GEORGIA: NATURAL ENERGY RESOURCES

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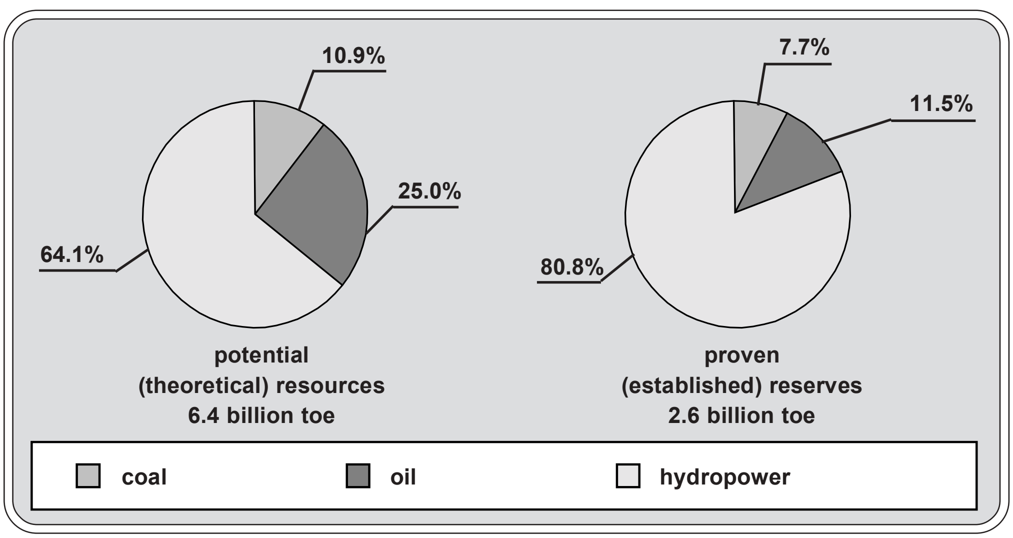
This article examines Georgia's natural fuel and energy resources (FER), both conventional (hydropower, oil, gas, coal) and non-conventional (alternative). Special attention is paid to hydropower and to alternative energy sources. The author assesses the current level of their development in the republic.

Overview of Natural Energy Resources and Their Development

Energy resources have a special place among natural resources. Their great importance is primarily due to the fact that these resources are the starting point for any kind of production; they determine the pace and scale of the development of all sectors of the economy and humanity as a whole.

Figure 1

Structure of Georgia's Conventional Energy Resources[1]



[1] Compiled from the materials of the Georgian Institute of Economics.

Generally speaking, Georgia is not very rich in FER, but almost all kinds of these resources are found in its territory in greater or lesser amounts. Despite its limited reserves of fossil fuel, the republic cannot be regarded as a region poor in energy resources in general, because its rivers hold huge amounts of hydropower, largely compensating for the fuel shortage in the country. Another reason is that Georgia is rich in alternative energy sources (sun, thermal waters, wind, etc.).

An approximate structure of the country's conventional FER is presented in Fig. 1, which shows that hydropower makes up the main part of both potential (theoretical) resources and proven (established balance) reserves (64.1% and 80.8%, respectively). Altogether, potential resources add up to 6.4 billion tons of oil equivalent (toe), and established balance reserves, to 2.6 billion toe.

These energy resources (together with alternative resources) constitute Georgia's total energy potential, which should basically ensure the development of the republic's energy sector.

Nevertheless, the FER development level in Georgia is currently very low (see Table 1).

Table 1

Conventional Energy Resources in Georgia[2]

Resources	Hydropower billion kWh	Coal million tons	Oil million tons
Theoretical resources	135.8	2,355	438.3
Balance reserves	68.5	430	110.9
Production in 2006	5.3	0.005	0.06
Production as a share of balance reserves, %	7.8	0.001	0.05

Hydropower Resources

The country's water resources include rivers, glaciers, lakes, ground waters and wetlands. Their total annual flow is 65.8 cubic km, including transit flows of 9.3 cubic km. These resources are distributed unevenly across the republic's territory: 49.7 cubic km (or 75.5% of all water resources) are concentrated in its western part, and 16.1 cubic km (24.5%) in its eastern part.

