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BURNS AND ROE ENTERPRISES, INC.

ZUGDIDI INFORMATION for DELIVERY ORDER No. 25

GEORGIA

March 1997

Prepared by:	**Burns & Roe Enterprises, Inc.**
Submitted to:	**U.S. Agency for International Development**
Contract No.:	**CCN-0002-Q-00-3154-00** **Energy Efficiency and Market Reform Project** **Delivery Order No. 25**

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Burns and Roe Enterprises, Inc.
1400 K Street N.W., Suite 1050, Washington, DC 20005
(202) 408-6831 Fax (202) 408-6835

March 18, 1997

Mr. Iqbal M. Chaudhry
U. S. Agency for International Development
320 21st Street N.W., Rm 4440 NS
Washington, DC 20523

Subject: Contract CCN-0002-Q-00-3154-00
Delivery Order No. 25 - Georgia
Zugdidi Geothermal District Heating System
EBRD Reconstruction Proposal - Preliminary Draft Report

Dear Mr. Chaudhry:

The Government of the Republic of Georgia has requested that the EBRD assist in preparing a district heating project for Zugdidi to utilize geothermal energy. USAID has agreed to fund a preloan project assessment and provide the services of Burns and Roe Enterprises to undertake the tasks specified in Delivery Order No. 25.

Attached is a copy of the preliminary report on the Zugdidi Geothermal Assessment prepared in Tbilisi by ARCI Consulting under the direction of Burns and Roe Enterprises, Inc. This report covers about 60% of the ARCI work required for preparation of the EBRD Pre-Loan Assessment.

The work remaining for completion of the Delivery Order includes, but is not limited to, the following:

1. Limited testing of the resource/wells (May 1997)

2. Privatization and Ownership Proposal

   a. Development of a program of institutional reforms for the Government of Georgia to privatize the geothermal production and district heating systems by means of a joint stock company.
   b. Recommendations on a company ownership structure, legal framework and management requirements for implementing and operating the Zugdidi geothermal production and district heating distribution system, maintenance practices, staffing and training needs, etc.
   c. Description of the legal requirements and framework for company relationships with local authorities, the Government of Georgia, international business and the EBRD.

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3. Preparation of tender documents if project is approved by EBRD.

4. Preparation of Final Report.

Also attached is a translation from Russian of a report titled "Assessment of Operational Reserves (Capacity) of Thermal Water in Zugdidi-Tsaishi Deposit (Republic of Georgia)" published October, 1984. This report provides a great deal of history on the development of the resource, the geology and geochemistry up to that time.

We have also included about thirty pages of miscellaneous documents previously prepared over the past year which we hope you will find of interest to point out the importance of the success of the Zugdidi project to Georgia. Some of this information has been provided to Ambassador Courtney.

Zugdidi is about 2 Km from the border to Abkazia and the Inguri hydro power plant and is of political importance for maintaining stability in the region. Zugdidi is economically important because of the large number of commercial enterprises located in the region. These enterprises are key elements in implementing the institutional reforms necessary for privatization and developing a strong free market economy. Already there is strong interest by German companies in forming joint ventures with these enterprises.

The success of these reforms, encouraging foreign investment and redevelopment of the infrastructure, will strengthen the ability of the local government to provide the cash flow necessary to repay the EBRD loan.

If you have any questions, please call me at (202) 408-6831, x14.

Prepared by:
John E. Hallberg, P.E.
Task Manager

Sincerely,

Douglas D. Tuckhorn
Project Director-Caucasus

Attachments
c: P. Feeney, USAID, (T)
J. Hallberg, BREI (NJ) (w/o attach)
L. Hultin, EBRD (UK)
Z. Menteshashvili, BR (T)
W. Smith, USAID (Y)
G. Weynand, USAID (DC)
Pf: 5924:2.1.2

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ATTACHMENT

(ZUGDIDI INFORMATION)

1. Memo Re: Zugdidi, to Doug Tuckhorn, copy Gordan Weynand for Ambassador Cortney
2. Memo Re: Geothermia, Ltd., to Doug Tuckhorn, copy Gordon Weynan for Ambassador Cortney
3. Diagram of Zugdidi Infracture Development
4. List of Commercial Enterprises in Zugdidi
5. USAID/BREI Exit Interview, Friday, 9 August 1996
6. Zugdidi Geothermal Assessment Status for EBRD, 30 July, 1996
7. Meeting Notes - EBRD, Tuesday, 30 July, 1996
8. Article in Tbilisi Newspaper "Droni" (Times) About USAID
9. List of Work Tasks for Zugdidi Study
10. Lists of Zugdidi Data and Heat Consumers
11. Certificate on Zugdidi Water Supply System
12. Geothermex Preliminary Report (March 1996)

To: Mr. Douglas D. Tuckhorn
Burns and Roe Ent. Inc.
From: Alexander Arobelidze
ARCI Consulting

TUE 27 FEB. 1996
CC: GORDON WEYNAND

In reply to your request concerning possibilities of solvency demands of Zugdidi district thermal resource, we would like to inform you of the following:

Taking into account traditional way of economy development in the region, it should be noted, that the significant gross weight of the private sector (it can be proved by the fact, that 75-80% of the population is private single familica with a small land site for agricultural production.

This very part, according to solvency, is ready to purchase thermal energy in beneficial sales terms for their own green houses heat supply.

Zugdidi industrial sector is in acute state due to power defficiency, however, privatization procedures and active work can turn it into solvent consumer of the heat supply. It concerns such prospective enterprises, as: Paper Mill, Two Tea Factories, Chicken Farm, Preserves (conserves) Factory, Pig Farm, Ceramics Factory. Also the consumers are supposed to be Dairy, Hospital and Bakeries.

It should be noted, that the resourt potential of the region, particularly, the existing climate resort Tsaishi, which uses the heat and medicinal qualities of the existing geothermal waters.

In view of prospective investment improvements, the transit-geographical location of Zugdidi near the main highway connecting Georgia with Russia should also be mentioned. After the stabilisation of the situation in Abkhasia, Zugdidi will again acquire the feature of main commercial centers with appropriate infrastructure and services like restaurants, small motels, etc.

However, taking into account priority rating, we could mention, that the most prospective directions of utilising of thermal energy in the region will be private green houses, both individual and corporate for vegetables, fruit and citroses. These facilities and also the residential sector in the nearest future will determine the solvency demand on thermal energy.

To: Mr. Douglas D. Tuckhorn
"Burns and Roe Ent. Inc."

TUE 27 FEB. 1996
CC: GORDON WEYNAND

From: Alexander Arobelidze
ARCI Consulting

MEMO

In reply to your request regarding legal status of the company "Geothermy, Ltd" activity, we want to inform the following:

We contacted the company representatives and they gave us the information we enclose below:

It is a private company, the founders of which are the physical persons, specialists with long experience in the point-in-question, i.e. geothermy and geology.

The company was set to develop and utilise geothermal resources of Georgia based on the existing wells.

Under the Municipal order of 1989, the company "Geothermy Ltd." was granted the right to rent Lisi deposits for the period of 20 years to develop it more efficiently in the market economy situation.

Based on the above mentioned rights, the company performed minor repair work of the system and utilisation, also, it signed agreement with the Municipal Heat Department to use district hot water and heat network and thermal substations for hot water supply management for the consumers.

By now, the company has entered into several agreements with the residents, as well as with commercial consumers. The self-financed works are being performed for technical testing of the project hydrosyphon, the price of which amounts to $45.000, which is 50% of the costs required for carrying out the testing.

