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# PRE-FEASIBILITY REVIEW OF 500 KV TRANSMISSION LINE – SOUTH GEORGIA

Advisory Assistance to the Ministry of Energy of Georgia  
P.E.D. IQC – Contract No. DOT-I-00-04-00020-00 Task Order # 800



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# CONTENTS

EXECUTIVE SUMMARY .....	5
INTRODUCTION.....	6
1. SHORT HISTORY OF THE “500 KV TRANSMISSION LINE - SOUTH GEORGIA” PROJECT .....	7
2. SHORT TECHNICAL DESCRIPTION OF THE PROJECT .....	12
3. CURRENT CONDITION OF THE 500 KV TRANSMISSION LINE - SOUTH GEORGIA.....	13
4. INFORMATION ON THE PROPOSED PROJECT: 500 KV LINE - TBILSRESI-SOUTH GEORGIA-ZESTAPHONI-AKHALTSIKHE-TURKEY .....	13
5. TRANSMISSION LINE TARIFF ESTIMATES.....	16
6. ADDITIONAL INFORMATION .....	29
PHOTOS.....	30
APPENDICES.....	47
APPENDIX 1 – Conclusion #9-101 - dated July 26, 1985 of the Department of Power Projects’ Expertise of the Ministry of Energy and Electrification of the USSR - Regarding Justification Materials on Design and Construction of 500 kV Line Azerbaijan TPP-Armenia NPP-Zestaponi and 500 kV Line Tbilisresi-South Georgia-Samtredia-Enguri HPP (Georgian, Armenian and Azerbaijan SSR).....	48
APPENDIX 2 – General Routing Plan of 500 kV High Voltage Line Tbilisresi-South Georgia- Samtredia-Enguri HPP - 1984 .....	49
APPENDIX 3 – Order #539p of the Council of Ministers of the Georgian SSR - June 5, 1987 .	50
APPENDIX 4 – 500 kV Line Tbilisresi-Enguri HPP. Stage I – Tbilisresi-South Georgia- Zestaponi. Volume 1 – Materials of Route Selection and Approval for Overhead 500 kV Transmission Line.....	51
APPENDIX 4.1 – Detailed Routing Plans of 500 kV Line Tbilisresi-South Georgia-Zestaponi ..	52
APPENDIX 5 – 500 kV Line Tbilisresi-Enguri HPP. Stage I – Tbilisresi-South Georgia- Zestaponi. Volume 8.1 – Financial Documentation: Combined Expenses and Budget of Construction Costs .....	53
APPENDIX 6 – Working Group Report: Results of Technical-Economical Assessment of Power Exchange between Georgia, Azerbaijan and Turkey, Ankara, Turkey, May 1998 .....	54
APPENDIX 7 – Additional Materials on Construction of Power Transmission Line Connecting with Turkish Power System & Substation. Volume I – Project Description and Drawings, Tbilisi, 1999.....	55
APPENDIX 7.1 – 500-400 KV Line Routing Plan from Akhaltsikhe to Border with Turkey - 199956	
APPENDIX 8 – Order #33 of the Minister of Energy of Georgia - June 14, 1999.....	57
APPENDIX 9 – Order #57 of “Electrogadatsema” – June 15, 1999 .....	58
APPENDIX 10 – Order #1-3/589 of the Ministry of State Property Management - dated August 16, 2002 – Regarding establishment of “SakTurkAzKseli, Ltd” .....	59
APPENDIX 11 – Conclusion of Audit by “Temo Ltd” - July 12, 2002.....	60
APPENDIX 12 – Order #1-3/618 of the Ministry of State Property Management - September 4, 2002 – Regarding renaming “SakTurkAzKseli, Ltd” into “EnergoTrans, Ltd”.....	61
APPENDIX 13 – Protocol #1 - February 11, 2000 and Protocol #2 - March 3, 2000 of Russian-Georgian working group on Cooperation in Power Sector .....	62
APPENDIX 14 – Agreement between RAO UES and Georgian Government on Construction of 500 kV Transmission Line Zestaponi-Akhaltsikhe-Border with Turkey - July 2000 .....	63
APPENDIX 15 – Volume II – 500 kV Line Zestaponi-Akhaltsikhe-Border with Turkey, Technical-Economic Justification – Tbilisi, 2000 .....	64
APPENDIX 16 – Volume III – Cost Estimates – 500 kV Line Zestaponi-Akhaltsikhe-Border with Turkey, Technical-Economic Justification – Tbilisi, 2000 .....	65
APPENDIX 17 – Decision #44/10 - April 10, 2001 by State Commission of Georgia of Land Use and Protection – Regarding allocation of land in Aspindza and Akhaltsikhe regions for construction of 500 kV line; Agreement on Land Allocation by State Department of Land Management of Georgia; GSE’s and SakRusEnergo’s Letters .....	66
APPENDIX 18 – Inventory Acts on Suspended Construction of the 500 kV Line Tbilisresi- South Georgia-Zestaponi.....	67

APPENDIX 19 – Energotrans’ Letter #23 - Mar 16, 2004.....	68
APPENDIX 20 – E-mail Correspondence with TEIAS.....	69
APPENDIX 21 – UCTE Expansion Plans .....	70

# EXECUTIVE SUMMARY

This pre-feasibility study introduces a project concept of the proposed 500 kV transmission line - South Georgia as a potential investment opportunity. The study provides a brief history of the project, information regarding the initial (approved) design projects, including information on prior construction, a discussion of the current condition, information on prerequisites for a new design, summary of the technical description and parameters, and a discussion of the merits of continued construction and use of the line. We also give a general economic assessment of the project.

The document was developed using existing data, photos taken during an inspection of the facilities and auxiliary infrastructure, and other information received from construction managers and other specialists. None of the sources were verified, and we have made no attempt to assess the data and analysis contained in them. Our very preliminary estimates of the economic characteristics of the 500 kV transmission line operations are based on the best data available to us.

Since the suspension of its construction the line has generated recurring interest from various parties and several initiatives have been launched for its completion, but so far none has been carried out.

# INTRODUCTION

Georgia's largest generation potential comes from naturally renewable resources of environmentally clean hydro and wind power. Its hydro power potential is estimated at up to 80 billion kWh annually, of which up to 60 billion kWh may be economically attractive, while the remainder is attributable to smaller rivers. Georgia has significant existing hydro generation, to which additional production is anticipated in the medium term future. Currently there are about 60 larger and smaller capacity power stations with an annual maximal output capability of about 8 - 9.5 billion kWh. That is, less than 15% of the theoretically usable hydro potential is currently used. An economic feasibility study of wind energy resources was carried out in 1990s, showing a theoretical potential of about 5 billion kWh annually.

Besides hydro, there is approximately 650 MW of existing thermal capacity in eastern part of the country (Gardabani, south-east from Tbilisi). In addition 2 units (150-160 MW) of Combined Cycle Gas Turbine power plants are being built. Thermal generation is mostly used for winter season to balance low water availability in winter, but their output would also be available for export at competitive prices in off peak demand season (spring-summer).

Despite this large potential, there is a significant generation-load imbalance in the Georgian power system: two-thirds of Georgia's energy resource is located in the north-western part of the country, while two thirds of the domestic demand is located in eastern Georgia, and most of the expected export market is located in countries to the south of Georgia. Power delivery to these markets requires a reliable high voltage transmission network. At present only one strong line connects West and East Georgia, the 500 kV transmission line "Imereti" – "Kartli-II" – "Kartli-I". There is a constant power flow from east to west and in case of any fault on this line, especially during autumn or winter, a large power deficit in the east is incurred, including frequent total blackouts of the system.<sup>1</sup> Even for planned repairs of the 500 kV line there is no alternative route which could be used to deliver power from West to East. This is obviously harmful for the economy and the country's ability to reliably interconnect with neighboring countries' systems. Having only one 500 kV longitudinal backbone between generation and load in the Georgian system not only reduces internal reliability of the grid, but also limits existing and future power swap or export potential.

At the same time, countries in the region (especially Turkey, Iran, Iraq) are experiencing rapid economic growth and offer large potential demands for electric power capacity and energy.

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<sup>1</sup> According to blackout statistics provided by Georgian State Electrosystem (GSE - high voltage transmission and dispatch company) there were:

25 partial and 7 complete system blackouts in 2003;  
37 partial and 5 complete system blackouts in 2004;  
30 partial and 2 complete system blackouts in 2005 (January-July).

# 1. SHORT HISTORY OF THE “500 KV TRANSMISSION LINE - SOUTH GEORGIA” PROJECT

Work on strengthening the transmission network and increasing connection lines with neighboring republics began in the 1980s. On July 26, 1985 the Department of Power Projects' Expertise of the Ministry of Energy and Electrification of the USSR reviewed initial project materials that envisaged construction of new transmission lines in South Georgia connecting electricity systems of Southern Caucasus republics with 500 kV lines and strengthening Georgia's internal transmission network ([APPENDIX 1 – Conclusion #Э-101 - dated July 26, 1985 of the Department of Power Projects' Expertise of the Ministry of Energy and Electrification of the USSR](#)).

Soviet development plans included construction of the following 500 kV lines:

- 500 kV switching point at Akstafa, with (2x14 km) connection to 500 kV line Azgres–Mukhranis Valley;
- 500 kV line Akstafa–Armenia (127 km);
- 500 kV line Azgres–Akstafa (227.5 km);
- 500 kV switching point in Armenia-South Georgia (117 km);
- 500 kV switching point South Georgia;
- extension of 500 kV open switchyard at Azgres;
- 500 kV substation in Armenia;
- 500 kV line Tbilisresi-Zestaponi-Samtredia-Enguri HPP (385 km);
- 500 kV cell and Installation of reactors at Enguri HPP;
- Installation of reactors at Tbilisresi;
- 500 kV line Enguri HPP–Sokhumi (108 km);
- 500 kV line Sokhumi–Adler (123 km).

The 500 kV transmission line - South Georgia was originally conceived and designed by the Georgian, Armenian, Azerbaijan and Middle Asia Departments of the Soviet Union's Design-Exploration and Scientific-Research Institute of Power Systems and Electric Networks “EnergoSetProekt” (PowerNetworkDesign). The design was part of larger development plans (mentioned above) with the goal of connecting the electricity systems of Russia and all three Trans-Caucasian Republics by means of new 500 kV transmission lines, and to improve reliability of the Georgian power system. The initial design included a 500 kV line section connecting Tbilisresi Thermal Power Plant in Gardabani directly with Enguri HPP ([APPENDIX 2 – “General Routing Plan of 500 kV High Voltage Line Tbilisresi-South Georgia-Samtredia-Enguri HPP” - dated 1984](#)), but the intended construction schedule was to split it into two parts and do the 1<sup>st</sup> stage from 1988-1990 as construction of Tbilisresi-Zestaponi section; then do a 2<sup>nd</sup> stage between 1990-1992 as construction of the Zestaponi-Samtredia-Enguri HPP section ([APPENDIX 1, p.13 – Conclusion #Э-101 - dated July 26, 1985 of the Department of Power Projects' Expertise of the Ministry of Energy and Electrification of the USSR](#)).