Annual precipitation levels are highest (up to 4,000 mm) in the coastal zone of the western part of the Greater Caucasus and the front ranges of southwestern Georgia, and lowest (50 mm) in the southeastern part of the country (Iori-Alazani interfluve). The republic has 26,600 rivers with a total length of 59,747 km. Stream density is 0.85 km per square km. The largest river in Georgia is Rioni, which carries an annual average of 12.6 cubic km of water into the Black Sea. The Kura River at the border with Azerbaijan has a flow of 8.2 cubic km.[3]

At present, the balance technical energy potential of annual river flow per capita is about 13,600 kWh.

According to the data of the Gruzgidroproekt Institute (Georgian HydroProject Institute) out of the total number of rivers in the country 319 stand out in terms of their energy indicators. Their poten-

[2] See: *Prirodnye resursy Gruzii*, Moscow, 1962-1964, and the materials of the State Statistics Department of Georgia.

[3] See: Materials of the Commission for the Study of Productive Forces (KEPS) under the Presidium of the Georgian Academy of Sciences.

tial capacity is 15.63 million kW, and annual power generation, 135.8 billion kWh. Of these, 208 are relatively large and medium rivers with an aggregate capacity of 14.78 million kW, and the remaining 111 rivers are small, with a capacity of 851 thousand kW (5.4% of total capacity).

The energy of the surface flow of Georgian rivers totals 228.5 billion kWh, and its capacity, 26.1 million kW. For every square kilometer of Georgian territory there is an average of 3.27 million kWh of surface flow energy, including 5.06 million kWh in Western Georgia and 1.73 million kWh in Eastern Georgia. Overall, the western part of the country has 72.1% (164.8 billion kWh) of total energy, and its eastern part, 27.9% (63.7 billion kWh). Out of this total, the potential resources of small, medium and large rivers add up to 135.8 billion kWh, or about 60% of total surface flow energy (see Table 2).

Table 2

Potential (Theoretical) Hydropower Resources in Georgia[4]

Resources	Capacity, million kW	Energy, billion kWh	%
Total surface flow	**26.08**	**228.5**	**100.0**
including: Overland flow (surface runoff)	**10.46**	**92.7**	**40.5**
Large, medium and small rivers suitable for energy generation	**15.62**	**135.8**	**59.5**

Table 2 shows that the potential hydropower resources of the country's large and medium rivers are close to 136 billion kWh, and its technical hydropower resources (technically possible to exploit) amount to 68 billion kWh. As regards economic hydropower resources (economically profitable to exploit), these amount to 32 billion kWh.

Meanwhile, the republic's hydropower resources remain largely untapped: in 2006, Georgian hydropower plants (HPPs) generated 5,322 million kWh of electricity (or only 7.8% of the technically possible figure).

Based on the latest achievements in hydraulic engineering, tens of large and medium-sized economical HPPs can be built on the country's rivers.

Of particular importance here is integrated use of medium and small rivers for power generation. According to the Georgian Energy and Hydraulic Engineering Research Institute, very small rivers in the republic could be used to build up to 100 HPPs with a total output of 3.9 billion kWh. For small rivers, the figures are 150 HPPs and 17.5 billion kWh, respectively, and for medium rivers, 45 HPPs and 18.4 billion kWh.

It should be taken into account, however, that HPP construction calls for large capital investments and takes a long time. And this, together with seasonal generation, significantly limits the opportunities for utilizing water power.

Georgia has favorable conditions for the construction of hydropower plants, because 40% of its total technical hydropower resources are concentrated in eight major rivers (Kura, Rioni, Enguri, Tskhenistskali, Kodori, Bzyb, Khrami and Aragvi). At present, about 16.6% of these resources are being used. In the near future, it is planned to continue developing the Rioni River, and eventually the Enguri River (see Table 3).

[4] Compiled from the data of the Georgian HydroProject Institute.

Table 3

Georgia's Economic Hydropower Resources by River[5]

Rivers	In billion kWh	As % of total
Enguri	10.0	31.3
Rioni	7.5	23.4
Tskhenistskali and Lajanuri	2.5	7.8
Shaori and Tkibula	0.3	0.9
Kodori	2.5	7.8
Bzyb	1.5	4.7
Kura and Aragvi	3.0	9.4
Khrami and Paravani	1.1	3.4
Alazani in Tusheti	3.2	10.0
Other	0.4	1.3
Total	32.0	100.0

It should be noted that these figures are based on 1990s data and need to be updated. According to the Georgian Energy and Hydraulic Engineering Research Institute, the updated figures will undoubtedly be higher.

