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RENEWABLE ENERGY POTENTIAL IN GEORGIA AND THE POLICY OPTIONS FOR ITS UTILIZATION

Prepared by World Experience for Georgia for Winrock International under Sub Agreement 5708-07-04
February 2008

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WORLD EXPERIENCE FOR GEORGIA

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Introduction

The Energy Policy of Georgia states the objectives of forming the legal and institutional framework for improved Energy Efficiency, as well as exploring and implementing measures for utilization of renewable energy sources (RES) in Georgia. In compliance with this provision of energy policy, the Ministry of Energy has requested Winrock International to assist with drafting energy efficiency and renewable energy laws. The current study has been conducted by the foundation “World Experience for Georgia” for Winrock International in the framework of this task. This study is a first step in developing policy recommendations for Georgia’s renewable energy strategy and policy options for use in drafting the Law on Renewable Energy Sources.

In our report we have relied on previous studies in the various fields of renewable energy, and the principles and methods of evaluating renewable energy performance and potential; we have strived develop practical conclusions for policy actions. The report has been prepared in a short period of three months, and does not wholly cover all the issues related to development of renewable energy in Georgia. Additionally, we were unable to fully represent information about Abkhazia for political reasons.

In this report, the term renewable energy sources (RES) comprises the following:

Small hydro power – Small hydro power plants (SHPP), below the capacity of 10 megawatts (MW), are considered as renewable for the purpose of this study. The 10 MW threshold is conventional, and it conforms with existing tradition, legislation and EU definition of small hydro power.[1] Large hydro power plants are frequently excluded from current RES discussions due to their substantial environmental impacts.

Wind power– due to short lead times, minor environmental impacts, the possibility for modular construction and gradual increase of capacity, wind power is considered to be renewable without limitation of capacity.

Biomass – the amount of biomass that can be recovered through the natural growth and recreation process of plants is attributed to renewable energy sources. E.g. the wood cut and burnt in excess of sanitary norms is not considered as renewable.

Solar and Geothermal Energy sources are also considered renewable without limitation.

Wherever appropriate, different policy actions are suggested for off-grid (servicing isolated customers), mini-grid (connected to a local distribution grid), and grid-connected (transmission grid) renewable energy sources.

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[1] http://ec.europa.eu/energy/library/599fi_en.pdf 1997 EC White Paper “Energy For The Future: Renewable Sources Of Energy”

The terminology used to describe renewable energy potential varies from study to study. Throughout this document we will use the following definitions.

Theoretical potential – is an estimate of the total annual amount of potential energy of certain renewable energy sources available in nature.

Technical potential – is an estimate of the usable portion of that theoretical potential, based on current, state of the art technologies

Achievable Potential – is the energy potential that can be reasonably achieved within existing institutional and physical limitations (e.g., terrain, another use of the same resource, roads, etc,). Achievable potential is a benchmark to which the current state of RES utilization should be compared.

Economic potential – is the total energy that can be annually obtained through cost-effective measures at current or projected market conditions, technology costs, and other economic factors. Economic costs and cost-effectiveness are evaluated from the perspective of society rather than the individual project developer.

It is not straightforward to apply these definitions uniformly to vastly different energy sources; however, an attempt is made to stick to these conventions as much as possible.

Finally, there has been a common tendency to dismiss renewable energy potential by using arguments like:

- **Renewable energy potential is small compared to traditional energy sources (?)**
- **Renewable energy sources are more expensive (?)**
- **Development, control and management of traditional energy sources requires large administrative resources (?)**
- **Technologies are not mature and reliable (?)**

In the current study we try to examine these and other assertions in detail; we try to draw neutral conclusions in order to support economically- and technically-justified decision making by policymakers.

Main abbreviations and units used in this report:

RES – renewable energy sources
GNERC – Georgian Energy Regulatory Commission
ESCO – Electricity System Commercial Operator
RES – Renewable energy sources
MoE – Ministry of Energy of Georgia

HPP – Hydropower plant
SHPP – Small hydropower plant

CDM – Clean Development Mechanism under the Kyoto Protocol
ERPA – Emission Reductions Purchase Agreement

TPES – Total Primary Energy Supply
TOE – Tons of Oil Equivalent energy
kTOE – kilotons of oil equivalent
MTOE – Million Tons of Oil Equivalent energy

kW – Kilowatt
MW – Megawatt
GWh – Gigawatt hour
TWh – Terrawatt hour

Chapter 1
Executive Summary

1.1. Background Information on Renewable Energy Sources in Georgia

Georgia has vast resources of almost all types of renewable energy – solar, wind, geothermal, hydro, and biomass. The achievable annual potential of all RES can be estimated at 10-15 terawatt hours (TWh) or equivalently around one million tons of oil equivalent (MTOE) energy; this is enough energy to meet over a third of Georgia's annual energy needs. However, only a very small part of this potential is used currently; the share of renewable energy in Georgia's energy balance is approximately one percent. Currently the amount of electricity generated from renewable energy sources (RES) is approximately 3 percent of the total amount of electricity produced (excluding large hydropower generation).

When making policy decisions on renewable energy development, the task of policymakers is to harness the market forces to harmonize individuals' interests with that of the country's—thus creating an optimal result for energy producers, energy consumers and for Georgia. This challenge requires a wise and careful approach and the deployment of finely-tuned policy instruments at the disposal of the state.

The conclusions and recommendations of the current study are based on discussions held with various specialists in the energy sector, who are involved in RES development The material in this report is largely based on the ideas and information presented by these practical specialists and representatives of scientific and academic institutions, as well as the results of previous comprehensive studies of RES technical potential. As an important part of our work, a discussion workshop was conducted where the leading specialists actively involved in the development of renewable energy in Georgia presented their findings and their views on the potential of renewable energy technologies and sources in Georgia and on optimal ways of their utilization.

However, due to time constraints these discussions were necessarily limited in scope, leaving out many issues that require more detailed and comprehensive analysis; thus, it is desirable to continue the policy dialogue and research in RES development issues. Further research can bring a double benefit by 1) identifying the optimal policy decisions for RES development in Georgia and 2) creating the capacity and public environment for supporting these policy options.

1.2. Legal and Institutional Environment for RES Development

There are a number of international documents having relevance to development of renewable energy sources in Georgia. These include: the Energy Charter Treaty[1]; Framework Convention on Climate Change and the Kyoto Protocol;[2] the Energy Community Treaty[3]; European Neighborhood Policy .[4] and others.

For Georgia, who has joined or requested membership to organizations that execute and/or abide by these regulating documents, implementation of the recommendations and opportunities given by these documents is both beneficial and in some cases mandatory. In addition to providing technical assistance and guidance, several of these international energy agreements offer financial incentives and project financing opportunities for Georgia to develop RES projects and undertake energy sector reforms to harmonize its energy legislation with international standards.

If Georgia's aspirations towards European Union accession are to be pursued, Georgia needs to take into account the new EU targets for renewable energy development in its RES policy development. The opportunities and financial incentives associated with the Clean Development Mechanism should be seized, and the requirements for the harmonization of Georgia's regulatory framework with European standards will need to be pursued.

The Clean Development Mechanism (CDM) of the Kyoto Protocol is an important instrument to be fully utilized in expanding energy efficiency and renewable energy activities in Georgia. Georgia has considerable potential to develop many CDM projects that will have the possibility to generate tens of millions of dollars in carbon revenue over the next few years by leveraging investments in the energy, waste, forestry and agricultural sectors. The recently approved programmatic approach to carbon crediting offers additional opportunities for small-scale RES development.

International institutions are playing the leading role in development of RES in Georgia up to now. USAID, the United Nations Development Program (UNDP), the German development bank KfW, and the Global Environment Facility (GEF), EBRD, Norwegian Government and others are supporting a great number of activities including pilot projects, policy analysis, trainings, and more. These programs are implemented by different agencies including PA Consulting, Winrock International, the Energy Efficiency Center, the Association of Energy Engineers, and others.

The USAID Rural Energy Program implemented by Winrock International is working to construct several off-grid mini-hydro facilities and biogas digesters for rural farmers, as well as helping to rehabilitate grid-connected, small hydro power plants. The Rural Energy Program has facilitated also facilitated the important improvements in the Electricity Market Rules that allow small hydro-plants to sell their non-contracted electricity to ESCO. The UNDP has sponsored RES pilot project research including a feasibility study on introducing high efficiency stoves in Georgia. The European Bank for Reconstruction and Development has started a new $30 million program to finance RES and energy efficiency projects in Georgia. EBRD financing is to be provided in the form of a credit line where Georgia's participant banks will on-lend to

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[1] http://www.encharter.org/
[2] http://unfccc.int/
[3] http://eur-lex.europa.eu/LexUriServ/site/en/oj/2006/l_198/l_19820060720en00180037.pdf
[4] http://ec.europa.eu/world/enp/documents_en.htm

private sector industrial entities for energy efficiency and rational energy utilization investments.

Continued involvement of international donor organizations in RES development offers further opportunities for Georgia. However if Georgia is to reap the benefits of these investments, the country must build a common and comprehensive RES strategy and policy framework.

Georgia's Legal and Institutional Framework

Currently there is no special legislation devoted to development of Renewable Energy Sources in Georgia. Electricity sector legislation partly addressed the grid connected electricity from RES (hydropower, wind power), while other types of renewable energy are not covered by corresponding legislative acts. There is even no established clear and consistent definition of renewable energy sources to be used uniformly across Georgia's legislation. Moreover, there is no designated authority charged exclusively with developing RES. Consequently, domestic RES development has had only a moderate success up to now.

Although there has been a renewed attention to RES and especially small hydro plants in the last two years, the State Strategy and Long Term Action Plan for RES development is still lacking. Such a strategy should be a comprehensive document based on sound and transparent economic principles and should be a part of general energy strategy, in order to streamline all legislative and institutional changes needed for successful development of RES of all types.

There has been an attempt to develop the Concept of State Renewable Energy Development Program that has been approved with the Presidential decree in March 1998. The document included provisions for subsidies, guarantees of power purchase at favorable prices and tax benefits, however, these provisions were not subsequently transformed into in any realistic action program or strategy.

The modest gains made in the form of tax breaks and incentive pricing under that presidential decree were later dismantled in the Tax code of 2005. Prior to January 1st 2005, RES developers received tax benefits including VAT exemption, land use tax exemption, and property and profit tax exemption for renewable energy equipment import, manufacturing and operation. The new tax code and current customs legislation do not provide any special treatment for import, manufacturing or realization of RES equipment or energy efficient appliances.

The document of Main Directions on State Policy in the Energy Sector,[5] stipulate Georgia's goal of RES development and contains concrete development milestones for SHPPs and wind power plants through 2015. However the policy measures for implementation of these goals proved to be insufficient and the projected numbers remain largely unrealistic.

There has been a series of welcome changes in the law on Electricity and Natural Gas as well as in Electricity Market Rules that are directed to creating the favorable environment for small grid connected plants. For example, under recent amendments the small hydro plants can sell all

[5] http://www.minenergy.gov.ge/index.php?m=291

their output to ESCO at average ESCO tariff. Also, under the amendments of June 2007 to the Law on Electricity and Natural Gas, the Ministry of Energy was given the right to “define the newly built plants (not only the small plant), whose output in full or partially is subject to mandatory purchase by ESCO at the long term tariffs set by NERC” (Article 3. Clause1. M). This amendment is a l way to provide incentives to new renewable energy plants, however at the same time there is a need to specify the principles and criteria to be used by the ministry in “defining” such a plant or defining the share of output subject to mandatory purchase. The principles for setting the long term tariffs by Georgia’s National Energy Regulatory Commission should be specified as well. In general, there is a need for further conceptual and technical improvements to make these provisions fully effective and beneficial. The consistency with the requirements of least cost development of the whole energy sector, establishment of transparency and market principles needs to be assured.

There are a number of other barriers, listed below, that need to be addressed in order to allow the rapid development of RES in Georgia.

- The market for RES electricity needs to be developed. Although Georgia does not produce enough energy to satisfy domestic demand, there is an excess of electricity from hydro plants in summer; thus there is no internal need for additional electricity from wind farms or SHPPs on the grid during this season.
- A sound and reliable legal framework for RES needs to be formulated, otherwise the frequency and quality of legislation changes may have a discouraging effect on investment decisions.
- Information on the benefits developers and local communities can derive from RES development and utilization should be made widely available.
- The fees and rules for grid connection, power wheeling tariffs, long term tariff methodology and other regulatory documents need to be developed.

In summary, the few existing provisions in legislation in support of RES development need to be expanded and supplemented by adequate implementation mechanisms, such as: special legislation, supplementary regulatory documents, tax incentives, implementation agencies and information campaigns. The initiatives for RES development should be coordinated under a state strategy and plan for energy sector development and be based on sound market principles and transparency.

1.3. Energy Balances in Georgia

The total primary energy supply in Georgia is approximately 3.3 million tons of oil equivalent (MTOE). Per capita energy consumption is 0.74 tons of oil equivalent energy (TOE). Here are several characteristics of Georgia’s energy supply and use:

- 70% of the total primary energy supply in Georgia comes from imported resources
- 45% of the total energy is imported natural gas and 25% is imported oil products
- the biggest indigenous energy resource is hydro energy (18%), followed by firewood (12%)

- renewable energy sources comprise less than 1% of Georgia's energy budget (excluding hydro power).

Natural gas is being imported throughout the year; however as can be seen from Figure 1.1, the imports increase in winter, 3-4 times compared to summer months.

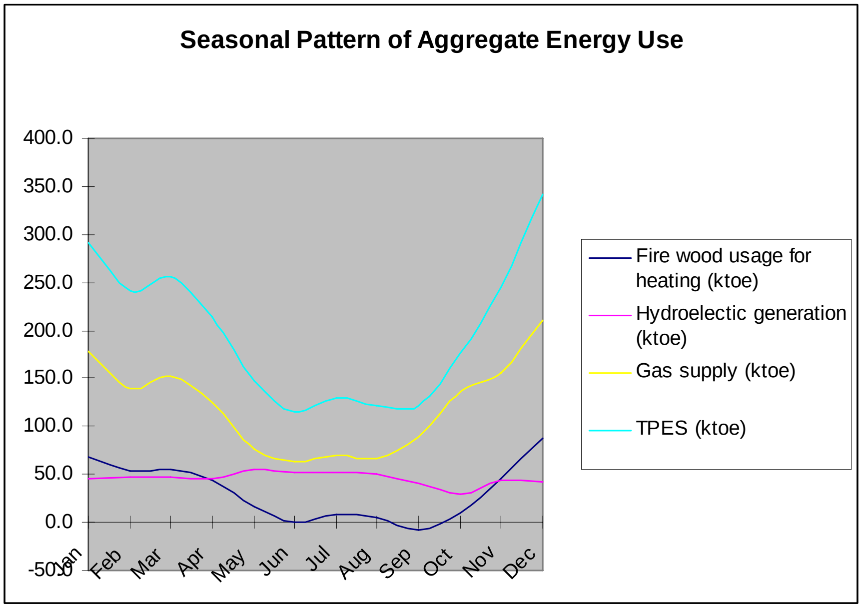

Figure 1.1. *Seasonal structure of aggregate energy use, kilotons of oil equivalent (kTOE)*

Total electricity supply in Georgia is around 8.3 terawatt hours (TWh) per year; domestic hydro power plants supply 80% of this. The contribution of small hydro-plants (with actual capacity of less than 10 MW) in the electricity balance is approximately 4%.

The seasonal pattern of electricity supply and consumption is shown in Figure 1.2.

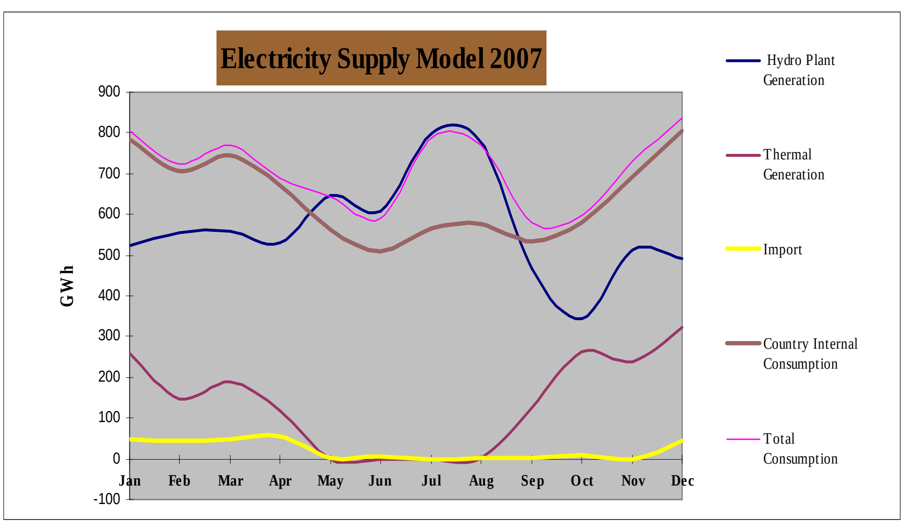

Figure 1.2. *Seasonal structure of **e**lectricity supply*

From the figure above one can see that:

- the generation of domestic hydropower plants dominates the supply side and exceeds in-country demand in summer months.
- thermal power plants operating on imported gas produce only in winter months.

Form Figures 1.1 and 1.2 one can conclude that:

- RES can contribute to Georgia's energy security by replacing imported gas throughout the year.
- development of electricity generation from RES strongly depends on developing the market in summer months when there is already an excess of hydropower.

1.4. Renewable Energy Potential in Georgia

Small Hydro Potential

Currently there are 33 small hydropower plants (SHPPs) in Georgia, and their total capacity is 85 megawatts (MW); in the balance year 2006-2007 their electricity generation comprised 295 million kWh. The share of SHPPs in total hydro capacity is 3.1%, while generation amounts to 5.35%. In Georgia's annual electricity balance (including thermal plants), SHPPs contribute 1.9% in capacity and 3.8% in output. The bulk of SHPP generation falls during spring and summer months, i.e., in the period when the generating capacity of medium and large hydropower plants (HPPs) significantly exceeds Georgia's energy demand.

In Georgia 360 rivers can be considered as having significant energy potential. The total theoretical hydro energy potential of *small rivers* is estimated at 40 TWh/year while the technical potential is evaluated at 19.5 TWh per annum.[2] The achievable SHPP potential is estimated by experts to be 20-25% of this value. Thus the long term RES policy can more realistically target 4-5 TWh of energy generation from small hydro plants per annum.

The technical small hydropower potential has roughly the same seasonal distribution as the rest of the hydropower generation, i.e., the maximum output falls during summer months as can be seen from Figure 1.3. This is a serious problem that generally hinders the development of energy generation in Georgia since currently there is no internal market for additional small hydro power in the summer months— the period of their maximal output.

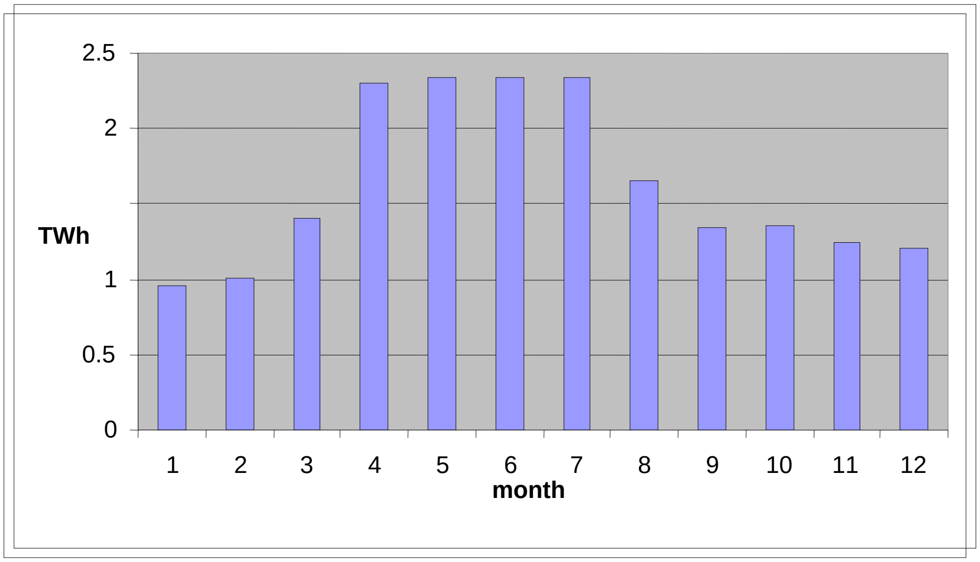

Figure 1.3. Technical Potential of SHPP Generation by Months

Wind Power Potential

Measurements of wind speed have been carried out in Georgia on 165 meteorological substations during several decades. Based on processing and analysis of these data, it has been proven that the total theoretic wind energy potential amounts to 1300 gigawatt hours (GWh) and exceeds the total theoretic river energy potential (135 GWh) almost ten times. The most favorable regions for wind energy development have been also determined based on these data.

The wind energy research center "Karenergo" has developed the "Georgian Wind Energy Atlas,"[6] based on existing meteorological data and their own perennial measurements using the contemporary measurement equipment of NRG Systems in the most of the prospective locations.

[6] "Georgian Wind Energy Atlas", M.S.Gelovani et al., Editor A.Zedginidze, Karenergo-ISTC, Tbilisi, 2004

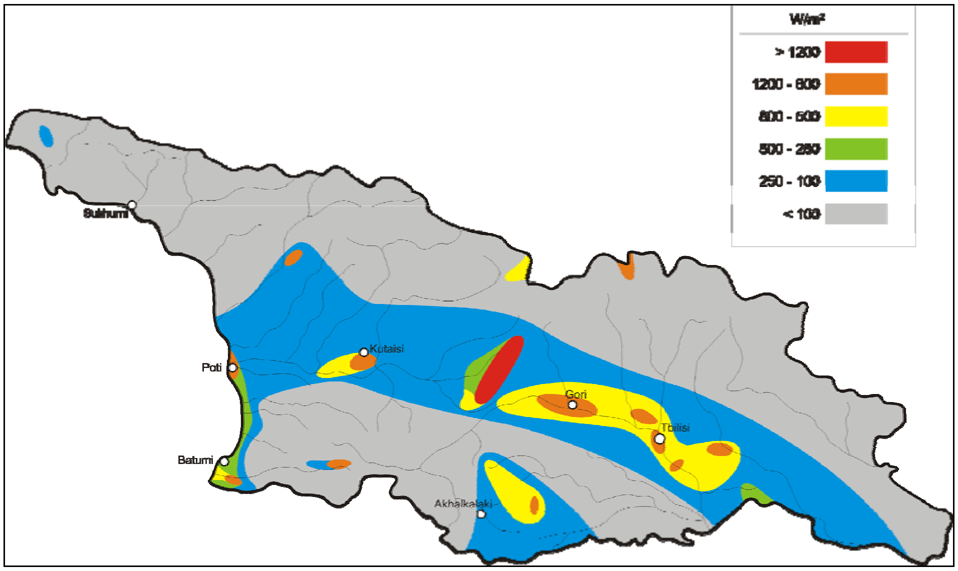

Figure 1.4. Average annual wind energy distribution on the territory of Georgia at the height of 50 meters above the ground level; Source: Karenergo.

Based on the wind energy potential, the technical potential of wind power has been assessed with the use of analytical methods and WASP software from the Danish laboratory Risø. The distribution of wind energy potential throughout Georgia is shown in Figure 1.5..

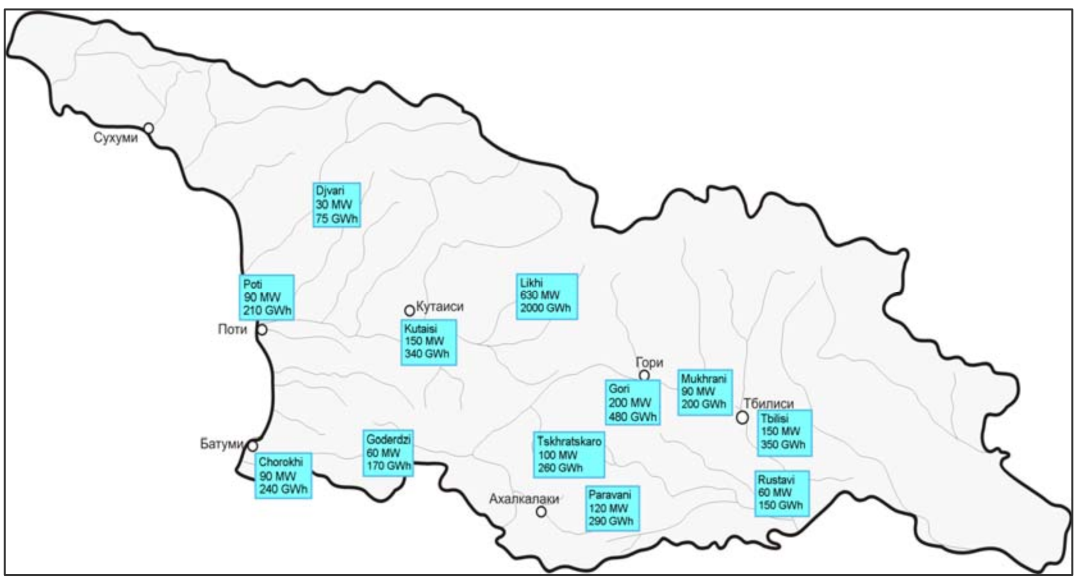

Figure 1.5. High productive potential wind farms in the regions of Georgia; Source: Karienergo

The calculations show that about **2000 MW of capacity and 5 GWh energy per annum**, or otherwise about 60% of today's electricity consumption in Georgia can be obtained. This estimate covers the most promising areas with the highest wind potential. Smaller sites with high wind potential are not reflected in this report.

Many of the potential wind farm sites show a favorable seasonal output pattern with maximum potential output in winter months. This conforms best with seasonal domestic energy demand in Georgia, indicating that wind energy has good potential to offset external energy dependence in winter.

Biomass Energy Potential

There is a need for a comprehensive evaluation of biomass energy potential in Georgia; the data obtained and quoted by different authors significantly differs. Approximate data is given in this research.[7] The estimated energy potential of wheat crops residues amounts to 280 million kWh, corn crops – 750 million kWh, other corn and legume cultures – 270 million kWh. Therefore, total energy potential of corn cultures' residues consists of 1.3 TWh/year or 112 thousand tons of oil equivalent energy (TOE) per year. The total energy potential of residues from farming and poultry breeding consists of 6.9 GWH; that is equal to 0.6 million tons of oil equivalent (MTOE).

According to municipal data of Tbilisi and Kutaisi, 900 thousand tons of residential waste is annually accumulated in dumps; 90 million cubic meters of biogas can be obtained by re-treatment of these residues. In Tbilisi, 160 million cubic meters of biogas can be annually obtained from the city's sewerage water cleaning station (servicing 1.2 million people). Energy of this biogas can amount to 1 GWH/year; that is equal to 92 TOE. The estimated energy potential of various types of biomass is given in Table 1.1.

Type of Biomass	Quantity (10^3 tons)	Energy (TWh/year)	Energy Equivalent
Residues from corn and legume cultures	**870**	**1,3**	**112 thousand TOE**
Residues from cattle farming and poultry breeding	**1670**	**6,9**	**$760*10^6$ m^3 Natural Gas**
Domestic residues	**900**	**0,6**	**$60*10^6$ m^3 Natural Gas**
Residues from sewerage water cleaning station	**250**	**1,0**	**$92*10^6$ m^3 Natural Gas**
Forest and its residues	**700**	**2,7**	**200 thousand TOE**
Total		**12,5**	

Table 1.1. Energy potential by biomass types.[8]

[7] N. Arabidze. "Elaboration of Rational Schemes of Combined Thermal Plants Working on Bio Fuel Based on Synergy Energy Approach and Thermodynamic Researches". Candidate of Technical Sciences Thesis, Tbilisi 2005.

[8] It is important to note that the amount of forest included in Table 1.1 corresponds to the environmentally allowable limit; in reality the forest reserves are heavily overexploited.

As shown in Table 1.1, the energy potential of the main biomass types in Georgia amounts to 12.5 TWh. For comparison one can note that the energy generated by the Georgian energy system does not exceed 8 TWh today. This estimate does not incorporate the potential of farming energy crops.

Solar Energy Potential

The distribution of average daily irradiation on horizontal surface on the territory of Georgia is shown in Figure1.6.

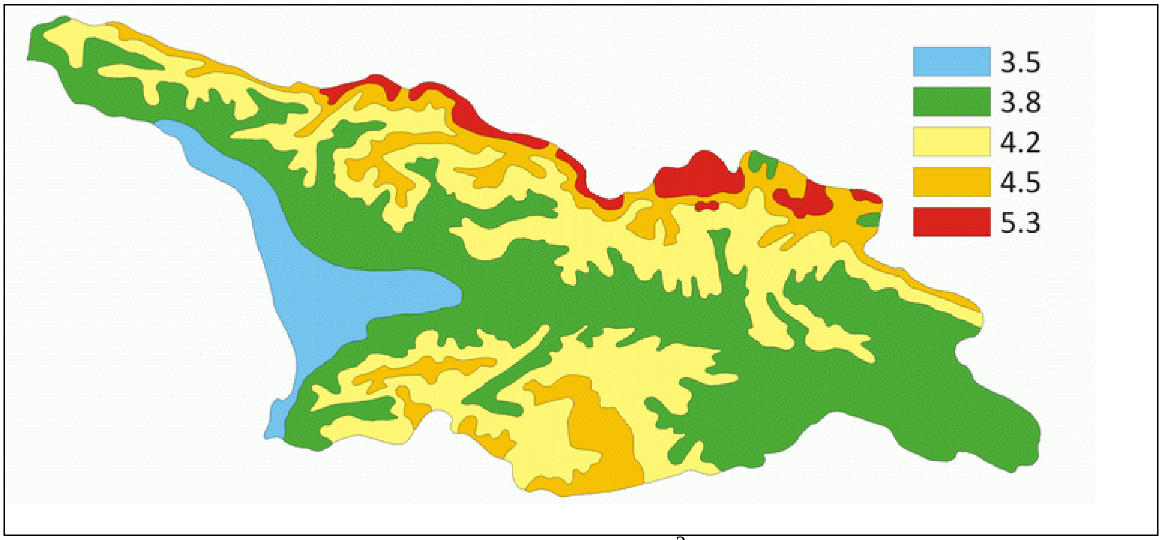

Figure 1.6. Average daily solar radiation in kWh/m^2; Source: the solar energy cadastre of Georgia compiled by "Sun House."

An average of 1550 kWh of solar energy is annually irradiated on a surface of one m^2 in Georgia.[9] This is equivalent to about 190 kWh of electricity or 1200 kWh of thermal energy (hot water) annually based on current efficiencies of photovoltaic or water heating panels.

There is no reliable data on the current state of solar energy utilization. However, there is an upward trend in the annual number of installations conducted over the last few years.

The achievable **economic potential of solar energy use** in Georgia can be estimated through analogies with other countries**.** Estimating this to be about (0.2-0.4)% of total primary energy supply (TPES) we arrive at equivalent of to **5-10 kTOE,** or roughly **60-120 GWh** of energy annually. More than 70% of this potential is realizable in the months of April through September; however it can still substantially contribute to the reduction of energy dependence by replacing the need for gas currently used for hot water supply throughout the year.

[9] G.G.Svanidze, V.P.Gagua, E.V.Sukhishvili – Renewable Energy Resources of Georgia, Tbilisi 1987

Currently there are no legal acts in support of development of solar energy use in Georgia. Until recently the solar systems received tax benefits and were exempt from the VAT. However the new tax code has eliminated these and other benefits. As a result, the price of solar panels in Georgia has increased by 35-40% due to transportation and the taxation costs after importing.

Geothermal Potential

There are approximately 206 wells and 4 springs of geothermal water with temperatures between 30 and 110^0 Celsius located in 44 deposits in Georgia. About 80% of this geothermal potential is located in West Georgia. The total theoretical thermal capacity of all geothermal sources at t^0-25^0C was estimated at 300 MW of thermal capacity. Total achievable potential is estimated at 30% or 100MW of thermal capacity.[10] The temperatures of geothermal deposits are not very high and are mostly suitable for heating and hot water supply.

The use of geothermal energy currently is quite limited. In Tbilisi, "Geothermia LLC" operates six geothermal wells for hot water supply to a section of the Saburtalo district. The total output of geothermal water is 4 000 m^3/24 hrs; 79 residential block buildings are supplied with thermal water with 55 ^{0} C temperature and 15 residential block buildings are supplied with thermal water with 70 ^{0} C temperature. "Geothermia" is currently trying to commercialize the hot water supply system. The prices for geothermal water are not regulated and are determined by the LLC itself. In other locations the geothermal energy is mostly used by the neighboring population in an unorganized way.

The potential for heating in selected locations is as follows: Khobi – 1.2 MW. Senaki – 11 MW, Samtredia – 5MW, Vani- 5 MW.

There are a few potential projects for use of geothermal water for agricultural and industrial use:

- the agricultural complex on the basis of Zugdidi-Tsaishi geothermal deposit (185 GWh/year);
- Tbilisi hot water supply and space heating three-phase project:

Tbilisi stage 1	46 GWh/year
Tbilisi stage 2	92 GWh/year
Tbilisi stage 3	490 GWh/year.

The feasibility of these and other projects requires further study in order to determine economically viable options and volumes of geothermal energy utilization.

[10] N. Tsertsvadze, G. Buachidze, O.Vardigoreli "Thermal Waters of Georgia", Tbilisi, 1998

In order to promote the use of geothermal energy in other locations it is necessary to implement a number policy measures including:

- transparent rules for obtaining licenses for geothermal wells
- clear regulations on land use and property rights for wells and pipe routes
- clear definitions on price regulations and subsidies for different groups of consumers.[11]

A Summary of RES Potential in Georgia
The estimated potential of different types of RES in Georgia is summarized in Table 1.2. below:

RES Type	Theoretical Potential	Technical Potential	Achievable Potential	Economical Potential
Small Hydro	40 TWh	19.5 TWh	5TWh	
Wind	1300TWh		5TWh	
Bio Mass		12.5 TWh	3-4TWh	
Solar	1550 kWh/m^2			60-120GWh
Geothermal	300MW	100MW	700-800 GWh	

Table 1.2. Summary of estimated RES potential in Georgia

In total the estimated achievable RES potential in Georgia amounts to 10-15TWh or equivalently 0.9-1.3 MTOE per year.

1.5. Conclusions and Recommendations

Primary Barriers to RES Development

Currently there is no State strategy or programs advancing RES development. In the absence of a general vision and realistic targets, the fragmentary legislative initiatives do not fully address the needs of RES development.

Other main barriers for RES development are:

- the absence of a market for RES electricity in the summer period. In the conditions of excess hydropower in summer, small hydro plants or wind farms can not compete with existing hydro generation;
- a lack of consistent and clear energy legislation in support of RES;
- insufficient organizational capacity devoted to RES development by the State;

[11] Renewable Energy Strategy , "Georgia – Promoting the Use of Renewable Energy Resources for Local Energy Supply", POSCH & PARTNERS Consulting Engineers UNDP- 2007

- the taxation system; which lacks incentives and preferences for RES;
- low public awareness and lack of information for various stakeholders including developers and policy makers.

Recommendations

Increased state involvement and activity is the crucial factor for proper development of renewable energy sources in Georgia. The institutional and legal framework for development of RES needs to be substantially reworked and in many respects created anew. For this purpose:

- a comprehensive and sound state policy for renewable energy with clearly defined priorities and quantitative targets should be formulated;
- a Law on Renewable Energy Sources should be formulated and passed;
- a designated authority should be assigned to implement the main directions of state RES policy;
- the RES strategy should be developed based on further economic and technical analyses and discussions with relevant officials from the Ministry of Energy, Ministry of Environment, GNERC and other official structures.

In order to properly utilize the significant potential offered by RES there is a need for prompt energetic and well prepared comprehensive actions. Action items are detailed below.

- Implement tax benefits for RES. The tax benefits should be designed and implemented based on proper economic analyses and include VAT exemptions, accelerated depreciation, property and profit tax benefits, etc.

- Develop a stable long-term mechanism to export or conduct a seasonal swap of excess power in summer. This condition is a necessary for developing grid-connected RES**,** and should be developed into a Regional Energy Market. The ESCO should be assigned to purchase electricity and organize the export and seasonal exchange of electricity.

- Long-term energy planning is essential for RES development. Development of RES is closely related to the development of the rest of energy sector. Therefore a long-term, economically and technically sound energy sector plan is a necessary condition for RES strategy planning.

- Strengthen the use of international resources for development of RES including the Clean Development Mechanism and donor funding.

- Develop long-term tariff and fee setting methodologies for grid-connected RES. This should address long term feed-in tariffs, grid connection fees, power transit fees, mini-grid and grid connected RES etc.

- Provide Information and promote awareness. A series of national information campaigns should be prepared to overcome low public awareness of domestic RES potential.

Special training programs should be developed and practical training implemented. Energy consulting centers should be established in the regions.

- Enact stricter environmental legislation on waste disposal and recycling to stop environmental contamination with biomass and promote its usage for energy purposes.

- Implement simplified and clear procedures of RES project approval, e.g., issuing construction permits, land and water usage permits, etc.

- Harmonize legislation to address RES in a uniform manner and in compliance with the state strategy on RES development. As a first step uniform terminology should be defined and used in different legislative documents.

There is a need for further analysis of economic policy and technical issues.

The methods for policy analysis include:

- long term energy planning,
- transmission tariff and connection fee setting,
- economic analysis of feed-in tariffs,
- differential tariff setting for mini-grid and grid-connected small hydro and wind power plants etc.,
- an economic justification of tax incentives, and
- an economic assessment of mandatory regulations for using the RES (e.g., solar collectors) should be developed.

In addition the technical research needs to be conducted to:

- develop a more accurate solar cadastre of Georgia,
- develop a more accurate energy balance of Georgia including reliable statistics of wood consumption,
- study the current conditions and parameters of geothermal resources, and
- study the potential for fuel production from farming of energy crops.

Chapter 2
Legal and Institutional Issues of Renewable Energy Utilization

The experiences of developed countries show that the proper and wide utilization of renewable energy sources (RES) strongly depends on reasonable and economically-justified protectionist policies of the state. This is achieved by adopting corresponding legislation and creating a favorable investment climate. Various levers exist for creating such an environment in Georgia.

2.1. International Aspects of Renewable Energy Source Development

There are a number of international documents bearing importance to development of renewable energy sources and energy efficiency in Georgia:

- Energy Charter Treaty and Energy Charter Protocol on Energy Efficiency and Related Environmental Aspects (PEEREA)[1]
- Framework Convention on Climate Change and the Kyoto Protocol[2]
- European Neighborhood Policy [3]
- European Commission “Green Paper, “A European Strategy for Sustainable, Competitive and Secure Energy” of 2006[4]
- Energy Community Treaty[5]
- Memorandum of Understanding on CDM trading signed with Denmark in 2004[6].

For Georgia, which has joined or requested membership in organizations that execute and/or abide by these regulating documents, implementation of the recommendations and opportunities given by these documents is both beneficial and in some cases mandatory. In addition to providing technical assistance and guidance, several of these international energy agreements offer financial incentives and project financing for Georgia to undertake energy sector reforms.

In March 2007 EU heads of state made a commitment to achieve at least a 20% reduction of greenhouse-gas emissions by 2020 compared with 1990 levels. The EU agreed to go even further and reduce its emissions by an overall 30% provided that other countries such as the US commit to comparable emissions reductions. The new targets are significantly higher than the 8% overall target the EU agreed to be reached by 2012 under the Kyoto Protocol. The EU endorsed "a binding target of a 20% share of renewable energies in overall EU energy consumption by 2020." A 10% minimum target for biofuels was also agreed.[7]

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[1] http://www.encharter.org/
[2] http://unfccc.int/
[3] http://ec.europa.eu/world/enp/documents_en.htm
[4] http://ec.europa.eu/energy/green-paper-energy/index_en.htm
[5] http://eur-lex.europa.eu/LexUriServ/site/en/oj/2006/l_198/l_19820060720en00180037.pdf
[6] glwww.mst.dk/inter/03090111.htm
[7] http://www.consilium.europa.eu/ueDocs/cms_Data/docs/pressData/en/ec/93135.pdf

This decision should be another incentive for Georgia, with its aspirations of acceding to the EU, to promote the use of domestic renewable energy.

2.1.1. The Clean Development Mechanism of the Kyoto Protocol

The Clean Development Mechanism of the Kyoto Protocol is an important instrument to be fully utilized in developing energy efficiency and renewable energy activities in Georgia. This is a project-based mechanism designed to promote investment in projects which reduce or sequester emissions of greenhouse gases in developing countries, including Georgia.

The Kyoto Protocol has created a significant opportunity for countries that are not members of the Organization for Economic Cooperation and Development (OECD), such as Georgia, to leverage investments in clean technologies and energy efficiency through the sale of carbon dioxide (CO_2) emission reduction credits. To meet commitments under the Kyoto Protocol by 2012, OECD countries have a demand for approximately 3 billion tons of emission reductions, with a market value estimated to be between U.S. $ 20 - 25 billion.[8]

Georgia meets the eligibility requirements to sell emission reductions from projects at the international carbon market under the Clean Development Mechanism (CDM). According to the “Resolution of the Government of Georgia #2,” passed on 20 January 2005, the Ministry of Environment Protection and Natural Resources has been appointed as the Designated National Authority for executing the CDM. By the “Resolution #172,” passed on 29 September 2005, a Coordination Board for the implementation of the CDM was created. This board is chaired by the Minister of Environment and comprised of representatives of the Ministries of Finance, Energy, and Economy, among other stakeholders. Subsequently a “Procedure of the Activities of the Coordination Board” has been approved.

Georgia has considerable potential to develop many CDM projects, especially in the renewable energy and energy efficiency sectors. Georgia will have the possibility to generate tens of millions of dollars in carbon revenue over the next few years by leveraging investments in the energy, waste, forestry and agricultural sectors. A programmatic approach currently being developed under the CDM will present prospects to undertake large-scale programs like the replacement of incandescent bulbs; these programmatic initiatives would be eligible for additional CDM funding.

Carbon reduction revenue is potentially available for projects in Georgia that:

- increase the efficiency of power generation—this includes rehabilitation and modernization of existing hydro power plants,
- makes use of renewable energy technologies,
- minimize emissions associated with gas transportation and distribution,
- decrease losses in power transmission and distribution, and
- increase energy efficiency in the residential sector.

[8] State And Trends Of The Carbon Market 2007 , Karan Capoor, Philippe Ambrosi, World Bank Institute - 2007

Georgia may also capitalize on financial incentives for projects that:

- improve waste management and the capture of methane from landfills and wastewater,
- increase removal by biological sequestration of greenhouse gases from the atmosphere, e.g., by planting trees or managing forests or reforesting degraded/deforested lands, and
- generate biogas from various types of biomass.

For Georgia, a reduction in the generation of 1.0 Megawatt-hour will typically reduce CO_2 emissions by 0.379 ton.[9] The value of one ton of CO_2 reduced under CDM projects, which is now under negotiations in Georgia, is reported to be currently in the range of 10 USD.

Since carbon revenues are typically payable in strong currencies by buyers with high credit ratings, these revenues can be used to increase a financiers' confidence in a project and to leverage additional capital from international finance institutions and others.

Timing is critical for CDM projects as the window of opportunity is rapidly closing due to uncertainty in the carbon market at the end of 2012, the first commitment period under the Kyoto Protocol. The bulk of project-based transactions are targeted at meeting OECD compliance needs through 2012, emphasizing the need for quick action given the long lead time between project preparation and the "first yield" of emission reductions.

International finance institutions, donors and several industrialized countries have programs targeted to support Georgia and other developing countries in institutional and technical capacity building to implement CDM projects. Some of these organizations have special carbon funds to buy emission credits; these organizations bring to the table the ability to mobilize in-house and external expertise, links to sources of funding, and technical support for carbon project development and supervision. In November 2004 a Memorandum of Understanding on cooperation on CDM projects was signed by the Government of Georgia and the Government of Denmark.

After several rounds of discussions, the Executive Board of the CDM agreed on the basic rules for a Program of Activities to qualify for earning carbon credits under the CDM in June 2007.[10] This is a major achievement and will open the way for a new class of CDM activities such as a distributed program replacing lighting bulbs.

On August 31, 2007, the first Emission Reductions Purchase Agreement (ERPA) was signed, with participation from the International Bank for Reconstruction and Development (IBRD of the World Bank), the Community Development Carbon Fund, and the Energy Efficiency Centre of Georgia.

This is the first Kyoto Protocol Clean Development Mechanism agreement in Georgia. The agreement will come into force after procedures are finalized between the United Nations Framework Convention on Climate Change and the Ministry of Environment and Natural

[9] http://www.climatechange.telenet.ge/CDM-baseline.htm
[10] http://www.carbon-financeonline.com/index.cfm?section=features&action=view&id=10675

Resources of Georgia.

The Energy Efficiency Centre of Georgia acts as a bundling agency for this ERPA and shall bundle Verified Emission Reductions of nine Small Hydro Power Stations rehabilitated in the frame of the USAID-funded Rural Energy Development Program.

2.1.2. Energy Community Treaty

In May 2007 Georgia applied for observer's status in the Energy Community Treaty and was granted this status in December 2007.[11] This will be another step towards integration into European structures, improving energy security and the harmonization of legislation with Europe. The Energy Community Treaty will help to improve the environmental situation in relation to Network Energy and related energy efficiency, foster the use of renewable energy, and set out the conditions for energy trade in the single regulatory space. This is an important provision that can help Georgia to improve its legal and regulatory environment for RES and to pave the way for energy trade arrangements.

The treaty requires from each Contracting Party to provide to the European Commission a plan to implement "Directive 2001/77/EC" of the European Parliament and of the "Council of 27 September 2001" on the promotion of electricity produced from renewable energy sources in the internal electricity market; the plan must also address "Directive 2003/30/EC" of the European Parliament and of the "Council of 8 May 2003" on the promotion of the use of biofuels or other renewable fuels for transport. These provisions can promote the development of the state plan for RES development in Georgia as well.

2.1.2 Involvement of International Institutions

To date, international institutions are playing the leading role in development of RES in Georgia.

- **The United Nations Development Program (UNDP)** is conducting a project to promote the use of renewable energy resources for local energy supply. This UNDP/GEF project started in April 2004 and will last for four years. It also includes funding from the German development bank, KfW. The objective of the project is to remove key barriers to the increased utilization of renewable energy for local energy supply.

  It will introduce leveraged financing for a pilot renewable energy fund/credit line to overcome financial barriers. The Program will also address public awareness and capacity barriers. The project is expected to enhance the capacity of local entrepreneurs to develop bankable investment proposals, to structure financing for the projects and to manage development and implementation. The project, implemented by the Ministry of Environment and Natural Resources, has already undertaken 10 feasibility studies, one

[11] http://www.energy-community.org/

on the use of geothermal energy in Tbilisi. The fund will have a total of €5.11 million from KfW plus $2.0 million from GEF.

Two significant studies have been completed under this project, covering the proposal for an RES strategy in Georgia and the use of biomass for energy production. The former study[12] provides recommendations mostly on development of small hydropower and geothermal resources. The latter study[13] analyzes the options for producing High Efficiency Stoves, Fuel Pellets and Briquettes and development of biomass production in Georgia. The studies provide a number of important recommendations some of them to be analyzed in more detail for incorporation into the framework of future renewable energy policy.

- Additionally, the financial assistance from **USAID** enabled PA Consulting and Winrock International to implement energy programs; among them, is a project implemented by the latter called **"Rural Energy Program"** This is a four-year, $12.7 million program focusing on small hydropower rehabilitation and construction, renewable energy and energy efficiency options, and policy work.

  The main objectives/activities of the program are:
  - increase hydro power supply,
  - improve access to energy project financing (RE/EE),
  - increase use of renewable energy and energy efficiency,
  - enhance institutional capacity and legal, policy and regulatory environment,
  - improve integrated natural resource management, and
  - conduct public outreach

  More than 15 small hydropower projects have been completed and 13 projects were developed with financing totaling $6.58 million. Additionally the Rural Energy Program has held numerous training sessions, performs energy audits and public outreach campaigns. These projects have demonstrated that there is much potential for developing municipal and community-based renewable energy projects.

- **The European Bank for Reconstruction and Development (EBRD)** has started a new credit line framework for energy efficiency and renewable energy projects. The Framework will consist of loans to participating banks in Georgia, Armenia & Azerbaijan in the amount of up to $60 million. The participating banks will on-lend to the private sector for energy efficiency and renewable energy projects. The Project will increase financial intermediation; financing for rational energy utilization; provide benefits in terms of energy resource utilization; and assist in mitigating increasing energy prices and high energy intensity in the region.

[12] Renewable Energy Strategy , "Georgia – Promoting the Use of Renewable Energy Resources for Local Energy Supply", POSCH & PARTNERS Consulting Engineers UNDP- 2007
[13] "Pre-Feasibility Study on Producing High Efficiency Stoves, Fuel Pellets and Briquettes in Georgia, and Related Environmental, Social and Economic Benefits" UNDP - 2007

With the approval of the Framework, $30 million becomes available to four participating banks for renewable energy and energy efficiency projects in Georgia. EBRD financing is to be provided in the form of a credit line where the Participant Banks will on-lend to private sector industrial entities for energy efficiency and rational energy utilization investments. The use of proceeds will also be extended for on-lending to individuals for residential energy efficiency investments. The maximum sub-loan amount under the framework will be USD 2.5 million. An important element of the program is that EBRD is prepared to purchase carbon emission credits earned by the Energy Efficiency and renewable energy projects financed under the program.

The Project will be complemented by grant funding to engage consultants in order to prepare energy audits, review investment proposals, support companies in securing funding from Participant Banks, and provide implementation support.

2.2. Legislative and Regulatory Environment and Barriers for RES Development

The development of RES in Georgia is regulated by the following legal and regulatory documents:

- Law on Electricity and Natural Gas
- "Main Directions of State Policy in Georgian Energy Sector"
- Law on Use of Natural Resources
- Law on Forest Use
- Tax Code
- Customs Code
- Electricity Market Rules
- Gas Market Rules
- Legal acts of the Ministry of Energy
- Legal acts of GNERC
- Presidential Decree on Development of Nontraditional Energy Sources in Georgia.

It should be noted that the above legal acts and regulations are not enough to create a sufficiently favorable environment for development of all RES (including hydro electric generation, wind, solar, biomass and geothermal and firewood), which creates barriers in attracting investments in this field. Only electricity generation is addressed to some extent by Georgia's legislation.

Notably there is no state strategy document devoted specifically to RES. With the decree of the President of Georgia "On the Development of the Utilization of Non-traditional Energy Sources in Georgia" signed March 3, 1998, the concept of the State Renewable Energy Development Program was approved. The concept includes statements like:

- Provision of a 10-12% subsidy by the Government to the producers of "environmentally clean" energy

- Guarantee by the Government to producers to purchase energy at favorable prices
- Carrying out reduced tax policy for environmentally clean energy producers.

Governmental staff was ordered to start developing such a program. However, the provisions of the presidential decree were not implemented and no State Program was formulated.

Current legislation lacks a clear and consistent definition of Renewable Energy Sources. For example, the Law on Electricity and Natural Gas (Article 3. clause 1. L and M) and The Main Directions of State Policy in the Energy Sector (Chapter II, Article 1. and article 2.clause 2.3.) employ two different terms — "Renewable Energy Sources" and "Alternative Energy Sources." These two terms are used separately and also together. One can suppose that these terms have the same meaning however it would be better to use one term. It should be clearly defined what is meant by each term: "Renewable Energy Sources" and "Alternative Energy Sources". This issue may seem unimportant, but on November 19, 2007 at the USAID funded workshop held, by WEG in cooperation with Winrock Georgia,, it caused a significant controversy among energy specialists. Some professionals think that wind farms of more than 10 MW are still considered RES, the same should be true for medium and large hydro plants. Others consider that fire wood, comprising up to 20-30% of total primary energy supply, should also be included in RES. **Thus, an important first step to be taken is to define the legal language for renewable energy sources covered by RES legislation.**

Nevertheless, the Law on Electricity and Natural Gas and The Main Directions of State Policy in Energy Sector is a welcome attempt to create a favorable environment for RES development; the former states as its objective, "To facilitate the preferential use of local hydropower, renewable, alternative and natural gas resources" (article 1. clause 2.d.).

The Law goes on to define RES-related functions of the Ministry of Energy:

- To facilitate production (extraction) of energy resources, utilization of renewable (alternative) energy sources, energy efficiency measures . . . (article 3. clause 1.L).

- To develop renewable and alternative energy sources and support of the return on corresponding investments, define the newly built stations (generation licensee or a small generation plant), whose output (capacity), in full or partially, is subject to mandatory purchase by ESCO (the Electricity System Commercial Operator), at the long term tariffs predefined by GNERC (the regulatory commission); provisions of clause 4 of this article do not apply to this sub-clause (article 3. clause 1. sub-clause M).[14]

In the "Main Directions of State Policy in Georgian Energy Sector" there is more space devoted to RES,[15] although these references are not comprehensive:

[14] The Ministry's right to "deregulate" the station – i.e. allow the free trade without fixed tariff.
[15] "Main Directions of State Policy in Georgian Energy Sector" Parliamentary Bill N 3190-Is, June 7, 2006

- Natural conditions of Georgia allow significant development of alternative energy sources (article 1.clause d)
- Development of heat supply and cogeneration systems, study and implementation of the measures necessary for utilization of renewable energy sources (chapter II, clause 1.2.)
- There are some clauses that should provide concrete benefits to renewable sources; for example the law calls for:
- At the initial stage, deregulation of small hydropower plants (up to 10 MW) (Chapter 2, article 2. clause 2.1)
- "Use of alternative energy sources, provided that utilization of traditional and alternative energy sources will have the same conditions (Chapter 2, article 2. clause 2. sub-clause 3.).

However the above statements need to be refined, since wording of many statements of these documents requires conceptual and technical improvements. Examples are given below.

- Providing "the same conditions" to RES as to the traditional energy sources can not be considered as "facilitation of preferential use" of the RES.

- The Ministry of Energy defines the newly built plant (not only the small plant), whose output, full or partially full, is subject to mandatory purchase by ESCO at the tariffs defined by GNERC (Article 3. Clause1.M). This provision can be partly considered as a guarantee of return on investment; however there is no definition of principles and criteria to be used by the ministry in defining such a plant or by GNERC in defining the tariffs, which is important for the confidence of investors. In addition, the ministry's authority to deregulate the plant (i.e. to allow the trade at free prices) does not extend to such new plants and thus they may have problems in accessing the market at free market prices if they choose to do so.

- In the "Main Directions of State Policy in Georgian Energy Sector," only small hydropower plants and wind energy are addressed to some extent. According to the program included in this document, the energy generated on new small hydropower plants should amount 500 GWh. The energy generated by wind farms should amount to 183 GWh in 2007. This program was not implemented and the projected numbers remain largely unrealistic. One of the reasons may be the absence of a favorable legislative environment. This factor further emphasizes the need for developing an adequate legislative framework for RES.

<u>Legislation addresses the issues of SHPPs to some extent.</u> According to the Law on Electricity and Natural Gas and to Market Rules, the small hydro plants - those with a generation capacity less then 10MW - are given the following rights (article 2. clause 5.):

- SHPPs do not need generation licenses,
- they do not need export licenses,
- they do not have fixed tariffs (deregulation),
- SHPPs can sell their output through direct contracts to any customers, and
- the excess of output, not contracted through direct contracts, should be purchased by ESCO.

These conditions should be beneficial for stimulating SHPP development; however in case of full deregulation there are other negative factors hampering development which are enumerated below.

- The seasonal pattern of SHPP generation (dependence on water flow, climate conditions), maximum generation is in spring and summer when the hydropower generation potential already exceeds Georgia's internal demand.
- Power transmission fees (wheeling fees) on the transmission and distribution networks (article 2, sub clause h, article 42, clauses 6, 7, .8 and article 46I): A methodology for setting such fees is not available yet. Although, presumably power transmission tariff will be equal to the distribution tariff. Thus, supply of power, generated at HPP, to direct customers through the transmission network will turn out to be actually uncompetitive.
- Network connection rules and cost allocation are not defined.

The frequency of substantial changes in Georgia's energy legislation is another discouraging factor for investment into the sector. In 2006-2007 there were three fundamental changes in the Law on Electricity and Natural Gas. The Electricity Market Rules were significantly amended four times during one year alone and require further changes. Such frequent change of legislation creates an image of an unstable energy investment environment and may cause a negative impact on the development of RES.

The banking sector of Georgia needs to be actively involved in financing RES development. The Energy sector is a capital-intensive field where investment payback period is often more than 10 years. The interest rates at the capital Georgian market (12-18%) and available short-term loans are not effective for financing the energy projects. The new EBRD credit line may change this situation by involving a number of major Georgian banks and providing the financing at a rate that is less expensive than the existing market rate. It would be desirable for the Georgian government to continue active interaction with international donor organizations in order to obtain more and cheaper financing for RES development.

Looking forward, Georgia needs State programs for RES development; this is a necessary condition for utilizing the country's renewable energy reserves. Georgia's programs should contain realistic numerical parameters for RES capacity and output, and have clear and achievable benchmarks. The document of "Main Directions of State Policy in Energy Sector" [16] provides such targets till 2015 however, only for small hydropower and wind power development. Additionally, the donor involvement including USAID "Rural Energy Program" implemented by Winrock International showed that there is a significant potential for developing municipal and community-based renewable energy projects.

Local municipalities play an important role in the development of RES all over the world and Georgia can better utilize this untapped resource to support the emerging RES sector. Local municipalities typically govern issues of land utilization, permits, design approvals etc. Additionally the support of local authorities for RES can be reflected in tax reductions or total

[16] http://www.minenergy.gov.ge/download.php?file=kanonieng/State_Policy_English.pdf

exemption from local taxes, power purchase agreements, the provision of favorable credits, assistance in providing necessary project development information, etc. In Georgia local authorities do not have defined obligations and leverages in promoting the development of RES. Their only role is issuance of construction permits for hydro plants of capacity under 2 MW. As a result, the development of RES in the regions depends mostly on private initiatives, and the time, resources, and insights of local authorities are not tapped.

The current existing methodology of establishing long-term tariffs requires harmonization with the new legislation and realities**.** Economically justified tariffs should be established for a sufficient period to provide the predictable stream of revenues with the return on investment enough to attract credible investors.

Although deregulation has been implemented by law, and small hydro plants are allowed to sell to individual consumers on the grid, **the situation with power transit tariffs is not still clear**. GNERC has not established the tariff system for delivering power to particular customers through transmission and distribution networks. Thus the customers are not certain about their actual costs if they buy their electricity from SHPPs.

Another price uncertainty is related to the fees, procedures and methodology for calculating grid connection prices for RES. The grid code and grid or mini-grid connection fees do not exist now.

Summarizing the above analysis one can conclude that the few provisions supporting RES development in the current legislation require developing adequate implementation mechanisms;

There is a need for a stable and predictable mechanism to export excess power in summer. The successful "energy-transfer" event of 2007, when Georgia exported more than 500 GWh to neighboring countries, is not backed up by a long-term contract or any other institutional arrangement like a regional market mechanism. There is a need for some agency to take the lead on this task and to develop the long-term mechanisms for seasonal power exchange where the energy generated by RES could also be included.

Successful RES development requires tax benefits. Until 2005 the legislation provided a number of important concessions to RES. According to the Tax code that was in effect through January 1st 2005:

- The land plots used for renewable energy source utilization equipment and for manufacturing energy-saving appliances (energy efficient lamps) were exempt from the land tax (Chapter 24, clause 158.1.r).
- The profit obtained from manufacturing and the realization of renewable energy source utilization equipment and energy saving appliances (energy efficient lamps) was exempt from the profit tax (Chapter 5, clause 47.k).
- Import of the same equipment and appliances was exempt from the VAT (Chapter 14, clause 101.sh.).

Currently the Tax Code (enacted from January 1st, 2005) and customs legislation do not provide any special treatment for import, manufacturing or realization of RES or energy efficiency equipment and appliances.

There is a need for a government agency that would have concrete obligations, targets and leverages to implement the state policy in the field of Renewable Energy by creating a favorable legal and institutional environment for RES development and acting as one-stop shop for permitting, certification, etc, for developers. The only department presently tasked with RES issues is in the Ministry of Economic Development; this department is mostly concerned with the promotion of bio-digesters in the regions and does not play a policy role.

It is fair to conclude that for RES development to take a boost, substantial changes must be made to Georgia's energy legislation.

Chapter 3
World Experience in Development of Renewable Energy Policies

3.1. Renewable Energy, as a Policy Concept

Renewable energy is derived from resources that are generally not depleted by human use, such as the sun, wind, water movement, geothermal energy. These primary sources of energy can be converted into heat, electricity, and mechanical energy in several ways. There are some mature technologies for conversion of renewable energy such as hydropower, biomass, and waste combustion. Other conversion technologies, such as wind turbines and photovoltaics, are already well developed, but they have not yet achieved market penetration that many expect they will ultimately reach.

Climate change, continuing dependence on oil and other fossil fuels, growing imports, and rising energy costs are making our societies and economies vulnerable. These challenges call for a comprehensive and ambitious response. In this complex picture of the future prospects of development of energy trends, renewable energy sources (RES) are the only ones that stand out in terms of their ability to reduce greenhouse gas emissions and pollution, exploit local and decentralized energy sources, and stimulate world-class high-tech industries. Major challenges facing the global energy system today are interlinked – both financially, through global energy and capital systems, and politically, in future agreements under the United Nations Framework Convention on Climate Change. Dealing with these challenges requires a comprehensive approach and coordinated action.

The UN says that this year's scientific report from its Intergovernmental Panel on Climate Change (IPCC) has "made clear beyond doubt that climate change is a reality", which poses a serious threat to the future development of the world's economies, societies and ecosystems. "We cannot go on this way for long," the UN secretary general, Ban Ki-moon, has said. "We cannot continue with business as usual. The time has come for decisive action on a global scale." In order to meet these challenges the United Nations organized a climate change conference on the Indonesian island of Bali from December 3-14 2007. Delegates from 189 nations, together with observers from intergovernmental and non-governmental organizations, met to negotiate a new pact to succeed the Kyoto protocol, which expires in 2012, although what concrete policy schemes and mechanisms might be developed to replace it, is unclear so far.[1]

Under the Kyoto Protocol, the reduction of greenhouse emissions is considered as a paramount precondition for sustainable development. Renewable energy sources are addressing all these fundamental issues of future clean energy trends.