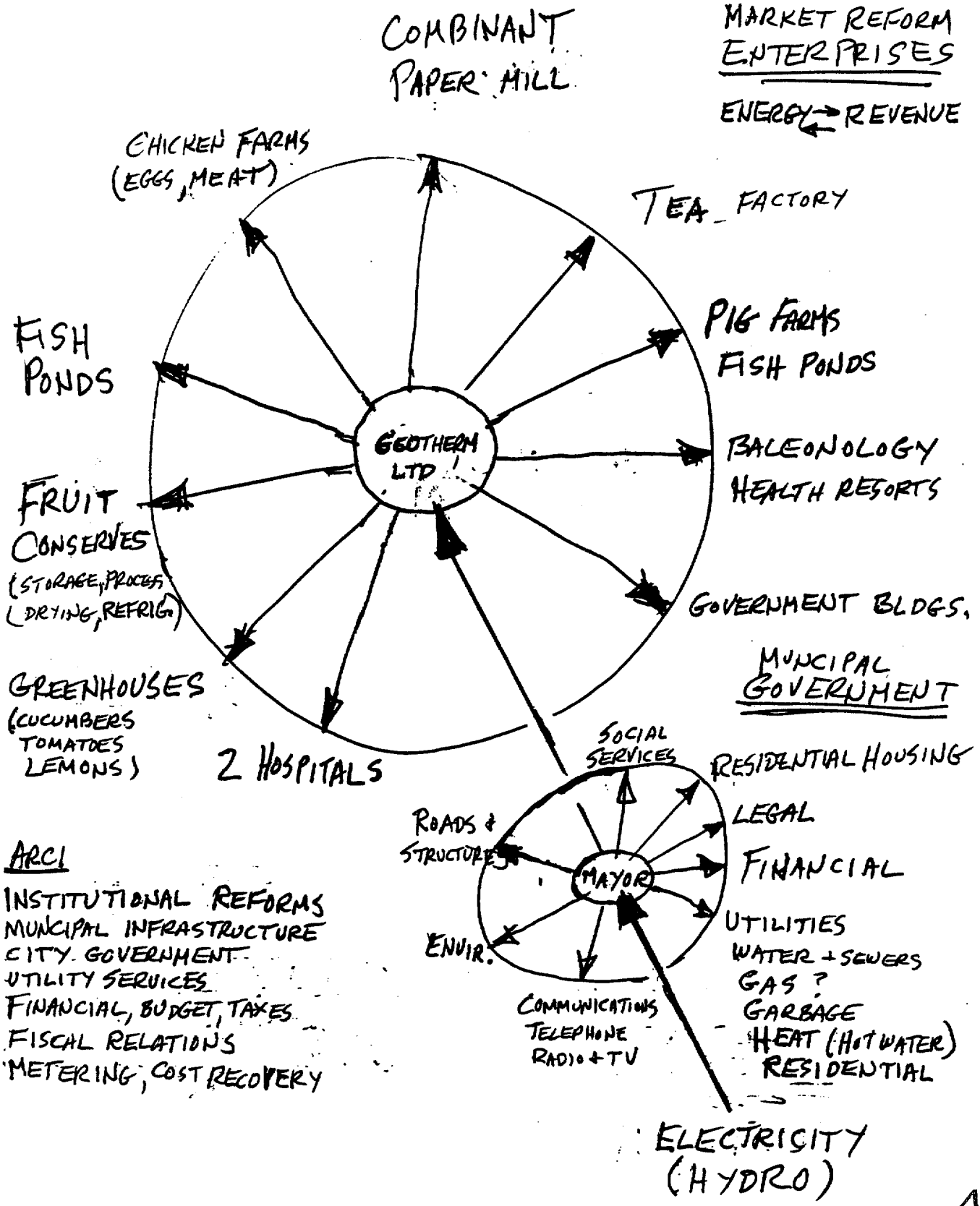
At the moment, under the legislation, the company submitted the documents again to gain the license from the Ministry of Environmental Protection on Lisi geothermal deposit utilisation. The decision on granting licenses will be issued on March 1, 1996.

Another such license is supposed to be obtained for Zugdidi deposit, too.

ZUGDIDI

Friday March 1, 1996

INFRASTRUCTURE DEVELOPMENT



ARC1

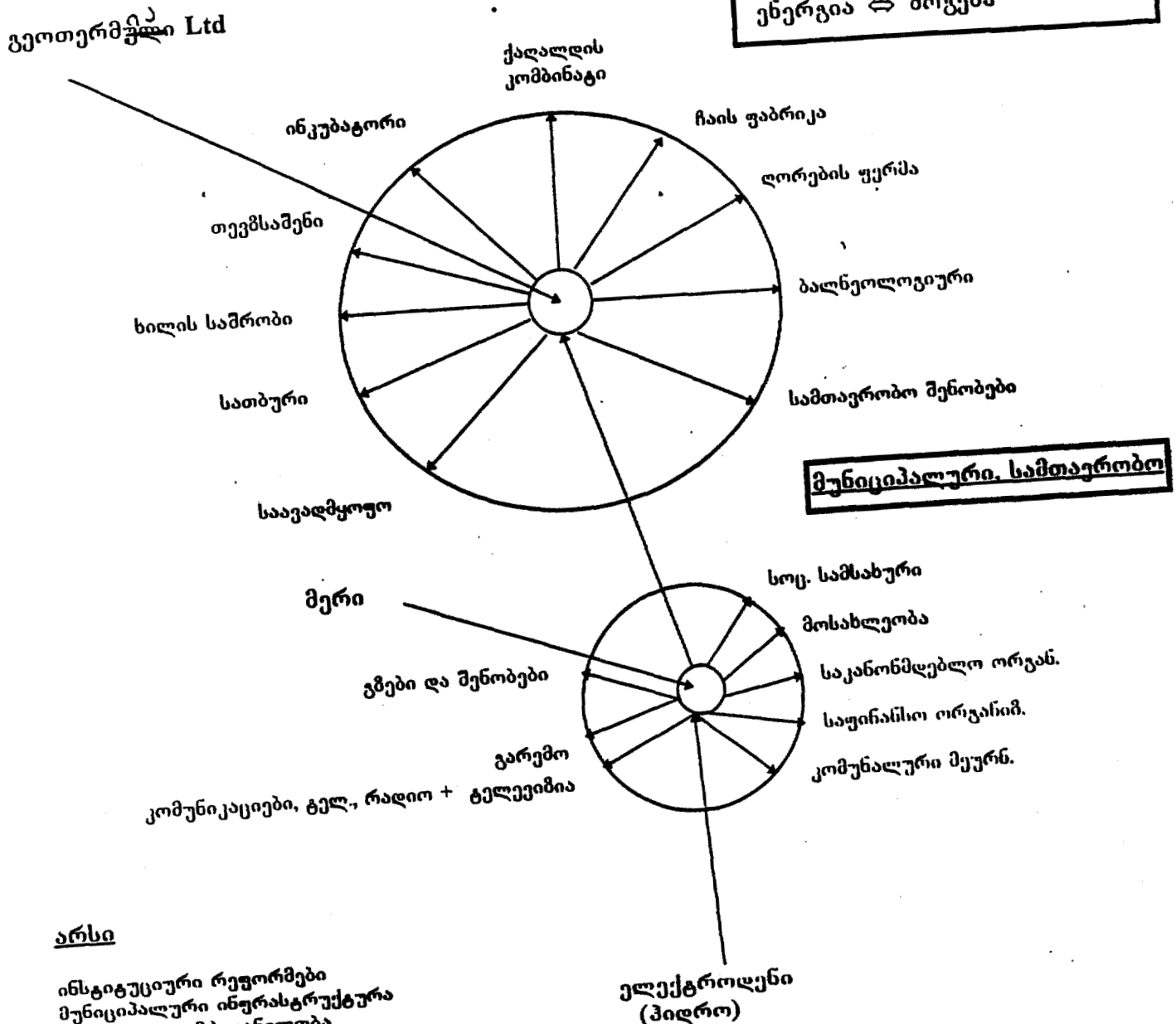
INSTITUTIONAL REFORMS
MUNCIPAL INFRASTRUCTURE
CITY GOVERNMENT
UTILITY SERVICES
FINANCIAL, BUDGET, TAXES
FISCAL RELATIONS
METERING, COST RECOVERY

