier (producing heat and constantly supplying heat to the consumer except for temporary stops for maintenance) from a State Commission under the Ministry of Economy. Currently KE is only buying 25 MW of energy from EG in the summer even though it can supply 40 MW. KE feels that heat supply from EG is currently not reliable and therefore is obtaining the remaining 15 MW from Pajurio Mediena (burning of wood chips) and Klaipedos Baltica (furniture manufacturer contributing a small amount of heat through the burning of wood). EG can back up its geothermal heat production with its gas boilers, but this would not be financially sustainable in the longer perspective if KE continues to pay only LTL 46/MWh.

The State Commission consists of 10-15 people, including an employee of KE. The Commission will not certify the plant until EG has resolved its remaining technical problem (gypsum crystallization) and can supply heat reliably. EG can actually already supply heat at full capacity using its boilers which run on natural gas. The Commission, however appears to be certifying the plant according to the reliability of

only its geothermal supply capacity, given that the plant was built to produce geothermal heat. EG believes that it will be able to solve its remaining technical issues and obtain certification by mid-2003, whereupon it should be able to receive 54 LTL/MWh for the heat it supplies. It seems that the State Commission may have been overly stringent, requesting very minor changes from EG, such as erecting a sign to identify the plant.

*5.2 Factors generally subject to government control:*

Government commitment. GOL in general met its obligations under the Loan Agreement (Article 3.01) in providing counterpart funding, although the transfers were not always executed on schedule. The Government is now covering EG's loan repayment obligations until it is financially viable and capable of repaying from its own resources.

Overly stringent regulations. At the time of project appraisal, no regulation existed in Lithuania for the discharge of saline waters. During project implementation however, new environmental regulations came into force limiting the amount of saline water that EG could dispose in a given time period. As such, storage tanks and a separate pipeline had to be built for used, saline geothermal water. The low discharge rate (1.5 $m^3$/h) means that water in the tank (2000 $m^3$) cannot be emptied very quickly. Had the regulation been established earlier on in the project, a settling pond, with a much larger volume, would have been built instead of storage tanks.

*5.3 Factors generally subject to implementing agency control:*

Auditing and accounting. Despite the lack of training in formal International Accounting Standards (IAS), EG's accounting practices improved by the end of the project, largely due to efforts during Bank supervision missions. EG now has a statement of company accounting policies and has established and documented an internal control system, which will help improve its financial management.

Quality of management. During the early stages of the Project, it became evident that EG needed managerial assistance to ensure successful, continued project implementation. In order to strengthen the company's managerial capacity, an advisor was provided using a Flemish TF. The support was of great help to EG. Quarterly and semi-annual reporting by EG were satisfactory throughout project implementation. For the majority of the project, the staff of EG (the PIU for the project) remained as originally constituted. However, in the final year of the Project, the Managing Director was changed. The new Director is committed to making EG profitable and working very hard together with the staff of the geothermal plant.

*5.4 Costs and financing:*

Implementation of the project was delayed by 2.5 years. Technical difficulties, although resolved in the end, and slow initial preparation of bidding documents for well drilling were the major reasons for the delay, which required that the loan closing date be extended four times. The extensions were crucial to ensuring the smooth operation of the plant once commissioned.

The first extension was requested early on in the project because the first round of bids submitted for the drilling of the wells were not suitable and a new set of tender documents had to be prepared which took considerable time. The second extension was required to incorporate measures into the Project design to increase the energy output of the geothermal plant. The third extension was needed to install the 3 hot water boilers after KE announced it would no longer provide driving heat to EG during the summer. The final loan extension was connected to the clogging of the injection well filters with gypsum crystals and was needed to ensure the availability of funds for fracturing, which in the end was not needed; only financing for the clean-up of the wells was needed. Other factors that delayed the project included: cancellation of

financing by EU Phare for the construction of the geothermal flowline, the need to drill a second injection well and delayed installation of the control and regulation system for the plant.

Despite the many delays, primarily caused by the technical difficulties that faced the project, a cost overrun did not occur. In fact, the project, originally estimated at $18.02 million, finally cost US$ 17.55 million. In addition, the cost for technical assistance through TFs (Flemish and CIDA) of US$ 77,000 and US$ 27,344 respectively should be mentioned. The total cost is therefore US$ 17.65 million. Project savings are attributable to the lower than estimated cost of the absorption heat pumps. Over US$ 5.0 million in project savings made it possible to address the many technical difficulties experienced during the course of the Project, including problems such as the need to drill a second injection well and construct an additional geothermal flowline to the plant, install hot water boilers, build sewage tanks and lay a sewage pipe, purchase a spare production well pump motor, and clean-up clogged injection well filters (see Section 3.4 and Annex 2 for greater detail). Project cost savings also made it possible to install additional equipment (heat exchangers and economizers for the hot water boilers and a heat accumulation tank) to increase the efficiency, and thus heat extraction capacity of the plant.

## 6. Sustainability

*6.1 Rationale for sustainability rating:*

The overall sustainability of the project is rated "likely". Environmental sustainability of the project is highly likely given the renewable nature of geothermal energy. While unexpected technical issues are largely resolved, a few still remain. Capacity to address technical issues is likely given management and staff experience gained through training and operation of the plant and new, additional financing obtained from DEPA. Financial problems pose the most uncertainty with respect to the plant's sustainability. Explanations for these ratings are given below.

**Technical sustainability (Likely)**

The majority of the technical issues that delayed the project have been resolved. These technical issues were unexpected and can be explained to a large extent by the demonstration and pioneer nature of the project. At the time of project preparation, the idea of using low temperature geothermal energy for heat supply had never been attempted in Lithuania, and had only been implemented in Scandinavia and Germany. At a limited number of locations in Europe, use of geothermal water at a temperature of 60-65 °C had been demonstrated. In fact, the Bank itself had very little involvement worldwide in geothermal projects.

The plant began supplying heat in March 2001. From March 2001 to October 2002, EG provided 238,145 MWh of heat to the district heating system. The plant currently supplies 25 MW of heat in the summer and 40 MW in the winter. During this time (March 2001 to October 2002), the plant was stopped three times for installation of equipment, clean-up of injection wells and maintenance at KE. The majority of technical start-up problems have now been resolved. However, a remaining major technical issue, which is preventing EG from producing at its full capacity, involves the formation of gypsum crystals in the plant's pipes, valves and absorption heat pumps. This problem should be resolved by mid-2003 with grant financing of approximately US$ 0.3 million from DEPA. The proposal is to mechanically clean the plant equipment and flow line, and inject an inhibitor substance (called Dequest 2060S) into the system to prevent the future formation of gypsum crystals. Once this has been done, a certain amount of the substance will be injected on a continuous basis to prevent a reoccurrence of the problem. The choice of inhibitor has been carefully reviewed by both the Lithuanian Ministry of Environment, the Regional Environmental Protection Board in Klaipeda, and DEPA. A lot of review work was carried out and the inhibitor was finally declared acceptable from an environmental point of view.

**Financial sustainability (Likely)**

*Price for EGs heat*
The price that EG is able to obtain for the heat it supplies will definitely be a limiting factor in terms of its financial sustainability. Currently, it only receives LTL 46/MWh from KE. EG is trying to solve its remaining technical issues so that it can be certified as a reliable heat supplier by the State Commission under the MOE, which is reviewing the plant. Once EG is certified, it is expected KE will have to honor the price of LTL 54/MWh specified in the ToP contract and the Presidential price commission that controls power, heat and water prices. EG also appealed to the courts to make KE pay the price agreed in the ToP contract, but has not been successful.