Table 3.1 on the next page shows carbon dioxide emissions released from fossil fuels Worldwide.

[1] Q&A: Bali climate change conference, Q&A: Jessica Aldred, Guardian Unlimited, December 3, 2007.

	Emissions (million metric tons)	Share of total emissions (percent)	Emissions per capita (metric tons per person)	Emissions per unit of GDP (metric tons per million US$)
United States	5,769	22.1	19.6	480.9
China	4,769	18.3	3.7	574.7
European Union	3,847	14.8	8.4	310.8
Russia	1,512	5.8	10.5	1006.5
Japan	1,211	4.6	9.5	314.9
India	1,103	4.2	1.0	313.2
Brazil	323	1.2	1.8	211.3
Middle East	1,183	4.5	6.5	854.5
Africa	815	3.1	0.9	366.3
Rest of the world	5,547	21.3	3.3	458.6
World	**26,079**	**100.0**	**4.1**	**443.7**

Table 3.1. Energy-related Emissions of Carbon Dioxide in 2004.
Source: World Energy Outlook 2006[2]

Despite many attractive aspects associated with RES and the existing innovative technologies of its applications, there are still many barriers to be overcome in order to allow penetration of renewable energy into competitive markets. Different types of impediments are encountered as a technology progresses towards the marketplace. In the initial stages of development, technical impediments usually predominate. Later, in order for a technology to become cost-effective, market impediments such as inconsistent pricing structures need to be overcome. Next, there are institutional, political and legislative impediments which hinder the market technologies, including problems arising from the lack of awareness and lack of suitable institutional and regulatory structure. Finally, there are other impediments, which result from a lack of experience with planning regulations, which hinder the public acceptance of a technology. It is clear that policies that aim to maximize the market penetration of renewable energy technologies should address the full spectrum of impediments. The most important obstacle is that renewable energy applications are more expensive than those based on fossil fuels. Measures to address these impediments include a wide variety of market stimulation measures, such as:

- guaranteed purchase for renewable electricity (with price support),
- “green electricity” schemes,
- investment grants,
- tax breaks,
- promotional measures,
- large scale demonstration and market stimulation schemes,
- government targets for renewable energy deployment,
- voluntary agreements with utilities to increase deployment, and
- modification of legislation to allow market access to renewables.

[2] Emissions from fuel combustion only. GDP in billion US$ at 2005 prices and Pops. (PPP-purchase power parity)

It is necessary to develop and implement sustainable energy policies, based on correct cost comparisons of different technologies, including such arguments as environmental protection, reduction of greenhouse emissions, and energy security. Policy-makers increasingly rely on studies to support their efforts to set policy goals and identify the most appropriate measures to achieve them.

Renewable energy policy scenarios have become an integral part of the energy policy-making process in many of the world's leading economies. By looking at plausible future trends in a systematic manner, scenarios support the early detection of emerging issues and help policy-makers to provide a bridge between science and policy.

It is known that in the absence of comprehensive policy instruments (measures) no policy can be implemented. The following energy policy instruments can be identified:

- regulatory instruments,
- economic instruments (subsidies and pricing system),
- planning instruments, and
- persuasive (information) instruments.

The application of different types of measures varies across different countries. In general, the countries which have been most successful in stimulating deployment and encouraging the growth of renewable energy industries are those which have adopted an integrated package of market stimulation and promotion measures, coupled with strong government support.

3.1.1 Policies and measures for common action to support RES penetration

Based on the discussion of impediments and the measures which can be adopted to overcome these, one may assume that the most successful strategy for support of renewable energy will be via a "chain of support" to address all impediments which face renewable energy technologies at different stages of their progression to the marketplace. Table 3.2 illustrates such a "chain of support."

Technical Impediments	**Support technical Development** (R&D to reduce costs and improve efficiently)
Market Impediments	**Full cost pricing of competing technologies** (remove subsidies, incorporate external costs)
	Ensure a full value price for renewable energy (value renewables – socio-economic factors)
Institutional, political and legislative impediments	**Market stimulation** (guaranteed purchase, premium prices, investment support, tax breaks, low interest loans)
	Awareness of opportunity (awareness for industry, utilities, developers, via dissemination, methodologies for assessement of markets and resources)

Institutional, political and legislative impediments, continued.

Harnessing commercial finance (assurance of technical performance via standards and certification, establishing long-term confidence, joint implementation)
Reduce transaction costs (grid connection, regional energy centres, standardized assessment techniques)
Ensure availability of skilled people (training, awareness, dissemination, demonstrations, qualifications)
Overcome planning impediments (minimize environmental impact, raise awareness of benefits and opportunities by planners)

Table 3.2. The Chain of Support for Renewable Energy Technologies.
Source: OECD[3]

Based on this chain, a number of possible policies and measures for common action can be identified:

- actions directed to overcome technical impediments,
- actions directed to overcome market impediments, and
- actions directed at institutional, political and legislative impediments.

The European Union keeps the leading position throughout the world in promoting Kyoto Protocol issues through its renewable energy policy. The main reasons for supporting renewable energy policy in the EU can be summarized as follows:

- Environmental protection, e.g., the reduction of greenhouse gas emissions (Kyoto protocol), risk management for nuclear power;
- Enhancing energy supply security, e.g., reducing import dependence within the energy system, coping with scarcity of fossil and nuclear fuels;
- Enhancing economic competitiveness through job creation and new markets such as the carbon one (technological leadership).

The EU's renewable energy policy is reviewed in the following section.

[3] OECD Working Papers, Vol. VI, Penetration of Renewable Energy in the Electricity Sector, # 66, Paris 1998, p.9.

3.2. Renewable Energy Policy in the EU

3.2.1 RES Development in the EU

The EU and the world are at the cross-roads of their energy future.
According to the EU Directive 2001/77/EC[4] renewable energy sources (RES) include the following, non-fossil energy sources:

- wind power (onshore and offshore),
- solar power (photovoltaic and solar thermal electricity),
- geothermal power,
- hydro power (small scale and large scale),
- wave power,
- tidal power,
- biomass, and
- biogas (including landfill and sewage gas).

The European Council of March 2006 called for EU leadership on renewable energies and asked the Commission to produce an analysis on how further to promote renewable energies over the long term, for example by raising their share of gross consumption to 15% by 2015. The European Parliament has by an overwhelming majority called for a 25 % target for renewable energies in the EU's overall energy consumption by 2020.

The Road Map, an integral part of the Strategic European Energy Review, set out a long term vision for renewable energy sources in the EU. It proposed for the EU to establish a mandatory target of 20% for renewable energy's share of energy consumption in the EU by 2020, and lay down a pathway for mainstreaming renewable energy sources into EU energy policies and markets. It also proposed a new legislative framework for the promotion and the use of renewable energy in the European Union.

Reaching the target will generate major greenhouse gas emissions savings, reduce annual fossil fuel consumption by over 250 million tons of oil equivalent (Mtoe) energy by 2020, of which approximately 200 Mtoe would have been imported, and spur new technologies and European industries. These benefits will come at an additional cost of between €10-18 billion per year, on average between 2005 and 2020, depending on energy prices.

In 1997, the European Union started working towards a target of a 12% share of renewable energy in gross consumption by 2010 representing a doubling of the contribution from renewable energies compared with 1997. The historical development of the electricity generation from renewable energy sources is shown in Figure 3.1.

[4] The European Parliament and the Council of the European Union 2001, Art. 2

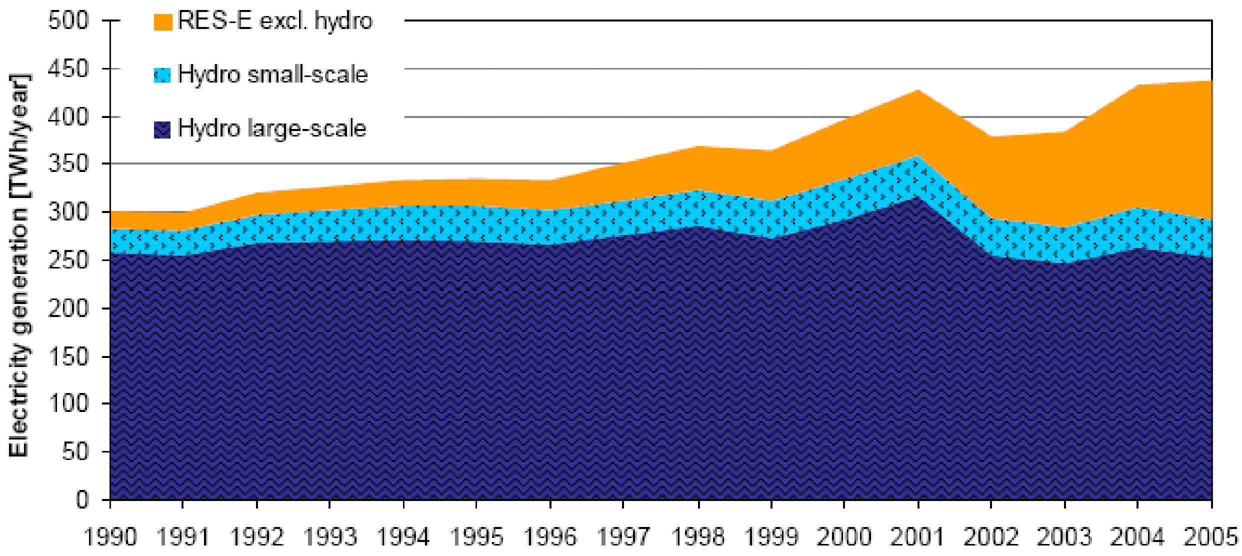

Figure 3.1. Development of RES-electricity generation in the EU-25 countries from 1990 to 2005. Source: Based on EUROSTAT data. [Eurostat 2006]

It illustrates that the largest share of electricity from RES has been generated with hydro energy. The amount of electricity produced by hydro power plants has remained on a constant level since 1990; the fluctuation is due to a varying precipitation. In contrast, the amount of electricity generated from other sources, such as wind energy or biomass has constantly increased during recent years, as shown in Figure 3.2.

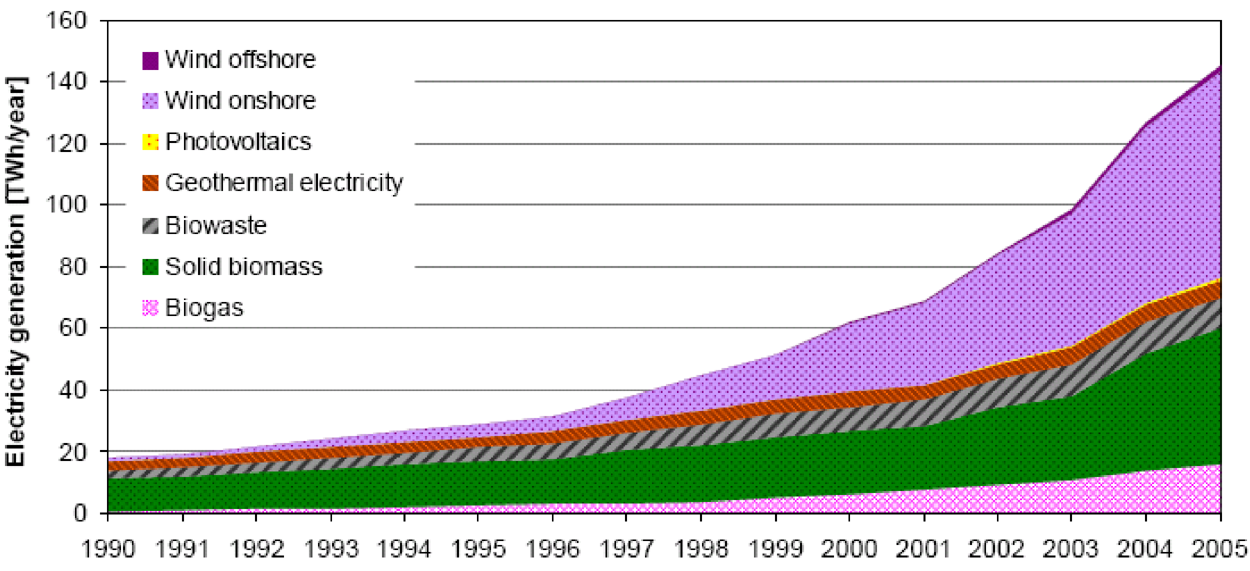

Figure 3.2. Historical development of RES-electricity excluding hydro power in the EU-25 countries from 1990 to 2005. Source: Based on EUROSTAT data. [Eurostat 2006].

Still the EU looks unlikely to reach a contribution from renewable energy sources exceeding 10% by 2010, although the European Union will nonetheless come close to its target for renewable electricity. Wind energy, in particular, has made good progress and has broken through the target of 40 GW by 2010 five years ahead of schedule. Biomass electricity has gone from a yearly growth rate of 7% in previous years to 13% in 2003 and 23% in 2005.

Biomass in 2005 contributed 70 TWh, which means a saving of 35 million tons of CO_2 and 14.5 million tons of oil equivalent (mtoe) energy less fossil fuel consumption. In spite of this progress, current projections indicate that the 12% target will not be met.

There are several reasons for this. **Even though the cost of most RES is declining— in some cases quite dramatically— at the current stage of energy market development RES will often not be the short–term, least-cost option. In particular, the failure to systematically include external costs in market prices gives an economically unjustified advantage to fossil fuels compared with renewables.**

The progress across the EU has been uneven and some national policies have been inadequate for achieving the EU target. Some national policies have proven vulnerable to changing political priorities. The absence of legally binding targets for renewable energies at EU level, the relatively weak EU regulatory framework for the use of renewables in the transport sector, and the complete absence of a legal framework in the heating and cooling sector means that progress to a large extent is the result of the efforts of a few committed Member States.

Electricity generation from renewable energy sources in the different EU Member States is shown in the Figure 3.3.

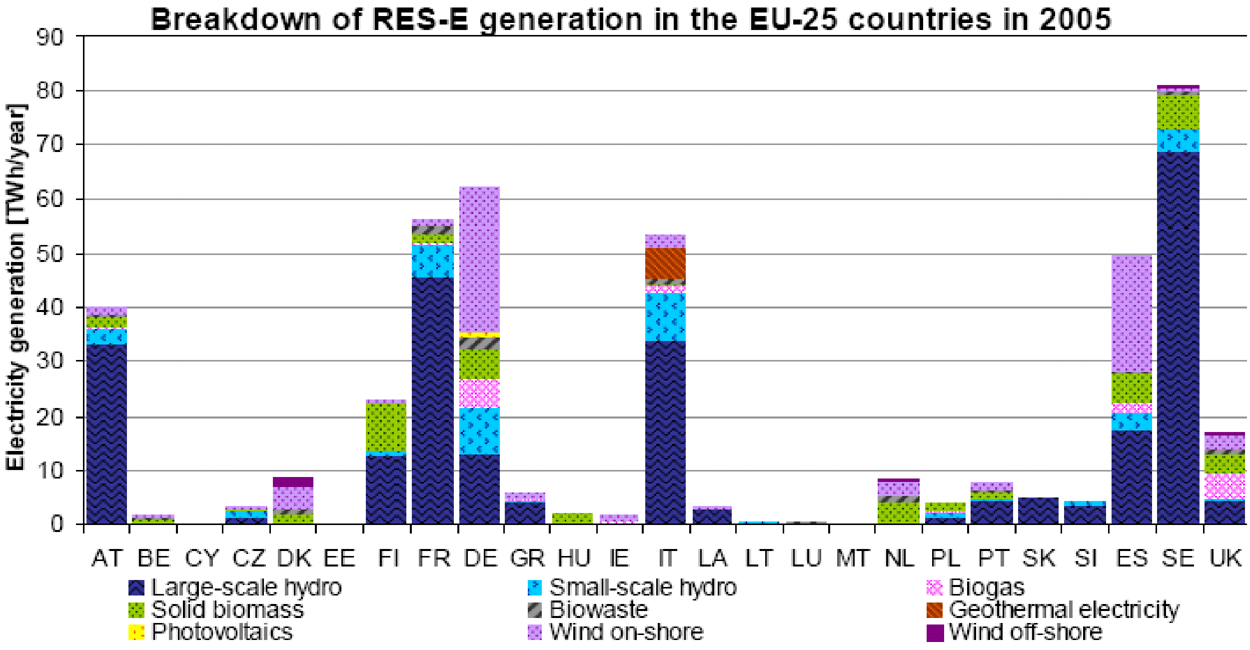

Figure 3.3. Electricity generation from RES in the EU 25 Member States in 2005. Source: Fraunhofer Institute Systems and Innovation Research, Energy Economics Group.[5]

Policy measures have been adopted in the form of targets, either in a political context such as the 12% renewables target of 1997 and renewable electricity Directive.[6] Only in the electricity sector has substantial progress been made, on the basis of the adopted by the

[5] Evaluation of different feed-in tariff design options- Best practice paper for the International Feed-in Cooperation. Fraunhofer Institute Systems and Innovation Research, Energy Economics Group. 2007. (Further *EDFTDO 2007)*

[6] Directive 2001/77/EC on the promotion of electricity produced from renewable sources of energy in the internal market (OJ L 283, 27.10.2001, p. 33).

European Parliament and the EU Council in 2001, and the targets set will almost be met (Figure 3.4).

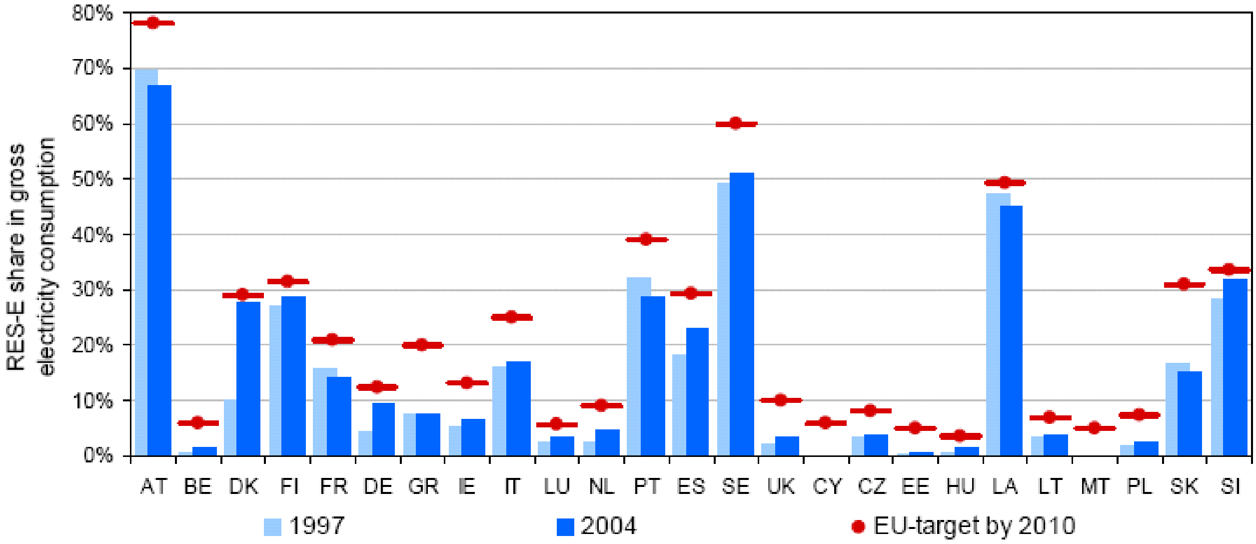

Figure 3.4. RES-electricity penetration in 1997 and 2004 and national target by 2010 in the EU-25 countries. Source: *EDFTDO 2007*

The differences in the regimes for electricity, biofuels and heating and cooling established at EU level are reflected in the development of the three sectors: clear growth in electricity, the recent start of solid growth in biofuels, and slow growth rates for heating and cooling.

As a further explanation, it should be noted that energy efficiency has not been as high as expected and that overall energy consumption therefore has been higher than expected. A considerably bigger contribution from renewable energy sources to reach the 12% target, which is expressed as a percentage of overall energy consumption (as opposed to a share of overall energy production) is thus required. In accordance with Electricity Directive all Member States have adopted national targets for the proportion of electricity consumption from renewable energy sources(Figure 3.4). If all Member States achieve their national targets, 21% of overall electricity consumption in the EU will be produced from renewable energy sources by 2010. With current policies and efforts in place and unless current trends change, the European Union will probably achieve a figure of 19% by 2010. Nine Member States are now fully on track to reach their target, with some of them reaching the target early.[7]

Biofuels are the only available large scale substitute for petrol and diesel in transport. Given the precarious security of supply situation for oil (and thus for the transport sector), in 2003 the EU adopted the biofuels Directive (2003/30/EC), with the objective of boosting both the production and consumption of biofuels in the EU. Since then the Commission has set out a comprehensive strategy for developing the biofuels sector.[8]

The biofuels directive established a reference value of a 2% share for biofuels in petrol and diesel consumptions in 2005 and 5.75% in 2010. This should be compared to their share of 0.5% in 2003. The indicative targets set by Member States for 2005 were less ambitious, equating to an EU share of 1.4%. The share achieved was even lower, at 1%. Progress was

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[7] Denmark, Germany, Finland, Hungary, Ireland, Luxembourg, Spain, Sweden and the Netherlands
[8] An EU Strategy for Biofuels - COM(2006) 34, 8.2.2006

uneven, with only three Member States reaching a share of more than 1%. One Member State, Germany, accounted for two thirds of total EU consumption.

In addition to the cost factor, there are three main reasons for the slow progress. First, appropriate support systems were not in place in most Member States. Second, fuel suppliers have been reluctant to use bioethanol (which accounted for only 20% of total biofuel consumption) because they already have an excess of petrol, and the blending of bioethanol with petrol makes this worse. Third, the EU regulatory framework for biofuels is underdeveloped, particularly in relation to the need for Member States to translate their objectives into action.

Member States were due to adopt national indicative targets for 2010 in 2007. Some have already done so. Most of these have followed the reference value set in the directive (a 5.75% share). Nevertheless, taking into account the disparities between the targets that Member States announced for 2005 and the low shares that many achieved, the 2010 target is unlikely to be achieved with present policies in transport biofuels. There has been some progress, particularly since the adoption of the Directive in transport biofuels, but not enough to reach the targets adopted. In the use of renewable energy sources for heating and cooling there has been hardly any progress since the 1990s.

The heating and cooling sector accounts for approximately 50% of overall EU final energy consumption and offers a largely cost-effective potential for using renewable energies, notably biomass, solar and geothermal energy. Based on the targets for electricity and biofuels, heating would have to contribute 80 Mtoe by 2010 in order for the 12% overall renewable energy target to be met. However, with renewables today accounting for less than 10% of the energy consumed for heating and cooling purposes, this potential is far from being exploited.

The Community has not so far adopted any legislation to promote heating and cooling from renewable sources. However, the 12% overall target for renewable energy sources set in 1997 created an implicit target for heating and cooling of an increase from approximately 40 Mtoe in 1997 to 80 Mtoe in 2010. Whilst the directive on the promotion of cogeneration (the CHP Directive[9]) and the Energy Performance of Buildings Directive promote efficient heating, renewable energy in heating has grown only slowly[10]. Biomass use dominates renewable heating consumption and the bulk of this is in domestic wood heating. Little growth has occurred in the use of efficient wood-burning stoves and boilers, or biomass CHP (for industrial use), despite their potential for reducing emissions. Several European countries have promoted other types of renewable heating, with some success. Sweden, Hungary,

France and Germany make the greatest use of geothermal heat in Europe; Hungary and Italy lead with low-energy geothermal applications. Sweden has the largest number of heat pumps. Solar thermal energy has taken off in Germany, Greece, Austria and Cyprus. That said, policies and practices vary widely across the EU. *There is no coordinated approach, no coherent European market for the technologies, and no consistency of support mechanisms*.
As a result of the inertia in the heating and cooling sector, even where some of the technologies are cost competitive, the lack of an appropriate policy including targets and the inability to remove administrative barriers and provide consumers with information on

[9] Directive 2004/8/EC on the promotion of cogeneration (OJ L52, 21.2.2004, p. 50).
[10] Directive 2002/91/EC on energy performance of buildings (OJ L1, 4.1.2003, p. 65).

available technologies and inadequate distribution channels very little progress has been achieved in this sector. As a consequence, the contribution that the heating sector should have provided towards meeting the 12% overall renewable target in 2010 is insufficient.(Figure.3.5)

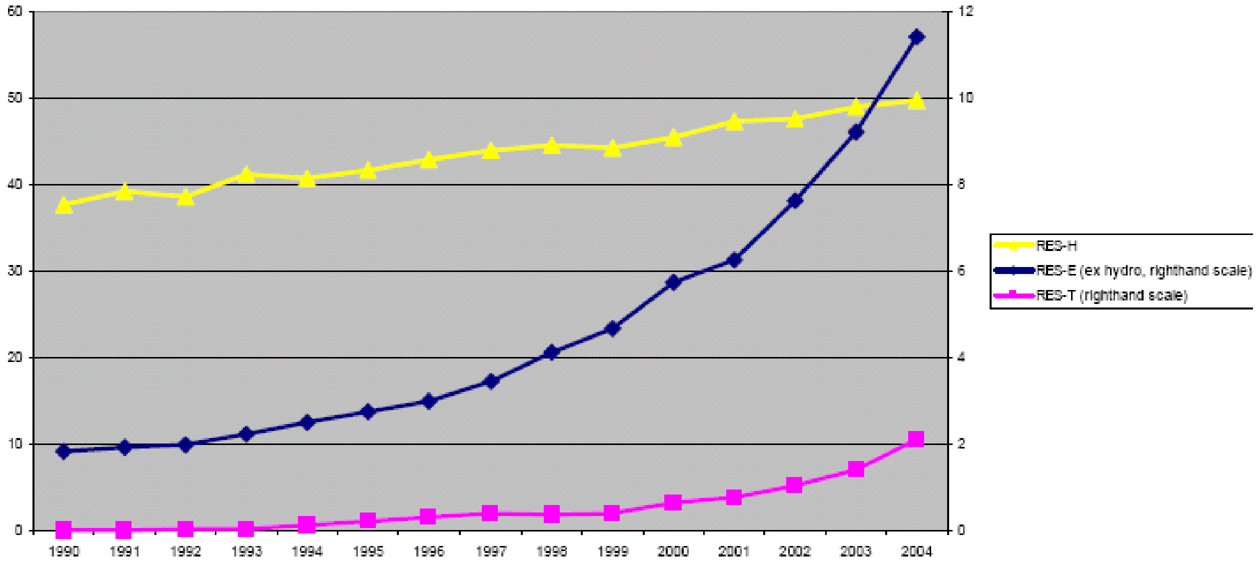


Figure 3.5. The contribution of renewable energy (electricity, transport and heat) 1990 -2004 (Million Tons of Oil equivalent). Source: Commission of the European Communities.[11]

For renewables to become the "stepping stone" to reaching the dual objective of increased security of supply and reduced greenhouse gas emissions, it is clear that a change in the way in which the EU promotes renewables is needed. Strengthening and expansion of the current EU regulatory framework is necessary. It is, in particular, important to ensure that all Member States take the necessary measures to increase the share of renewables in their energy mix. Industry, Member States, the European Council and the European Parliament have all called for an increased role for renewable energy sources.

3.2.2. The Policy Principles

On the basis of the experience gained, a number of key principles for the future renewable energy policy framework need to be established. With a view to significantly increase the share of renewable energy sources in the EU's energy mix, the Commission considers that such a framework should:

– be based on long term mandatory targets and stability of the policy framework,
– include increased flexibility in target setting across sectors,
– be comprehensive, notably encompassing heating and cooling,
– provide for continued efforts to remove unwarranted barriers to renewable energies deployment,
– take into consideration environmental and social aspects,
– ensure cost-effectiveness of policies, and
– be compatible with the internal energy market.

[11] Commission of the European Communities. Communication from the Commission to the Council and the European Parliament. Renewable Energy Road Map. Renewable energies in the 21st century: building a more sustainable future. Brussels, 10.1.2007. COM (2006) 848 final.

3.2.3 An overall EU target

A policy on renewable energy is a cornerstone in the overall EU policy aimed at reducing dependence on imported fossil fuels and CO_2 emissions. Since the 1990s the EU has taken various measures aimed at promoting renewable energy, be it in the shape of technology programmes or specific policy initiatives. Policy measures have been adopted in the form of targets, either in a political context such as the 12% renewables target of 1997, or under sector-specific legislation, such as the biofuels and renewable electricity Directives, which also provide a set of measures aimed at facilitating the achievement of the targets set.

In many sectors of the economy, targets are used to provide clarity and stability to industry, to allow them to plan and invest with a higher degree of certainty. Providing targets at the European level augments this stabilising impact: EU policy generally has longer time horizons and avoids the destabilizing effects of short term domestic political changes. To be effective, targets have to be clearly defined, focused and mandatory. The "12% renewables" target is a good political target, but has proven insufficient to develop the renewable energy sector.

The Commission believes that an overall legally binding EU target of 20% of renewable energy sources in gross consumption by 2020 is feasible and desirable. Such a share would be fully in line with the level of ambition expressed by the European Council and by the European Parliament.

A target for biofuels

Biofuels cost more than other forms of renewable energy. But they are currently the only form of renewable energy which can address the energy challenges of the transport sector, including its almost complete reliance on oil and the fact that greenhouse gas reductions in this sector are particularly difficult to obtain. Therefore the Commission proposes to include, in the new framework, legally binding minimum targets for biofuels. A clear indication of the future level of these targets is needed now, because manufacturers will soon be building vehicles that will be on the road in 2020 and will need to run on these fuels.

The minimum target for biofuels for 2020 should, on the basis of conservative assumptions, be fixed at 10% of overall consumption of petrol and diesel in transport[12]. To ensure a smooth implementation of this target, the Commission, in parallel, intends to propose the appropriate modifications to the fuel quality directive (98/70/EC).

3.2.4. National targets and Action Plans; putting policy into practice

Given the largely national basis for support measures in renewable energy, the overall EU target will need to be reflected in mandatory national targets. The contribution of each Member State to achieving the Union's target will need to take into account different national circumstances. Member States should have flexibility to promote the renewable energies most suitable to their specific potential and priorities. The precise way in which Member States plan to achieve their targets should be set out in National Action Plans to be notified to the Commission. These Action Plans should contain sectoral targets and measures consistent with achieving the agreed overall national targets, demonstrating substantial progress compared to the agreed 2010 renewable energy targets. In implementing the national targets in practice, Member States will need to set their own specific objectives for

[12] The Impact Assessment prepared for the Road Map - SEC(2006) 1719 - and the Commission Staff Working Document accompanying the Biofuels Progress Report - SEC(2006) 1721 - analyze the impact of various biofuel shares. The Impact Assessment explains why a 10% share in 2020 is appropriate.

electricity, biofuels and heating and cooling, which would be verified by the Commission to ensure that the overall target is being met.
Proposals for legislation on the overall target and the minimum target for biofuels, together with provisions to facilitate a higher uptake of renewable energies in the three sectors, including the necessary monitoring mechanisms were planned to be put forward in 2007. This process should ensure that the overall EU target is met in a fair and equitable manner and should clearly strengthen the existing political and legal framework.

3.2.5. Instruments to support RES

The current discussion within EU Member States about various renewable promotion schemes focuses on the comparison of two systems, the *feed-in tariff (FIT) system* and the *quota regulation* in combination with a *tradable green certificate (TGC)* market. The system of fixed feed-in tariffs allows electricity generators to sell RES at a fixed tariff for a determined period of time. Alternatively, the feed-in tariff can be paid in the form of an additional premium on top of the electricity market price. Currently FITs are applied by 17 of the 25 EU Member States as main instrument to support the generation of RES and by 1 country (Italy) only for electricity
generation from PV energy.

The quota obligation based on TGCs is a relatively new support scheme and has replaced other policy instruments in Belgium, Italy, Sweden, the UK and Poland in recent years. The basic element of the system is the obligation for a particular party of the electricity supply chain (e.g., consumers, suppliers or generators) to provide a specified minimum share in total electricity consumption from renewable energy sources. Besides the quota target, a market for renewable energy certificates is established. By giving RES producers the possibility to sell certificates on the market, they receive financial support in addition to the electricity sales on the power market.

Other policy instruments such as tender schemes, which grant financial support to projects with the lowest generation costs following a bidding round, are no longer used in any European country as the dominating policy scheme. However, there are instruments like production tax incentives and investment incentives, which are frequently used as supplementary measures. Figure 3.6 gives an overview of the currently dominating support schemes in the EU.

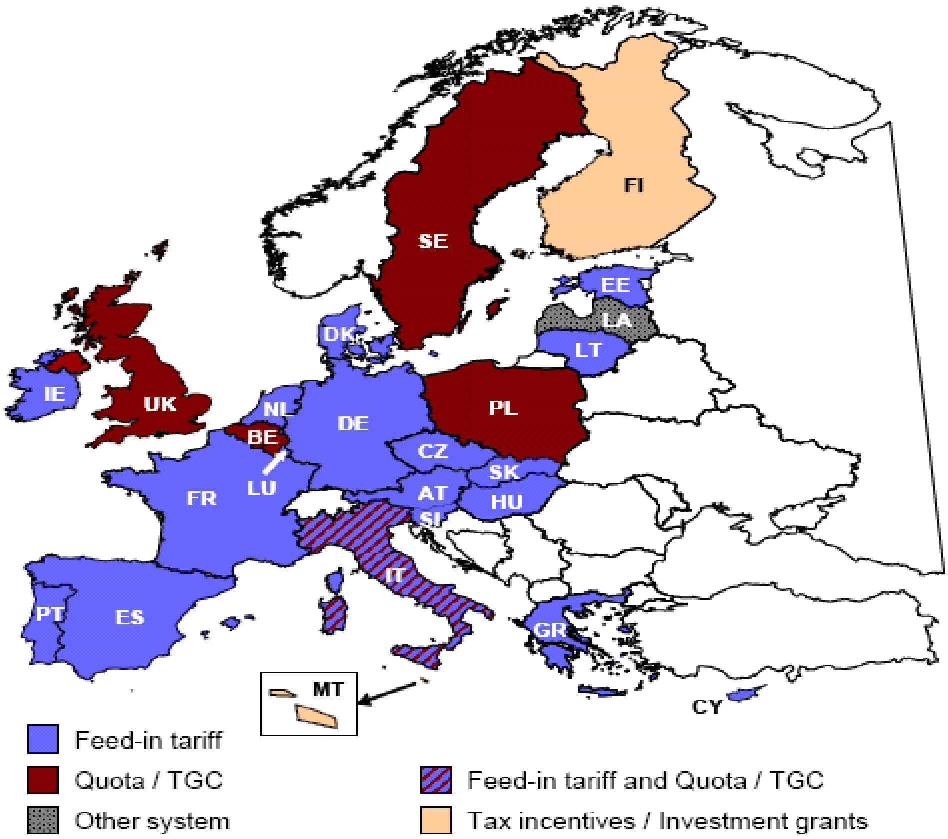


Figure 3.6. Currently applied schemes for the support of electricity from RES in the EU-25 countries. Source: *EDFTDO 2007*

3.2.6. Discussion of current policy schemes

The most widespread instrument to stimulate renewable energy sources has been subsidies. In general, they can be divided into subsidies on renewable energy capacity and subsidies on renewable energy output. Subsidies on installed capacity only stimulate supply but not the demand for renewable electricity. Moreover, subsidies on installed capacity might be unfairly distributed if the total amount of subsidy is limited, and they have to be abolished if the technology that is stimulated becomes too widespread. Subsidies on output or Electricity Feed-In Law in Germany where utilities are forced to accept renewable electricity produced in their area for which they must pay a premium tariff have proved to be very successful in promoting the deployment of renewable energy sources. However in a market situation such a system will disadvantage those utilities that happen to be in areas with a large potential of renewable energy sources. These utilities will have to pay more premium tariffs because in their area more renewable electricity will be offered than in the areas of the competitors. To avoid this a EU-wide compensation mechanism should be designed. Another disadvantage is that there will be no strong incentive for investors to drive down cost by improvement of operation and efficiency. Furthermore, in the future subsidies might be considered as an unlawful regulation according to the trade agreements within the European Union. One way to give all players an equal opportunity that includes a mechanism to drive down cost is to provide a limited subsidy on output that is awarded to only a limited number of investors.

These investors will have to compete for the subsidy through a bidding system. For each bidding round only the most cost-effective offers will be selected to get the subsidy. This system currently prevails in the United Kingdom and Ireland (The Non-Fossil Fuel

Obligation or NFFO). It has been proven to be very successful in driving down cost, but it has encountered other problems. Potential investors in a bidding system are faced with several uncertainties. First the chance of winning a bid is relatively low. Second, although every winning investor gets a period of 5 years to implement the project this has not been enough in many cases because of planning problems and local resistance against construction of the renewable electricity plants (e.g., wind). Third, for every NFFO-round (every 2 years) it is unclear which part of the money available will be available for which renewable technology. Preferences among the deciding experts can change easily according to the latest fashion. Due to all these uncertainties, no long term-planning has been possible.

3.2.7. Green certificate system

The major characteristic of a green certificate system is that electricity produced by renewable sources is certified. These certificates have two purposes. First, they can serve either as an accounting mechanism in the case obligations set by the government have to be met, or as a proof to customers of green electricity that a certain amount of renewable electricity has been produced. Second, green certificates facilitate the creation of a green certificate market that functions independently from the market of electricity as a commodity.

Creation of green certificates
Green certificates are created by the producers of electricity. Producers receive a certificate for each pre-defined unit of electricity produced from renewable energy sources that is put on the grid. Consumers of electricity are allotted with targets for the consumption or sale of electricity from renewable sources. In order to show that they meet their targets, these consumers have to hand over certificates at a given point in time. Penalties are set if they are not able to fulfill their obligations. Therefore, consumers have an incentive to buy certificates from the producers and the certificates become valuable. It is expected that competition between producers and increasing supply of green certificates will lead to a decline in the price of electricity from renewable sources. In this respect, the green certificate system is considered as a cost effective way to meet the renewable energy target.

Green certificate market
Consumers will pay a price for the certificates in order to meet their target. The price will depend on the market, i.e. on demand (that is fixed by the target) and supply. With low supply of green certificates, price will be high, which will be an incentive for new producers to provide renewable electricity. Moreover, in theory renewable energy will be provided in an efficient way because those producers who can provide renewable electricity at the lowest price will be able to sell their labels.
In the green certificate quota model, the distribution companies or utilities face an obligation for electricity generated from renewable energy sources. Thus at the date of settlement, the utilities have to show the proper amount of green labels. The price of green labels could be passed on to the consumers of electricity in the form of a general price increase.

Functions and issues in implementing green certificates
It is possible to identify six different functions in the institutionalization of a green certificates system:

1. Issuing certificates
2. Verification of the issuing process
3. Registration of certificates and trade
4. Exchange market

5. Banking of the certificates
6. Withdrawing of certificates from circulation.

Green certificates are issued at the moment that actual green electricity is registered at the kWh-meter. The certificates are withdrawn from circulation at the moment that a customer accounts for his obligation by presenting the certificates to the registration authority of the government. Certificates are also withdrawn if their period of validity expires. Between issuing and withdrawing green certificates, the certificates are accounted and can be traded. Accounting and trading of green certificates could be done by the owner of the certificates, but also by a 'bank', for example an energy utility or an association of producers. The organization of the green certificate exchange could be coupled to e.g., the electricity exchange. All these activities require proper registration and verification.
Apart from these institutional functions, there are other issues that have to be addressed in order to make a system of tradable green certificates work properly:

- the definition of renewables used
- the time aspects of the obligation
- the penalty for not reaching the target
- the place of an obligation.

3.2.6. Feed-in tariff design options

The majority of EU- 25 Member States apply a variety of different feed-in tariff designs. The differences range from the fact whether or not a purchase obligation exists, to the method used for the determination and the adjustment of the tariff level. Distinct concepts are applied to account for different generation costs within one technology (such as stepped tariff designs). Some of the Member States apply a tariff degression to take technological learning into account and to avoid overcompensation. Table 3.3 shows the different FIT designs that are used in the EU Member States.

Country	Purchase obligation	Stepped tariff	Tariff degression	Premium option	Equal Burden Sharing?	Forecast obligation
Austria	x	x	-	-	x[1)]	-
Cyprus	x	x	-	-	x	-
Czech Rep.	x (for fixed tariff)	x	-	x	x	-
Denmark	x (except for wind onshore)	x	-	x (wind)	x[1)]	-
Estonia	x (for grid losses)	-	-	x (new draft)	x	x (new draft)
France	x	x	x (wind)	-	x	-
Germany	x	x	x	-	x[1)]	-
Greece	x	x	-	-	x	-
Hungary	x	-	-	-	x	-
Ireland	x	x	-	-	x	-
Italy	x	x	x (PV)	-	x	-
Lithuania	x	-	-	-	x	-
Luxembourg	x	x	-	-	x	-
Netherlands[3)]	-	x	-	x	[2)]	-
Portugal	x	x	-	-	x	-
Slovakia	x (for grid losses)	x	-	-	x	-
Slovenia	x (for fixed tariff)	x	-	x	x	x
Spain	x (for fixed tariff)	x	-	x	x	x

1) Austria, Denmark and Germany apply an equal burden sharing with advantages for electricity intensive industries (see Chapter 4 on page 57).

2) In the Netherlands each electricity consumer contributes the same amount of money to RES-E support, regardless of the amount of electricity consumed (see Chapter 4 on page 57).

3) In the Netherlands no FITs are paid for electricity from RES-E plants that applied for support after the 18th of August 2006.

Table 3.3. Feed-in Tariff Designs in the EU Member States. Source: *EDFTDO 2007*

General conditions of a FIT design

Determining the support level

One of the most important aspects of a feed-in tariff design is the determination of the tariff level and the duration of support. One possibility is to set the tariff level based on the **electricity generation costs** from renewable energy sources. Alternatively, the support level of RES can be based on the **avoided external costs** induced by electricity generation using renewable energy sources. Subsequently, these two concepts will be explained.

3.2.8. Tariffs based on electricity generation costs

As the electricity generation costs vary according to the RES technology, a feed-in tariff design should provide technology-specific tariff levels. The following factors influence the power generation costs and therefore should be taken into account when the tariff levels are determined:

- Investment for the plant
- Other costs related to the project, such as expenses for licensing procedures
- Operation and maintenance (O&M) costs

- Fuel costs (in the case of biomass and biogas)
- Inflation
- Interest payments for the invested capital
- Profit margins for investors

According to the expected amount of electricity generated and the estimated lifetime of the power plant, a level of remuneration can be fixed.
Most EU countries that apply feed-in tariffs use the concept based on electricity generation costs to determine the tariff level.

Including avoided external costs in the determination of the tariff level
Besides the electricity generation costs, other factors, such as the avoided external costs, can be considered when fixing the level of remuneration. External costs arise *"when the social or economic activities of one group of persons have an impact on another group and when that impact is not fully accounted, or compensated for, by the first group"*[13]
Among others, the following possible external costs can be taken into account for electricity generation:

- Climate change
- Health damage from air pollutants
- Agricultural yield loss
- Material damage
- Effects on the energy supply security

Besides the external costs, those expenses can be taken into account that would occur, if RES-electricity plants did not exist and the electricity would have to be generated in conventional power plants.

The Example of Portugal
In **Portugal** RES producers receive a monthly payment that is calculated by a special formula. The elements of the formula represent different factors that influence the costs avoided due to the electricity generation from RES. The following factors are included in the formula:
• A fixed contribution on the plant capacity to reflect the **investment for conventional power plants** that would have to be built, if the RES plant did not exist
• A variable contribution per kWh of electricity generated that corresponds to the **power generation costs** of those hypothetical conventional power plants
• An environmental parcel corresponding to the **costs for CO2 emissions** prevented due to RES generation, multiplied by a technology-specific coefficient
• Different tariff levels for electricity generated during **day and night time**
• **Adjustment to inflation**
• A factor that represents the avoided **electrical losses in the grid** due to the RES plant

3.2.9. Evaluation of the different concepts to determine the tariff level

It has been shown in the past that the level and the guaranteed duration of support as well as investment security have been crucial to attract investors and to increase the exploitation of RES. Since the power generation costs of different RES technologies vary, a successful FIT

[13] European Commission 2003, p. 5.

design should provide technology-specific tariff levels. The remuneration should cover the electricity generation costs and provide a reasonable profit margin. On the other hand the costs for RES support have to be covered by somebody. Typically these costs are included in the electricity price and therefore are transferred to the electricity consumers.
High FITs lead to benefits for the investors, but also to a higher burden on society (e.g., the electricity consumers).
Most of the EU countries with feed-in tariffs apply the technology-specific option of feed-in tariffs. Table 3.4 shows the remuneration levels and the period of guaranteed support in the EU countries.

		Tariff level in 2006 [€ Cents/kWh] and duration of support for different technologies[1]						
Country		Small hydro	Wind onshore	Wind offshore	Solid biomass	Biogas	PV	Geothermal
Austria		3.8 - 6.3 *13 years*	7.8 *13 years*	-	10.2 - 16.0 *13 years*	3.0 - 16.5 *13 years*	47.0 - 60.0 *13 years*	7.0 *13 years*
Cyprus		6.5 *no limit*	9.5 *15 years*	9.5 *15 years*	6.5 *no limit*	6.5 *no limit*	21.1 - 39.3 *15 years*	-
Czech Republic	**fix**	8.1 *15 years*	8.5 *15 years*	-	7.9 - 10.1 *15 years*	7.7 - 10.3 *15 years*	45.5 *15 years*	15.5 *15 years*
	premium	10.5 *15 years*	12.5 *15 years*	-	10.0 - 12.0 *15 years*	9.9 - 12.5 *15 years*	49.0 *15 years*	18.0 *15 years*
Denmark		-	7.2 *20 years*	-	8.0 *20 years*	8.0 *20 years*	8.0 *20 years*	6.9 *20 years*
Estonia		5.2 *7 years*	5.2 *12 years*	5.2 *12 years*	5.2 *7 years*	5.2 *12 years*	5.2 *12 years*	5.2 *12 years*
France		5.5 – 7.6 *20 years*	8.2 *15 years*	13.0 *20 years*	4.9 – 6.1 *15 years*	4.5 - 14.0 *15 years*	30.0 – 55.0 *20 years*	12.0 – 15.0 *15 years*
Germany		6.7 - 9.7 *30 years*	8.4 *20 years*	9.1 *20 years*	3.8 - 21.2 *20 years*	6.5 – 21.2[2] *20 years*	40.6 – 56.8 *20 years*	7.2 – 15.0 *20 years*
Greece		7.3 - 8.5 *12 years*	7.3 - 8.5 *12 years*	9.0 *12 years*	7.3 - 8.5 *12 years*	7.3 - 8.5 *12 years*	40.0 – 50.0 *12 years*	7.3 - 8.5 *12 years*
Hungary		9.4 *no limit*	9.4 *no limit*	-	9.4 *no limit*	9.4 *no limit*	9.4 *no limit*	9.4 *no limit*
Ireland		7.2 *15 years*	5.7 - 5.9 *15 years*	5.7 - 5.9 *15 years*	7.2 *15 years*	7.0 - 7.2 *15 years*	-	-
Italy		-	-	-	-	-	44.5 – 49.0 *20 years*	-
Lithuania		5.8 *10 years*	6.4 *10 years*	6.4 *10 years*	5.8 *10 years*	5.8 *10 years*	-	-
Luxembourg		7.9 – 10.3 *10 years*	7.9 - 10.3 *10 years*	-	10.4 - 12.8 *10 years*	10.4 - 12.8 *10 years*	28.0 - 56.0 *10 years*	-
Netherlands		14.7 *10 years*	12.7 *10 years*	14.7 *10 years*	12.0 - 14.7 *10 years*	7.1 - 14.7 *10 years*	14.7 *10 years*	-
Portugal		7.5 *15 years*	7.4 *15 years*	7.4 *15 years*	11.0 *15 years*	10.2 *15 years*	31 - 45 *15 years*	-
Slovakia		6.1 *1 year*	7.4 *1 year*	-	7.2 - 8.0 *1 year*	6.6 *1 year*	21.2 *1 year*	9.3 *1 year*
Slovenia	**fix**	6.0 - 6.2 *10 years*	5.9 - 6.1 *10 years*	-	6.8 - 7.0 *10 years*	5.0 - 12.1 *10 years*	6.5 - 37.5 *10 years*	5.9 *10 years*
	premium	8.2 - 8.4 *10 years*	8.1 - 8.3 *10 years*	-	9.0 - 9.2 *10 years*	6.7 - 14.3 *10 years*	8.7 - 39.7 *10 years*	8.1 *10 years*
Spain	**fix**	6.1 - 6.9 *no limit*	6.9 *no limit*	6.9 *no limit*	6.1 - 6.9 *no limit*	6.1 - 6.9 *no limit*	23.0 - 44.0 *no limit*	6.9 *no limit*
	premium	8.6 - 9.4 *no limit*	9.4 *no limit*	9.4 *no limit*	8.6 - 9.4 *no limit*	9.4 *no limit*	25.5 *no limit*	9.4 *no limit*

1) For the countries using a different currency than Euro, the exchange rate of the 1st of January 2006 is used [OANDA Corporation 2006].
2) The maximum value given for Germany is only available if all premiums are cumulated. This combines the enhanced use of innovative technologies, CHP generation and sustainable biomass use.

Table 3.4. Level and duration of support for RES plants commissioned in 2006.
Source: *EDFTDO 2007*

Stepped tariff designs
As already was mentioned most EU countries apply distinct tariffs for different RES technologies in order to reflect the technology-specific generation costs. However, power generation costs may also differ between plants within the same RES technology due to the plant size, the type of fuel used, or the diverse external conditions at different sites, like wind yield or solar radiation. Especially the costs of electricity from wind energy vary significantly depending on the wind yield, as Figure 3.7 illustrates.

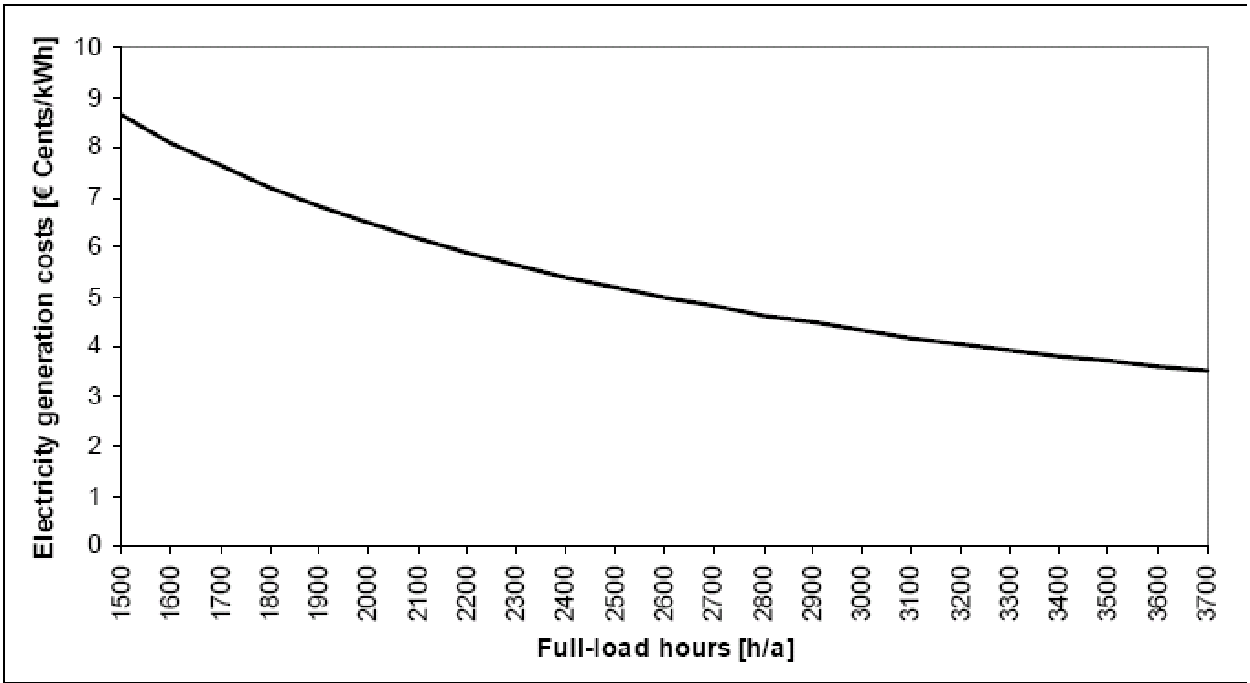


Figure 3.7 Electricity generation costs of wind energy in Germany[14]
Source: *EDFTDO 2007*

A possible solution to take these differences in the costs of electricity generation within the same RES technology into account is a *stepped tariff design*, which implies, that different levels of remuneration are paid for electricity of the same RES technology. The opposite of a stepped tariff design is called a *flat tariff design*. In this case the same level of remuneration is paid for all plants of the same technology without considering the electricity generation costs.

The following three groups of stepped tariff designs can be outlined:

1. Tariff level depending on location
2. Tariff level depending on plant size
3. Tariff level depending on fuel type.

Energy policy should provide incentives to exploit the most efficient sites first and also to use in each region the kind of RES which is most suitable under the local conditions. Thus a system with FITs should be organized which renders the return on investment slightly higher

[14] Assumptions: Investment.1067 €/kW, Lifetime: 20 years, Interest rate: 6.6%, O&M costs: 3% of investment

for plants at cost efficient locations compared to sites at locations with less favourable conditions.

Tariff degression

The system of a tariff degression can be described as follows: The tariff level depends on the year, when the RES plant starts to operate. Each year the level for new plants is reduced by a certain percentage. However, the remuneration per kWh for commissioned plants remains constant for the guaranteed duration of support. Therefore the later a plant is installed, the lower the reimbursement received. The tariff degression can be used to provide incentives for technology improvements and cost reductions. Furthermore it minimizes the risk of over-compensation. Ideally the rate of degression is based on the empirically derived progress ratios for the different technologies. Germany, France (for wind energy) and Italy (for PV) apply a support system for RES with a tariff degression.

Tariff degression can be used to incorporate technological learning in RES policy. The predetermined percentage of degression causes higher transparency and security for potential investors than reducing the tariff level during a periodical revision. However, rising prices of input factors like steel for wind turbines or silicon for PV devices may lead to an unexpected increase in the price of RES plants. In order to maintain RES projects attractive for investors, the price development of the most important input factor could be taken into account to determine the tariff level. On the other hand this could lead to increased plant prices, if the plant producers know that the degression rate is variable.

3.2.10. Purchase obligation

The concept of a *purchase obligation* implies that electricity grid operators, energy supply companies or electricity consumers are obliged to buy the power generated from RES. Most EU Member States provide a purchase obligation, however, in some countries the following exceptions are applied:

- No purchase obligation for electricity offered on the spot market
- Purchase obligation only to the extent of electricity network losses

Spain, the **Czech Republic**, **Slovenia** provide the possibility of selling the electricity from RES directly on the spot market. In addition to the market price, the RES generators receive a premium per kWh of electricity. This concept, called *premium tariff design*, is used as an alternative to the *fixed tariff design* and the RES producers can choose one of the two options. While a purchase obligation is provided in these countries for the fixed tariff design, there is no purchase guarantee in the case of the premium tariff design.

In **Denmark** operators of wind onshore turbines (connected to the grid since 2003) have to sell the generated electricity according to a premium tariff design without a guaranteed purchase and there is no alternative fixed tariff option offered.

A purchase obligation is a possibility to provide investment security and to attract investors.The administrational complexity of this instrument is relatively low. Without a guaranteed purchase the investors request a higher return on investment to cover the increased risk.

One objection with respect to the purchase obligation is the fact that it does not represent market compatibility, because the electricity has to be bought independently from the demand. The premium option without a purchase guarantee is an attempt to enhance market compatibility. Typically such mechanisms to raise the market compatibility lead to an increase of tariff levels. The evaluation of a purchase obligation is summarized in Table 3.7

3.11. Premium versus fixed tariff design

A feed-in tariff can be paid to RES generators as an overall remuneration (the *fixed tariff*) or alternatively as a premium, that is paid on top of the electricity market price (the *premium tariff*). In the case of a fixed tariff design, RES producers receive a certain level of remuneration per kWh of electricity generated. In this case, the remuneration is independent from the electricity market price. In contrast, the development of the electricity price has an influence on the remuneration level under the premium option. Hence, the premium tariff represents a modification of the commonly used fixed tariff towards a more **market-based** support instrument. Figure 3.8 shows share of electricity sold with the premium option for the different technologies.

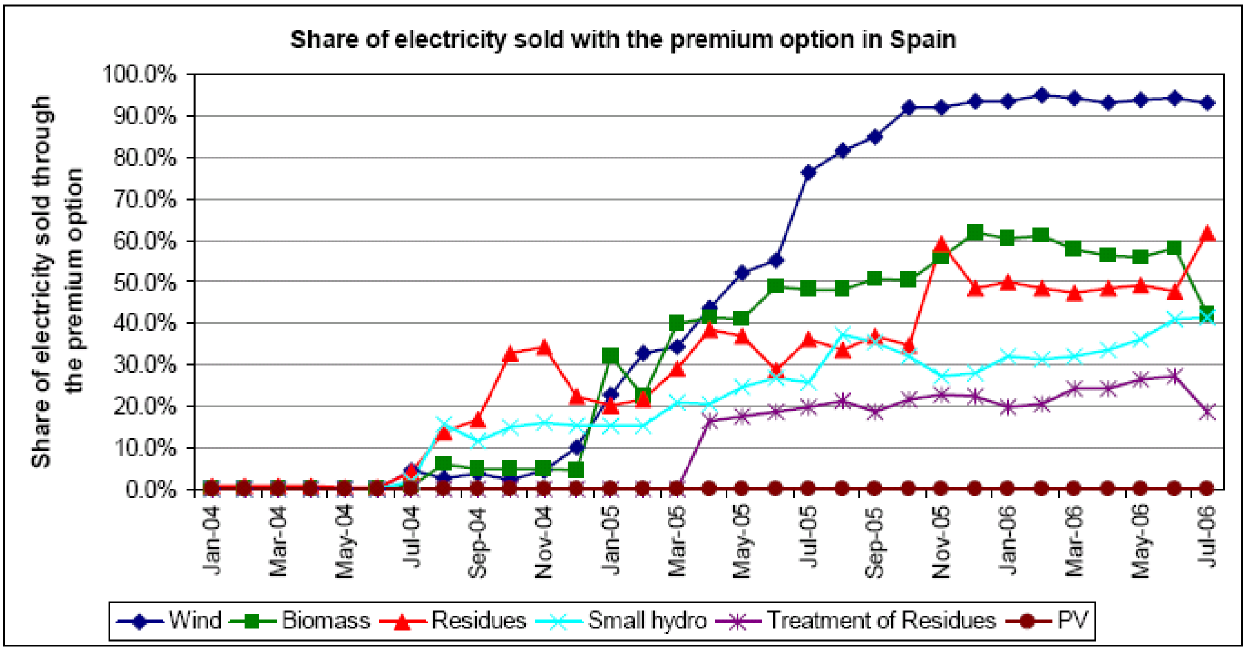


Figure 3.8. Share of electricity sold with the premium option in Spain from January 2004 to July 2006. Source: *EDFTDO 2007*

The premium option shows a higher compatibility with the liberalized electricity markets than fixed feed-in tariffs. This involves a better and more efficient assignment of the grid costs, particularly as regards the management of the alternative routings and supplementary services. The risk for the RES producers is larger in the case of the premium option, because the total level of remuneration is not determined in advance and there is no purchase obligation as is typically the case with the fixed option. Therefore the remuneration of the premium option has to be higher than the one of the fixed tariff option in order to compensate the higher risk for RES producers. Table 3.5 summarizes the advantages and disadvantages of a premium tariff design in comparison to a fixed tariff design.

Advantages	Disadvantages
• More market orientated and less market distortion • More demand orientated • Provides an incentive to feed electricity into the grid, in times of peak demand	• No purchase guarantee, therefore less investment security • Most likely higher costs for electricity consumers, especially if the market price rises • Operators of wind and solar power plants can hardly influence the time of electricity generation and therefore are not able to take advantage of feeding electricity into the grid at peak demand

Table 3.5. *EDFTDO 2007.*

3.3. Conclusions

Despite its obvious strategic importance, energy produced from renewable sources in most cases is still too expensive to compete successfully with traditional energy in the open market. Thus in order to introduce and successfully employ renewable energy it is necessary to develop and implement:

1. sustainable energy policies, based on long-term strategic vision, incorporating such arguments as environmental protection, reduction of greenhouse emissions and energy security;
2. sustained government intervention in order to safeguard market access for renewables, including policy planning, regulations, various energy policy instruments and market stimulation measures.

Today all these is presented in various forms and stages of development in the EU, which is the obvious global leader in implementing renewable energy policies. Despite the visible overall success, concrete results are still uneven across the countries and sectors and need constant adjustment and streamlining in order to safeguard sustainable development of green energy market. Besides it should be kept in mind that whatever instruments (regulatory, economic, planning, etc.) are employed, the price difference caused by introduction of renewable energy into traditional energy market is almost always passed on to the final consumers.

Among the concrete instruments employed by the EU in order to safeguard market access for renewable energy, the following two are invariably employed across the board:

- feed-in tariffs
- tradable green certificates.

Based on the different options for feed-in tariff designs presented the following policy recommendations are proposed:

1. **RES support requires continuity and long term investment policy.**
   A stable, transparent policy framework is crucial for a successful and continuous exploitation of REES-E. Therefore feed-in tariffs should be accompanied by long term targets and sufficiently long periods for which the tariff is guaranteed. However,

the tariffs for new installations have to be revised regularly in order to control, if they are still corresponding to the policy goal.

2. **Technology-specific tariff levels should be applied.**
   In order to reflect the varying electricity generation costs of the different REES-E technologies, technology-specific tariff levels, sufficiently high to cover the power generation costs should be provided. These tariff levels should ensure to reach the policy goals of a country and incentives should be provided to exploit those REES first, which are most cost efficient at the particular location. On the other hand, technologies that are not ready for the market yet, should be supported as well, in order to allow them acting on the market and to gain experience, which leads to cost reductions in the future.

