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BURNS AND ROE ENTERPRISES, INC.

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DELIVERY ORDER No. 31
Least Cost Plan for the Energy Sector

GEORGIA

Technical Report
ELECTRICITY DEMAND FOR GEORGIA: 1998 - 2020

July, 1998

Prepared by:	**Burns & Roe Enterprises, Inc.**
Submitted to:	**U.S. Agency for International Development**
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Center for Energy Efficiency (CENEf)

Electricity Demand for Georgia: 1998-2020

Prepared for

Burns an Roe Enterprises, Inc.

under the contract No. 5826-067 For Work Order 31: Georgia: Least Cost Development Plan (USAID Prime Contract No. CCN-Q-00-93-00154-00)

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1. Introduction

To identify potential for building additional power sources in Georgia and to develop a Least Cost Plan for local utility there is a need to estimate future electricity demand for the region and to evaluate electricity efficiency improvement potential utilization impact on the consumption patterns and loads.

Such task is a challenge for any country. It is a much more challenging exercise for Georgia. "Georgia Energy Sector Memorandum" developed by the World Bank on January 16, 1996 states:

> Since declaring independence in 1991, Georgia has gone through a very difficult period of deep economic recession and political instability. The economic shock caused by the dissolution of the Soviet Union (FSU) took place on the background of domestic political problems.

In 1995-1997, some improvements of economic situation were displayed by official statistics. The economic crisis was substituted by a period of recovery. GDP moderate but steady growth resulted in energy demand increase. Simultaneously, domestic electricity production grew up so that net electricity import was reduced. Nevertheless, obstacles for accelerated economic growth still remain, and the major of them are strong Georgia's dependence on energy import and large external debt.

The break-up of monetary and trade links among the FSU republics, and the ensuing deterioration of trade caused mainly by the sharp increase in import fuel prices, had a negative impact on the Georgian economy which, by the World Bank's accounts, has shrunk to less than one-fifth of its size in the Soviet era.

Shortage of energy was one of the main reasons of the economic decline. In 1990, 87% of primary energy supply was imported from abroad, mainly from Russia and Turkmenistan. As economic crisis expanded, and energy import prices rose to the world level, Georgia's ability to import energy became progressively limited. By 1994, net energy import was just 45% of 1990 level. Domestic production of hydropower, coal and oil in the same period significantly declined. The shortage of energy was partially offset by use of extensive fuelwood which went uncontrolled and threatened to forest and the environment.

Analytical tools used to make future projections of electricity demand are developed for more or less stable economies. It is not just an issue of tuning models to Georgian economy specifics, but rather it is the issue of developing a set of models capable to deal with the economy which simultaneously:

- got caught in a vicious cycle of falling production and exports and the subsequent inability to pay for imports, but
- demonstrated that economic crisis was substituted by a period of recovery, and
- ready to spurt on a track of economic recovery, but
- is coming through the transition period from centrally planned to a market economy, and
- future trajectories of economy are very uncertain, plus
- has a substantial sector of shadow economy, which somehow have to change its gray color to white one as recovery process will continue; but

- has very limited resources to fuel economic recovery by export revenues.

All these present specific features of Georgian economy multiply complexity of the estimation of future electricity demand and load curves for the country.

Center for Energy Efficiency was selected by the Burns and Roe Enterprises, Inc. to develop projections of electricity demand for Georgia with evaluation of electricity utilization efficiency improvement potential under the contract No. 5826-067 For Work Order 31: Georgia: Least Cost Development Plan (USAID Prime Contract No. CCN-Q-00-93-00154-00).

The Center for Energy Efficiency (CENEf) is an independent, non-for-profit organization, founded to promote energy efficiency and environmental protection in Russia and the Newly Independent States (NIS). The Center was founded in September 1991.

This contract is not the first example of CENEf's cooperation with Burns and Roe. In 1997 CENEf successfully conducted Energy Seminar jointly with Burns and Roe Enterprises, Inc.