1 მარტი, 1996

ზუგდიდი

ინფრასტრუქტურა

კომერციული ორგანიზაციები
ენერგია ⇔ მოგება



არსი

ინსტიტუციური რეფორმები
მუნიციპალური ინფრასტრუქტურა
ქალაქის ხელმძღვანელობა
კომუნალური მეურნეობა
საფინანსო, საბიუჯეტო, საგადასახადო
~~ფისკალური~~ ურთიერთობა
გამომვები, საფასურის ანაზღაურება

კერძო საწარმოები	COMMERCIAL ENTERPRISES
მეწველი საქონლის ფერმა - რძე, ყველი	DAIRY FARM MILK CHEESE
მეღორეობის ფერმა - ხორცი	PIG FARM - MEAT
მეფრინველეობის ფერმა - კვერცხი	CHICKEN FARM EGGS
მეფრინველეობის ფერმა - ხორცი	CHICKEN FARM MEAT
სათბურები - ?	GREENHOUSES
საცხობები - ?	BAKERIES
ცაის ქარხანა	TEA FACTORY (2)
თევზსაშენი - საკვები	FISH PONDS — FOOD
კონსერვების ქარხანა, ჯემი, პავიდლო, ხილის შენახვა	CONSERVES FACTORY JAM, JELLY, FRUIT STORAGE
ქაღალდის ფაბრიკა	PAPER MILL (GOVT)
კერამიკული ქარხანა	CERAMICS FACTORY
სანელებლების ქარხანა	SPICE FACTORY - LAUREL, ETC
საღებავების ქარხანა	PAINT FACTORY
საავადმყოფო (სახ.)	HOSPITAL (GOVT)
გეოთერმია	GEOTHERMIA
"ნოსტრადამუსი"	NOSTRADAMUS

June 6, 1996

POTENTIAL COMMERCIAL CONSUMERS OF HEAT & POWER

FOOD TECHNOLOGY INFORMATION

1. Greenhouses - products, tomatoes, strawberries, cucumbers, citrus, beans, etc.
2. Mushroom Production - technology, equipment
3. Drying - vegetables, fruits, papaya, onions, garlic, etc.
4. Chicken - meat and egg production, refrigeration, heat and hot water
5. Silviculture - fish ponds
6. Refrigeration - ice making, cold storage
7. Bakeries -
8. Dairy Products - Heat and Power, Refrigeration, Cheese Making
9. Meat Processing & Storage
10. Food Processing - cooking, canning, freezing

Other

Laundries, Bath houses, Manufacturing, etc.

USAID Exit Interview
Friday, 9 August 1996

A trip to Tbilisi, Georgia began on Tuesday, 23 July 1996 for 17 days to work with ARCI Consulting, the Burns and Roe local subcontractor on the following delivery orders:

D.o. No. 11 - Tbilisi District heating System Improvement Program
D.o. No. 25 - Zugdidi Geothermal assessment

The purpose of this trip was to meet with EBRD to present findings of Zugdidi Geothermal Phase I preliminary assessment, discuss EBRD loan requirements, and continue preparing Tbilisi District Heating rehabilitation proposals.

Other than preliminary data gathering and preparation of a testing cost estimate, ARCI has not yet been authorized to work on Zugdidi. However, ARCI has been released to prepare design and cost estimates for three Tbilisi district heating thermal station rehabilitation projects. Main focus has been directed to develop annual electrical and thermal load profiles and obtain vendor data and budgetary cost estimates and prepare conceptual designs and space layout requirements.

Technical reports and drawings containing original data and design information describing the Zugdidi geothermal resource and distribution systems were obtained from Sakburgeothermia during the last trip and translated from Russian to English. Based on review of this information, discussions with Georgian geologists and visual inspection of wells, GeothermEx submitted a partial preliminary report on 25 July.

A very important recommendation is that flow and injection testing should be conducted in order to make a realistic assessment of the potential magnitude and life of the geothermal resource. About $250,000 is estimated for the program of which more than half will be for permanent installed materials and equipment. If this testing cannot be done for the EBRD pre-loan assessment, then the Zugdidi project may have to be extended in two or more phases with some of testing being included during a limited first phase utilization of hot water for schools and residential consumption. Burns and Roe and ARCI will evaluate and present by mid-September a strategy for development of project.

As soon as ARCI starts working on the Zugdidi project, specialists will gather local information required as part of market survey to determine residential and commercial demand forecasts for thermal energy and revenue requirements. This will include determination of ownership structure and relationship for institutional and commercial enterprises.

A specification and requisition for purchase of a computer and "Heatmap" software program for modeling the Zugdidi wells and district heating distribution system has been prepared.

USAID Delivery Order No 25
Zugdidi Geothermal Assessment
Status 30 July, 1996

Introduction:

- The government of the Republic of Georgia has requested that the EBRD assist in preparing a district heating project for Zugdidi to utilize geothermal energy.
- The EBRD funded a study "Geothermal Resources in the Republic of Georgia" by the Icelandic firm of Virkir-Orkint Consulting Group Ltd. of Reykjavik which included a discussion of the resource at Zugdidi.
- USAID has agreed to fund a pre-loan assessment by Burns & Roe Enterprises Inc. and its subcontractors to undertake specified tasks.

Scope of Work - Phase I

- Review existing documentation
- Quantify geothermal resource
- Prepare district heating system design
- Residential and commercial demand forecast
- Conduct market survey
- Preliminary financial analysis
- Ownership structure - institutional and commercial
- Preliminary risk analysis

Preliminary Results

- Two trips were made to Zugdidi (October, 1995 and February 1996) by Burns & Roe, ARCI and Geothermia.
- Geothermal wells were visually inspected.
- Technical reports and drawings were obtained and translated into English.
- Meeting were held with government, municipal and commercial enterprise officials.
- Preliminary data was submitted by entities.
- Preliminary report prepared by GeothermEx.
- Flow test design and cost estimate prepared.

Findings and Recommendations

- There is great potential for developing the resource.
- There is great potential for developing the commercial enterprises as thermal consumers to financially support the financing.
- A testing program as recommended by Geothermex must be implemented to quantify the resource before continuing with the detailed assessment.

12

Meeting Notes
Tuesday, 30 July, 1996

A meeting was held at the Metekhi Hotel at 7 PM to discuss status of USAID Delivery Order No. 25 - Zugdidi Geothermal Project assessment for EBRD financing.

Attendees:

Lars Hultin	European Bank for Reconstruction and Development
John E. Hallberg	Burns and Roe Enterprises
Alexander Arobelidze	ARCI Consulting
Ivane Zazashvili	SAKTRANSGAZ
David Bakashvili	SAKBURGEOTHERMIA

The purpose of the meeting was intended to present to EBRD our findings during the first phase assessment. However, ARCI has not yet been authorized to proceed with their scope of work. Therefore, a brief summary of preliminary work accomplished to date was presented. The preliminary report for EBRD/USAID review will have to be submitted later this year.

We first discussed the problem of trying to determine the present organizational structure and chain of command of various departments involved in geothermal energy. ARCI Consulting will describe the ownership structure and institutional reforms in the preliminary report. As understood at this time, ownership is primarily state, with division of responsibility indicated as follows:

30% Sakburgeothermia
Exploitation
Care of 90% of geothermal wells
Own two drilling rigs

50% Municipality
Distribution

20% Geothermia, Ltd (Quasi-private)
Operation

As discussed during this meeting, the following EBRD criteria and suggestion should apply to the Zugdidi geothermal district heating project:

1. Financing is for public project ($10 million minimum)

2. Loan is to the Government with guarantees through Minister of Finance.

3. The Ministry of Energy shall declare the Zugdidi geothermal district heating rehabilitation project as a priority.

4. It is suggested to incorporate the majority of resource testing expenses within the project cost as part of normal startup testing.