3. **Energy policy should provide mechanisms to ensure the penetration and to improve the integration of REES-E into the grid.**
   A feed-in tariff design should provide a purchase obligation or an alternative measure ensuring, that the REES-E generators may sell their electricity on the market receiving a fixed tariff or a premium on top of the market price. A forecast obligation for REES-E may facilitate the integration of the electricity from REES into the grid. However it should be carefully analyzed, which market actor should be obliged to forecast fluctuating power generation in order to minimize the costs for the energy system.

4. **A premium tariff option can be applied to increase market orientation.**
   A premium tariff design allows REES-E generators to sell their electricity directly on the spot market, receiving a premium on top of the electricity market price. Such a system without a purchase obligation may create higher market compatibility than the fixed tariff option. Furthermore it provides an incentive to feed electricity into the grid in the periods of peak demand. One disadvantage is, that the premium option typically causes higher costs than the fixed tariff option and that the costs of the system may increase strongly if the conventional electricity price increases.

Chapter 4
Energy Balances in Georgia

This chapter covers the information necessary for evaluating the potential effects of energy efficiency and renewable energy development on Georgia's total energy supply and consumption. Along with the aggregate energy balance, the electricity and natural gas balances are broken out separately. Available information about energy use by different consumer categories is presented and the issues of energy security are discussed in relation to electricity, natural gas and aggregate energy balances.

4. 1. Aggregate Energy Balance of Georgia in 2006

The discussion of energy balances and energy consumption patterns has twofold importance for the current study. One of the objectives is to quantify and evaluate Georgia's dependence on imported energy and to analyze the seasonal character of this dependence from the point of view of the country's energy security. Another main objective is to analyze energy consumption for different types of energy, breaking the analysis out for various end uses and into different consumer categories, in order to identify and evaluate the potential energy savings.

The Statistics Department of Georgia currently does not prepare energy balances, so the relevant data should be collected from different sources and compiled into an aggregate balance. The aggregate Energy Balance of Georgia for 2006 is given in Table 4.1, and is based on annual reports of relevant agencies (e.g., Saknakhshiri, Saknavtobi, Association of Oil Product Producers & Importers) and preliminary data to be published by Statistics Department of Georgia in annual report for 2006.

Energy Balance of Georgia 2006 (kilotons of oil equivalent—KTOE)

#		Coal	Crude Oil	Oil Prod-ucts	Natural Gas	Hyd-raulic Energy	Renew-able	Fire-wood and waste	Elec-tricity	Thermal Energy	Total
10	Production	4	64		17	457	14	385			**941**
11	Import	3		792	1517				65		**2377**
12	Export		-53	-3					-12		**-68**
13	Stock Build Up	-1	2	4	-3						**2**
15	Primary Production 15=10+11-12±13	6	13	793	1531	457	14	385	53	0	***3252***
20	Electricity plants, Boilers			-6	-508	-457			638	32	**-301**
21	Oil refineries		-13	12							**-1**
22	Other transfor-mations and losses			-14	-346				-91		**-451**
30	Energy Supply 30=15±20±21-22	6	0	785	677		14	385	600	32	***2499***
40	Industrial Sector 40=41+42+43+44	2	0	92	167	0	0	0	116	12	**389**
41	Metallurgy			3	5				43	3	**54**
42	Chemical production & Petrochemistry			17	27				36	3	**83**
43	Nonmetallic materials			15	18				13	2	**48**
44	Other production	2		57	117				24	4	**204**
50	Transportation 50=51+52+53	3		512	24				52	0	**591**
51	Aviation, marine			24	4				4		**32**
52	Railway and automobile transport	3		448	14				36		**501**
53	Unspecified transport			40	6				12		**58**
60	Other sectors 60=61+62+63+64	1		181	293		14	385	432	20	**1326**
61	Agriculture			64	58		0	20	14	4	**160**
62	Services	1		16	28		6	24	16	16	**107**
63	Households			75	201		8	329	396	0	**1009**
64	Unspecified			26	6		0	12	6	0	**50**
70	Non-energy consumption			0	193			0			**193**

Table 4.1. Aggregate energy balance 2006

Year 2006 was not a typical year for the Georgian Energy Balance; Georgia experienced disruptions in gas supply from Russia in the beginning of the year and disruptions from additional rehabilitation of Enguri Hydropower Plant (HPP) in the spring and summer of 2006, a major source of electric energy in Georgia.

The annual 2006 structure of energy supply in Georgia is given in Figure 4.1.

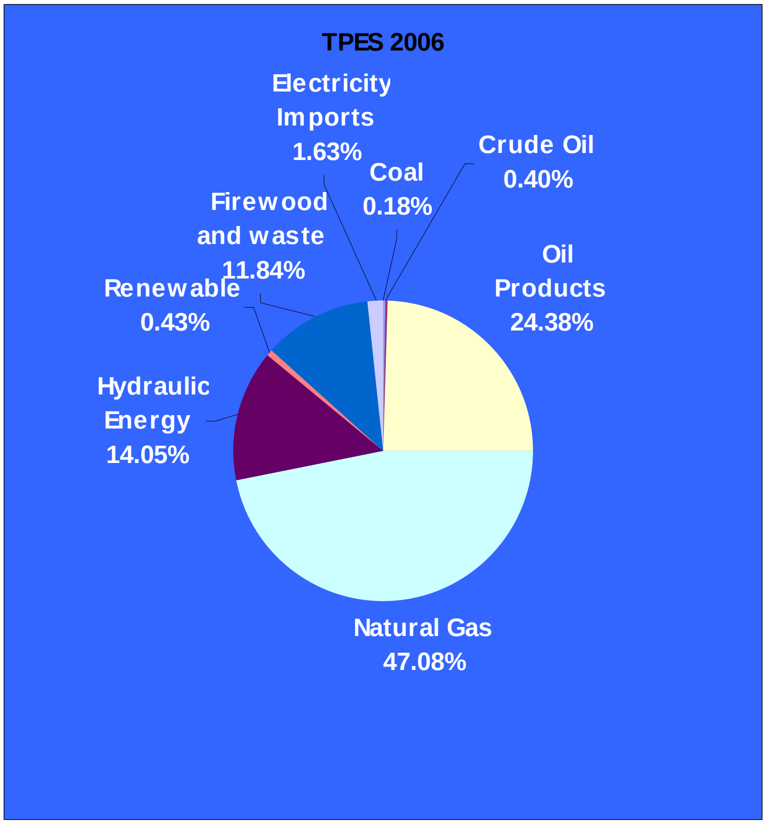


Figure 4.1 Structure of Total Primary Energy Supply (TPES) in Georgia, 2006

The energy balance of 2006 shows the following features of energy supply and consumption:

- Out of the total primary energy supply in the country, about 71% (47% natural gas and 24% oil products) was imported;
- Out of the total imported energy the major share (64%) comes as natural gas and about 33% as oil products;
- The contribution of firewood to indigenous energy supply is comparable to that of hydraulic energy;
- The share of renewable energy sources, other then small hydro, in the energy balance is negligible, less then 0.5%.

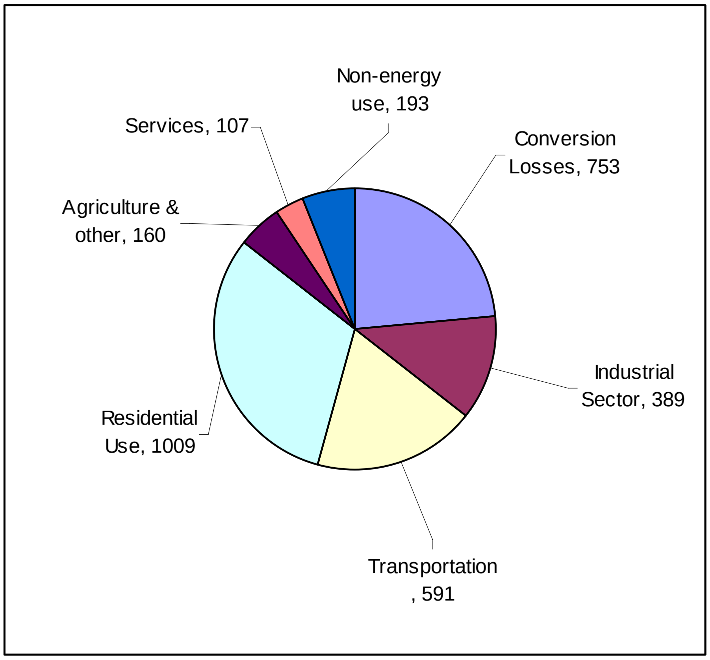


Figure 4.2 Total energy consumption in Georgia (kilotons of oil equivalent)

The structure of energy end use is shown in Figure 4.3. The analysis reveals that:

- Energy use of households (including personal transport) is about 53% of the total in-country energy consumption. It exceeds 3 times the energy use of industry and 8-10 times the consumption of the agriculture and services sector;
- There is a significant share of gas conversion losses. A great deal of it is (301 kilotons of oil equivalent—KTOE) can be cut in half by more efficient thermal generation technologies. A detailed analysis taking into account the potential demand and generation regimes together with economic analysis could provide more insight into the economic feasibility of addressing this issue through more efficient cogeneration and combined cycle technologies.

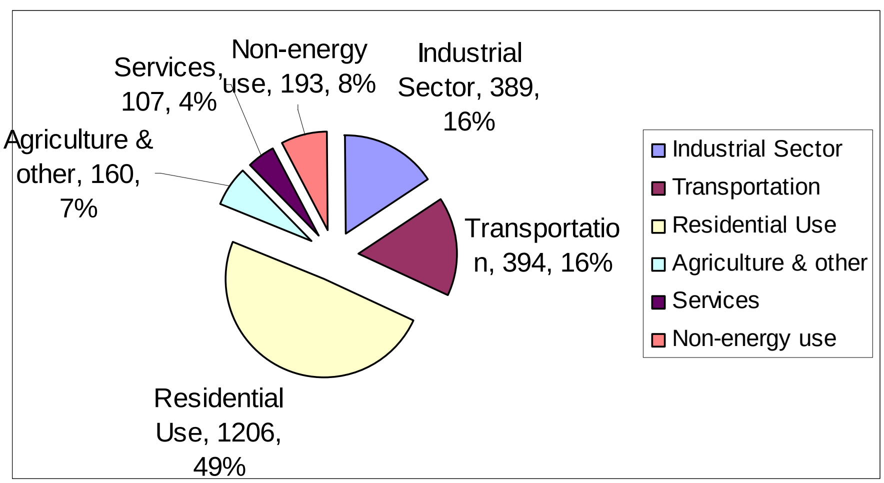


Figure 4.3. Structure of Useful Energy Consumption in Georgia (kilotons of oil equivalent)

Per capita energy supply in Georgia in kilograms of oil equivalent (kgoe) is summarized below in table 4.2:

	KgOE/person	Units
Total Energy Supply (TPES)	738	N/A
Natural Gas Supply	348	427 normal m^3/year
Oil Products	178	-
Electricity	160	1863 kWh/year

Table 4.2 Per capita energy supply; kilograms of oil equivalent

Table 4.2 shows that energy consumption is much lower in Georgia than in developed countries, and countries of the former Soviet Union; these consumption figures can be compared with the parameters of previous years and similar parameters of other countries.[1] Relatively low per capita energy consumption reflects the structure of economy and the climatic conditions, but it does not change the main conclusion of this analysis— there is a significant energy saving potential in Georgia.

4.2. Electricity Balances

4.2.1. The 2006 Electricity Balance

Electricity supply was essentially unrestricted in 2006. Thus demand was not curtailed by a supply limitation and the 2006 electricity balance correctly represents the existing structure and seasonal patterns of electricity demand. There was a tariff increase in the middle of the year (June 1, 2006), that may have changed the behavior of different consumer groups; however, more in-depth analysis and detailed data is needed to make well justified conclusions on this matter.

The details of the 2006 electricity supply and consumption balance are given in Appendix 1. The dynamics of electricity demand over the year is shown in Figure 4.4 on the next page.

[1] http://earthtrends.wri.org/text/energy-resources/variable-351.html

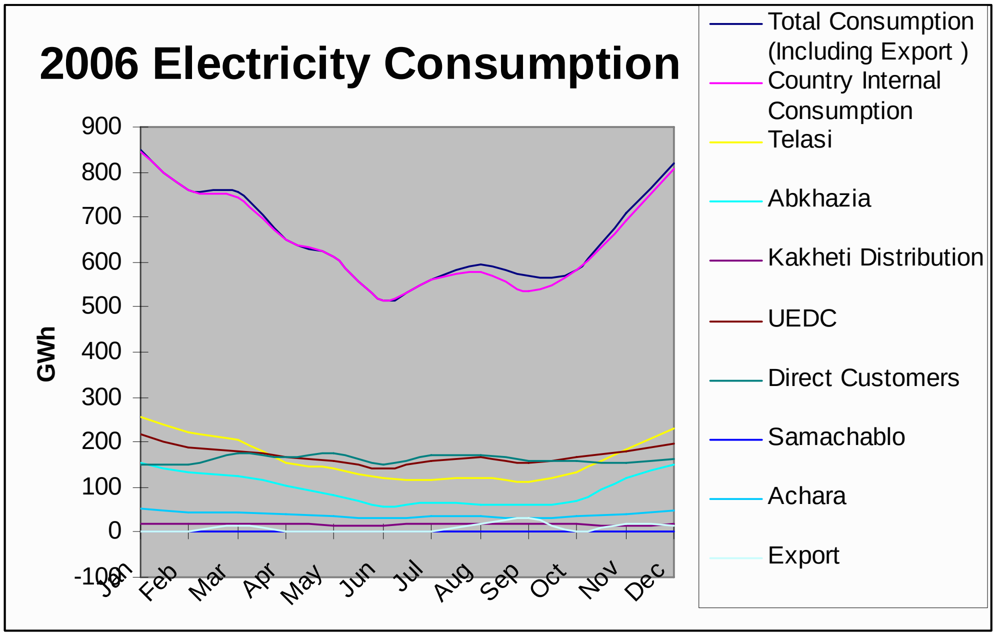


Figure 4.4. Seasonal variation of electricity consumption in 2006

While the electricity demand pattern may have been typical, the supply of electricity in 2006 was not. Due to the shutdown of Enguri HPP for major rehabilitation in the spring and summer months, the year was marked with higher levels of electricity imports and the operation of thermal power plants in summer months; this is unusual for the Georgian power sector in recent years. Seasonal dynamics of electricity supply in 2006 is shown in Figure 4.5.

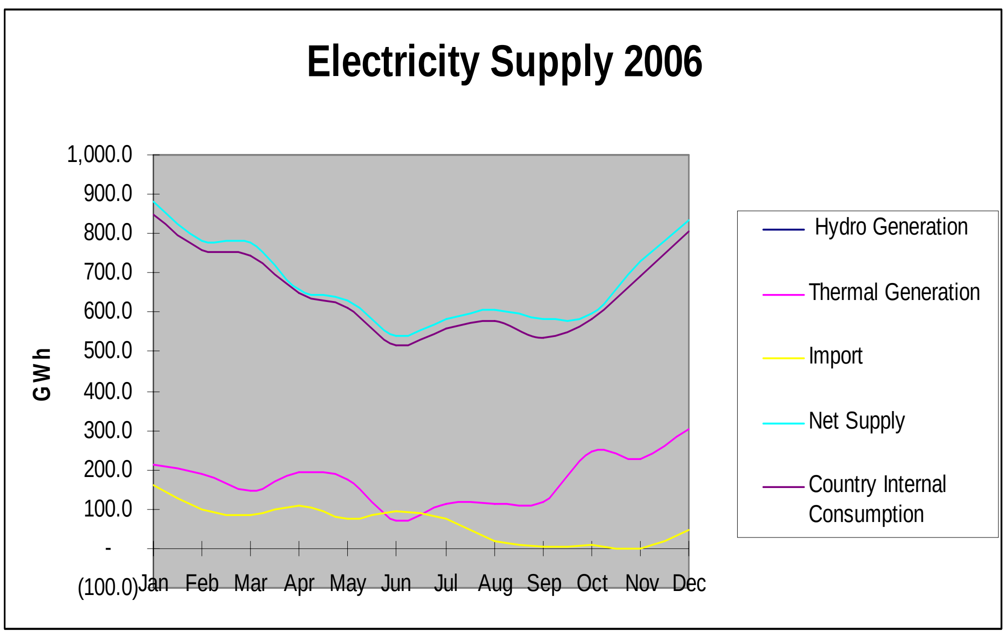


Figure 4.5. 2006 electricity supply patterns

Year 2006 was fairly anomalous; Georgia experienced reduced hydropower generation in the summer months combined with an increase in imports and thermal generation. Starting in

August, the import was minimized and from September onward the power system started getting back to its normal mode of operation.

Electricity imports were relatively high in 2006 due to the rehabilitation of Enrguri HPP; however, a more recent trend in Georgia's energy sector has been to reduce electricity imports and replace them with gas imports, for local thermal generation of electricity.

The structure of supply in 2006 is shown in Figure 4.6.

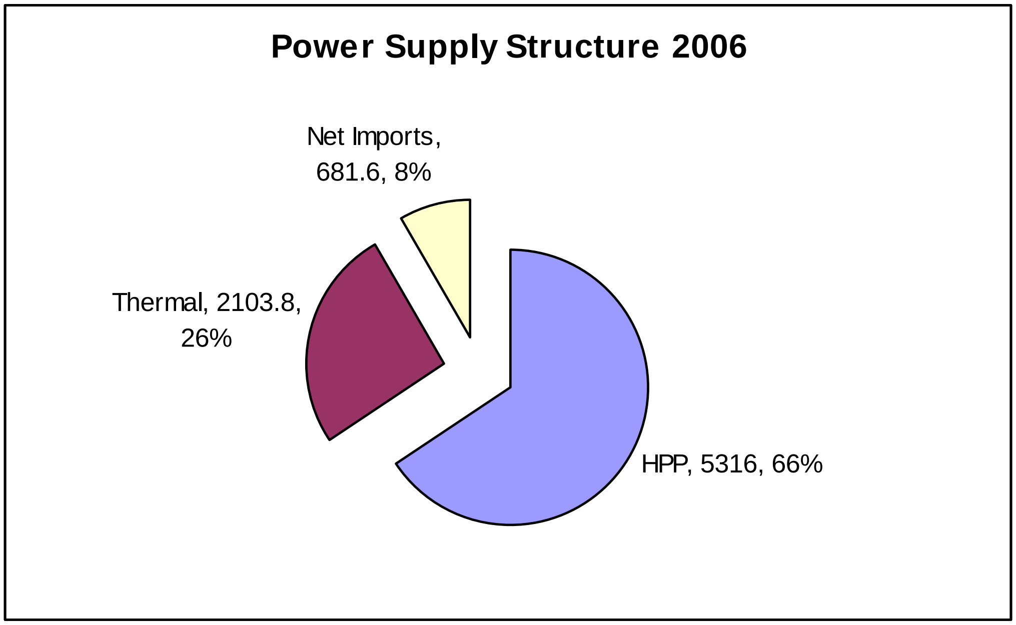


Figure 4.6. Electricity Supply Structure 2006 (GWh)

Total electricity supply and consumption in 2006 was 98% compared to that of the previous year. The history of electricity supply and demand over recent years does not show significant growth of demand.

	2000	**2001**	**2002**	**2003**	**2004**	**2005**	**2006**
Total Production	7446.0	6942.0	7256.0	7163.0	6706.0	7100.0	7419.9
HPP	5905.6	5571.5	6742.9	6527.9	5892.9	6070.0	5316.0
Thermal	1540.4	1370.5	513.5	635.1	813.2	1030.6	2103.8
Imports	611.5	877.6	713.2	844.2	1210.0	1399.0	777.6
Exports	210.5	523.3	244.5	109.3	-	120.0	96.0
Consumption	7847.0	7296.3	7724.7	7898.0	7916.0	8379.0	8197.4
Net Imports	401.0	354.3	468.7	735.0	1210.0	1279.0	681.6

Table 4.3. Dynamics of Electricity Supply and Demand over 2000-2006 (GWh)

The stability of demand may be caused by two different reasons: 1) the increase in collection rates of distribution companies has resulted in less consumption by those who were previously getting electricity for free; 2) tariff increases may have influenced the level of consumption of different customer categories, customers who tend to reduce their electricity bills to affordable levels.

The share of useful (legal) consumption has increased since 2000 when electricity consumption was aggravated by unpaid and wasteful consumption of uncontrolled consumers. Since then the collection rates have dramatically improved and the same amount of electricity that was essentially wasted in 2000 is now a part of economic turnover. Although this is a significant achievement, the collection levels of distribution companies need to be improved further; this will be a significant contribution to efficient energy use.

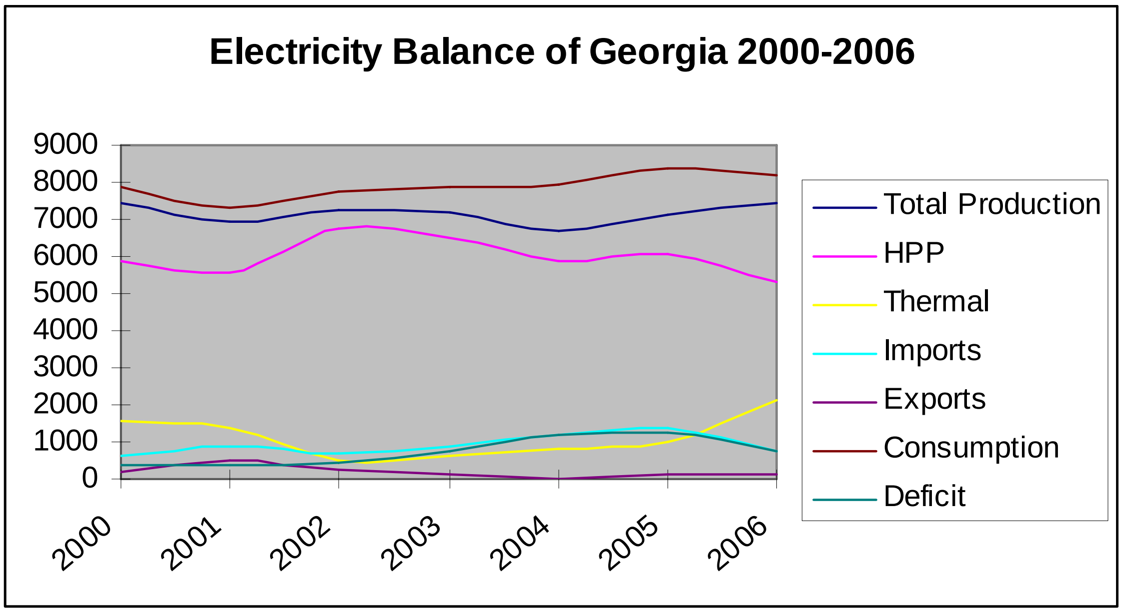


Figure 4.7. Dynamics of energy balance in Georgia (GWh)

The chart shows that there is a trend towards increasing local generation and reducing imports in 2006, in spite of the reduction in hydro generation during that time. This was achieved through higher total generation for thermal power plants.

4.2.2 Model 2007 Electricity Balance

As a reference electricity balance for our study we constructed the "2007 Model Electricity Balance" which is based on actual 2007 January-August data and 2006 September – December data.[2] We convert this data into the model January-December balance by simply rearranging the months and thus September-December 2006 data is used as substitute for September-December of 2007. The details of the 2007 Model Electricity Balance electricity supply and consumption balance are given in Appendix 2.

[2] The data for July- August 2007 will be included by the end of the study when actual data will become available. Meanwhile we use dummy data for these two months.

Our assumption is that consumption patterns between 2006 and 2007 do not differ significantly, and the desire is to have as recent and as representational of a supply picture as possible. Indeed, As can be seen from Figure 4.5, the consumption pattern of 2007 closely follows that of 2006. The supply picture of 2006 was specific due to Enguri HPP rehabilitation; however we assume that from September onward, generation returned to a typical operational regime. The benefit of such an approach is that it reflects the current electricity consumption pattern and also represents the supply-side corresponding to ordinary operating conditions of the Georgian Power Sector.[3]

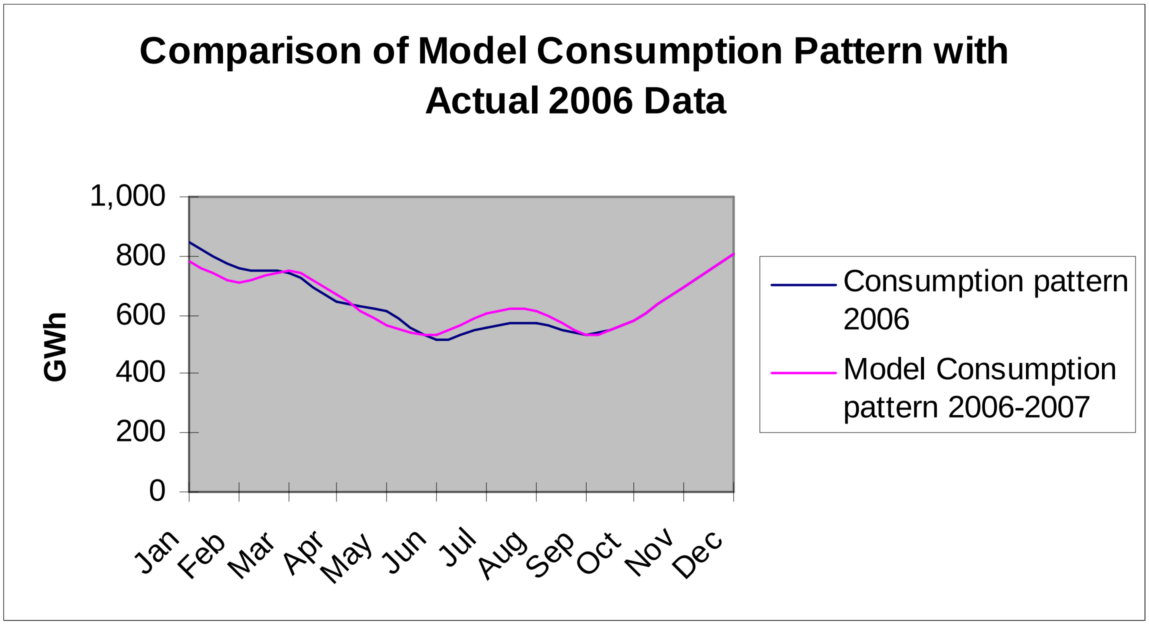


Figure 4.8. Consumption patterns 2006 and Model 2007

[3] There is some deficiency in such an approach since we can not properly account for the electricity to be imported in winter in return for the summer export of 2006. However we are aware of this problem and take this into consideration when formulating main conclusions.

The 2007 model electricity supply diagram is given in Figure 4.9.

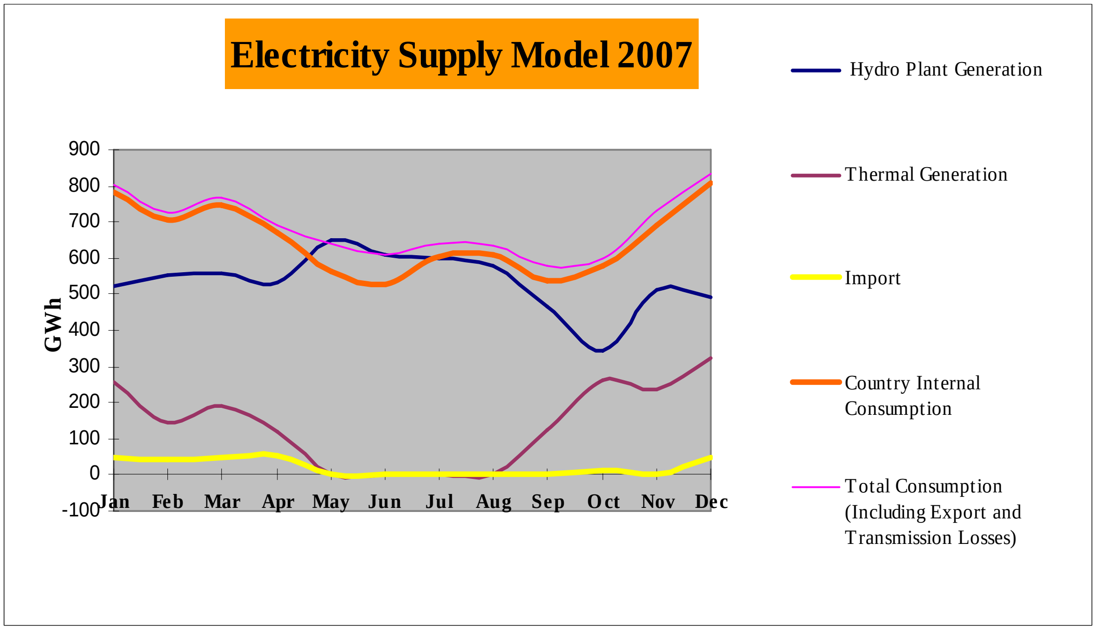


Figure 4.9. Electricity supply dynamics 2007

The chart above clearly shows the seasonal features of electricity generation in Georgia:

- Hydropower generation dominates the supply and increases in the summer months.
- Thermal power plants are operating only in winter months and are used to make up for the lack of hydro generation.
- Electricity imports can be used in winter season to back up and supplement local thermal generation.

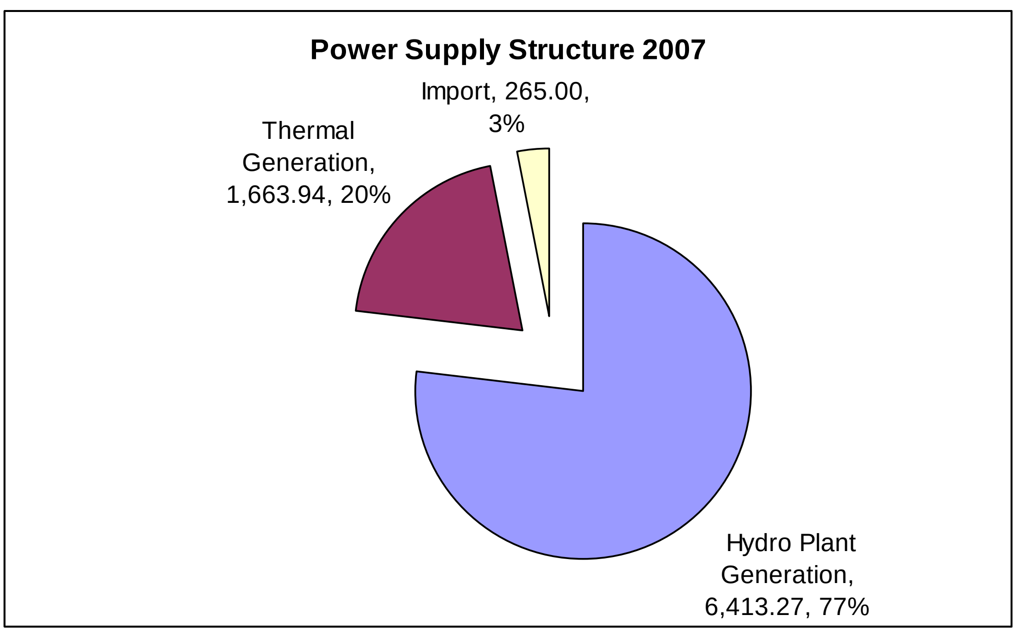


Figure 4.10. Structure of power supply 2007

Remarkably, an export potential has been successfully used in 2007 to arrange the seasonal energy swap with neighboring countries. This kind of swap can benefit all parties involved. According to the recent information from ESCO a total of 614.4 GWh-s has been exported, by September 1, in 2007. This is a significant success and this energy exchange with neighboring countries should be properly reflected in the present analysis after the exchange transaction will be finalized.

Seasonal Variation of Energy Cost

Considerable seasonal variation of generation sources results in the seasonal variation of energy supply costs. In particular, the higher share of thermal power and imports used in the winter season contributes to higher supply cost. In order to evaluate the cost of supplying the power in different months we have constructed a chart of effective monthly generation tariffs. Tariffs approved by Georgian National Energy Regulatory Commission (GNERC) have been applied.[4] Although, according to the Market Rules and GNERC resolutions, the generators can sell for less than the GNERC-approved tariff caps; we are not aware of such facts at the time of writing this report.

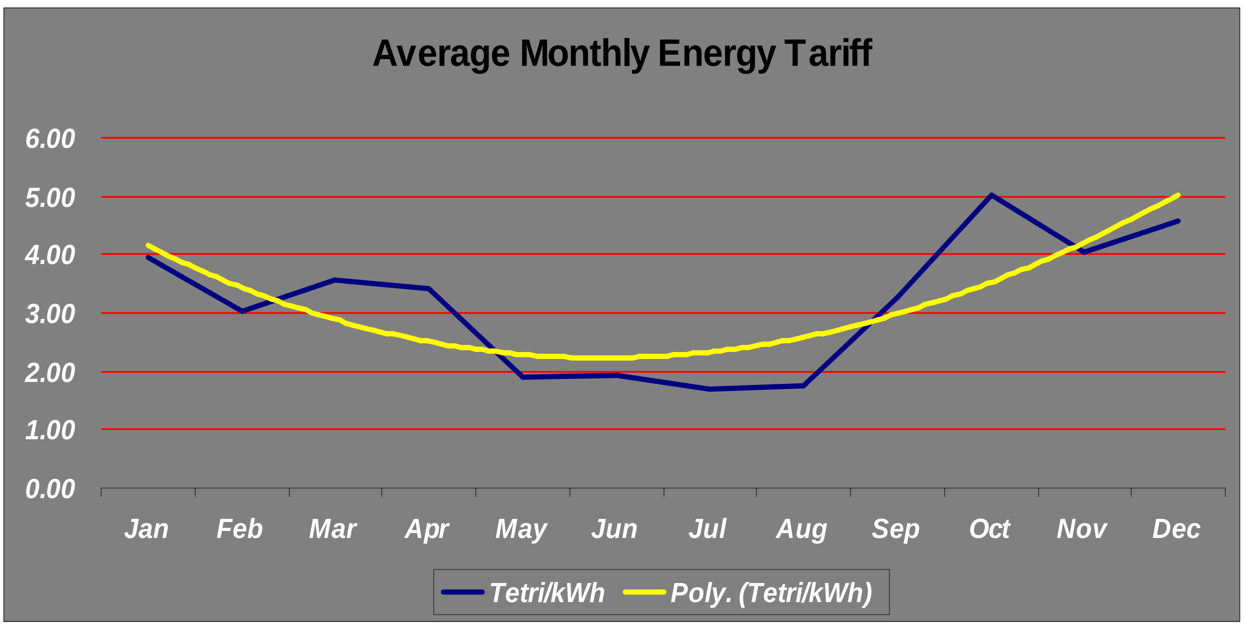


Figure 4.11. Seasonal variation of effective electricity tariff

The graph shows that the cost of supplying electricity more than doubles in winter months compared to the summer period where hydropower is sufficient to cover in-country needs. The details of calculation can be found in Appendix.3.

[4] GNERC resolution #18 of May 15, 2006 and subsequent resolutions.

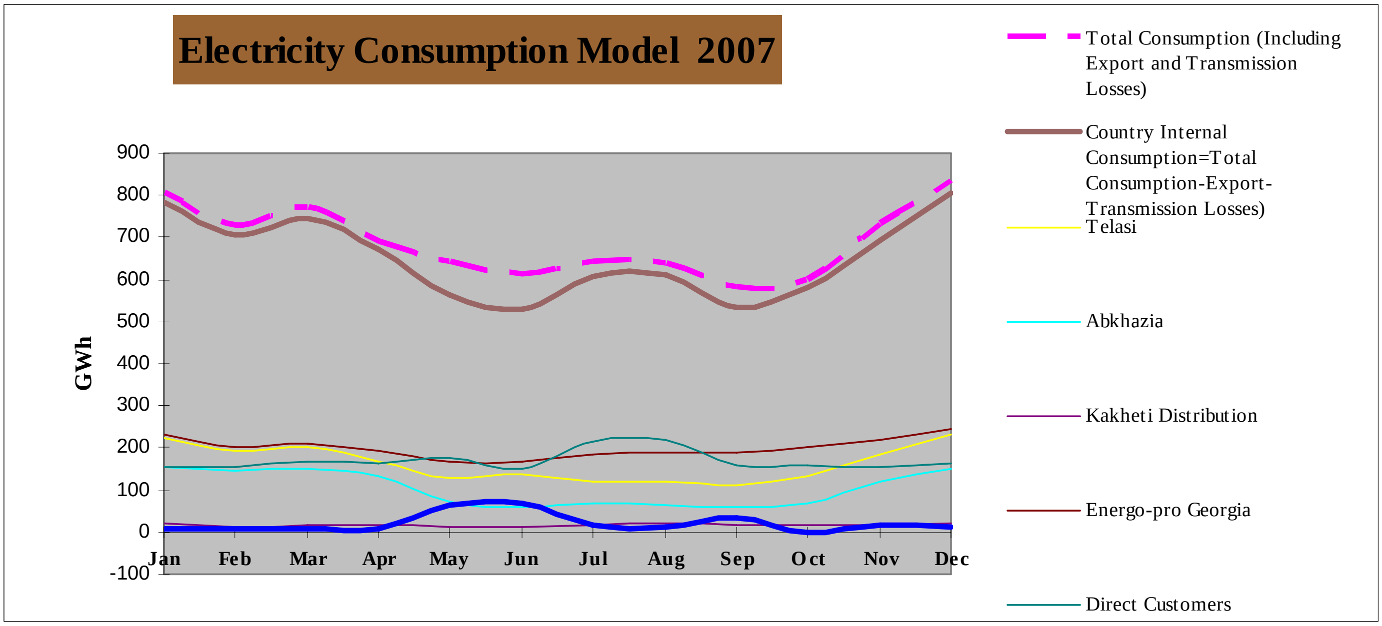


Figure 4.12. Seasonal structure of electricity consumption model

The chart shows that:

- Seasonal variation of electricity consumption is mainly caused by distribution companies.[5]
- Big industrial consumers (direct customers) show reversed seasonal pattern of consumption – their consumption slightly increases in summer.
- In summer there is a surplus of electricity allowing the Georgian power system to export the energy.
- There is no import of electricity in this model even in winter months, since the recent tendency is to increase in country thermal generation and reduce electricity imports. This feature can be corrected later when the volume of actual import will be known.

[5] A more detailed analysis shows that this in turn is mainly caused by increase of residential consumption in winter months.

The annual structure of electricity consumption is shown in Figure 4.13.

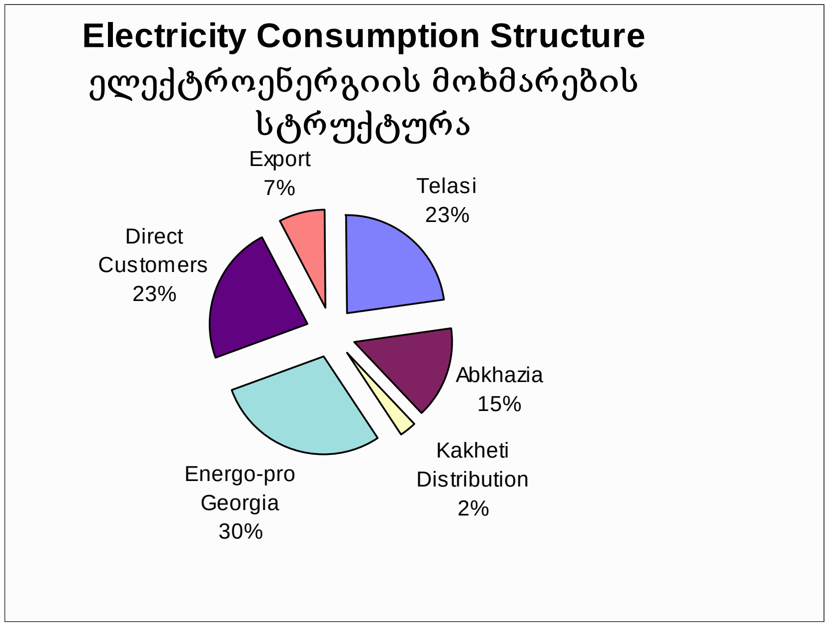


Figure 4.13. Electricity consumption by wholesale consumers

Figure 4.13 shows that the biggest wholesale consumer is Energo-Pro Georgia (30%), followed by Telasi (23%) and the aggregate consumption of Georgia’s large industries, referred to above as Direct Customers (23%).

A breakdown of direct consumers by their consumption is given in Figure 4.14.

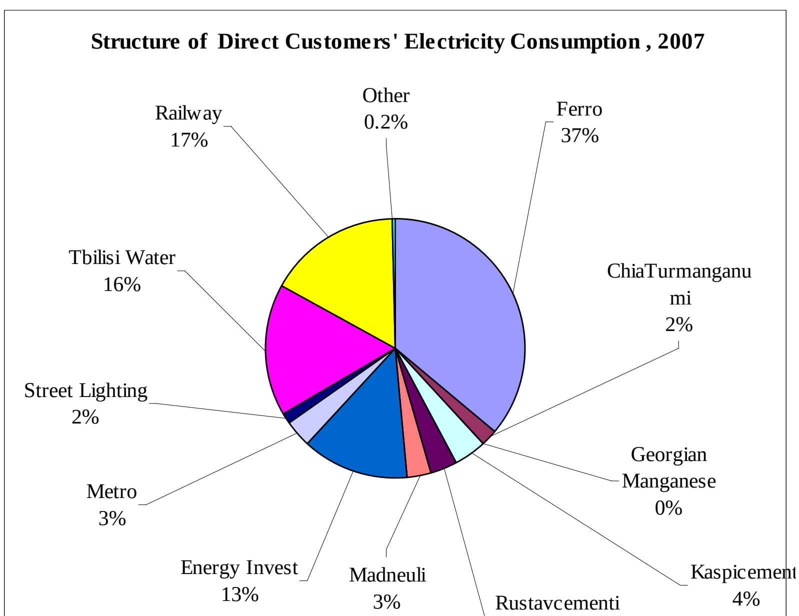


Figure 4.14. Consumption by Direct customers

Zestaphoni Ferric Alloy plant is the biggest direct consumer followed by Railway and Tbilisi Water. A detailed energy audit in these enterprises could reveal a savings potential that can be material for the whole country energy balance.

4.2.3. Excess of Hydroelectric Resources

According to the statistics from previous years and the estimates of various experts, there is a significant excessive hydraulic energy resource in the Georgian power system that needs to be duly utilized. The failure in using this resource can lead to unproductive waste of water.

There are two different reasons that can result in unproductive water waste at hydropower plants:

1. Water pouring or "waste of water" can be caused by malfunctioning of a hydropower plant or technical difficulties at hydro-technical structures. For instance, in 2001, due to the lack of maintenance on power plants and hydro-technical structures for the flooding period, the high filtering of water, and erroneous regimes of operation, there was a waste of water equivalent to 1.5 billion kWh of electricity. Of which 0.6 billion kWh was lost due to the damage of Enguri dam's spillway hole. During five months of 2002, the water, equivalent to 312 million kWh of electricity, was wasted unproductively because of the lack of maintenance at Georgia's hydropower plants, excluding Enguri HP. In the same period, the damage of Enguri dam's spillway hole caused loss of water equivalent to 250 million kWh of electricity. In total there has been a waste of water equivalent to 562 million kWh in five months.[6] However, the maintenance works completed in 2004-2006, have significantly reduced unproductive waste of water caused by technical malfunctioning.

2. The second possible reason for water waste is the surplus of hydraulic energy compared to system demand during the months of May-July. In this period, the water discharge in rivers strongly increases, and electricity usage considerably decreases. As a results an unproductive discharge of water in hydro plants may happen. Specialists estimate the amount of excessive energy at approximately 700-800 million kWh annually, or about 10% of in-country electricity generation, of the value of approximately 30 million GEL by today's tariffs. In 2007 a great deal of this resource has been successfully utilized for export.

The problem of seasonal imbalance is not new for Georgian energy system. It has continued for years, caused by one main reason – Georgian power plants were planned and constructed based on the needs of united energy system of Soviet Union. After the breakdown of the Soviet Union, and isolation of the Georgian energy system, some of the capacity remained unloaded in the summer. The strategy of new generation development has to take into account this in country seasonal energy imbalance.

[6] Energogeneratsia 2001 annual report

In spite of the fact that Georgia has excess hydropower production capacity, it does not directly contribute to country's energy independence and requires additional measures like energy swaps with neighboring countries to bring the benefit to Georgia.

Georgia's seasonal hydropower imbalance needs to be more closely studied to be effectively resolved. Some of potential solutions to this problem are:

1. Introduce seasonal tariffs in summer – this will stimulate economic sectors to exploit the resources proficiently;
2. Develop the stable regional mechanisms of seasonal energy exchange including a regional electricity market;
3. Develop the strategy of new generation development that takes into account these seasonal energy imbalance issues.

4.3. Natural Gas Balances

Like electricity balance, the natural gas balance in 2006 was also atypical due to excess gas imports for electricity generation.

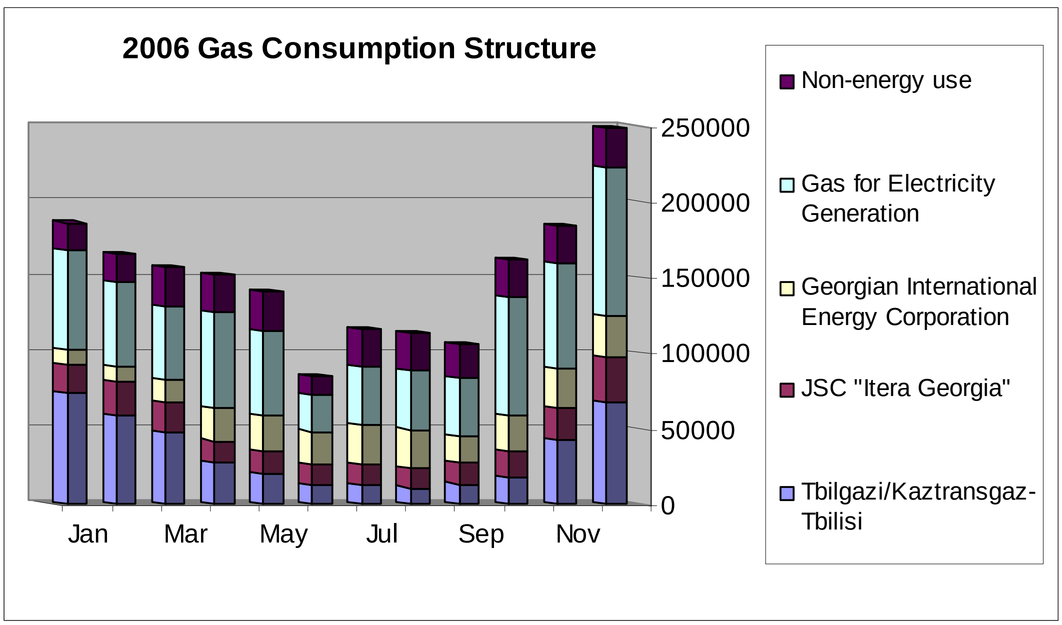


Figure 4.15. Monthly Gas Consumption Structure in Georgia 2006

As can be seen from Figure 4.15, gas use for electricity generation occurred throughout the year. The seasonal variation of gas consumption is much more pronounced in Tbilisi (Kaztransgas-Tbilisi) then in other regions of Georgia (Itera Georgia), indicating that gas use for heating is more intensive in Tbilisi than in other places (Cf. Appendix 4)

The chart in Figure 4.13 shows the gas consumption by different wholesale consumers.

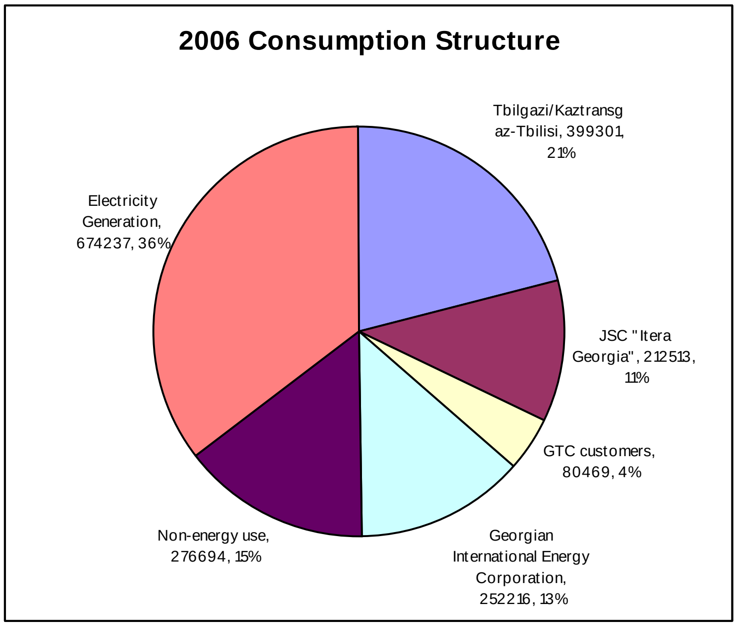


Figure 4.16. Georgia's annual 2006 gas consumption structure in thousand cubic meters

As can be seen from the chart the biggest share of gas (36%) was used for electricity generation and the biggest wholesale consumer is Kaztransgaz-Tbilisi (21%).

In order to develop a more typical model gas balance that would reflect the recent situation, in analogy with model 2007 electricity balance, we have reconstructed a model gas balance for 2007. This is based on actual 2007 January-June, and actual 2006 September-December data. *(July-August data are forecast)* (Cf. Appendix.4.).

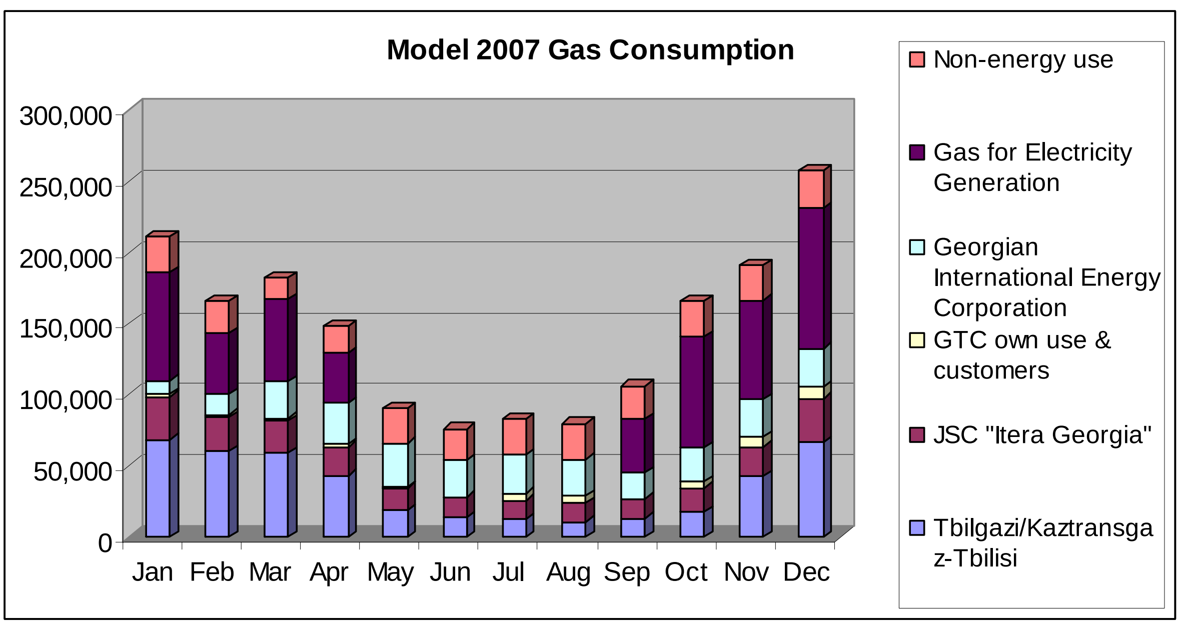


Figure 4.17. Monthly gas consumption model

In the 2007 gas consumption model, Kaztransgas-Tbilisi preserves its seasonal consumption pattern. Thermal power plants are not generating energy in summer months and accordingly there is no gas use for electricity generation in summer; the share of gas used for electricity generation is reduced, compared to that of 2006 (Figure 4.18.).

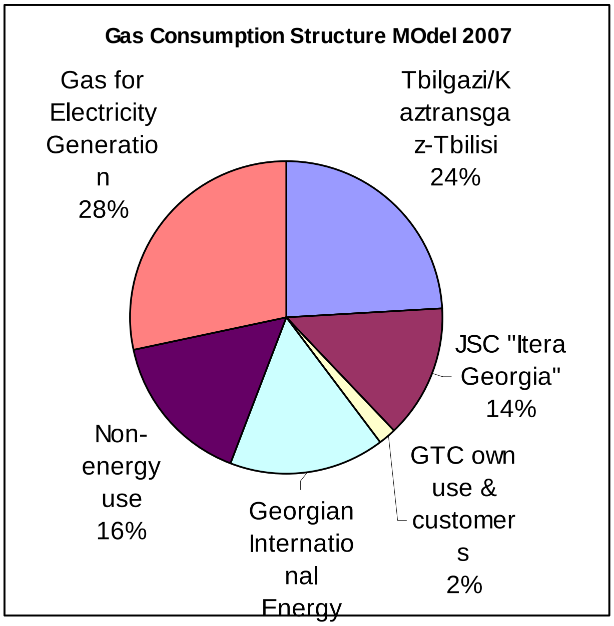


Figure 4.18. Annual Model Gas Consumption

The gas consumption model can be used to evaluate the gas usage for heating with good accuracy. (Cf. Appendix 6) For this purpose we subtract from the annual gas usage curve the gas used for electricity generation and another component (mainly cooking and hot water supply) that remains constant over the whole year (assumed to be equal to June consumption) the remaining variable seasonal component is attributed to gas usage for heating (c.f. Figure 4.19.).

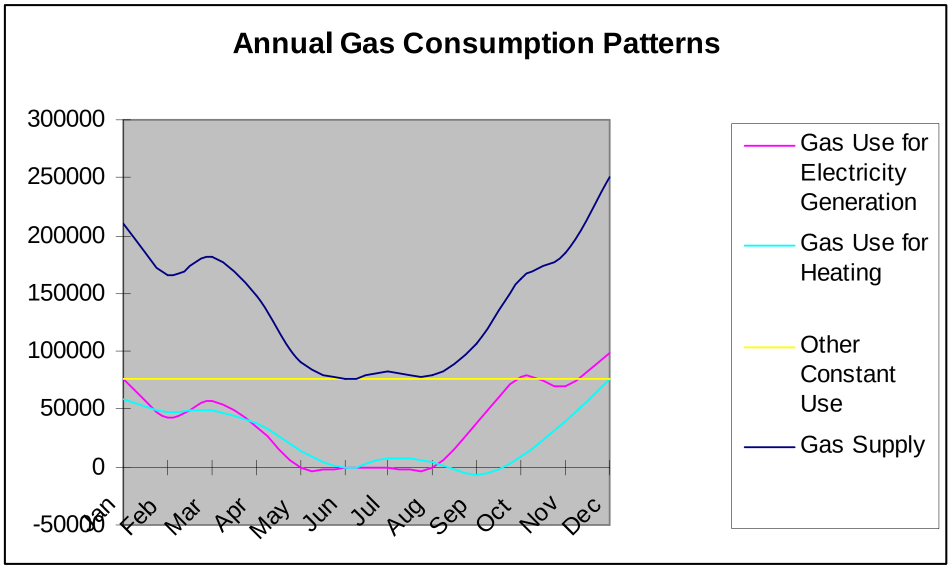


Figure 4.19. Seasonal patterns of gas consumption

With such assumptions we can estimate that gas consumption for heating in all sectors of economy is 290-330 million cubic meters (area under the light blue curve). Accordingly the rough picture of gas end-use is depicted in Figure 4.20.

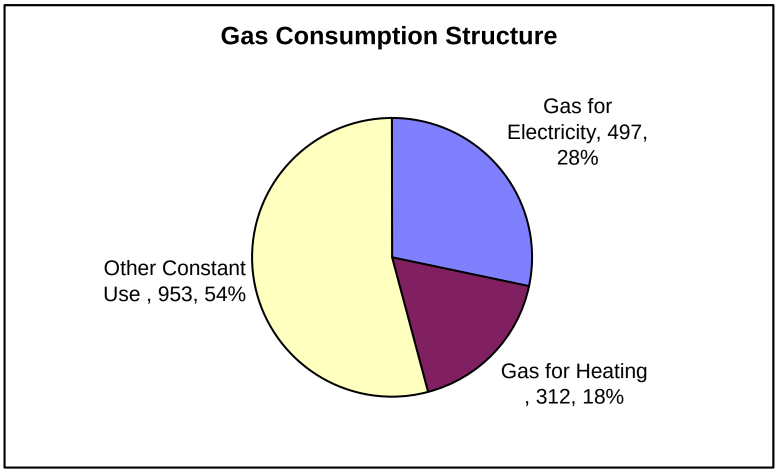


Figure 4.20. Annual gas consumption by end use

Because of significant uncertainty related to different gas suppliers and their prices it is not currently feasible to make any meaningful forecast of the gas supply structure and potential prices. At the time of writing this report it has been announced that the gas price from the Azeri gas supply will increase to the international market level.

4.4. Energy Dependence of Georgia and Model Aggregate Energy Balance

Energy Security can be defined as a short term and long term reliability of energy supply at affordable prices. Such a definition can be applied at the level of individual consumers, consumer groups or at the level of a whole country. Absolute measure of energy security at the country level requires analysis of different long term and short term risks related to technical, market and political factors of external energy supply to the country. These factors of Energy Security are specific to countries and their concrete regional conditions. Rigorous analysis of energy security involving all these factors is a complex task that goes beyond the scope of this study. Instead, we will simply assume that reduction in the amount of imported energy of a particular type correspondingly reduces the energy dependence of the country, and thus by reducing the risks related to that supply, increases energy security.

4.4.1. Model Aggregate Energy Balance

Energy balance is the main instrument for analyzing a country's dependence on external energy imports. In case of Georgia the main factor of energy security is its dependence on fossil fuel imports from neighboring countries (71% of total primary energy supply). Another critical factor of country's energy dependence is the pronounced seasonality of its energy consumption and supply patterns.

To analyze the issues related to country's energy independence we needed an energy balance that would reflect the typical expected consumption patterns in the nearest time. For this purpose we have constructed a model aggregate energy balance of 2007. As input we have used the actual 2006 energy balance, Model 2007 Electricity Balance and Model 2007 Gas Balance and assumed that supply and consumption of other types of energy (except electricity and gas) will remain essentially the same as in 2006. We expect that such an energy balance better reflects the typical expected energy situation in Georgia in the nearest future. A summary of the model balance is presented in the Table 4.4:

Model Energy Balance of Georgia (**kilotons of oil equivalent KTOE**)											
#		**Coal**	**Crude Oil**	**Oil Products**	**Natural Gas**	**Hydraulic Energy**	**Renewable**	**Firewood and waste**	**Electricity**	**Thermal Energy**	**Total**
10	Production	4	64		17	574	14	385			**1058**
11	Import	3		792	1462				23		**2280**
12	Export		-53	-3					**-32**		**-88**
13	Stock Build Up	-1	2	4	-3						**2**
15	Primary Production 15=10+11-12±13	6	13	793	1476	574	14	385	-9.21	0	3252
20	Electricity plants, Boilers			-6	-401	-574			708	32	**-241**
21	Oil refineries		-13	12							**-1**
22	Other transformations and losses			-14	**-346**				-91		**-451**
30	Energy Supply 30=15±20±21-22	6	0	785	677		14	385	600	32	***2499***
40	Industrial Sector 40=41+42+43+44	2	0	92	167	0	0	0	116	12	**389**
41	Metallurgy			3	5				43	3	**54**
42	Chemical production & Petrochemistry			17	27				36	3	**83**
43	Nonmetallic materials			15	18				13	2	**48**
44	Other production	2		57	117				24	4	**204**
50	Transportation 50=51+52+53	3		512	24				52	0	**591**
51	Aviation, marine			24	4				4		**32**
52	Railway and automobile transport	3		448	14				36		**501**
53	Unspecified transport			40	6				12		**58**
60	Other sectors 60=61+62+63+64	1		181	293		14	385	432	20	**1326**
61	Agriculture			64	58		0	20	14	4	**160**
62	Services	1		16	28		6	24	16	16	**107**
63	Households			75	201		8	329	396	0	**1009**
64	Unspecified			26	6		0	12	6	0	**50**
70	Non-energy consumption			0	193			0			**193**

Table 4.4. Model 2007 Energy Balance of Georgia

In the 2007 model balance we are using, the same heating value of 8070 kCal/m^3 is used for deriving the 2006 energy balance. However due to the higher share of Azeri gas in 2007 and its *higher heating value, the average heating value of gas may need to be reconsidered. The amendment can be made after the exact mix of Azeri and Russian gas becomes known.*

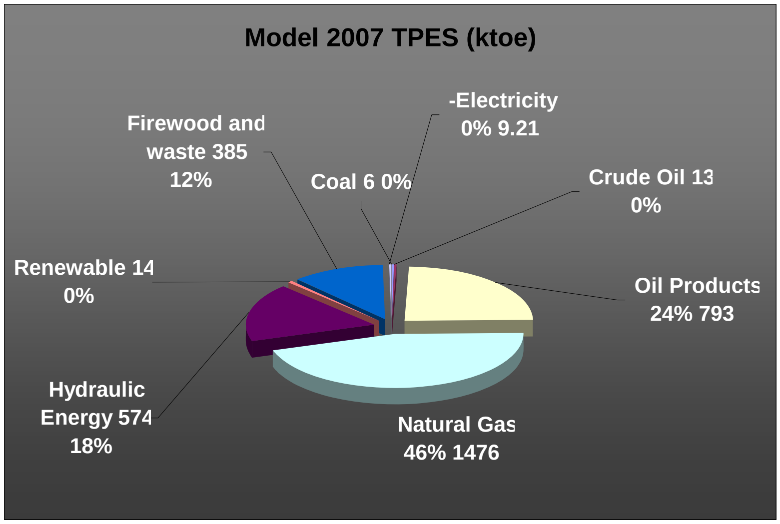


Figure 4.21. Structure of energy supply

The main conclusions from the model Aggregate Energy Balance are almost the same as in case of 2006 balance:

- 69% of the total primary energy supply in country comes from imported resources
- 46% of imported energy is natural gas and 25% oil products
- The biggest indigenous energy resource is hydro energy (18%), followed by firewood (12%)

If we exclude oil products and gas used as feedstock for industry from consideration, the structure of energy supply in Georgia looks as shown in Figure 4.22.