The project design development started in 1987 with identifying the corridor for Tbilisresi-Zestaponi section and routes for supporting roads ([APPENDIX 3 – Order #539p of the Council of Ministers of the Georgian SSR - dated June 5, 1987](#)). Design work by “EnergoKselProekti” (PowerNetworkDesign Institute – Georgian Branch of “EnergoSetProekt”) for this section was finished by the end of 1988. The Project Documentation consists of 9 volumes ([APPENDIX 4, p.3&4 – 500 kV Line Tbilisresi-](#)

Enguri HPP. Stage I – Tbilrsesi-South Georgia-Zestaponi. Volume 1 – Materials of Route Selection and Approval for Overhead 500 kV Transmission Line). The length of the section is 246 km. The detailed drawings and line routing plans of this section are given in APPENDIX 4.1 (APPENDIX 4.1 – Detailed Routing Plans of 500 kV Line Tbilrsesi-South Georgia-Zestaponi). Construction cost for this section of the transmission line was estimated as 61 831 000 Rubles, based on 1984 year prices (APPENDIX 5, p.9 – 500 kV Line Tbilrsesi-Enguri HPP. Stage I – Tbilrsesi-South Georgia-Zestaponi. Volume 8.1 – Financial Documentation: Combined Expenses and Budget of Construction Costs).

Construction started in 1989 and continued until 1991. The work was carried out by mobile mechanized units of Construction Trust “KavkazElektroSetStroi” (Caucasus Electric Network Construction). Distribution of line sections for construction between units of KavkazElektroSetStroi is given below in Figure 1. The works completed during the construction (by 1991) included: fully completed sections of the line with total length of 42 km; installed poles – 80 km; pole foundations – 60 km.

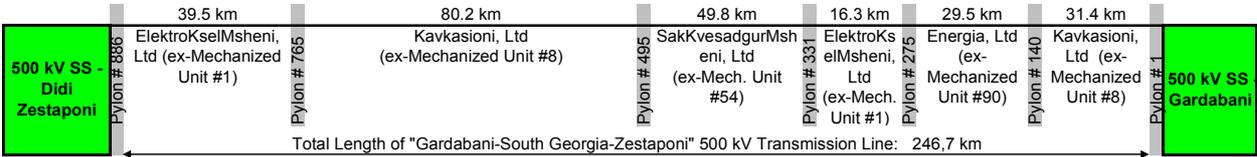


Figure 1: Distribution of Line Sections for Construction Between Mobile Mechanized Units of “KavkazElektroSetStroi” Construction Trust

Starting from 1992 further construction became impossible due to political events in Georgia. As constructed sections of the line were left unenergized and unprotected during all the years after suspension of its construction, it was significantly plundered.

By 1997-98 a new initiative to interconnect the Azerbaijan, Georgian and Turkish power systems via this 500 kV line evolved. Under this initiative Azerbaijan and Georgia would jointly export electricity to Turkey. Total export of 2.5 billion kWh/annum (300 MW on average) for the first 5 years, increasing to 5 billion kWh/annum (600 MW on average) in the following years, was planned. In addition to its export, Azerbaijan intended to cover its debt to Turkey for power supplies to Nakhichevan. This line would also help resolving the issue of power supply to isolated Nakhichevan (part of Azerbaijan bordering Turkey and separated from the rest of Azerbaijan by Armenia).

Based on the agreement between Azerbaijan, Georgia and Turkey, a preliminary design and technical-economic justification (feasibility study) for a new project extending Tbilrsesi-South Georgia-Zestaponi 500 kV line to Akhaltsikhe and then to the previously agreed (before May-July 1998 agreement – see below in text) connection point in Turkey – Kars was elaborated by “EnergoKselProekti” in 1998 (Figure 2).

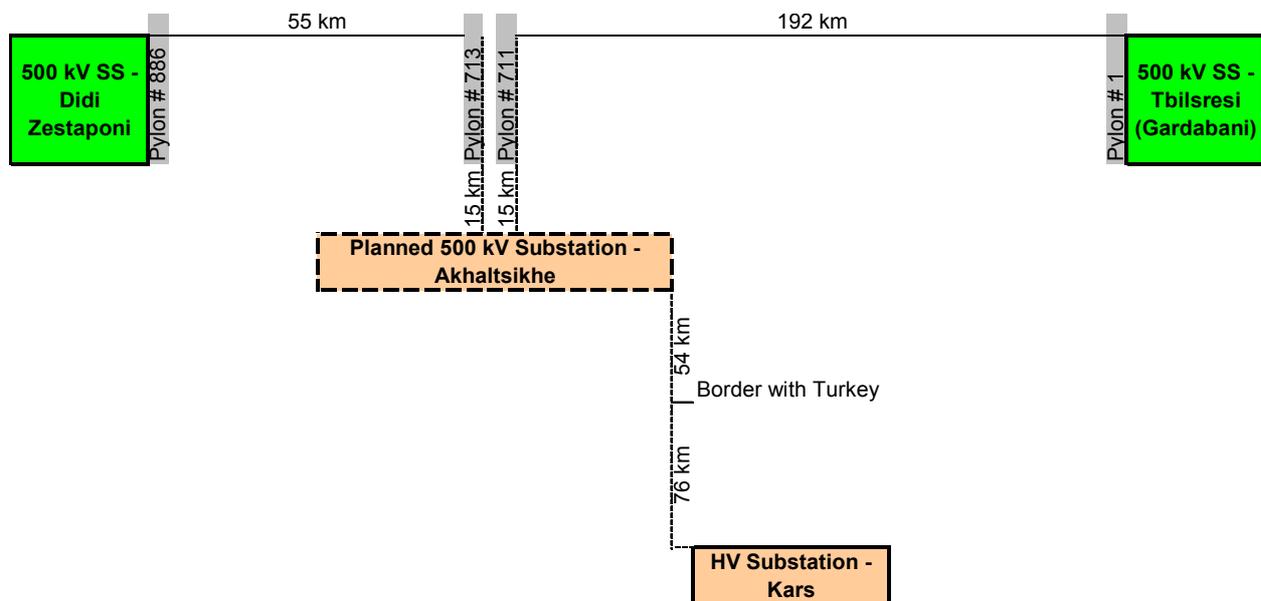


Figure 2: 1998 - 500 kV Line Extension Plan to Turkey

First Protocol on Cooperation in Power Sector between Georgia and Turkey was signed in Tbilisi on January 30, 1997. Shortly Azerbaijan also joined the initiative. After several high level meetings in Ankara, Baku and Tbilisi, a joint Protocol on Intentions between Azerbaijan, Georgia and Turkey was signed in Ankara on March 6, 1997. At the following meeting in Ankara on November 20-21, 1997 it was agreed to (a) elaborate and analyze options for power exchange between Azerbaijan, Georgia and Turkey; (b) set up an executive committee for decision making and further development of power exchange project. On the first session of the Steering Committee on Exchange of Power between Azerbaijan, Georgia and Turkey held in Baku on February 2-4, 1998 a working group to conduct a technical and economic analysis for the proposed power exchange options was established. After Tbilisi's (June 9-10, 1998) and Ankara's (July 20-21, 1998) meetings and review of the Working Group's report following decisions and recommendations were adopted:

- Although it was not possible to immediately implement (due to problems within power systems of participating countries), the preference was still given to future synchronous parallel operation;
- 500/400 kV transformer location was defined as Georgia (Akhaltsikhe) for its economic and technical feasibility.
- 670 MW Deriner HPP Substation was chosen as a connection point in Turkey as this would provide much stronger (400 kV instead of 154 kV from Kars to the rest of Turkish power grid) connection. Besides, length of the high voltage transmission line to be built from Akhaltsikhe would be shorter on 27 km (98 km instead of 125 km – Akhaltsikhe-Kars).

Combined construction costs of the reviewed options are given in the Working Group's Report ([APPENDIX 6](#), p.78 – "Working Group Report: Results of Technical-Economical Assessment of Power Exchange between Georgia, Azerbaijan and Turkey", Ankara, Turkey, May 1998). The export price at the Turkish border used for financial calculations by the working group was set at **3.5 cent/kWh**. The parties agreed to sign a trade and construction agreements. Trade agreement was prepared by Turkish side and provided to Georgian and Azerbaijan for review ([APPENDIX 7](#), p.72-73 – Additional Materials on Construction of Transmission Line Connecting with Turkish Power System and Substation. Volume I – Project Description and Drawings, Tbilisi, 1999. **Protocol #3** -

dated July 20-21, 1998). According to the last protocol on this issue signed on May 19, 1999 in Baku between Azerbaijan and Georgia, both countries agreed to sell equal volumes of electricity to Turkey. As both Azerbaijan and Georgia had old electricity debts to Turkey, it was agreed that each country would negotiate and cover its own debt in excess of agreed equal volumes sold. It was also acknowledged that 500 kV line Azerbaijan-Georgia-Turkey is a joint project requiring attraction of outside investor funds. Before announcing a tender, Georgia and Azerbaijan were planning to request from Turkey a guarantee on schedules, volumes and price of the electricity to be purchased. After recovering investment costs the line had to be transferred to the respective states based on its location ([APPENDIX 7, p.75-77](#) – Additional Materials on Construction of Transmission Line Connecting with Turkish Power System and Substation. Volume I – Project Description and Drawings, Tbilisi, 1999. **Protocol between Azerbaijan and Georgia** - dated May 18, 1999).

An organization which was put in charge of implementation of this project from Georgian side was formed in 1999 ([APPENDIX 8](#) - Order #33 of the Minister of Energy of Georgia - dated June 14, 1999; [APPENDIX 9](#) - Order #57 of “Electrogadatsema” – dated June 15, 1999). Initially it was an affiliate of the National Transmission Company (Electrogadatsema) called “Management of SakTurkAzKseli Construction”. Later (in 2002) it was separated from Electrogadatsema and an independent limited liability company with 100% state ownership was established which received ownership of the assets of partially built 500 kV Transmission Line “South Georgia” under a status of “suspended construction” ([APPENDIX 10](#) – Order #1-3/589 of the Ministry of State Property Management - dated August 16, 2002 – Regarding establishment of “SakTurkAzKseli, Ltd”). Its property (including the line and stored remaining construction materials) was inventoried and assessed by an audit company “Temo, Ltd” and valued at **38 077 868 GEL** as of July 1, 2002 ([APPENDIX 11](#) – Conclusion of Audit by “Temo Ltd” - dated July 12, 2002). In the same year SakTurkAzKseli, Ltd was renamed to EnergoTrans, Ltd ([APPENDIX 12](#) – Order #1-3/618 of the Ministry of State Property Management - dated September 4, 2002 – Regarding renaming SakTurkAzKseli, Ltd into EnergoTrans, Ltd).

Due to various reasons the Azerbaijan-Georgia-Turkey transit project was not realized in 1998-99, but by 1999-2000 Russia became interested in the possibility of electricity export via possible Kavkasioni-Imereti-Zestaponi-Akhaltzikhe-Kars line to the Turkish power market. After two meetings in Tbilisi of a Russian-Georgian working group ([APPENDIX 13](#) – Protocol #1 - dated February 11, 2000 and Protocol #2 - dated March 3, 2000 of Russian-Georgian working group on Cooperation in Power Sector), which were follow-ups of the initial inter-governmental Russian-Georgian Protocol on Cooperation in Power Sector signed on January 17, 2000, an agreement on Zestaponi-Akhaltzikhe-Turkey 500 kV line construction was concluded ([APPENDIX 14](#) – Agreement between RAO UES and Georgian Government on Construction of 500 kV Transmission Line Zestaponi-Akhaltzikhe-Border with Turkey - dated July 2000).