The new Heat Law that the GOL is in the process of passing should also help EG to obtain a higher price for its heat and create greater demand for heat produced from renewable energy. The Law will stipulate that renewable energy be used and developed as much as possible. It will also establish guidelines to regulate the relationship among heat suppliers and set conditions for the purchase of heat from alternative sources of energy. It is expected that the Law will come into effect in mid-2003. The Law should help to reduce the monopoly control that KE currently has over heat supply (buying energy from EG at 4.6 LTL/kWh and making a huge profit selling it at 10.69 LTL/kWh) and increase the price that EG can obtain for the heat it sells.

*Demand for EG's heat*
The likelihood is that the plant will never operate at its full installed heat capacity (48 MW), at least not in the short to medium term due to current technical limitations of the district heating system. The district heating plant (KE) can only use 25 MW of EG's energy in the summer and only 40 MW in the winter (although the new Heat Law might force KE to buy more heat from EG). The only way that EG will be able to increase demand for its heat is if it signs more contracts with new companies (20 can be accommodated in the FEZ) that plan to establish themselves in the FEZ or if KE adjusts its system so that it can receive more heat from EG. EG's price for heat is far below that of KE's, making it attractive to the companies in the FEZ. It has already signed one contract with JSC Espersen, a fish processing plant. While JSC Espersen only requires 0.8 MW of heat, it will pay LTL 85/MWh.

Construction of a pipeline linking EG to the FEZ (being paid for by UAB Ukmerges Energiya (UE)) is complete. UE will sell the heat to industries being established in the FEZ. At the moment, the pipeline's capacity is 8 MW, which could take at least 10 years to reach.

*Price of fossil fuels*
EG's future financial sustainability also depends to a large degree on fossil fuel prices. The higher the prices for mazut and natural gas, the better EG's financial outlook. Russia is the main supplier of gas and mazut, and it is expected that the prices within a three year period will be in par with international prices, which makes it very likely that the current price level will sustain.

*Committed management and staff*
In the past year, Geoterma's director changed. The new director has more practical experience in running a heat generation plant since he worked for the Klaipeda district heating system. He seems committed to making the geothermal plant financially viable and is committed to pressing KE to honor the price agreement made in the ToP contract. In addition, EG's staff, as a result of extensive training, now have the knowledge required to run the plant.

**Environmental sustainability (Highly Likely)**

Use of geothermal energy from the Klaipeda plant reduces $CO_2$, $SO_2$, $NO_x$ and TPM emissions that would otherwise enter the atmosphere if the geothermal plant did not exist and fossil fuels were burned to generate heat. Geothermal energy is renewable. If properly run and technically sound, the plant can operate for many years with minimal stoppages, providing a environmentally clean and sustainable source of heat. (see Annex 3 for graphs showing the reduction of emissions over time as a result of heat production at the geothermal plant). However, the environmental achievement is clearly dependent on resolution of the current technical problem, which is regarded as likely.

*6.2 Transition arrangement to regular operations:*

*Use of existing Vidmantai wells*
The Vidmantai wells that were given to EG at the start of the project by LPC as their contribution to the share value of the project, were thought to be unproductive since they are capped. However, geothermal water in these deeper these wells (68°C) seems to have the potential to be used for medicinal purposes. EG's Director is interested in trying to support the efforts to establish a spa resort in Palanga using the geothermal water from these wells. If so, the wells could have a clear positive impact on EG's financial sustainability.

*Construction of new geothermal plants*
The potential for expansion of geothermal energy in Lithuania in the future may be possible given the EU's renewable energy requirement of 12%. Lithuania will probably aim/be able to achieve 7%. This will depend, of course, on the specific economic and financial sustainability of any given plant. Further geothermal plants will likely only be justified in areas where the population is greater than 50,000. While the cost of building new plants will not be as high as it was for Klaipeda given the know how and lessons learned from the demonstration plant, there is still a significant cost involved, especially for drilling the wells. Furthermore, more than 50% of the investment in the case of Klaipeda was in the form of grant financing, which will likely not be available for future plants. However, in view of the increasing price of fossil fuels, and Russia's intention to adjust those prices, the establishment of new geothermal projects in Lithuania should become more competitive and result in financially sustainable operations. An increase in the tariff is more than likely to happen, as all the DH companies now are becoming more aware of cost recovery and tariff collection than in the past. It is clear from this project that generation of heat from geothermal water in Klaipeda is more cost effective than using fossil fuels, despite the fact that a substantial cost reduction could have been achieved if the Project had been implemented in a different way, and a number of unforeseen costs been avoided through better planning and supervision.

## 7. Bank and Borrower Performance

***Bank***

*7.1 Lending:*

The Bank's performance during identification, preparation, and appraisal was satisfactory. The Project was prepared in response to a request from the GOL, which, in turn, committed itself to explore the country's existing renewable geothermal resources on the basis of results from the Baltic Geothermal Energy Study (BGES). The Project was identified, prepared and appraised in close cooperation with the Government and potential donors. The Bank's team included a mix of environmental, technical, economic, financial and procurement specialists with extensive knowledge of the energy sector and Bank operations. The team was comprised of headquarter and field-based staff with good knowledge of local conditions.

Several risks were identified during appraisal: (a) lower than expected temperature of the geothermal water; (b) lower than expected flow of geothermal water; (c) delayed implementation due to limited administrative capacity in Lithuania for development of a new energy resource; (d) delayed installation of needed boiler capacity in the event KE would not provide the required level of heat to drive the absorption heat pumps; and (e) reduced world market prices for fossil fuels.

These were well-predicted risks and most of them were encountered during the various phases of implementation; however in close cooperation with partners, including the Government and the Bank team, the Project implementation was able to mitigate the emerging problems.

Reduced heat demand during the summer period was not identified as a risk, as at the time for appraisal, KE was ready to buy EG's base load of more than 40MW needed to produce hot water for Klaipeda during the summer. Also the reduced sales price for generated heat was not foreseen, as it was assumed the signed and agreed ToP contract fairly and clearly indicated a price based on actual market prices for fossil fuels. Yet, in reality, KE did not abide by the contract.

During preparation, appraisal, and implementation, the Bank had a very close relationship with the only donor involved, the Government of Denmark, whose representatives participated in every mission. The Bank team had an important role in resolving problems between the donor representatives and the implementing agency.

The Project is fully consistent with the Bank's safeguard policies valid at the time of appraisal, and was placed in the "B" environmental screening category.

*7.2 Supervision:*

The Bank's performance during supervision was satisfactory.

Supervision missions visited Klaipeda regularly at 6 month intervals or less. Between missions, continuous implementation support was provided from both the Bank's Washington and Vilnius offices. During the active supervision period, the Bank team remained constant, as did the consultant team provided by the Danish Government.

At the beginning of the Project, a short term consultant supported by the Flemish Government provided managerial support to EG, including providing advice to EG on financial, institutional development, and procurement issues.

The Bank exercised considerable flexibility with respect to Project implementation, allowing 4 extensions of the Project's closing date, enabling EG to cope with all the plant's unforeseen technical problems and achieve the original Project objectives.