In 1995, under the contract with RCG/Hagler, Bailly, Inc. CENEf developed the "Energy Demand Projections for the Krasnodar Kray and North Caucasus" (51 p.). Later, in 1996 CENEf has developed a report "Evaluation of Tariff Policy Impacts on a Utility's Revenues" (40 p.), with results of modeling pricing policy impacts for three Russian Utilities. In 1997 CENEf has developed a book "Introduction to Integrated Resources Planning" (in Russian, 253 pages).

In 1996-98, Center for Energy Efficiency (CENEf), with the support provided by US DOE and Pacific Northwest National Laboratory, has been implementing a project **"Model Program of Improving District Heating Efficiency"**. Such a model program was developed and calibrated on projects for nine Russian cities (Chelyabinsk, Kostroma, Lytkarino and others) and one oblast (Orlovskaya oblast). Based on this model energy efficiency improvement programs with the total budget of $US 220 million were developed. Three of them were rewarded World Bank loans.

CENEf was the first Russian organization which was rewarded direct contracts by the US AID to establish Russian Energy Managers Association.

Given report consists of seven sections. This introduction is followed by the Section 2 describing the scope of work for CENEf in this assignment.

In the Section 3 the economic development of Georgia in 1990-1998 is characterized by the set of historical statistics. The question of reliability of such data is placed in a focus of discussion. Georgian GDP is shown by major sectors of economy as well as special attention was given to the industrial sector. This section serves as a basis for building scenarios of Georgian economic development.

Section 4 presents historical statistics on electricity and related heat demand, electricity usage patterns for major end-use categories, levels of electricity use, intensities, and key types of electrical devices, availability, load characteristics, rates of installed capacity retirements, current tariffs and future tariff projections.

Section 5 describes the model complex, which was build by CENEf to develop electricity demand projections, based on scenarios of Georgian economic

development. This description was made on the basis of comparison with forecasting tools used by the other groups of researchers. This section also explains how the most promising programs for achieving substantial electricity savings were incorporated in particular models.

Energy efficiency improvement opportunities in Georgia are considered in the section 6. Special consideration was given to industrial and residential sectors.

Section 7 is devoted to the description of three basic scenarios of economic development of Georgia as well as results of corresponding model runs to evaluate the related electricity consumption.

Comparison of electricity demand projections is presented in the final, eighth, section.

The CENEf team was led by Igor Bashmakov. The major contribution to the implementation of the scope of work was provided by the following CENEf's experts: Vladimir Zhuze, Svetlana Sorokina, Yuri Dashevsky, and Alexander Perevozchikov.

All models, but GEL were developed by Igor Bashmakov. Models for the residential sector - GELRES - and energy balance model - GEB - were calibrated by Svetlana Sorokina. GEL was developed and calibrated by Alexander Perevozchikov.

Data and information collection was performed by I. Bashmakov, V. Zhuze, Yu. Dashevsky. Other members of CENEf's staff also substantially contributed to the work.

CENEf appreciates the contribution to the data collection process and consultations provided by the office staff, especially by Zurab Menteshashvili, Ketino Alatashvili and Teimury Mikiashvili.

Invaluable assistance and on land support was provided to the CENEf's team by the Burns and Roe Tbilisi Office staff.

2. Scope of work

The purpose of this project is to

- develop electricity and heat demand projections, based on scenarios of Georgian economic development, and
- identify programs for achieving substantial savings in electric energy.

Task 1. Data Collection and Data Validation

With assistance provided by Burns and Roe Enterprises, Inc. and local Georgian staff retained by BREI CENEf collected necessary statistical data to be used in development and calibration of models. Such data include:

a) historical statistics on electricity and related heat demand;

b) electricity usage patterns, for major end-use categories, various industry classifications and economic sectors of Georgia;

c) levels of electricity use, intensities, and key types electrical devices;

d) availability, load characteristics, rates of installed capacity retirements,

e) current tariffs and future tariff projections,

f) technical and economic data on energy efficiency measures including their total and incremental capital and operating costs and their expected services life times.