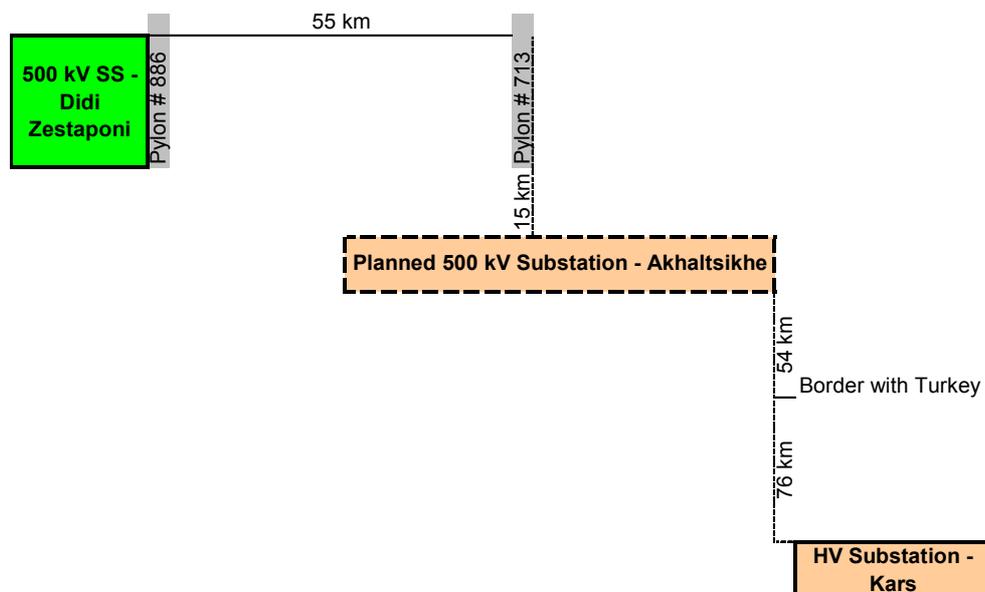


Figure 3: 2000-01 SakRusEnergo’s - 500 kV Line Extension Plan to Turkey

In follow up to the above-mentioned Russian initiative, SakRusEnergo, which is a joint venture with 50% Georgian (state) and 50% Russian (RAO UES) shares and owns 500 kV transmission backbone in Georgia, has ordered EnergoKselProekti a preliminary design and technical-economic justification (feasibility study) for the section of transmission line between Zestaponi-Akhaltzikhe-Turkish border (Figure 3). The feasibility study and preliminary design was completed by 1999-2000. “Additional Materials on Construction of Transmission Line Connecting with Turkish Power System and Substation” (APPENDICES 7 & 7.1) prepared by EnergoKselProekti in 1999 for Azerbaijan-Georgia-Turkey interconnection project was used as Volume I for the study ordered by SakRusEnergo. Volumes II & III of this study were developed by EnergoKselProekti in 2000 (APPENDICES 15 & 16 – Vol. II & III – 500 kV Line Zestaponi-Akhaltzikhe-Border with Turkey, Technical-Economic Justification – Tbilisi, 2000).

The land and corridor from Akhaltsikhe to the border with Turkey for the transmission line was approved by the State Commission on Land Use and Protection of Georgia (APPENDIX 17 – Decision #44/10 - dated April 10, 2001 by State Commission of Georgia of Land Use and Protection – Regarding allocation of land in Aspindza and Akhaltsikhe regions for construction of 500 kV line; Agreement on Land Allocation by State Department of Land Management of Georgia; GSE’s and SakRusEnergo’s Letters). Later this project was also suspended due to lack of funding from the Russian side.



### 3. CURRENT CONDITION OF THE 500 KV TRANSMISSION LINE - SOUTH GEORGIA

Several sections of the line were completed and ready for acceptance. Some of characteristic remaining pylons are captured in the photos attached (Photos 1-11 & 14-15). At many places foundations were laid for the pylons, but pylons were never erected (Photos 12-13 & 16-18). As noted above, in 1992 it became impossible to continue construction of the line due to the political events that took place in Georgia. During that time no attention was paid to the line, which was thus considerably plundered: aluminum conductors were removed from the pylons; many of the pylons are stripped from structural elements (Photos 19-21); isolators have been damaged on a number of pylons. The last inventory assessment was done in Sep-Oct 2003 (APPENDIX 18 - Inventory Acts on Suspended Construction of the 500 kV Line Tbilisresi-South Georgia-Zestaponi) and its brief results are visualized below (Figure 4). Most of construction and installation materials were also stolen from the warehouses, although quite large amounts of concrete foundations and glass isolators still remain in storage areas (Photo 22-24).

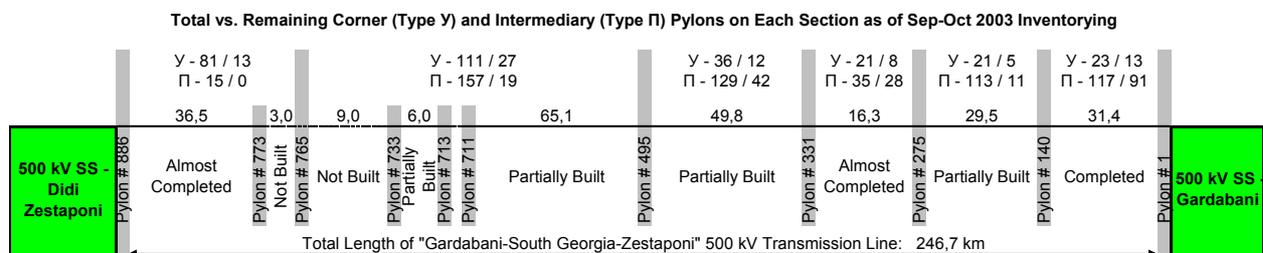


Figure 4: Remaining Pylons of the 500 kV Line

In addition some technical damage also took place in 2003-2004 during construction of Baku – Çeyhan Oil and Gas Pipelines (APPENDIX 19 – Energotrans’ Letter #23 - dated Mar 16, 2004). The route of the Baku – Çeyhan Oil and Gas Pipelines crosses the South Georgia 500 kV Line in 10 places. Construction norms were violated on a number of points. E.g.: the base of pylon #394 was damaged; and intersection of the High Voltage line with the Pipeline was done in violation of construction standards (Photos 29-30). In some places that are several kilometers long, the pipeline passes in parallel with the 500 kV line, very close to it, probably in violation of construction standards (Photo 28).

### 4. INFORMATION ON THE PROPOSED PROJECT: 500 KV LINE - TBILSRESI-SOUTH GEORGIA-ZESTAPHONI-AKHALTSIKHE-TURKEY

After disintegration of the Soviet Union the functions of the South Georgia 500 kV Line can become broader than originally intended. Namely, besides strengthening Georgian power grid and increasing its reliability closing a 500 kV circle from south, the line can also serve as a connection of Turkish, Iranian and Iraqi electricity systems with Georgian and Russian power system. These connections are mutually beneficial for a number of reasons:

- The above-mentioned countries generate electricity mainly by using oil and gas which is more expensive and environmentally damaging than potentially imported power;
- The existing and future Georgian large reservoir hydro power plants will be able to provide considerable assistance in covering peak demands in the power systems of these countries. This is especially true for summer months when Georgia has abundant water resources available for export which exactly coincides with southern countries peak demand due to increased air conditioning;
- Transit of cheaper electricity from Russia to these countries can increase dramatically;
- Azerbaijan will be able to supply its electricity to the population of Nakhichevan region;
- Stronger intersystem ties in the region would give possibility of gradual reduction of power generation (and potential future shut down) of the Armenian nuclear power plant, which is important not only for Armenia, but for the environmental safety of the whole region.

Although project documentation extending Tbilisresi-South Georgia-Zestaponi line to Turkey was done by EnergoKselProekti for a connection point at Kars, later Deriner HPP substation was preferred by the Georgian-Azerbaijan-Turkish Working Group's recommendations in 1998 (APPENDIX 6 – "Working Group Report: Results of Technical-Economical Assessment of Power Exchange between Georgia, Azerbaijan and Turkey", Ankara, Turkey, May 1998) (Figure 5 & 6). There is also an alternative point of Borçka HPP substation being considered by TEIAS (Turkish High Voltage Transmission Company) at the moment (see ADDITIONAL INFORMATION below and APPENDIX 20 – E-mail Correspondence with TEIAS).

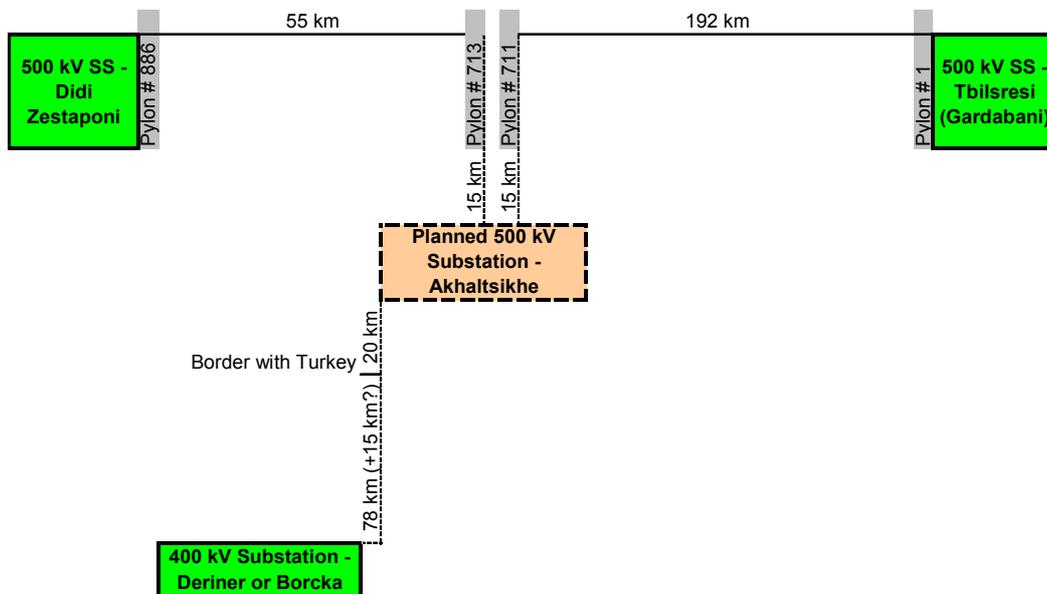


Figure 5: Proposed 500 kV line project with extension to Deriner or Borçka Substations in Turkey