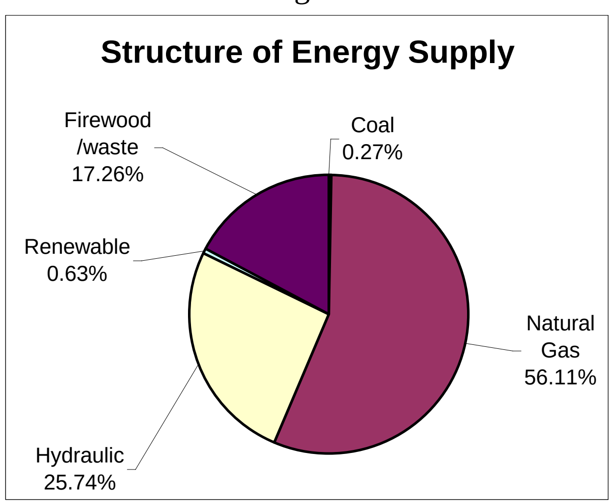


Figure 4.22. Structure of energy supply for energy use in Georgia

It can be seen that 57% of energy needs of households and economy (ex. transportation) is covered by imported natural gas.

4.4.2. Parameters of Energy Dependence

A country's dependence on imported energy resources can be measured by the share of these external resources in total primary energy supply. As can be seen from the aggregate energy balance this parameter for Georgia is about 70%. If we exclude oil products from our consideration and focus only on energy use then 56.7% of energy needs are covered by imported natural gas and the rest by indigenous hydro resources and fire-wood

Energy dependence of Georgia is sharply seasonal decreasing in summer and increasing in the winter season. This increased dependence is aggravated by the fact that in winter months the capacity of suppliers as well as transportation capacities are much more loaded, thus it becomes harder to make up for the interruption of supply from some particular source[7].

Seasonal pattern of energy use in Georgia is given in Figure 4.23. Here we have neglected the energy carriers other than hydro-energy, gas and fire-wood. Indeed, other energy sources currently contribute only a few percents to the total energy use in Georgia.

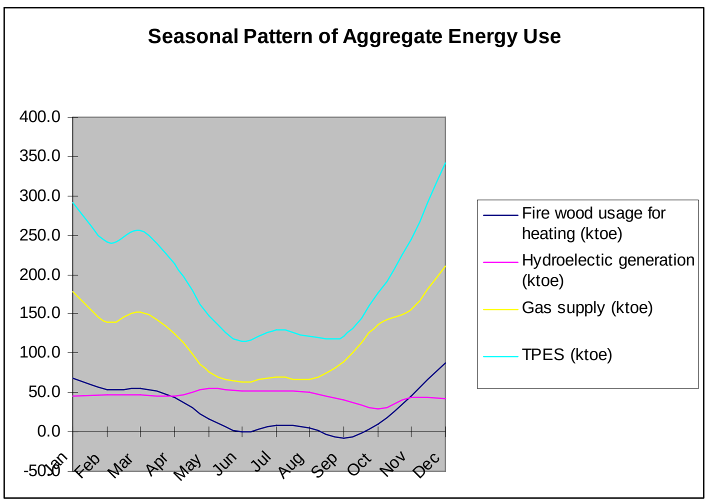


Figure 4.23. Seasonal structure of aggregate energy use

Georgia is energy deficient over the whole year. Although there is a surplus of hydraulic energy in summer months, it still can not replace the gas imported in the same period of year even if fully utilized.

While analyzing the energy security and external dependence issues one needs to take into consideration this seasonality (Cf. Appendix.5). Indeed, interruption of external energy supply will have much more damaging results in winter, when the share of imports is higher, than in summer, when local hydropower generation has more potential. To account for this seasonality, we introduce

[7] In this study we do not consider the issues of system stability and the short term deficit that can be experienced by the power system. This is a task for separate study incorporating loss of load probabilities and other system stability parameters.

the Energy Dependence Seasonal Index (EDSI) equal to the amount of imported energy in each particular month divided by total energy import in the year. While considering any measure for increasing the energy supply or reducing consumption, we have to weigh it with EDSI in order to determine its relative importance compared with other possible measures and the potential input in energy security. The chart for EDSI derived from the above pattern looks as follows:

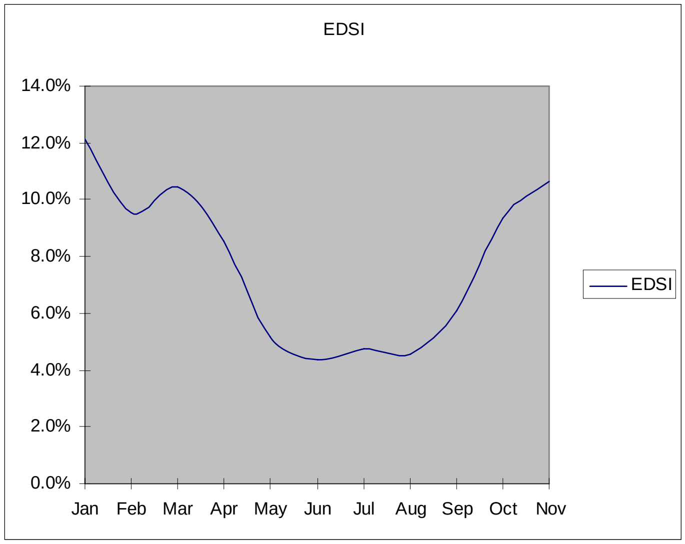


Figure 4.24. Energy dependence seasonal index

One can notice that EDSI shows increased dependence on imports in winter months.

As the carriers of energy, electricity and gas can replace each other in many applications. At the same time, the limitations of existing distribution networks and energy appliances do not allow the use of these energy carriers interchangeably in many cases. Interchangeability would require substantial time and investment. Thus while analyzing the energy security issues we should focus on both these carriers and consider both the electricity and gas balances.

Since there is no significant production of fossil fuels in Georgia, the thermal plants can not directly contribute to the country's energy independence and energy security. What is being achieved by construction of new thermal plants is more capacity in converting the energy of imported fossil fuels into electricity. Operation of thermal plants can add to diversity of supply by allowing import of gas instead of electricity. Thermal plants are necessary for the stability of the power system and in optimizing the production of hydro-plants, however their contribution to energy security is of secondary importance.

For this reason we introduce a separate parameter to characterize the dependence of electricity supply on external imports.

The analog of Energy Dependence Seasonal Index for electricity is ESDIE. ESDIE measures the seasonal dependence on external energy supply for electricity usage and demonstrates a profound seasonal behavior (cf. Figure 4.22).

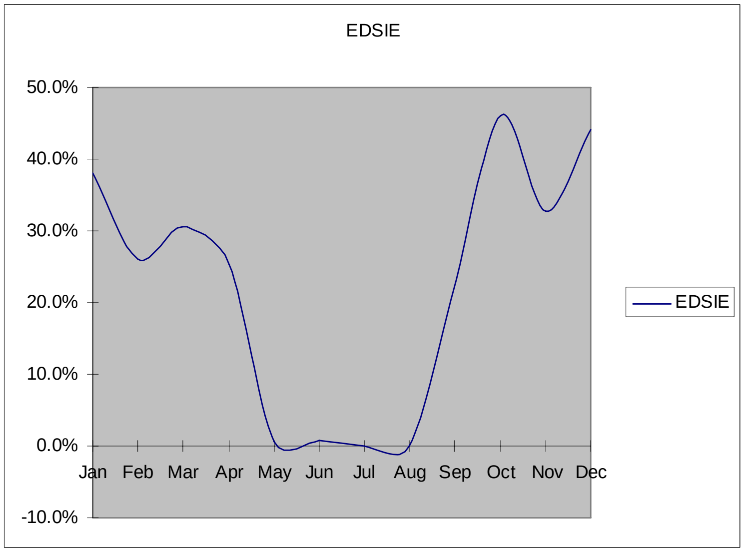


Figure 4.25. Electricity dependence seasonal index

This graph demonstrates the high importance of electricity supply increase or consumption reduction measures in winter months and it also shows that if some measure can give a positive contribution to electricity balance in summer months, its contribution to energy independence will still be zero, unless some additional measures will be taken (e.g., energy swap arrangements or some sort of energy storage) to shift the effect to the period when the country is strongly dependent on external energy supply.

4.5. Consumption by Consumer Categories

Estimate of energy efficiency and Energy saving potential requires detailed information about consumption of various types of energy by different consumer categories. The quality and availability of data in distribution companies does not always allow us to make sufficiently detailed analysis. So in some cases we had to supplement the factual data by expert estimates and our own surveys.

UEDC/Energo-Pro has a more detailed breakdown of consumption by customer categories than Telasi. Consumers are classified into activity categories and their total consumption can be analyzed. However the data are not always reliable and some consumer categories show questionable seasonal behavior. A detailed breakdown of consumption patterns by Energo-Pro consumer categories can be found in Appendix.6. Here we present only the aggregate data at the distribution company level.

Telasi

Telasi classifies its customers into four main categories: Residential, Commercial, Budget and Central Customers. Monthly consumption patterns by these consumer categories is given in Figure 4.26.

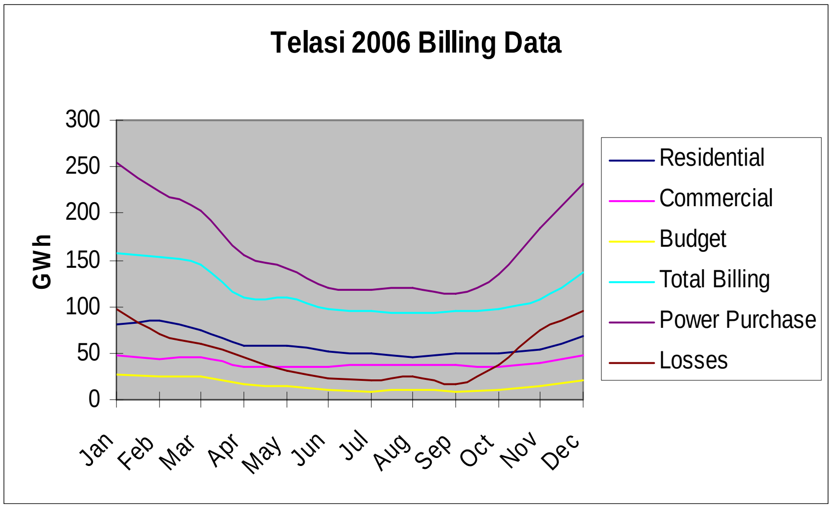


Figure 4.26 Telasi power supply and consumption patterns

Residential consumers represent the biggest consumer class with 37% share in total Telasi annual power purchase (Figure 26) and 53% in billing. The share of losses is still high at 30% and exceeds the allowable annual technical losses (12.4%) by 17.6%. The seasonal pattern of losses follows that of total consumption and approaches its maximum in winter months, when Georgia is most dependent on power imports.

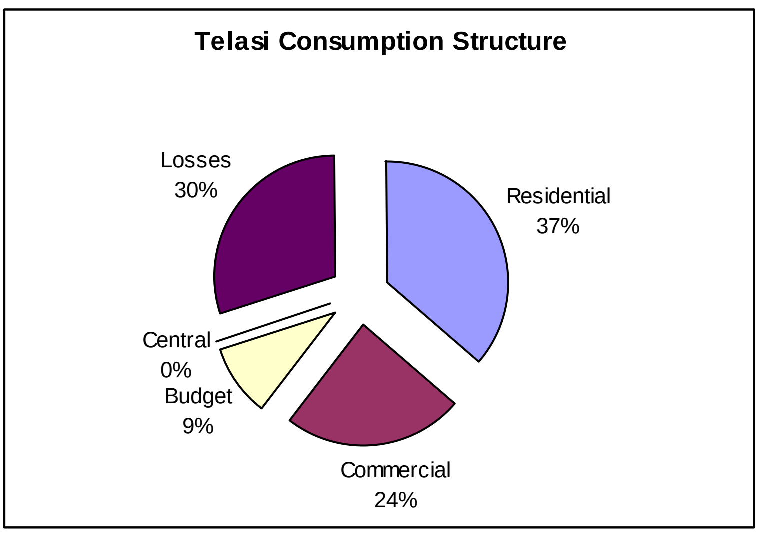


Figure 4.27. Telasi annual consumption structure

The consumption of residential consumers is seasonal and indicates electricity use for heating. More detailed monthly power purchase and consumption patterns of Telasi can be found in Appendix.7.

<u>UEDC/Energo-Pro</u>

The Assets of UEDC – United Electricity Distribution Company of Georgia and Achara Distribution Company of Georgia were acquired by Energo-Pro in June 2007. So the data on 2006 and the beginning of 2007 were acquired from billing systems of these separate distribution companies, while subsequent analysis and forecasts relate to Energo-Pro United data (cf. Appendix4.6.). The Consumption structure of UEDC/Energo-Pro can be seen in Figure 4.28, below.

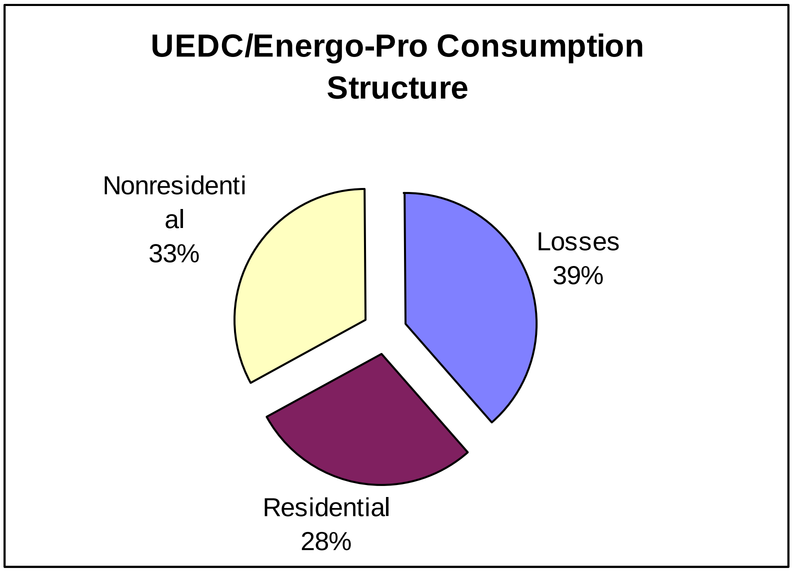


Figure 4.28. Energo-Pro annual consumption structure

Residential consumption in UEDC/Energo-Pro has a smaller share compared to that of Telasi, while the percentage of losses is higher. The higher total losses can be attributed to both higher technical and commercial losses in the Energo-Pro network.

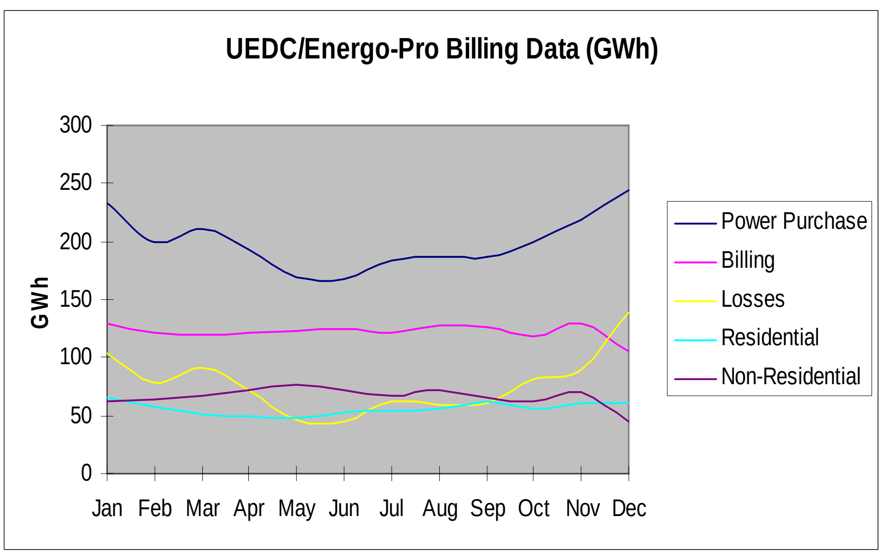


Figure 4.29. Energo-Pro power supply and consumption patterns

UEDC power purchase has a less pronounced seasonal pattern that can be attributed to a lower share of residential consumption, and also is indicative of less use of electricity for heating purposes.

Achara

Achara's billing data was obtained from Energo-Pro Georgia and represents the period before Energo-Pro purchased the Achara distribution company's assets.

Figure 4.30 below shows the seasonal variation of billing in total and by customer categories. The irregularities of the consumption pattern can be attributed to the quality of data obtained from the Achara billing data base (Appendix.8).

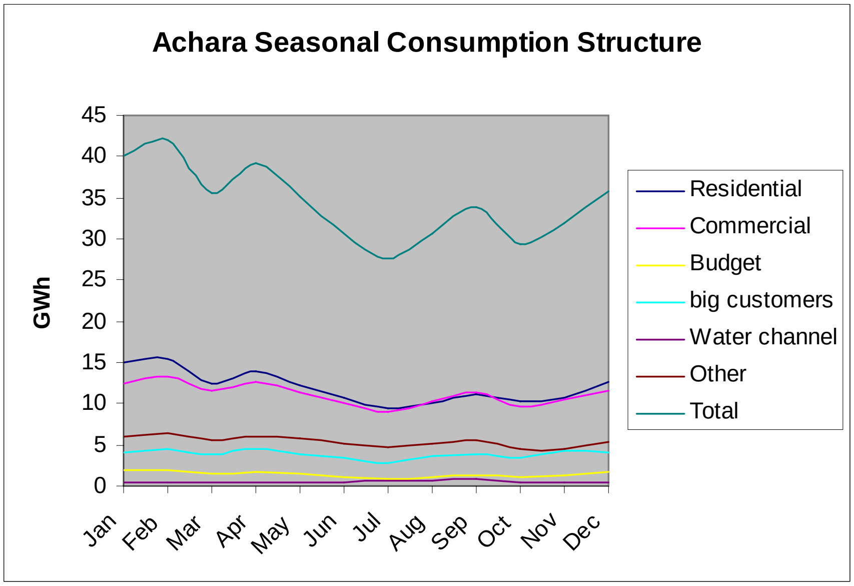


Figure 4.30. Achara power supply and consumption patterns

The chart in Figure 4.28 shows the annual consumption structure of Achara Distribution Company by customer categories.

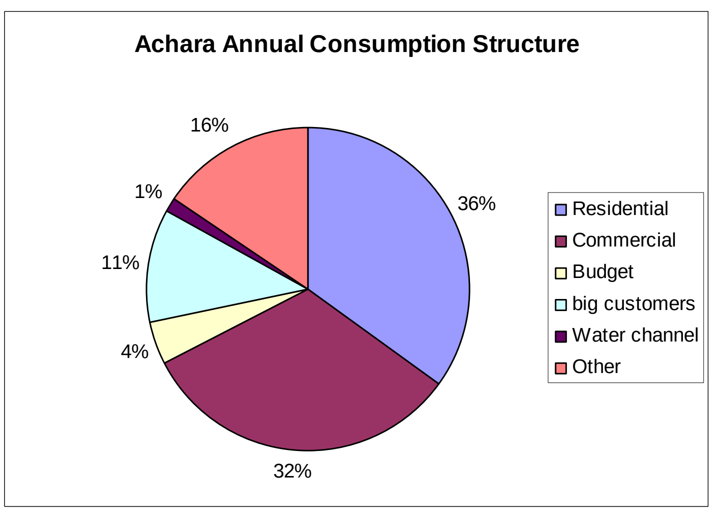


Figure 4.31. Achara annual electricity consumption structure

Kakheti

Kakheti represents a small percentage of consumption compared with other distribution companies.

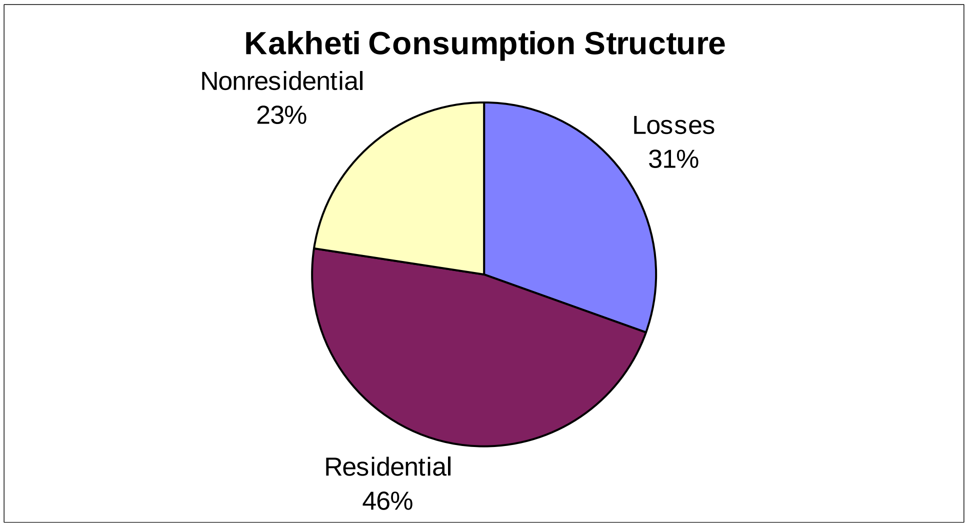


Figure 4.32. Kakheti annual electricity consumption structure

At the time of writing this report the data from Kakheti distribution company had not been obtained. So we have reconstructed the seasonal behavior based on UEDC consumption patterns and used Kakheti information on the May 2006 consumption structure (Appendix.9.)

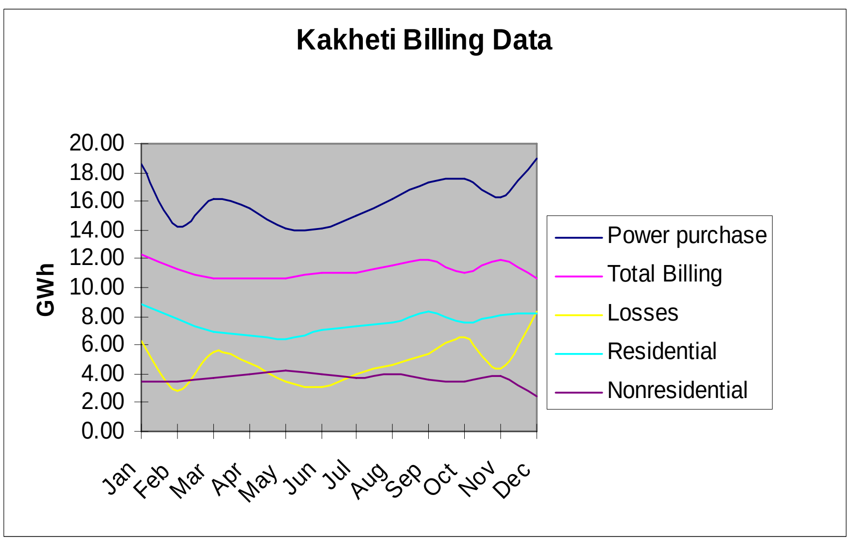


Figure 4.33. Kakheti power supply and consumption patterns (reconstruction)

The consumption of residential consumers is less seasonal than in the case of Telasi and indicates reduced use of electricity for heating.

<u>Commercial Losses in Electricity Distribution Companies</u>

Table 4.5 summarizes the level of technical and commercial losses in electricity distribution companies.

	Power Purchase	Technical Losses	Billing	Comm. losses	Comm. losses %
Telasi	1,955.4	242.5	1,398.8	314.1	16.1%
Energo-Pro	2,394.0	358.4	1,468.1	567.5	23.7%

Table 4.5. Commercial losses in distribution companies (GWh)

The figures for commercial losses (electricity theft) have been derived by subtracting the official allowances for technical losses approved by GNERC from the power purchase.[8] The remaining figures of losses, the level of theft in these distribution companies with fair accuracy. The figures also represent the potential for savings by reducing this theft. According to expert estimates, these losses could be cut into half within two years, using cost-effective measures.

Gas Consumption in Tbilisi

Tbilisi gas consumption information was obtained from "Kaztransgas-Tbilisi" (Cf. Appendix.10). The data shows a great share of losses, up to 42%, which is almost equal to the total billing of residential customers. Billing of nonresidential customers amounts to only 14% of total gas supply to Tbilisi.

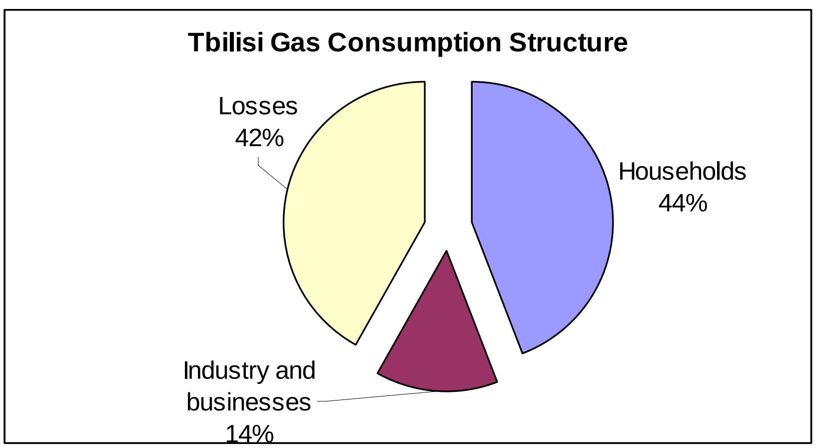


Figure 4.34. Kaztransgas-Tbilisi annual consumption structure

The annual gas consumption chart shows a sharp seasonal variation of consumption. Maximum gas consumption in December differs from the August minimum by almost 7 times. The high percentage of losses can be attributed mostly to commercial loss (theft) of gas and indicates a

[8] GNERC Resolution #17, of May 11 2006.

significant potential for saving, since usually non-paid consumption exceeds paid demand several times.

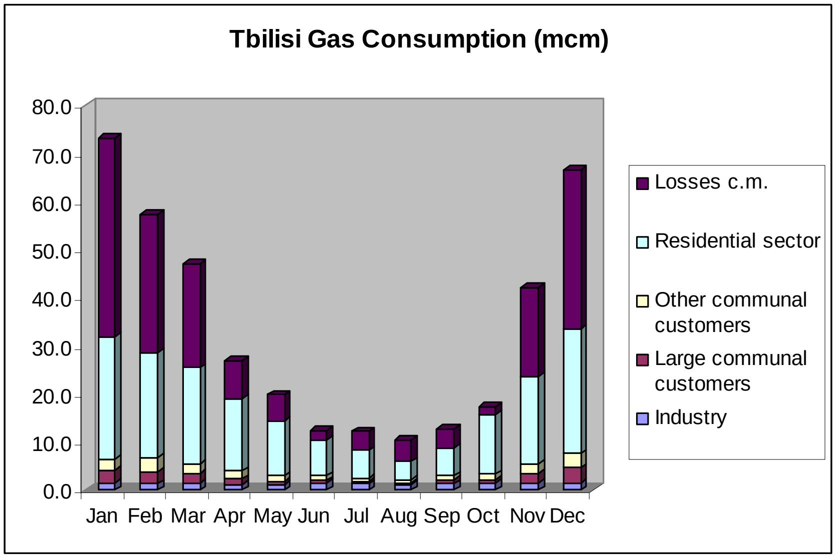


Figure 4.35. Kaztransgas-Tbilisi gas supply and consumption pattern (million m^3)

The seasonal difference in gas supply and consumption is much sharper than that in electricity. This reflects the use of a great portion of gas for heating and indicates the need of a closer study of the possibilities of gas saving by reducing the heating load.

Other Gas Distribution Companies

There are a great number of gas distribution companies in the cities and regions of Georgia, mostly owned by Itera-Georgia. It was not possible to get information about consumption by customer categories from all these small distribution companies. So because of this shortage of information we will assume the same structure of consumption as in Tbilisi.

Chapter 5
Renewable Energy Potential in Georgia

There have been a number of studies and additional research performed to make accurate estimates of renewable energy potential in Georgia. The methodology and criteria of these studies have been diverse. For consistency and for the sake of comparison the following definitions will be used.

- Theoretical potential – is an estimate of total physical potential energy of certain renewable energy resource available annually in nature.
- Technical potential – is an estimate of usable part of that theoretical potential based on current state of the art technologies
- Achievable Potential – reasonably achievable within institutional and physical limitations (terrain, ownership, other use of the same resource, roads, etc,). This is a benchmark that current state of RES utilization should be compared to. The achievable potential can be considered as potential energy reserve for energy security reasons.
- Economic potential – total energy that can be potentially obtained annually through cost effective measures at current or projected market conditions, cost of technology and other economic factors. The economic rather than financial cost, and cost effectiveness for the society rather than individual developer is understood here.

The task of policymakers is to create the favorable conditions by making economic potential cost effective for developers. In some particular cases the energy security reasons can justify implementing of the measures that would otherwise by uneconomical.

5.1. Small Hydro Power Plant Potential

5.1.1. Introduction

The construction of small hydropower plants (SHPP), as well as utilization of other renewable sources, has been prioritized worldwide, both by developed countries and by international financial institutions. Through their initiatives and support, developing and transitional economy countries, including Georgia, have started to actively develop in this direction.

Generally, interest in renewable energy sources (RES) is determined by a few factors including:

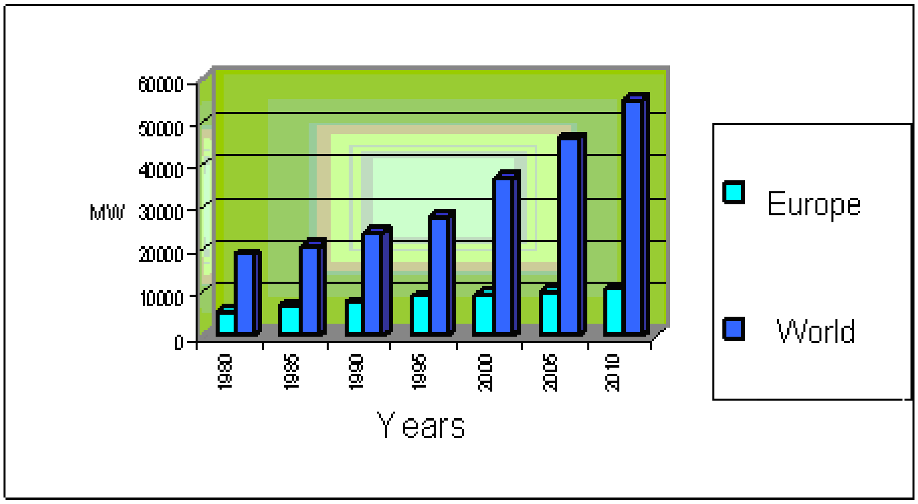
- reduction of fossil hydrocarbon reserves,
- drastic price escalation for fossil fuel energy carriers,
- growth of demand on energy carriers, and
- negative environmental impact of producing and utilizing almost all types of energy.

With the exception of wind energy development, the utilization of most renewable energy resources and the construction of SHPPs are primarily focused on satisfying local energy needs; that is energy for separate buildings, settlements, enterprises etc. However, after development of respective technologies, they may significantly contribute to issues such as:

- increasing the level of energy independence and energy security,
- development of a country’s economy,

- improvement of living conditions, and
- improvement of environmental conditions.

For these reasons, in 1997 the EU countries set a goal of raising their share of renewable energies of total energy consumption to 12% by 2010.[1] As for SHPPs, the total installed capacity of SHPPs in EU countries are to increase by 17%, compared with 2005, expanding to 12 GW in 2010. The anticipated growth worldwide will be from 20% and 46 thousand MW up to 55 thousand MW (Cf. Figure 5.1).



	1980	1985	1990	1995	2000	2005	2010
MW (EU)	5900	6700	7700	9000	9600	10300	12000
MW (World)	19000	21000	24000	27900	37000	46000	55000

Figure 5.1. Development of SHPP capacity worldwide and in Europe
Source: www.ESHA.be

5.1.2. Classification of Small Hydropower Plants

The classification of SHPPs (i.e., small, micro, pico, etc.) depends on the structure of hydro energy potential of the country and the policies for its development. Hence the definition varies per country (Cf. Table 5.1).

[1] EU White Paper for Renewable Energy 1997

Country	micro	mini	small
	Capacity KW		
Sweden			1500
Asian countries			15000
Latin America	100	100-1000	1000-10000
Russia, China, USA			25000
Georgia	1-100	100-1000	1000 - 10000

Table 5.1. Classification of SHPPs in different countries
Source: www.ESHA.be

By convention and taking into account the local conditions, SHPPs in Georgia may be classified into three groups:

Micro hydropower plants (HPPs) (1-100 kW) are those whose appliances can be found in retail shops and who install the equipment as a part of service. The cost of construction and installation work is relatively low and does not exceed 40% of the total cost of the station.

Mini HPPs (100-1000 kW) are those whose construction is also possible in a short time and at a relatively low cost. The value of construction and installation work comprises approximately 50% of the total cost. The time needed for design and permits for such stations is equivalent to the time spent undertaking the construction and installation.

Small HPPs (1000-10 000 kW) are those whose construction processes are almost identical to those of medium HPPs. Therefore, the cost of these civil engineering works is comparatively high. Also, more time is required to agree upon the design with the relevant authorities and to conduct the construction and installation works.

5.1.3. Georgia's Small Hydro Power Plant Sector Today

Construction of SHPPs in Georgia dates back to more than 100 years. The first HPP (Borjomi HPP) was built in 1898. The rapid construction of small HPPs began from 1922, after approval of the "GOELRO" plan, which aimed at full electrification of the Soviet Union. This trend was observed until the 1960s, when construction of more powerful HPPs was undertaken. In this period, up to 400 SHPPs were constructed in Georgia (Figure 5.2.) out of which only 25 are operating presently.

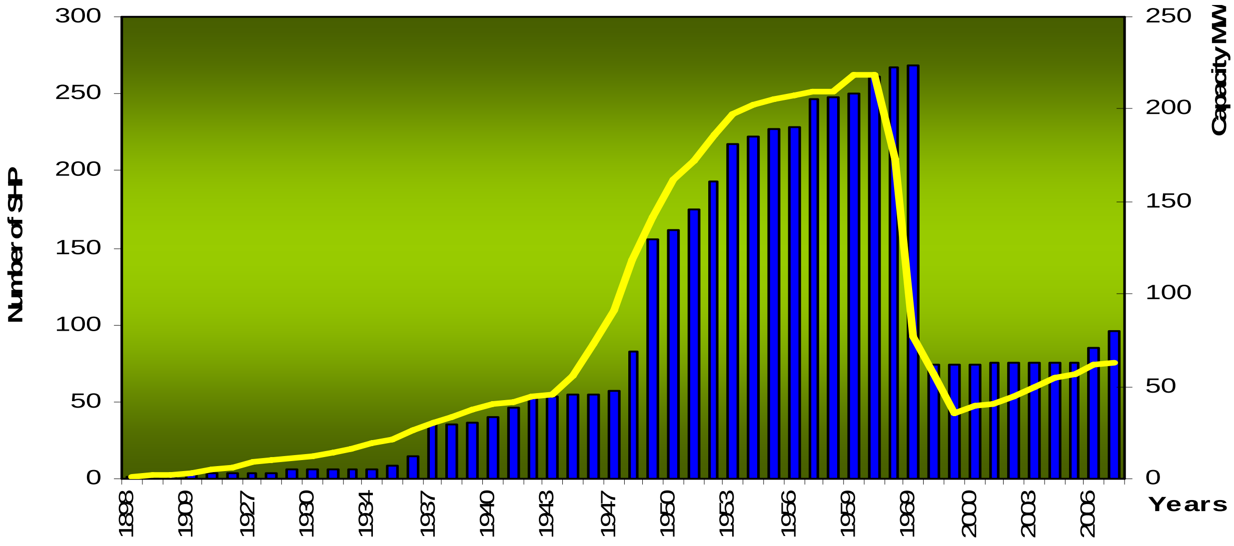


Figure 5.2. Dynamics of SHPP construction and operation in Georgia

Currently there are 33 small HPPs in Georgia (Table 5.2), and their total capacity is 85 MW, in the balance year 2006-2007 their electricity generation comprised 295 million kWh.

	Name	Capacity mw	Generation, mln kWh	Tariff, tetri/kWh
1	**Bjuja HPP**	12.240/9.0	63.0/50.0	1.89
2	**Kabali HPP**	1.5	10.0/10.0	2.5
3	**Satskhenisi HPP**	14.0/10.0	61/50.0	2.33
4	**Alazani HPP**	4.8	20/20.0	2.33
5	**Martkophi HPP**	3.870	15.0/6.0	2.5
6	**Sioni HPP**	9.140	38.0/24.4	2.33
7	**Machakhela HPP**	1.430	12.5/10.0	2.5
8	**Sanalia HPP**	3.0	13.0/12.0	2.5
9	**Tiripfoni HPP**	3.0	14.0/5.0	2.5
10	**Anglo-Meskheti**	2.080	18.2/12.0	2.5
11	**Misakcieli HPP**	2.780	13.0/5.0	2.5
12	**Chkhori HPP**	5.35	25.0/15.0	2.5
13	**Ritseula HPP**	6.0	36.0/22.0	2.5
14	**Chala HPP**	1.5	2.0	5.0
15	**Dashbashi HPP**	1.260	9.0/5.0	2.5
16	**Igoeti HPP**	1.765	11.0/4.0	2.5
17	**Ab HPP-electro**	1.754	11.0/7.0	2.5
18	**Energetik**	0.494	0.8	5.0
19	**Squri HPP**	1.028	5.3/5.0	2.5
20	**Kinkisha HPP**	0.74	4.0/3.0	2.5
21	**Rustavi HPP**	0.51	2.0	4.33
22	**Kekhvi HPP**	0.98	5.0/5.0	2.5
23	**Kazbegi HPP**	0.28	1.6/1.6	2.5
24	**Intsoba HPP**	1.75	7.1	5.0
25	**Mashavera HPP**	0.9	1.7	4.17
26	**MOS-99 /**	0.465	1.4	5.0

27	**Zvareti HPP**	0.3	2.0	2.5
28	**Achi HPP**	1.028	2.2	2.5
29	**G. TaraSvili**	0.45	0.6	5.0
30	**Khertvisi HPP**	0.294	2.0	2.5
31	**Meqvena HPP**	0.12	0.8	2.5
32	**Goresha HPP**	0.125	0.26	4.076
33	**Suramula HPP**	0.1	0.5	5.0
	Total	**85.063**	**409 Projected** **295 Actual**	

Table 5.2 SHPPs operating in Georgia*

The share of SHPPs in total hydro capacity is 3.1%, while generation amounts to 5.35% of total hydro output. In the annual electricity balance (including thermal plants) the SHPPs contribute 1.9% in capacity and 3.8% in output (Cf. Figure 5.3). This shows that although the contribution of SHPPs is small, their plant factor is about double of that for the rest of the power system.

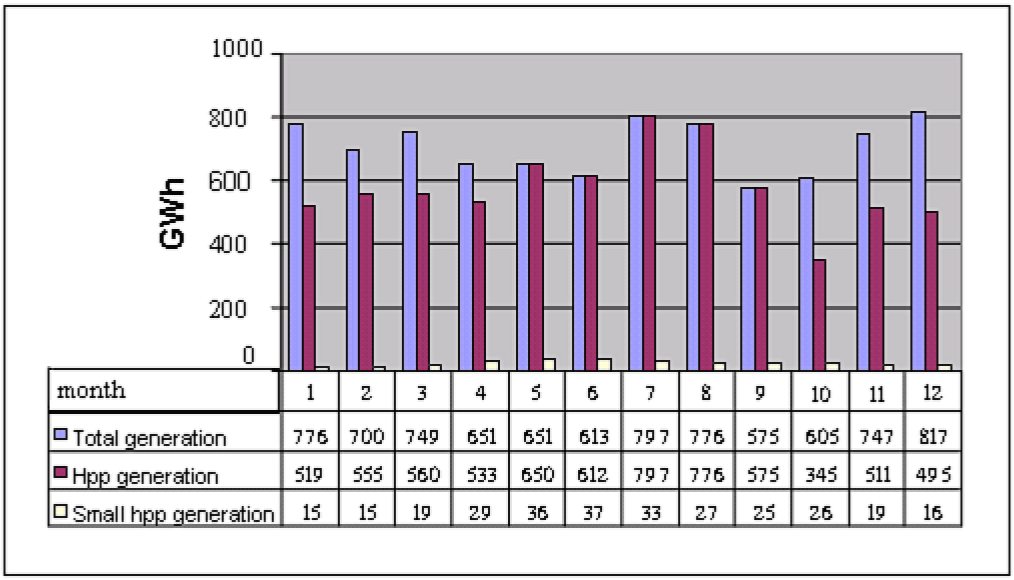


Figure 5.3. Contribution of SHPPs in annual electricity generation in 2006

The seasonal generation pattern of SHPPs is provided in Figure 5.4, which shows that the bulk of SHPP generation falls during the spring and summer months, i.e. in the period when the generating capacity of medium and large HPPs significantly exceeds the demand in Georgia. This imbalance has resulted in the unproductive spill of water at HPPs over a number of years (as per expert estimation, the water equivalent to 600-800 GWh was spilled annually). The exception was in spring and summer of 2007, when the Georgian electricity system managed to export more than 500 GWhs of electric energy to neighboring states.

* This list includes also those HPPs whose designed installed capacity is above 10 MW, however the current actual capacity is less than 10 MW.

The peculiarity of Georgia's energy balance is mainly caused by the designed and actual operation regimes of HPPs; Georgia's HPPs were designed for peaking operation in the united energy system of the USSR and not for meeting Georgia's national energy demands.

This is a serious problem, which generally hinders the development of energy generation in Georgia. Currently the Georgian economy can not consume the electricity generated by existing HPPs in the spring-summer season, to say nothing about generation from new prospective small or big HPPs. Therefore facilitation of exports should be viewed as a crucial factor for stimulating the construction of SHPPs.

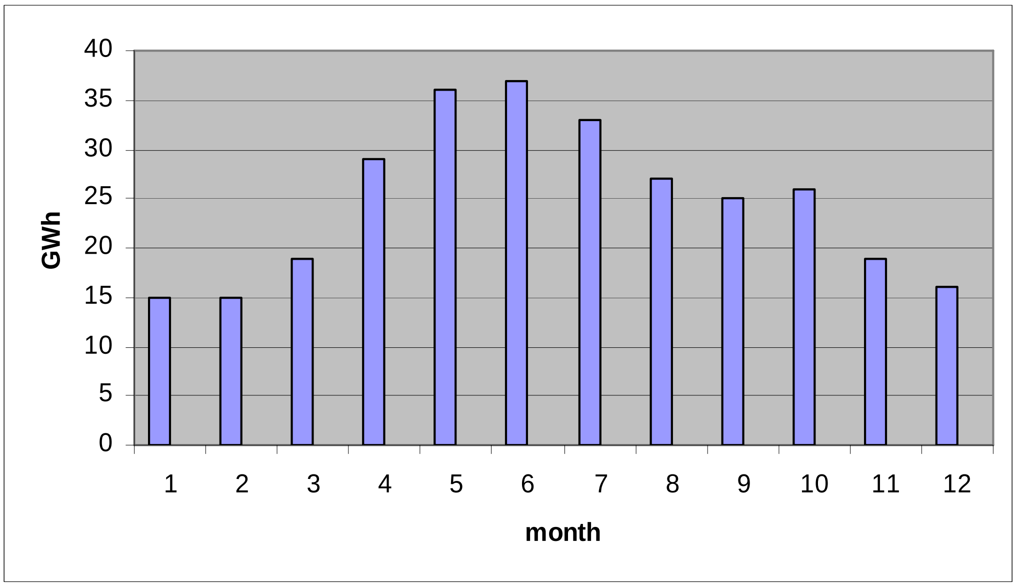


Figure 5.4. Monthly Generation of SHPPs in Georgia.

5.1.4. Hydro energy potential of SHPP

5.1.4.1. Technical Hydro Energy Potential of SHPPs

In Georgia there are 360 rivers with considerable energy potential. The total theoretical hydro energy potential, per estimations of various authors[2,3,4], comprises 136.9 - 159.4 TWh per annum. Technical available potential has been estimated at 81-90 TWh per annum. Included in this, is the total theoretical hydro-energy potential of SHPPs of 40 TWh/year and technical potential estimated at 19.5 TWh per annum.[5]

[2] Renewable energy sources of Georgia Svanidze G. G., Gagua V P, Sukhiashvili E. V. 1987
[3]Use of non-traditional sources in Georgian energy. Tchogovadze G.I, Khatchaturian R.A 1989
[4] Energy resources of Georgia and problem of their rational using A.A..Dzidziguri 1992
[5]Cadastre of SHPP Technical Potential of the Georgian Rivers. Solomonia O,. Dadiani M,. Tsabadze N., 2006

Technical Small Hydro Energy Potential is defined as the total potential energy of small rivers that can be in principle utilized, based on the current state of energy generation and construction technologies. The following assumptions are made while assessing this potential.[5]

- Only elevations below 2500 m above sea level are considered.
- HPP design starts at the cross section of river, where average annual water discharge exceeds 0,2 m^3/sec.
- The length of the river section to be used for energy generation purposes should not exceed 6-7 km, with maximal drop of – 500 m.
- Above the 1000 m benchmark, the penstocks are used in design, while at the lower elevations the design includes open derivation channel. and
- The length of the river section corresponds to the length of derivation.

The distribution of technical SHPP energy potential in Georgian regions is shown in Table 5.3. According to this table, the total technical hydro energy potential of SHPP comprises 19.5 TWh, out of which 70% (13.7 TWh) falls in west Georgia. It should be noted that about 30% (4.4 TWh) of technical small hydro energy potential of west Georgia is located in Abkhazia; this is more than 22% of the country's entire technical small hydro energy potential.

	Region name	**Number of Rivers**	**Total Capacity (Thd.KW)**	**Potential Annual Output (GWh)**		
				spring - summer	fall - winter	total
1	Abkhazia	64	752	2248	2126	4374
2	Achara	25	244	794	631	1425
3	Samegrelo Svaneti	36	450	1311	935	2246
4	Guria	9	174	610	518	1128
5	Racha-Lechkhumi	28	444	1743	729	2472
6	Imereti	42	677	1169	867	2036
	Total West Georgia	**204**	**2741**	**7875**	**5806**	**13681**
7	Kakheti	41	416	1456	974	2430
8	Kvemo Kartli	21	40	151	90	241
9	Mtskheta-Tianeti	38	270	1084	529	1613
10	Shida Kartli	26	146	521	314	8345
11	Samtskhe-Javakheti	26	117	389	282	671
	Total East Georgia	**152**	**989**	**3601**	**2189**	**5790**
	Total Georgia	**356**	**3 730**	**11476**	**7995**	**19471**

Table 5.3. Small hydro energy potential by regions and seasons.[5]

Technical hydro energy potential of SHPP is characterized by profound seasonality (Cf. Figure 5.5). The period of maximum generation falls during the spring and summer seasons, which goes underutilized due to lack of demand. Looking ahead, as Georgia economically develops and consumers embrace air conditioning systems, power consumption in the summer season should increase, which will facilitate development of small energy; however, at this stage, facilitating electricity export and off-grid local development are keys to hydro power expansion in Georgia. .

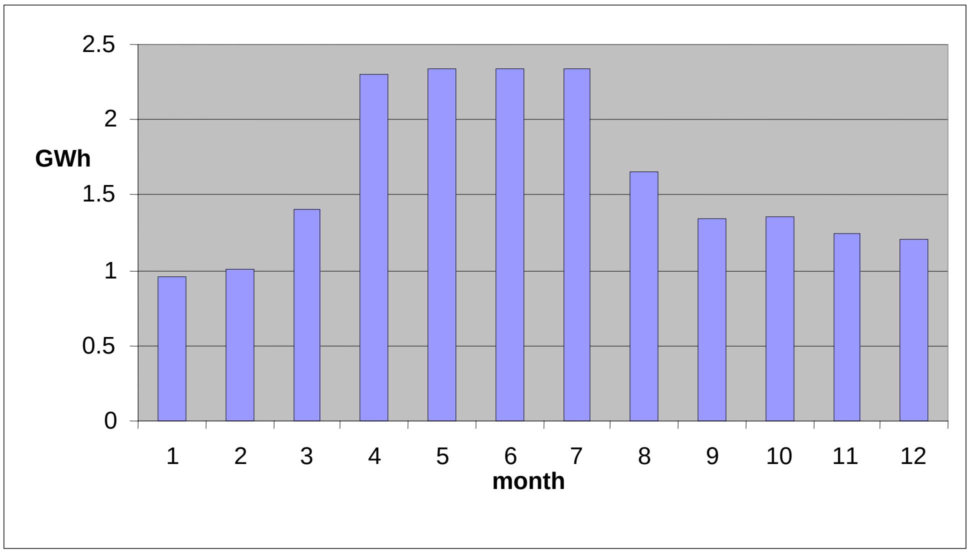


Figure 5.5. Technical Potential of SHPP by Months

5.1.4.2. Economic hydro energy potential of SHPPs

Appropriately defining economically-justifiable hydro energy potential of SHPP is a complex task and depends on many legal, technical and economic factors, such as:

- The legal base defining the market structure,
  - energy supply and demand,
  - prospects of economic development and growth in demand (especially energy intensive sectors),
  - quality of life and solvency of the population,
  - climatic conditions of the country,
  - environmental issues,
  - the level of development of the construction industry,
  - existing tariffs and energy generation costs (including thermal generation),
  - the state of development of transmission and distribution network and gas supply transmission and distribution systems, and
  - the possibility of energy exports to neighboring countries.

In the Soviet Period the economically justified potential of SHPP was estimated at 3-7 billion kW, however this estimate has questionable relevance to the current situation. The SHPP economical potential for each particular case should be done individually based on economic parameters of a particular project.

5.1.5. Economic Parameters of SHPPs

5.1.5.1. Construction Costs

Economic parameters of SHPPs depend on capital costs, duration of construction, operational costs, cost of financing etc. The cost of 1 kW installed capacity worldwide varies in the range of USD 800-2000 depending on the type, capacity and geographical location of the plant.[6]

The capital cost is determined by three main factors – cost of generation equipment, civil construction cost and grid connection cost. This can be roughly broken down as follows: design, construction-installation works – 30-40% of total cost of HPP, generation units – 40-50%, grid connection – 10 - 15%. The same breakdown can be applied to mini HPPs. As for the micro HPPs, the design and construction-installation costs are minimal (10% of the total value); however the cost of equipment is higher and amounts to 500-2000 USD.

An estimate of SHPP construction costs is provided in Table 5..4 below.

	Micro HPP	Mini HPP	Small HPP
Design, permits, agreements		5%	5%
Generation units	80%	50%	40%
construction- installation works	10%	30%	40%
startup and grid connection	10%	15%	15%
Total	100%	100%	100%

Table 5.4. Breakdown of capital costs for SHPP, mini and micro HPPs.

Taking into account the conditions of Georgia, and first of all tariffs established at electricity market, the small HPP whose 1kW installed capacity cost does not exceed USD 1200 can be deemed as economically feasible. In such case, for 10 year time horizon and 15-20% return on investment, the cost of generated power will be 9 tetri/kv/hr (USD 1=GEL1.6) which corresponds to the most expensive electricity at Georgian market.

[6] WB Renewable Energy Toolkit http://web.worldbank.org/WBSITE/EXTERNAL/TOPICS /EXTENERGY/EXTRETOOLKIT/0,,contentMDK:20794260~menuPK:2069844~pagePK:64168445~piPK:64168309~theSitePK:1040428,00.html

The above values refer to grid connected SHPPs. The capital cost of off-grid SHPPs working for one or several consumers, increases by approximately 20% at the expense of additional frequency regulator.

Stages and estimated durations of SHPP construction are shown in Table 5.5.

	Micro HPP	**Mini HPP**	**Small HPP**
Design, permits, agreements	4-5 months	4-6 month	6-10 month
Construction and installation	3-4 months	5-6 month	6-12 month
Startup-commissioning	up to 1 month	1-2 month	1-2 month
Grid connection works carried out in parallel with construction and installation	3-4 months	5-6 month	6-12 month
Total	**7-10 month**	**10-14 month**	**13-24 month**

Table 5.5. Stages and periods of SHPP construction.

As can be seen from above, substantial time is required for design, permits and agreements, which indicates the necessity of improvements in legislation and regulations.

5.1.5.2. Operation Costs and Taxes

Operation costs of SHPP which are included in the tariff by GNERC are:

- maintenance, 5-10% of the tariff
- consumable materials for operation 5-10%
- salaries 10-20%.

Taxes are:

- property tax 1%
- profit tax 20%
- tax for using water (per various river basins)
- VAT 18%
- social taxes 20% (to be cancelled from January 1, 2008).

5.1.6. Institutional Environment and Barriers to SHPP development

Construction and operation of SHPP are regulated by the following normative acts in Georgia:

- Law on Electricity and Natural Gas
- Electricity Market Rules
- Normative acts of the Ministry of Energy

- Normative acts of GNERC
- Main Directions of Energy Policy of Georgia.

These documents provide the following privileges to SHPPs:

- No requirement for power generation license
- Tariff is not fixed (deregulation)
- Possibility to sell electricity through direct contracts to any customers
- No need for electricity export license.
- ESCO is obliged to purchase all of the electricity not sold through direct contracts.

On the one hand, the given privileges should be stimulating the development of SHPPs; however, they appear as impediments to a certain extent, especially compared to previous arrangements when there was an obligation for distribution companies to purchase the output of SHPPs.

The difficulties of SHPPs are caused by several factors listed below.

- SHPPs (especially newly built ones) are not competitive with large and medium capacity power plants in the cost of generation.
- SHPPs have profound seasonality and dependence on river runoff conditions.
- They have an unfavorable annual generation profile, with maximum production in summer when power generation exceeds the consumption demand;
- SHPPs have undefined power wheeling tariffs;
- Transmission and distribution network connection fees are also not defined.

In order to promote the development of SHPPs the following measures should be implemented.

- Power purchase agreements with new SHPPs should be made at favorable feed-in tariffs and for an extended period of time (10 years).
- ESCO should be obliged to purchase the output of SHPPs with further obligation to engage in long-term export arrangements for summer power surplus;
- Provide tax benefits, including VAT exemption, for equipment import, construction works, etc, and further corporate tax benefits.
- Georgia should dvelop state programs supporting new SHPPs.
- Include concrete measures for SHPP support into the Main Directions of State Energy Policy.
- Simplify procedures with local authorities (i.e. land allocation, permits, local power purchase agreements (PPAs)).

5.2. Development of Wind Energy in Georgia

5.2.1. Introduction

Mankind has been using wind energy for over two millennia, but an interest in wind energy waned during the start of the industrial-scale production of fossil fuel in the nineteenth century. An interest in wind energy was rekindled during the western energy crisis of the 1970s, and while the crisis has been resolved, the need for diverse and cleaner energy sources has remained. This is caused by a decrease of fuel resources, a rapid increase of their cost, and the ecological problems caused by their excessive use.

Wind energy is the solar energy transferred into the kinetic energy of an air stream. It is renewable and unlimited in contrast to fossil fuel. The theoretic potential of wind energy in the entire world exceeds the hydro potential approximately 10 times. Wind energy is not concentrated in a certain region of the world; it is spread much more equally. Wind energy practically does not pollute atmosphere by greenhouse gases and therefore, does not raise problems of global warming. Utilization of wind energy decreases the dependence of many countries on imported fuel, consequently, decreases their dependence on the fossil fuel exporting countries, and significantly increases their energy supply security.

5.2.2. Development of Wind Energy in the World

Development of the wind energy has a high importance in well-developed industrial countries as well as in developing countries. The capacity of wind energy generation has increased four times in the last six years and has achieved 70000 MW. Along with highly developed countries like Germany, Spain, Denmark, USA, wind power plants have been constructed in the countries like Egypt, Lithuania, and Armenia.

Germany, which is the leader in wind energy utilization, will generate 20% of the whole generation on wind power plants till 2020. Spain plans to increase wind power plants' capacity to 20 000 MW by 2011. China is planning to increase the capacity of wind power plants to 30 000 MW for 2011. India will accomplish wind power plants' capacity to 12 000 MW till 2012. Egypt is planning to build the new wind power plants with a total capacity of 850 MW.[7] Ukraine plans to build 300 MW capacity wind power plant in the Crimea peninsula. The first 2.5 MW pilot wind power plant has been constructed in Armenia. Armenia plans to construct additional 60 MW capacity plants in the future.

The cost of electricity generated by wind power plants has already become competitive with the energy generated by traditional power plants. For example, an initial cost of the energy generated by wind power plants in USA, varies between 2.6 and 5 cent/kWh (depending on wind speed and availability), while the cost of electricity generated by coal power plants is about of 3.5-6 cent/kWh.

[7] "Global Wind Energy Council (GWEC) statistics" 2007

A further decrease of wind energy generation cost is predicted in the future. Capacities of wind power plants in different countries of the world are represented in Figure 5.6.

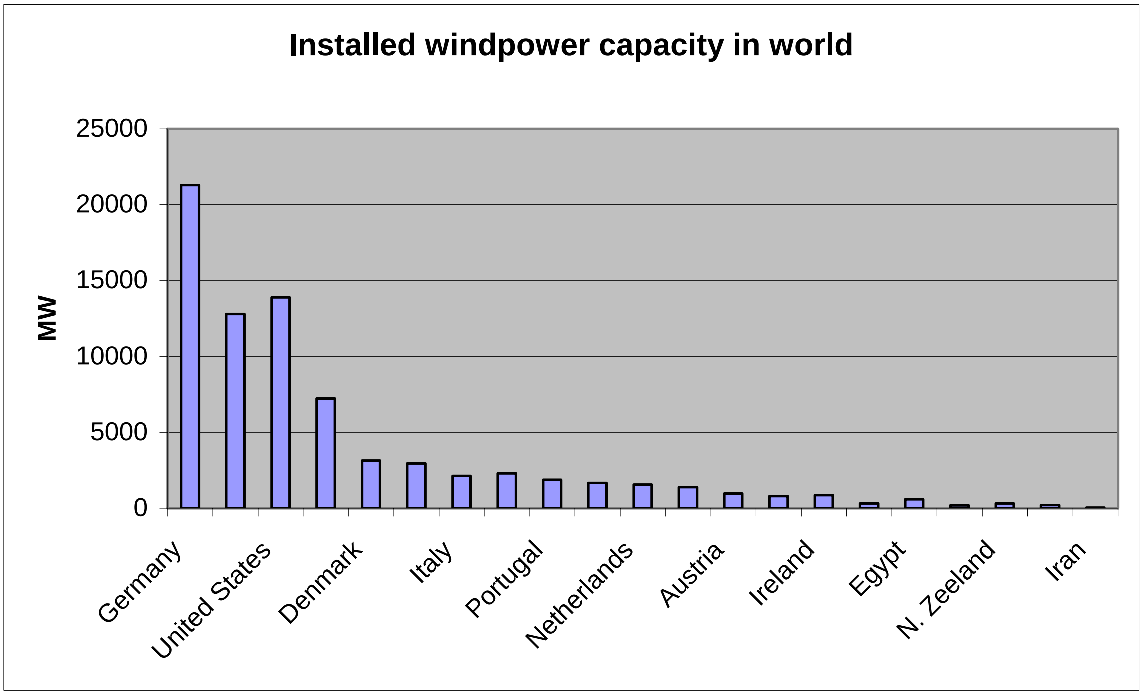


Figure 5.6. 2007 statistics of wind power development in selected countries[8]

The territory of wind farms can be used for other purposes including agriculture. Wind farms may cover big territory, but the land actually occupied by wind turbines is no more than 1.5% of the total surface area.

Figure 5.7. Agricultural use of wind farm territory; Source Karenergo Scientific Wind Energy Center

[8] "European Wind Energy Association (EWEA) statistics 2007"

5.2.3. Wind Energy Potential in Georgia

Assessment of the wind power potential and compilation of the wind cadastre is the main necessary task that goes before the practical utilization of wind energy potential. Energy generated by the wind power plant is proportional to the cube of air flow speed ($E \sim v^3$) and its duration. Therefore, the periodicity and accuracy of wind speed measurements has the high importance for wind cadastre assessment.

Measurements of wind speed have been carried out in Georgia on 165 meteorological stations during the several decades. Based on processing and analysis of these data, it was proved that the total theoretic wind energy potential amounts to 1 300 GWh. For the sake of comparison one has to note that total theoretic river energy potential is about 135 GWh. The most promising regions for wind energy development have been also determined based on these data.

Therefore, through gradual development of wind energy potential it is possible to significantly reduce the dependence on imported energy resources and to increase the country's energy security level.

For practical and effective utilization of wind energy potential, in addition to existing meteorological data, it is necessary to adjust the wind cadastre and conduct detailed investigation of prospective regions with modern and more accurate equipment and software.

Remarkable investigations have been carried out in this direction in Georgia. The Wind energy research center "Karenergo", based on existing meteorological data and own perennial measurements with contemporary NRG system equipment, has elaborated and published the "Georgian Wind Energy Atlas."[9] Perennial data from 43 meteo-stations 3-5 year measurements conducted in prospective locations using meteorological masts of NRG.