All of this shows that Georgia is a country well endowed with hydropower resources.

Coal Reserves

Many years of research on Georgia's mineral resource base shows that despite its small territory the republic has many deposits of valuable minerals. The most important of these are oil and coal as a power plant fuel (steam coal).

Coal deposits were discovered in Georgia in the first half of the 19th century. Information initially appeared about deposits in Tkibuli, then in Akhaltsikhe and Gelati, and finally in Tkvarcheli. But until the 1930s geological exploration of these deposits was episodic.

Rapid development of natural resources in Georgia (including coal deposits) began after World War II. Coal production started in Tkibuli, while the first mine was being built in Tkvarcheli. Commercial production of brown coal in Akhaltsikhe began after 1948.

To date, nine coal deposits have been discovered in the country's territory, but only three of them are of commercial importance: Tkibuli-Shaori and Tkvarcheli bituminous coal deposits and Akhaltsikhe brown coal deposit. Most of the republic's coal reserves are concentrated in these deposits.

As of 1 January, 2006, the Tkibuli-Shaori deposit accounted for 78.8% of Georgia's balance coal reserves, followed by Akhaltsikhe with 16.6% and Tkvarcheli with 4.6% (see Table 4).

[5] Compiled from the materials of the Georgian Academy of Sciences.

Table 4

Coal Reserves in Georgia
(*million tons*)[6]

Deposits	Balance reserves by category					Off-balance resources
	A	B	C_1	$A+B+C_1$	C_2	
Total reserves	3.8	216.0	210.1	429.9	54.7	13.7
including: Tkibuli	3.8	170.3	164.9	339.0	49.8	3.7
Tkvarcheli	—	6.1	13.5	19.6	0.5	1.6
Akhaltsikhe	—	39.6	31.7	71.3	4.4	8.4

The most valuable Georgian coals—bituminous coals belonging to the PZh (steam and rich) and sometimes to the GZh (gas and rich) group—come from Tkvarcheli. They are coking coals and, when mixed with Tkibuli gas coals, allow the production of quite acceptable metallurgical coke.

The calorific value of the country's bituminous coals is directly dependent on their ash content and varies widely. In laboratory conditions, the figure for Tkvarcheli coals is 7,500-7,800 kcal/kg for an ash content of 4-6%, 5,500-6,500 kcal/kg for 10-20%, and 3,500-4,500 kcal/kg for 30-40%, and for Tkibuli coals, 5,500-6,500 kcal/kg for an ash content of 20-30%. The average figures for ash content and calorific value are 30% and 5,500 kcal/kg for Tkvarcheli coals and 30.5% and 5,300 kcal/kg for Tkibuli coals.[7]

Akhaltsikhe brown coal is a low-rank energy resource. Its average calorific value does not exceed 2,750 kcal/kg, and its ash content is about 40%. In view of this, and also due to high production costs, coal production in Akhaltsikhe was stopped in 1987.

It should be noted that geological conditions for coal mining in Georgia are very difficult, while the coal produced belongs to the hard-cleaning category. Coal is mined at great depths in mountain areas; its methane content is considerable (from 20 to 45 cubic meters per ton); coal is self-ignitable (especially at the Tkibuli-Shaori deposit); and working conditions are very difficult (with temperatures of 22-26°C or higher).

The republic's coal deposits are sufficiently well explored, so that any future discovery of new significant reserves in its territory is unlikely. But geologists believe that there may be coal beds at great depths (1,500-1,700 meters). Balance reserves of coal naturally lag far behind its geological reserves. At the Tkibuli-Shaori deposit alone, the latter are estimated at one billion tons.