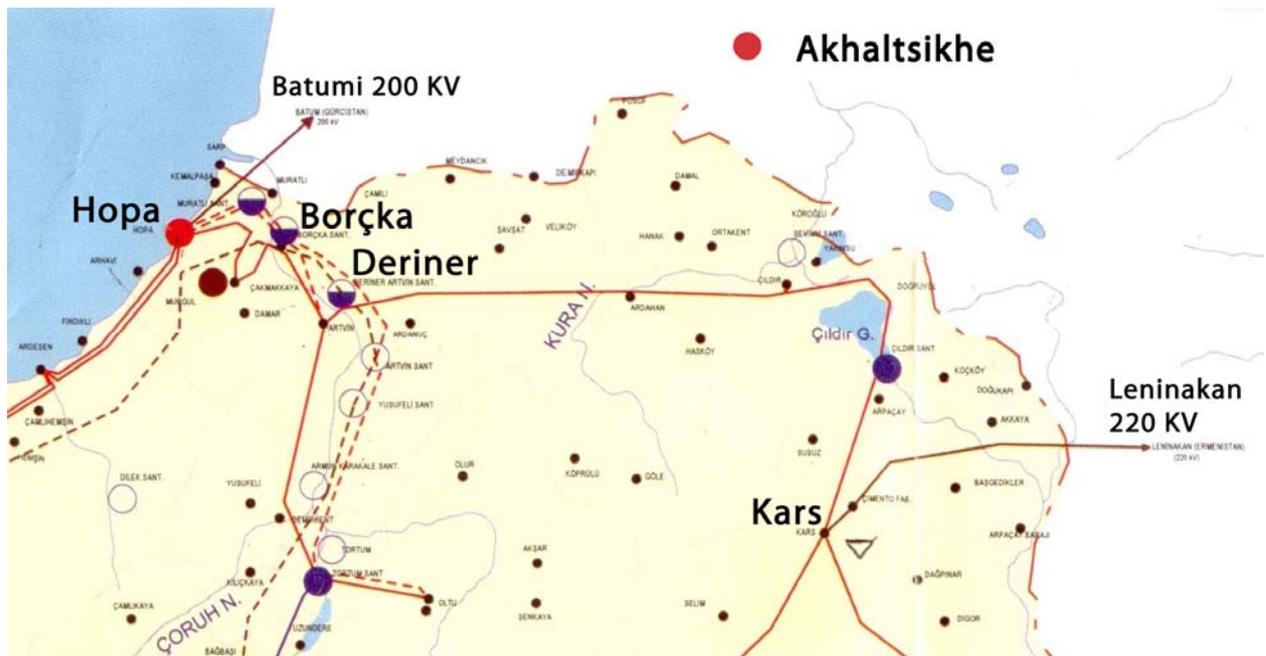


Figure 6: Relative location of Kars, Deriner and Borçka Substations in Turkey.

The proposed line could be extended from Zestaponi 500 kV Substation to Enguri HPP as it was originally intended, or directly to planned Khudoni HPP (Figure 6). Having a second 500 kV line in parallel to Imereti 500 kV line connecting Didi Zestaponi SS with Enguri HPP would significantly increase redundancy and reliability of the high voltage transmission network and provide stronger link to Enguri-Vardnili cascade and Russian power system.

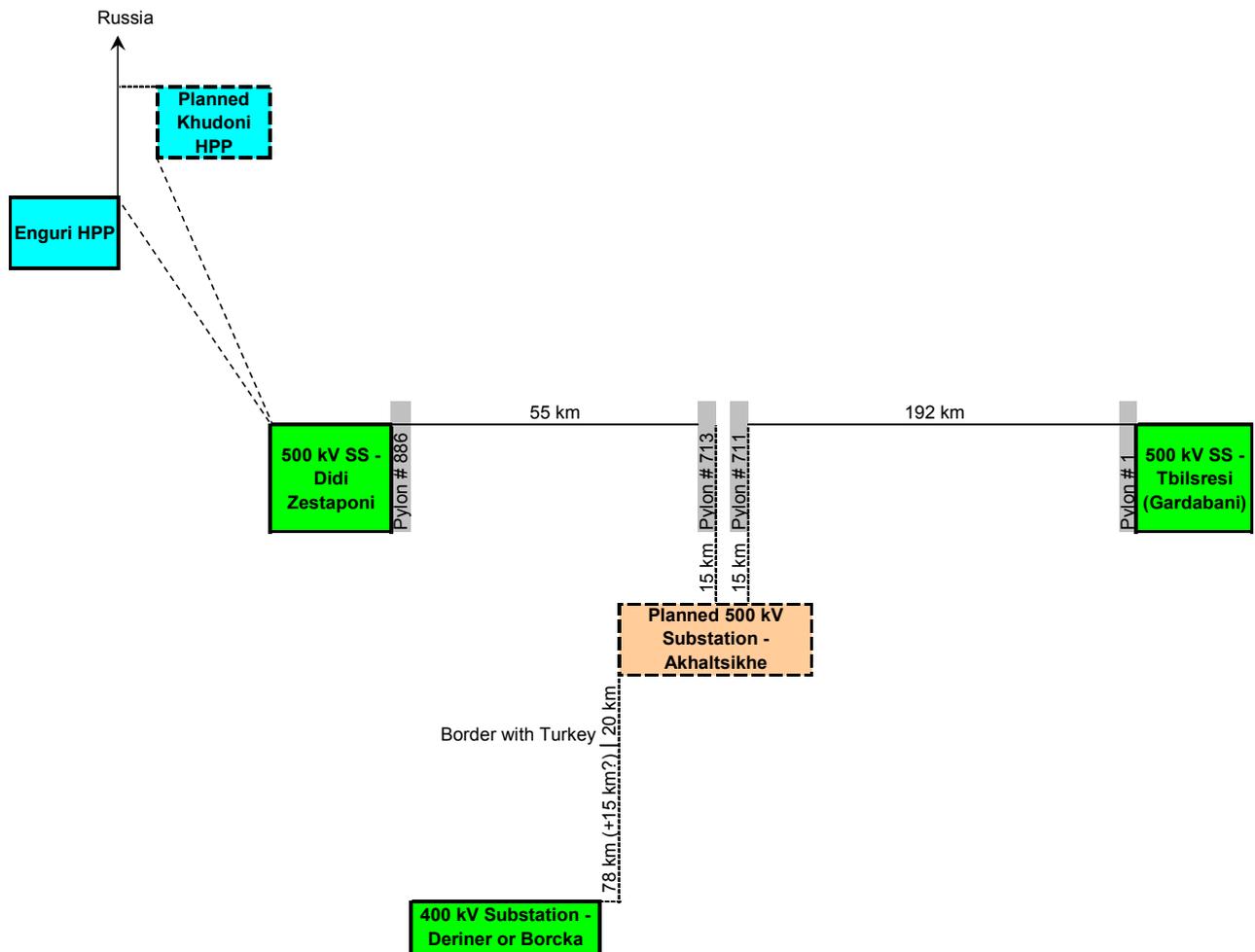


Figure 6: Proposed 500 kV line project with extension to Deriner/Borçka Substations in Turkey and to Enguri/Khudoni HPP

## 5. TRANSMISSION LINE TARIFF ESTIMATES

This section provides basic cost and tariff estimates for three major discrete segments of the proposed South Georgia 500 kV Transmission Line Project, with rather different conditions for required construction. We provide both low and high cost estimates, based on recent similar experience, as described below.

### Selection of Segments for Cost Analysis:

The South Georgia 500 kV Transmission Line project has two major components: that from Tbilisresi connecting to Zestaponi and Turkey, and that from Enguri Hydro Power Plant (or Khudoni Hydro Power Plant) to Zestaponi. Their construction condition and the implication of that for construction cost estimates are summarized below:

Tbilisresi – Zestaponi - Turkey: This is a “T” shaped segment on which the stem of the “T” runs 207 km approximately east-west along an established corridor, on which a substantial portion of construction was already completed. The top of the “T” runs approximately 90 km north-south, and connects the Turkish border to the Zestaponi

station. The join of the “T” is at Akhaltsikhe. The necessity for this design is to assure stability and reliability of the grid once the new connections are made. While a detailed assessment of cost to completion should be made, much of the construction on the east-west line has been completed; thus we believe that the cost for completion of the east-west line segment may be near the minimum cost estimate per km. The north-south section is actually a composite of several sub-segments, each with somewhat different conditions. There are 70 km from Zestaponi to Akhaltsikhe and 20 km from Akhaltsikhe to the Turkish border. On the section from Zestaponi to Akhaltsikhe 43 km (out of 70 km) was already completed, thus its rehabilitation should be expected to be near the minimum cost estimate. The remaining 27 km to Akhaltsikhe and 20 km from Akhaltsikhe to the Turkish border are new construction and thus may be closer to the higher per km estimate.

Zestaponi to Enguri or Khudoni: This segment runs about 194 km (to Enguri), along originally designed in 1985-88 corridor. Were the connection instead made to Khudoni, the distances and design questions would be similar. No construction has taken place for this segment. However, there is an existing 500 kV line “Imereti” which currently serves for transmission of power from Enguri and/or, Khudoni, and/or for transit of Russian exports, to Zestaponi. The originally planned route runs westwards from Zestaponi and then turns north towards Enguri HPP. The originally planned corridor may be changed and directed to Enguri or Khudoni HPP with a shorter route, but for this study we would assume originally planned 194 km.

Because of the diverse conditions and new nature of this segment, it should be initially assumed the construction costs may be closer to the high estimate.

### **Basis for Cost Estimates:**

Below is estimated expected range of construction costs and associated tariffs for the major segments of the proposed transmission lines. Although original cost estimates are available for some parts of the designed transmission system, these are dated and in some cases based on Soviet cost methods. As we have not conducted a current engineering cost study, we instead estimated cost and tariff levels from comparable current experience of cost per km of construction for 500 kV transmission lines in similar country conditions (Russia, Vietnam, Pakistan). Similarly structured cost data on North American transmission line construction, which is also available, was not employed. North American data is not comparable to conditions in Georgia, due to strong differences in labor, environmental costs, legal and right of way costs, and other factors. Based on the most relevant experience, the cost for transmission line construction ranged from about \$250,000/km to about \$500,000/km.

We thus valued the South Georgia line segments based on that range of possible costs. These results are reported in the [Table 1](#) below:

	<b>Major Segments</b>	
	<b>Tbilsresi - Zestaponi - Turkey Border</b>	<b>Enguri - Zestaponi</b>
<b>Capacity (MW):</b>	500	500
<b>Availability %</b>	60%	60%
<b>Hours in year</b>	8760	8760
<b>Capability, MWH</b>	2 628 000	2 628 000
<b>Length of Line Segments, km</b>	297	194
<b>Per km Cost Estimates:</b>		
<b>Low</b>	\$ 250 000	\$ 250 000
<b>High</b>	\$ 500 000	\$ 500 000
<b>Total Cost, US \$</b>		
<b>Low</b>	\$ 74 250 000	\$ 48 500 000
<b>High</b>	\$ 148 500 000	\$ 97 000 000
<b>Total Cost, Lari at \$1.00=1.80 GEL:</b>		
<b>Low</b>	133 650 000	87 300 000
<b>High</b>	267 300 000	174 600 000

Table 1: Construction Cost Estimates for Major Segments

### Assumptions of Tariff Analysis

Our tariff analysis rests on several important basic assumptions. First, for each major segment, we computed break-even stand-alone tariffs for the scenario assumptions, using both the low and high cost estimates for each. That is, we assumed that each of the two major segments could be self-financing. Thus use of a particular segment in a transport path would incur the tariff only for that segment. Use of two or more segments would incur the tariff required for each segment used. Within Georgia at present the existing high voltage system tariff presumes a form of “area” pricing, but which is also in some cases moderated for specific interconnects to particular customers. Thus, this segmented pricing is consistent with existing philosophies within Georgia. It also however focuses attention on the specific costs and financing requirements of each part of the combined project.