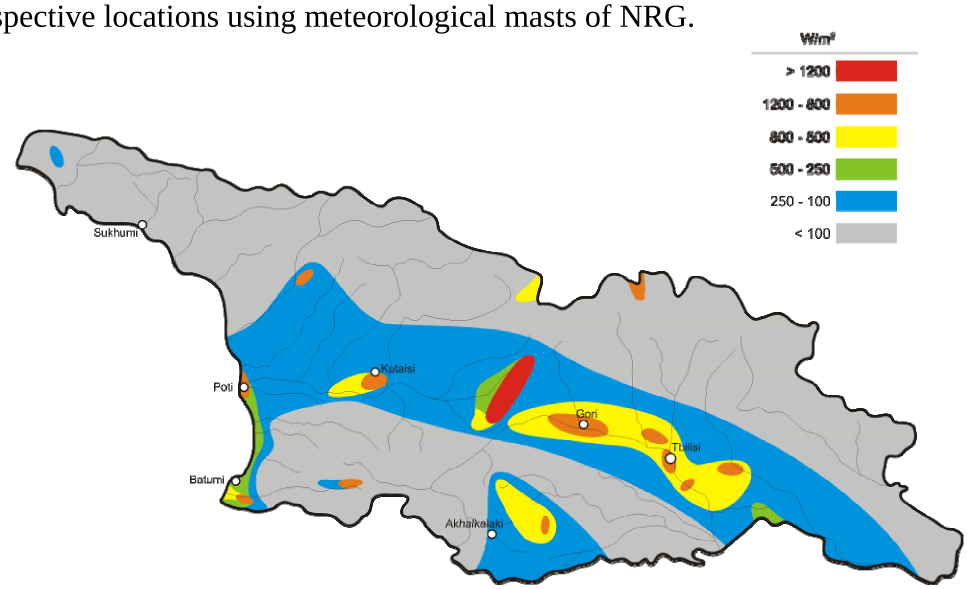


Figure 5.8. Average annual wind energy distribution on the territory of Georgia at the height of 50 m above the ground level; Source Karenergo Scientific Wind Energy Center

[9] "Georgian Wind Energy Atlas", M.S.Gelovani et al., Editor A.Zedginidze, Karenergo-ISTC, Tbilisi, 2004

The technical potential of wind power has been assessed with the use of methods and WASP software of Danish laboratory Risø . The calculations have shown that about 2000 MW of capacity and 5 GWh energy per annum can be obtained. Distribution of wind energy potential throughout Georgia is shown on Figure 5.9, below.

The capacities and annual output for the most prospective potential big wind farms in Georgia are shown below.

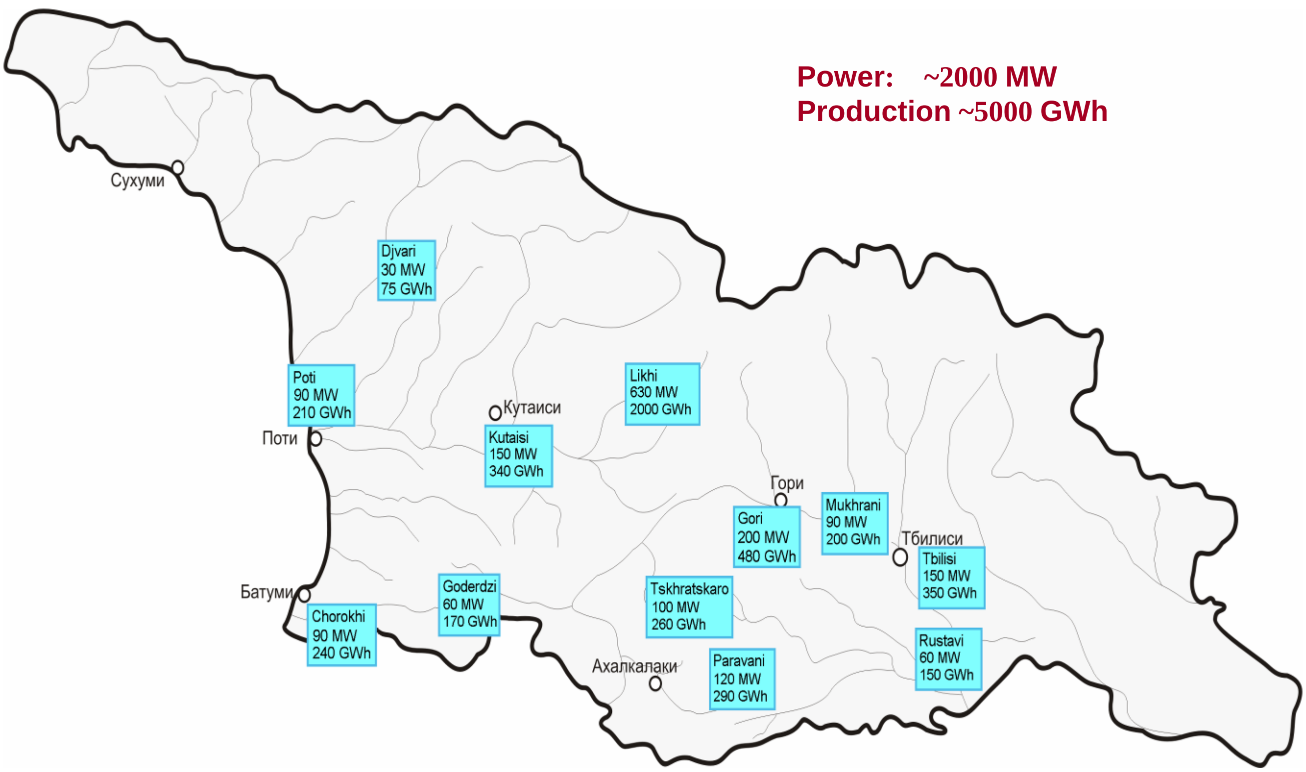


Figure 5.9. Potential big wind farms in the regions of Georgia; Source: Karenergo Scientific Wind Energy Center

According to these data, the wind power potential throughout Georgia is quite remarkable and its utilization can essentially increase the level of energy supply security in Georgia and at the same time, will be helpful for economic growth. This estimate covers the most promising areas with the highest wind potential and the possibility of constructing large wind farms. There are other local places with high wind potential that are not reflected in this report.

It has to be noted that the higher share of wind energy goes to winter months when hydro power plants suffer shortages of water. The possible wind power plants' generation near the city Kutaisi and the Chorokhi river water gap are represented as an example in Figures 5.2.4.

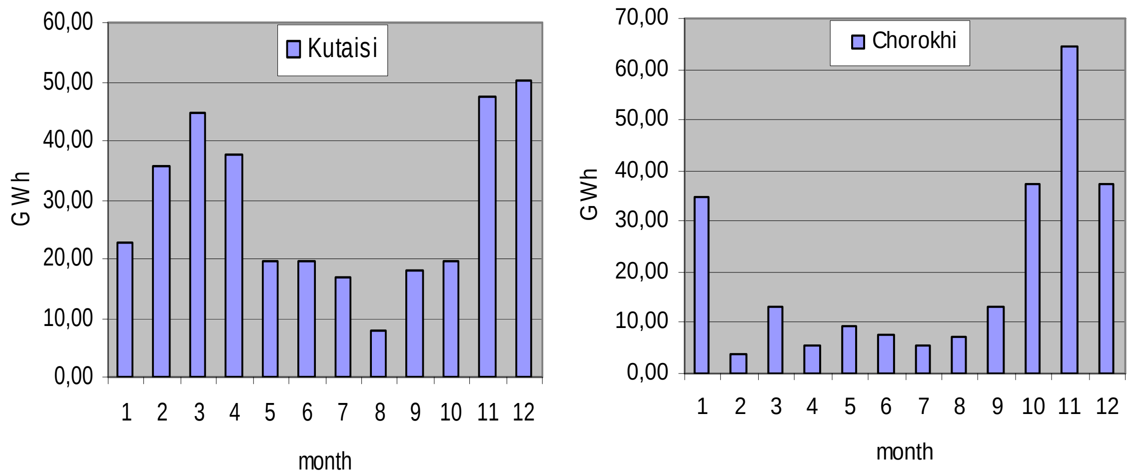


Figure 5.10. Seasonal patterns of energy generation and potential wind farms near Kutaisi and near Chorokhi river.

5.2.4. Condition of Wind Energy Utilization in Georgia

The feasibility studies of wind energy utilization in Kutaisi and Mounteen-Sabueti regions, have been carried out by Japanese companies (“Nichimen Corporation” and “Tomen Corporation”) in 1999 and 2000. It was proved that construction of wind power plants can be cost effective in these regions and will make a significant contribution to the energy balance of the country.

Furthemore the wind energy research center “Karenergo” has developed several business plans for wind farm development in other locations for attracting potential investors. Despite the positive conclusions made by foreign experts, the aforementioned projects have not been developed for a variety of reasons.

The main reasons are:

1. wind power utilization traditions do not exist in Georgia and it was difficult to obtain state support
2. a guarantee of the generated energy purchase does not exist
3. the electricity tariff was artificially low in that period.

Therefore, wind energy potential is not realized in Georgia.

5.2.5. Recommendations for Wind Energy Development

World expirience shows that State support is necessary for wind energy development. This support varies by country, but generally the State obliges distribution companies to buy wind-generated energy in almost all countries.

Besides, in most countries, a beneficial feed-in tariff is set up for wind power plants for a certain period of time, usually 5-10 years. In several countries, the State also subsidizes wind energy for a certan period.

We conclude that following steps should be taken in order to develop wind energy in Georgia:

1. Guaranteed purchase by distribution companies of energy generated at wind power plants
2. Setting a benefitial feed-in tariff for wind power plants for a certain period of time
3. VAT exemption of windpower equipment imports
4. Tax benefits for georgian and foreign investors investing in windpower development.

5.3. Prospects of Biomass Use in Georgia

5.3.1. What is Biomass?

The term "biomass" describes a suite of organic substances of animal and plant origins. It can be divided into primary biomass— plants, animals, microorganisms, and secondary biomass— residues from primary biomass conversion and animal life activity.

Examples of biomass are:

- felled firewood,
- residues from forest exploitation,
- residues from the wood industry,
- residues from agriculture crops,
- residues from the agriculture processing industry,
- residues from farming,
- residues from sewage treatment, and
- residential waste.

5.3.2. Why should we use the biomass?

Mankind has used biomass since prehistoric times, but its share in satisfying the energy demand of society has been significantly reduced since discovering abundant fossil fuel recourses during the last century.

Contemporary energy demand is primarily satiated with fossil fuel recourses; however rising fuel prices and delivery disruptions have drastically increased the importance of utilizing the array of renewable energy resources. If one takes into account the fact that fossil fuel resources are limited and the costs of oil are other fossil fuels are expected to continue to increase, pursuing renewable energy development is essential for energy security and economic development. Finally, traditional energy resources play a leading role in global climate; developed and developing countries are developing strategies and binding agreements to lower their energy consumption from these sources.

Biomass is one of best accumulators of solar energy and therefore is a renewable energy source. Energy accumulated in biomass can be directly converted into the energy needed or into other, technically more appropriate fuel**.**

The use of biomass in the energy sector has the following positive consequences:

- this resource is renewable and therefore not limited;
- biomass is spread almost everywhere;
- it is cheap compared to fossil fuel;
- biomass can be used directly or converted into other appropriate fuel, stored and used when needed;
- it significantly reduces greenhouse gas emissions;
- biomass can significantly contribute to the energy supply; and
- biomass development will create new jobs in the regions.

5.3.3. Biomass energy potential in Georgia

Estimating biomass quantity and energy potential is important for bio energy development. Unfortunately, the complete evaluation of biomass energy potential in Georgia has not been carried out. The data obtained and quoted by different authors significantly differs from each other. Fairly reliable data is given in the work, where the energy potential of biomass from corn and technical crops' residues, as well as farming residues, is estimated.[10] The report's biomass energy calculations and assessment are made using standard methodology accounting for particular coefficients of residues and their collection rates; residues of animal origin are estimated according to the number of animals. The coefficient representing the technical possibility of collecting biomass residues is also accounted for. The volume of biogas production from residues and its energy content are incorporated into energy potential calculations.

According to the thesis,[1] the energy potential of wheat crops residues consists of 280 million kWh, corn crops – 750 million kWh; and other corn and legume cultures – 270 million kWh. Therefore, total energy potential of corn cultures' residues consists of 1.3 TWh/year. That is 112 000 tons of oil equivalent (TOE). The cost of 112 000 tons of TOE at current oil prices ($95/barrel and 7.4 barrel per ton)is about 80 million USD.

Based on the same work[1], the total energy potential of residues from farming and poultry breeding is 6.9 TWh/year. That is equal to 734 million m^3 of natural gas a cost of 172 million USD.($235/$10^3$ m^3)

Residential waste is one type of biomass. Nine hundred thousand tons of waste annually accumulate in Tbilisi and Kutaisi dumps according to municipal data. An estimated 90 million m^3 biogas can be obtained by re-treating these residues; this would equal 64 million m^3 of natural gas valued at 15 million USD today.

[10] N. Arabidze. "Elaboration of Rational Schemes of Combined Thermal Plants Working on Bio Fuel Based on synergy Energy Approach and Thermodynamic Researches". Candidate of Technical Sciences Thesis, Tbilisi 2005.

Approximately 160 million m^3 of biogas can be annually obtained from the sewage water cleaning station of Tbilisi (1.2 million population). The resulting biogas energy is estimated to be 1 TWh/year ; that is equal to 100 million m^3 of natural gas priced at 25 million USD.

It is almost impossible to obtain reliable data on forest and forest residues. The bark processing and wood cutting processes have not been properly documented during the last years. Therefore data from the Georgian Department of Statistics are mainly estimates.[11] It should be noted that estimates we obtained during our interviews and consultations with independent experts are almost similar to data of the Department of Statistics. According to these data, 8 million m^3 of forest was annually cut for the population's energy needs. The total energy of this amount of bark is 22 TWh/year which is equal to 1.9 million TOE/year. Based on these data one can estimate that during the last several years, Georgia's population has met 50% of its energy needs with firewood. This circumstance would be good if not for the norms of forest felling; for sustainable forest development, the volume of forest cutting should not exceed 1 million m^3[12]. Therefore, the renewable energy potential of forest and forest residues must be set to 1 million m^3 of bark energy, amounting to approximately 2.7 TWH. This energy equals 200 thousand TOE, priced at 140 million USD at current oil prices.

The energy potential of different types of biomass and the economic benefits accrued from their proper usage is summarized in Table 5.6 below.

Type of Biomass	**Quantity (10^3 ton)**	**Energy (10^9 kWh)**	**Equivalent**	**Cost (10^6 USD)**
Residues from corn and legume cultures	870	1.3	112 thousand TOE	80
Residues from cattle farming and poultry breeding	1670	6.9	$734 \cdot 10^6$ m^3 Nat.Gas	172
Domestic residues	900	0.6	$64 \cdot 10^6$ m^3 Nat.gas	15
Residues from sewage water cleaning station	250	1.0	$100 \cdot 10^6$ m^3 Nat.Gas	25
Forest residues	700	2.7	200 thousand TOE	140
Sum		**12.5**		**432**

Table 5.6. Biomass energy potential in Georgia; Cost calculated using the price of oil $95 per barrel. and oil density 7.4 barrel/ton)

[11] "Energy Consumed by Households". Department of Statistics of Georgia. Tbilisi, 2001.
[12] G. Gigauri "Basics of Forestry in Georgia " Tbilisi 1980

Therefore, energy potential of the major biomass sources in Georgia amounts to 12,5 thousand TWh. For comparison one can note that the total energy generated by Georgia's electricity generators is about 8 TWh.

In addition to existing biomass potential, Georgia has significant perspectives to create energy plantations and generate bio fuel from biomass (bio ethanol or bio diesel). Worldwide, unoccupied agricultural areas are primarily used for energy plantations, making development of this energy source particularly attractive. Energy plantations are considered to be one of the most promising and effective methods of energy generation in the world and look very promising for Georgia, as well.

According to an initial study carried out by the Georgian High Technology Center (in collaboration with specialists in different fields), energy plantations can be planted on Georgia's lands not used for agricultural purposes and bio fuel (bio ethanol, bio diesel) can be produced. The business plan is currently under preparation; however, according to preliminary estimates 3 tons of bio ethanol can be produced from the plant *Topinambur* planted on 1 hectare on such plantations. The estimated cost of one liter of bio ethanol does not exceed 0.35 USD. Additionally, high energy yield crops like Rapes and Pilotweed can be planted. In all these cases the produced bio ethanol will be competitive with conventional fuels.

5.3.4. Utilization of biomass energy potential

Because of the wide variety of biomass sources, different methods are used for energy production or for its conversion into the other type of fuel.

Methods of biomass conversion differ according to its dampness. If moisture content is less than 50%, thermo-chemical processes are used for biomass conversion into energy or another fuel type. If the water content exceeds 50%, it is appropriate to use biologic or bio technical processes.

Thermo chemical processes comprise:

- direct combustion for heat generation,
- pyrolysis (thermal decomposition),
- gasification, and
- Liquefying for production of liquid fuel.

Bio-technologic conversion methods comprise:

- methanic boiling,
- ethanol fermentation,
- anaerobic fermentation with hydrogen obtainment.

Direct combustion of biomass is the oldest and most widely utilized method. However, the possibilities of its perfection are not completely realized. The most common type of biomass direct combustion equipment is the domestic oven whose perfection (especially in Georgia) is far from desirable. For larger-scale technological energy purposes, biomass direct combustion is carried out in special burners using designs and technology processes that are different than the common stove. While offering technological simplicity, this method has serious defects, particularly for Georgian applications.

Biomass pyrolysis is the process where carbohydrates existing in biomass anaerobically (without oxygen present) and decompose at the temperatures of 450-550 ^{0}C. Any firm organic material is subject to pyrolysis; 300 kg of charcoal, 140 m^3 of gas (10MJ/m^3), 50 liters of vinegar acid, 70 liters of bark oil and other chemical products might be obtained from 1 ton of dry wood. The charcoal obtained by means of pyrolysis does not contain sulfur and phosphorus. Because of that, it is broadly used in high level steel production. It should be noted that wood coal might be used instead of firewood as well. One great feature of biomass pyrolysis process is that charcoal ovens have higher efficiency rates and no harmful substances are being released into the atmosphere during the production process.

Biomass gasification is conducted at 800-1500 ^{0}C temperatures in the atmosphere of air, or oxygen and water. Synthesis-gas or generator gas obtained through this process has the heat content of 15 000 kJ/m^3. Biomass gasification is used in autonomous systems of heat and electricity supply. Although biomass gasification is considered as a more promising direction than the method of direct combustion, gasification still can not compete with the traditional steam cycle energy systems yet. For example, the cost of a 10 MW plant is high and varies between $1800-2500/kW. The cost of generated electricity is around 5-10c/kWh.

Biogas liquefaction is used for fuel production from the biomass of oily plants. This method is broadly used in the process of so-called bio diesel production. The price of bio diesel obtained through this method is around 50-60 cents/liter and is competitive with traditional fuels.

Methanic boiling is a bio-technological process. It is represents a relatively complicated process of multi-stage decomposition of different bio polymers existing in biomass and in anaerobic conditions by means of bacterial flora. The final result of this process is a gas mixture that is called biogas and which mainly consists of 60% methane (CH_4) and 40% carbon dioxide (CO_2). Biogas production by production means of methanic boiling is appropriate for high dampness biomass and the residues of food industry, domestic waste, water treatment waste, and farming. Biogas can also be obtained from algae.

5.3.5. Biomass Energy Use in the World

Four percent of all generated energy in the USA is obtained from biomass. Power plants of 9000 MW capacity operate with forest and agriculture residues while 3300 MW plants use municipal residues.

In Denmark centralized biogas production stations are in operation and they convert 1.5 million tons of biomass to produce 50 million m^3 biogas annually.

In Austria biomass covers 15% of Total Primary Energy Supply and is second after hydraulic energy. More than 500 small and medium capacity centralized heating stations have been constructed during the last 15 years. Austria plans to cover 40% of heating demand with biomass energy by 2010.

In Sweden biomass covers 19% of Total Primary Energy Supply. Currently 22 TWh of electricity is generated by means of bio fuel; residues of forestry are mainly used.

In Norway – which is rich in oil and hydro resources and where 99% of energy is generated in hydro plants, biomass covers 4.4% (13.6 TWH) of Total Primary Energy Supply. The development of bio energy is being promoted through the Renewable Energy Fund and other national policies.

In Brazil bio ethanol is produced from sugar cane biomass; this has reduced gasoline consumption in transportation almost in half. Fuel import expenses have been reduced by 120 billion USD after these plants have started operation.

In Poland biogas, bio ethanol and pyrolise gas are produced from biomass. The share of bio energy amounts to 2.9%. This is 548 MWh of electricity and 100 million Gigajoules of heat.

In China, India and Nepal tens of millions of small and average capacity bio digesters are converting farming residues.

In Lithuania one pig farm (11 000 pigs) creates biogas using a 3x300 m^3 bioreactor installed with financial support (700 thousand USD) from the Danish government. The obtained biogas is used in a co-generation plant Producing 700 MWh of electricity and 1600 MWh of heat annually.

In Moscow a 10 MW thermal power plant is being constructed next to Lyubertsi region aeration station. The biogas from sewage will be used as fuel.

5.3.6. Use of Biomass in Georgia

Unfortunately the use of biomass in Georgia is being made inefficiently and unsustainably.

Firewood has covered almost 50% of the population’s energy demand during the last 15 years and this has created significant problems. Georgian forestry, the main firewood source, can sustainably satisfy just 15% of Georgia’s energy demand. Therefore the present use of forestry at such wasteful pace can result in environmental catastrophe such as landslides, desertification, and sedimentation of rivers.

In Georgia firewood is mainly used in domestic ovens with low capacity and effectiveness. Recently there has been some attempt to construct a more efficient oven, but the final goal has not been reached yet. Ovens, represented in Figure 5.11 are efficient, if used simultaneously for heating and cooking.

Figure 5.11. Efficient stoves produced in Georgia; Source: Bioenergy Ltd.

As for the other biomass types, they practically are not in use. Energy products worth approximately 430 million USD are being lost annually.

Along with energy and economic benefits, conversion of biomass residues has significant environmental importance. Almost none of the 540 wood processing entities existing in Georgia use the sawdust produced. This sawdust is usually dumped in the surrounding area or into the closest river.

Another example is the environs of poultry farms in Georgia, shown in Figures 5.12. Due to natural decomposition, these residues contaminate the atmosphere with methane; one molecule of methane is capable of contributing to global warming at 21-times the rate of one molecule of carbon dioxide or hydrogen. Additionally unprocessed poultry residues contaminate the soil and can cause algae blooms and fish kills in waterways.

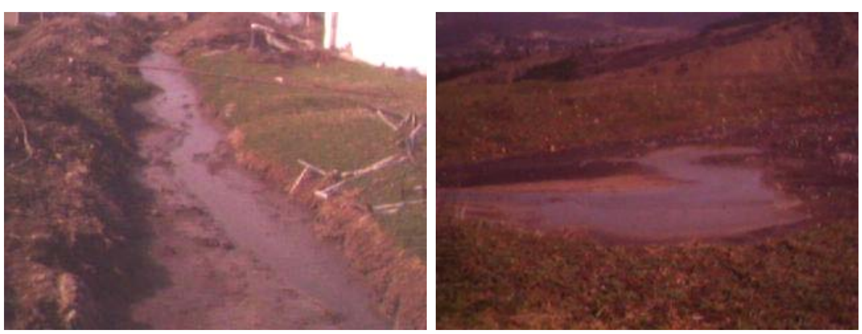


Figure 5.12. Examples of environment contamination due to poultry farm residues.
Source: Levan Tavartkiladze for EuropeAid

It is obvious that these residues create serious environmental problems. Yet the production of biogas from these residues can address these environmental problems as well as significantly improve the energetic end economic condition of the farm.

Currently design work is underway in Georgia for a biogas generating complex at a farm where 9.5 ton residues from 120 thousand chickens are accumulating per day. The complex will annually generate 2,200 MWh of electricity and 4,000 MWh of thermal energy.

The only developing method of biomass usage in Georgia is energy generation through conversion of farming residues. It should be noted that this work is being pioneered and further carried on by a few enthusiastic specialists. More than 400 bio digesters, generating biogas from farming residues (Figure 5.13) have been designed and installed; international donors have primarily funded these efforts to date. Most bio gas activities in the country are small-scale operations characterized by non-stable seasonal working regimes and low-level biogas production intensity – 0.2 - 0.3 m^3 of biogas per day from 1 m^3 of bioreactor volume.

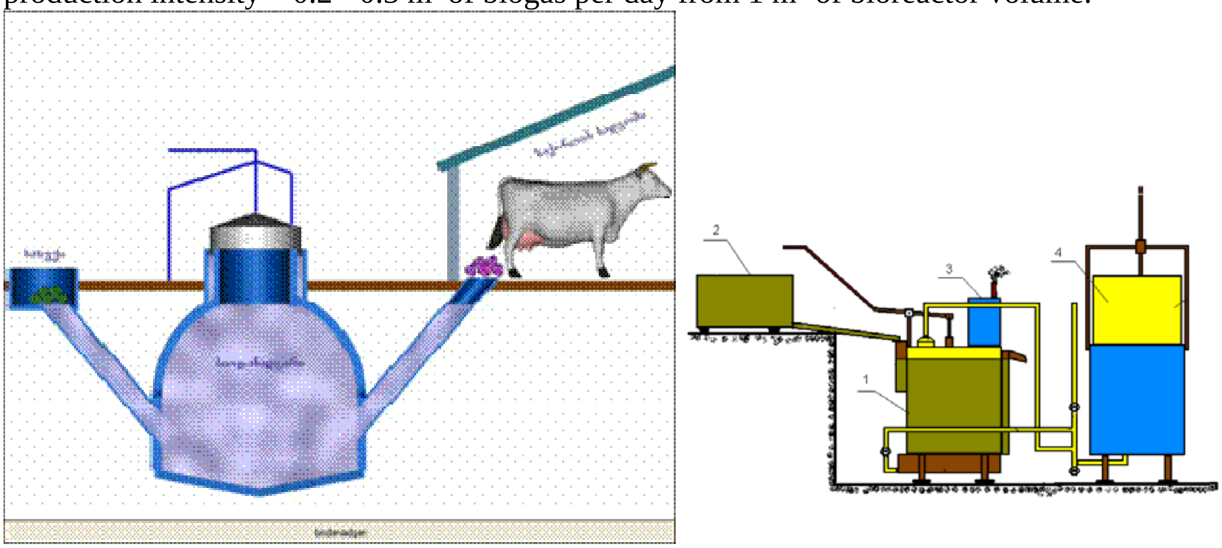


Figure. 5.13. Schematics of bioreactor (left) and high intensity bioreactor (right);
Source: Georgian High Technology Center

The high intensity biogas reactor (3 - 4 m^3 of biogas from 1 m^3 volume in a bio reactor), developed by Georgian High Technology Center is represented in Figure 5.13. In 2001 it was installed for a family of villagers in Lisi, and the reactor worked for 5 years. During that time, the family constantly obtained biogas and did not use natural gas and firewood during that period. Similar reactors have been installed by means of international financing in the village Kvemo Khodasheni and private animal farms near Akhaltsikhe city.

These bioreactors require relatively careful maintenance and observance of operation procedures that are more complicated compared to wood burning; also in years past wood, the input, was once available for free given lenient forestry management enforcement. For this reason some of the installed bioreactors operated only for a few years and then the owners switched to conventional wood burning. Now improved forest management makes it impossible to obtain free wood, and thus bioreactors are becoming more attractive energy generation sources.

5.3.7. Measures for Utilization of Biomass Potential

Utilization of biomass potential in Georgia is essential because of two main reasons.

1. Biomass utilization increases energy security.
2. It decreases greenhouse gas emissions into the atmosphere that are beneficial from environmental and economic points of view.

The enthusiasm of specialists is not enough to further development and expansion of this sector; world experience shows that state support is essential here. The State has to prioritize biomass utilization development and reflect this in renewable energy law and other laws and regulations.

The approach pursued in Germany can serve as a good example for Georgia. The law enacted in Germany obliges the country's energy system to purchase renewable energy at fixed feed-in tariffs, assuring the sector's development. Additionally, Germany supports banks that give beneficial credits to create and develop renewable energy enterprises.

In order to promote the utilization of existing biomass potential, it is also important to enact the law on biomass residues disposal whereby large cities, large animal farms, the wood processing industry and other industrial biomass sources would be obliged to recycle their residues.

5.4. Solar Energy and the Prospects of Its Use in Georgia

5.4.1 Introduction

While discussing the solar energy we will refer to more conventional technologies: electrical solar cells or photovoltaics, and solar panels for water heating.

A *solar cell* or *photovoltaic cell* is a device that converts light energy into electrical energy. Typically these are the devices of low capacity used for remote locations mainly for powering communication devices or other low consumption appliances. Individual cells are used for powering small devices such as electronic calculators. Assemblies of cells are used to make solar modules, which may in turn be combined into in photovoltaic arrays (Cf. Fig 5.14.) with the desired peak DC voltage and current to provide the light and/or feed electric bigger devices (radio or TV sets etc.). Photovoltaic arrays are typically used in combination with batteries and if common home appliances there is a need for DC/AC converter as well.

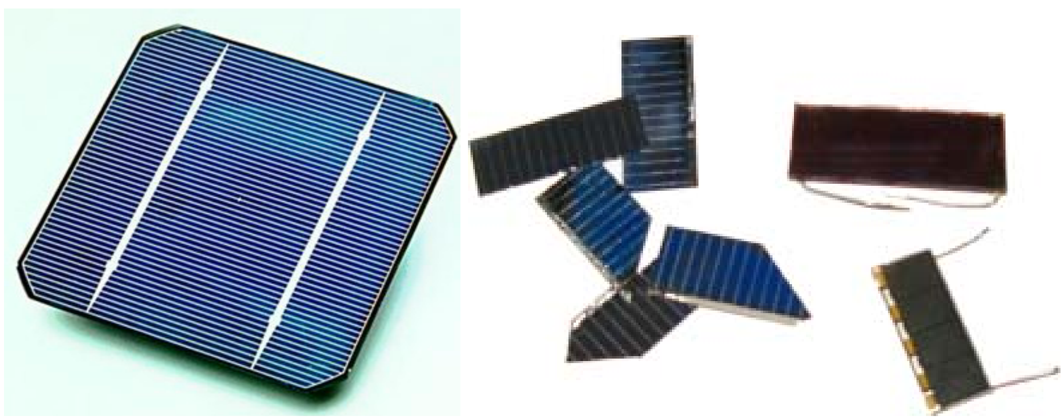


Figure 5.14. Solar module and solar arrays
Source: Wikipedia

A cheaper and widely used way of utilizing the solar energy is water heating with solar collectors. Flat solar collector consists of a thin absorber sheet (usually copper, to which a black or selective coating is applied) backed by a grid or coil of fluid tubing and placed in an insulated casing with a glass cover. Fluid is circulated through the tubing and transports the heat from the absorber to an insulated water tank or to a heat exchanger.
As a recent development, polymer flat plate collectors are being produced in Europe. Polymers, being flexible and therefore freeze-tolerant, are able to contain plain water instead of antifreeze, so that in some cases it becomes possible to avoid a need for heat exchangers.

Figure 5.15. Solar water heater panels
SOURCE: “Sun House”

Evacuated tube collectors consists of rows of parallel transparent glass tubes, each of which contains an absorber tube. The tubes are covered with a special light-modulating coating. In an evacuated tube collector, sunlight passing through an outer glass tube heats the absorber tube contained within it. The absorber can either consist of copper (glass-metal) or specially-coated glass tubing (glass-glass)

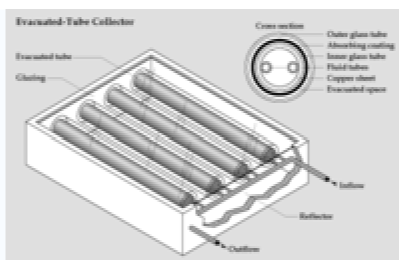


Figure 5.16. Evacuated (or vacuum) tubes panel.
Source: Wikipedia

The solar water heaters are used mostly for hot water supply and in more limited numbers also for support of space heating systems.

5.4.2 Solar Energy Potential of Georgia

The existing cadastre of solar potential in Georgia[1] presented below in Fig.5.17 is compiled from the data of 8 actinometrical stations located throughout the country. Extrapolation to cover the whole territory was made using average temperatures at the particular locations.

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[1] G.G.Svanidze, V.P.Gagua, E.V.Sukhishvili – Renewable Energy Resources of Georgia, Tbilisi 1987

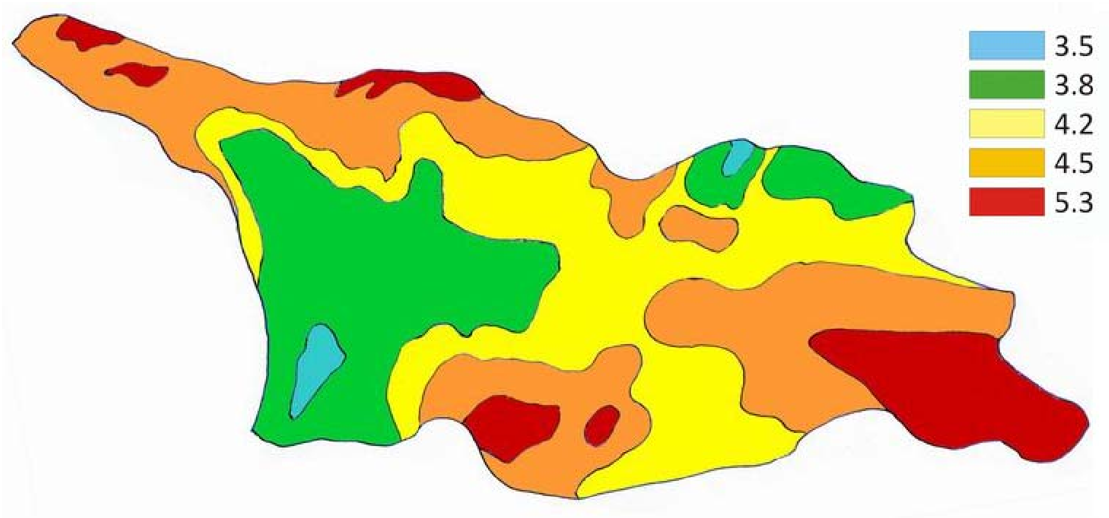


Figure 5.17. Existing solar cadastre of Georgia showing average daily solar radiation in kWh/m^2

From a climatic point of view, the strong and diverse reliefs of such a mountainous country make extrapolation from just 8 metering stations unreliable. For this reason, the Center of Sustainable Energy – "Sun House"[2] has started measurements in different locations where they have installed solar panels. The measurements are taken in dozens of locations and results are extrapolated to the whole territory of Georgia using the elevation from sea level (and corresponding air transparency) as basis for extrapolation. The picture obtained and displayed below in Fig.18 is quite different from Figure 5.17[1].

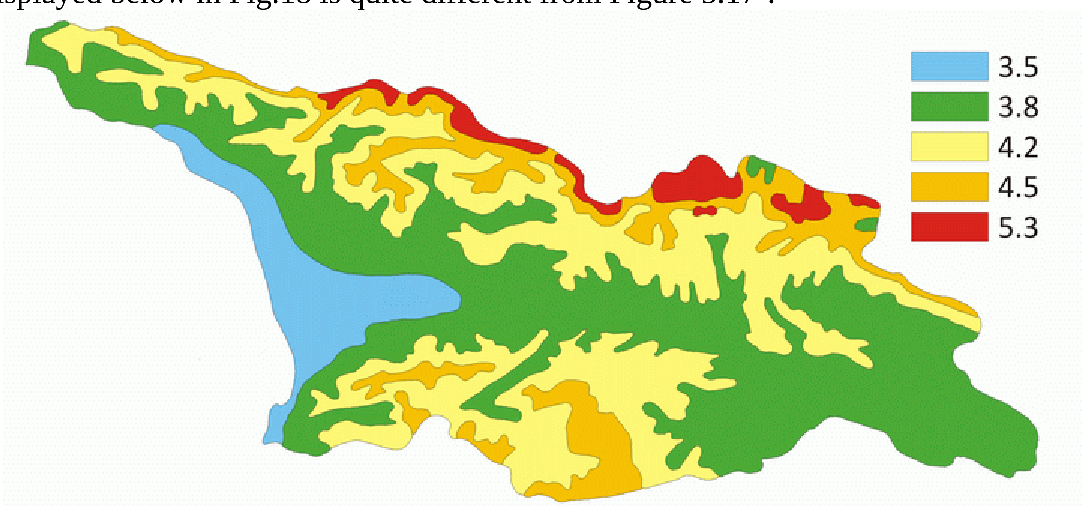


Figure 5.18. Cadastre compiled by "Sun House". Daily solar radiation in kWh/m^2

[2] Center of Sustainable Energy – "Sun House" has the work experience– of 20-25 years. in design, installation and service of photo electro and water heating solar systems. Scientific research and Consulting. has installed more than 150 systems, with the total capacity of 30 kW

One can see that there is a significant difference between these two cadastres. The newly compiled one is more detailed and shows less average solar radiation. However to a great extent, it still relies on approximations and the number of measurement points as well as the time series of measurements should be extended.

For an estimate of solar energy potential we still use the established results of Ref. 1., according to which: the average of 1550 kWh solar energy is annually irradiated to a horizontal surface of 1m^2 in Georgia. The conversion coefficient of photo-voltaic modules is approximately 12-15% and about 60-95% for water heating collectors. Based on these estimates, one can calculate that on average about 190 kWh electric energy can be annually obtained from 1 m^2 surface of solar photovoltaic panels and 1200 kWh thermal energy (hot water) from solar water heating panels.

Solar energy is obviously subject to significant seasonal variations shown below.

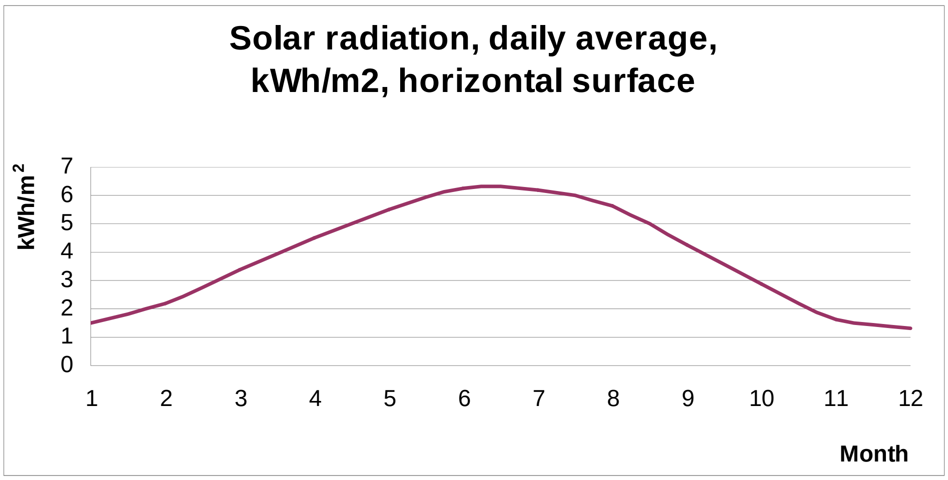


Figure 5.19. Seasonal dependence of solar radiation in Georgia

Source: “Renewable Energy Sources of Georgia”[3]

The diagram shows that the potential of solar energy is sharply seasonal and varies by more than a factor of four from mid-summer to mid-winter. This curve does not directly represent the amount of energy obtainable from solar radiation but can be used as a first approximation.

It is not straightforward to determine the achievable economic potential of solar energy in Georgia. For information and benchmarking we just present the two numbers:

[3] G.Svanidze, V.P.Gagua, E.V.Sukhishvili, Tbilisi 1987, “Seasonal dependence of solar radiation in Georgia.”

“In Israel the government regulation, enacted under the planning and construction lawn 1980, requiring the placing of solar water heating systems in new private dwellings, greatly advanced the usage of solar energy. This regulation along with the positive, cumulative results that followed has placed Israel first in the world in the use of solar energy per capita (3% of the primary national energy consumption).[4]

In Turkey the utilization of solar energy amounted to 390 kilo tons of oil equivalent (KTOE) in 2005, which was 0.45% of Total Primary Energy Supply[5] (85.2 MTOE[6]).

Thus, if we assume that in Georgia the achievable economic potential is (0.2-0.4)% of Total Primary Energy Supply **then we will arrive at 0.2%* 2500 KTOE = (5-10) KTOE. or roughly 60-120 GWh of energy annually.**

Although more than 70% of this potential is realizable in the months of April through September, solar power can contribute to reducing energy dependence by almost completely replacing the need for gas currently used for hot water supply throughout the year.

5.4.3 Solar power use in Georgia today

Due to the absence of adequate statistics it was difficult to estimate the total number of installed solar systems in Georgia. However anecdotal evidence from one supplier indicates there may be a tendency of accelerated penetration of solar systems.

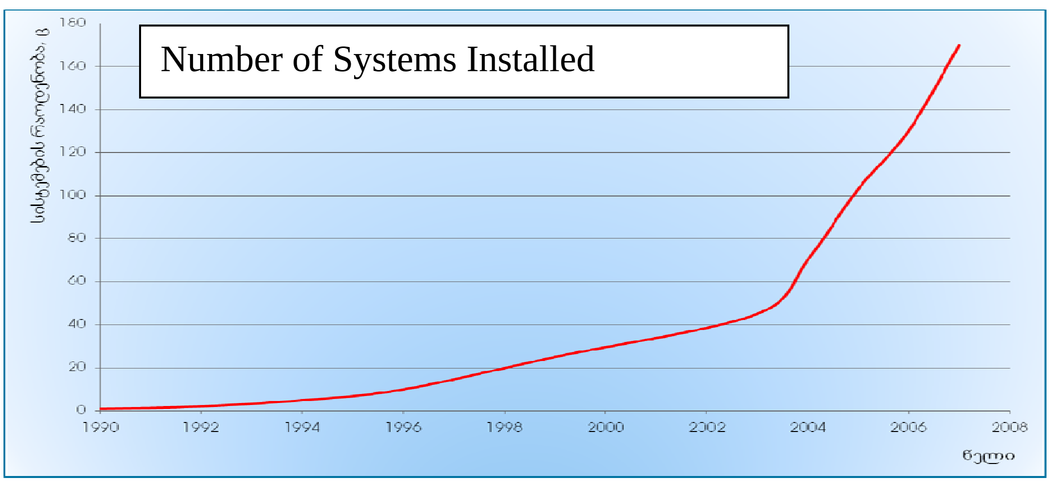


Figure 5.20. Tendency of solar panel installation SOURCE: “Sun House”

[4] Samuel Neeman Institute Solar energy for the production of heat Summary and recommendations of the 4th assembly of the energy forum at SNI” 2007 http://www.neaman.org.il/neaman/publications/publication_item.asp?fid=590&parent_fid=490&iid=3639

[5] See the General Directorate of Electrical Power Resources in Turkey http://www.iea.org/textbase/work/2002/marrakech/Eie.pdf

[6] See the United Nations Human Development Reports `http://hdrstats.undp.org/indicators/219.html`

5.4.5 Economics of Solar Systems

The most efficient and popular systems are the solar water heaters. There is a danger of freezing in winter, therefore the system requires the anti freeze solution to circulate and heat the water in the heat exchanger. The cheapest systems are with self circulation and provide about 110 liters/day of hot water at 60^0C temperature. The 180 liters/day systems cost approximately $1800-2000. The forced circulation systems with controllers, pumps and heat exchangers are more expensive and cost about 4-7 thousand USD. .

The cost breakdown is:
- 70-80% for equipment and appliances
- 20-30% for design and installation.

The cost for photovoltaic (PV) systems are approximately $13-18 per watt of installed systems and they are mostly used for remote locations where there is no alternative supply of power. PV systems have proven to be helpful in alleviating the migration from high mountainous villages. After installing solar systems people are able to receive the TV/radio signals, have electric lighting and in several cases have chosen not to leave their villages even in winter season.

The sizing and profitability of solar installations has to be calculated in each particular case separately. (CF. Example of installation assessment Fig.5.21)

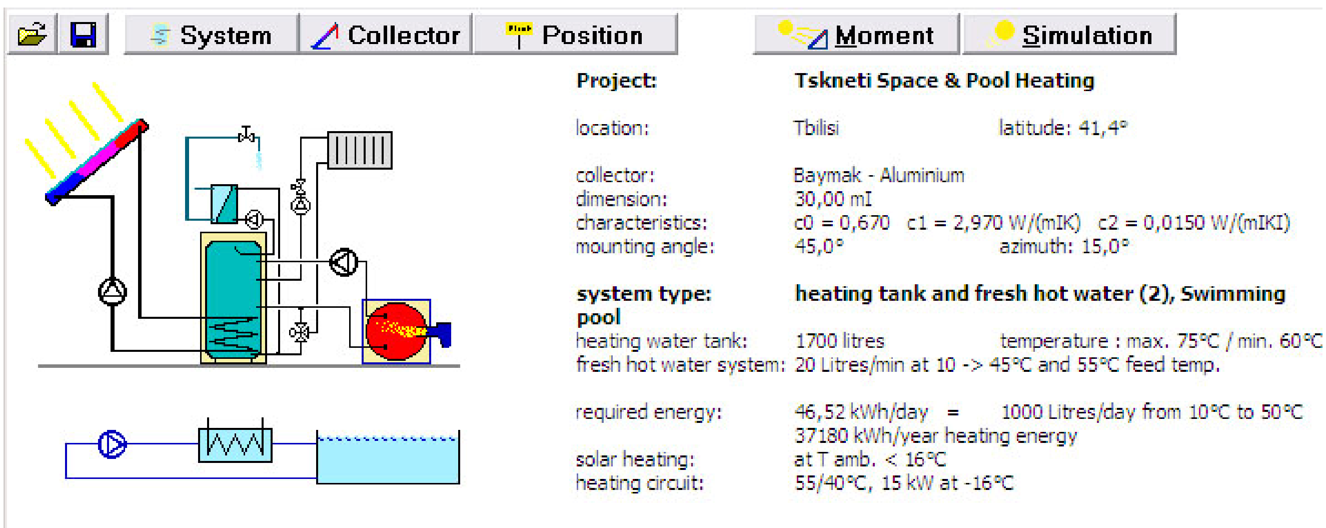


Figure 5.21. Solar system sizing calculation with *Getsolar* software.

According to the average estimates from Solar House:
- for photo electric systems the initial investments' payback period is about 20 years, but has no alternative in non-powered regions;
- for water heating systems, the initial investments' payback period is about 3-9 years; these are most profitable in applications where hot water expense is high and the main load is in summer (swimming pools, hotels).

5.4.6. The Need for State support of solar power

There are a number of specialized private companies doing the installation of solar systems: SpecHelioTbomontaji, Ekoeni, Aido, and Solar House, etc. Some of them manufacture cheap systems locally; however, most of the systems are imported.

Currently there are no legal acts in support of developing solar energy use in Georgia. Until recently the solar systems received tax benefits and were exempt from the VAT. However the new tax code has eliminated these benefits. As a result, after import the price of solar panels in Georgia increases by 35-40% due to transportation and taxation costs.

For comparison, below are several examples of policy measures in support of solar energy development used by different countries:

- direct financial subsidization (on the solar collectors in Germany - 110€/m^2);
- tax relief/decrease (tax on profit has been decreased by 75% in Greece in 1994, which was equal to a 30% subsidy);
- purchase of clean (net) energy by a high, guaranteed tariff (in Germany 41-56 €c/kWh);
- long-time and low-rate credits (market-1% in Germany);
- so-called "white certificates" (since 2005 energy generating companies in Italy are obliged to carry out energy saving activities or purchase the "white certificates," which are issued for raising energy efficiency, solar installation, etc);
- Building Decree (since 2006, in Spain, the solar water heating system has to be installed on every refurbished or newly built house).

The main force driving the development of renewable energy in all EU countries are the national policies, while the increase of energy costs is a secondary factor.

5.5. Geothermal Resources in Georgia and Prospects of Their Development

Geothermal energy is a promising if somewhat untapped source of renewable energy in the world. According to the data of the Third Annual World Geothermal Congress in 2005, approximately 1100 special wells have been drilled from 2001 – 2005 and nearly 800 million dollars had been invested in developing this resource; the total estimated thermal capacity of world geothermal fields is 16,210 megawatts:[7]

- Geothermal energy can be used for agricultural purposes such as heating greenhouses, and powering the initial processing of products from poultry, cattle farms, and fish farms, for fruit drying, irrigation, ground heating, and more,
- in the residential sector for heating and hot water supply,
- recreation and sports/fitness establishments, and
- for power generation.

5.5.1 Geothermal resources in Georgia

In Georgia, thermal waters have been used for hygienic and balneology purposes for centuries; Its utilization for energy purposes began in 1951. The forecasted reserve of thermal waters in Georgia comprises 960,000 -1,000,000 m^3/day (350,000,000– 400,000,000 m^3/year).[8] By 1993, the proven reserve of thermal waters in Georgia comprised 90,000 m^3/day (33,000,000 m^3/year).

Presently, there are up to 250 natural springs and artificial wells of thermal water with water temperatures ranging from 30 to 108 degrees Celsius. Their overall withdrawal comprises 160,000 m^3/day (58,000,000 m^3/year). Figure 5.22 shows the map of thermal waters of Georgia.

[7] The Third Annual World Geothermal Congress, Antalya, Turkey, 2005
[8] N. Tsertsvadze, G. Buachidze, O.Vardigoreli “Thermal Waters of Georgia”, Tbilisi, 1998

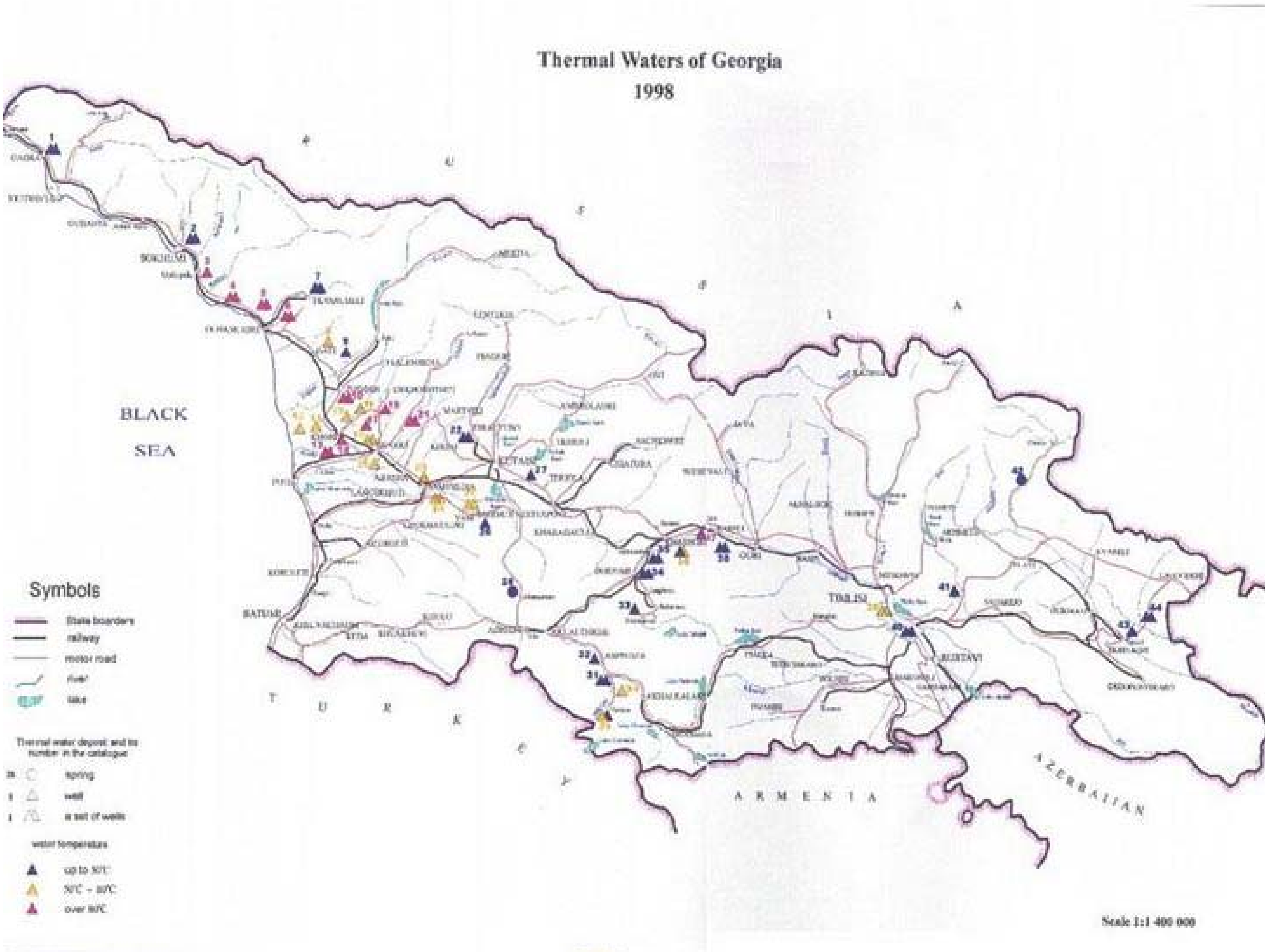


Fig 5.22. Map of Geothermal waters of Georgia; Source: Tsertsvadze et al.ref.2

Table 5-11 shows the main characteristics of hydro thermal deposits having energy potential and currently existed in the territory of Georgia.[2] ..

A TABLE OF BASIC INDEXES OF THERMAL WATERS DEPOSITS OF GEORGIA

Deposit No	Name of the deposit	Well No	Tempera-ture t °C	Dis-charge m^3/day	Thermal capacity Δt=t-25°C	The amount of saved equivalent fuel thousand t/year
1	Gagra	3	38-43	920	0,8	1,14
2	Besleti	2	39-41	370	0,25	0,34
3	Dranda	1	93	1500	4,8	7,0
4	Kindgi	11	75-108	26600	95	141,2
5	Mokvi	8	100-105	13470	48,9	73,5
6	Okhurei	2	104	3500	12,8	19,1
7	Tkvarcheli	2	35-38	690	0,35	0,53
8	Rechkhi	1	77	1080	2,6	4,5
9	Saberio	1	34	1230	0,5	0,8
10	Zugdidi-Tsaishi	15	78-98	24564	69,8	103,8
11	Torsa	1	63	108	0,2	0,3
12	Okros Satsmisi	1	63	104	0,2	0,3
13	Kvaloni	2	78-98	4300	11,6	17,2
14	Khobi	1	82	450	1,1	1,7
15	Bia	1	65	2600	4,8	7,2
16	Japshakari	1	64	120	0,2	0,3
17	Zeni	1	80	372	0,9	1,4
18	Zana	1	101	400	1,4	2,1
19	Menji	3	57-65	5750	9,2	13,6
20	Isula	1	75	370	0,9	1,3
21	Nokalakevi	2	80-82	700	1,8	2,6
22	Tskaltubo	75+4spr.	31-35	20000	7,7	11,5
23	Samtredia	1	61	3000	4,9	7,2
24	Vani region	3	52-60	2152	3,2	4,8
25	Vani	2	60	2780	4,5	6,8
26	Amagleba	1	41	346	0,3	0,5
27	Simoneti	1	42	520	0,4	0,6
28	Abastumani	3 spr.	48	1040	1,1	1,7
29	Vardzia	3	45-58	1330	1,75	2,7
30	Tmogvi	1	62	520	0,9	1,3
31	Nakalakevi	3	34-58	795	0,64	1,05
32	Aspindza	1	42	864	0,7	1,0
33	Tsikhisjvari	1	32	1000	0,34	0,5
34	Borjomi	25	30-41	537	0,4	0,6
35	Akhaldaba	4	33-42	500	0,26	0,43
36	Tsromi	5	39-55	732	1,03	1,64
37	Agara	1	82	260	0,7	1,1
38	Khvedureti	2	45-49	140	0,15	0,2
39	Tbilisi I	7	56-70	3760	6,5	9,9
40	Tbilisi II	5	38-48	1111	0,82	1,16
41	Ujarma	1	42	50	0,04	0,06
42	Torgvas-Abano	1 spr.	35	800	0,4	0,6
43	Tsnori	1	37	864	0,5	0,75
44	Heretiskari	2	34-37	3300	1,65	2,6
all		206 wells 8 springs		135599	307,1	458,4

Table 5.7. Geothermal sources in Georgia; Source: Georthermia Ltd.

As can be seen from the map and the table, most of the wells are placed in west Georgia where more than 80% of the country's known geothermal resources are located. The temperatures of geothermal deposits are not very high and are better suited for heating and hot water supply purposes. The energy potential of geothermal water allows for the construction of various capacity, centralized heating systems in the following cities: Khobi – 1.2 MW. Senaki – 11 MW, Samtredia – 5 MW, Vani- 5 MW.

The estimate of proven geothermal reserves may be somewhat unrealistic for today. The reason is the inefficient mode of operation of many of the deposits. Due to direct discharge, the pressure in these water containing horizons lowers down and correspondingly the withdrawals of the productive wells drop. For example, picture 5.23 shows Lisi-5 well multi-year dynamics of withdrawals which clearly shows the tendency of output lowering.

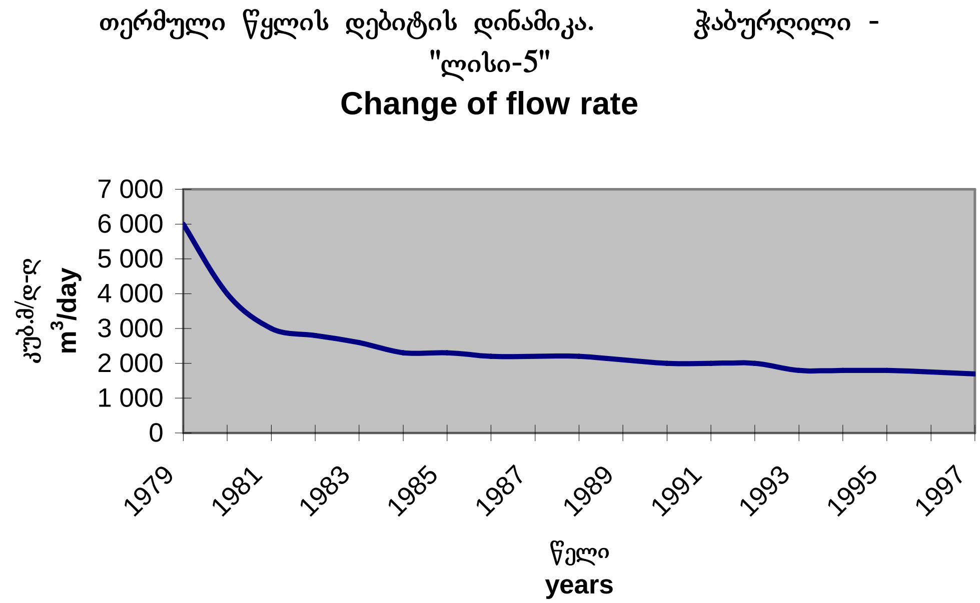


Figure 5.23. Dynamics of Thermal Water Debit. Well – Lisi – 5 SOURCE; “Geothermia” Ltd

5.5.2 Current Conditions of Geothermal Heating – Hot Water Supply in Georgia

Tbilisi Geothermal Deposit

Since 1997 LLC Geothermia holds the license to operate the Tbilisi geothermal field. It carries out scientific research, projecting activities and operates the fields. Geothermia has provided information about their operations below.

- as of November 2007 six geothermal fields are operating. Among them two are re-injected;
- The total withdrawal of geothermal water is 4000 m^3/day;
- 79 residential block buildings in Tbilisi are supplied with thermal water with 55 ^{0} C temperature;

- 15 residential block buildings are supplied with thermal water with 70 ^{0} C temperature;
- 15 block buildings are furnished with communal water meters;
- the price of thermal water was 1,7 Gel/per person/month. Currently with improved metering it has been set at 2 Gel per ton;
- the level of payment collections for geothermal water is 15-17%. Currently sanctions are being implemented against non-payers.

LLC Geothermia with support of the Global Environmental Fund (GEF) intends to implement the project of Geothermal Circulation System No. 1 in Tbilisi.

Zugdidi-Tsaishi Geothermal Deposit

- there are nine wells at Zugdidi-Tsaishi deposit with water temperatures of 78-79^0 C;
- Geothermal water of Zugdidi-Tsaishi field has low mineralization – 1.6-2.5 g/l.

Presently the geothermal resources in the territory of Zugdidi-Tsaishi are not utilized in an organized way. The Potential of the fields is mainly used chaotically by nearby population for heating of greenhouses.

5.5.3 Potential Geothermal Projects in Zugdidi

In 1997-98 with the financial support of USAID, Zugdidi-Tsaishi geothermal field was hydraulically tested as a geothermal point, and consequently experts identified that this field has enough high potential (withdrawal 25,000m^3/day, temperature 82-95^0 C) in order to utilize this for thermal energy supply of the city of Zugdidi, also for agricultural-complex development.

The scheme of location of wells in Zugdidi Tsaishi geothermal field is shown below in Figure 5.23.

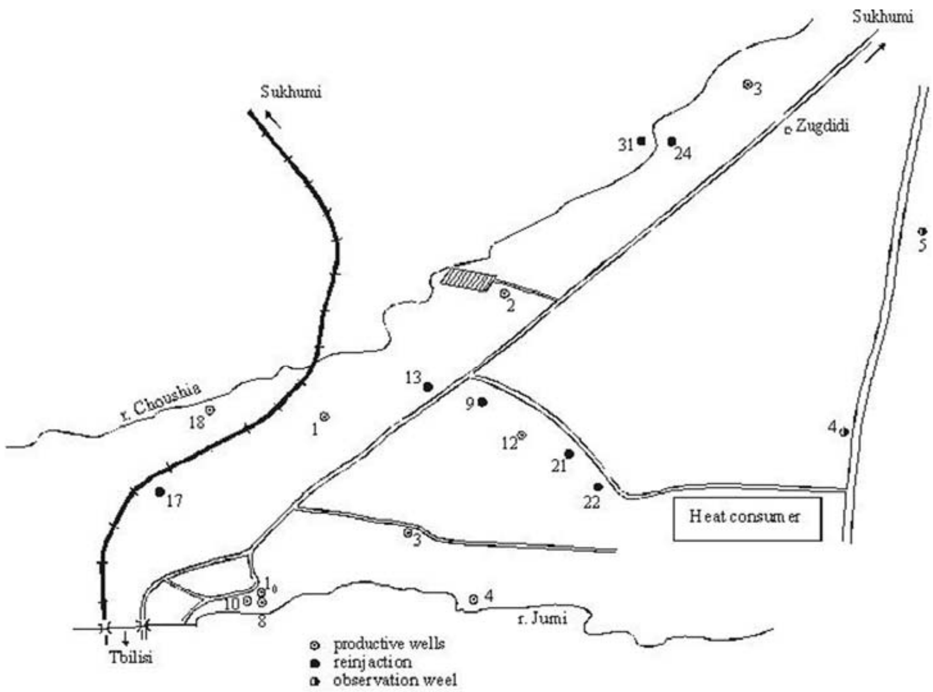


Figure 5.24. The scheme of location of wells in the Zugdidi Tsaishi geothermal field SOURCE: Geothermia Ltd.