From the standpoint of integrated rational use of Georgian coal deposits, younger coals (so-called liptobioliths) are of particular interest. It has been proved that concentrates obtained from these coals can be used to produce plastics required for the economy. They can also be used for power generation. In terms of quality, Tkibuli liptobiolith shales compare favorably with Estonian shales and even surpass them. Through gasification in chamber furnaces, liptobioliths are now used to produce high-calorific household gas.[8]

The republic has peat deposits as well. Its current peat reserves are estimated at 813.2 million cubic meters. The largest deposits are found in the vicinity of Lake Paliastomi. In view of its high ash

[6] Compiled from the data of the State Geology Department of Georgia.
[7] See: *Prirodnye resursy Gruzii. Toplivnye resursy*, Vol. V, Moscow, 1963.
[8] Ibid., p. 90.

content, peat is of little importance as a power plant fuel, but is used in Georgia to produce agricultural fertilizers. Experts believe, however, that it can be used (in the form of bricks) to heat greenhouses and lemon farms. Peat bricks are a good household fuel; one ton of such bricks equals 3-4 cubic meters of firewood.[9]

Georgia is the only country in Transcaucasia with significant coal deposits. Nevertheless, today there is virtually no production of this useful fossil fuel, even despite the negative energy balance. In 2001-2006, the country produced an average of 5-6 thousand tons of coal, whereas in the past its production exceeded 3 million tons (for example, in 1958).

Oil and Gas Reserves

The geological exploration of Georgian oil fields in effect began in 1868. That year, a special department was set up in Tbilisi with the support of Professor G. Abikh, but actual exploration work was started only in 1877. In 1881, Georgian engineer B. Tsulukidze explored for oil in Navtlugi; later on, such work was organized by foreign specialists.[10]

Systematic intensive oil exploration in the republic began in 1929-1930, but significant oil reserves could not be found for a long time, so that the scale of oil production was insignificant. The situation markedly improved by 1947 with the discovery of new oil fields. From 1984, oil production in Georgia fell sharply as a result of unexpected water encroachment. At present (as of 1 January, 2007), the country has 16 producing fields, including Mirzaani, Patara-Shiraki, Norio, Samgori-Patardzeuli, Taribani, Shromisubani-Tskaltsminda, and others. Five companies are engaged in oil production: CanArgo Energy, Frontera, Anadarko, Ioris Veli and Teleti. The country's geological oil reserves in the B+C category total about 180 million tons, including recoverable reserves in this category of 11.0 million tons. In 2006, oil production in Georgia was only 63.5 thousand tons.

Experts believe that there are fairly large oil and gas reserves in the Black Sea (in the Ajara-Supsa water area). According to surveys carried out by Anadarko-Georgia Company specialists, offshore oil reserves alone come to about 0.5-3 billion tons.

The quality of produced oil varies from field to field. The oil of Gare-Kakheti (Mirzaani, Patara-Shiraki, Taribani) is of medium gravity, for the most part containing small amounts of sulfur and wax. In the gasoline fraction, hydrocarbon prevails, while its resin content is insignificant.

The heaviest oil found in the fields around Tbilisi is Norio crude: its gasoline content is low and the presence of sulfur and wax is insignificant.

Samgori-Patardzeuli oil is sweet oil of medium gravity. Its wax content is 4.5%, and the presence of resin is insignificant. This oil has the highest gasoline content.

Guria oil typically has a high resin content coupled with an insignificant sulfur and wax content; the gasoline yield is low.

Eastern Chaladidi oil has a relatively high gravity and a high content of sulfur, wax and resin; its gasoline content is low.

Studies carried out by the Academician Melikishvili Institute of Physical and Organic Chemistry of the Georgian Academy of Sciences show that an increase in oil production in the republic creates wide opportunities for the development of related industries. For example, Samgori oil and low-octane gasoline could be used to produce ethylene, polyethylene and other products.

Gas fields of commercial importance have not yet been discovered in the country, although gas has often been found during exploratory drilling. Such cases were recorded back in 1954-1963, while

[9] Ibid., p. 252.
[10] See: *Proceedings of the Institute of Economics and Planning*, Tbilisi, 1972, p. 193 (in Georgian).