Next, in Georgia at present there are three fees that may be charged to a transmission system shipper, apart from the transmission tariff itself. None of those other three fees are included into the tariff computations for this study, since none reflects a cost specific to the construction nor operation of any line segment. It is a matter of policy for the State of Georgia to determine the treatment of those other components. These components are: (1) a fee for dispatch service (currently set at rates from 0.0012 to 0.0015 Lari/kWh depending on customer charged); (2) a fee to recover the proper value of high voltage system transmission losses (currently set at 0.001 Lari/kWh); (3) a fee to recover the cost of past debts of the power system to neighboring countries (currently

set at 0.001 Lari/kWh). We assume that a suitable fee related to dispatch service would be charged, and a suitable mechanism for compensation of losses would also be required, but have not attempted to evaluate those fees or requirements. We make no judgment on the fee for recovery of past debts. We have also not analyzed here the additional cost of generation capacity required for assuring line stability nor load reliability. Such costs may differ greatly based not only on the design of the transmission line, but also its intended use, and the form of contracting for its use (for example, the form of priority of use and thus avoidance of interruption assured in the transit agreement).

Next, we evaluated two basic scenarios for each of the line segments: that in which 100% of the capital came from private sources, and that in which 50% came from private sources, and 50% from some form of International Financial Institution financing, at 2.5% cost. We assumed the investor would seek not less than a 15% after-tax rate of return. Therefore, we state tariffs that would give a 15% rate of return after tax in the first year, but may give higher returns in later years. This higher return could occur since the tariff level we present in the summary analysis is that which breaks even at 15% in the first year, and presumably remains fixed thereafter. However, as depreciation is recovered, the return on equity provided by the fixed tariff could increase in later years, depending on whether the depreciation is applied to retire principal of debt, reinvested, or recovered by the investor. Rather than presume discount rates that investors might use, we thus simply state the total level of tariff that would also break-even at 15% in later years. To simplify capital accounts, we assumed that when part of the capital is financed by debt, that depreciation received offsets the principal of that debt first. The other assumptions are stated on the summary sheets.

## **Results of Tariff Analysis**

The results of our tariff analysis are given in the summary tables below. [Table 2](#) summarizes the tariff results for the two lines in the 50% private equity case. [Table 3](#) gives tariff results for the 100% private equity case. [Table 4](#) then has four pages summarizing the low and high cost analysis for the 50% and the 100% equity cases of Tbilisresi–Zestaponi–Border with Turkey segment. [Table 5](#) shows four pages of details for cost and tariff analysis of the Enguri (Khudoni) to Zestaponi segment.

<b>Major Segments</b>		
	<b>Tbilsresi - Zestaponi - Turkey Border</b>	<b>Enguri - Zestaponi</b>
<b>Current Similar Tariff/kWh</b>	0,00180	0,00180
<b>Break-Even Tariff, Lari per kWh:</b>		
<b>Low</b>	0,00776	0,00639
<b>High</b>	0,01551	0,01146
<b>Minimum % Rate of Return</b>		<b>15%</b>
<b>Private Equity Capital %</b>		<b>50%</b>

Table 2: Range of Tariffs in 50% Equity Case

<b>Major Segments</b>		
	<b>Tbilsresi - Zestaponi - Turkey Border</b>	<b>Enguri - Zestaponi</b>
<b>Current Similar Tariff/kWh</b>	0,00180	0,00180
<b>Break-Even Tariff, Lari per kWh:</b>		
<b>Low</b>	0,01170	0,00897
<b>High</b>	0,02339	0,01661
<b>Minimum % Rate of Return</b>		<b>15%</b>
<b>Private Equity Capital %</b>		<b>100%</b>

Table 3: Range of Tariffs in 100% Equity Case

**Transmission Line Cost Analysis; Minimum Range of Capital Cost  
Tbilsresi - Zestaponi - Turkey Border**

Operating Costs Per km estimated \$ millions	\$	0,010
Construction cost to be capitalized \$ Millions	\$	74,25
Depreciation Period of construction cost, years		20
Interest Rate on Construction Loan		2,5%
Share of Construction cost from Private Capital		50,0%
Desired after tax rate of Return on private equity		15,0%
Income Tax Rate		20,0%
Depreciation Method:		Flat
Annual Depreciation, \$ millions:	\$	3,71

	Year	1	2	3	4	5	6	7	8	9	10
<b>Plant Accounts:</b>											
Net Undepreciated Plant, Start of Year:	\$	74,25	\$ 70,54	\$ 66,83	\$ 63,11	\$ 59,40	\$ 55,69	\$ 51,98	\$ 48,26	\$ 44,55	\$ 40,84
Net Ownership Equity	\$	37,13	\$ 37,13	\$ 37,13	\$ 37,13	\$ 37,13	\$ 37,13	\$ 37,13	\$ 37,13	\$ 37,13	\$ 37,13
Net Debt After Apply Depreciation to Amortization	\$	37,13	\$ 33,41	\$ 29,70	\$ 25,99	\$ 22,28	\$ 18,56	\$ 14,85	\$ 11,14	\$ 7,43	\$ 3,71
<b>Cost of Capital (Depreciation + Cost of Capital + Operation Costs)</b>											
Cost of Equity	\$	5,57	\$ 5,57	\$ 5,57	\$ 5,57	\$ 5,57	\$ 5,57	\$ 5,57	\$ 5,57	\$ 5,57	\$ 5,57
Income Tax on Equity Earnings	\$	1,11	\$ 1,11	\$ 1,11	\$ 1,11	\$ 1,11	\$ 1,11	\$ 1,11	\$ 1,11	\$ 1,11	\$ 1,11
Annual Interest Cost of Debt	\$	0,93	\$ 0,84	\$ 0,74	\$ 0,65	\$ 0,56	\$ 0,46	\$ 0,37	\$ 0,28	\$ 0,19	\$ 0,09
Annual Depreciation	\$	3,71	\$ 3,71	\$ 3,71	\$ 3,71	\$ 3,71	\$ 3,71	\$ 3,71	\$ 3,71	\$ 3,71	\$ 3,71
<b>Subtotal, Cost of Capital:</b>	\$	11,32	\$ 11,23	\$ 11,14	\$ 11,04	\$ 10,95	\$ 10,86	\$ 10,77	\$ 10,67	\$ 10,58	\$ 10,49
<b>Annual Operating Costs</b>		-	-	-	-	-	-	-	-	-	-
<b>Total Annual Costs</b>		11,32	11,23	11,14	11,04	10,95	10,86	10,77	10,67	10,58	10,49
<b>Expected MWH Flows on Line</b>		2 628 000	2 628 000	2 628 000	2 628 000	2 628 000	2 628 000	2 628 000	2 628 000	2 628 000	2 628 000
<b>Required Tariff in \$/kwh:</b>		0,00431	0,00427	0,00424	0,00420	0,00417	0,00413	0,00410	0,00406	0,00403	0,00399
<b>Required Tariff in Lari/kwh</b>		0,00776	0,00769	0,00763	0,00756	0,00750	0,00744	0,00737	0,00731	0,00725	0,00718

Table 4.1: Cost and Tariff Analysis for Tbilsresi–Zestaponi–Border with Turkey Segment in **50% Equity & Low Capital Cost Estimate Case**

**Transmission Line Cost Analysis: Maximum Range of Capital Cost  
Tbilsresi - Zestaponi - Turkey Border**

Operating Costs Per km estimated \$ millions	\$	0,010
Construction cost to be capitalized \$ Millions	\$	148,50
Depreciation Period of construction cost, years		20
Interest Rate on Construction Loan		2,5%
Share of Construction cost from Private Capital		50,0%
Desired after tax rate of Return on private equity		15,0%
Income Tax Rate		20,0%
Depreciation Method:		Flat
Annual Depreciation, \$ millions:	\$	7,425

	Year	1	2	3	4	5	6	7	8	9	10
<b>Plant Accounts:</b>											
Net Undepreciated Plant, Start of Year:	\$	148,50	\$ 141,08	\$ 133,65	\$ 126,23	\$ 118,80	\$ 111,38	\$ 103,95	\$ 96,53	\$ 89,10	\$ 81,68
Net Ownership Equity	\$	74,25	\$ 74,25	\$ 74,25	\$ 74,25	\$ 74,25	\$ 74,25	\$ 74,25	\$ 74,25	\$ 74,25	\$ 74,25
Net Debt After Apply Depreciation to Amortization	\$	74,25	\$ 66,83	\$ 59,40	\$ 51,98	\$ 44,55	\$ 37,13	\$ 29,70	\$ 22,28	\$ 14,85	\$ 7,43
<b>Cost of Capital (Depreciation + Cost of Capital + Operation Costs)</b>											
Cost of Equity	\$	11,14	\$ 11,14	\$ 11,14	\$ 11,14	\$ 11,14	\$ 11,14	\$ 11,14	\$ 11,14	\$ 11,14	\$ 11,14
Income Tax on Equity Earnings	\$	2,23	\$ 2,23	\$ 2,23	\$ 2,23	\$ 2,23	\$ 2,23	\$ 2,23	\$ 2,23	\$ 2,23	\$ 2,23
Annual Interest Cost of Debt	\$	1,86	\$ 1,67	\$ 1,49	\$ 1,30	\$ 1,11	\$ 0,93	\$ 0,74	\$ 0,56	\$ 0,37	\$ 0,19
Annual Depreciation	\$	7,43	\$ 7,43	\$ 7,43	\$ 7,43	\$ 7,43	\$ 7,43	\$ 7,43	\$ 7,43	\$ 7,43	\$ 7,43
<b>Subtotal, Cost of Capital:</b>	\$	22,65	\$ 22,46	\$ 22,28	\$ 22,09	\$ 21,90	\$ 21,72	\$ 21,53	\$ 21,35	\$ 21,16	\$ 20,98
<b>Annual Operating Costs</b>		-	-	-	-	-	-	-	-	-	-
<b>Total Annual Costs</b>		22,65	22,46	22,28	22,09	21,90	21,72	21,53	21,35	21,16	20,98
<b>Expected MWH Flows on Line</b>		2 628 000	2 628 000	2 628 000	2 628 000	2 628 000	2 628 000	2 628 000	2 628 000	2 628 000	2 628 000
<b>Required Tariff in \$/kwh:</b>		0,00862	0,00855	0,00848	0,00841	0,00833	0,00826	0,00819	0,00812	0,00805	0,00798
<b>Required Tariff in Lari/kwh</b>		0,01551	0,01538	0,01526	0,01513	0,01500	0,01488	0,01475	0,01462	0,01449	0,01437

Table 4.2: Cost and Tariff Analysis for Tbilsresi–Zestaponi–Border with Turkey Segment in **50% Equity & High Capital Cost Estimate Case**