The possible technological scheme of Zugdidi heat supply follows.

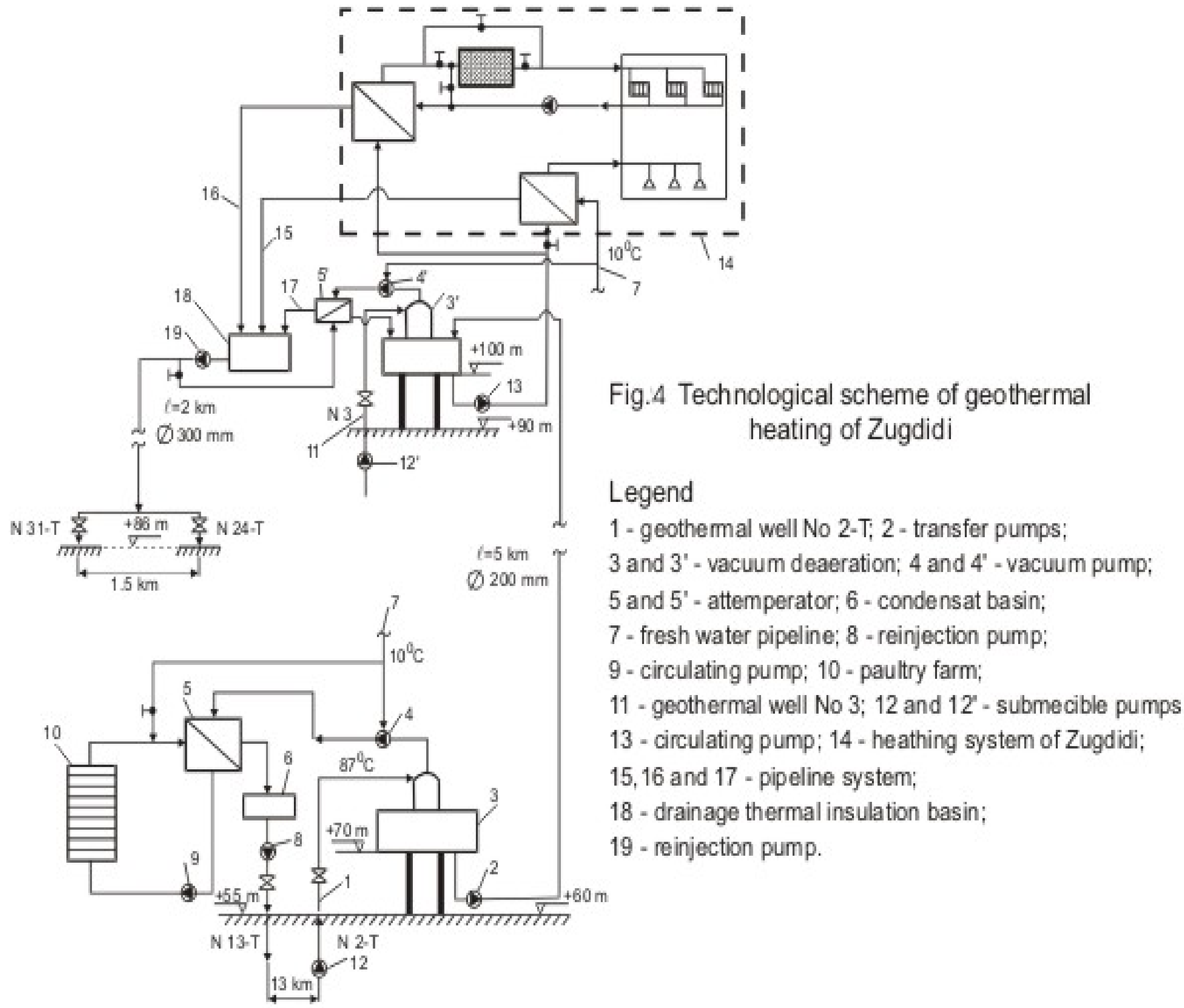


Figure 5.25. The technological scheme of a possible thermal supply of Zugdidi

Since the demand on electricity decreases in summer, one of the problems of geothermal water utilization is using the geothermal energy efficiently in summer. In order to make development of geothermal fields cost effective, the existence of a consumer who needs the thermal energy during the whole year is crucial. Such a consumer may be the potential Zugdidi Tsaishi Agro Complex, the concept of which has been developed under a USAID program by the company Burns and Roe Enterprises, Arci Consulting and LLC Geothermia, in the scope of the Feasibility Study of Zugdidi-Tsaishi Field Development.

Developing an Agro complex on the Basis of the Zugdidi-Tsaishi Geothermal Field

The technological scheme of Zugdidi-Tsaishi potential agro complex is shown in Figure 5.26 and 5.27 and the field's thermal load and the project's proposed outputs are presented in 5.28 and Table 5.8..

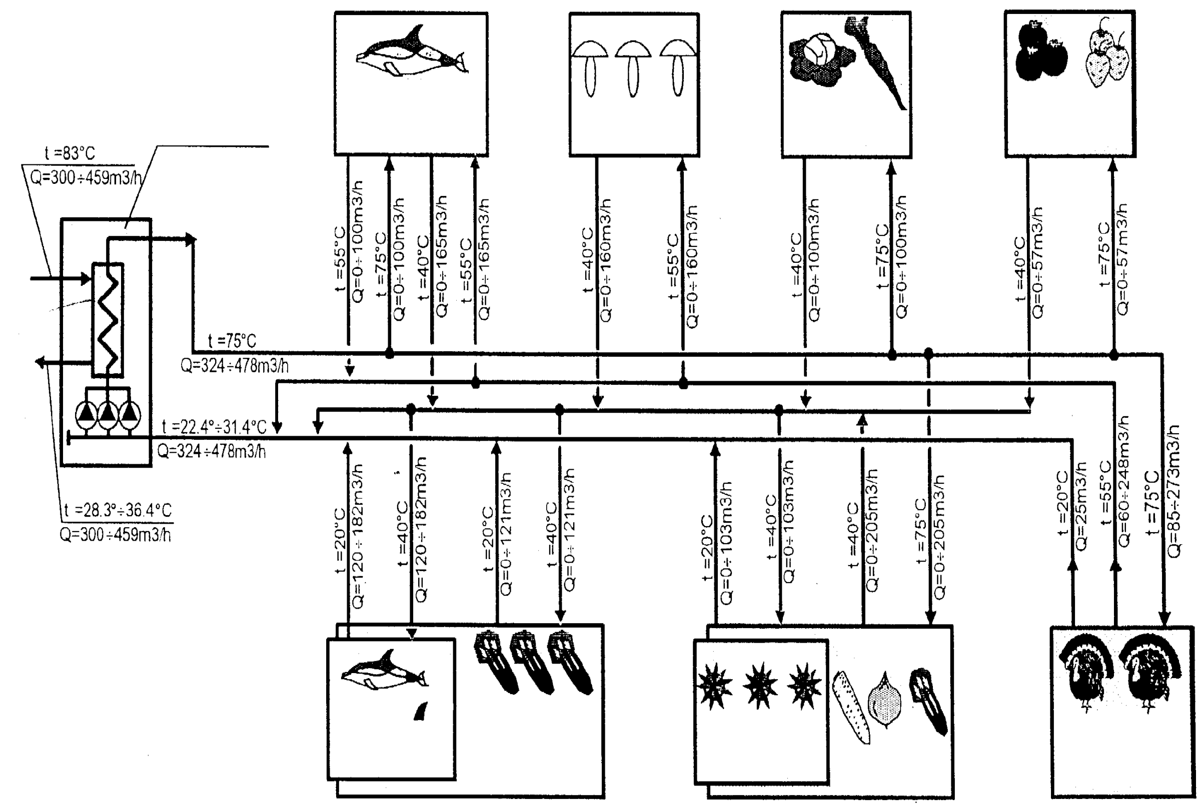


Figure 5.26. Technological scheme of Zugdidi Tsaishi potential agricultural complex.

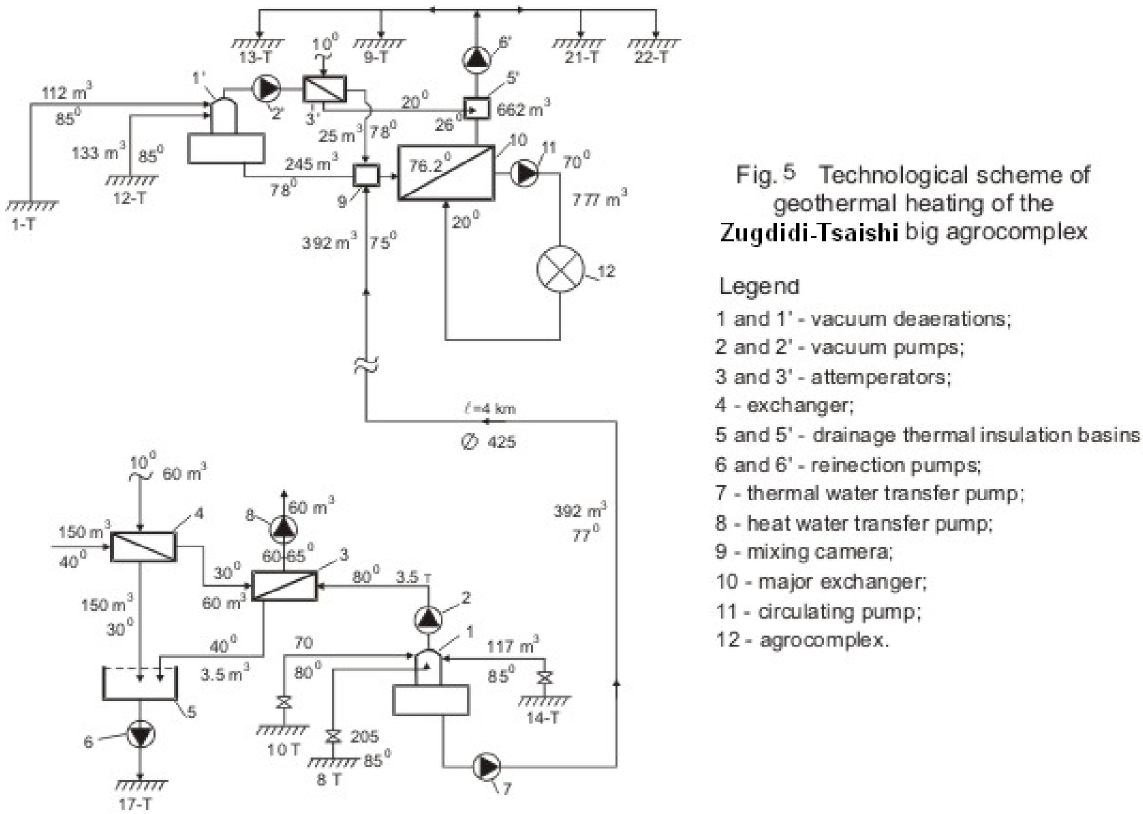


Figure 5.27. Technological scheme of thermal supply of Zugdidi Tsaishi Agricultural Complex

An important benefit for the use of geothermal resource is existence of demand for the heat over the whole year. Fig. 5.28 shows the expected thermal load of prospective Zugdidi-Tsaishi Agricultural. Complex

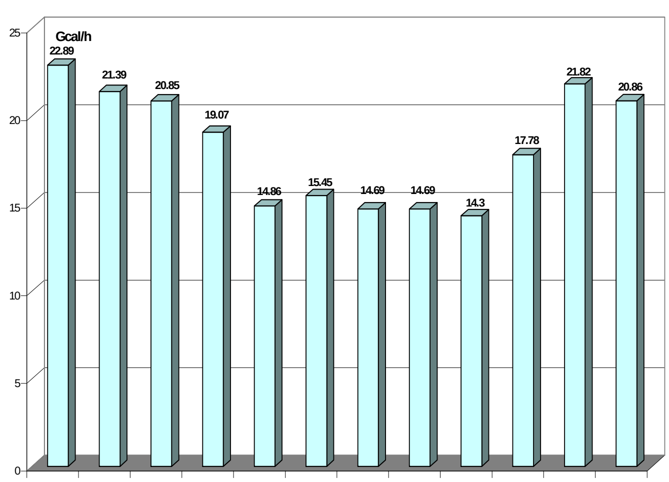


Figure 5.28. *Seasonal thermal load of Zugdidi Tsaishi Agro complex*

Agro Project Components	Productivity	Expenses
1. arrangement of thermal supply system for geothermal circulation system and agro complex		8,03 million USD
2. Poultry farming	600 tons of meat per annum	3,3 million USD
3. Greenhouse farming	1800 tons of vegetables per annum	4,2 million USD
4. Fish farming	120 t fish per annum	3,3 million USD
5. Fish breeding farms	2000 t fish per annum	1,2 million USD
6. Cold storage for vegetables	2000 t	1,5 million USD
7. Various drying appliances		1,5 million USD
8. Mushroom farming	1500 tons per annum	4,9 million USD
9. Production of vegetables on open heated ground	1500 tons per annum	2,0 million USD
Total		29,93 million USD
Simple payback		3,5 year (authors estimation)
calculated cost of geothermal heat		9,1 million USD /(MW/hr) (authors estimation)
Energy share in the cost of products produced by the agro complex using heat energy		40% (authors estimation)

Table 5.8. Technical Economic Parameters of Zugdidi Tsaishi Agro complex

The expected heat consumption of Zugdidi-Tsaishi Agro Complex is about 180 GWh/year.

5.5.4 The Tbilisi Heating-Hot Water Supply Project on the Base of Tbilisi Geothermal Water Field

Preliminary geophysical research indicates the possibility of geothermal fields in the entire territory of Tbilisi. Taking into account this opinion that the Tbilisi geothermal water heating-hot water supply concept has been developed; this envisages the location of geothermal wells in the territory of existing districts' heating boilers. The wells' locations are shown in Figure 5.31. This concept requires additional research, especially taking into account that thermal routes and the indoor thermal supply networks practically do not exist.

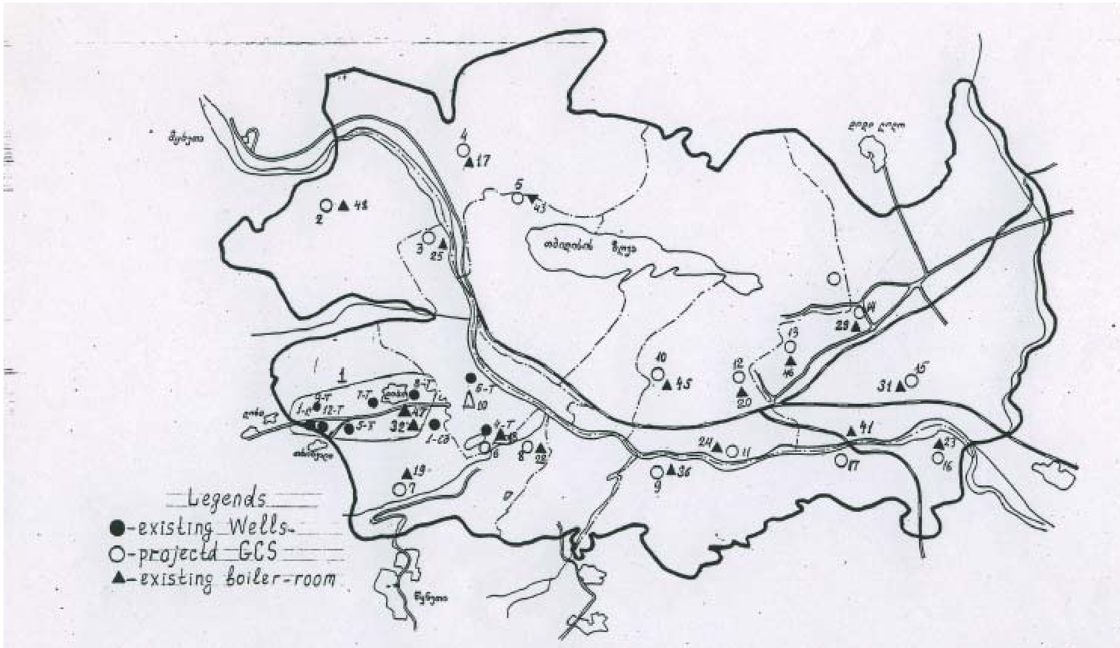


Figure 5.29. Location of wells in the Tbilisi geothermal field

Parallel with this and with the financial support of the Global Environmental Fund and the involvement of the climate change bureau of the Ministry of Environment and LLC Geothermia, the project on thermal supply of Saburtalo region was developed in 2000. The project envisages the arrangement of geothermal circulation systems in particular districts of the field. The geothermal water cooled in the interim heat exchanger of such system will be injected back by means of special well. Figure 5.33. shows the principal scheme of the # 1 geothermal circulation system of Tbilisi.

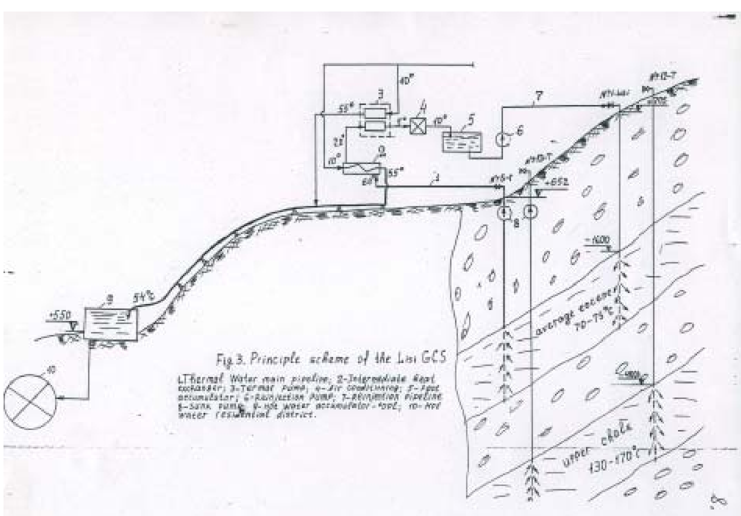


Figure 5.30. The principal scheme of the Number 1 geothermal circulation system of Tbilisi

Below, in Table 5.9 the phases of hot water and heat supply project to Saburtalo region are presented.

Initial Stage (2007-2008)

Arrangement of geothermal hot water supply for 30 000 customers of Saburtalo region.

	donors		
Total value of the project	Global Environmental Fund	Tbilisi Municipality	Owner – private structure
3,94 million USD	2,5 million USD	1,0 million USD	0,4 million USD

Energy Supply	cost of geothermal heat	IRR	annual net profit	Simple Payback
46 GWh/year	13,04 US dollars/(MWh)	15,8 %	0,8 million USD/year	5 years

Second Stage (2009-2011) - arrangement of geothermal supply for Saburtalo region customers.

Overall Cost of the Project	Expected Energy Output
5,5 million USD	92 GWh/year

Prime cost of Geothermal Heat	IRR	Annual Net Profit	Simple Payback
20,12 US dollars(MW/h)	16,2 %	1,2 million USD/year	4,6 years

Third Stage (2012-2015) - Double contour geothermal circulation system arrangement for 100 000 customers of Saburtalo region.

Overall Cost of the Project	Expected Energy Output	
32 million USD	490 GWh/year	

Prime Cost of Geothermal Heat	IRR	Annual Net Profit	Simple Payback
20,0 USD/(MWh)	-	5 million USD/year	-

Table 5.9. Technical and Financial Parameters of Tbilisi Geothermal supply project

Evaluation of key technical economic parameters of Saburtalo region hot water supply and heating project are provided in Table 5.10.

The initial stage (2007-2008)

Arrangement of geothermal hot water supply system for 30 000 customers of Saburtalo region
Phase -1 (2007-2008 yr)
Installation of geothermal hot water supply for 30 000 customers

	Donors		
Total project cost	GEF	Tbilisi municipality	Owner private enterprise
3,94 million USD	2,5 million USD	1,0 million USD	0,4 million USD

Prime cost of geothermal heat	IRR	Annual net profit	Simple Payback
13,04 USD/MWh	15,8 %	0,8 million USD/yr	5 years

Phase -2 (2009-2011 yr)
Installation of geothermal heating for 30 000 customers

Total project cost	5,5 million USD

Cost of geothermal heat	IRR	Annual net profit	Simple Payback
20,12 USD/MWh	16,2 %	1,2 million USD/yr	4,6 years

Phase -3 (2009-2011 yr)
Installation of geothermal heating with two-loop pipe work for 100 000 customers

Total project cost	32 million USD

Prime cost of geothermal heat	IRR	Annual net profit	Simple Payback
20,0 USD/MWh	-	5 million USD/yr	-

Table 5.10. Technical Economic Parameters of Tbilisi Geothermal supply project

As a conclusion, we can state that it is advisable to assess more closely the current condition of geothermal resources to achieve a better estimate of their potential and to reveal potential projects. At the same time there is a possibility to take more concrete steps for development of Tbilisi and Zugdidi-Tsaishi fields and implement profitable projects there.

Chapter 6
Valuation of Renewable Energy

6.1. Rationale for Renewable Energy Development

Renewable energy is often considered by policymakers and even by specialists as lying outside of the main stream of energy sector development and having only a secondary, supplemental role.

The arguments referred to in such an approach are that:

- the potential of renewable energy is of a much smaller scale,
- renewable energy is more expensive than that provided by traditional sources, and
- it takes large, administrative resources to develop RES.

Thus the time and effort is mostly devoted to large traditional projects.

The previous chapter has showed that the potential of RES is quite significant in Georgia. Here we would like to examine other arguments as well. The costs and expected benefits of RES development should be carefully examined in order to develop a rational RES strategy in the framework of a larger energy strategy for the country.

Along with pure economic criteria, the development of renewable sources is primarily motivated by:

- improved energy supply security,
- development of rural and remote areas,
- increased economic activity and employment opportunities, and
- reduced environmental impact.

In many cases the cheaper cost can be added as an additional benefit, especially for off-grid applications of renewable energy.

Below we will consider some of these issues.

6.2. The Costs of Renewable Energy

The single major cost component of renewable energy is capital cost. Fuel for renewable technologies (water, solar radiation, farming and forestry residues, geothermal water, etc.) is essentially free. The capital and O&M costs for various renewable and traditional electricity generation technologies are presented in Appendix 6.1. The comparison shows that the cost of installed capacity for wind generators at the capacity of 5 MW and higher are substantially less than that of small hydro power plants of comparable size.

Figures 6.1 – 6.3 present the costs of energy for various traditional and renewable energy generation technologies in 2004 and projected costs for 2015; the figures are taken from the World Bank REToolkit assessment of renewable technology costs.[1] The numbers shown represent the economic costs of electricity generated through various off-grid, mini-grid and grid-connected technologies. The costs of financing and taxes are not taken into account. The calculations are made for India which can be argued to correspond to costs in Georgia reasonably well. Along with the current costs, the projections through 2015 are made based on recent cost change trends and the maturity of certain technologies. Attention should be paid to capacity factors quoted alongside with technology capacities since this defines the cost of energy to a great extent.

Figure 6.1 shows that for capacities below 1 KW, pico hydro generation is the cheapest technology, while solar PV (photovoltaic) remains the most expensive source. However the solar PV panels have the advantage of depending only on solar radiation, and even the most expensive solar power remains competitive with engine generators.

While these comparisons are helpful in evaluating the cost-efficiency of a myriad of energy supply options, Section 6.3 will delve into external factors that also play a major role in determining the cost effectiveness of each energy generation option.

[1] http://web.worldbank.org/WBSITE/EXTERNAL/TOPICS/EXTENERGY/EXTRETOOLKIT/0,,
contentMDK:20794260~menuPK:2069844~pagePK:64168445~piPK:64168309~theSitePK:1040428,00.html

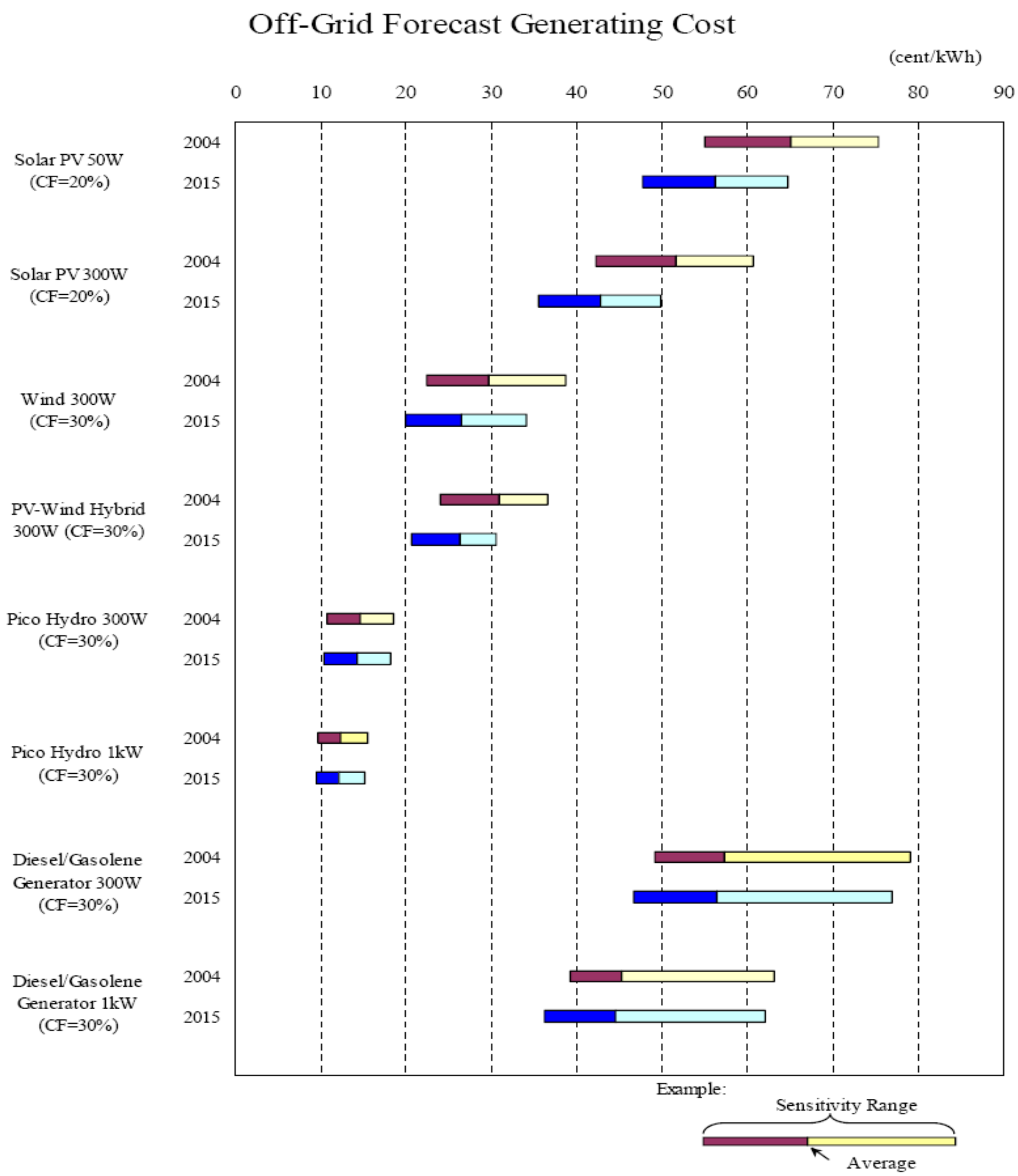


Figure 6.1. Electricity Costs: Off-Grid Generation Technologies (2004 & 2015)
Source: World Bank REToolkit

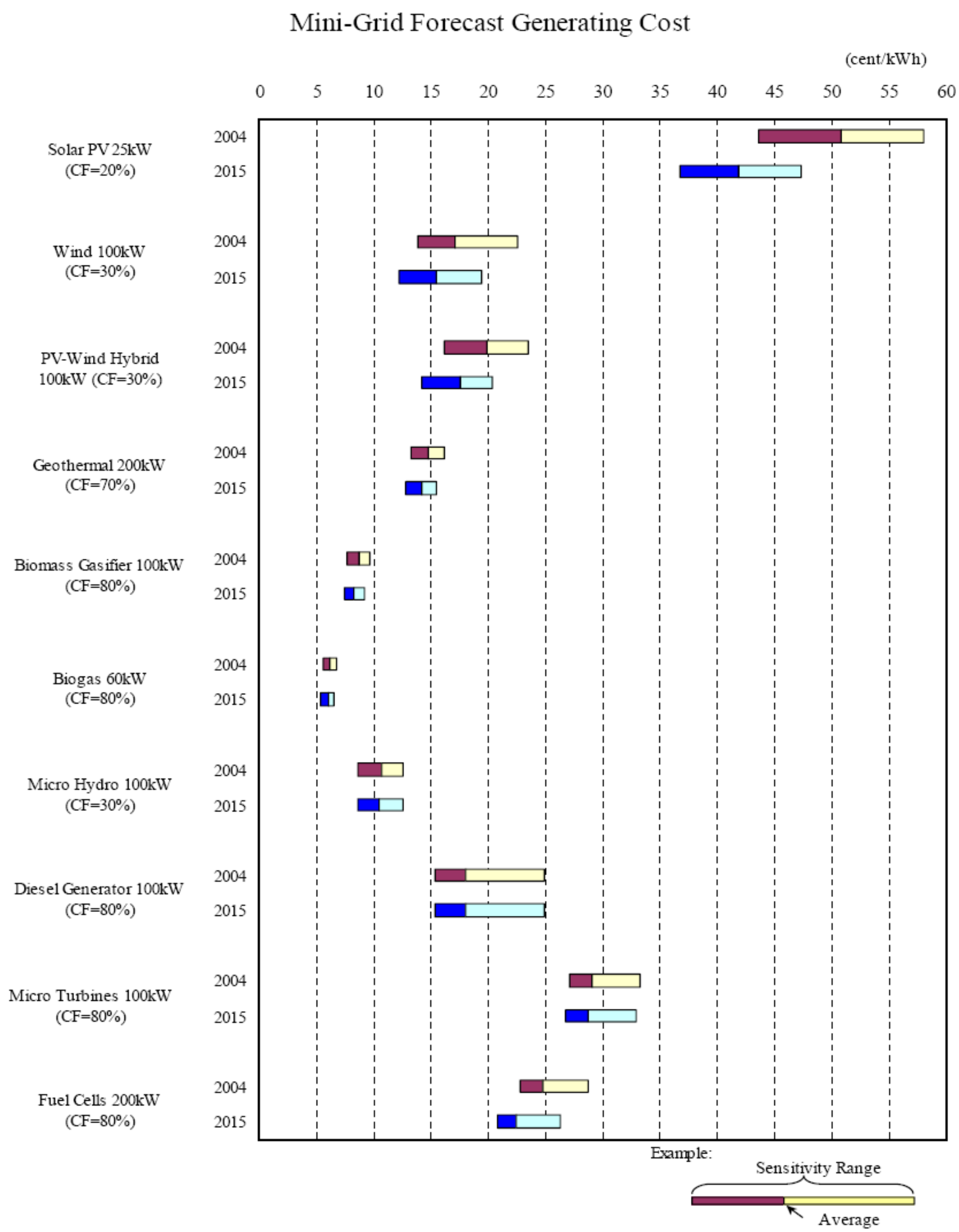


Figure 6.2. Electricity Costs : Mini-Grid Connected Generation Technologies (2004 & 2015)
Source: World Bank RETooIkit

In mini-grid applications, biogas generators are the leading price technology. The renewable technologies, including mini hydro, geothermal and small wind generators, remain more economical than diesel generators and micro-turbines.

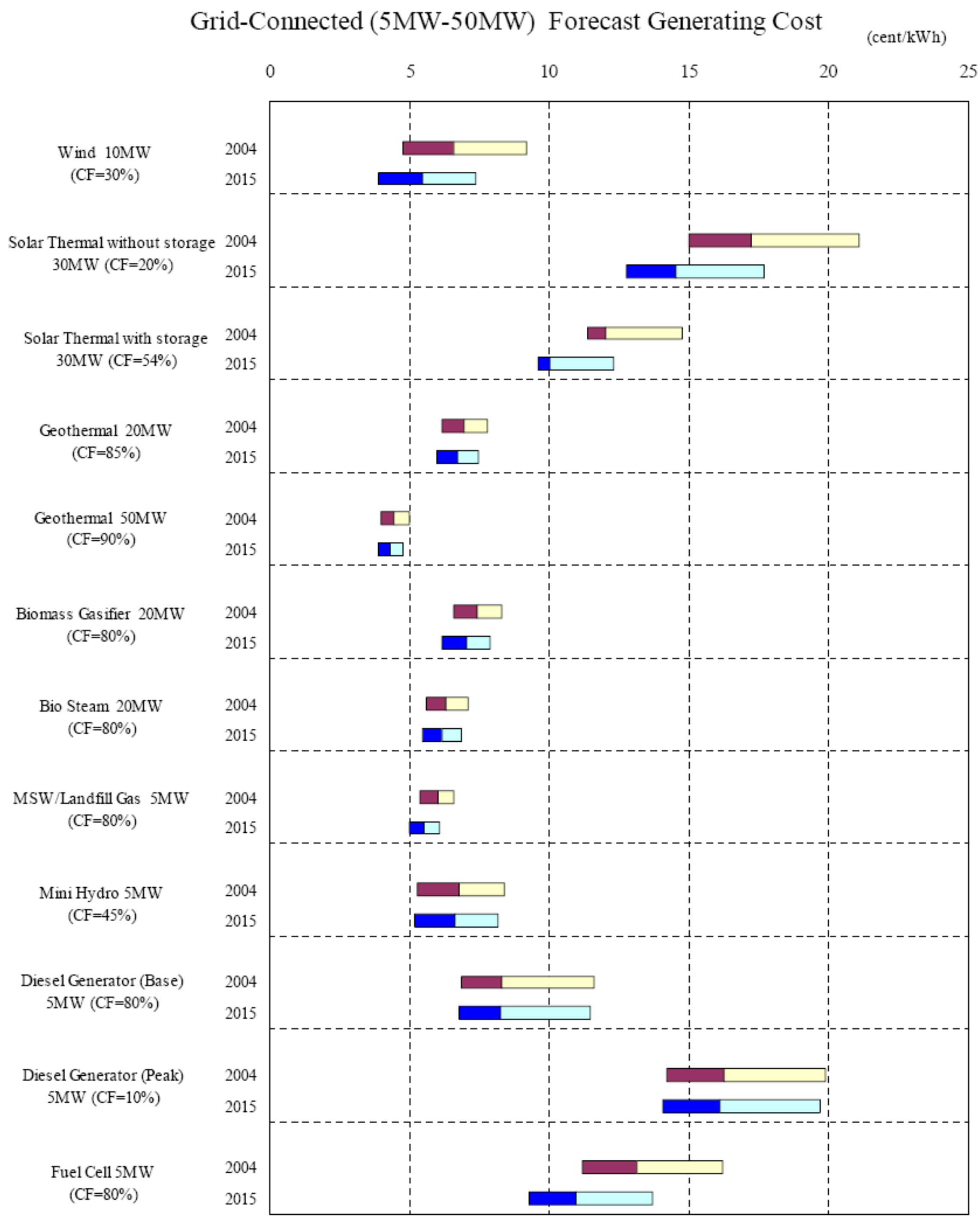


Figure 6.3. Grid-Connected Generation Technologies (2004 & 2015)
Source: World Bank RETookit

One can notice that in grid-connected applications, wind power is competitive with mini hydro power. Solar power remains the most expensive for all energy intervals.

6.3. Large Traditional Generation versus Renewable Energy Sources Generation: Accounting for Externalities

The decision to develop a particular renewable energy source is based largely on the cost of the technology; however as mentioned before, there are a variety of local and global external factors that may affect the final decision and justify the implementation of RES, even in case when the initial price seems high. The state may choose to provide incentives for development of specific renewable energy technologies or projects based on a variety of factors other than the base cost of energy production.

- The decision to develop RES is much more affected by local conditions than for larger traditional technologies. For instance, the existence or absence of an electricity or gas supply network, the availability of cheap energy resources or the existence of local guaranteed consumers can significantly affect whether investors or the state pursues the development of an energy supply option.

  With a more comprehensive accounting of external conditions, even the most expensive RES options can sometimes be more competitive than traditional energy generation sources; this reinforces how important it is to account for externalities.

Figure 6.4 shows the main factors that can have an impact on the penetration of renewable energy technologies.

- Although the cost of generation by existing or new plants of traditional technology can be less then that of RES, the latter may still be more competitive and suitable for supplying energy. This may happen in remote locations where there is no energy distribution network, or in cases where the cost of generation from renewable technologies is competitive with the grid tariff, that along with the cost of generation includes the costs of transmission, dispatch and distribution of energy. This is also one of the factors for development of distributed generation.
- Local conditions such as: the existence of local, guaranteed consumers, the possibility to develop additional local businesses (hotel etc.), eliminating environmental pollution (manure to be used in biomass energy generation), can add to the value of a renewable technology so that there will be a desire to pay a higher premium for resolving some local problems.
- Global external factors like the avoidance of greenhouse gas emissions can add to economic viability of more expensive renewable energy projects and thus expand the area of renewable energy development.
- Last but not the least are security considerations. Here, the country or a particular consumer may choose to pay an additional premium for the renewable energy

implementation in order to reduce the risk of energy supply termination or to reduce exposure to price increases and price volatility.

One or several of these factors can be important in each particular situation where investors or the state is considering how best to develop energy sources, and they are essential to consider when economically evaluating projects.

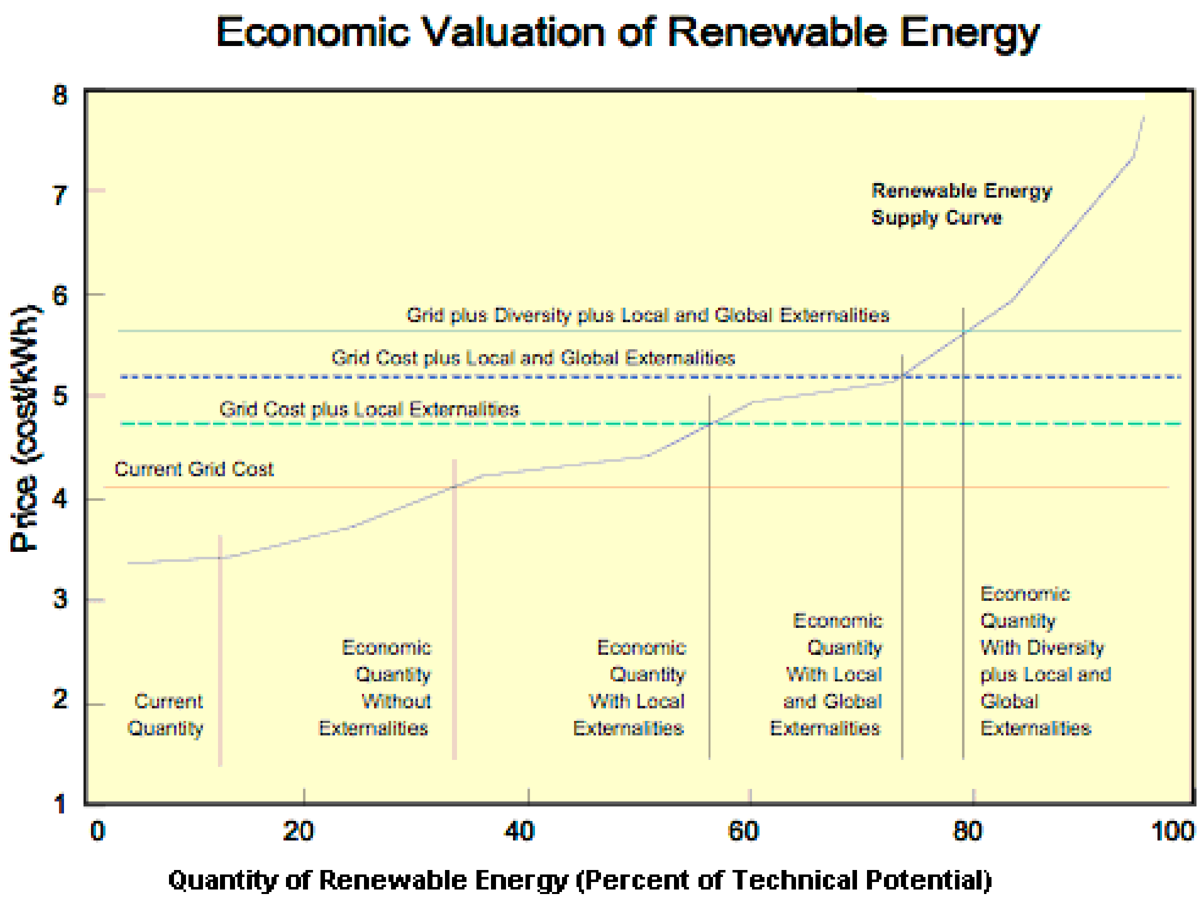


Figure 6.4. External factors affecting the price to be paid for RES.

Proper accounting for externalities may have a crucial effect on RES development. For instance, one can argue that mini-grid connected SHPPs and wind power generators should have the feed-in tariffs comparable to distribution tariffs in the area. Indeed they are doing the same job as transmission and distribution grids do, by delivering the power to local customer groups. They reduce the load on both transmission and distribution systems and reduce the need for their capital expansion in case of load growth. Thus a careful analysis may identify the value of feed-in tariffs that can guarantee both economic benefits for the whole society and financial viability of RES projects.

6.4. Contribution to Energy Security

Energy security is quite an important consideration for Georgia. As mentioned before about 70% of Georgia's Total Primary Energy Supply (TPES) and about 55% of energy use (without the transport sector) is coming from imported energy sources, primarily from natural gas.[2] Figure 6.5 shows the structure of energy supply by primary energy sources (excluding oil products).

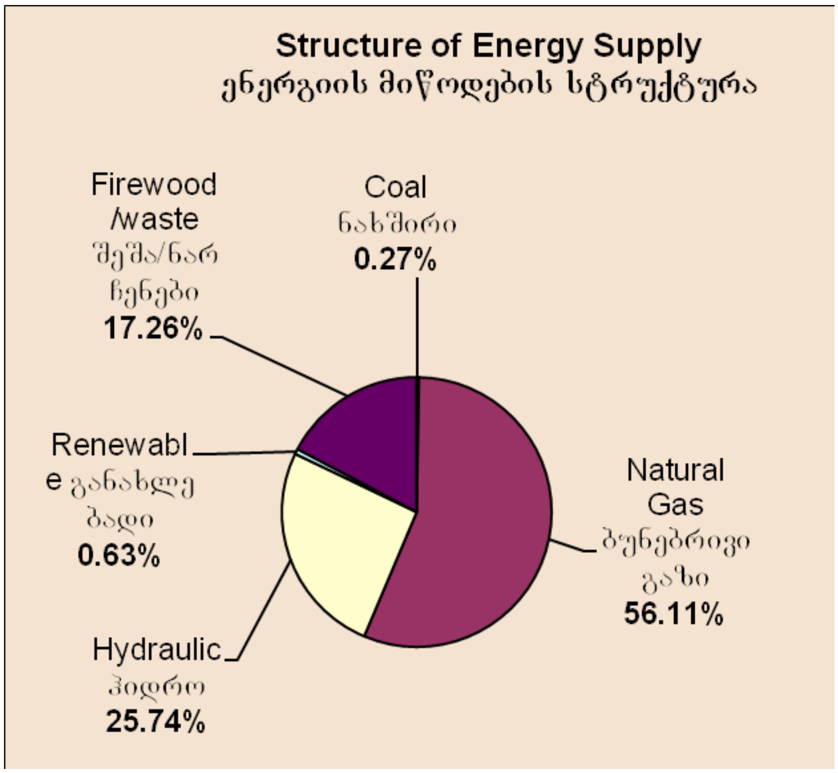


Figure 6.5. Structure of Georgia's energy supply.

Figure 6.6 shows the seasonal pattern of energy consumption in Georgia. As can be seen the natural gas is being imported throughout the year, however the volume of imports and correspondingly the degree of dependence on imports increases in winter months by almost four times the dependence in the summer period.

Thus the renewable energy sources that can offset natural gas imports, have the potential to contribute to improved energy security of the country throughout the year.

[2] The practice of recent years is to reduce the electricity imports to the level of swaps between summer and winter, thus instead of net import of electricity, more gas is imported to generate the needed electricity in Georgian thermal plants.

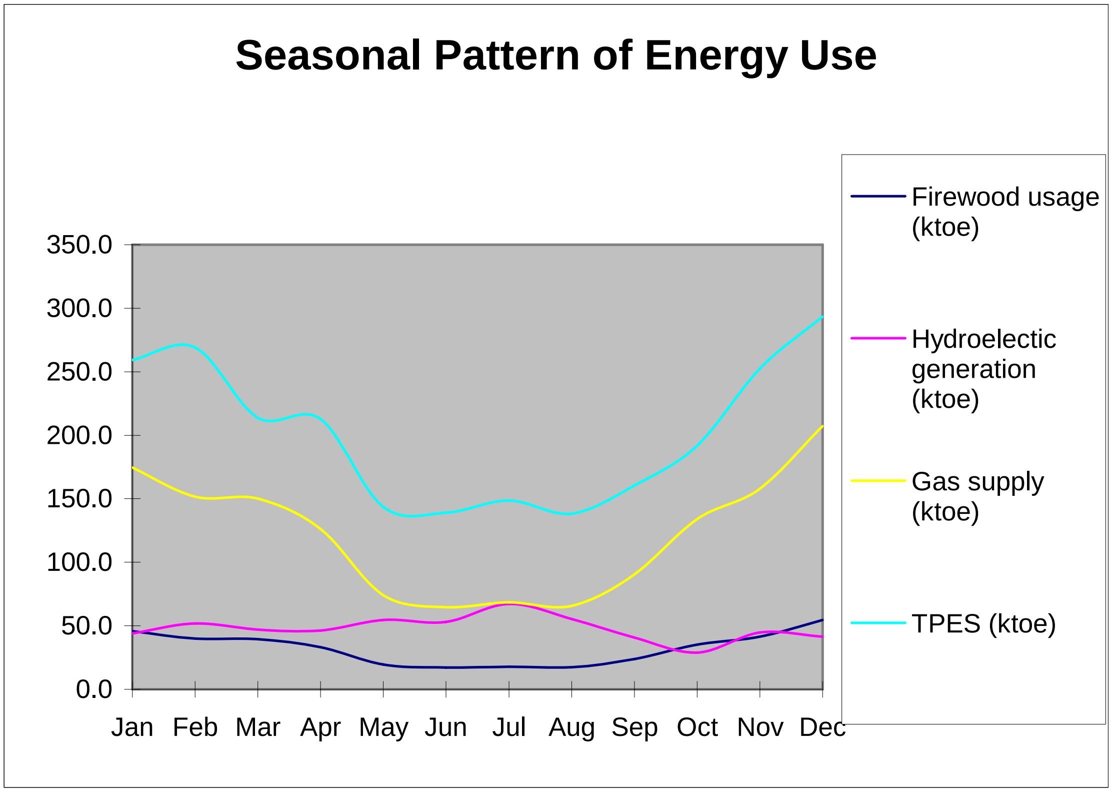


Figure 6.6. Seasonal pattern of energy use by type of energy source.

Figure 6.7 shows the annual patterns of electricity supply and demand in Georgia. Thermal generation using imported natural gas is needed only in the cold seasons of the year. In summer domestic hydro generation is sufficient for the country's needs and even significantly exceeds in-country demand. Thus, the country's electricity supply depends on external sources only in cold periods of the year. Correspondingly new RES generation can contribute to the country's energy security to the extent that it can replace the need for thermal generation in winter months. In summer the output of such a plant will add to the excess of electric energy from hydro plants and will require finding a market outside the country, as was done in 2007..

While there are no impediments to developing off-grid renewable energy sources, development of grid-connected electricity generation requires the same kind of support as traditional electricity generation. Namely there should be some kind of guaranteed market or power purchase agreements provided.

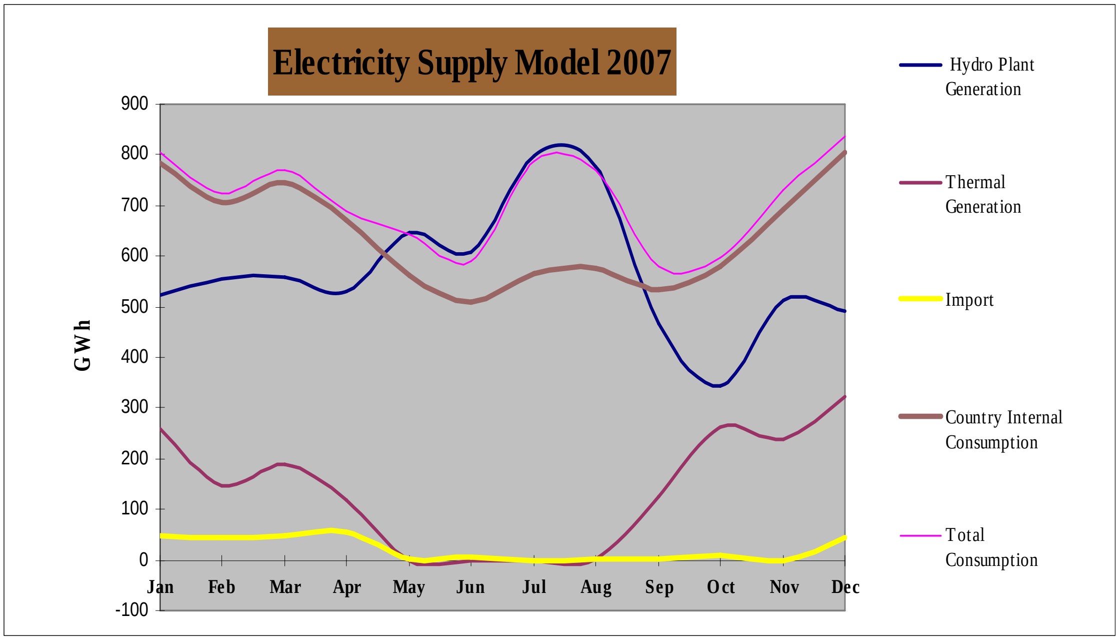


Figure 6.7. Electricity generation and consumption seasonal patterns in Georgia.

The seasonality of electricity supply and the country's demand pattern have a significant influence on the capacity of certain generation plants to contribute to Georgia's energy security. For illustration, Figure 6.8 depicts varying generation patterns of two different plants with the same total annual output.

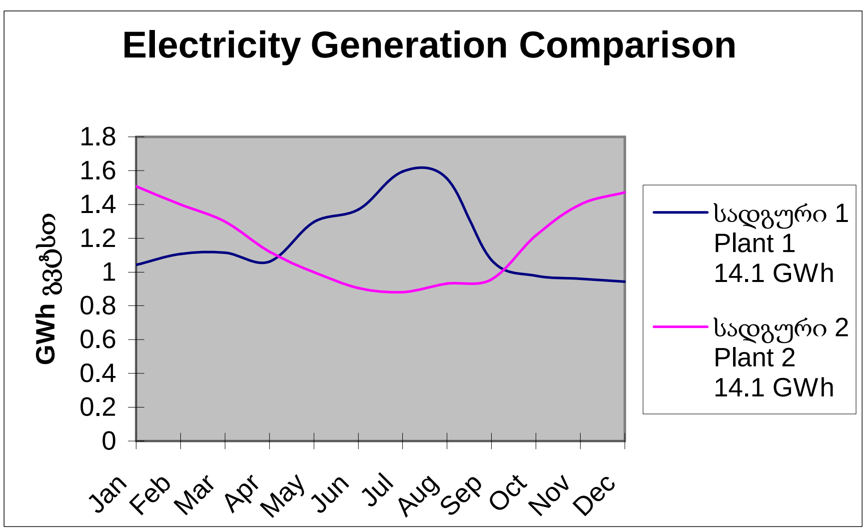


Figure 6.8. Comparison of two generation plants with different seasonal output patterns.

Although these two plants have the same total output, their generation differs significantly during the winter months. Thus the one with higher output in the cold seasons has the higher potential to contribute to energy security and higher potential to satisfy in-country demand.

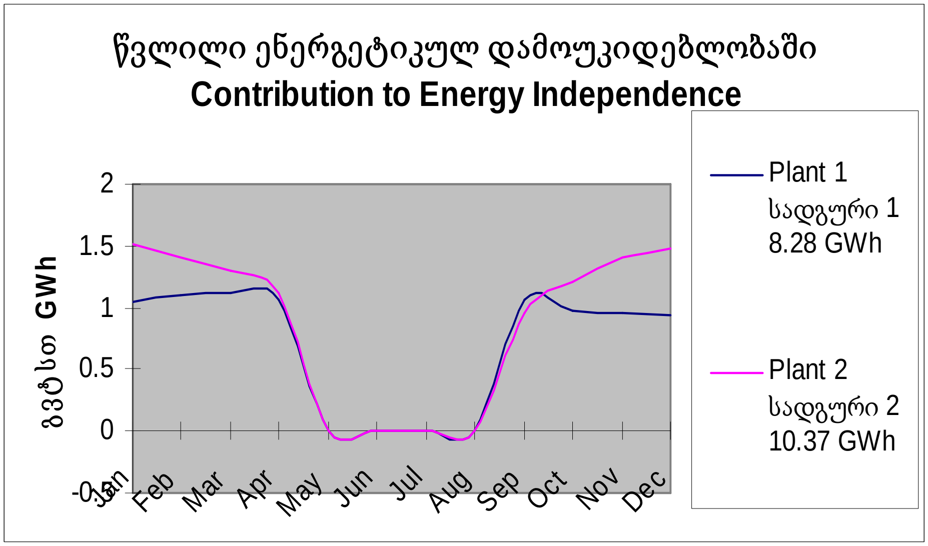


Figure 6.9. Comparison of the capacity of two plants to offset thermal generation.

It is clear from these graphs that the market will support the development of RES projects that have higher outputs during the cold seasons of the year. State policy should also give preference to such plants since they will make a larger contribution to Georgia's energy security.

As can be seen from the above analysis, although on average the large-scale traditional technologies may be cheaper, RES can be still play a valuable role in increasing Georgia's energy security. It is also remarkable that development of small-scale local RES does not require central planning or financing. These efforts are mostly done by local communities, particular energy users, or developers. Thus the state does not need to devote many administrative or financial resources; it just needs to remove various barriers and create a favorable environment for RES development to proceed.

Chapter 7
Conclusions and Recommendations

7.1. Prioritizing RES Development in Georgia

As discussed in the Introduction there are many misconceptions about renewable energy sources and their potential to meet the country's energy needs. Discussed in this report and summarized below, RES can make substantial contributions to Georgia's energy supply and do so affordably, reliably and easily. However, for RES development to expeditiously proceed in Georgia, the sector initially needs a favorable environment for investment. We conclude this report by reviewing the main obstacles to RES development in Georgia and how best to overcome them.

Renewable Energy Sources can comprise a large stake in Georgia's Total Primary Energy Supply. While the potential of renewable energy can be comparatively smaller on a site by site basis, the collective amount of energy that can be produced in Georgia is very significant. As discussed in detail throughout Chapter 5, there is sound scientific research documenting the vast renewable energy potential in Georgia. In total the estimated achievable RES potential in Georgia amounts to 10-15 terawatt hours (TWh) or equivalently 0.9-1.3 million tons of oil equivalent (MTOE) energy per year, which is about 30% of current Georgia's total primary energy supply. In contrast to traditional energy plants, RES can be developed step by step, by gradually increasing generation capacity to significant levels. Substantially lower lead-times allow RES to bring energy to the market quicker, compared to traditional energy sources.

Renewable Energy Sources can be price-competitive with traditional energy sources; as discussed in Chapter Six, RES can be more expensive than traditional energy sources on average, but specific conditions of each site as well as proper accounting for environmental external costs related to traditional energy sources can make RES a cheaper alternative for satisfying particular energy needs (in amount, capacity or security of supply).

Indeed, the traditional pricing of energy fails to take into account the true costs of its production. Most traditional energy sources produce significant amounts of carbon dioxide emissions contributing to global warming; these sources also produce pollutants such as sulfur dioxide and nitrous oxides during the combustion process, which adversely affects human health and the environment; it is also expensive to mitigate. Large hydro power plant construction can cause environmental damage to river ecosystems and contribute to the loss of arable land. Most renewable energy source projects avoid these adverse consequences and thus are not laden with hidden costs. In fact, the Clean Development Mechanism (CDM) is an economic tool developed and used by European Union to bring these unaccounted benefits of RES into the market place; in effect, the CDM's projects support the payment of a higher premium for cleaner energy, often making RES less expensive than traditional fossil-fuel based sources.

Despite the present pricing methodology, there are several instances where RES is actually cheaper than traditional energy sources. For instance, at higher capacities wind power is fully competitive with large hydro power and has the additional benefit of modularity. In areas of low population density far from urban centers, the maintenance and operation of the distribution system (the energy grid) comes at a considerable expense. These expenses and the costs of distributing electricity over longer distances are reflected in the final energy grid tariff and shared amongst a larger pool of consumers; however if these costs were not subsidized by the larger customer pool, RES would certainly be more competitive in these low-density, more rural areas.

Finally, RES can offer stability and reliability that the existing power system lacks. The US embassy is considering installing a wind turbine for supplemental power supply to balance the poor quality of power from the grid.

Looking around the corner, ongoing technological and production break-throughs, as well as the burgeoning price of fossil fuels, will most likely continue to improve the financial competitiveness of RES compared to traditional energy sources.

Creating a favorable investment environment can set Georgia on an easy, self-propelling RES development path. Developing renewable energy sources does not require government involvement in planning, funding, development or management. These are mostly the tasks of small enterprises, local municipalities or local communities. In this sense it is easier for government to develop RES than it is to develop traditional energy sources. What RES development does require is a favorable investment environment, and this environment is created with special legislation and a comprehensive state strategy. Moreover, off-grid RES technologies are even easier to support since they do not require specific instruments like tariffs, connection fees, central market development etc., and can be simply promoted through fiscal and financial incentives.

Right now, this favorable investment environment does not exist for RES in Georgia. This next section reviews key obstacles facing the RES sector and how Georgia can overcome them.

7.2. Main Barriers to RES Development

Georgia does not have programs or a developed strategy in place to jumpstart RES market development. These instruments should incorporate realistic numerical parameters for RES capacity and output and have clear and achievable benchmarks. The document of “Main Directions of State Policy in Energy Sector” provides some targets, but only for small hydro power and wind power development. Furthermore, these numbers are already outdated and need to be reviewed based on realistic assumptions and using sound planning methodology and analytical tools. Finally, given that the government is very keen to attract new investments, it would be very beneficial for a government program to provide information on RES possibilities and optimal locations.

In the electricity sector there have been attempts to promote the development of small hydropower plants through recent changes in the Law on Electricity and Natural Gas. However this advancement needs to be refined and expanded in order to form the comprehensive legislative and institutional framework necessary for developing Georgia's indigenous renewable energy sources.

Other main barriers for RES development are listed below.

- A lack of demand during the summer period is the biggest impediment for developing electricity from grid-connected RES. With the present conditions of excess hydropower in summer, the new small hydro power plants and wind farms will not be competitive with existing hydro generation.

- Insufficient organizational capacity devoted to RES development by the State does not allow for Georgia to properly address all the challenges facing RES development. To our knowledge there is no dedicated authorized group of people working on RES development strategy, plans or policy.

- The taxation system is no longer supportive of RES development. In 2005 Georgia abolished tax benefits for RES investment in the country's new tax code. Tax reductions or local tax exemptions are two very powerful economic tools that Georgia is currently under-utilizing to encourage RES development. The benefits brought to Georgia from increased energy security and cleaner domestic energy production can offset the temporary loss of tax revenue.

- The legal initiatives in support of RES introduced in various legal documents such as Electricity and Natural Gas Law, and Electricity Market Rules and State Energy Policy are welcome, but at the same time they are fragmentary and ambiguous. In order to be enforceable and effective these legal initiatives require more objective reasoning, harmonization with other legislation, and the development of proper implementation mechanisms.

- Public awareness on renewable energy potential and opportunities is low. There are very few information campaigns or analytical research projects underway that domestically promote RES.

7.3. Policy Recommendations for the Government of Georgia

Increased state involvement and activity are crucial factors in properly developing renewable energy sources in Georgia. The institutional and legal framework for RES development needs to be substantially reworked and in many respects created anew. Below are the primary ways the Government of Georgia can deliver this engagement and renewal.

- A comprehensive and sound state policy for renewable energy, with clearly defined priorities and quantitative targets, should be formulated. This will help to harmonize the current fragmentary steps for RES development and coordinate the efforts on:
    - cultivating the market for RES (especially electricity),
    - implementing tax benefits for RES,

  - providing information and technology support for RES developers,
  - harmonizing different parts of legislation for RES support,
  - coordinating the efforts of different donors, and
  - creating a department concerned with RES development issues.

- A Law on Renewable Energy Sources, consistent with state policy on the energy sector and the state strategy on RES development, providing for supportive institutional and legal environment for RES development should be formulated and ratified.

- A designated authority should be assigned and enabled to develop and implement the main directions of state RES policy.

In order to properly develop and utilize the significant potential offered by RES there is a need for prompt energetic and well-prepared comprehensive actions, which are subsequently detailed.

- <u>Tax benefits for RES should be implemented.</u> In cases where development of RES has proven to be of benefit for society, the tax burden should not be an impediment, preventing its development. Thus, tax benefits should be designed and implemented based on proper economic analysis including VAT exemption, accelerated depreciation, property and profit tax benefits, etc. As an option, the tax benefits on Renewable Energy and energy saving equipment and technologies existing before January 1, 2005 could be restored.

- <u>Develop long term tariff- and fee-setting methodology for grid-connected RES.</u> This should include clear rules and principles for determining long-term feed-in tariffs, grid connection fees, power transit fees, mini-grid and grid-connected RES.