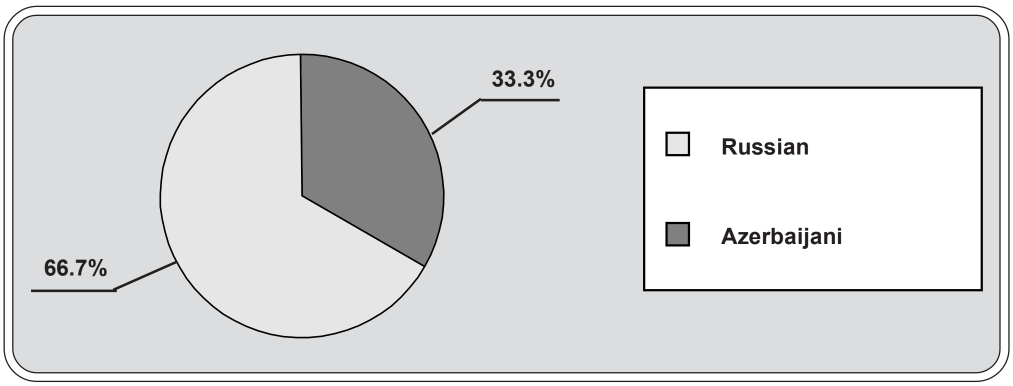
a major flow of natural gas was for the first time obtained in Georgia in 1967, when a gas pool was tapped at a depth of 2,712 meters. The well No. 11 was in operation for three days.[11]

This fact suggests that the republic's subsoil holds natural gas in commercial amounts and that it will eventually occupy an important place in the country's fuel balance.

As of 1 January, 2007, there were three gas fields included in Georgia's State Oil and Gas Balance: Ninotsminda, Samgori and Rustavi. Their total reserves are 8,317 million cubic meters (Mcm), including 2,513 Mcm in Category C_1 and 5,804 Mcm in Category C_2. The only producing field today is Ninotsminda; in 2006, it produced only 21.4 Mcm of gas. The republic's current demand for natural gas is met from imports. In 2007, gas imports are projected at about 1.8 billion cubic meters, including 66.7% from Russia and 33.3% from Azerbaijan (see Fig. 2).

Figure 2

Satisfaction of Georgia's Demand for Natural Gas in 2007



Alternative Energy Resources

Apart from the above, Georgia has other energy sources, whose development and rational use in the near future will to some extent improve the country's energy balance. These are renewable energy sources, primarily thermal waters, wind and solar energy.

Thermal waters began to be used in the republic a long time ago: in 1987, their production reached 17.6 Mcm. In contrast to conventional energy resources, they are constantly renewed and are virtually unlimited. Georgia's balance reserves of thermal waters, as approved by the State Commission on Mineral Reserves back in the 1990s, total 112,484 cubic meters per day (cm/d), including 22,630 cm/d in Category A, 6,110 cm/d in Category B, and 83,744 cm/d in Category C_1.

Artesian wells have brought to the surface hot waters with a significant flow and a temperature of 65-100°C. Most of these wells are located close to population centers.

The country's thermal waters have a large calorific potential and a low degree of mineralization (0.22-2.9 grams per liter), causing virtually no corrosion or scaling.

Another promising avenue in Georgian conditions is use of **solar energy**. Due to its geographical location, the republic is among the countries best endowed with solar energy and is part of the so-called Earth's Sunbelt (45° N to 45° S).

[11] See: *Proceedings of the Institute of Economics and Planning*, Tbilisi, 1972, p. 193.

In most regions of Georgia, annual sunshine duration values are high, ranging from 200 to 250 days. The republic's rational characteristics point to real prospects for solar engineering in its territory. Use of solar energy for space and water heating in Georgia is a very promising area. Solar water heaters could be used on a particularly large scale.

Georgia was the first Soviet republic to start using solar water-heating units: at a metal plant in Tbilisi in 1950, a public bath in Sukhumi in 1951, etc. By 1957, 17 heaters of this kind were built in the republic, and some of these had a fairly high efficiency (43%). The solar heaters built in the 1950s are no longer in operation.

The Tbilisi Zonal Research and Design Institute for Standard and Experimental Design of Housing and Public Buildings (TbilZNIIEP) has designed an experimental one-storey single-family country or summer house equipped with an integrated solar heating and hot water system.

The results obtained in the use of solar energy in the national economy show the need for even wider research in this area. According to the Georgian Energy and Hydraulic Engineering Research Institute, the following tasks have been accomplished to date:

— monthly and annual solar radiation values (sunlight levels) have been determined for 28 sites in the country;

— the republic's territory has been divided into uniform solar radiation zones;

— the optimum tilt of solar water heaters has been established for Georgian conditions;

— efficiency factors for solar water heaters have been established for uniform zones.