5. It is suggested to propose ownership structure by means of Joint Stock Company with 51% minimum government ownership. It will be advantageous to include the thermal recipient commercial enterprises to participate. An example is the joint venture German-Georgian tea factory.

7. A business plan with thorough market research as backup shall be submitted.

8. Some terms of the loan:
   - Interest rate - 1% above LIBOR, variable
   - One percent front end fee
   - One percent interest on unused funds
   - Period of loan - 15 years
   - Interest payment due immediately upon signing
   - Up to two year grace period for principal payments while project is completed, ready to operate.

9. If project is not selected for public financing, a backup strategy shall be investigated to seek private project financing from EBRD and other sources. EBRD will only provide 35% financing with $10 million minimum loan for private projects. This means a $30 million private development project possibly incorporating secondary financing for the large thermal host enterprises. It would help to find foreign investment through joint ventures of a large holding company to secure this sum of investment. However, the potential returns from the enterprises revenues could be very attractive to investors, and export of quality food products could secure badly needed hard currency for Georgia.

USA Humanitarian Aid to Georgian Energy System

Energy deficiency in Georgia turned into an unsurpassable problem. During summer, when there is heat and floods, the country has some hydro power supply, but as soon as the flood is over and winter comes, electricity is supplied to the population during a few limited hours. Nobody knows for how long this situation is going to last, nobody knows when to expect a significant change.

Though it is well known that a lot of money (loans and humanitarian aid) has been spent for energy purposes during the last few years, if we consider only sums granted by the US government, it is already a considerable amount.

USAID, Agency for International Development is the general coordinator of American humanitarian aid. The Agency employed a US company "Burns and Roe" to accomplish a program of studies and some part of rehabilitation work. In 1994 aid of 4,5 million dollars was assigned for the assistance program a part of which was used to purchase materials and equipment, while the rest of the sum was used to prepare tender documents for three projects:

1. Water Treatment Facility for Tbilisi Power Plant;
2. Condenser Tube Cleaning System for Tbilisi Power Plant;
3. Replacement of turbine and governor at Rioni Hydro Power Plant.

The tender documents were prepared in accordance with the rules of European Bank and World Bank and include technical and legal parts.

The program financed by 1995 budget included a study of Tbilisi district heating system. "Burns and Roe" repaired boilers for Maternity Hospitals N 4 and N5, City Mental Hospital and Burns Center. This program is planned to be continued in 1996.

The company also studied the possibilities of heating Tbilisi residential districts by means of geothermal energy. There is an opinion that this way it is possible to heat region with 120 000 population in Tbilisi.

Similar studies were carried out in the city of Zugdidi. Zugdidi municipality is ready to direct some funds to heat Zugdidi schools and hospitals by means of geothermal water. It is even more promising to use geothermal water for industrial purposes.

"Burns and Roe" specialists will also study the gas supply system (condition of the pipeline and the pump stations) and prepare technical documentation. This problem is common for Georgia and Armenia.

The company performed inspection and verification program and prepared inspection documents for Unit N 10 at Tbilisi Thermal Power Plant.

At present the issue of allocation of large loans for Georgia by World Bank and European Bank is being discussed. The loans will be used for rehabilitation programs of Unit N 10 (Tbilisi Thermal Power Plant) and hydro power stations. The hydro power plants selected for rehabilitation program are: Khrami 2, Tkibuli, Lajanuri and Vartsikhe. "Burns and Roe" specialists worked out several options of the projects.

There are also plans to rehabilitate Georgian power network. The Feasibility Report for this project was also prepared by "Burns and Roe". And even this is not a complete list of "Burns and Roe" activity in Georgia.

Galya Gotoua, Reporter

"Droni" (Times) -Tbilisi, Georgia
Article published 23-26 July,1996

გამოდის 1991 წლიდან

დრონი

№56 (350)

23 — 26 ივლისი, 1996 წელი

რედაქცია ხელმძღვანელობს ეროვნულ პრესის პრინციპებით

გაზეთის ფასი: 40 თეთრი
თბილისს გარეთ ფასი სახელშეკრულებო

BEST AVAILABLE COPY

3 გვ.

გენერალური პროკურორის მოადგილეობის შემსრულებელი შეეპრალებაის ანაესზე არ წამოიგო „ეხედრილის შეექვნელი ავსტრიაში ეოალეს“

ახალი ეტაპი ბრძოლა კორუფციასთან

ძრაბანელი დიმბაბშვილიდან დეპორტირებული სანელენი ფოსკენ ქრიმინალური დიმბაბშვილის გაპლიდ?

5 გვ.

ვინ არის დამნაშავე 9 აპრილის ტრაგედიაში?

6 გვ.

რადუევი ცოცხალია, ამბობენ

—

დუდაევიც

7 გვ.

ხახალეიშვილის ჩემპიონობა ტერორიზმს შეეწირა

– ჩვენი კორესპონდენტის რეპორტაჟი აფლანდიდან

აშშ-ის ჰუმანიტარული დახმარება საქართველოს ენერგეტიკას

ენერგეტიკული დ. ი-ციტი საქართველოსთვის გადაულახავ პრობლემად იქცა. ზაფხულის თვეებში სიცხისა და წყალუიდობების წყალობით ელექტრონი ასე თუ ისე გვაქვს, მაგრამ ჩამოონება ჩამოსადნობი მყინვარები და ჩვენც ისევ დაგესვამენ „შიერ ენერგეტიკულ ულუფაზე". არ.ინ იცის, როდემდე გაგრძელდება ასე. არავინ იცის, როდის შეიცვლება ვითარება თვისობრივად.

არადა ფაქტია, რომ საქართველოს ენერგეტიკაში უკვე რამდენიმე წელია უამრავი ფული — კრედიტი თუ ჰუმანიტარული დახმარება — იყრება. რა ღირს თუნდაც ამერიკის შეერთებული შტატების მიერ გარანტის სახით გამოყოფილი თანხები.

საქართველოში ჰუმანიტარული დახმარების კენერალური კოორდინატორი გახლავთ სააგენტო USAID-ი, რომელმაც კვლევითი სამუშაოების ჩატარება და ნაწილობრივ მათი შესრულება დააკისრა ფირმა „Burns and Roy"-ს. 1994 წლის დახმარების პროექტით გამოყოფილი იყო 4 მილიონი დოლარი, რომლითაც 1995 წელს შეიძინეს საწვავი, ალჰერვილობა, თანხის ნაწილი კი მოხმარდა ტენდერის დოკუმენტაციის მომზადებას შემდეგი ობიექტებისთვის:

1. თბილისის თეც-ში ქიმიური საამქროს შშენებლობა.

2. თბილთეცის კონდენსატორის მილების გამწმენდი სისტემის შექმნა.

3. რიონის კაის ორი ტურბინისა და სიჩქარის რეგულატორის შეცვლა.

ტენდერისთვის მომზადებული დოკუმენტაცია შედგებოდა ევრობანკსა და მსოფლიო ბანკის წესების მიხედვით მომზადებულ ტექნიკურ და იურიდიულ ნაწილებისგან. ასევე, ჩატარდა სპეციალური ექსპერტიზა, რათა დადგენილიყო, ხომ არ ეწინააღმდეგება აღნიშნული წესები საქართველოს კანონმდებლობას.

1995 წლის ბიუჯეტის მიერ დაფინანსებული პროგრამა ითვალისწინებდა თბილისის გათბობის სისტემის შესწავლას. ფირმა „Burns and Roy"-მ გაარეკონტა მე-4 და მე-5 სამშობიარო სახლებისა და დამწვრობის ცენტრის საქვაბეები. ეს სამუშაო გაგრძელდება 1996 წლისაც.

ფირმამ შეისწავლა თბილისელთა ბინების გეოთერმული წყლის ენერგიით გათბობის შესაძლებლობა. არსებობს აზრი, რომ ამ გზით მოხერხდება 120 ათასი თბილისელის ოჯახის გათბობა.