With assistance provided by Burns and Roe Enterprises, Inc. CENEf collected necessary statistical data for evaluation a potential and costs to improve energy efficiency. Such data were collected partly by conducting energy audits and partly by collecting statistical data.

Three trip reports are presented in attachment A.

Task 2. Electricity Demand Scenarios

Based on data collected, CENEf created and calibrated the complex of models it possesses to be used for the purposes of energy demand projections. Model output provided demand broken by energy consuming sectors and by industrial branches as well as projections of electric energy and related heat load profiles The time frames and scenarios was extended through the year 2020.

To make projections CENEf, advised by Burns and Roe Enterprises, Inc. developed and run three scenarios for the region. Demand scenarios incorporated the potential for energy efficiency improvements.

Task 3. DSM Impact Assessments

A list of energy efficiency measures (EEMs) that can be employed in Georgia was compiled. Impacts of those measures on the reduction of both the electricity consumption and the level of peak demand were evaluated along with EEMs penetration rates.

Impact of those EEMs was used as an input to projection model. Those EEMs which demonstrated the most significant impact were selected for further more detailed studies by other participants in the project.

The result of this task was summarized and explained in a separate section of the project final report on the potential on energy efficiency.

Task 4. Local Workshop

CENEf's experts participated in two-day workshop meeting for all participants presenting preliminary results of forecasting with the evaluation of reliability of such results, explanation of methods used for making projections, as well as preliminary conclusions of the DSM impact assessment work.

CENEf prepared the draft version of the final report for review and discussion with the study participants.

Task 5. Final Report

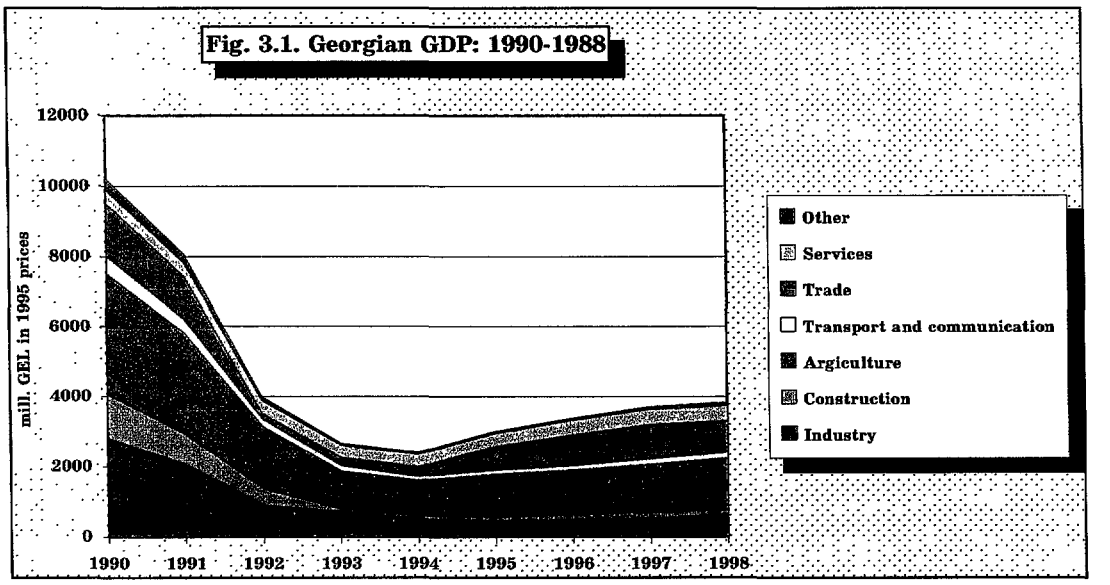
CENEf will prepare a detailed English language final report. That report will explain the methodology, describe the data used, and elaborate on the results of the demand assessment work. It will also include the section on the potential for energy efficiency improvements prepared in connection with task 3, above.