Apart from so-called Big Energy, solar power can be used in various spheres of the economy: residential heating, hot water supply, and also in greenhouses, dryers, etc. It can be used to obtain low mechanical energy (1-5 kW). Work along these lines has been conducted at the Institute of Machine Mechanics of the Georgian Academy of Sciences. An appropriate device developed at the Institute has been tested at the solar concentrator in Makhachkala. This device was manufactured at the Krzhizhanovskiy Moscow Power Engineering Institute.

The country's mountainous terrain provides good opportunities for the use of **wind energy**. Relatively stable strong winds are observed in the republic in the fall and winter months, i.e., when the need for energy is greatest.

Theoretical wind energy resources in Georgia are 1.3 TWh and in some areas with higher wind speeds (4.1 meters per second), 4.5 billion kWh. Average wind speed ranges from 0.5 to 0.9 m/sec. In some parts of the country, the figure is higher: 1.5 m/sec.

Climatic studies of space-time solar radiation patterns and wind regimes as the basis for an inventory of solar and wind energy resources were carried out back in the 1980s. The republic was divided into administrative and economic zones depending on their potential resources of solar and wind energy. Sketch maps were compiled showing the distribution of renewable energy resources in Georgian territory.[12]

At present, intensive work is underway on the practical use of wind power. A wind energy resource atlas of Georgia was published in 2004. It presents regional estimates of the wind energy potential based on the criterion of wind power density. These studies cover the country's entire territory.

The atlas contains all data required to select sites for building wind power plants and for making technical and economic assessments. The work is based on data obtained by weather stations over many years in combination with relatively short (2-5 years) runs of wind speed and direction measurements at weather towers located in the most promising areas of Georgia. The authors applied an advanced

[12] See: G. Svanidze *et al.*, *Vozobnovliaemye energoresursy Gruzii*, Leningrad, 1987.

technique developed by the Danish national laboratory Risf and used to compile the European and Russian wind atlases.[13]

The use of wind power in the republic is projected along two main lines:

— implementation of batch-produced low-power wind turbines (water supply, grain threshing and milling, etc.);

— construction of groups of high-power wind plants.

At present, wind energy in the country is virtually untapped, but the *Main Lines of State Policy in the Energy Sector of Georgia*, approved by Parliament, provide for the construction in the short term of a 120 MW wind power station[14] with its subsequent expansion. It is known that seasonal generation of electricity by wind power plants can increase sharply when they are used in combination with HPPs. Research in this area is of great importance to the republic's mountain areas from the standpoint of stable electricity supply.

Georgia has an opportunity to use energy from **biomass and waste**, which can meet a part of the country's energy demand, including in rural areas. The energy potential of different kinds of biomass is estimated at 3.2-4.7 billion kWh. Given rational use of waste, the country can annually save 260 thousand toe.

Apart from the above-mentioned energy resources, Georgia is rich in hydrogen sulfide, a material required for the development of **hydrogen-based** energy. As we know, commercial production of hydrogen has recently undergone considerable changes. Since the 1990s, international oil companies have regarded hydrogen as a "second oil." Iceland has been chosen as a testing ground for this purpose.

Hydrogen production technologies can also be implemented in Georgia, because the county is well endowed with hydropower resources, geothermal waters and hydrogen sulfide deposits in the Black Sea. At the present stage, the authorities are considering the implementation of two projects in the territory of the republic:

(a) a study of the operation of hydrogen-fueled transport, to be carried out on the Black Sea coast, and the development of an infrastructure for the use of hydrogen and hydrogen sulfide, which will make it possible to use hydrogen obtained in the course of technological processes during subsequent development of Black Sea reserves;

(b) production of hydrogen for commercial purposes using electric power. There are plans to produce hydrogen at electric power stations during floods and with the use of surplus electricity generated at night.[15]

As it follows from the above, Georgia cannot be ranked among countries poorly endowed with energy resources. It has an untapped energy potential and is able to offer a great deal to serious foreign partners by way of cooperation.

Georgia's long-term economic interests call for a sharp improvement in the development of all natural fuel and energy resources so as to enhance the country's energy self-sufficiency.

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[13] See: *Wind Energy Atlas of Georgia*, Tbilisi, 2004.
[14] See: *Main Lines of State Policy in the Energy Sector of Georgia*, Tbilisi, June 2006 (in Georgian).
[15] See: *The Energy Strategy of Georgia*, Tbilisi, 2004, p. 183 (in Georgian).