ანალოგიური გამოკვლევები განხორციელდა ზუგდიდშიც. ზუგდიდის მუნიციპალიტეტი უკვე მზადაა გამოყოს თანხები ქალაქის სკოლებისა და საავადმყოფოების გეოთერმული წყლებით გასათბობად. უფრო დიდი პერსპექტივები ელის გეოთერმული წყლის წარმოებაში გამოყენებას.

ფირმის სპეციალისტები შეისწავლიან გაზმომარაგების სისტემას (მაგისტრალის, სატუმბო სადგურების მდგომარეობას), ამზადებენ ტექნიკურ დოკუმენტაციას. ეს ამოცანა საერთოა საქართველოსა და სომხეთისათვისაც.

ფირმის მიერ მომზადებულია მე-10 ენერგობლოკის ინსპექციის პროექტის შესახებ დოკუმენტაცია.

ახლა განიხილება მსოფლიო ბანკისა და ევროპის რეკონსტრუქციისა და განვითარების ბანკების მიერ საქართველოსთვის მსხვილი კრედიტების გამოყოფა. ეს თანხები საგარაუდოდ მე-10 ბლოკისა და ჰიდროელექტროსადგურების რეკონსტრუქციაში ჩაიდება. პირველად რეკონსტრუქციისათვის არჩეულია სრაბი-2, ადეანურპესი და ვარციხე. საერთონტო სამუშაოები, შესაძლოა, განახორციელონ სპეციალისტებმა ფირმიდან „HARZA", „Burns and Roy"-ს ექსპერტებმა კი შეიმუშავეს რამოდენიმე ვარიანტი პროექტისა.

არსებობს თბილისის ელექტროგენერაციის სისტემის წესრიგში მოყვანის გეგმები. ტენდერის მოსაწყობი დოკუმენტაციაც ასევე „Burns and Roy"-მ მოამზადა. ეს სულაც არ არის მთლიანი ჩამონათვალი იმ საქმიანობისა, რაც ფირმა „Burns and Roy"-მ საქართველოში განახორციელა.

BEST AVAILABLE COPY

I. Existing Data on Zugdidi Thermal Water Deposit

- Importance of geothermal energy in fuel-energy balance of Georgia
- Organization structure of using geothermal energy supply
- History of exploration and operation of Zugdidi thermal water deposit
- Physical & geographic and climate conditions of Zugdidi region
- Short geological description of the deposit
- Hydro-geological and geothermal conditions of Zugdidi region
- Aggressive properties of Zugdidi thermal water and methods of suppressing them
- Necessity of carrying out reinjection tests
- Prognosis of reinjection test results
- Estimation of environmental results of using geothermal resources
- Making a hydro geological map (1:25 000)
- Making a plan of the location of wells, substations and pipelines based on topographic data
- Making drawings of well sections
- description of the present day condition of wells and buildings (Drills, pipelines, pump stations, electric circuits etc.)
- Making tables of the main parameters of wells
- Study of project proposals of using Zugdidi deposit geothermal resources that have been worked out previously

II. Development of Zugdidi Geothermal Heat Supply Project

- Making of questionnaires and collection of data on possible consumers. ← *
- Making schemes of possible consumers in t.Zugdidi with a table of main technological characteristics, indicating number and periods of consumption during different months of the year (m 1:5000). ← *
- Making maps of I and II priority pipelines and equipment, indicating the existing and designed pipelines, equipment and power circuits.
- Technological calculation for the two systems of heat supply:
  a) without using heat pumps
  b) using heat pumps
- Comparison and choice of a heat supply scheme for two systems, indicating consumers and technical characteristics of the equipment (pumps, heat exchangers, heat pumps, transformers, generators, control-measuring equipment, meters etc.)
- Working out draft projects of specific constructions:
  a) civil work
  b) technological part
  c) electric part

- Working out specifications of the equipment, materials and types of work, including prices.
- Calculation of capital costs for technical and refrigerating facilities (per area and output unit). ← *
- Calculation of operation costs in different months, indicating peak loads.
- Structure of the organization which will operate the geothermal heating system
- Calculation of cost and price of heating energy unit and determination of payback terms of capital expenses.
- Working out of a calendar plan.
- Determination of geothermal system efficiency compared to organic fuel.
- Calculations and choice of heat pumps and refrigerating equipment. — *
- Estimation of expenses for reconstruction of the inner system of heat supply in one of high building, including installation of meters in every flat. — *
- Environmental study connected with the construction and operation of geothermal system of heat supply.

III. Preliminary Financial Analyses and Proposals According to the Type of Property

- Estimation of expected earnings and transition of funds based on tariffs and solvency of consumers (residential, commercial, municipal and industrial).
- Estimation of operation expenses taking into consideration permanent and variable costs in different months.
- Analyses of financial risk connected with the accuracy of calculated needed investments and estimation of income, importance of accurate information.
- Working out a characteristics of a private company that wants to own the operation system of Zugdidi geothermal heat supply.
- Working out recommendations of improving legal structure and administrative demands necessary for operation and the start-up of geothermal heating system.

From: Zugdidi Unified Multibranch Enterprise of Communal-Utility Services

To: Arsi Studio manager Mr. Alexander Arobelidze

A list of documents:

1. Certificate on power supply condition
2. Certificate on water supply condition
3. Certificate on Poultry Farm condition
4. Certificate on possible heating area =about 100 000 m^2 - residential.
   90 m^2 state buildings

5. Tea Factory N1	for heating and hot water supply
6. Clinical Hospital	10 000 m^2
7. Central Municipal Hospital	5600 m^2
8. Tuberculosis Hospital	
9. Wine Factory	for technological process
10. Bakery	for heating
11. Tea Weighting Factory "Odishi"	8410 m^2 36 800 m^3
12. Repair-Mechanical Plant	450 m^2
13. Machine Construction Plant	21.154 8120

From: Zugdidi Unified Multibranch Enterprise of Communal-Utility Services

To: Arsi Studio manager Mr. Alexander Arobelidze

March 21, 1996

Data Concerning Thermal Water Supply to Zugdidi Schools, Collages and Other Budget Organizations

There are 15 schools, 28 nurseries, two universities (one commercial and one state) and one collage in the city. They were heated automatically but now neither of them is supplied with hot water.

After the discussions with you we think it is reasonable to use thermal water for heating and hot water supply and according to the preliminary data the pipeline should be connected to:

1. University on King D. Agmashenebeli st.
2. Military unit
3. N 62 School of Professional-Technical Training
4. Schools N 1, 2, 4, 10
5. Nursery N 1. Nursery of Engury Power Plant
6. Military office
7. Financial office
8. Tax department
9. Zugdidi City Trade Department
10. Sakenergo Zugdiidi Office
11. Building of Communal-Utility Service Enterprise etc.

According to the preliminary data the above mentioned organizations will be able to pay the hot water and heating charges. Besides during the design work it must be taken into consideration that outer piping for hot water supply to the buildings will need rehabilitation, while the inner piping has to be totally replaced.

Manager of the Enterprise

N.Malaskhia

Supply System

Zugdidi is supplied drinking water from 3 head structures. Water is supplied to the town by Rechkho-Tskivi pipeline, the volume was 400 liter/sec. This pipeline is on Abkhazian territory, Gali region. The head structures, pump station and 35/6 kv power substation are also located there. 2 pumps are installed at the pump station instead of 3. Power of each pump is 800 kw. During winter, when there was power deficiency, problem, the pump station operated with interruptions due to the low frequency.

Because of the political situation in Abkhazia Rechkho-Tskiri pipeline does not operate now and there is no way to protect the equipment from robbery. 35/6 kv substation, 2500 kW transformer, 12 oil circuit breakers are out of order at the pump station. The cables and controlling equipment are stolen.