3. Economic Development of Georgia: 1990-1998

3.1. Evolution of Georgian GDP

Georgia has reestablished its independence in 1991. This important political event was followed by civil wars, ethnic conflicts and economic catastrophe. Some decline of the nation's GDP was already registered in 1989 and 1990. It was followed by the dramatic recession during the first years of independence, particularly exacerbated by the civil war. Extreme shortage of resources to stop the catastrophe as well as very unstable political situation were the major reasons for 1994 GDP drop to the 30% of 1990 level. (See Fig. 3.1).

The problems were exacerbated in Georgia by the human and material damage caused by war, declining morale and total erosion of law and order. It has been impossible, under such circumstances, to develop a self-sustaining economy.



The political stabilization started in 1994-1995 eventually went hand in hand with the economic stabilization. In 1994-1997, the government made a number of efforts to improve the situation, including stricter monetary control, fiscal reforms, strengthening the financial sector, accelerating the process of privatization, foreign exchange and trade regimes, maintenance of a minimum social safety net.

In 1995-1997, official statistics registered high growth rates in all sectors of the economy, the highest in construction, transport and trade. Nevertheless, all experts stress that these growth figures are extremely subjective given the size of the shadow economy in Georgia.

The economic crisis was substituted by a period of recovery, but the crisis was so deep, that three years of such a recovery did not let GDP to approach to the 1990 level. The impressive GDP growth actually corresponds to an extremely small volume of economic activity.

According to the "Georgian Economic Trends" - Third Quarter 1997:

Per capita income still remains very low, probably about USD 800 for 1997 - comparable to some of the richer African countries. There are reasons to be skeptical of these figures.

This skepticism does exist due to large share of shadow economy, which is not accounted by the official statistics. Therefore, the quality of statistical data arises as crucial issue in any analytical exercise on Georgian economy.

There is a number of statistical sources which provide inconsistent information even on the volume of GDP in current prices, not to speak on GDP in constant prices. (See Table 3.1).

Table 3.1. GDP in current prices, million GEL

	1	2	3*	4*	5*	6
1990	14.90		23.24	14.10		
1991	19.10		17.78	17.70		
1992	138.00		136.67	136.40		
1993	25.30	27.50	26.09	26.00		
1994	1418.90	1418.90	1768.54	1190.00		
1995	2615.00	3137.00	3693.49	3017.00	2632.9	2615.90
1996	4547.00	4547.00		4389.90	3691.30	
1997					4866.40	

1. Human Development Report. Georgia 1997. p. 95
2. Human Development Report. Georgia 1997. p.15
3. Georgia 1995. State Department of Statistics (factor costs)
4. Georgian Economic Trends. 3 quarter 1997 (factor costs). TACIS
5. Georgian Economic Trends. Fourth Quarter 1997 (factor costs).
6. Report on Hydropower stations rehabilitation. May 1997. ICEE, BEA Consulting, EUT.

The problem of economic statistics low accuracy was exaggerated by the fact that in 1990 -1996 three currencies consequently were used in Georgia - rubles, coupons and finally - lari. As a result the value of GDP presented in lari depends on the exchange rates used by the given statistical source.

Nevertheless, even when Georgian lari was already used as the only currency, the gap between the upper and the lower estimates of GDP equals to 41% in 1995 and to 23% in 1996. Those numbers are true indicators of Georgian economic statistics accuracy.

There are two more very important factors, which affect the accuracy of metering Georgian GDP:

- so called shadow, gray or black economy. The gray economy existed in Georgia even prior the independence. Statistical Department of Georgia estimates that the shadow economy represents one third of Georgia's GDP. The shadow economy is believed to constitute a particularly large share of the trade, transport and construction sectors. This sector grew further fertilized by the heavy tax burden which squeeze the legal part and push many small scale private sector enterprises to move to the informal sector. Many of them would find official tax burdens too much to bear at present.

- accounting GDP produced in Abkhazia. This region was included into statistics in early 90s, and the extent of coverage the economic activities in Abkhazia since that time is not quite clear.