*7.3 Overall Bank performance:*

Overall, Bank performance was satisfactory. Preparation and supervision were closely coordinated with the co-financier, which enabled emerging problems to be resolved satisfactorily. At the same time. the Bank remained firm on critical issues, thus ensuring satisfactory donor follow-up on technical issues and appropriate Government intervention on management and contract compliance issues.

***Borrower***

*7.4 Preparation:*

Borrower performance during preparation was satisfactory. During preparation and appraisal, the

Government and the beneficiaries remained highly committed to the Project, as they saw it as an opportunity to reduce the country's dependence on imported fossil fuels and also a possibility to meet their international commitment to reduce greenhouse gas emissions.

*7.5 Government implementation performance:*

The Ministry of Energy, and later Ministry of Economy, budgeted adequate counterpart resources for Project implementation. However, for a short period, the MOE did not provide enough financial support to EG in order to cover operational expenses, as agreed in the Loan Agreement. During the final years of the Project, however, the MOE has shown strong support and taken full responsibility to assure that EG could continue to pay its staff and cover operational expenses during the period of the plant's reduced capacity, when technical problems reduced revenues. In addition, MOE agreed to cover the repayment of the Bank loan up to 2004, to ease the financial burden on EG. Borrower performance during implementation was satisfactory.

Both the Municipality of Klaipeda and KE showed considerable interest in the Project during its preparation, but after the municipality took over the district heating company, its interest changed dramatically. First of all, there was a decision made to alter the use of the Eastern Boiler House, resulting in: (a) no provision for driving heat during the summer period when the boiler house would be shut down, and (b) an overall reduction in the need for energy to produce hot water during the summer period. Secondly, KE no longer acknowledged the agreed ToP contract, paying only a reduced amount for the heat provided. Hence the performance of the municipality and KE is rated as unsatisfactory, as KE's original agreements were included as part of the basis for the Project's economic and financial justification.

*7.6 Implementing Agency:*

EG showed at all times a strong interest and commitment in ensuring the success of the Project, and effectively used its contacts with owners (the mother company LPC and the MOE) to reach Project objectives. However, due to its lack of experience with the chosen absorption heat pump technology, the implementation of the Project was delayed at one point by a technical dispute. The subsequent debate resulted in a clear justification of the chosen technology and, perhaps, a better understanding of the technology, but the debate halted the project implementation for about six months. The recent change in management, has created a more dynamic approach for the implementation of the business plan.

As part of Project financing, the Danish Government provided technical assistance through a consultant company, that was responsible for detailed design, preparation of bidding documents, and supervision during the physical implementation of the Project. This support did not live up to expectations and has caused considerable delay in the implementation, as well delays in rectifying design problems. It is very clear that these delays resulted in financial losses for EG, and contributed to the reluctance by the State Commission to certify the geothermal plant. Due to these aspects, the rating of the implementing agency is unsatisfactory.

*7.7 Overall Borrower performance:*

The overall Borrower performance is rated as satisfactory. The Implementing Agency's overall performance has been rated as unsatisfactory due to the poor performance of the consultant responsible for detailed design, supervision and technical assistance during Project implementation. In view of EG's quite and GOL's quite satisfactory performance, the overall Borrower performance is rated as satisfactory.

## 8. Lessons Learned

The project was in many ways of a pioneer nature given that this was the first geothermal project undertaken in Lithuania and one of the first geothermal projects funded by the Bank. Many lessons have

been learned from this demonstration project. The Borrower, implementing agency, Bank, cofinanciers and consultants involved in the project have gained a wealth of knowledge related to design and implementation of geothermal projects. This new knowledge can now be used for the future development of geothermal resources not only in Lithuania, but more broadly in the ECA region and at a global level, where the development of alternative energy sources will become increasingly more important as greater efforts are made to find solutions to the growing problem of climate change.

*Major positive lessons learned from the projec*t

The Project has demonstrated:

- possibilities for using low temperature-based geothermal energy in Lithuania and elsewhere where it is available;
- the potential for the development and construction of geothermal energy plants in other locations in Lithuania;
- opportunities for using geothermal energy for other purposes, for example health care, medicine, tourism, relaxation etc.;
- that the cost price of heat energy produced in a geothermal plant is lower than traditionally produced heat; and
- that heat produced in a geothermal plant can substitute for the use of large amounts of fossil fuels, and contribute to reduced GHG emissions, thereby having a clear and positive effect on the global environment.

*Major negative lessons learned from the project*

The Project has encountered several problems, which to a certain extent could have been avoided:

- Wrong location of the first injection well. The site was proposed by the local authorities in Klaipeda, although EG preferred another location. EG should have been more insistent during the decision making process, thereby avoiding the unforeseen additional cost for a second injection well;
- Insufficient analysis of geothermal water. A more prudent analysis may have discovered the gypsum problem, and the now proposed mitigation measures then could have been included in the Project design;
- Control of the water flow and temperature should have been done at time of drilling the wells, instead of when the equipment was delivered;
- More intensive supervision and technical assistance by the Danish consultant during Project implementation could have reduced the time needed for start up and solving technical problems;
- Demand forecasts for the overall heat needs of Klaipeda were over estimated, following the conversion to a market economy. As in the case of water demand, experts failed to anticipate the drop in use once the meters were installed and customers were required to pay for heat. The fixed price in the ToP contract may not be the lowest that KE can obtain for heat, but given that the sales price for heat in Klaipeda is more than 100% above the purchase price for geothermal heat, KE could afford to pay the price specified by the formula in the ToP contract without impacting end users. Moreover, the price for geothermal heat is less than KE's production cost;
- Less interest on KE's part in the potential use of geothermal heat. KE has continuously used the situation of the geothermal plant not being certified by the state commission as a reason to pay a price below the ToP contract. Involving the district heating company more from the beginning would have been the most logical solution. The geothermal plant could have been part of KE, and just been regarded as one of its heat generation units. However, at the time of Project preparation, all the district heating companies in Lithuania were part of the LPC. Moreover, the LPC was virtually bankrupt due to large losses caused by the many district heating companies belonging to it, and therefore such a solution was not accepted by the Bank. A choice was made not to pursue including the geothermal plant in KE, first because LPC's financial situation was extremely strained at the time of project preparation due to the loss making district heating (DH) enterprises which it owned, and second because at the time of appraisal of the Klaipeda Geothermal Demonstration Project (KGDP), efforts were underway to unbundle the DH companies, which

in fact happened in 1997, after the KGDP was already approved.

In the event of a future geothermal project, it is highly recommended that the plant be part of the district heating company in order to optimize benefits (environmental, economic and financial).

In view of the negative technical problems experienced during the Project, it could be debated if a turn-key contract would have been better in more clearly defining responsibilities during the implementation phase. Certainly, a higher cost would have been the result, but given the lost time and lost revenues experienced for nearly two years, it appears that a turn-key contract would have been more cost effective. The risk of failure would then have clearly rested with the supplier.

## 9. Partner Comments

*(a) Borrower/implementing agency:*
**Government of Lithuania - Borrower**

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2003-06-17 (27.4-51)-3-3260

Mr. Anders Halldin
The World Bank, Warsaw Office
Warsaw Financial Center, 9th Floor
53 Emilii Plater str., 00-113 Warsaw, Poland

Re: Klaipeda Geothermal Demonstration Project (Loan No 4013-LT)

Dear Mr. Halldin,

The Ministry of Economy of the Republic of Lithuania and the Ministry of Environment of the Republic of Lithuania accept in principal the comments prepared by the JSC "Geoterma" with respect to the final report (fmd attached) of the Klaipeda Geothermal Demonstration Project (Loan No 4013LT) and have no additional comments.