The second source of water supply is Rukhi head structure at river Enguri. Its capacity is 30-40 L/sec. and it does not supply the town, but only villages Rukhi and Abastumani. Rukhi pipeline consists of head structures, catchment and pump station with 2 installed pumps, 200 kwt each.

The third source of water supply is Olori head structure. Its capacity varies from 60 to 150 L/sec. The pipeline supplies water to Enguri Power station settlement, village Jvari and almost all the villages located along r.Enguri banks up to town Zugdidi. Consequently this source is insignificant for the town.

In order to save the situation the authorities of the town took timely steps to supply residential houses with water. 11 wells operate in the town with an average capacity 70-80 L/sec. This completely settled the problem of supplying drinking water to the residential houses of the town. Artesian depth pumps are installed at the wells. That's why in winter, when power frequency is low, the motors often get out of order. Besides the residential houses, enterprises and private companies of the town have 10 their own wells, total capacity of which is 70 L/sec. So there are 21 wells in the whole, their total capacity is 150-160 L/sec.

In order to solve the problem of supplying Zugdidi with water, construction of 30 km pipeline, connected to Jvari reservoir, including cleaning structures, started in 1988. The pipeline will operate at gravity flow, that will make it possible to supply the town with drinking water during power deficiency periods.

According to the preliminary estimates 5 million US dollars are necessary to finish the construction. Some part of the work 2 km is already finished. At present the construction works are stopped, because there is no funding.

It is impossible to solve the problem of water supply to the town in the nearest future without rehabilitation of Recckho-Tsaishi pipeline after the existing problems of the political stabilization in Abkhazia settled. It is impossible to find an equal debit until Jvari-Zugdidi pipeline is built. According to the preliminary estimate 70-80 thousand US dollars are needed for the rehabilitation. It is also necessary to find a way of financing the construction of Jvari pipeline, that will bring us closer to the solution of the problem. As to the drinking water supply to village Tsaishi the problem can be settled by means of wells and installation of equipment on river Jumi.

June 6, 1996

DELIVER ORDER NO. 25
GEOTHERMAL DISTRICT HEATING
ZUGDIDI, GEORGIA

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3.0 ASSESSMENT OF THE ZUGDIDI GEOTHERMAL RESOURCE

3.1 Regional Geography and Climate

The city of Zugdidi is located in the western part of the Republic of Georgia, some 25 kilometers from the Black Sea coast, and over 200 kilometers west of the national capital, Tbilisi. Zugdidi and its suburban district of Tsaishi are between 30 and 100 meters in elevation above sea level. Generally, the region is flat to gently rolling in topography. However, immediately to the north rise the majestic peaks of the Great Caucasus mountains, reaching over 3,000 meters in elevation at a distance less than 50 kilometers from the city. At a much greater distance to the south, across the valley of the Rioni River, rise the Lesser Caucasus mountains.

Climatologically, the area is characterized by cold winters and hot summers, the coldest month, January, averaging about 5°C in temperature, and the hottest months, July and August, averaging about 22°C to 23°C. Maximum temperature during summer days may reach 30°C, or even 40°C under extreme conditions. Winter night-time lows, typically in December, January and February, may be -5°C to -10°C, with the lowest temperature recorded as ~~-19°C.~~ Mean annual air-temperature is 14°C.

Precipitation is moderate to abundant, usually varying between about 500 and 1,000 mm per year, and occurring on an average of 160 days per year. This precipitation is most abundant between the months of November through March, with a pronounced drier season during April through October. However, in some years, individual months of the drier season may have greater precipitation than individual months of the wetter season. It is rare for any winter month to have less than 70 mm of rain or snow, or for any dry season month to have less than 50 mm of rain. Maximum monthly precipitation in any season can exceed 200 mm in certain years, and on rare occasions 300 mm.

Wind direction in winter typically is from the east (continental wind), whereas summer wind direction is from the west (marine wind). The climate year-round is humid, with high relative humidity increasing the sense of discomfort in both the hottest and the coldest periods.

3.2 Regional and Local Geology

The east-west trending valley of the Rioni River is a structural basin that is believed to widen and deepen to the west. Zugdidi lies along the northwestern margin of this basin. The basin is underlain by an essentially sedimentary suite of Mesozoic and Cenozoic rocks to a depth of at least 3 kilometers, and perhaps to much greater depth in the west beneath the Black Sea.

In the Zugdidi area, Jurassic claystone, marl, sandstone and dolomite, interbedded with basaltic lava flows and gypsite lenses, all of an unknown maximum thickness, are overlain by a 2-kilometer thick sequence of Cretaceous limestone, claystone, marl and dolomite, with rare intervals of volcanic tuff debris. This, in turn, is overlain by a sequence of Paleocene to Pliocene marls and clays, to a maximum of about one kilometer in thickness. This entire sequence has been folded lightly and faulted in places, and then planed off by erosion. The result is that, in drilling, individual

rock units may be missing or repeated. The truncated Pliocene surface is covered by a thin veneer of Quaternary alluvial and fluvial deposits, mostly unconsolidated sands, gravels, silts and clays.

On the flanks of the Great Caucasus mountains, north of Zugdidi, are exposed Precambrian, Paleozoic and Early Mesozoic metamorphic and igneous rocks of widely varied composition, along with Late Mesozoic and Cenozoic igneous rocks. Quaternary volcanism is present much farther to the south in the Lesser Caucasus mountains.

3.3 Regional Hydrological and Geothermal Systems

Precipitation, as mentioned earlier, is plentiful in the Zugdidi area, and is very abundant in the Great Caucasus mountains to the north. As a result, surface runoff of rainfall and snow melt gives rise to numerous year-round rivers and streams. The west-flowing Rioni River, the largest in the region, originates high in the Caucasus mountains, and is supported by numerous tributary streams that flow from the north. In the immediate vicinity of Zugdidi, the Inguri River is the principal surface stream. It flows southward from the high Caucasus, entering the Black Sea directly, without joining the Rioni River. Within 20 or 30 kilometers of Zugdidi, numerous smaller streams flow in courses parallel to the Inguri River, most going directly to the Black Sea, while a few unite with the Rioni River en route. Thus, the entire region has abundant surface water flow.

The Inguri River has a total length of 200 kilometers, and drains an area of some 4,000 square kilometers. It flows all year. However, flow is at a maximum during June and July, fed by snow melt in the Great Caucasus. The season of low flow is winter, through about March, despite locally abundant winter rains. This shows the importance of the Great Caucasus mountains as a feed source for surface water.

The same scheme is observed in the subsurface water regime. Subsurface water flow parallels the surface streams, from the north to south and from east to west. Recharge to aquifers, both shallow and deep, is believed to come from water that infiltrates on the mountain slopes of the Great Caucasus. It is reported that karst terrain is present locally, which greatly aids in this subsurface recharge. Water produced from deep wells at Zugdidi, and elsewhere, flows under an artesian head. This strongly suggests hydraulic continuity between the deep sedimentary basin and its recharge areas in the Great Caucasus mountains. As additional evidence of this deep recharge of water beneath the basin, chemical analyses of water from deep wells in the Zugdidi region show increasing mineralization with increased distance from the Great Caucasus mountains. This suggests that water slowly moves downgradient into the deep basin, becoming more mineralized with time as a result of water-rock interaction.

Subsurface water temperature, however, decreases towards the center of the Rioni River basin; and the depth to a given isotherm increases basinward. This suggests several things about the nature of the thermal system. First, there appears to be no heat source beneath the basin. Instead, the source of heat appears to be associated with the flanks of the Great Caucasus mountains. This source may be one or more cooling intrusive bodies at depth, or highly radiogenic igneous rocks (granitic rocks?) within the Caucasus block. Second, it appears either that the heated fluid from the Caucasus margins does not move basinward rapidly, and thus cools by conduction, or that this fluid is diluted by larger quantities of cold subsurface water moving downgradient from the east within the

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basin. Finally, the thermal gradients calculated from measurements made in deep wells in Zugdidi and the surrounding areas are not representative of magmatic heat sources. They are, instead, more typical of deep circulation under conditions of 'normal' regional heat flow or only slightly greater than 'normal.'