**Transmission Line Cost Analysis; Minimum Range of Capital Cost  
Tbilsresi - Zestaponi - Turkey Border**

Operating Costs Per km estimated \$ millions	\$	0,010
Construction cost to be capitalized \$ Millions	\$	74,25
Depreciation Period of construction cost, years		20
Interest Rate on Construction Loan		2,5%
Share of Construction cost from Private Capital		100,0%
Desired after tax rate of Return on private equity		15,0%
Income Tax Rate		20,0%
Depreciation Method:		Flat
Annual Depreciation, \$ millions:	\$	3,71

	Year	1	2	3	4	5	6	7	8	9	10
<b>Plant Accounts:</b>											
Net Undepreciated Plant, Start of Year:	\$	74,25	\$ 70,54	\$ 66,83	\$ 63,11	\$ 59,40	\$ 55,69	\$ 51,98	\$ 48,26	\$ 44,55	\$ 40,84
Net Ownership Equity	\$	74,25	\$ 73,13	\$ 72,00	\$ 70,88	\$ 69,75	\$ 68,63	\$ 67,50	\$ 66,38	\$ 65,25	\$ 64,13
Net Debt After Apply Depreciation to Amortization	\$	-	\$ -	\$ -	\$ -	\$ -	\$ -	\$ -	\$ -	\$ -	\$ -
<b>Cost of Capital (Depreciation + Cost of Capital + Operation Costs)</b>											
Cost of Equity	\$	11,14	\$ 10,97	\$ 10,80	\$ 10,63	\$ 10,46	\$ 10,29	\$ 10,13	\$ 9,96	\$ 9,79	\$ 9,62
Income Tax on Equity Earnings	\$	2,23	\$ 2,19	\$ 2,16	\$ 2,13	\$ 2,09	\$ 2,06	\$ 2,03	\$ 1,99	\$ 1,96	\$ 1,92
Annual Interest Cost of Debt	\$	-	\$ -	\$ -	\$ -	\$ -	\$ -	\$ -	\$ -	\$ -	\$ -
Annual Depreciation	\$	3,71	\$ 3,71	\$ 3,71	\$ 3,71	\$ 3,71	\$ 3,71	\$ 3,71	\$ 3,71	\$ 3,71	\$ 3,71
<b>Subtotal, Cost of Capital:</b>	\$	17,08	\$ 16,88	\$ 16,67	\$ 16,47	\$ 16,27	\$ 16,07	\$ 15,86	\$ 15,66	\$ 15,46	\$ 15,26
<b>Annual Operating Costs</b>		-	-	-	-	-	-	-	-	-	-
<b>Total Annual Costs</b>		17,08	16,88	16,67	16,47	16,27	16,07	15,86	15,66	15,46	15,26
<b>Expected MWH Flows on Line</b>		2 628 000	2 628 000	2 628 000	2 628 000	2 628 000	2 628 000	2 628 000	2 628 000	2 628 000	2 628 000
<b>Required Tariff in \$/kwh:</b>		0,00650	0,00642	0,00634	0,00627	0,00619	0,00611	0,00604	0,00596	0,00588	0,00580
<b>Required Tariff in Lari/kwh</b>		0,01170	0,01156	0,01142	0,01128	0,01114	0,01100	0,01086	0,01073	0,01059	0,01045

Table 4.3: Cost and Tariff Analysis for Tbilsresi–Zestaponi–Border with Turkey Segment in **100% Equity & Low Capital Cost Estimate Case**

**Transmission Line Cost Analysis: Maximum Range of Capital Cost  
Tbilsresi - Zestaponi - Turkey Border**

Operating Costs Per km estimated \$ millions	\$	0,010
Construction cost to be capitalized \$ Millions	\$	148,50
Depreciation Period of construction cost, years		20
Interest Rate on Construction Loan		2,5%
Share of Construction cost from Private Capital		100,0%
Desired after tax rate of Return on private equity		15,0%
Income Tax Rate		20,0%
Depreciation Method:		Flat
Annual Depreciation, \$ millions:	\$	7,425

	Year	1	2	3	4	5	6	7	8	9	10
<b>Plant Accounts:</b>											
Net Undepreciated Plant, Start of Year:	\$	148,50	\$ 141,08	\$ 133,65	\$ 126,23	\$ 118,80	\$ 111,38	\$ 103,95	\$ 96,53	\$ 89,10	\$ 81,68
Net Ownership Equity	\$	148,50	\$ 146,25	\$ 144,00	\$ 141,75	\$ 139,50	\$ 137,25	\$ 135,00	\$ 132,75	\$ 130,50	\$ 128,25
Net Debt After Apply Depreciation to Amortization	\$	-	\$ -	\$ -	\$ -	\$ -	\$ -	\$ -	\$ -	\$ -	\$ -
<b>Cost of Capital (Depreciation + Cost of Capital + Operation Costs)</b>											
Cost of Equity	\$	22,28	\$ 21,94	\$ 21,60	\$ 21,26	\$ 20,93	\$ 20,59	\$ 20,25	\$ 19,91	\$ 19,58	\$ 19,24
Income Tax on Equity Earnings	\$	4,46	\$ 4,39	\$ 4,32	\$ 4,25	\$ 4,19	\$ 4,12	\$ 4,05	\$ 3,98	\$ 3,92	\$ 3,85
Annual Interest Cost of Debt	\$	-	\$ -	\$ -	\$ -	\$ -	\$ -	\$ -	\$ -	\$ -	\$ -
Annual Depreciation	\$	7,43	\$ 7,43	\$ 7,43	\$ 7,43	\$ 7,43	\$ 7,43	\$ 7,43	\$ 7,43	\$ 7,43	\$ 7,43
<b>Subtotal, Cost of Capital:</b>	\$	34,16	\$ 33,75	\$ 33,35	\$ 32,94	\$ 32,54	\$ 32,13	\$ 31,73	\$ 31,32	\$ 30,92	\$ 30,51
<b>Annual Operating Costs</b>		-	-	-	-	-	-	-	-	-	-
<b>Total Annual Costs</b>		34,16	33,75	33,35	32,94	32,54	32,13	31,73	31,32	30,92	30,51
<b>Expected MWH Flows on Line</b>		2 628 000	2 628 000	2 628 000	2 628 000	2 628 000	2 628 000	2 628 000	2 628 000	2 628 000	2 628 000
<b>Required Tariff in \$/kwh:</b>		0,01300	0,01284	0,01269	0,01253	0,01238	0,01223	0,01207	0,01192	0,01176	0,01161
<b>Required Tariff in Lari/kwh</b>		0,02339	0,02312	0,02284	0,02256	0,02228	0,02201	0,02173	0,02145	0,02117	0,02090

Table 4.4: Cost and Tariff Analysis for Tbilsresi–Zestaponi–Border with Turkey Segment in **100% Equity & High Capital Cost** Estimate Case

**Transmission Line Cost Analysis; Minimum Range of Capital Cost  
Enguri - Zestaponi**

Operating Costs Per km estimated \$ millions	\$	0,010										
Construction cost to be capitalized \$ Millions	\$	48,5										
Depreciation Period of construction cost, years		20										
Interest Rate on Construction Loan		2,5%										
Share of Construction cost from Private Capital		50,0%										
Desired after tax rate of Return on private equity		15,0%										
Income Tax Rate		20,0%										
Depreciation Method:		Flat										
Annual Depreciation, \$ millions:	\$	2,43										
	<b>Year</b>	<b>1</b>	<b>2</b>	<b>3</b>	<b>4</b>	<b>5</b>	<b>6</b>	<b>7</b>	<b>8</b>	<b>9</b>	<b>10</b>	
<b>Plant Accounts:</b>												
Net Undepreciated Plant, Start of Year:	\$	48,50	\$ 46,08	\$ 43,65	\$ 41,23	\$ 38,80	\$ 36,38	\$ 33,95	\$ 31,53	\$ 29,10	\$ 26,68	
Net Ownership Equity	\$	24,25	\$ 24,25	\$ 24,25	\$ 24,25	\$ 24,25	\$ 24,25	\$ 24,25	\$ 24,25	\$ 24,25	\$ 24,25	\$ 24,25
Net Debt After Apply Depreciation to Amortization	\$	24,25	\$ 21,83	\$ 19,40	\$ 16,98	\$ 14,55	\$ 12,13	\$ 9,70	\$ 7,28	\$ 4,85	\$ 2,43	
<b>Cost of Capital (Depreciation + Cost of Capital + Operation Costs)</b>												
Cost of Equity	\$	3,64	\$ 3,64	\$ 3,64	\$ 3,64	\$ 3,64	\$ 3,64	\$ 3,64	\$ 3,64	\$ 3,64	\$ 3,64	\$ 3,64
Income Tax on Equity Earnings	\$	0,73	\$ 0,73	\$ 0,73	\$ 0,73	\$ 0,73	\$ 0,73	\$ 0,73	\$ 0,73	\$ 0,73	\$ 0,73	\$ 0,73
Annual Interest Cost of Debt	\$	0,61	\$ 0,55	\$ 0,49	\$ 0,42	\$ 0,36	\$ 0,30	\$ 0,24	\$ 0,18	\$ 0,12	\$ 0,06	
Annual Depreciation	\$	2,43	\$ 2,43	\$ 2,43	\$ 2,43	\$ 2,43	\$ 2,43	\$ 2,43	\$ 2,43	\$ 2,43	\$ 2,43	\$ 2,43
<b>Subtotal, Cost of Capital:</b>	\$	7,40	\$ 7,34	\$ 7,28	\$ 7,21	\$ 7,15	\$ 7,09	\$ 7,03	\$ 6,97	\$ 6,91	\$ 6,85	
<b>Annual Operating Costs</b>		1,94	1,94	1,94	1,94	1,94	1,94	1,94	1,94	1,94	1,94	1,94
<b>Total Annual Costs</b>		9,34	9,28	9,22	9,15	9,09	9,03	8,97	8,91	8,85	8,79	
<b>Expected MWH Flows on Line</b>		2 628 000	2 628 000	2 628 000	2 628 000	2 628 000	2 628 000	2 628 000	2 628 000	2 628 000	2 628 000	
<b>Required Tariff in \$/kwh:</b>		0,00355	0,00353	0,00351	0,00348	0,00346	0,00344	0,00341	0,00339	0,00337	0,00334	
<b>Required Tariff in Lari/kwh</b>		0,00639	0,00635	0,00631	0,00627	0,00623	0,00619	0,00615	0,00610	0,00606	0,00602	

Table 5.1: Cost and Tariff Analysis for Enguri (Khudoni) – Zestaponi Segment in **50% Equity & Low Capital Cost Estimate Case**

**Transmission Line Cost Analysis: Maximum Range of Capital Cost  
Enguri - Zestaponi**

Operating Costs Per km estimated \$ millions	\$	0,010
Construction cost to be capitalized \$ Millions	\$	97,0
Depreciation Period of construction cost, years		20
Interest Rate on Construction Loan		2,5%
Share of Construction cost from Private Capital		50,0%
Desired after tax rate of Return on private equity		15,0%
Income Tax Rate		20,0%
Depreciation Method:		Flat
Annual Depreciation, \$ millions:	\$	4,85