The Ministries are positive that the project completion could be assessed as a success, provided technical shortcomings of the project are eliminated as soon as possible. The Ministries of Economy and Environment would like to thank the World Bank, the Global Environment Facility, the Danish Environmental Protection Agency and other establishments that made their contribution to implementation of the project.

Yours sincerely,

Artfiras Dainius
Under-secretary

APPROVED (June 17, 2003)
Arvydas Dragunas
State Secretary of the Ministry of Environment

**Enterprise Geoterma - Implementing Agency**

KLAIPEDA GEOTHERMAL DEMONSTRATION PROJECT
LOAN NUMBER 4013 LT
FINAL REPORT
KLAIPEDA
2003

## 1. Basic Information on the Loan and Assistance

The Loan Agreement (No 4013 LT) between the Republic of Lithuania and the International Bank for Reconstruction and Development on the loan of 5,9 million USD was signed on 28 June 1996.

The Subsidiary Loan Agreement between the Ministry of Finance of the Republic of Lithuania and the JSC "Geoterma" was signed on 16 October 1996. Annex No 1 to the latter Subsidiary Loan Agreement between the Ministry of Finance of the Republic of Lithuania and the JSC "Geoterma" was signed on 15 May 2002.

The Global Environment Facility Trust Fund Grant Agreement (No TFO28313) between the Republic of Lithuania and the International Bank for Reconstruction and Development on the grant of 4,6 million SDR was signed on 28 June 1996.

The Subsidiary Grant Agreement between the Ministry of Finance of the Republic of Lithuania and the JSC "Geoterma" was signed on 25 October 1996.
The subsidiary grant of 3,0 million USD was allocated by the Danish Environmental Protection Agency (DEPA) for the Project.

On 30 April 1997 the Technical Assistance Agreement between Dansk 01ie og Naturgas AS (hereinafter referred to as DONG) and the JSC "Geoterma was made. The Grant financed by the DEP A was administered by DONG.
The Klaipeda Geothermal Demonstration Project was intended to complete on 31 January 1999.

<u>The Loan closing date</u>
The Loan closing date extension was made for a few times from the original date, which was 31 July 1999. The last extension by the World Bank notice was fixed for 30 April 2003.

<u>Reallocation of the Loan and Grant</u>
In order to maximize effectiveness in the achievement of Project objectives, the Loan and Grant amounts were reallocated by categories (activities, services).

## 2. Project Implementation

*2.1 Execution management*
The JSC "Geoterma" was established in 1996 with the aim to implement the Project. The JSC "Geoterma" under the management of its administration and together with its highly skilled staff operated on the basis

of the basis of its administrative, financial, engineering and environmental practice.

*2.2 Procurement Information*
Procurement of goods, works and services required for the Project and financed from the funds of the Loan and the Grant was executed in accordance with the requirements laid down in Section 2.0.2 of the Project Agreement. Guidelines for the procurement procedure were followed without any deviation during the Project Implementation process. The Word Bank reviewed ad approved the procurement procedures. The procurement activities covered thirty-one (31) Open International Tenders. All the procurement procedures were canied out and successfully completed by the end of 2002.

*2.3 Contracting*
On completion tender procedures, the Tender Commission used to assess all the bids on the basis of the evaluation criteria listed in the tender documents. All the fmdings and recommendations as well as confirmations were obtained from the Bank as required.

**3. Financial Information**
The first disbursements from the Loan and of the Grant funds were made in May 1997, and the last disbursement was made in May 2002. No serious deviations or delays in payment procedures took place.

**4. Project Implementation Problems and Their After-effects**
Faults were not avoided, due to which construction of the plant was delayed. Just a few major faults might be mentioned.

The construction of two injection wells was initially planned, from which geothermal water through one injection well would be returned back to the aquifer after heat transfer through absorption heat pumps. The plan did not answer the purpose in practice. One injection well could not accept the whole geothermal water from two production wells. As a result, another one injection well was drilled in 1997.

The injection wells were not properly cleaned during the commissioning of the plant and the quality of cleaning was not tested by a video camera, due to which the pressure in the wells was increased during the commissioning of the plant, and injectivity of the injection wells was decreased, therefore, the clean-up of the wells was performed on March-April, 2002.

Another problem is gypsum precipitation in geothermal water pipes and equipment. While preparing of the injection wells for cleaning, development of gypsum crystals was observed. The problem would be resolved in due time, provided that before designing of the plant full analysis of geothermal water were performed and the construction experience of the Republic of Slovakia and geothermal plants of other countries were used regarding introduction of inhibitors to geothermal water. However, this was not realized in practice.

The technical assistance and training component was developed fragmentarily in the Project. The Technical Assistance Agreement made between DONG and the JSC "Geoterma" in April 30, 1997 provided for that all operators of the Klaipeda Geothermal Demonstration Plant will be trained in the Thisted Geothermal Plant in Denmark. However, not a single employee of the JSC "Geoterma" was trained in Denmark. Operators of the Klaipeda Geothermal Demonstration Plant attended the course for boiler operators in Lithuania and special operation permits were issued.

Suppliers of equipment concerned trained the Lithuanian operators to operate absorption, submersible, injection pumps and other equipment. The SCAD A system installation engineers from Lithuania trained them to automatically control the plant. The staff and administration of the JSC "Geoterma" trained

themselves to work on-site during the project implementation.

However, the problem relating to the gypsum precipitation in the plant has not yet been resolved. All the pipelines and equipment within the plant are contaminated by gypsum crystals. At. present only one of the two pairs of the absorption heat pump units is in operation, i.e. only one pair of the absorption heat pumps operates at 50 % of its capacity. Besides, the gypsum precipitation problem was noticed as far back as 2001, but elimination, of the problem has been procrastinated so far. The clean-up project activities are planned, however, without any explanatory reason (as the funds been
reserved for the said activities), to complete by the consultants of DONG in December 2003. One fears that the plant's operation may be discontinued by the said moment. If, the gypsum problem is not resolved, the Klaipeda Geothermal Demonstration Project might be considered a failure.

The after-effects of all the referred project faults are as follows:

- all the above-mentioned project faults have postponed the approval of the plant as fit for exploitation with the corrected capacity of 41 MW, including 17MW capacity generated by geothermal water, for about four years;
- the plant did not produce -500 thousand MW of heat and receive income in the amount of23 million Litas (if calculated at the level of 46 Lt/MWh) in 2001-2003;
- while the plant is not approved as fit for exploitation, the price approved by the state authorities in the amount of 53,9 LtJMWh cannot be fixed;
- at present the JSC "Geoterma" operates at a loss, therefore, in 2002 the Government of the Republic of Lithuania deferred reimbursement of the loan and interest payment for two years. The loan to JSC "Geoterma" is repaid from the budget of the Republic of Lithuania.

**5. Project Advantages**

Upon elimination of all the said shortcomings and faults in the plant and clean-up of its equipment and pipelines from crystal precipitation as well as installation of preventive systems against crystallization, the Klaipeda Geothermal Demonstration Plant might be a modem thermal plant meeting the global technology standards.