The entire zone along the Caucasus front, from northwest of Sukhumi, southeast into the center of the country, is characterized by thermal springs and artesian thermal water wells. Zugdidi is a part of this trend. Viewed overall, this pattern supports a model in which there is very deep circulation of meteoric water along the front of the Great Caucasus, either within highly folded rocks or along faults that cut these rocks. The water is heated under conditions of near-normal thermal gradient, and then rises towards the surface because of its lowered density. This water then flows basinward within aquifers of Mesozoic age, cooling by conduction or by dilution. The water interacts with its host rocks, thereby becoming increasingly mineralized with time.

This appears to be the provenance of the Zugdidi geothermal waters. The same mechanism may apply to most of the Georgian thermal waters. Based on this model, the most attractive targets for geothermal development are to be found near the basin margins in sedimentary aquifers that exhibit hydraulic continuity with the recharge areas of the Great Caucasus. Zugdidi appears to be one of the most favorable representatives of these conditions.

Several government organizations drilled at least 23 thermal-water wells in the Zugdidi-Tsaishi area of the structural basin, beginning in 1950 and continuing into the 1980's. Well depths varied greatly, between about 600 meters and 3,728 meters. Most, if not all, of the wells penetrated thermal-water-bearing strata of Lower Cretaceous (Neocomian) age. These strata are formed of fractured, occasionally vuggy, and possibly cavernous limestone, dolomite and marl, up to 865 meters in thickness.

Depth to the thermal reservoir ranges from as shallow as 750 meters to as much as 2,450 meters, reflecting the structural complexity of the Cretaceous section beneath the basin floor. Similarly, drilled thickness of the reservoir rock has varied greatly, exceeding 1,240 meters in one hole, this also being a function of rock folding and fault offset, and subsequent erosion. Some holes penetrated through the reservoir into Jurassic sedimentary and volcanic rock; others were completed in the reservoir. Capping the reservoir is an impermeable chalky limestone of Upper Cretaceous and Paleocene age.

Temperatures measured in the Zugdidi-Tsaishi thermal system are reported to be between 81° C and 102°C. It is unclear which measurements were made downhole in the reservoir, and which represent water discharge at the surface. Most (perhaps all) wells flowed under artesian pressure, at least immediately after being drilled and in some cases are still capable of flowing. Fluid chemistry was reported to be mainly Calcium-Sodium-Sulfate-Chloride in composition, with total dissolved solids ranging up to 24,000 mg/liter.

Wells were tested immediately after being drilled and completed, and at various intervals subsequently. However, there have been no measurements made in recent years, and most, if not all, wells have been damaged during that time. Test data can be said to represent an initial condition in what probably were undamaged wells. Because of damage to the wells, probably not one today can

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perform comparably to the test data.

3.4 Aggressive Behavior of the Thermal Water

Wells at the Zugdidi-Tsaishi geothermal field presently show extensive evidence of scale deposition and corrosion. However, it is uncertain whether this represents a true picture of well performance under preferred conditions of production; or whether the scaling and corrosion represent the results of well damage and/or a lack of routine well maintenance.

Total dissolved solids (TDS) have been measured for produced waters from many Zugdidi and Tsaishi wells. These analyses show 9,000 to 24,000 mg/liter TDS, mainly SO_4 and Ca, followed in abundance by Cl and Na, and then by Mg and HCO_3 ions. This is fairly typical of low-enthalpy waters derived from a non-magmatic regime, usually from a reservoir in older basaltic rock and/or organic-rich sedimentary rock. However, it is not known when or under what conditions the sampling and analyses were performed, or if they are truly representative of the geothermal reservoir fluid.

Gas concentrations also are reported for selected wells at both Zugdidi and Tsaishi. They range from 20 to 33 cm^3/liter by volume (approximately 2.0 to 3.3 volume-%). In composition, the gases principally are N_2 and CO_2. No analysis is provided for H_2S. The extremely high concentration of N_2 suggests that contamination by admixture of air is occurring in the shallow subsurface or in the well bores. Here, again, the conditions under which sampling was done are not known, nor are the conditions of sample preservation and chemical analysis.

Deposition of calcium carbonate scale can be expected from waters of this general chemistry (assuming that the analyses are approximately accurate). Such scaling typically takes place where the fluid undergoes a pH change and/or where there is a sudden decrease in fluid flowing pressure. Most often this occurs at or near the wellhead. This is especially the case where fluid is discharged to the atmosphere without confinement, such as in a flowing artesian well, or in a well whose surface valves have been removed or damaged. Both sets of conditions occur at Zugdidi-Tsaishi.

There is no indication of silica scale formation, or of other less-common scales. However, chemical analyses of the scale deposits at Zugdidi and Tsaishi wells will be necessary in order to determine the actual scale composition.

Calcium carbonate scale can either be removed or prevented, depending upon field conditions. Removal can be by mechanical scraping, which is practical and inexpensive, and is carried out at many geothermal fields worldwide; or by acidization of the wellbore, which is more expensive and more likely to damage the well casings, and which therefore is less commonly used. Prevention of scaling is done by injection of chemicals downhole to change fluid pH or to otherwise modify fluid behavior, and thus to retard to even eliminate scale precipitation. This is often done in geothermal wells, but requires the availability of suitable chemical additives, which may not be the case presently or in the near future in Georgia.

Well design also can be modified to reduce scale formation by eliminating abrupt changes in well diameters or drops in pressure. The principal pressure drop is associated with unconfined

discharge at the surface in an artesian well. This may be an argument in favor of installing pumps on wells in the future.

In any case, scale deposition can be suppressed by one means or another, after chemical analyses of well fluid and scale have been made anew and studied. The occurrence of calcium carbonate scale should not be considered a limiting factor on the development and utilization of the Zugdidi-Tsaishi geothermal reservoir.

Corrosion typically takes place where air is allowed to mix with the geothermal fluid, causing oxidation of H_2S (where present) to H_2SO_4, and of various other gases (if present) to such other acids as HCl. No reliable analyses of H_2S are presented. Therefore, careful sampling and analyses of non-condensible gases in the geothermal fluid is a necessary first step in the determination of the corrosion potential. One report states that steel corrosion rates are between 0.14 and 0.16 mm/year at Zugdidi-Tsaishi. Here, again, it is not known whether this represents laboratory tests, or actual downhole or wellhead measurements, or under what conditions.

If wells can be constructed at Zugdidi-Tsaishi to prevent air admixture with the thermal fluid, as is commonly done in geothermal fields worldwide, the potential for corrosion can be reduced significantly, and perhaps even avoided completely. If corrosion cannot be eliminated or kept to acceptable levels, the use of soft steels for casings and valves, and/or the injection of pH modifiers (neutralizing solutions) may be useful, although potentially costly.

To summarize, there appears to be a potential for both scale deposition and corrosion at Zugdidi-Tsaishi. The intensity of these potentials cannot be determined at this time, because of the lack of suitable chemical analyses and because of uncertainties regarding well construction and operating conditions. Scaling most certainly can be contained or even eliminated at relatively low cost if proper well construction and operating practices are followed. Corrosion also can be reduced or eliminated if the mixing of air with geothermal fluid can be avoided. This should not be too great a problem, if proper practices are followed. Because the fluid is of relatively low enthalpy, and appears to be of relatively benign composition, scale control and minimization of corrosion should be possible at the Zugdidi-Tsaishi field.