	Year	1	2	3	4	5	6	7	8	9	10
<b>Plant Accounts:</b>											
Net Undepreciated Plant, Start of Year:	\$	97,00	\$ 92,15	\$ 87,30	\$ 82,45	\$ 77,60	\$ 72,75	\$ 67,90	\$ 63,05	\$ 58,20	\$ 53,35
Net Ownership Equity	\$	48,50	\$ 48,50	\$ 48,50	\$ 48,50	\$ 48,50	\$ 48,50	\$ 48,50	\$ 48,50	\$ 48,50	\$ 48,50
Net Debt After Apply Depreciation to Amortization	\$	48,50	\$ 43,65	\$ 38,80	\$ 33,95	\$ 29,10	\$ 24,25	\$ 19,40	\$ 14,55	\$ 9,70	\$ 4,85
<b>Cost of Capital (Depreciation + Cost of Capital + Operation Costs)</b>											
Cost of Equity	\$	7,28	\$ 7,28	\$ 7,28	\$ 7,28	\$ 7,28	\$ 7,28	\$ 7,28	\$ 7,28	\$ 7,28	\$ 7,28
Income Tax on Equity Earnings	\$	1,46	\$ 1,46	\$ 1,46	\$ 1,46	\$ 1,46	\$ 1,46	\$ 1,46	\$ 1,46	\$ 1,46	\$ 1,46
Annual Interest Cost of Debt	\$	1,21	\$ 1,09	\$ 0,97	\$ 0,85	\$ 0,73	\$ 0,61	\$ 0,49	\$ 0,36	\$ 0,24	\$ 0,12
Annual Depreciation	\$	4,85	\$ 4,85	\$ 4,85	\$ 4,85	\$ 4,85	\$ 4,85	\$ 4,85	\$ 4,85	\$ 4,85	\$ 4,85
<b>Subtotal, Cost of Capital:</b>	\$	14,79	\$ 14,67	\$ 14,55	\$ 14,43	\$ 14,31	\$ 14,19	\$ 14,07	\$ 13,94	\$ 13,82	\$ 13,70
<b>Annual Operating Costs</b>		1,94	1,94	1,94	1,94	1,94	1,94	1,94	1,94	1,94	1,94
<b>Total Annual Costs</b>		16,73	16,61	16,49	16,37	16,25	16,13	16,01	15,88	15,76	15,64
<b>Expected MWH Flows on Line</b>		2 628 000	2 628 000	2 628 000	2 628 000	2 628 000	2 628 000	2 628 000	2 628 000	2 628 000	2 628 000
<b>Required Tariff in \$/kwh:</b>		0,00637	0,00632	0,00627	0,00623	0,00618	0,00614	0,00609	0,00604	0,00600	0,00595
<b>Required Tariff in Lari/kwh</b>		0,01146	0,01138	0,01129	0,01121	0,01113	0,01105	0,01096	0,01088	0,01080	0,01071

Table 5.2: Cost and Tariff Analysis for Enguri (Khudoni) – Zestaponi Segment in **50% Equity & High Capital Cost Estimate Case**

**Transmission Line Cost Analysis; Minimum Range of Capital Cost  
Enguri - Zestaponi**

Operating Costs Per km estimated \$ millions	\$	0,010										
Construction cost to be capitalized \$ Millions	\$	48,5										
Depreciation Period of construction cost, years		20										
Interest Rate on Construction Loan		2,5%										
Share of Construction cost from Private Capital		100,0%										
Desired after tax rate of Return on private equity		15,0%										
Income Tax Rate		20,0%										
Depreciation Method:		Flat										
Annual Depreciation, \$ millions:	\$	2,43										
	<b>Year</b>	<b>1</b>	<b>2</b>	<b>3</b>	<b>4</b>	<b>5</b>	<b>6</b>	<b>7</b>	<b>8</b>	<b>9</b>	<b>10</b>	
<b>Plant Accounts:</b>												
Net Undepreciated Plant, Start of Year:	\$	48,50	\$ 46,08	\$ 43,65	\$ 41,23	\$ 38,80	\$ 36,38	\$ 33,95	\$ 31,53	\$ 29,10	\$ 26,68	
Net Ownership Equity	\$	48,50	\$ 46,08	\$ 43,65	\$ 41,23	\$ 38,80	\$ 36,38	\$ 33,95	\$ 31,53	\$ 29,10	\$ 26,68	
Net Debt After Apply Depreciation to Amortization	\$	-	\$ -	\$ -	\$ -	\$ -	\$ -	\$ -	\$ -	\$ -	\$ -	
<b>Cost of Capital (Depreciation + Cost of Capital + Operation Costs)</b>												
Cost of Equity	\$	7,28	\$ 6,91	\$ 6,55	\$ 6,18	\$ 5,82	\$ 5,46	\$ 5,09	\$ 4,73	\$ 4,37	\$ 4,00	
Income Tax on Equity Earnings	\$	1,46	\$ 1,38	\$ 1,31	\$ 1,24	\$ 1,16	\$ 1,09	\$ 1,02	\$ 0,95	\$ 0,87	\$ 0,80	
Annual Interest Cost of Debt	\$	-	\$ -	\$ -	\$ -	\$ -	\$ -	\$ -	\$ -	\$ -	\$ -	
Annual Depreciation	\$	2,43	\$ 2,43	\$ 2,43	\$ 2,43	\$ 2,43	\$ 2,43	\$ 2,43	\$ 2,43	\$ 2,43	\$ 2,43	
<b>Subtotal, Cost of Capital:</b>	\$	11,16	\$ 10,72	\$ 10,28	\$ 9,85	\$ 9,41	\$ 8,97	\$ 8,54	\$ 8,10	\$ 7,66	\$ 7,23	
<b>Annual Operating Costs</b>		1,94	1,94	1,94	1,94	1,94	1,94	1,94	1,94	1,94	1,94	
<b>Total Annual Costs</b>		13,10	12,66	12,22	11,79	11,35	10,91	10,48	10,04	9,60	9,17	
<b>Expected MWH Flows on Line</b>		2 628 000	2 628 000	2 628 000	2 628 000	2 628 000	2 628 000	2 628 000	2 628 000	2 628 000	2 628 000	
<b>Required Tariff in \$/kwh:</b>		0,00498	0,00482	0,00465	0,00448	0,00432	0,00415	0,00399	0,00382	0,00365	0,00349	
<b>Required Tariff in Lari/kwh</b>		0,00897	0,00867	0,00837	0,00807	0,00777	0,00747	0,00718	0,00688	0,00658	0,00628	

Table 5.3: Cost and Tariff Analysis for Enguri (Khudoni) – Zestaponi Segment in **100%** Equity & **Low** Capital Cost Estimate Case

**Transmission Line Cost Analysis: Maximum Range of Capital Cost  
Enguri - Zestaponi**

Operating Costs Per km estimated \$ millions	\$	0,010
Construction cost to be capitalized \$ Millions	\$	97,0
Depreciation Period of construction cost, years		20
Interest Rate on Construction Loan		2,5%
Share of Construction cost from Private Capital		100,0%
Desired after tax rate of Return on private equity		15,0%
Income Tax Rate		20,0%
Depreciation Method:		Flat
Annual Depreciation, \$ millions:	\$	4,85

	Year	1	2	3	4	5	6	7	8	9	10
<b>Plant Accounts:</b>											
Net Undepreciated Plant, Start of Year:	\$	97,00	\$ 92,15	\$ 87,30	\$ 82,45	\$ 77,60	\$ 72,75	\$ 67,90	\$ 63,05	\$ 58,20	\$ 53,35
Net Ownership Equity	\$	97,00	\$ 92,15	\$ 87,30	\$ 82,45	\$ 77,60	\$ 72,75	\$ 67,90	\$ 63,05	\$ 58,20	\$ 53,35
Net Debt After Apply Depreciation to Amortization	\$	-	\$ -	\$ -	\$ -	\$ -	\$ -	\$ -	\$ -	\$ -	\$ -
<b>Cost of Capital (Depreciation + Cost of Capital + Operation Costs)</b>											
Cost of Equity	\$	14,55	\$ 13,82	\$ 13,10	\$ 12,37	\$ 11,64	\$ 10,91	\$ 10,19	\$ 9,46	\$ 8,73	\$ 8,00
Income Tax on Equity Earnings	\$	2,91	\$ 2,76	\$ 2,62	\$ 2,47	\$ 2,33	\$ 2,18	\$ 2,04	\$ 1,89	\$ 1,75	\$ 1,60
Annual Interest Cost of Debt	\$	-	\$ -	\$ -	\$ -	\$ -	\$ -	\$ -	\$ -	\$ -	\$ -
Annual Depreciation	\$	4,85	\$ 4,85	\$ 4,85	\$ 4,85	\$ 4,85	\$ 4,85	\$ 4,85	\$ 4,85	\$ 4,85	\$ 4,85
<b>Subtotal, Cost of Capital:</b>	\$	22,31	\$ 21,44	\$ 20,56	\$ 19,69	\$ 18,82	\$ 17,95	\$ 17,07	\$ 16,20	\$ 15,33	\$ 14,45
<b>Annual Operating Costs</b>		1,94	1,94	1,94	1,94	1,94	1,94	1,94	1,94	1,94	1,94
<b>Total Annual Costs</b>		24,25	23,38	22,50	21,63	20,76	19,89	19,01	18,14	17,27	16,39
<b>Expected MWH Flows on Line</b>		2 628 000	2 628 000	2 628 000	2 628 000	2 628 000	2 628 000	2 628 000	2 628 000	2 628 000	2 628 000
<b>Required Tariff in \$/kwh:</b>		0,00923	0,00890	0,00856	0,00823	0,00790	0,00757	0,00723	0,00690	0,00657	0,00624
<b>Required Tariff in Lari/kwh</b>		0,01661	0,01601	0,01541	0,01482	0,01422	0,01362	0,01302	0,01242	0,01183	0,01123

Table 5.4: Cost and Tariff Analysis for Enguri (Khudoni) – Zestaponi Segment in **100%** Equity & **High** Capital Cost Estimate Case

## 6. ADDITIONAL INFORMATION

- On Tbilisresi-Zestaponi section of the line pylon numbering inconsistencies were noticed by an independent expert Mr. Simon Bakhturidze hired by CORE for this review. Pylon numbers of the extension point to Akhaltsikhe (from Tbilisresi-South Georgia-Zestaponi line) may not be #711-713. It seems that during construction not all pylons were erected in exact accordance to the project documentation. The number of total needed pylons may be less than in original design. Obviously, in order to determine the exact condition and quantity of the remaining transmission line, a new more thorough than previously conducted inventory assessment is needed.
- Pylon construction modification is advisable. Pylons being assembled on site with nuts and bolts from angular construction materials are more subject to plundering by population ([Photos 19 & 21](#)). Welded constructions should be used at least on the lower parts of the pylons.
- Former military shooting polygon was chosen as a location for Akhaltsikhe 500/400 kV Substation in Preliminary Design and Technical-Economic Justification prepared by EnergoKselProekti ([Photos 32-33](#)). This location requires building a double line extension from Tbilisresi-South Georgia-Zestaponi line (Pylons #711-713) on approximately 15 km and provision of water supply from Akhalkalaki city water utility system.