The advantage of the KGDP lies in the fact that its experience could be used for implementation of future activity plans, including the development of geothermal energy in Lithuania, if this is economically and fmancially feasible. Besides, the geothermal water from the KGDP could be used for balneology by constructing geothermal pools.

The project of the plant creates the structure for the following:

- long-term operation of the Klaipeda Geothermal Demonstration Plant, whichsupplies heat to the Klaipeda Free Economical Zone;
- gradual improvement of air quality in the Klaipeda city and prevention of global climate changes;
- demonstration of environment-friendly methods of energy supply in Lithuania.

Alfonsas Bickus,
Director of the JSC "Geoterma"

*(b) Cofinanciers:*

**Danish Environmental Protection Agency (DEPA)**

To a large degree, the Geothermal Demonstration Project in Klaipeda is a replica of a similar plant in Thisted in Northern Denmark. Before the Danish plant was constructed, thorough geological and hydrological tests were carried out. In addition to this survey it was decided to build a small plant. A production well and an injection well were drilled and linked to the pilot processing plant. When the pilot plant had demonstrated that geothermal energy could be generated, the plant was modified and extended to its present size. Had this gradual implementation been applied in Klaipeda, some of the geothermal flow problems which were experienced might have been detected and remedied at a very early stage in the project.

Although a special management workshop was conducted before the implementation of the plant was launched and a Dutch management consultant advised EG for a short period after the workshop, certain cooperative problems have hampered the communication between Lithuanian and Danish personnel.

Still, some language problems make cooperation between Lithuanians and Danes difficult. English must be mastered by the leading staff if the important transfer of technology and management shall succeed. Alternatively, efficient interpretation needs to be provided throughout the process in order to facilitate communication. Undoubtedly, time will cure this problem as the younger, English speaking Lithuanian generation gains access to the positions in middle and top management.

A manual should be prepared to present a detailed technical and financial evaluation of the planning and implementation of the project, how problems were detected and eliminated, and how local personnel were trained to operate and maintain the plant. The manual should include information and lessons learned at all phases of the project, from geological, hydrological and chemical analysis of the source, to the final commissioning of the works.

*(c) Other partners (NGOs/private sector):*
N/A

## 10. Additional Information

## Annex 1. Key Performance Indicators/Log Frame Matrix

**Outcome / Impact Indicators:**

| Indicator/Matrix | Projected in last PSR[1] | Actual/Latest Estimate |
|---|---|---|
| | | |

No Key Performance Indicators/Log Frame Matrix were required at time of project appraisal

**Output Indicators:**

| Indicator/Matrix | Projected in last PSR[1] | Actual/Latest Estimate |
|---|---|---|
| | | |

[1] End of project

## Annex 2. Project Costs and Financing

| Component | Appraisal Estimate US$ million | Actual/ Latest Estimate (1) US$ million | Percentage of Appraisal |
|---|---|---|---|
| | | | |
| **Investment Component** | **12.59** | **14.21** | 113 |
| Drilling Operation | 1.91 | 2.7 | 141 |
| Completion of Wells | 0.69 | 0.6 | 87 |
| Control and Evaluation of Drilling Operations | 0.15 | 0.4 | 267 |
| New Injection Well* | 0 | 1.45 | |
| Cleanup of Injection Well Filters* | 0 | 0.37 | |
| Spare Motor for Second Production Well* | 0 | 0.11 | |
| Brine Pumps - Submersible and Injection Pumps* | 0 | 0.97 | |
| Building and Civil Works | 0.52 | 1.6 | 308 |
| Connection to Boiler House and External Pipeline | 0.73 | 0.45 | 62 |
| Geothermal Flowline to New Injection Well* | 0 | 0.25 | |
| Heat Exchangers for Absorption Heat Pumps | 0.71 | 0 | 0 |
| Absorption Heat Pumps | 6.34 | 1.97 | 31 |
| Hot Water Boilers for Driving Heat* | 0 | 1.04 | |
| Heat Exchangers and Economizers for Boilers* | 0 | 0.53 | |
| Heat Accumulation Tank* | 0 | 0.12 | |
| Circulation Pumps (district loop and heat accumulator)* | 0 | 0.09 | |
| Local Design of Buildings and Flowline** | 0 | 0.09 | |
| Sewage Tanks and Pipeline* | 0 | 0.12 | |
| Filters, Valves and Internal Piping | 0.82 | 0.71 | 87 |
| Power, Control and Regulation | 0.72 | 0.64 | 89 |
| | | | |
| **Technical Assistance and Training** | **2.26** | **2.55** | **113** |
| | | | |
| **Project Implementation Support** | **0.24** | **0.09** | **38** |
| | | | |
| **TOTAL BASELINE COST** | **15.09** | **16.85** | **112** |
| Physical Contingencies | 0.75 | | |
| Price Contingencies | 1.78 | | |
| | | | |
| **TOTAL PROJECT COST** | **17.62** | **16.85** | **96** |
| Interest during construction | 0.4 | 0.4 | |
| | | | |
| | | | |
| **TOTAL FINANCING REQUIRED** | **18.02** | **17.25** | **96** |

* New Addition to Investment

** New Addition to TA

(1) The total cost does not include funds required to rectify the current gypsum crystallization problem at the geothermal plant (0.3 million for pressure expansion tanks, nitrogen buffers and an inhibitor to cleanup gypsum crystals). This additional will be covered by an additional grant from the Danish Government.

**Project Costs by Procurement Arrangements (Appraisal Estimate)** (US$ million equivalent)

| Expenditure Category | Procurement Method[1] ICB | NCB | Other[2] | N.B.F. | Total Cost |
|---|---|---|---|---|---|
| 1. Works | 0.75<br>(0.23) | 0.00<br>(0.00) | 0.00<br>(0.00) | 0.00<br>(0.00) | 0.75<br>(0.23) |
| 2. Goods | 13.85<br>(12.01) | 0.00<br>(0.00) | 0.00<br>(0.00) | 0.09<br>(0.00) | 13.94<br>(12.01) |
| 3. Services | 0.00<br>(0.00) | 0.00<br>(0.00) | 0.16<br>(0.16) | 2.77<br>(0.00) | 2.93<br>(0.16) |
| 4. Miscellaneous | 0.00<br>(0.00) | 0.00<br>(0.00) | 0.00<br>(0.00) | 0.00<br>(0.00) | 0.00<br>(0.00) |
| 5. Miscellaneous | 0.00<br>(0.00) | 0.00<br>(0.00) | 0.00<br>(0.00) | 0.00<br>(0.00) | 0.00<br>(0.00) |
| 6. Miscellaneous | 0.00<br>(0.00) | 0.00<br>(0.00) | 0.00<br>(0.00) | 0.00<br>(0.00) | 0.00<br>(0.00) |
| Total | 14.60<br>(12.24) | 0.00<br>(0.00) | 0.16<br>(0.16) | 2.86<br>(0.00) | 17.62<br>(12.40) |

Since the table does not allow the separation of financing from the WB Loan and the GEF Grant, the total amount of both the loan and the grant is shown, given that the same procurement guidelines apply to both sources of financing. In addition to the investment costs, the Loan was also supposed to cover interest during construction totaling US$ 400,000. As such, the total Project cost at appraisal was estimated to be US$ 18.02 million.