- <u>Create a stable and predictable long-term mechanism for exporting the country's excess power in summer;</u> this is an important condition for developing grid-connected RES**.** To create a stable export market, the government can start by negotiating bilateral long-term agreements on electricity sales or seasonal swaps; eventually these trading arrangements should develop into a Regional Energy Market. Electricity System Commercial Operator (ESCO) or another designated entity shall be assigned to purchase electricity and organize the export and seasonal exchange of this electricity.

- <u>Undertake long-term energy planning.</u> Development of RES is closely related to the development of the rest of energy sector. In order for the state policy on renewable energy sources to be efficient there is a need to develop general policy and a long-term development plan for the energy sector, based on sound economic and technical principles.

- <u>Strengthen the coordinated use of international resources for development of RES.</u> Several international organizations have special carbon emission credit programs, like the Clean Development Mechanism, that can be used to finance or secure favorable loan rates for RES project implementation. The various donor initiatives should be coordinated with RES state strategy.

- Cultivate information and awareness. The level of public awareness of renewable energy technologies is insufficient. A series of national information campaigns should be prepared to overcome this problem. These campaigns should include information on simple applications of renewable energy sources (e.g. efficient stoves, solar panels), existing financial instruments, and state concessions (e.g. available loans, and tax benefits). Special training programs should be developed; practical trainings and local demonstrations implemented, and energy consulting centers should be established in the regions.

- Stricter environmental legislation on waste disposal and recycling should be introduced that would forbid environmental contamination of waste streams with biological residues, and thus promote the development of biomass usage for energy purposes.

- Clear and simple procedures for RES project approval, construction, and land and water use permits should be introduced.

- Harmonize Georgia's legislation including energy-related laws and regulations, the tax code and other legal documents within the framework of Georgia's RES development strategy. As a first step the government should: improve and harmonize the terminology in different legislative documents; clarify the provisions for small hydro power in the Electricity and Gas Law and in the Market Rules; and make these two documents clear and consistent with each other and with the renewable energy strategy.

7.4. Recommendations for Further Policy Research

The current study is not a comprehensive policy research document. The development of proper RES strategy and policy requires further economic and technical research in many issues mentioned above.

The analytical methods and tools should be developed for:

- long term planning,
- transmission tariff- and connection-fee setting,
- economic analysis of feed-in tariffs,
- differential tariff setting for mini-grid and grid-connected small hydro and wind power plants, etc.,
- the economic justification of tax incentives, and
- the economic assessment of mandatory regulations for using RES (e.g. solar collectors for new building construction).

These and some other important issues are not covered in the present report.

The analytical work should be followed by internal discussions with the participation of relevant officials from the Ministry of Energy, Ministry of Environment, GNERC and other official structures in order to define the proper course of actions for development of RES policy.

Other specific research activities for developing background information necessary for policy making include:

- a study of solar potential in Georgia,
- an accurate energy balance of Georgia including reliable statistics of wood consumption,
- a study of current conditions of geothermal resources including the business, feasibility of expanding geothermal usage, and
- a study of the potential for fuel production from farming energy crops.

Appendices

Appendix 11.

Power Generation Technology Capital Cost Projections

World Bank – Renewable Energy Toolkit

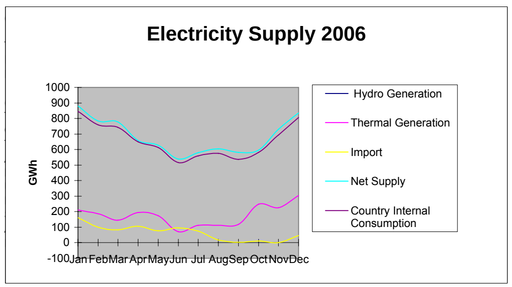
Appendix1

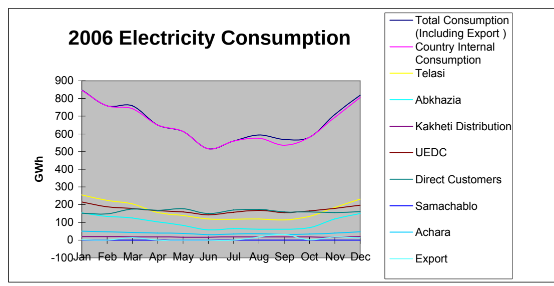
Electricity Supply, 2006

(GWEM/ESCO d	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Sum
Hydro Generatio	506,898,490	495,645,611	549,433,305	358,546,919	376,009,041	370,335,195	393,482,209	475,614,208	460,310,163	338,102,281	505,674,793	485,999,901	**5,316,052,116**
Thermal Generati	211,122,449	187,234,606	144,593,459	194,186,121	174,957,547	71,570,301	112,808,192	112,476,414	117,717,311	248,214,022	224,816,910	304,103,822	**2,103,801,154**
Import	162,137,745	100,701,020	84,238,239	106,316,362	77,015,908	95,927,357	74,486,802	16,658,400	3,761,036	10,747,532	104,227	45,474,014	**777,568,642**
Net Supply=Gene	**880,158,684**	**783,581,237**	**778,265,003**	**659,049,402**	**627,982,496**	**537,832,853**	**580,777,203**	**604,749,022**	**581,788,510**	**597,063,835**	**730,595,930**	**835,577,737**	**8,197,421,912**

Electricity Consumption, 2006

(GWEM data), m	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Sum
Total Consumption (Including Export)	**847,260,871**	**758,561,181**	**757,953,320**	**649,161,919**	**613,532,843**	**516,275,176**	**559,764,075**	**594,075,229**	**567,689,209**	**581,746,081**	**710,317,358**	**819,195,655**	**7,975,532,917**
Country Internal Consumption=Total Consumption-Export-Transmission Losses)	**846,064,113**	**758,561,181**	**743,097,472**	**649,161,919**	**613,532,843**	**516,275,176**	**559,764,075**	**575,857,372**	**536,258,604**	**581,187,831**	**693,094,737**	**806,599,608**	**7,879,454,931**
Telasi	254,679,874	223,792,758	203,453,009	154,821,155	139,839,914	120,090,107	117,593,621	119,260,634	113,129,935	134,307,560	183,778,989	231,127,189	**1,995,874,745**
Abkhazia	153,225,144	133,991,134	124,183,721	102,477,564	83,728,166	58,388,577	64,216,261	60,894,598	60,809,288	69,998,720	118,955,860	150,805,582	**1,181,674,615**
Kakheti Distributi	19,666,043	19,232,427	18,263,781	17,638,270	16,324,672	15,996,829	16,952,488	18,396,827	17,251,056	17,602,794	16,334,182	19,046,514	**212,705,883**
UEDC	215,968,888	187,261,215	179,258,488	166,307,964	159,445,100	142,352,808	156,831,260	168,475,033	154,766,503	165,258,513	179,233,103	197,834,792	**2,072,993,667**
Direct Customers	151,550,897	148,149,997	174,718,697	168,411,356	177,379,625	149,234,367	170,630,878	172,653,960	158,420,555	159,402,705	155,385,731	161,022,084	**1,946,960,852**
Samachablo	0	0	0	0	0	0	0	0	0	0	0	0	**-**
Achara	50,973,267	46,133,650	43,219,776	39,505,610	36,815,366	30,212,488	33,539,567	36,176,320	31,881,267	34,617,539	39,406,872	46,763,447	**469,245,169**
Export	1,196,758	0	14,855,848	0	0	0	0	18,217,857	31,430,605	558,250	17,222,621	12,596,047	**96,077,986**
Transmission loss	**32,897,813**	**25,020,056**	**20,311,683**	**9,887,483**	**14,449,653**	**21,557,677**	**21,013,128**	**10,673,793**	**14,099,301**	**15,317,754**	**20,278,572**	**16,382,082**	**221,888,995**





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Electricity Supply, 2006

No.	(GWEM data), m	January	February	March	April	May	June	July	August	September	October	November	December	Sum
	GENERATION													
	Generation of Hy	**506,898,490**	**495,645,611**	**549,433,305**	**358,546,919**	**376,009,041**	**370,335,195**	**393,482,209**	**475,614,208**	**460,310,163**	**338,102,281**	**505,674,793**	**485,999,901**	**5,316,052,116**
1	Enguri	206,593,234	190,565,288	171,065,925				50,517,716	249,403,262	254,501,952	105,038,109	217,318,202	207,106,935	**1,652,110,623**
2	Vardnili	46,676,976	38,639,335	31,985,222	21,871,080	22,871,904	11,586,960	18,101,424	39,330,588	39,184,860	20,420,532	30,197,112	42,305,604	**363,171,597**
3	Khrami 1	32,618,111	50,216,943	48,328,236	38,571,583	28,001,950	26,545,525	19,507,326	17,971,169	12,059,700	19,141,565	14,911,167	26,817,315	**334,690,590**
4	Khrami 2					4,273,837	28,496,343	25,346,720	20,747,642	16,335,311	17,349,606	2,353,349	3,300,838	**118,203,646**
5	Shaori	7,152,600	6,208,900	7,333,600	10,560,415	6,702,100	2,489,900	5,573,164	185,991			1,948,877	18,873,600	**67,029,147**
6	Dzevruli	15,963,708	7,274,146	6,158,657	12,801,396	11,912,414	10,883,758	6,541,706	3,805,051	705,782		504,931	7,774,167	**84,325,716**
7	Moonlake Georg	3,644,608	1,372,934	1,245,424	2,959,944	3,026,019	4,336,776	2,448,354	699,497	94,961			2,343,137	**22,171,654**
8	Jinvali	48,968,132	42,561,890	41,981,632	44,928,800	50,444,192	52,349,878	41,890,736			1,192,252	32,543,806	33,494,166	**390,355,484**
1	Vartsikhe	48,556,332	70,080,841	85,453,288	74,436,276	76,897,519	71,464,122	64,134,681	40,390,573	33,864,337	42,739,165	60,504,119	52,541,159	**721,062,412**
2	Rioni	20,273,638	21,873,331	25,402,068	24,972,905	26,054,026	25,239,726	26,434,315	24,195,677	23,375,264	25,194,608	25,748,092	21,709,653	**290,473,303**
3	Gumati	12,263,326	10,384,839	22,354,033	22,986,363	21,674,506	25,633,927	25,294,307	15,943,226	13,827,455	17,842,713	19,786,081	12,237,329	**220,228,105**
4	Lajanuri	10,100,560	7,239,409	26,748,002	16,216,716	34,123,187	38,282,790	35,399,862	22,634,495	16,813,703	22,423,013	33,077,638	11,635,204	**274,694,579**
5	Bjuja	1,786,218	1,549,926	4,036,830	7,430,640	8,662,374	4,772,334	3,911,292	1,590,960	3,028,536	3,657,318	4,085,634	2,322,012	**46,834,074**
6	Alazani	2,133,914	1,012,471	-	-	-	1,317,629	76,262	632,002	356,515	-	-	-	**5,528,793**
7	Atshesi	4,681,339	6,620,312	9,681,274	9,428,893	9,682,971	3,441,960	5,418,015	1,207,011	2,778,756	3,985,548	7,010,064	7,009,404	**70,945,547**
8	Chitakhevi	8,229,960	7,632,740	10,982,280	10,421,380	10,853,660	9,149,720	9,762,140	7,180,820	7,301,020	9,045,200	8,653,320	7,620,860	**106,833,100**
9	Zahesi	14,306,889	12,114,071	23,523,415	21,913,798	20,316,994	10,935,079	11,878,140	4,422,871	5,989,193	10,195,368	12,074,888	11,312,809	**158,983,515**
10	Ortachala	7,665,840	7,176,600	11,226,960	9,435,240	9,602,280	9,144,720	7,475,760	3,271,320	3,728,520	6,154,200	7,097,400	6,595,560	**88,574,400**
11	Martkopi	478,132	352,333	432,793	380,207	215,783	343,014	441,447	370,844	880,509	1,127,692	966,500	-	**5,989,254**
12	Sioni	2,423,627	2,161,492	1,900,520	2,000,811	2,320,708	3,737,429	3,853,277	4,173,389	2,971,877	2,202,703	465,205	-	**28,211,038**
13	Tetrikhevi	3,009,912	2,264,696	2,799,655	2,047,812	985,718	2,098,906	2,515,138	1,573,086	2,961,268	4,265,026	3,791,580	32,116	**28,344,913**
14	Satskhenisi	4,722,703	3,810,432	4,219,547	3,364,364	1,622,465	4,065,180	4,703,069	2,186,519	4,538,508	6,194,799	5,366,526	93,304	**44,887,416**
15	Xadori	-	372,632	6,617,002	15,297,923	19,009,796	18,209,466	16,189,111	9,341,894	10,427,384	14,095,550	11,334,585	6,305,245	**127,200,588**
1	Abhesi	215,333	188,513	164,732	153,263	152,611	123,809	150,785	127,114	113,223	121,923	135,491	142,346	**1,789,143**
2	AlgeTi	-	-	-	-	-	-	280,940	477,424	591,096	434,920	155,348	-	**1,939,728**
3	Chalahesi	308,400	405,600	564,800	497,600	222,600	18,200	45,000	24,000	20,244	99,552	259,936	95,464	**2,561,396**
4	Ckhorhesi	390,629	68,474	480,329	1,129,984	1,165,834	1,011,264	919,529	270,426	343,464	290,789	-	-	**6,070,722**
5	Dashbashi	512,422	574,598	539,114	600,761	698,724	710,771	706,853	552,776	289,845	249,329	242,638	270,162	**5,947,993**
6	Intsobahesi (feri)	73,000	51,300	310,062	427,039	413,665	443,608	389,476	267,655	296,110	302,606	318,046	172,894	**3,465,461**
7	Kabalhesi	137,352	256,280	245,648	-	225,892	-	-	-	-	-	-	-	**865,172**
8	Kakharetihesi	-	-	-	-	-	-	-	-	-	-	-	-	**-**
9	Mashaverahesi	-	-	-	-	-	-	-	-	-	77,626	188,288	185,825	**451,739**
10	Misaqcieli ento	474,387	384,156	237,785	355,918	395,017	329,576	345,632	435,838	445,901	400,104	407,892	524,459	**4,736,665**
11	Ritseulahesi	1,864,170	1,471,217	2,528,428	2,477,559	2,507,155	2,255,785	2,316,377	1,285,809	1,548,589	2,205,448	2,408,595	1,546,503	**24,415,635**
12	Squrhesi	117,846	90,541	80,189	71,889	76,653	125,906	131,059	119,408	128,781	156,471	205,906	155,343	**1,459,992**
13	Tiriphonhesi	-	-	-	-	-	-	46,221	335,188	475,503	662,319	896,966	615,181	**3,031,378**
14	KHertvisihesi	44,738	45,840	50,735	58,325	75,698	80,630	70,616	78,751	54,014	55,352	31,666	-	**646,365**
15	Machakhelahesi (t	480,000	596,550	714,270	708,825	744,435	647,580	580,260	374,205	-	583,965	631,770	775,665	**6,837,525**
16	Kekhvihesi	-	-	-	-	-	-	-	-	232,358	162,510	9,216	5,524	**409,608**
17	Kazbegihesi	30,454	26,981	40,850	39,210	76,354	62,924	85,499	7,727	29,852	6,600	19,315	35,782	**461,548**
18	Energetiki	-	-	-	-	-	-	-	-	15,772	27,800	24,644	44,336	**112,552**
	Generation of Th	**211,122,449**	**187,234,606**	**144,593,459**	**194,186,121**	**174,957,547**	**71,570,301**	**112,808,192**	**112,476,414**	**117,717,311**	**248,214,022**	**224,816,910**	**304,103,822**	**2,103,801,154**
1	Mtkvari	138,239,015	148,448,520	58,436,164	130,612,678	141,446,498	1,503,513			72,431,630	153,993,181	145,137,855	159,200,429	**1,149,449,483**
2	Tbilsresi	72,883,434	38,786,086	81,445,885	55,506,274	27,863,429	36,171,498	71,758,502	77,424,474	111,981	44,821,821	48,171,315	108,963,093	**663,907,792**
3	Air Turbine (Energy Invest)			4,711,410	8,067,169	5,647,620	33,895,290	41,049,690	35,051,940	45,173,700	49,399,020	31,507,740	35,940,300	**290,443,879**
	Country Internal	**718,020,939**	**682,880,217**	**694,026,764**	**552,733,040**	**550,966,588**	**441,905,496**	**506,290,401**	**588,090,622**	**578,027,474**	**586,316,303**	**730,491,703**	**790,103,723**	**7,419,853,270**
	Total Import	**162,137,745**	**100,701,020**	**84,238,239**	**106,316,362**	**77,015,908**	**95,927,357**	**74,486,802**	**16,658,400**	**3,761,036**	**10,747,532**	**104,227**	**45,474,014**	**777,568,642**
	Including:													-
1	*Armenia*	*58,007,218*	*67,305,789*	*57,135,007*	-	-	-	*3,299,789*	-	-	-	-	-	*185,747,803*
	trl Alaverdi	48,943,772	61,992,379	57,135,007	-	-	-	3,299,789	-	-	-	-	-	171,370,947
	trl Ninotsminda	6,626,756	3,362,627	-	-	-	-	-	-	-	-	-	-	9,989,383
	trl Lalvari	2,436,690	1,950,783	-	-	-	-	-	-	-	-	-	-	4,387,473
2	*Russia*	*71,360,091*	*21,472,790*	*23,501,430*	*98,580,050*	*71,148,041*	*83,202,433*	*66,826,305*	*16,658,400*	*2,054,316*	*10,747,532*	-	-	*465,551,388*
	trl Kavkasioni	47,392,773	13,875,784	20,658,678	62,540,788	45,107,081	41,036,353	34,301,505	-	2,054,316	10,747,532	-	-	277,714,810
	trl Salxino	22,419,408	7,144,896	2,842,752	36,039,262	26,040,960	42,166,080	32,524,800	16,658,400	-	-	-	-	185,836,558
	trl Dariali	1,547,910	452,110	-	-	-	-	-	-	-	-	-	-	2,000,020
3	*Azerbaijan*	*4,084,403*	-	-	-	-	-	-	-	*1,706,720*	-	*104,227*	*13,712,391*	*19,607,741*
	trl Gardabani	4,084,403	-	-	-	-	-	-	-	-	-	-	-	4,084,403
	trl Gard paral	-	-	-	-	-	-	-	-	1,706,720	-	104,227	13,712,391	15,523,338
4	*Turkey*	*28,686,033*	*11,922,441*	*3,601,802*	*7,736,312*	*5,867,867*	*12,724,924*	*4,360,708*	-	-	-	-	*31,761,623*	*106,661,710*
	trl Achara	28,686,033	11,922,441	3,601,802	7,736,312	5,867,867	12,724,924	4,360,708	-	-	-	-	31,761,623	106,661,710
	Import+ Internal	**880,158,684**	**783,581,237**	**778,265,003**	**659,049,402**	**627,982,496**	**537,832,853**	**580,777,203**	**604,749,022**	**581,788,510**	**597,063,835**	**730,595,930**	**835,577,737**	**8,197,421,912**

Electricity Consumption, 2006
(GWEM data), mln.kwt.h

CONSUMPTION

No		January	February	March	April	May	June	July	August	September	October	November	December	Sum
	Distribution Com	**478,544,328**	**423,149,969**	**389,120,287**	**314,442,599**	**276,708,118**	**224,688,001**	**232,301,937**	**234,728,379**	**223,071,546**	**256,526,613**	**358,475,903**	**447,742,732**	**3,859,500,412**
1	Abkhazia	153,225,144	133,991,134	124,183,721	102,477,564	83,728,166	58,388,577	64,216,261	60,894,598	60,809,288	69,998,720	118,955,860	150,805,582	**1,181,674,615**
2	Samachablo													-
3	Achara	50,973,267	46,133,650	43,219,776	39,505,610	36,815,366	30,212,488	33,539,567	36,176,320	31,881,267	34,617,539	39,406,872	46,763,447	**469,245,169**
4	Telasi	254,679,874	223,792,758	203,453,009	154,821,155	139,839,914	120,090,107	117,593,621	119,260,634	113,129,935	134,307,560	183,778,989	231,127,189	**1,995,874,745**
5	Kakheti distributic	19,666,043	19,232,427	18,263,781	17,638,270	16,324,672	15,996,829	16,952,488	18,396,827	17,251,056	17,602,794	16,334,182	19,046,514	**212,705,883**
6	UEDC	215,968,888	187,261,215	179,258,488	166,307,964	159,445,100	142,352,808	156,831,260	168,475,033	154,766,503	165,258,513	179,233,103	197,834,792	**2,072,993,667**
	Direct Customer	**151,550,897**	**148,149,997**	**174,718,697**	**168,411,356**	**177,379,625**	**149,234,367**	**170,630,878**	**172,653,959**	**158,420,555**	**159,402,705**	**155,385,731**	**161,022,084**	**1,946,960,851**
1	Phero	55,378,287	58,796,296	70,279,138	67,496,963	68,979,112	59,594,786	63,823,911	61,781,814	52,799,263	47,073,306	48,191,493	48,223,898	**702,418,267**
2	Chiatur Manganes	2,998,730	2,552,118	3,306,137	3,211,406	3,279,878	3,018,617	3,153,980	3,348,253	3,332,405	3,598,582	3,571,780	3,639,831	**39,011,717**
3	Georgian Manganese													-
4	Kaspicementi	5,232,592	5,671,794	5,571,893	5,933,471	6,961,408	6,589,013	7,097,482	7,584,688	6,724,578	7,559,249	7,602,458	8,175,387	**80,704,013**
5	Rustavcementi	3,415,952	1,904,779	4,259,413	6,248,760	5,864,165	6,022,665	6,261,824	7,081,067	5,848,714	6,484,781	6,461,429	5,548,751	**65,402,300**
6	Madneuli	4439546	3946422	4482165	3499352	4248415	4197380	4775915	5126511	5192053	5706291	5811003	6100500	**57,525,553**
7	Energy Invest	17,669,099	16,979,334	23,263,321	22,744,594	24,526,642	11,462,802	24,817,062	25,260,006	23,286,489	24,994,261	22,641,365	23,953,239	**261,598,214**
8	Metro	5,904,661	5,479,013	5,822,480	5,304,761	5,348,491	5,163,765	4,905,617	4,806,426	4,890,889	5,358,347	5,528,893	5,899,779	**64,413,122**
9	Street Lighting	3,057,131	2,200,998	2,580,434	2,140,446	2,036,116	1,882,066	1,807,001	1,932,030	2,309,958	2,807,367	3,171,208	3,575,405	**29,500,160**
10	Tbilisi Water	27,194,830	25,011,682	27,179,862	24,106,639	27,623,378	26,769,681	28,011,566	28,073,408	26,432,688	27,415,840	25,475,993	25,603,704	**318,899,271**
11	Railway	26,260,069	25,607,561	27,973,854	27,724,964	28,512,020	24,533,592	25,976,520	26,576,387	26,563,856	27,656,035	26,530,495	30,127,995	**324,043,348**
														-
1	Railway (sacxenicy) o/c													-
2	Mtkvari o/c								672,319	241,405				**913,724**
3	Tbilsresi o/c									236,420	219,548	199,058		**655,026**
4	Tb. Water (Jin) s/m								411,050	520,030	365,400			**1,296,480**
5	Tb. Water (Tetr) o/c												82,346	**82,346**
6	Shaori HPP o/c									36,161	109,299	81,776		**227,236**
7	Dzevrula HPP o/c										50,345	63,725		**114,070**
8	Rusmetal (sion) o/c												35,533	**35,533**
9	Chkhorocku HPP o/c											37,226	37,122	**74,348**
10	Alazani HPP o/c											8,204	5,515	**13,719**
11	Martkopi HPP o/c												1,590	**1,590**
12	Kabali HPP o/c									2,286	4,054	9,625	11,489	**27,454**
13	Machakhela HPP o/c									3,360				**3,360**
14	Rusenergo Trans.l/c													-
	Sum	**630,095,225**	**571,299,966**	**563,838,984**	**482,853,955**	**454,087,743**	**373,922,368**	**402,932,815**	**407,382,338**	**381,492,101**	**415,929,318**	**513,861,634**	**608,764,816**	**5,806,461,263**
	Total Export	**1,196,758**	**-**	**14,855,848**	**-**	**-**	**-**	**-**	**18,217,857**	**31,430,605**	**558,250**	**17,222,621**	**12,596,047**	**96,077,986**
	Including													-
1	*Russia*									10,150	558,250			**568,400**
2	*Turkey*								9,235,257	31,253,310				**40,488,567**
3	*Azerbaijan*	1,196,758		2,887,645										**4,084,403**
4	*Azerbaijan (par)*			11,968,203					8,982,600	167,145		17,222,621	12,596,047	**50,936,616**
	Net Consumption	**631,291,983**	**571,299,966**	**578,694,832**	**482,853,955**	**454,087,743**	**373,922,368**	**402,932,815**	**425,600,195**	**412,922,706**	**416,487,568**	**531,084,255**	**621,360,863**	**5,902,539,249**
														-

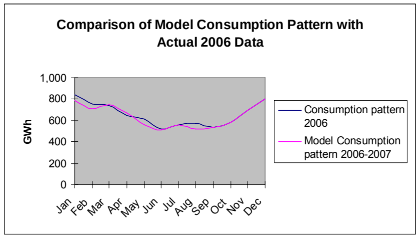
Dynamics of Electricity Balance 2000-2006

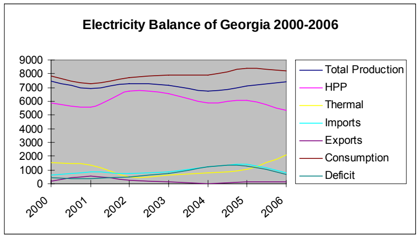
	2000	2001	2002	2003	2004	2005	2006
Total Production	7446	6942	7256	7163	6706	7100	7419.9
HPP	5905.6	5571.5	6742.9	6527.9	5892.9	6070	5316
Thermal	1540.4	1370.5	513.5	635.1	813.2	1030.6	2103.8
Imports	611.5	877.6	713.2	844.2	1210	1399	777.6
Exports	210.5	523.3	244.5	109.3	-	120	96
Consumption	7847	7296.3	7724.7	7898	7916	8379	8197.4
Deficit	401	354.3	468.7	735	1210	1279	681.6

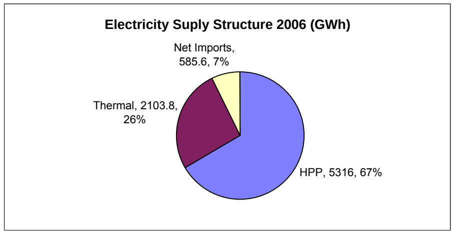
	2000	2001	2002	2003	2004	2005	2006
Total Production	7446	6942	7256.4	7163	6706.1	7100.6	7419.9
HPP	5905.6	5571.5	6742.9	6527.9	5892.9	6070	5316
Thermal	1540.4	1370.5	513.5	635.1	813.2	1030.6	2103.8
Imports	611.5	877.6	713.2	844.2	1210	1399	777.6
Exports	210.5	523.3	244.5	109.3	0	120	96
Consumption	7847	7296.3	7725.1	7897.9	7916.1	8379.6	8197.4
Net Imports	401	354.3	468.7	735	1210	1279	681.6

HPP	5316
Thermal	2103.8
Net Imports	585.6

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	
Consumption pa	846	759	743	649	614	516	560	576	536	581	693	807	7,879
Model Consump	784	706	746	671	563	508	559	520	535	580	693	806	7,672,655,702







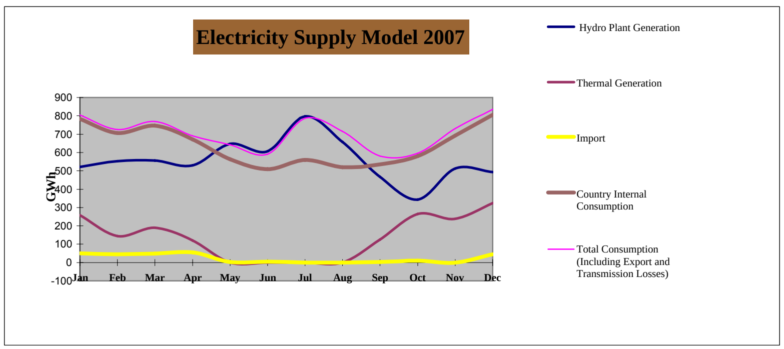
Appendix2

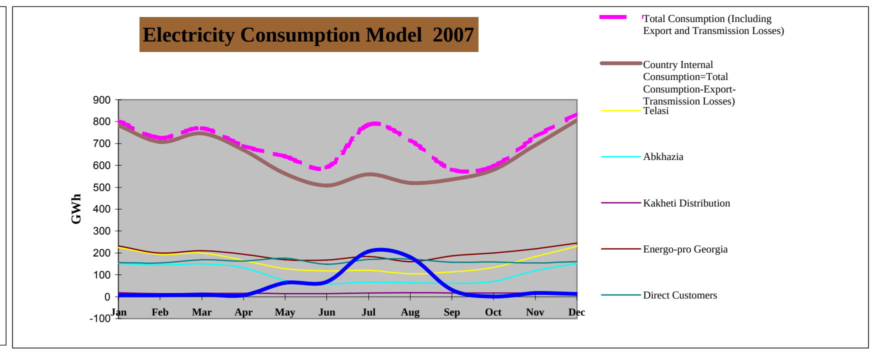
Model Electricity Balance 2007

(ESCO data), GWh

Electricity Generation, 2007	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Total
Hydro Plant Generation	521.70	553.25	557.00	530.63	647.67	607.40	796.80	656.80	466.84	343.00	512.88	492.90	6,686.87
Thermal Generation	257.66	145.11	189.47	119.15	0.32	0.32	0.30	0.00	125.21	264.04	239.15	323.51	1,664.24
Import	49.60	44.50	48.50	55.20	3.20	3.90	0.00	0.00	3.80	10.70	0.10	45.50	265.00
Generation Losses and Own Consumption	22.80	16.50	19.20	14.60	9.10	8.50	11.81	9.66	14.00	20.60	21.50	26.30	194.57
Net Supply=Generation+Import-Generation Loss	806.16	726.35	775.77	690.38	642.09	603.12	785.29	647.14	581.85	597.14	730.63	835.61	8,421.53
	466.84	343.00	512.88	492.90	521.70	553.25	557.00	530.63	647.67	607.40			

Electricity Consumption, 2007 (ESCO data), GWh	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Total
Total Consumption (Including Export and Transmission Losses)	804.05	725.43	769.50	689.92	641.40	590.23	786.57	715.81	580.87	596.46	730.25	835.35	8,465.84
Country Internal Consumption=Total Consumption-Export-Transmission Losses)	783.65	706.33	746.40	670.92	562.70	508.23	559.34	520.26	535.27	580.46	692.75	806.35	7,672.66
Telasi	224.30	193.60	200.00	166.50	128.30	117.81	121.20	105.00	113.10	134.30	183.80	231.10	1,919.01
Abkhazia	152.30	144.30	150.70	132.30	74.30	60.00	66.66	63.63	60.80	70.00	119.00	150.80	1,244.79
Kakheti Distribution	18.60	14.20	16.20	15.50	14.10	14.10	17.58	18.97	17.30	17.60	16.30	19.00	199.46
Energo-pro Georgia	232.50	200.10	210.30	193.30	169.30	168.00	183.27	160.00	186.70	199.90	218.60	244.60	2,366.57
Direct Customers	155.95	154.13	169.20	163.32	176.70	148.32	170.63	172.65	157.37	158.66	155.05	160.85	1,942.83
Export	6.70	7.20	9.70	7.10	64.40	68.00	207.00	180.00	31.50	0.60	17.20	12.60	612.00
Transmission losses	13.70	11.90	13.40	11.90	14.30	14.00	20.23	15.56	14.10	15.40	20.30	16.40	181.18
Disbalance=Net Supply-Total Consumption	2.11	0.92	6.27	0.46	0.69	12.89	-1.28	-68.67	0.98	0.68	0.38	0.27	-44.31





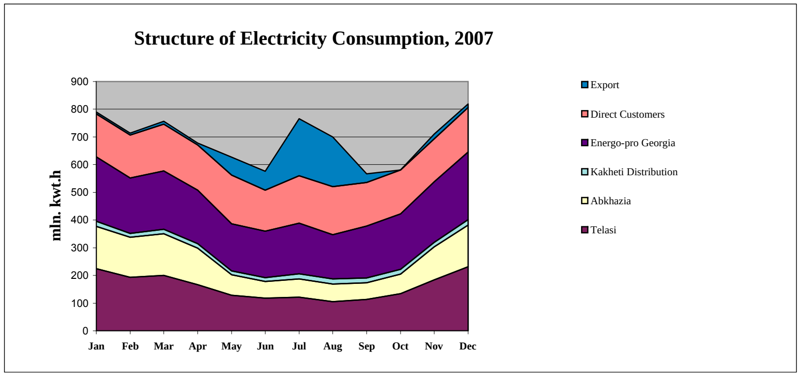
Initial Information▼

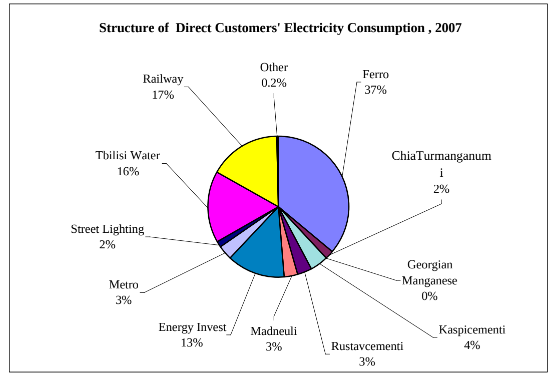
Electricity Supply, 2007	El. Balance 2007								El. Balance 2006				
(ESCO data), GWh	January	February	March	April	May	June	July	August	September	Octomber	November	December	Sum
Generation of Hydro Plants	521.70	553.25	557.00	530.63	647.67	607.40	796.77	656.79	466.84	343.00	512.88	492.90	6,686.82
inc. Control Dam Plants	367.85	397.46	343.51	291.48	378.19	354.77	579.12	506.17	327.48	165.31	303.96	346.86	4,362.17
Enguri	201.62	225.76	186.21	120.69	256.90	251.52	463.74	374.67	258.11	106.49	220.39	210.04	2,876.13
Vardnili	43.41	46.96	42.09	34.99	47.36	28.30	45.43	62.50	39.76	20.69	30.63	42.90	485.01
Khrami 1	30.43	33.57	27.79	24.44	6.49	14.81	16.30	20.03	12.27	19.37	15.11	27.18	247.78
Khrami 2	31.24	33.98	19.88	34.18	7.61	0.10	10.97	0.00	16.53	17.55	2.43	3.35	177.80
Shaori	12.68	8.01	12.07	19.07	12.78	10.45	5.89	12.00	0.00	0.00	1.93	19.17	114.04
Dzevruli	10.04	12.37	18.76	24.34	5.68	7.51	6.24	9.98	0.71	0.00	0.51	7.91	104.05
Moonlake Georgia	3.75	4.36	8.11	9.43	1.22	1.72	0.00	0.00	0.10	0.00	0.00	2.33	31.03
Jinvali	34.69	32.45	28.60	24.34	40.16	40.37	30.55	27.00	0.00	1.22	32.96	33.98	326.32
Inc. Seasonal Plants	153.85	155.78	213.49	239.15	269.47	252.64	217.65	150.62	139.35	177.69	208.92	146.04	2,324.66
Vartsikhe 2005	63.89	61.56	78.19	79.82	82.05	70.39	60.42	40.40	34.38	43.31	61.36	53.25	729.02
Gumati	13.08	13.79	20.28	25.25	23.12	31.24	27.61	16.10	14.00	18.05	20.08	12.37	234.99
Rioni	23.02	23.73	27.48	26.98	27.18	22.92	26.50	24.26	23.73	25.56	26.06	22.01	299.44
Lajanuri	11.05	14.00	25.96	31.74	50.41	38.54	29.50	23.70	17.04	22.72	33.57	11.76	310.00
Ortachala	6.29	6.39	9.23	10.24	5.48	9.53	6.54	3.38	3.75	6.29	7.20	6.69	81.01
Satskhenisi	0.00	0.00	0.00	1.32	5.38	5.17	4.54	3.69	4.56	6.29	5.48	0.10	36.52
Tetrikhevi	0.00	0.00	0.00	0.81	4.26	4.06	3.36	1.49	3.04	4.36	3.85	0.10	25.33
Zahesi	10.85	11.46	17.24	24.14	19.37	21.81	12.86	4.68	6.09	10.34	12.27	11.46	162.57
Bjuja	1.83	1.62	2.84	3.85	8.82	8.52	5.98	1.58	3.04	3.75	4.16	2.33	48.33
Chitakhevi	7.61	7.10	9.53	11.46	10.34	10.75	10.69	7.38	7.40	9.13	8.82	7.71	107.93
Eastern Energy Corporation (Khadori)	4.67	2.64	4.87	6.49	14.00	14.30	14.50	9.39	10.55	14.30	11.46	6.39	113.55
Atshesi	7.10	7.91	10.24	10.24	10.14	6.80	4.63	1.27	2.84	4.06	7.10	7.10	79.43
Total Small Plants	4.46	5.58	7.61	6.80	8.92	8.62	10.51	13.30	8.92	9.53	7.51	4.77	96.53
Generation of Thermal Plants	257.66	145.11	189.47	119.15	0.32	0.32	0.30	0.00	125.21	264.04	239.15	323.51	1,664.24
Mtkvari	171.70	144.89	141.91	47.98	0.00	0.00	0.00	0.00	77.02	163.83	154.36	169.36	1,071.06
Tbilsresi	80.32	0.00	32.34	24.26	0.00	0.00	0.00	0.00	0.11	47.66	51.28	115.96	351.91
Gas Turbine (Energy Invest)	5.64	0.21	15.21	46.91	0.32	0.32	0.30	0.00	48.09	52.55	33.51	38.19	241.26
Import	49.60	44.50	48.50	55.20	3.20	3.90	0.00	0.00	3.80	10.70	0.10	45.50	265.00
Russia	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	2.10	10.70	0.00	0.00	12.80
Turkey	40.50	34.90	38.60	35.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	31.80	180.80
Azerbaijan	9.10	9.60	9.90	20.20	3.20	3.90	0.00	0.00	1.70	0.00	0.10	13.70	71.40
Generation Losses and Own Consumption	22.80	16.50	19.20	14.60	9.10	8.50	11.81	9.66	14.00	20.60	21.50	26.30	194.57
Net Supply=Generation+Import-Generation Loss	806.16	726.35	775.77	690.38	642.09	603.12	785.26	647.13	581.85	597.14	730.63	835.61	8,421.49

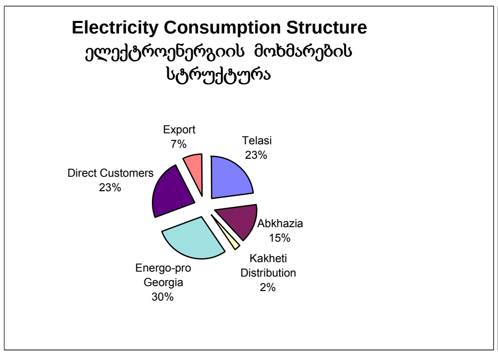
Electricity Consumption, 2007 (ESCO data), mln.kvt.h													
Total Consumption	**806.20**	**726.40**	**775.80**	**690.40**	**642.10**	**603.10**	**785.21**	**647.15**	**581.80**	**597.10**	**730.60**	**835.60**	**8,421.45**
Telasi	224.30	193.60	200.00	166.50	128.30	138.00	121.20	121.20	113.10	134.30	183.80	231.10	**1,955.40**
Abkhazia	152.30	144.30	150.70	132.30	74.30	60.00	66.66	63.63	60.80	70.00	119.00	150.80	**1,244.79**
Kakheti distribution	18.60	14.20	16.20	15.50	14.10	14.10	17.58	17.44	17.30	17.60	16.30	19.00	**197.93**
Energo-Pro Georgia	232.50	200.10	210.30	193.30	169.30	168.00	183.27	187.42	186.70	199.90	218.60	244.60	**2,393.99**
Direct customers	155.95	154.13	169.20	163.32	176.70	148.32	216.27	219.07	157.37	158.66	155.05	160.85	**2,034.89**
Export	6.70	7.20	9.70	7.10	64.40	68.40	207.03	53.84	31.50	0.60	17.20	12.60	**486.27**
Transmission losses	13.70	11.90	13.40	11.90	14.30	14.00	20.23	15.56	14.10	15.40	20.30	16.40	**181.18**
? ***Disbalance***	**0.04**	**0.05**	**0.03**	**0.02**	**0.01**	**-0.02**	**-0.05**	**0.02**	**-0.05**	**-0.04**	**-0.03**	**-0.01**	**-0.03**

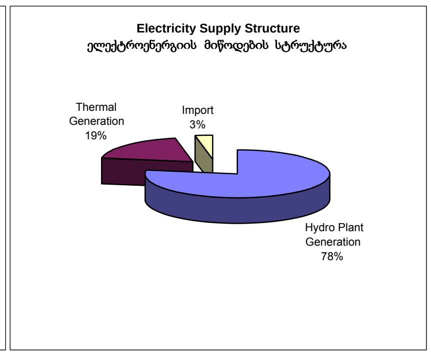
*** -Information for July and August is a forecast**

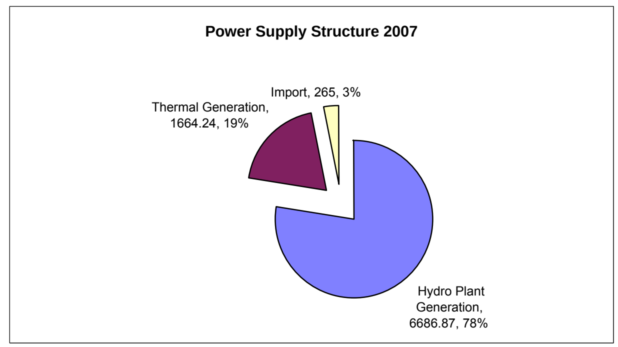
From ESCO data													
Direct Customers	**151,550,897**	**148,149,997**	**174,718,697**	**168,411,356**	**177,379,625**	**149,234,367**	**170,630,878**	**173,737,328**	**159,460,217**	**160,151,351**	**155,785,345**	**161,195,679**	**1,950,405,737**
Ferro	55,378,287	58,796,296	70,279,138	67,496,963	68,979,112	59,594,786	63,823,911	61,781,814	52,799,263	47,073,306	48,191,493	48,223,898	**702,418,267**
Chiatur Manganese	2,998,730	2,552,118	3,306,137	3,211,406	3,279,878	3,018,617	3,153,980	3,348,253	3,332,405	3,598,582	3,571,780	3,639,831	**39,011,717**
Georgian Manganese													-
Kaspicementi	5,232,592	5,671,794	5,571,893	5,933,471	6,961,408	6,589,013	7,097,482	7,584,688	6,724,578	7,559,249	7,602,458	8,175,387	**80,704,013**
Rustavcementi	3,415,952	1,904,779	4,259,413	6,248,760	5,864,165	6,022,665	6,261,824	7,081,067	5,848,714	6,484,781	6,461,429	5,548,751	**65,402,300**
Madneuli	4439546	3946422	4482165	3499352	4248415	4197380	4775915	5126511	5192053	5706291	5811003	6100500	**57,525,553**
Energy Invest	17,669,099	16,979,334	23,263,321	22,744,594	24,526,642	11,462,802	24,817,062	25,260,006	23,286,489	24,994,261	22,641,365	23,953,239	**261,598,214**
Metro	5,904,661	5,479,013	5,822,480	5,304,761	5,348,491	5,163,765	4,905,617	4,806,426	4,890,889	5,358,347	5,528,893	5,899,779	**64,413,122**
Street Lighting	3,057,131	2,200,998	2,580,434	2,140,446	2,036,116	1,882,066	1,807,001	1,932,030	2,309,958	2,807,367	3,171,208	3,575,405	**29,500,160**
Tbilisi Water	27,194,830	25,011,682	27,179,862	24,106,639	27,623,378	26,769,681	28,011,566	28,073,408	26,432,688	27,415,840	25,475,993	25,603,704	**318,899,271**
Railway	26,260,069	25,607,561	27,973,854	27,724,964	28,512,020	24,533,592	25,976,520	26,576,387	26,563,856	27,656,035	26,530,495	30,127,995	**324,043,348**
Other	**-**	**-**	**-**	**-**	**-**	**-**	**-**	**1,083,369**	**1,039,662**	**748,646**	**399,614**	**173,595**	**3,444,886**
Railway (sacxenicy) o/c													-
Mtkvari o/c								672,319	241,405				**913,724**
Tbilsresi o/c									236,420	219,548	199,058		**655,026**
Tb. Water (Jin) s/m								411,050	520,030	365,400			**1,296,480**
Tb. Water (Tetr) o/c												82,346	**82,346**
Shaori HPP o/c									36,161	109,299	81,776		**227,236**
Dzevrula HPP o/c										50,345	63,725		**114,070**
Rusmetal (sion) o/c												35,533	**35,533**
Chkhorocku HPP o/c											37,226	37,122	**74,348**
Alazani HPP o/c											8,204	5,515	**13,719**
Martkopi HPP o/c												1,590	**1,590**
Kabal HPP o/c									2,286	4,054	9,625	11,489	**27,454**
Machakhela HPP o/c									3,360				**3,360**
Rusenergo Trans.l/c													-


Structure of Electricity Consumption, 2007
mln. kwt.h
900
800
700
600
500
400
300
200
100
0
Jan
Feb
Mar
Apr
May
Jun
Jul
Aug
Sep
Oct
Nov
Dec
Export
Direct Customers
Energo-pro Georgia
Kakheti Distribution
Abkhazia
Telasi


Structure of Direct Customers' Electricity Consumption , 2007
Other
0.2%
Ferro
37%
Railway
17%
ChiaTurmanganum
i
2%
Tbilisi Water
16%
Street Lighting
2%
Georgian
Manganese
0%
Metro
3%
Energy Invest
13%
Madneuli
3%
Rustavcementi
3%
Kaspicementi
4%

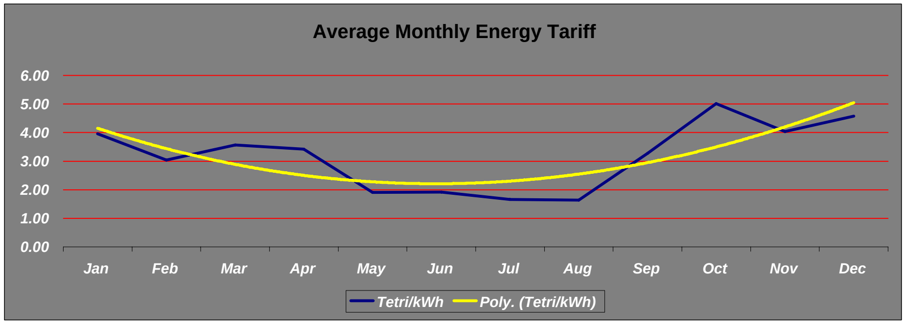

Electricity Consumption Structure
ელექტროენერგიის მოხმარების
სტრუქტურა
Export
7%
Telasi
23%
Direct Customers
23%
Abkhazia
15%
Energo-pro
Georgia
30%
Kakheti
Distribution
2%


Electricity Supply Structure
ელექტროენერგიის მიწოდების სტრუქტურა
Thermal
Generation
19%
Import
3%
Hydro Plant
Generation
78%


Power Supply Structure 2007
Import, 265, 3%
Thermal Generation,
1664.24, 19%
Hydro Plant
Generation,
6686.87, 78%

Appendix3.

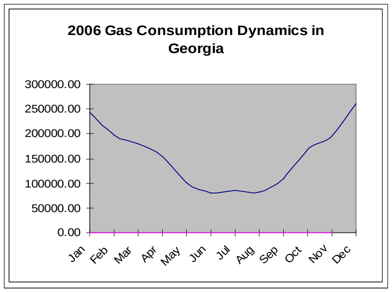
Tariff, tetri	January	February	March	April	May	June	July	August	September	Octomber	November	December	Annual
	Cost of Electricity Generation , 2006 (GEL)												
Cost of Hgeneration	**9,018,931**	**9,355,043**	**10,438,592**	**10,892,414**	**12,327,699**	**11,635,517**	**13,229,585**	**10,729,973**	**7,715,066**	**6,871,308**	**9,401,360**	**8,742,421**	**120,357,909**
	5,526,477	**5,840,225**	**5,442,162**	**5,182,120**	**5,310,904**	**5,057,160**	**7,513,041**	**6,867,657**	**4,024,944**	**2,134,260**	**3,973,378**	**5,252,563**	**62,124,891**
1.187	2,393,262	2,679,779	2,210,276	1,432,586	3,049,362	2,985,558	5,504,546	4,447,285	3,063,808	1,264,047	2,615,975	2,493,182	34,139,665
1.17	507,870	549,402	492,444	409,381	554,148	331,065	531,578	731,203	465,152	242,069	358,357	501,937	5,674,607
1.76	535,497	590,832	489,087	430,183	114,239	260,609	286,810	352,458	215,984	340,933	265,963	478,377	4,360,971
1.51	471,684	513,032	300,162	516,095	114,858	1,531	165,617	0	249,625	264,939	36,755	50,538	2,684,836
3.82	484,280	306,065	461,034	728,357	488,154	399,047	225,113	458,285	0	0	73,611	732,231	4,356,177
3.85	386,562	476,369	722,363	937,120	218,661	288,945	240,240	384,307	27,333	0	19,523	304,564	4,005,987
3	112,576	130,832	243,408	282,961	36,511	51,724	0	0	3,043	0	0	69,980	931,034
1.83	634,746	593,915	523,387	445,436	734,970	738,682	559,138	494,118	0	22,272	603,195	621,755	5,971,613
	3,492,454	**3,514,817**	**4,996,430**	**5,710,294**	**7,016,795**	**6,578,357**	**5,716,544**	**3,862,316**	**3,690,122**	**4,737,049**	**5,427,982**	**3,489,858**	**58,233,018**
1.25	798,682	769,523	977,434	997,718	1,025,609	879,817	755,300	505,000	429,767	541,329	766,988	665,568	9,112,734
3.64	476,227	502,069	738,337	919,229	841,704	1,137,039	1,005,040	586,040	509,452	657,120	730,953	450,385	8,553,596
3.5	805,781	830,629	961,968	944,219	951,318	802,231	927,500	849,065	830,629	894,523	912,272	770,284	10,480,419
3.8	420,081	531,846	986,613	1,206,288	1,915,416	1,464,503	1,121,000	900,600	647,465	863,286	1,275,659	447,059	11,779,815
2.5	157,201	159,736	230,730	256,085	136,917	238,337	163,375	84,475	93,813	157,201	180,020	167,343	2,025,233
2.33	0	0	0	30,720	125,243	120,517	105,759	85,954	106,339	146,511	127,606	2,363	851,013
	0	0	0	0	0	0	0	0	0	0	0	0	0
1.42	154,097	162,738	244,828	342,759	275,071	309,635	182,640	66,470	86,410	146,897	174,260	162,738	2,308,543
4	73,022	64,909	113,590	154,158	352,941	340,771	239,320	63,240	121,704	150,101	166,329	93,306	1,933,392
	0	0	0	0	0	0	0	0	0	0	0	0	0
7.16	334,037	188,803	348,560	464,746	1,002,110	1,023,895	1,038,200	672,539	755,213	1,023,895	820,568	457,485	8,130,049
3.85	273,327	304,564	394,371	394,371	390,467	261,613	178,409	48,934	109,331	156,187	273,327	273,327	3,058,225
Average Weigted Tariff for	1.729	1.691	1.874	2.053	1.903	1.916	1.660	1.634	1.653	2.003	1.833	1.774	**1.800**
Cost of TGeneration	**21,831,269**	**11,881,179**	**16,170,949**	**11,341,882**	**35,563**	**35,563**	**33,429**	**0**	**11,672,676**	**23,563,619**	**20,992,724**	**28,573,190**	**146,132,043**
8.186	14,055,536	11,860,991	11,617,153	3,927,538	0	0	0	0	6,304,962	13,411,106	12,636,049	13,863,949	87,677,285
9.015	7,240,771	0	2,915,489	2,186,617	0	0	0	0	9,590	4,296,511	4,622,585	10,453,564	31,725,128
9.488 11.143	534,962	20,187	1,638,307	5,227,727	35,563	35,563	33,429	0	5,358,123	5,856,002	3,734,090	4,255,678	26,729,631
Average Weigted Tariff for	0.847	0.819	0.853	0.952	1.114	1.114	0	0	0.932	0.892	0.878	0.883	**0.878**
	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	
Average Weigted Energy Tariff (TeTri)	3.958	3.041	3.565	3.422	1.908	1.920	1.664	1.634	3.275	5.014	4.042	4.571	**3.191**

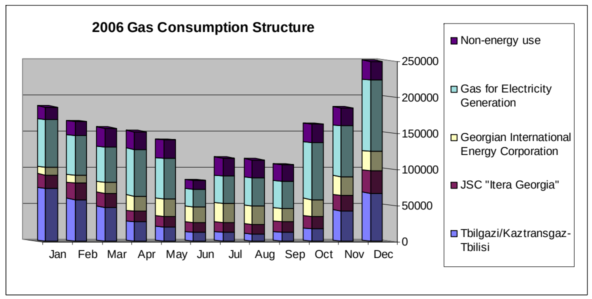


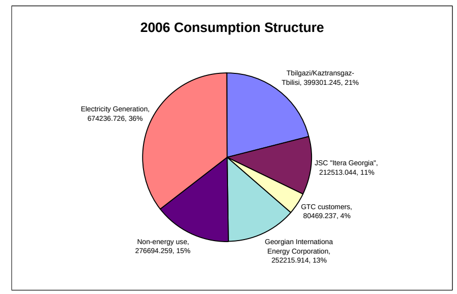
Appendix4

Gas Consumption 2006

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	**Total**
Tbilgazi/Kaztransgaz-Tbilisi	73248.49	58220.97	47019.70	26882.94	19879.32	12422.46	12252.80	10385.01	12825.46	17321.82	42245.83	66596.46	**399301.25**
JSC "Itera Georgia"	18750.96	22103.38	19744.17	14683.03	14226.55	13068.75	13495.99	13188.25	14070.91	17231.99	21162.10	30786.96	**212513.04**
GTC customers	12721.31	12888.08	11192.43	6389.62	3627.83	4070.22	4980.93	5358.36	40.91	4081.96	6832.47	8285.13	**80469.24**
Georgian International Energy Corporation	10495.40	10961.12	15400.73	21502.49	24745.59	22269.73	26641.21	25378.36	18182.92	23696.46	26098.52	26843.39	**252215.91**
Mtkvari TPP	40462.52	42447.41	17915.78	40433.54	44630.48	0.00	0.00	0.00	23744.93	47119.21	43990.07	49075.89	**349819.84**
Tbilsresi TPP	25107.47	12830.45	28899.09	19992.85	9341.78	13402.14	25119.66	27524.12	0.00	16068.98	16382.33	38071.95	**232740.81**
Gardabani Gas Turbine	0.00	0.00	1681.73	3734.07	1687.54	10717.76	12662.04	11235.81	13909.47	14931.63	9763.81	11352.23	**91676.07**
Non-energy use	17965.37	19127.01	25810.76	24740.86	25863.84	12594.52	25332.60	25144.20	23417.98	25391.54	24744.94	26560.66	**276694.26**
Total	169603.13	166768.43	158263.66	153356.90	141057.35	84475.84	115504.30	112855.75	106192.58	162259.20	185141.54	250749.29	**1806227.96**
Gas for Electricity Generation	*65569.99*	*55277.85*	*48496.60*	*64160.46*	*55659.80*	*24119.90*	*37781.70*	*38759.93*	*37654.40*	*78119.82*	*70136.20*	*98500.08*	**674236.73**



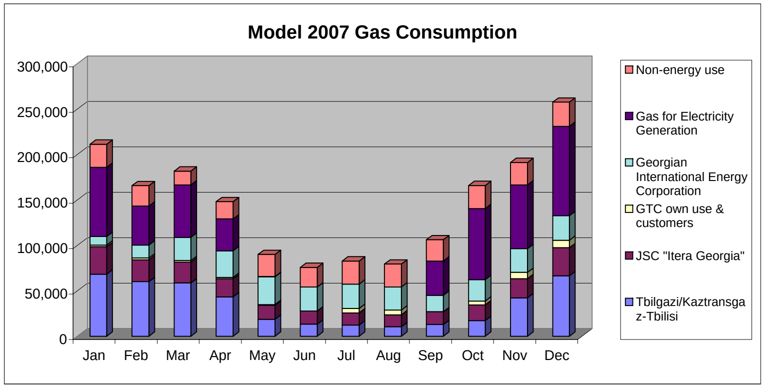


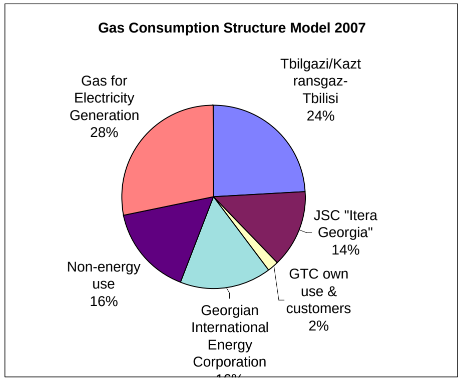


		2006				2007							
	Total	Sept	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug
Tbilgazi/Kaztransgaz-Tbilisi	399301.25	12825.46	17321.82	42245.83	66596.46	68373.41	60069.42	58624.74	43198.56	18745.23	13244.05	12252.80	10385.01
JSC "Itera Georgia"	212513.04	14070.91	17231.99	21162.10	30786.96	30032.08	24169.78	22915.36	20039.06	15505.37	14542.60	13495.99	13188.25
GTC customers	80469.24	40.91	4081.96	6832.47	8285.13	1999.82	1797.37	1804.23	1623.76	645.45	0.00	4980.93	5358.36
Georgian International Energy Corporation	252215.91	18182.92	23696.46	26098.52	26843.39	9344.16	14219.34	25551.23	29245.70	30615.27	26200.32	26641.21	25378.36
Mtkvari TPP	349819.84	23744.93	47119.21	43990.07	49075.89	49455.16	42807.36	42500.81	14138.51	0.00	0.00	0.00	0.00
Tbilsresi TPP	232740.81	0.00	16068.98	16382.33	38071.95	25063.82	0.00	10426.29	7317.66	32.75	0.00	0.00	0.00
Gardabani Gas Turbine	91676.07	13909.47	14931.63	9763.81	11352.23	1738.35	303.57	4804.25	13451.89	117.68	132.82	0.00	0.00
Non-energy use	276694.26	23417.98	25391.54	24744.94	26560.66	25171.53	22334.49	15096.78	19003.55	24279.51	21568.59	25332.60	25144.20
Total	**1895430.43**	**106192.58**	**162259.20**	**185141.54**	**250749.29**	**211178.32**	**165701.32**	**181723.69**	**148018.68**	**89941.25**	**75688.38**	**82703.53**	**79454.18**
Electricity Generation	674236.73	37654.40	78119.82	70136.20	98500.08	76257.33	43110.93	57731.35	34908.06	150.43	132.82	0.00	0.00
		242604.63	197102.83	179599.84	154119.31	100294.19	80214.36	85873.19	82648.02	109111.61	168722.44	194758.60	**261251.96**

Model 2007 Gas Consumption

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	TOTAL
	54,595,509	57,372,107	47,019,704	26,882,937	19,879,318	12,422,460	12,252,801	10,385,008	12,825,459	17,321,819	42,245,827	66,596,460	
Tbilgazi/Kaztransgaz-Tbilisi	68373.41	60069.42	58624.74	43198.56	18745.23	13244.05	12252.80	10385.01	12825.46	17321.82	42245.83	66596.46	**423882.79**
JSC "Itera Georgia"	30032.08	24169.78	22915.36	20039.06	15505.37	14542.60	13495.99	13188.25	14070.91	17231.99	21162.10	30786.96	**237140.45**
GTC own use & customers	1999.82	1797.37	1804.23	1623.76	645.45	0.00	4980.93	5358.36	40.91	4081.96	6832.47	8285.13	**37450.38**
Georgian International Energy Corporation	9344.16	14219.34	25551.23	29245.70	30615.27	26200.32	26641.21	25378.36	18182.92	23696.46	26098.52	26843.39	**282016.88**
Mtkvari TPP	49455.16	42807.36	42500.81	14138.51	0.00	0.00	0.00	0.00	23744.93	47119.21	43990.07	49075.89	**312831.93**
Tbilsresi TPP	25063.82	0.00	10426.29	7317.66	32.75	0.00	0.00	0.00	0.00	16068.98	16382.33	38071.95	**113363.78**
Gardabani Gas Turbine	1738.35	303.57	4804.25	13451.89	117.68	132.82	0.00	0.00	13909.47	14931.63	9763.81	11352.23	**70505.69**
Non-energy use	25171.53	22334.49	15096.78	19003.55	24279.51	21568.59	25332.60	25144.20	23417.98	25391.54	24744.94	26560.66	**278046.35**
Total	211178.32	165701.32	181723.69	148018.68	89941.25	75688.38	82703.53	79454.18	106192.58	162259.20	185141.54	250749.29	***1738751.95***
Gas for Electricity Generation	76257.33	43110.93	57731.35	34908.06	150.43	132.82	0.00	0.00	37654.40	78119.82	70136.20	98500.08	**496701.40**





Model 2007 Gas Supply

		Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	
	Consumption	211178.3	165701.3	181723.7	148018.7	89941.2	75688.4	82703.5	79454.2	106192.6	162259.2	185141.5	250749.3	***1738752.0***
	Losses	4858.2	3812.0	4180.6	3405.2	2069.1	1741.2	1902.6	1827.8	2443.0	3732.8	4259.2	5768.5	**40000.0**
1	SCP	33333.3	33333.3	33333.3	33333.3	33333.3	33333.3	33333.3	33333.3	33333.3	33333.3	33333.3	33333.3	**400000.0**
2	Azerbaijan	60727.0	47649.5	52256.9	42564.6	25863.7	21765.1	23782.4	22848.0	30537.0	46659.7	53239.8	72106.1	**500000.0**
3	Russia	101869.8	79932.2	87661.2	71402.3	43386.5	36511.1	39895.1	38327.7	51226.0	78271.8	89309.9	120958.3	**838752.0**
	Total Gas Purchase	**411966.55**	**330428.34**	**359155.72**	**298724.16**	**194593.94**	**169039.18**	**181617.04**	**175791.09**	**223731.84**	**324256.77**	**365283.77**	**482915.50**	1778751.95

Appendix5.