3.5 Results of Previous Well Testing

Data are available for the discharge of thermal fluid from various wells at Zugdidi and Tsaishi over time and under various flow conditions. Mass flow rates of up to 6,000 cubic meter per day are reported (well 10-T), and the average for 9 Tsaishi production wells (10-T, 8-T, 1-OP, 14-T, 17-T, 1-T, 16-T, 13-T and 2-T) is approximately 3,000 m^3/day. Transmissivity has been calculated in previous reports by Georgian scientists as 400 to 500 m^2/day, with a drawdown of less than 1 kg/cm^2, which is attractive for exploitation. Total sustainable yield from the Zugdidi-Tsaishi reservoir is estimated in various reports to be between 60,000 and 120,000 m^3/day of water at an average temperature of about 90°C. This picture is favorable for commercial utilization in space heating and industrial applications. Injection testing also has been carried out, apparently under conditions of gravity feed (zero wellhead pressure), which again is highly attractive, as it eliminates the need for pressurized pumping during disposal of residual fluids after utilization.

However, the actual conditions under which these measurements and calculations were made are unknown. Further, mass flow rates are reported to decrease significantly with time for several wells. Some wells reportedly have ceased to flow. It is not known why these declines have occurred, although several explanations (and possible remedies) can be suggested.

Individual wells may be interfering with each other, as a result of being spaced too closely together. This can be avoided or minimized by using a wider spacing. Unfortunately, the optimum well spacing cannot be calculated at present, given the uncertainties regarding the field data. Alternatively, the use of pumps rather than allowing artesian flow can maintain mass flow, even while allowing fluid levels to be drawn down in the reservoir. This, again, can be determined only after extensive well testing. It is also possible that total reservoir storage is limited, at least locally or within specific reservoir rock units, in which case sustainable yield may be less than the estimated 60,000 m^3/day. This seems less likely, given the high mass flow rates reported initially, the relatively good transmissivity, the small pressure drawdown, and the gravity feed acceptance in injection tests.

Another possibility, perhaps more likely, is that individual wells have been reduced in diameter by scale deposition, or have suffered mechanical damage such as casing collapse. This can easily explain a decrease in mass flow, or an abrupt cessation in flow, for individual wells, but usually does not affect an entire wellfield. However, it has been observed that almost all, if not all, wells at Zugdidi and Tsaishi have been damaged or exhibit scaling in surface piping. This may support the idea of scaling and well damage as a major cause of pressure and flow reduction. Scaling, as described elsewhere, can be controlled mechanically and chemically.

Given these conditions, it is not possible at this time to decide either the cause of mass flow declines or the optimum conditions under which these wells can be produced. Further testing is necessary, including both flow and injection tests, with and without pumps, accompanied by fluid sampling and chemical analysis of dissolved solids and non-condensible gases. It may ultimately be necessary to install pumps in various wells in order to maintain a desired production rate. The future pressure drawdown that would result from this is unknown at this time, and can be calculated only after well testing has been accomplished.

3.6 Recommended Testing Programme

A multi-step programme is recommended for the Zugdidi-Tsaishi wells, in order to determine the potential for commercial utilization of the thermal fluid. These tests are designed to be carried out in stages, using simple equipment in the initial steps, and involving more complex operations as warranted by the results of the initial steps. In this way, the expenditure can be minimized initially, until it is confirmed that a resource of potential value is present at the Zugdidi-Tsaishi geothermal field.

3.6.1 Survey of Existing Conditions

This should consist of three steps, carried out simultaneously. These are:

- A physical inventory of wells: how many wells are there; exactly where are they; what is their present condition; what equipment is present on-site; is the equipment in operating or repairable condition. A map and tables should be compiled show exact location and status. No specialized equipment is required for this survey.

- Samples of scale should be collected from each wellhead and/or surface discharge pipe for chemical analysis in a laboratory very experienced in such analyses. Sterile sample vials, preferably of polypropylene or polyurethane, should be used ot prevent sample loss during transportation. Sample size should be a minimum of several grams for each well.

- Attempts should be made to pass a metal bar ("sinker bar") down each well, to determine if blockages exist, and at what depth; if possible, sinker bars of varying diameter should be used, to obtain precise information on well diameter and blockages. Because several wells are capable of flowing high-temperature water, precautions must be taken against sudden eruptions; this may involve erecting a metal or wooden screen around the wellhead during probing. A truck-mounted winch, preferably motor driven, with an A-frame and up to 3,000 m of cable is required, along with the weighted bars. Meter intervals should be marked on the cable for ease of reading depth. Data should be compared with original data on well depth, diameter and casing conditions for each well, in order to determine which wells are still in communication with the reservoir.

This work should be done by a Georgian crew under the direction of an international expert, experienced in geothermal well drilling and testing activities. Approximately 3 weeks of field work is anticipated.

3.6.2 Analysis and Design of Well Tests

Based on this information, it should be determined which wells (if any) are available for immediate production testing, and which must be reconditioned or repaired before testing can be carried out. A detailed list of necessary equipment and supplies must be prepared, both for testing of the immediately available wells, and for reconditioning or repair of the damaged (but ultimately usable) wells. Along with this there must be a detailed estimate of cost and time required for the operations. As part of the testing programme, assuming that some well(s) can be used, an injection well must be identified and specifications given for injection testing. If no well(s) can be used or salvaged, it must be decided whether to drill new wells for testing and field development purposes. Here, again, an injection well must be identified for fluid disposal. This work should be done by a combined group of Georgian and international geothermal experts. Up to one calender month effort is anticipated.

3.6.3 Detailed Well Testing

Well testing should consist of the following elements:

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- Downhole logging of temperature, pressure, and well diameter, under flowing and shut-in conditions. This is necessary in order to determine the stabilized temperature profile, and the precise points of fluid entry into the well, as well as for use later in reservoir modeling. Several suites of measurement will be needed for each well until true stabilized conditions are reached.

- Short-term discharge tests, to determine whether long-term testing is useful (that is, does the well flow, and can it be kept discharging). This test may be 3 days to one week in duration.

- Long-term flow tests, with or without pump assistance, to determine well production characteristics. This test may follow immediately after the short-term test if results are satisfactory (the well continues to flow without unacceptable decline in pressure or mass flow rate). Test duration may be several weeks to several months for each well. Wells may be tested individually in sequence, or in some time-stepped or overlapping pattern, to obtain data on individual well performance with and without interference from nearby wells.

- Injection testing of selected wells as possible long-term disposal wells. This should be done initially without a pump, to determine if gravity flow is sufficient to accept all produced fluids, and later under pump pressure to obtain data on the number of wells needed for disposal during commercial operation. More than one disposal well probably will be needed ultimately.

- Chemical sampling and analysis of water and non-condensible gases. This should be done on several occasions for each well, throughout the course of the well tests, to determine true reservoir fluid chemistry. Care must be taken to avoid contamination, loss of species by precipitation, or loss of non-condensible gases during sampling, sample storage and transportation to laboratory. A laboratory experienced in such work should be selected, and results monitored through the submittal of doctored blank samples.

Such testing will probably require several months in total, including mobilization of equipment, actual test and sampling operations, chemical analyses, and data transmittal and compilation. An international expert in geothermal well testing should be on site for at least the start up and completion of activities. This would involve at minimum the training of Georgian counterpart staff, installation and calibration of equipment, collection of at least the first suites of data, preliminary data-quality analyses, and finally mobilization. An inspection trip midway in the well testing operations may also be required.

3.6.4 Modeling of Optimum Field Performance

Before a decision can be taken to proceed commercially with field development and utilization, there must be a serious analysis of the collected data. This probably will involve a wellbore and wellfield simulation, and the construction of a field model. The model and simulation will be used to predict resource size, long-term well behavior, well spacing, well maintenance requirements, and optimum production levels through time. Such matters as scaling, scale control,

and corrosion and corrosion control can be evaluated, as a part of field optimization. An inspection trip midway in the well testing operations may also be required.

3.6.5 Planning of Future Wells

A final step in the process will involve plans for additional production or injection wells. This will involve well design, well location, costing of drilling, logging and testing, preparation of drilling specifications, and possibly the preparation of tender documents. This step will depend, of course, on the justification that a commercially viable geothermal resource exists at the Zugdidi-Tsaishi field.