**Project Costs by Procurement Arrangements (Actual/Latest Estimate)** (US$ million equivalent)

| Expenditure Category | Procurement Method[1] ICB | NCB | Other[2] | N.B.F. | Total Cost |
|---|---|---|---|---|---|
| 1. Works | 6.07<br>(5.21) | 0.12<br>(0.11) | 0.00<br>(0.00) | 1.05<br>(0.00) | 7.24<br>(5.32) |
| 2. Goods | 6.97<br>(6.30) | 0.00<br>(0.00) | 0.00<br>(0.00) | 0.00<br>(0.00) | 6.97<br>(6.30) |
| 3. Services | 0.00<br>(0.00) | 0.00<br>(0.00) | 0.00<br>(0.00) | 2.64<br>(0.00) | 2.64<br>(0.00) |
| 4. Miscellaneous | 0.00<br>(0.00) | 0.00<br>(0.00) | 0.00<br>(0.00) | 0.00<br>(0.00) | 0.00<br>(0.00) |
| 5. Miscellaneous | 0.00<br>(0.00) | 0.00<br>(0.00) | 0.00<br>(0.00) | 0.00<br>(0.00) | 0.00<br>(0.00) |
| 6. Miscellaneous | 0.00<br>(0.00) | 0.00<br>(0.00) | 0.00<br>(0.00) | 0.00<br>(0.00) | 0.00<br>(0.00) |
| Total | 13.04<br>(11.51) | 0.12<br>(0.11) | 0.00<br>(0.00) | 3.69<br>(0.00) | 16.85<br>(11.62) |

Since the table does not allow the separation of financing from the WB Loan and the GEF Grant, the total amount of both the loan and the grant is shown (even if the the ICR guidelines only ask for details of the Bank loan, see note 1 below), given that the same procurement guidelines apply to both sources of financing. In addition to the investment costs, the Loan was also used to cover interest during construction totaling US$ 400,000. As such, the total final Project cost was US$ 17.25 million. In addition it should be

mentioned that there was a loss in exchange rate in SDR equal to US$ 0.602 M during the implementation period and a cancellation for part of the loan in the amount of USD 0.192 M, together totaling US$ 0.795 M.

[1/] Figures in parenthesis are the amounts to be financed by the Bank Loan. All costs include contingencies.

[2/] Includes civil works and goods to be procured through national shopping, consulting services, services of contracted staff of the project management office, training, technical assistance services, and incremental operating costs related to (i) managing the project, and (ii) re-lending project funds to local government units.

**Project Financing by Component (in US$ million equivalent)**

| Component | Appraisal Estimate | | | Actual/Latest Estimate | | | Percentage of Appraisal | | |
|---|---|---|---|---|---|---|---|---|---|
| | Bank | Govt. | CoF. | Bank | Govt. | CoF. | Bank | Govt. | CoF. |
| Investment Component | 12.40 | 2.60 | | 11.62 | 2.59 | | 93.7 | 99.6 | |
| Technical assisance Component | | | 2.62 | | | 2.64 | | | 100.8 |
| Interest during Construction | 0.40 | | | 0.40 | | | 100.0 | | |

# Annex 3. Economic Costs and Benefits

**Basic Information and Assumptions**

| | | Price ($) | Efficiency |
|---|---|---|---|
| Mazut(3%S) (US$/ton) | | 140 | 80% |
| Natural gas (US$/Thousand Cubic Meters) | | 110 | 85% |
| Geothermal heat(US$/MWh) | Current | 11.5 | 98% |
| | after 2003 | 15.4 | |
| | Free Economic Zone | 18.6 | |

**Environmental cost of pollutions($/ton)**

| | |
|---|---|
| CO2 emissions | 7 |
| SO2 emissions | 600 |
| NOx emissions | 250 |
| Particulates | 1000 |

**Enterprise Geoterma production**

| Energy resources | percentage |
|---|---|
| Geothermal Heat | **41%** |
| Natural Gas as driving heat | **59%** |

The project is estimated to reach its full production in 2008. NPV and ERR are calculated over 15 years with a terminal value at 10%.

**Energy productions**

| Year | 1996 | 1997 | 1998 | 1999 | 2000 | 2001 | 2002 | 2003 | 2004 | 2005 | 2006 | 2007 | 2008 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Total production, MWh | | | | | 586 | 103,309 | 189,000 | 237,720 | 264,800 | 265,800 | 267,300 | 269,300 | 270,800 |
| Geothermal Heat, MWh | | | | | 240 | 42,357 | 77,490 | 97,465 | 108,568 | 108,978 | 109,593 | 110,413 | 111,028 |
| Driving Heat from natural gas, MWh | | | | | 346 | 60,952 | 111,510 | 140,255 | 156,232 | 156,822 | 157,707 | 158,887 | 159,772 |

**Emission mitigation**

| Year | 1996 | 1997 | 1998 | 1999 | 2000 | 2001 | 2002 | 2003 | 2004 | 2005 | 2006 | 2007 | 2008 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **Scenario One: comparing with projects using Mazut** | | | | | | | | | | | | | |
| Total CO2 mitigation (ton) | | | | | 99 | 17,532 | 32,075 | 40,343 | 44,938 | 45,108 | 45,363 | 45,702 | 45,956 |
| CO2 mitigation from Geothermal energy (ton) | | | | | 84 | 14,721 | 26,932 | 33,875 | 37,734 | 37,876 | 38,090 | 38,375 | 38,589 |
| CO2 mitigation from driving heat NG (ton) | | | | | 16 | 2,811 | 5,142 | 6,468 | 7,205 | 7,232 | 7,273 | 7,327 | 7,368 |
| Total SO2 mitigation (ton) | | | | | 5 | 801 | 1,466 | 1,844 | 2,054 | 2,062 | 2,074 | 2,089 | 2,101 |
| Total NOx mitigation (ton) | | | | | 0 | 29 | 52 | 66 | 73 | 73 | 74 | 74 | 75 |
| Total Particulate Matters (TPM)(ton) | | | | | 0 | 11 | 21 | 26 | 29 | 29 | 30 | 30 | 30 |
| **Scenario Two: comparing with Natural Gas** | | | | | | | | | | | | | |
| Total CO2 mitigation (ton) | | | | | 72 | 12,768 | 23,359 | 29,380 | 32,727 | 32,851 | 33,036 | 33,283 | 33,469 |
| CO2 mitigation from Geothermal energy (ton) | | | | | 72 | 12,768 | 23,359 | 29,380 | 32,727 | 32,851 | 33,036 | 33,283 | 33,469 |
| CO2 mitigation from driving heat NG (ton) | | | | | | | | | | | | | |
| SO2 mitigation (ton) | | | | | | | | | | | | | |
| NOx mitigation (ton) | | | | | 0 | 36 | 66 | 83 | 92 | 92 | 93 | 94 | 94 |
| Particulates (ton) | | | | | | | | | | | | | |