There are several good plateaus with excellent access to the river Tsinubani for water supply and much closer (in couple hundred meters) from the extension point (Pylons #711-713) for potential 500/400 kV substation construction ([Photo 31](#)). In this case there is no need for a second 15 km transmission line stretch and dependency on city water supply is eliminated.

- According to TEİAŞ (Turkish High Voltage Transmission Company) connection point in Turkey was changed from Deriner to Borçka due to unavailability of a space in underground GIS substation built at Deriner HPP ([APPENDIX 20](#) – E-mail Correspondence with TEİAŞ). This slightly extends line length and insignificantly increases construction cost on Turkish side in comparison to Deriner connection point.
- According to the latest information provided by the Ministry of Energy of Georgia, in near future Turkey is planning to join European interconnected grid (UCTE) which would preclude TEİAŞ to synchronously interconnect with Georgian power grid ([APPENDIX 21](#) – UCTE expansion plans). In this case HVDC link would be required and current synchronous connection via existing 220 kV line “Ajara” would prove useless. This makes the proposed new high voltage line project vital for future power exchanges between Georgia and Turkey. HVDC back-to-back station may cost approximately another \$40–60 mln USD.
- According to the latest information provided by the Ministry of Energy of Georgia, EnergoTrans’ new management has obtained permissions on right of way for the high voltage line from local authorities of the regions on which the line passes and re-registered all respective land plots with the State Land Cadastre.

# PHOTOS



Photo 1: Tbilisres 500 kV SS in Gardabani



Photo 2: Portal for 500 kV Line - South Georgia at Tbilisres 500 kV SS in Gardabani (closer unfinished one)



Photo 3: Pylons #1 at the gate of Tbilisresi 500 kV SS in Gardabani



Photo 4: Pylons of the line leaving Tbilisresi 500 kV SS in Gardabani



Photo 5: Pylons at Tetrtskaro



Photo 6: Pylons at Tetrtskaro

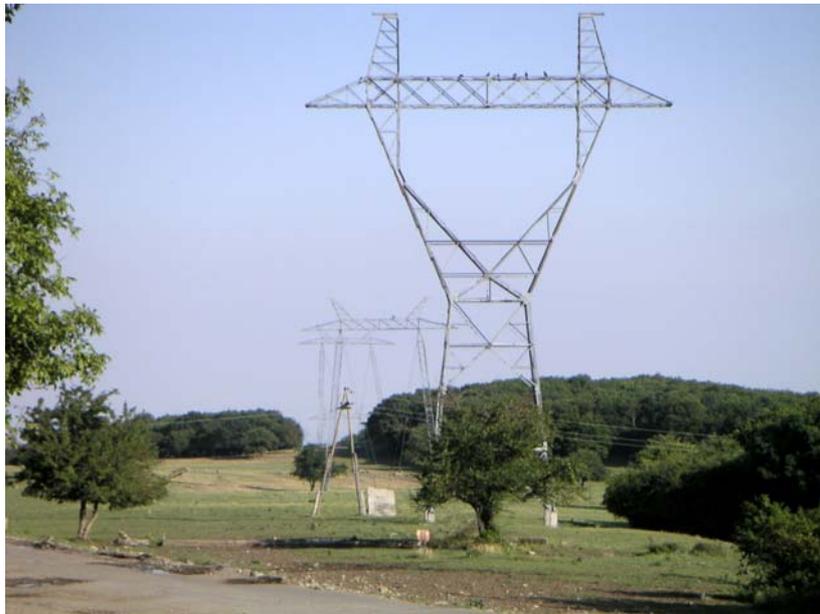


Photo 7: Pylons at Tetrtskaro



Photo 8: 500 kV line near Tsalka



Photo 9: Line near village Tsinubani



Photo 10: Line near village Tsinubani



Photo 11: Pylons in Tsinubani river canyon



Photo 12: Half-finished pylons in Tsinubani river canyon



Photo 13: Assembled but not installed pylon in Tsinubani river canyon



Photo 14: 500 kV line leaving Didi Zestaponi SS



Photo 15: Last pylon at Didi Zestaponi SS



Photo 16: Pylon foundation near Tsalka



Photo 17: Pylon foundation near Tsalka



Photo 18: Pylon foundation in Tsinubani river canyon



Photo 19: Plundered last pylon at Didi Zestaponi SS



Photo 20: Damaged toppled pylon



Photo 21: Remains of stolen pylon in Tsinubani river canyon



Photo 22: Warehouse in Atskuri



Photo 23: Warehouse in Atskuri



Photo 24: Warehouse in Atskuri



Photo 25: Mechanized Unit Base in Bagdati region



Photo 26: Mechanized Unit Base in Bagdati region



Photo 27: Mechanized Unit Base Workshop in Bagdati region



Photo 28: Baku-Çeyhan oil pipeline (ground trench visible near the pylons) crossing 500 kV line route



Photo 29: Damaged foundation by Baku-Çeyhan oil pipeline construction



Photo 30: Damaged foundation by Baku-Çeyhan oil pipeline construction



Photo 31: Valley near village Tsinubani – could be used as an alternative site for 500 kV SS near Akhaltsikhe

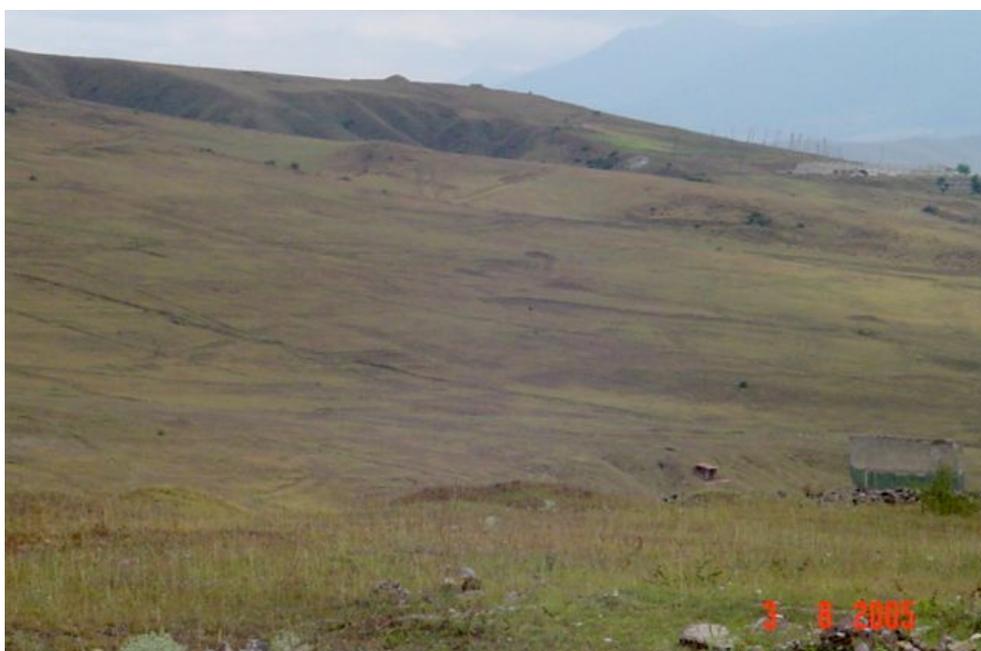


Photo 32: Military Base Shooting Site – currently planned site for 500 kV SS near Akhaltsikhe



Photo 33: Military Base Shooting Site – currently planned site for 500 kV SS near Akhaltsikhe

# APPENDICES

**APPENDIX 1** – Conclusion #Յ-101 - dated July 26, 1985 of the Department of Power Projects' Expertise of the Ministry of Energy and Electrification of the USSR - Regarding Justification Materials on Design and Construction of 500 kV Line Azerbaijan TPP-Armenia NPP-Zestaponi and 500 kV Line Tbilisres-i-South Georgia-Samtredia-Enguri HPP (Georgian, Armenian and Azerbaijan SSR)

**APPENDIX 2** – General Routing Plan of 500 kV High Voltage Line Tbilisresi-South Georgia-Samtredia-Enguri HPP - 1984

**APPENDIX 3** – Order #539p of the Council of Ministers of the Georgian SSR -  
June 5, 1987

**APPENDIX 4 – 500 kV Line Tbilisresi-Enguri HPP. Stage I – Tbilisresi-South Georgia-Zestaponi. Volume 1 – Materials of Route Selection and Approval for Overhead 500 kV Transmission Line**

**APPENDIX 4.1** – Detailed Routing Plans of 500 kV Line Tbilisresi-South Georgia-Zestaponi

**APPENDIX 5 – 500 kV Line Tbilisresi-Enguri HPP. Stage I – Tbilisresi-South Georgia-Zestaponi. Volume 8.1 – Financial Documentation: Combined Expenses and Budget of Construction Costs**

**APPENDIX 6** – Working Group Report: Results of Technical-Economical Assessment of Power Exchange between Georgia, Azerbaijan and Turkey, Ankara, Turkey, May 1998

**APPENDIX 7** – Additional Materials on Construction of Power Transmission Line Connecting with Turkish Power System & Substation. Volume I – Project Description and Drawings, Tbilisi, 1999

**APPENDIX 7.1 – 500-400 KV Line Routing Plan from Akhaltsikhe to Border with Turkey - 1999**

**APPENDIX 8 – Order #33 of the Minister of Energy of Georgia - June 14, 1999**

**APPENDIX 9 – Order #57 of “Electrogadatsema” – June 15, 1999**

**APPENDIX 10** – Order #1-3/589 of the Ministry of State Property Management -  
dated August 16, 2002 – Regarding establishment of “SakTurkAzKseli, Ltd”

**APPENDIX 11 – Conclusion of Audit by “Temo Ltd” - July 12, 2002**

**APPENDIX 12** – Order #1-3/618 of the Ministry of State Property Management - September 4, 2002 – Regarding renaming “SakTurkAzKseli, Ltd” into “EnergoTrans, Ltd”

**APPENDIX 13** – Protocol #1 - February 11, 2000 and Protocol #2 - March 3, 2000 of Russian-Georgian working group on Cooperation in Power Sector

**APPENDIX 14** – Agreement between RAO UES and Georgian Government on Construction of 500 kV Transmission Line Zestaponi-Akhaltzikhe-Border with Turkey - July 2000

**APPENDIX 15 – Volume II – 500 kV Line Zestaponi-Akhaltzikhe-Border with Turkey, Technical-Economic Justification – Tbilisi, 2000**

**APPENDIX 16** – Volume III – Cost Estimates – 500 kV Line Zestaponi-Akhalsikhe-Border with Turkey, Technical-Economic Justification – Tbilisi, 2000

**APPENDIX 17** – Decision #44/10 - April 10, 2001 by State Commission of Georgia of Land Use and Protection – Regarding allocation of land in Aspindza and Akhaltsikhe regions for construction of 500 kV line; Agreement on Land Allocation by State Department of Land Management of Georgia; GSE's and SakRusEnergo's Letters

**APPENDIX 18** – Inventory Acts on Suspended Construction of the 500 kV Line  
Tbilisresi-South Georgia-Zestaponi

**APPENDIX 19 – Energotrans’ Letter #23 - Mar 16, 2004**

## **APPENDIX 20 – E-mail Correspondence with TEIAS**

**APPENDIX 21 – UCTE Expansion Plans**