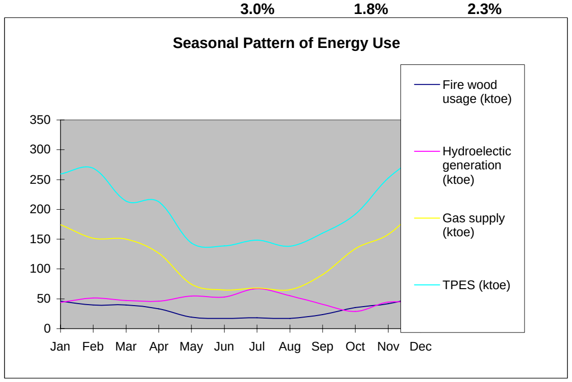
Seasonality and External Energy Dependence Parameters

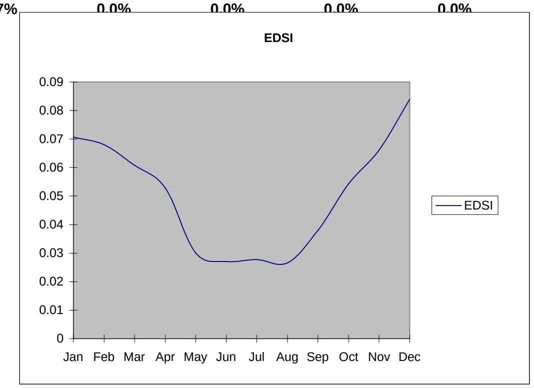
									125.21	264.04	239.15		
Electricity Supply	**Jan**	**Feb**	**Mar**	**Apr**	**May**	**Jun**	**Jul**	**Aug**	**Sep**	**Oct**	**Nov**	**Dec**	
Thermal Generation	257.66	145.11	189.47	**119.15**	0.32	0.32	0.00	0.00	125.21	264.04	239.15	323.51	**1,663.9**
Import	49.60	44.50	48.50	55.20	3.20	3.90	0.00	0.00	3.80	10.70	0.10	45.50	**265.0**
Export	-6.70	-7.20	-9.70	-7.10	-64.30	-68.60	-208.40	-180.50	-31.40	-0.60	-17.20	-12.60	**1,928.9**
Hydroelectric generation	521.70	553.25	557.00	530.63	647.67	607.40	796.80	656.80	466.84	343.00	512.88	492.90	**6,686.9**
Generation Losses and Own Con	22.80	16.50	19.20	14.60	9.10	8.50	11.81	9.66	14.00	20.60	21.50	26.30	**194.6**
Total Consumption	799.46	719.15	766.07	683.28	577.79	534.52	576.59	466.64	550.45	596.54	713.43	823.01	**10,350.2**

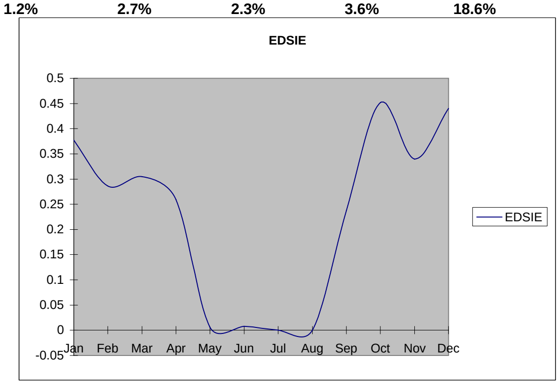
GAS SUPPLY	**Jan**	**Jan**	**Jan**	**Jan**	**Jan**	**Jan**	**Jan**	**Jan**	**Jan**	**Jan**	**Jan**	**Jan**	
Gas use (kcm)	211178.322	165701.323	181723.688	148018.681	89941.248	75688.378	82703.532	79454.176	106192.579	162259.2	185141.54	250749.286	1,738,752
Gas losses (est.)	9,105.15	7,144.37	7,835.19	6,381.97	3,877.90	3,263.38	3,565.84	3,425.74	4,578.59	6,995.96	7,982.55	10,811.29	74967.95
Gas supply	**220,283.48**	**172,845.69**	**189,558.88**	**154,400.65**	**93,819.15**	**78,951.75**	**86,269.37**	**82,879.92**	**110,771.17**	**169,255.16**	**193,124.09**	**261,560.58**	1,813,719.90
Gas supply for heating (mcm)	59232.614	46902.02	48303.963	37422.241	14102.443	-132.815	7015.154	3765.798	-7150.202	8451.007	39316.961	76560.83	333790.0

Total Energy Supply	**Jan**	**Feb**	**Mar**	**Apr**	**May**	**Jun**	**Jul**	**Aug**	**Sep**	**Oct**	**Nov**	**Dec**	
Fire wood usage (ktoe)	45.9	39.9	39.5	33.2	19.5	17.0	18.0	17.3	23.8	35.3	41.6	54.5	385.3
Hydroelectic generation (ktoe)	44.0	51.7	47.0	46.3	54.7	53.0	67.2	55.4	40.7	28.9	44.7	41.6	575.2
Gas supply (ktoe)	174.4	151.5	150.1	126.3	74.3	64.6	68.3	65.6	90.6	134.0	158.0	207.1	1465.0
Net Electricity Import	3.6	3.6	3.0	4.3	-5.1	-5.7	-17.3	-15.5	-2.5	0.8	-1.5	2.7	-29.6
TPES (ktoe)	259.4	269.1	213.7	212.7	143.7	139.0	148.6	138.3	160.4	191.8	252.4	293.4	2422.4

		Jan	**Feb**	**Mar**	**Apr**	**May**	**Jun**	**Jul**	**Aug**	**Sep**	**Oct**	**Nov**	**Dec**	
	30.4	31	28	31	30	31	30	31	31	30	31	30	31	**EDSI**
EDSI		**7.1%**	**6.8%**	**6.1%**	**5.3%**	**3.0%**	**2.7%**	**2.8%**	**2.7%**	**3.8%**	**5.4%**	**6.6%**	**8.4%**	**60.6%**
														EDSIE
EDSIE		**37.7%**	**28.6%**	**30.5%**	**25.9%**	**0.6%**	**0.8%**	**0.0%**	**0.0%**	**23.8%**	**45.2%**	**34.0%**	**44.0%**	**271.0%**
		3.0%	**1.8%**	**2.3%**	**1.7%**	**0.0%**	**0.0%**	**0.0%**	**0.0%**	**1.2%**	**2.7%**	**2.3%**	**3.6%**	**18.6%**



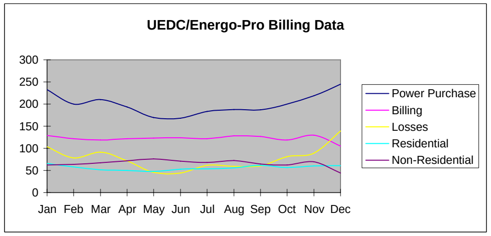


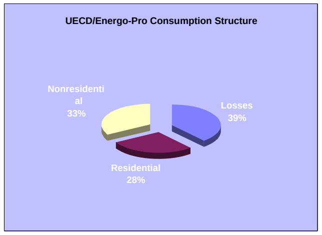


Appendix6.

UEDC/Energo-Pro Consumption Structure

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Total
Power Purchase	232.50	200.10	210.30	193.30	169.30	168.00	183.27	187.42	186.70	199.90	218.60	244.60	2,393.99
Billing	128.62	121.56	118.93	121.64	123.34	123.78	121.64	128.03	126.53	118.86	129.78	105.41	1,468.12
Losses	103.88	78.54	91.37	71.66	45.96	44.22	61.62	59.40	60.17	81.04	88.82	139.19	925.87
Residential	65.96	57.80	51.46	49.86	47.50	52.65	53.87	55.74	61.84	56.24	59.92	61.09	673.94
Non-Residential	62.67	63.76	67.47	71.78	75.84	71.13	67.77	72.28	64.69	62.62	69.86	44.32	794.18





MOTOR INTENSIVE ENTERPRISES

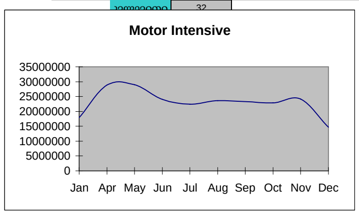
Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
31	28	31	30	31	30	31	31	30	31	30	31
1,099,789	1,119,091	1,338,069	1,808,467	1,100,224	1,037,076	1,219,799	1,259,634	1,175,215	1,186,841	1,242,402	924,547
1,219,996	1,721,138	873,114	799,742	810,548	616,406	560,433	481,361	452,128	658,249	1,094,910	460,170
732,596	859,820	789,313	1,240,154	947,324	782,098	685,561	616,280	551,702	518,910	938,475	660,940
3,971,254	8,471,544	3,968,450	10,208,354	9,309,757	8,985,518	8,133,910	8,908,703	9,018,919	8,857,862	7,430,505	5,448,719
9,200,106	7,800,404	26,169,518	13,449,440	15,448,667	11,211,641	10,705,779	10,814,386	10,770,057	9,967,785	12,148,400	5,786,036
668,986	1,904,341	692,461	928,160	871,863	1,084,243	749,066	1,063,997	860,497	883,363	654,531	499,659
986,974	1,030,216	786,689	466,473	483,992	330,099	366,883	514,570	496,052	773,950	602,210	917,423
17,879,733	**22,906,582**	**34,617,644**	**28,900,820**	**28,972,407**	**24,047,111**	**22,421,461**	**23,658,962**	**23,324,602**	**22,846,992**	**24,111,462**	**14,697,526**

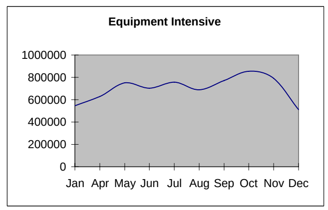
Equipment Intensive

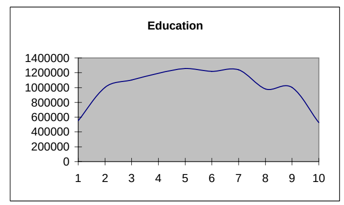
Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
228,981	301,530	271,223	251,373	386,730	330,338	358,172	331,889	414,199	363,070	326,134	226,102
108,262	118,442	113,160	162,472	128,209	134,861	150,762	117,218	113,342	176,538	196,985	92,403
200,135	191,051	186,590	200,325	212,869	209,600	221,399	211,466	215,366	197,297	256,117	183,244
6,913	10,143	10,728	13,950	24,355	27,247	27,830	27,247	28,461	118,009	13,184	8,375
544,291	**621,166**	**581,702**	**628,120**	**752,164**	**702,045**	**758,163**	**687,819**	**771,368**	**854,914**	**792,420**	**510,124**

Education

Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
157,767	103,607	132,136	198,316	285,897	282,705	346,841	342,560	345,466	281,396	433,378	185,082
48,852	45,557	63,127	47,798	85,884	96,497	96,714	106,752	84,820	70,609	53,039	31,470
27,451	258,388	9,766	131,326	20,119	17,107	25,936	21,444	20,863	20,984	87,509	23,256
40,817	41,201	49,980	37,522	40,771	50,543	47,285	32,896	42,809	36,100	61,588	51,759
208,405	172,803	206,379	501,728	478,024	585,336	563,072	620,350	604,777	461,595	269,292	155,937
67,682	70,984	55,391	85,973	189,996	162,468	175,729	93,470	140,436	110,612	97,774	81,515
550,973	**692,540**	**516,779**	**1,002,663**	**1,100,691**	**1,194,656**	**1,255,577**	**1,217,473**	**1,239,172**	**981,295**	**1,002,580**	**529,019**







OFFICES

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Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
72,918	62,335	86,336	103,787	125,553	163,604	150,933	137,522	300,541	136,960	104,783	91,568
850,956	815,098	713,702	873,041	1,721,691	2,143,520	1,727,356	1,531,997	1,471,132	1,381,155	1,892,456	750,605
195,748	242,401	194,976	281,114	487,559	414,530	474,698	429,769	448,991	346,405	263,777	307,741
182,669	228,165	173,411	236,724	268,115	320,753	333,114	263,944	276,780	294,805	213,246	168,412
60,516	28,017	16,408	45,540	58,222	71,446	60,936	75,526	80,869	58,655	36,899	26,527
1,362,807	**1,376,016**	**1,184,833**	**1,540,206**	**2,661,141**	**3,113,853**	**2,747,036**	**2,438,757**	**2,578,313**	**2,217,981**	**2,511,162**	**1,344,853**

Heat Consumers

Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
174,869	223,512	199,801	338,875	317,588	226,514	313,435	433,584	356,069	262,246	199,708	164,927
442,850	614,491	554,845	548,412	643,545	546,644	487,263	460,697	511,885	399,082	1,064,001	398,297
310,173	388,166	449,391	503,846	452,991	460,119	380,694	347,269	340,438	387,930	424,016	269,938
927,893	**1,226,169**	**1,204,037**	**1,391,133**	**1,414,124**	**1,233,278**	**1,181,392**	**1,241,550**	**1,208,391**	**1,049,257**	**1,687,725**	**833,162**

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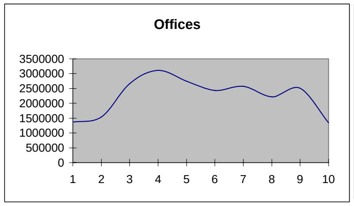
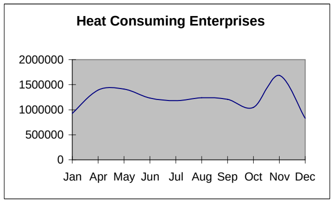
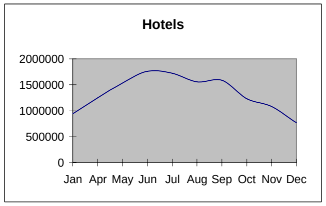
HOTELS

Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
943,455	1,026,090	1,815,726	1,246,856	1,529,352	1,759,774	1,720,621	1,555,094	1,588,124	1,229,144	1,085,305	767,551







Health Care Centers

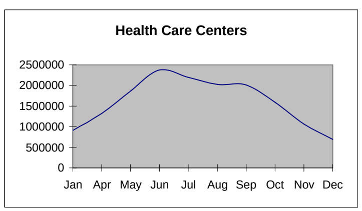
Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
439,038	493,050	368,411	497,893	779,819	908,694	855,152	781,546	787,150	640,462	517,272	358,599
424,908	1,222,095	358,720	616,539	1,011,955	1,395,404	1,267,679	1,183,707	1,164,110	898,035	517,457	315,878
45,348	19,687	26,719	208,450	72,557	74,383	71,019	59,928	63,436	53,094	32,707	16,323
909,294	**1,734,832**	**753,850**	**1,322,882**	**1,864,331**	**2,378,481**	**2,193,850**	**2,025,181**	**2,014,696**	**1,591,591**	**1,067,436**	**690,799**

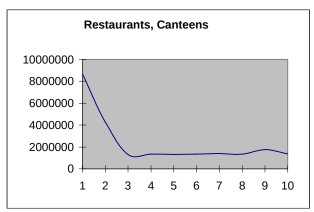
Restaurants & Canteens

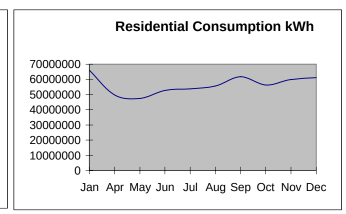
Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
363,117	413,784	479,246	442,107	432,631	385,084	390,372	438,067	404,242	385,186	472,005	395,962
8,290,903	1,200,795	903,040	3,839,836	886,705	966,370	913,357	910,996	995,340	958,450	1,291,105	972,364
8,654,020	**1,614,580**	**1,382,285**	**4,281,943**	**1,319,336**	**1,351,454**	**1,303,729**	**1,349,063**	**1,399,582**	**1,343,636**	**1,763,110**	**1,368,326**
143,454	238,757	185,955	125,250	205,584	252,209	255,758	247,832	213,479	194,768	238,191	120,677
1,724,373	1,907,222	1,904,985	1,608,402	1,620,440	1,773,691	1,835,047	1,933,398	1,606,463	1,597,471	2,128,167	1,539,534
201,588	125,296	137,313	145,622	165,587	209,473	180,994	187,698	174,672	153,881	188,845	127,514
2,069,415	**2,271,274**	**2,228,252**	**1,879,274**	**1,991,610**	**2,235,373**	**2,271,799**	**2,368,928**	**1,994,614**	**1,946,119**	**2,555,202**	**1,787,725**
29,191	22,967	23,690	27,568	35,310	38,939	39,245	30,836	34,334	31,567	28,619	22,125

Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
303,580	278,077	703,057	775,781	830,780	737,406	730,038	1,759,117	1,207,336	625,834	562,828	241,594
18,456	10,141	16,044	16,934	30,425	43,032	32,551	35,394	34,012	20,472	22,642	21,478
47,504	43,651	42,705	50,343	65,054	89,337	72,421	66,194	65,758	63,109	65,568	54,655
369,540	**331,869**	**761,806**	**843,058**	**926,260**	**869,775**	**835,010**	**1,860,705**	**1,307,105**	**709,415**	**651,038**	**317,727**
65,955,170	**57,800,631**	**51,457,557**	**49,855,653**	**47,501,365**	**52,652,232**	**53,870,246**	**55,744,237**	**61,842,152**	**56,244,574**	**59,921,779**	**61,091,492**

257,894	305,004	197,984	279,807	288,984	324,515	285,085	237,351	300,122	290,272	199,184	160,139
56,832	73,462	50,095	141,977	51,505	57,984	47,422	58,527	58,980	36,585	56,037	48,421
109,392	145,088	117,142	140,681	172,296	155,798	240,208	178,279	148,994	132,878	182,463	182,082
126,810	365,741	234,563	972,047	104,631	66,625	57,901	90,076	72,274	63,375	135,561	157,490
1,040,410	1,158,289	1,154,147	1,318,596	1,300,015	1,331,181	1,142,732	1,290,472	1,123,297	938,982	1,426,677	1,013,371
126,565	28,423	46,396	116,623	109,325	121,700	81,317	104,510	106,187	92,285	68,181	29,840
39,580	29,015	16,938	17,767	24,032	25,198	29,191	28,033	25,679	18,888	45,736	27,434
328,779	393,321	417,096	921,826	561,719	820,619	952,032	730,647	795,380	712,667	489,738	386,895
4,432,919	5,640,579	6,084,026	8,479,180	10,960,554	9,706,444	11,619,464	14,791,621	6,445,560	9,143,972	13,278,656	6,110,998
1,042,422	1,306,080	1,441,902	2,530,181	3,730,781	2,745,096	2,558,227	2,352,599	2,816,515	3,000,641	1,333,236	908,982
713,265	2,179,866	1,008,687	1,370,419	1,328,755	1,284,457	1,210,706	863,400	278,711			
13,083,318	13,788,151	15,838,854	12,662,039	12,656,411	14,048,309	12,172,492	14,523,191	12,145,578			
14,918,686	**17,303,843**	**15,355,161**	**17,013,578**	**19,862,115**	**11,892,988**	**14,430,546**	**17,215,468**	**9,025,651**			





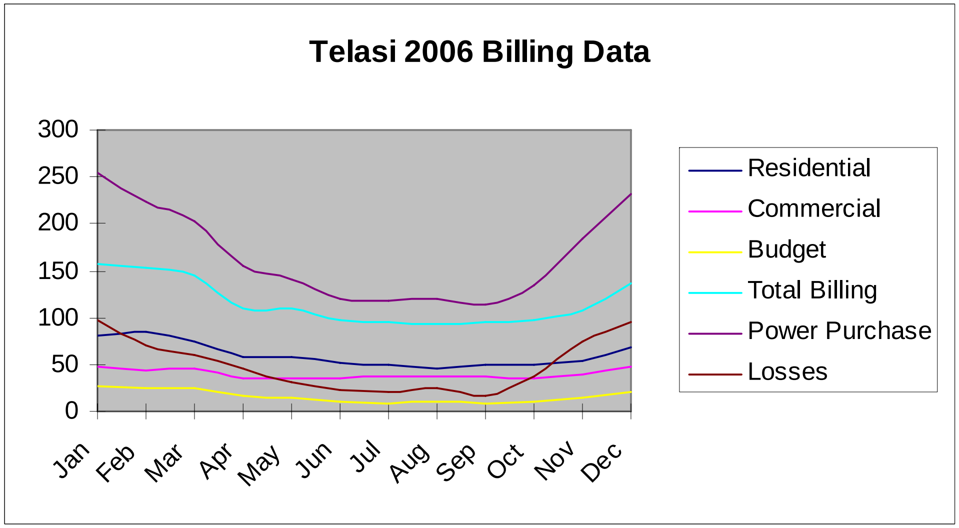


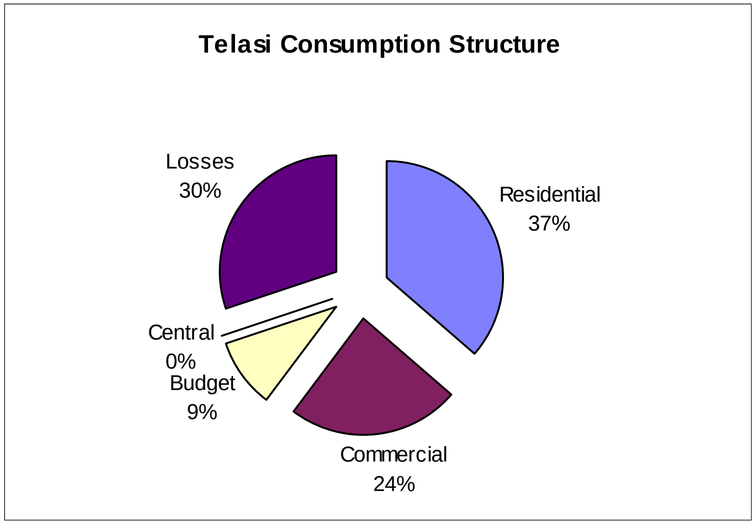
Appendix7.

Telasi 2006 Billing Data (GWh billed)

Telasi Data

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Total
Residential	80.61	85.2	74.82	58.55	58.45	52.15	49.86	46.11	49.47	50.64	54.39	67.55	727.8
Commercial	47.73	44.42	44.91	35.25	35.06	35.24	36.83	37.62	37.4	35.85	39.34	48.26	477.91
Budget	27.89	23.98	24.33	16.35	15.29	9.49	9.05	9.87	8.56	10.34	13.98	19.66	188.79
Central	0.3	0.16	0.22	0.18	0.15	0.14	0.14	0.14	0.72	0.65	0.79	0.68	4.28
Total Billing	156.53	153.76	144.28	110.33	108.95	97.02	95.88	93.74	96.15	97.48	108.50	136.15	1398.77
Power Purchase	254.68	223.79	203.45	154.82	139.84	120.09	117.59	119.26	113.13	134.31	183.78	231.13	1995.87
Losses	98.15	70.03	59.17	44.49	30.89	23.07	21.71	25.52	16.98	36.83	75.28	94.98	597.10

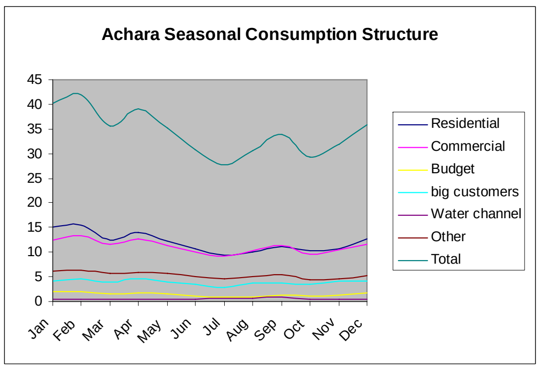


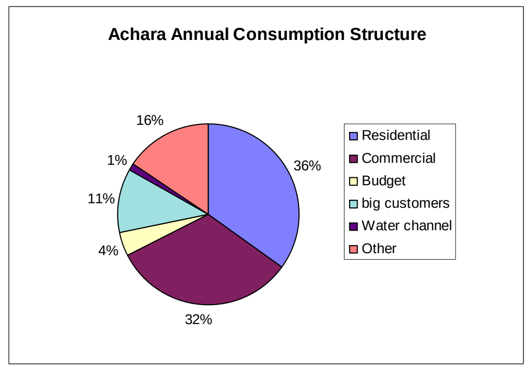


Appendix8.

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Total
Residential	15,364,872	14,218,855	12,702,147	13,762,336	12,515,358	10,494,598	9,647,888	10,182,153	11,082,668	10,394,576	10,625,420	12,984,001	143,974,873
Commercial	12,755,038	12,205,980	11,753,074	12,439,565	11,652,235	9,903,816	9,262,606	10,510,844	11,105,104	9,746,491	10,382,009	11,764,124	133,480,886
Budget	1,957,796	1,773,270	1,637,883	1,727,660	1,491,605	1,033,579	967,981	995,443	1,188,489	1,148,220	1,277,793	1,711,242	16,910,961
big customers	4,234,074	4,161,912	3,968,529	4,454,156	3,903,069	3,352,899	2,933,759	3,736,610	3,701,107	3,522,721	4,183,989	4,224,087	46,376,912
Water channel	347,130	346,286	464,113	382,043	398,961	519,254	593,165	585,003	765,847	516,231	489,507	402,687	5,810,227
Other	6,216,038	5,924,512	5,682,549	5,875,707	5,858,600	4,998,084	4,767,702	5,193,788	5,449,662	4,559,318	4,430,719	5,426,108	64,382,785
Refugees	208,189	124,202	234,534	172,560	473,441	80,220	283,980	131,557	67,560	63,480	93,610	135,790	2,069,123
Other	6007848.91	5,800,310	5,448,015	5,703,147	5,385,159	4,917,864	4,483,722	5,062,231	5,382,102	4,495,838	4,337,109	5,290,318	62,313,662

30.4	31	28	31	30	31	30	31	31	30	31	30	31	
	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Total
Residential	15.08	15.45	12.46	13.95	12.28	10.64	9.47	9.99	11.24	10.20	10.77	12.74	143.97
Commercial	12.52	13.26	11.53	12.61	11.43	10.04	9.09	10.31	11.26	9.56	10.53	11.54	133.48
Budget	1.92	1.93	1.61	1.75	1.46	1.05	0.95	0.98	1.20	1.13	1.30	1.68	16.91
big customers	4.15	4.52	3.89	4.52	3.83	3.40	2.88	3.67	3.75	3.46	4.24	4.14	46.38
Water channel	0.34	0.38	0.46	0.39	0.39	0.53	0.58	0.57	0.78	0.51	0.50	0.40	5.81
Other	6.10	6.44	5.58	5.96	5.75	5.07	4.68	5.10	5.53	4.47	4.49	5.32	64.38
Total	40.11	41.97	35.53	39.18	35.15	30.72	27.64	30.62	33.76	29.33	31.83	35.83	410.94





Appendix9.

KAKHETI DATA RECONSTRUCTION

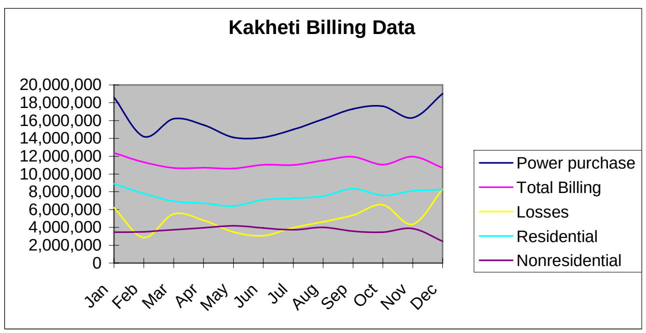
Based on may 2007 data

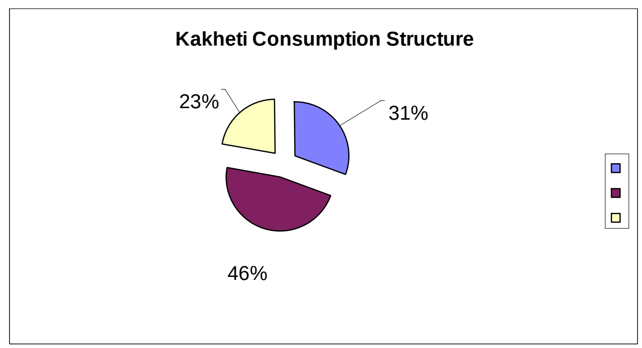
Billing		commercial	direct consumers	35kv	Nonresidential	Residential			Total Residential
						1-100	100-300	>300	
10,613,361		2627447	1470549	95200	4193196	5410281	726399	273889	6,410,569

UDC

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Residential	65,955,170	57,800,631	51,457,557	49,855,653	47,501,365	52,652,232	53,870,246	55,744,237	61,842,152	56,244,574	59,921,779	61,091,492
Nonresidential	62,669,512	63,762,379	67,472,467	71,779,761	75,838,555	71,127,411	67,773,888	72,281,618	64,686,025	62,615,625	69,858,088	44,318,848
Residential Pattern	1.39	1.22	1.08	1.05	1.00	1.11	1.13	1.17	1.30	1.18	1.26	1.29
Nonresidential Pattern	0.83	0.84	0.89	0.95	1.00	0.94	0.89	0.95	0.85	0.83	0.92	0.58

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Total
Power purchase	18,600,000	14,200,000	16,200,000	15,500,000	14,100,000	14,100,000	15,000,000	16,150,000	17,300,000	17,600,000	16,300,000	19,000,000	**194,050,000**
Total Billing	12,366,076	11,326,002	10,675,105	10,697,074	10,603,765	11,038,418	11,017,376	11,519,519	11,922,497	11,052,599	11,949,301	10,695,068	**134,862,801**
Losses	6,233,924	2,873,998	5,524,895	4,802,926	3,496,235	3,061,582	3,982,624	4,630,481	5,377,503	6,547,401	4,350,699	8,304,932	**59,187,199**
Residential	8,901,011	7,800,511	6,944,479	6,728,293	6,410,569	7,105,707	7,270,084	7,522,990	8,345,937	7,590,513	8,086,772	8,244,631	**90,951,496**
Nonresidential	3,465,065	3,525,491	3,730,626	3,968,781	4,193,196	3,932,712	3,747,292	3,996,529	3,576,560	3,462,086	3,862,529	2,450,437	**43,911,305**





Appendix10.1

Natural Gas Purchase and Distribution According to Billing Data

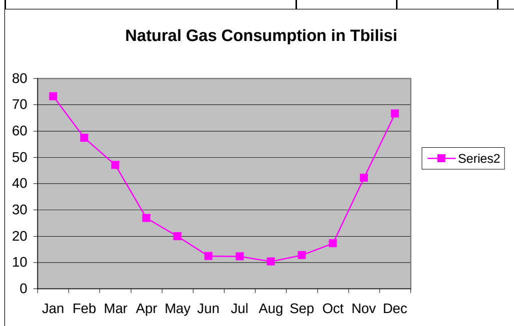
	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Sum	
Purchased by ltd. "yaztransgaz-Tbilisi" In total	**106169112**	**73360676**	**75918793**	**46875784**	**29221100**	**12422460**	**12252801**	**10385008**	**12825459**	**17321819**	**42245827**	**66596460**	**505595299**	
"Mtkvari Energetika" IX block	**7813157**	**3158123**											**10971280**	
"Tbilsresi"	**25107468**	**12830446**	**28899089**	**19992847**	**9341782**								96171632	
Received in the city in Total	**73248487**	**57372107**	**47019704**	**26882937**	**19879318**	**12422460**	**12252801**	**10385008**	**12825459**	**17321819**	**42245827**	**66596460**	*398452387*	**119535716**
Total realization, among this	**31824270**	**28686694**	**25488507**	**18935780**	**14313264**	**10440159**	**8266563**	**5944268**	**8678483**	**15788223**	**23636316**	**33539410**	**220263751**	178188636
Didi diRomi	757280	798602	637558	318646	216968	128270	113912	86334	123321	183231	651672	1066168	5081962	
Ltd "varkeTilairi"	801011	927102	731262	404652	265863	144412	136864	113772	152576	235631	664356	1145884	5723385	
Ltd "gardabangazi" (Kojori)	30150	24697	17113	8592	13926	3574	12115	9134	6042	7016	24523	26726	183608	
Ltd "iberia-2004" (Krtsanisi village)	17400	52589	17437	0	0	0	0	2696	7603	14578	37563	0	149866	
Tsavkisi-Shindisi	66300	71515	63509	33222	20940	12712	17100	15317	17631	35231	72234	88630	514341	
Tabaxmela	0	0	0	0	0	4253	6649	3239	4106	7035	4410	4935	34627	
Ltd "Vake"	0	0	0	9010	735	1193	1710	1917	2620	2900	4900	9000	33985	
Industry	1425694	1366363	1444730	1274589	1071107	1471704	1313143	1082741	1360065	1539998	1509480	1578542	16438156	
Large communal customers	2723384	2421620	2167685	1044845	719636	537531	440365	441306	721285	733272	2051788	3075560	17078277	
Communal customers									429832	508305	1039890	1539580	3517607	
Small communal customers	2101112	2845953	1805648	1609295	1116879	972496	785576	654641	483443	535002	876537	1328203	15114785	
Tax-free (embassies)	131674	103672	67089	47555	56966	19043	49349	31264	38459	39822	81773	114147	780813	
Residential sector, emong this:	**23770265**	**20074581**	**18536476**	**14185374**	**10830244**	**7144971**	**5389779**	**3501907**	**5331500**	**11946202**	**16617190**	**23562035**	**155612339**	
Samgori	2224134	1588869	1664331	1245516	1177789	641203	555082	351743	8	1240867	1416118	1950285	14055945	
Gldani	2033911	1463042	1533634	1356946	1155340	566745	397997	341859	1215	1078260	1477125	2137297	13543371	
Digomi	1170742	827151	887579	689004	383109	409944	308481	109118	400	526231	773189	1086432	7171380	
Chugureti	1413360	998994	1141389	741416	754691	546154	474024	238109	2246	781182	963076	1243916	9298557	
Saburtalo	3738837	3551072	2795832	2057451	1502349	1012154	757195	383077	27876	1574713	2592539	3620832	23613927	
Vake-Tskneti	2671856	2656153	2136121	1591908	1246186	460323	449994	310127	5259	1126020	1880801	2552745	17087493	
Mtatsminda	2054464	2090674	1506808	1428705	711551	513240	343734	264272	2140	924474	1486913	2225895	13552870	
Isani	2192207	1597921	1335506	1005572	627468	532222	433998	276583	846	714049	768239	1099949	10584560	
Vazisubani			439974	478007	280470	194246	161960	77246	243	538490	696579	1046406	3913621	
Saburtalo - Nutsubidze	1800920	1572257	1320587	972732	739122	494492	389572	217666	3441	806413	1365213	1870694	11553109	
Didube	1433162	1071997	1031431	778973	596405	433328	252992	206014	889	658250	898664	1317036	8679141	
Krtsanisi	578667	453939	422138	343768	203550	154958	147460	104314	534	316158	356175	573123	3654784	
Sanzona	2458005	2202512	2321146	998043	965568	662365	421245	381421	1316	979137	1202660	1746931	14340349	
Nadzaladevi				497333	486646	523597	296045	240358	6902	681958	739899	1090494	4563232	
Losses cub.m.	**41424217**	**28685413**	**21531197**	**7947157**	**5566054**	**1982301**	**3986238**	**4440740**	**4146976**	**1533596**	**18609511**	**33057050**	**178188636**	
%	**56.55**	**50.00**	**45.79**	**29.56**	**28.00**	**15.96**	**32.53**	**42.76**	**32.33**	**8.85**	**44.05**	**49.64**	44.72	

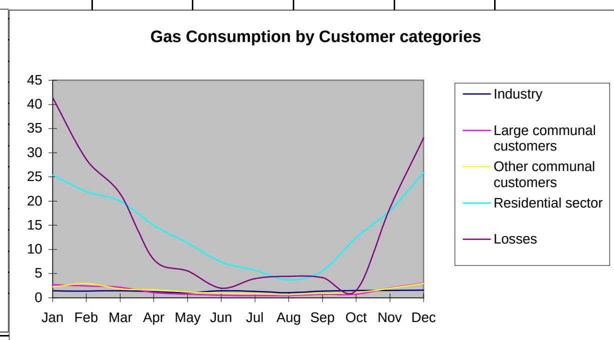
Inaccuracy in data. Has been multiplied by 100

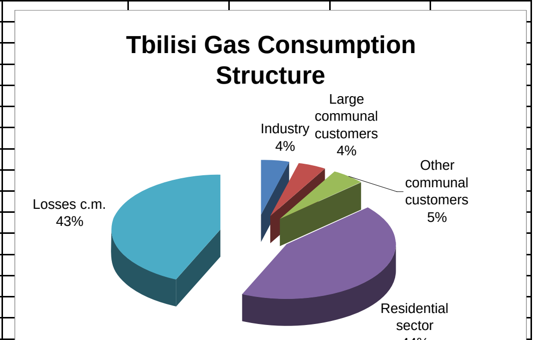
APPENDIX 10.2

Natural Gas Purchase and Distribution (mcm)

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Sum
Industry	1.4	1.4	1.4	1.3	1.1	1.5	1.3	1.1	1.4	1.5	1.5	1.6	16.4
Large communal customers	2.7	2.4	2.2	1.0	0.7	0.5	0.4	0.4	0.7	0.7	2.1	3.1	17.1
Other communal customers	2.2	2.9	1.9	1.7	1.2	1.0	0.8	0.7	1.0	1.1	2.0	3.0	19.4
Residential sector	25.4	21.9	20.0	15.0	11.3	7.4	5.7	3.7	5.6	12.4	18.1	25.9	172.6
Losses	41.4	28.7	21.5	7.9	5.6	2.0	4.0	4.4	4.1	1.5	18.6	33.1	172.9
Gas Purchase	73.2	57.4	47.0	26.9	19.9	12.4	12.3	10.4	12.8	17.3	42.2	66.6	398.5







C. Power Generation Technology Capital Cost Projections

SPV

Capacity	Contents	Units	2004			2010			2015		
			Minimum	**Probable**	Maximum	Minimum	**Probable**	Maximum	Minimum	**Probable**	Maximum
50W	Capital Cost	$/kW	5,830	**7,220**	8,590	5,230	**6,500**	7,760	4,660	**5,780**	6,870
	Fixed O&M	cent/kWh	2.76	**3.45**	4.14	2.76	**3.45**	4.14	2.76	**3.45**	4.14
	Variable O&M	cent/kWh	14.06	**17.58**	21.10	14.06	**17.58**	21.10	14.06	**17.58**	21.10
	Capacity factor	%	16%	**20%**	22%	16%	**20%**	22%	16%	**20%**	22%
300W	Capital Cost	$/kW	5,830	**7,220**	8,590	5,230	**6,500**	7,760	4,660	**5,780**	6,870
	Fixed O&M	cent/kWh	1.38	**1.72**	2.06	1.38	**1.72**	2.06	1.38	**1.72**	2.06
	Variable O&M	cent/kWh	4.71	**5.89**	7.07	4.71	**5.89**	7.07	4.71	**5.89**	7.07
	Capacity factor	%	16%	**20%**	22%	16%	**20%**	22%	16%	**20%**	22%
25kW	Capital Cost	$/kW	6,150	**7,320**	8,470	5,580	**6,590**	7,590	5,020	**5,860**	6,700
	Fixed O&M	cent/kWh	0.97	**1.21**	1.45	0.97	**1.21**	1.45	0.97	**1.21**	1.45
	Variable O&M	cent/kWh	3.98	**4.98**	5.98	3.98	**4.98**	5.98	3.98	**4.98**	5.98
	Capacity factor	%	16%	**20%**	22%	16%	**20%**	22%	16%	**20%**	22%
5MW	Capital Cost	$/kW	5,790	**6,880**	7,900	5,240	**6,190**	7,140	4,630	**5,500**	6,330
	Fixed O&M	cent/kWh	0.78	**0.97**	1.16	0.78	**0.97**	1.16	0.78	**0.97**	1.16
	Variable O&M	cent/kWh	0.19	**0.24**	0.29	0.19	**0.24**	0.29	0.19	**0.24**	0.29
	Capacity factor	%	16%	**20%**	22%	16%	**20%**	22%	16%	**20%**	22%

Wind

Capacity	Contents	Units	2004			2010			2015		
			Minimum	**Probable**	Maximum	Minimum	**Probable**	Maximum	Minimum	**Probable**	Maximum
300W	Capital Cost	$/kW	4,480	**5,240**	5,990	4,170	**4,850**	5,550	3,830	**4,450**	5,070
	Fixed O&M	cent/kWh	2.79	**3.49**	4.19	2.79	**3.49**	4.19	2.79	**3.49**	4.19
	Variable O&M	cent/kWh	3.92	**4.90**	5.88	3.92	**4.90**	5.88	3.92	**4.90**	5.88
	Capacity factor	%	20%	**30%**	40%	20%	**30%**	40%	20%	**30%**	40%
100kW	Capital Cost	$/kW	2,260	**2,700**	3,130	2,110	**2,500**	2,900	1,930	**2,300**	2,650
	Fixed O&M	cent/kWh	1.66	**2.08**	2.50	1.66	**2.08**	2.50	1.66	**2.08**	2.50
	Variable O&M	cent/kWh	3.26			3.26	**4.08**	4.90	3.26	**4.08**	4.90
	Capacity factor	%	20%	**30%**	40%	20%	**30%**	40%	20%	**30%**	40%
10MW	Capital Cost	$/kW	1,160	**1,400**	1,640	1,060	**1,260**	1,470	940	**1,120**	1,300
	Fixed O&M	cent/kWh	0.53	**0.66**	0.79	0.53	**0.66**	0.79	0.53	**0.66**	0.79
	Variable O&M	cent/kWh	0.21	**0.26**	0.31	0.21	**0.26**	0.31	0.21	**0.26**	0.31
	Capacity factor	%	20%	**30%**	40%	20%	**30%**	40%	20%	**30%**	40%
100MW	Capital Cost	$/kW	1,000	**1,200**	1,400	890	**1,080**	1,240	800	**960**	1,110
	Fixed O&M	cent/kWh	0.42	**0.53**	0.64	0.42	**0.53**	0.64	0.42	**0.53**	0.64
	Variable O&M	cent/kWh	0.18	**0.22**	0.26	0.18	**0.22**	0.26	0.18	**0.22**	0.26
	Capacity factor	%	20%	**30%**	40%	20%	**30%**	40%	20%	**30%**	40%

PV-Wind Hybrids

Capacity	Contents	Units	2004			2010			2015		
			Minimum	**Probable**	Maximum	Minimum	**Probable**	Maximum	Minimum	**Probable**	Maximum
300W	Capital Cost	$/kW	4,750	**5,530**	6,390	4,290	**4,980**	5,690	3,790	**4,420**	5,020
	Fixed O&M	cent/kWh	2.78	**3.48**	4.18	2.78	**3.48**	4.18	2.78	**3.48**	4.18
	Variable O&M	cent/kWh	3.94	**4.92**	5.90	3.94	**4.92**	5.90	3.94	**4.92**	5.90
	Capacity factor	%	25%	**30%**	40%	25%	**30%**	40%	25%	**30%**	40%
100kW	Capital Cost	$/kW	2,350	**2,800**	3,240	2,100	**2,520**	2,920	1,910	**2,240**	2,600
	Fixed O&M	cent/kWh	1.66	**2.07**	2.48	1.66	**2.07**	2.48	1.66	**2.07**	2.48
	Variable O&M	cent/kWh	5.12	**6.40**	7.68	5.12	**6.40**	7.68	5.12	**6.40**	7.68
	Capacity factor	%	25%	**30%**	40%	25%	**30%**	40%	25%	**30%**	40%

Solar Thermal

Capacity	Contents	Units	2004			2010			2015		
			Minimum	**Probable**	Maximum	Minimum	**Probable**	Maximum	Minimum	**Probable**	Maximum
30MW (without storage)	Capital Cost	$/kW	2,190	**2,450**	2,710	1,960	**2,200**	2,430	1,750	**1,960**	2,140
	Fixed O&M	cent/kWh	2.41	**3.01**	3.61	2.41	**3.01**	3.61	2.41	**3.01**	3.61
	Variable O&M	cent/kWh	0.60	**0.75**	0.90	0.60	**0.75**	0.90	0.60	**0.75**	0.90
	Capacity factor	%	49%	**54%**	59%	49%	**54%**	59%	49%	**54%**	59%
30MW (with storage)	Capital Cost	$/kW	4,230	**4,780**	5,320	3,840	**4,300**	4,750	3,420	**3,820**	4,220
	Fixed O&M	cent/kWh	1.46	**1.82**	2.18	1.46	**1.82**	2.18	1.46	**1.82**	2.18
	Variable O&M	cent/kWh	0.36	**0.45**	0.54	0.36	**0.45**	0.54	0.36	**0.45**	0.54
	Capacity factor	%	18%	**20%**	25%	18%	**20%**	25%	18%	**20%**	25%

Geothermal

Capacity	Contents	Units	2004			2010			2015		
			Minimum	**Probable**	Maximum	Minimum	**Probable**	Maximum	Minimum	**Probable**	Maximum
200kW Binary	Capital Cost	$/kW	5,990	**6,750**	7,520	5,860	**6,580**	7,290	5,680	**6,410**	7,140
	Fixed O&M	cent/kWh	2.40	**3.00**	3.60	2.40	**3.00**	3.60	2.40	**3.00**	3.60
	Variable O&M	cent/kWh	0.00	**0.00**	0.00	0.00	**0.00**	0.00	0.00	**0.00**	0.00
20MW Binary	Capital Cost	$/kW	3,410	**3,930**	4,450	3,320	**3,830**	4,320	3,250	**3,730**	4,200
	Fixed O&M	cent/kWh	1.52	**1.90**	2.28	1.52	**1.90**	2.28	1.52	**1.90**	2.28
	Variable O&M	cent/kWh	0.00	**0.00**	0.00	0.00	**0.00**	0.00	0.00	**0.00**	0.00
50MW Flash	Capital Cost	$/kW	2,100	**2,410**	2,720	2,060	**2,350**	2,260	2,000	**2,290**	2,590
	Fixed O&M	cent/kWh	1.20	**1.50**	1.80	1.20	**1.50**	1.80	1.20	**1.50**	1.80
	Variable O&M	cent/kWh	0.00	**0.00**	0.00	0.00	**0.00**	0.00	0.00	**0.00**	0.00

Biomass Gasifier

Capacity	Contents	Units	2004			2010			2015		
			Minimum	**Probable**	Maximum	Minimum	**Probable**	Maximum	Minimum	**Probable**	Maximum
100kW	Capital Cost	$/kW	2,230	**2,700**	3,190	2,100	**2,560**	3,010	2,020	**2,430**	2,840
	Fixed O&M	cent/kWh	0.27	**0.34**	0.41	0.27	**0.34**	0.41	0.27	**0.34**	0.41
	Variable O&M	cent/kWh	1.26	**1.57**	1.88	1.26	**1.57**	1.88	1.26	**1.57**	1.88
	fuel	cent/kWh	2.13	**2.66**	3.19	2.13	**2.66**	3.19	2.13	**2.66**	3.19
20MW	Capital Cost	$/kW	1,880	**2,300**	2,700	1,800	**2,180**	2,550	1,710	**2,070**	2,430
	Fixed O&M	cent/kWh	0.20	**0.25**	0.30	0.20	**0.25**	0.30	0.20	**0.25**	0.30
	Variable O&M	cent/kWh	0.94	**1.18**	1.42	0.94	**1.18**	1.42	0.94	**1.18**	1.42
	fuel	cent/kWh	2.00	**2.50**	3.00	2.00	**2.50**	3.00	2.00	**2.50**	3.00

Biomass Steam

Capacity	Contents	Units	2004			2010			2015		
			Minimum	**Probable**	Maximum	Minimum	**Probable**	Maximum	Minimum	**Probable**	Maximum
50MW	Capital Cost	$/kW	1,830	**2,150**	2,490	1,770	**2,090**	2,410	1,720	**2,040**	2,360
	Fixed O&M	cent/kWh	0.36	**0.45**	0.54	0.36	**0.45**	0.54	0.36	**0.45**	0.54
	Variable O&M	cent/kWh	0.09	**0.11**	0.13	0.09	**0.11**	0.13	0.09	**0.11**	0.13
	fuel	cent/kWh	2.00	**2.50**	3.00	2.00	**2.50**	3.00	2.00	**2.50**	3.00

MSW/Landfill Gas

Capacity	Contents	Units	2004			2010			2015		
			Minimum	**Probable**	Maximum	Minimum	**Probable**	Maximum	Minimum	**Probable**	Maximum
5MW	Capital Cost	$/kW	2,750	**3,140**	3,540	2,620	**2,980**	3,330	2,520	**2,830**	3,170
	Fixed O&M	cent/kWh	0.09	**0.11**	0.13	0.09	**0.11**	0.13	0.09	**0.11**	0.13
	Variable O&M	cent/kWh	0.10	**0.13**	0.16	0.10	**0.13**	0.16	0.10	**0.13**	0.16
	fuel	cent/kWh	0.80	**1.00**	1.20	0.80	**1.00**	1.20	0.80	**1.00**	1.20

Biogas

Capacity	Contents	Units	2004			2010			2015		
			Minimum	**Probable**	Maximum	Minimum	**Probable**	Maximum	Minimum	**Probable**	Maximum
60kW	Capital Cost	$/kW	2,450	**2,800**	3,130	2,410	**2,730**	3,060	2,340	**2,660**	2,970
	Fixed O&M	cent/kWh	0.15	**0.19**	0.23	0.15	**0.19**	0.23	0.15	**0.19**	0.23
	Variable O&M	cent/kWh	0.52	**0.65**	0.78	0.52	**0.65**	0.78	0.52	**0.65**	0.78
	fuel	cent/kWh	0.88	**1.10**	1.32	0.88	**1.10**	1.32	0.88	**1.10**	1.32

Pico/Micro Hydro

Capacity	Contents	Units	2004			2010			2015		
			Minimum	**Probable**	Maximum	Minimum	**Probable**	Maximum	Minimum	**Probable**	Maximum
300W	Capital Cost	$/kW	1,200	**1,500**	1,800	1,190	**1,485**	1,790	1,170	**1,470**	1,770
	Fixed O&M	cent/kWh	-	**-**	-	-	**-**	-	-	**-**	-
	Variable O&M	cent/kWh	0.72	**0.90**	1.08	0.72	**0.90**	1.08	0.72	**0.90**	1.08
	Capacity factor	%	25%	**30%**	35%	25%	**30%**	35%	25%	**30%**	35%
1kW	Capital Cost	$/kW	2,200	**2,600**	3,000	2,180	**2,575**	2,980	2,150	**2,550**	2,950
	Fixed O&M	cent/kWh	-	**-**	-	-	**-**	-	-	**-**	-
	Variable O&M	cent/kWh	0.43	**0.54**	0.65	0.43	**0.54**	0.65	0.43	**0.54**	0.65
	Capacity factor	%	25%	**30%**	35%	25%	**30%**	35%	25%	**30%**	35%
100kW	Capital Cost	$/kW	2,170	**2,500**	2,800	2,180	**2,470**	2,770	2,130	**2,450**	2,720
	Fixed O&M	cent/kWh	0.84	**1.05**	1.26	0.84	**1.05**	1.26	0.84	**1.05**	1.26
	Variable O&M	cent/kWh	0.34	**0.42**	0.50	0.34	**0.42**	0.50	0.34	**0.42**	0.50
	Capacity factor	%	25%	**30%**	35%	25%	**30%**	35%	25%	**30%**	35%

Mini Hydro

Capacity	Contents	Units	2004			2010			2015		
			Minimum	**Probable**	Maximum	Minimum	**Probable**	Maximum	Minimum	**Probable**	Maximum
5MW	Capital Cost	$/kW	2,070	**2,300**	2,590	2,020	**2,280**	2,540	2,000	**2,250**	2,500
	Fixed O&M	cent/kWh	0.59	**0.74**	0.89	0.59	**0.74**	0.89	0.59	**0.74**	0.89
	Variable O&M	cent/kWh	0.28	**0.35**	0.42	0.28	**0.35**	0.42	0.28	**0.35**	0.42
	Capacity factor	%	35%	**45%**	55%	35%	**45%**	55%	35%	**45%**	55%

Large Hydro

Capacity	Contents	Units	2004			2010			2015		
			Minimum	**Probable**	Maximum	Minimum	**Probable**	Maximum	Minimum	**Probable**	Maximum
100MW	Capital Cost	$/kW	1,770	**2,100**	2,440	1,750	**2,080**	2,410	1,730	**2,060**	2,380
	Fixed O&M	cent/kWh	0.40	**0.50**	0.60	0.40	**0.50**	0.60	0.40	**0.50**	0.60
	Variable O&M	cent/kWh	0.26	**0.32**	0.38	0.26	**0.32**	0.38	0.26	**0.32**	0.38
	Capacity Factor	%	40%	**50%**	60%	40%	**50%**	60%	40%	**50%**	60%

Pumped Storage Hydro

Capacity	Contents	Units	2004			2010			2015		
			Minimum	**Probable**	Maximum	Minimum	**Probable**	Maximum	Minimum	**Probable**	Maximum
150MW	Capital Cost	$/kW	2620	**3,110**	3,580	2,590	**3,080**	3,580	2,550	**3,050**	3,550
	Fixed O&M	cent/kWh	0.26	**0.32**	0.38	0.26	**0.32**	0.38	0.26	**0.32**	0.38
	Variable O&M	cent/kWh	0.27	**0.33**	0.39	0.27	**0.33**	0.39	0.27	**0.33**	0.39

Diesel/Gasoline Generator

Capacity	Contents	Units	2004			2010			2015		
			Minimum	**Probable**	Maximum	Minimum	**Probable**	Maximum	Minimum	**Probable**	Maximum
300W	Capital Cost	$/kW	660	**820**	980	650	**810**	970	640	**800**	960
	Fixed O&M	cent/kWh	-	**-**	-	-	**-**	-	-	**-**	-
	Variable O&M	cent/kWh	4.00	**5.00**	6.00	4.00	**5.00**	6.00	4.00	**5.00**	6.00
	Fuel	cent/kWh	39.50	**47.75**	70.60	34.90	**45.89**	66.92	37.34	**46.86**	68.88
1kW	Capital Cost	$/kW	510	**630**	750	500	**625**	750	500	**620**	740
	Fixed O&M	cent/kWh	-	**-**	-	-	**-**	-	-	**-**	-
	Variable O&M	cent/kWh	2.40	**3.00**	3.60	2.40	**3.00**	3.60	2.40	**3.00**	3.60
	Fuel	cent/kWh	32.09	**38.80**	57.36	28.35	**37.29**	54.37	30.34	**38.08**	55.97
100kW	Capital Cost	$/kW	490	**600**	710	490	**595**	710	480	**590**	700
	Fixed O&M	cent/kWh	1.60	**2.00**	2.40	1.60	**2.00**	2.40	1.60	**2.00**	2.40
	Variable O&M	cent/kWh	2.40	**3.00**	3.60	2.40	**3.00**	3.60	2.40	**3.00**	3.60
	Fuel	cent/kWh	9.63	**12.15**	19.15	8.99	**11.83**	18.51	9.57	**12.12**	19.10
5MW	Capital Cost	$/kW	470	**560**	650	460	**555**	650	460	**550**	640
	Fixed O&M	cent/kWh	0.80	**1.00**	1.20	0.80	**1.00**	1.20	0.80	**1.00**	1.20
	Variable O&M	cent/kWh	2.00	**2.50**	3.00	2.00	**2.50**	3.00	2.00	**2.50**	3.00
	Fuel	cent/kWh	2.86	**3.94**	7.27	2.67	**3.79**	6.97	2.85	**3.93**	7.24

Micro Turbine

Capacity	Contents	Units	2004			2010			2015		
			Minimum	**Probable**	Maximum	Minimum	**Probable**	Maximum	Minimum	**Probable**	Maximum
150W	Capital Cost	$/kW	730	**900**	1,070	640	**780**	920	560	**680**	800
	Fixed O&M	cent/kWh	0.80	**1.00**	1.20	0.80	**1.00**	1.20	0.80	**1.00**	1.20
	Variable O&M	cent/kWh	2.00	**2.50**	3.00	2.00	**2.50**	3.00	2.00	**2.50**	3.00
	Fuel	cent/kWh	22.56	**24.25**	28.44	21.72	**23.40**	27.60	22.56	**24.24**	28.44

Fuel Cells

Capacity	Contents	Units	2004			2010			2015		
			Minimum	**Probable**	Maximum	Minimum	**Probable**	Maximum	Minimum	**Probable**	Maximum
200kW	Capital Cost	$/kW	2,900	**3520**	4,150	2,340	**2,820**	3,300	1,750	**2,100**	2,450
	Fixed O&M	cent/kWh	0.08	**0.10**	0.12	0.08	**0.10**	0.12	0.08	**0.10**	0.12
	Variable O&M	cent/kWh	3.60	**4.50**	5.40	3.60	**4.50**	5.40	3.60	**4.50**	5.40
	fuel	Cent/kWh	13.67	**14.70**	17.24	13.17	**14.18**	16.73	13.67	**14.69**	17.24
5 MW	Capital Cost	$/kW	2,900	**3515**	4,150	2,340	**2,820**	3,300	1,750	**2100**	2,450
	Fixed O&M	cent/kWh	0.08	**0.10**	0.12	0.08	**0.10**	0.12	0.08	**0.10**	0.12
	Variable O&M	cent/kWh	3.60	**4.50**	5.40	3.60	**4.50**	5.40	3.60	**4.50**	5.40
	fuel	Cent/kWh	2.10	**3.12**	5.70	2.01	**3.06**	5.56	2.09	**3.12**	5.70

Combustion Turbine

Capacity	Contents	Units	2004			2010			2015		
			Minimum	**Probable**	Maximum	Minimum	**Probable**	Maximum	Minimum	**Probable**	Maximum
150MW	Capital Cost	$/kW	380	**450**	520	370	**430**	490	360	**420**	480
	Fixed O&M	cent/kWh	0.24	**0.30**	0.36	0.24	**0.30**	0.36	0.24	**0.30**	0.36
	Variable O&M	cent/kWh	0.80	**1.00**	1.20	0.80	**1.00**	1.20	0.80	**1.00**	1.20
	Fuel	cent/kWh	3.09	**4.60**	8.40	2.98	**4.50**	8.22	3.10	**4.61**	8.42

Combined Cycle

Capacity	Contents	Units	2004			2010			2015		
			Minimum	**Probable**	Maximum	Minimum	**Probable**	Maximum	Minimum	**Probable**	Maximum
300W	Capital Cost	$/kW	510	**600**	690	500	**580**	660	480	**560**	640
	Fixed O&M	cent/kWh	0.08	**0.10**	0.12	0.08	**0.10**	0.12	0.08	**0.10**	0.12
	Variable O&M	cent/kWh	0.32	**0.40**	0.48	0.32	**0.40**	0.48	0.32	**0.40**	0.48
	Fuel	cent/kWh	2.09	**3.10**	5.66	2.01	**3.04**	5.54	2.10	**3.11**	5.68

Coal Steam

Capacity	Contents	Units	2004			2010			2015		
			Minimum	**Probable**	Maximum	Minimum	**Probable**	Maximum	Minimum	**Probable**	Maximum
300MW	Capital Cost	$/kW	810	**930**	1,050	790	**910**	1,030	770	**890**	1,010
	Fixed O&M	cent/kWh	0.31	**0.38**	0.46	0.31	**0.38**	0.46	0.31	**0.38**	0.46
	Variable O&M	cent/kWh	0.29	**0.36**	0.43	0.29	**0.36**	0.43	0.29	**0.36**	0.43
	Fuel	cent/kWh	1.52	**1.80**	2.66	1.33	**1.66**	2.44	1.39	**1.71**	2.51

Coal IGCC

Capacity	Contents	Units	**2004**			**2010**			**2015**		
			Minimum	**Probable**	Maximum	Minimum	**Probable**	Maximum	Minimum	**Probable**	Maximum
300MW	Capital Cost	$/kW	1,060	**1,200**	1,360	950	**1,080**	1,210	850	**960**	1,070
	Fixed O&M	cent/kWh	0.72	**0.90**	1.08	0.72	**0.90**	1.08	0.72	**0.90**	1.08
	Variable O&M	cent/kWh	0.17	**0.21**	0.25	0.17	**0.21**	0.25	0.17	**0.21**	0.25
	fuel	Cents/kWh	1.40	**1.66**	2.45	1.22	**1.53**	2.25	1.28	**1.58**	2.32

Coal AFBC

Capacity	Contents	Units	2004			2010			2015		
			Minimum	**Probable**	Maximum	Minimum	**Probable**	Maximum	Minimum	**Probable**	Maximum
300MW	Capital Cost	$/kW	910	**1,050**	1,190	870	**1,000**	1,130	830	**950**	1,080
	Fixed O&M	cent/kWh	0.40	**0.50**	0.60	0.40	**0.50**	0.60	0.40	**0.50**	0.60
	Variable O&M	cent/kWh	0.27	**0.34**	0.41	0.27	**0.34**	0.41	0.27	**0.34**	0.41
	Fuel	cent/kWh	1.19	**1.39**	1.93	1.22	**1.43**	1.99	1.24	**1.46**	2.05

Oil Steam

Capacity	Contents	Units	2004			2010			2015		
			Minimum	**Probable**	Maximum	Minimum	**Probable**	Maximum	Minimum	**Probable**	Maximum
300MW	Capital Cost	$/kW	710	**820**	930	700	**810**	910	690	**800**	900
	Fixed O&M	cent/kWh	0.28	**0.35**	0.42	0.28	**0.35**	0.42	0.28	**0.35**	0.42
	Variable O&M	cent/kWh	0.24	**0.30**	0.36	0.24	**0.30**	0.36	0.24	**0.30**	0.36
	Fuel	cent/kWh	3.18	**4.36**	8.06	3.00	**4.23**	7.78	3.20	**4.38**	8.09