**Economic analysis Scenario One: comparing with projects using Mazut**

| Year | 1996 | 1997 | 1998 | 1999 | 2000 | 2001 | 2002 | 2003 | 2004 | 2005 | 2006 | 2007 | 2008 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Benefit from cost savings(000$) | | | | | (106) | (106) | 1,348 | 1,382 | 1,576 | 1,583 | 1,593 | 1,607 | 1,617 |
| Benefit from emission reduction(000$) | | | | | 4 | 622 | 1,138 | 1,432 | 1,595 | 1,601 | 1,610 | 1,622 | 1,631 |
| Total Benefit(000$) | | | | | (103) | 516 | 2,486 | 2,813 | 3,171 | 3,184 | 3,203 | 3,228 | 3,248 |
| Investment cost(000$) | | 2,748 | 2,539 | 6,261 | 3,279 | 1,254 | 675 | | | | | | |
| NPV (000$, discount rate at 10%) | 6,392 | | | | | | | | | | | | |
| ERR | 14.8% | | | | | | | | | | | | |

**Economic analysis Scenario Two: comparing with projects using Natural Gas**

| Year | 1996 | 1997 | 1998 | 1999 | 2000 | 2001 | 2002 | 2003 | 2004 | 2005 | 2006 | 2007 | 2008 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Benefit from cost savings(000$) | | | | | (108) | (318) | 960 | 894 | 1,033 | 1,037 | 1,045 | 1,054 | 1,061 |
| Benefit from emission reduction(000$) | | | | | 1 | 98 | 180 | 226 | 252 | 253 | 254 | 256 | 258 |
| Total Benefit(000$) | | | | | (107) | (219) | 1,140 | 1,120 | 1,285 | 1,290 | 1,299 | 1,310 | 1,319 |
| Investment cost(000US$) | - | 2,748 | 2,539 | 6,261 | 3,279 | 1,254 | 675 | | | | | | |
| NPV (000$,Discount rate at 10%) | (5,200) | | | | | | | | | | | | |
| ERR | 4.7% | | | | | | | | | | | | |

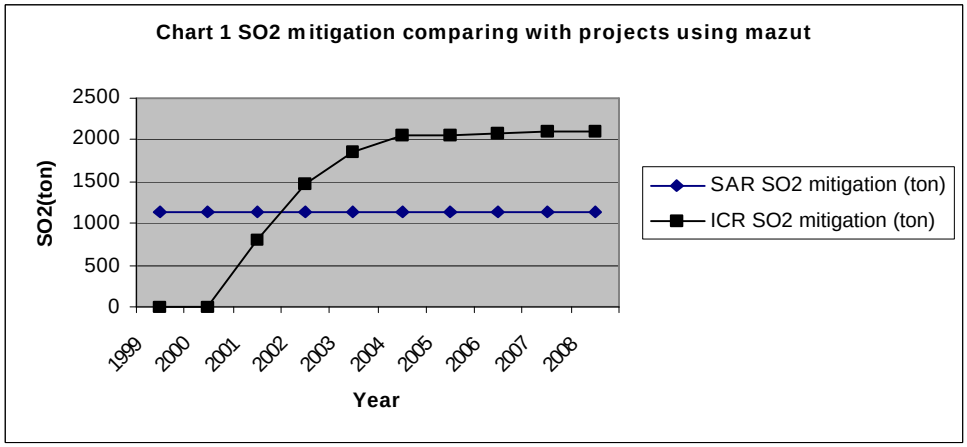
Chart 1 SO2 mitigation comparing with projects using mazut
SO2(ton)
2500
2000
1500
1000
500
0
1999
2000
2001
2002
2003
2004
2005
2006
2007
2008
Year
SAR SO2 mitigation (ton)
ICR SO2 mitigation (ton)

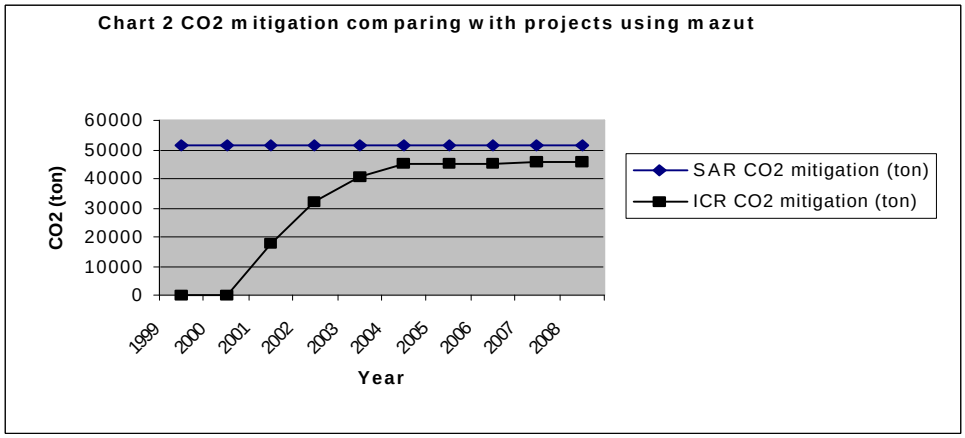
Chart 2 CO2 mitigation comparing with projects using mazut
CO2 (ton)
60000
50000
40000
30000
20000
10000
0
1999
2000
2001
2002
2003
2004
2005
2006
2007
2008
Year
SAR CO2 mitigation (ton)
ICR CO2 mitigation (ton)

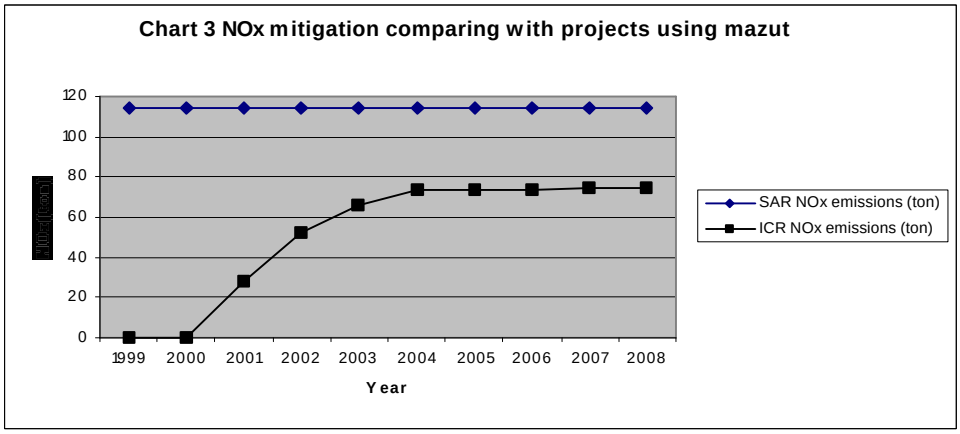
Chart 3 NOx mitigation comparing with projects using mazut
120
100
80
60
40
20
0
1999
2000
2001
2002
2003
2004
2005
2006
2007
2008
Year
SAR NOx emissions (ton)
ICR NOx emissions (ton)

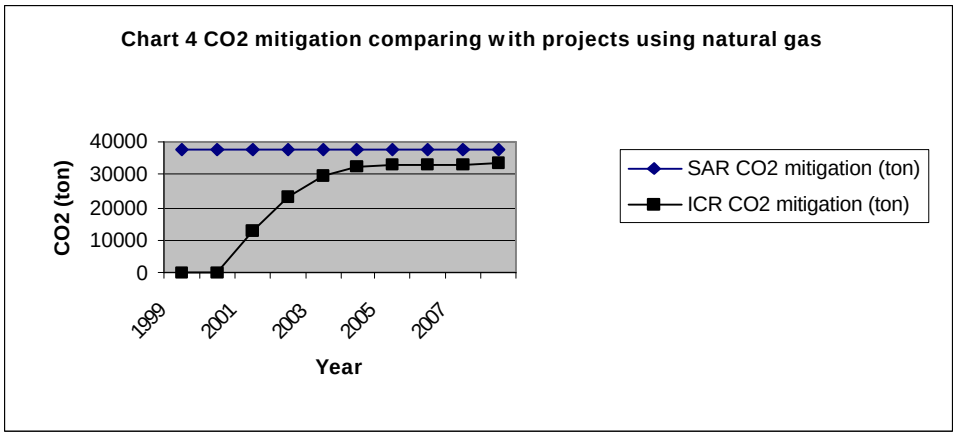
Chart 4 CO2 mitigation comparing with projects using natural gas
CO2 (ton)
40000
30000
20000
10000
0
1999
2001
2003
2005
2007
Year
SAR CO2 mitigation (ton)
ICR CO2 mitigation (ton)

## Annex 4. Bank Inputs

*(a) Missions:*

| Stage of Project Cycle | No. of Persons and Specialty (e.g. 2 Economists, 1 FMS, etc.) | | Performance Rating | |
|---|---|---|---|---|
| Month/Year | Count | Specialty | Implementation Progress | Development Objective |
| **Identification/Preparation** | | | | |
| Mar 7-14, 1994 (Identification) | *2* | Task Manager<br>Regional Environmental Specialist | | |
| Aug 29 - Sept 9, 1994 (Pre-Appraisal) | *6* | Task Manager<br>Regional Environmental Specialist Regional Energy Specialist<br>Financial Analyst<br>Procurement Advisor<br>Economist | | |
| **Appraisal/Negotiation** | | | | |
| Mar 13-24, 1995 (Appraisal) | *7* | Task Manager<br>Regional Environmental Specialist<br>Regional Energy Specialist<br>Financial Analyst<br>Legal Councilor<br>Economist<br>Environmental Economist | | |
| Jan 25, 1996 | *1* | Task Manager | | |
| **Supervision** | | | | |
| Sept 8-12, 1996 (Supervision 1) | *3* | Team Leader<br>Environmental Specialist<br>Procurement Specialist | | |
| Sept 1-5, 1997 (Supervision 2) | *4* | Team Leader<br>Financial Analyst<br>Regional Environmental Specialist<br>Procurement Specialist | S | S |
| Mar 23-27, 1998 (Supervision 3) | *3* | Team Leader<br>Environmental Specialist<br>Financial Analyst<br>Regional Environmental Specialist | S | S |
| Dec 7-11, 1998 (Supervision 4) | *3* | Team Leader<br>Regional Environmental Specialist<br>Financial Analyst | S | S |
| Apr 26-30, 1999 (Supervision 5) | *3* | Team Leader<br>Environmental Specialist | S | S |

| | | | | | |
|---|---|---|---|---|---|
| | | | Financial Analyst | | |
| | Nov 3-8, 1999<br>(Supervsion 6) | *2* | Team Leader<br>Financial Analyst | S | HS |
| | May 1-5, 2000<br>(Supervision 7) | *2* | Team Leader<br>Financial Analyst | S | HS |
| | Sept 24-29, 2000<br>(Supervision 8) | *3* | Team Leader<br>Environmental Specialist<br>Financial Analyst | S | HS |
| | Apr 30 -<br>May 7, 2001<br>(Supervision 9) | *3* | Team Leader<br>Environmental Specialist<br>Financial Analyst | S | U |
| | Nov 28 -<br>Dec 5, 2001<br>(Supervision 10) | *2* | Team Leader<br>Financial Analyst | S | U |
| | Apr 7-12, 2002<br>(Supervision 11) | *2* | Team Leader<br>Financial Analyst | U | U |
| **ICR** | | | | | |
| | Nov 17-27, 2002<br>(ICR Mission 1) | *4* | Team Leader<br>Economist<br>Financial Analyst<br>Operations Analyst | S | S |
| | 04/01/03<br>(ICR Mission 2) | *4* | Team Leader<br>Economist<br>Financial Analyst<br>Regional Environmental Specialist | S | S |

*(b) Staff:*

| Stage of Project Cycle | Actual/Latest Estimate | |
|---|---|---|
| | No. Staff weeks | US$ ('000) |
| Identification/Preparation | | 381 |
| Appraisal/Negotiation | | 40 |
| Supervision | | 370 |
| ICR | | 67 |
| Total | | 858 |

The costs shown above represent the total amounts used from the Bank (0.375 M) and GEF (0.307 M) budgets for the Project preparation, supervision and completion work, as well as the TFs (0.176 M) used for different tasks under project preparation and implementation.

## Annex 5. Ratings for Achievement of Objectives/Outputs of Components

(H=High, SU=Substantial, M=Modest, N=Negligible, NA=Not Applicable)

| | *Rating* |
|---|---|
| ☐ *Macro policies* | ○ *H* ○ *SU* ○ *M* ○ *N* ● *NA* |
| ☐ *Sector Policies* | ○ *H* ○ *SU* ● *M* ○ *N* ○ *NA* |
| ☐ *Physical* | ● *H* ○ *SU* ○ *M* ○ *N* ○ *NA* |
| ☐ *Financial* | ○ *H* ○ *SU* ● *M* ○ *N* ○ *NA* |
| ☐ *Institutional Development* | ○ *H* ● *SU* ○ *M* ○ *N* ○ *NA* |
| ☐ *Environmental* | ● *H* ○ *SU* ○ *M* ○ *N* ○ *NA* |
| *Social* | |
| ☐ *Poverty Reduction* | ○ *H* ○ *SU* ● *M* ○ *N* ○ *NA* |
| ☐ *Gender* | ○ *H* ○ *SU* ○ *M* ○ *N* ● *NA* |
| ☐ *Other (Please specify)* | ○ *H* ○ *SU* ○ *M* ○ *N* ● *NA* |
| ☐ *Private sector development* | ○ *H* ○ *SU* ● *M* ○ *N* ○ *NA* |
| ☐ *Public sector management* | ○ *H* ○ *SU* ○ *M* ○ *N* ● *NA* |
| ☐ *Other (Please specify)* | ○ *H* ○ *SU* ○ *M* ○ *N* ● *NA* |

## Annex 6. Ratings of Bank and Borrower Performance

(HS=Highly Satisfactory, S=Satisfactory, U=Unsatisfactory, HU=Highly Unsatisfactory)

| *6.1 Bank performance* | *Rating* |
|---|---|
| ☒ *Lending* | ○ *HS* ● *S* ○ *U* ○ *HU* |
| ☒ *Supervision* | ○ *HS* ● *S* ○ *U* ○ *HU* |
| ☒ *Overall* | ○ *HS* ● *S* ○ *U* ○ *HU* |

| *6.2 Borrower performance* | *Rating* |
|---|---|
| ☒ *Preparation* | ○ *HS* ● *S* ○ *U* ○ *HU* |
| ☒ *Government implementation performance* | ○ *HS* ● *S* ○ *U* ○ *HU* |
| ☒ *Implementation agency performance* | ○ *HS* ● *S* ○ *U* ○ *HU* |
| ☒ *Overall* | ○ *HS* ● *S* ○ *U* ○ *HU* |

## Annex 7. List of Supporting Documents