High rates of inflation led to the situation when nominal GDP grew 327 - told in 1990-1997 on the background of very deep real GDP decline.

To fulfill the given scope of work the data on evolution of real GDP are required. Estimates of annual growth rates provided by different sources are presented in Table 3.2. All four sources disagree on a rate of GDP evolution in every single year.

Table 3.2. Annual rates of GDP (%)

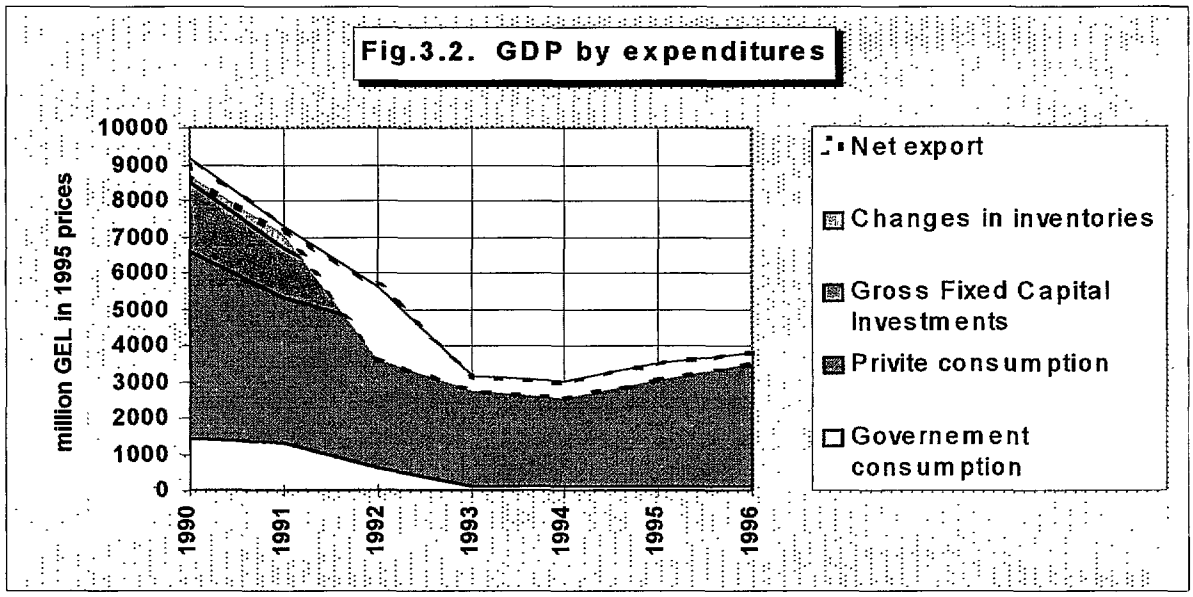
	1	2	3	4
1990	-15.0			-12.4
1991	-20.1	-18.04	-21.0	-13.8
1992	-39.7	-41.61	-44.2	-40.3
1993	-29.3	-32.55	-29.3	-39.0
1994	-12.1	-7.43	-11.0	-35.0
1995	3.3	0.34	-2.4	2.4
1996	11.2	19.00	11.4	13.7
1997		12.00		

1. Human Development Report. Georgia 1997. p. 15
2. Georgia 1995. State Department of Statistics (factor costs)
3. Economic Trends. 3 quarter 1997 (factor costs)
4. Report on Hydropower stations rehabilitation. May 1997. ICEE, BEA Consulting, EUT.

So evident disagreement in the evaluation of GDP - the most aggregated macroeconomic index - proves that low reliability of statistical data is the major evil to fight with to get the exercise done.

3.2. GDP by expenditures

GDP evolution by expenditures is presented at Fig. 3.2. Net export value is negative, exceeding since 1992 both capital investments and changes in inventories. Government consumption fell down considerably, whereas private consumption after a significant drop in 1990-94 displayed a growing trend (while being still under the 1990 level).



It should be noted here that investments recorded in official statistics can be underestimated because a large size of shadow economy. In spite of this note, no other data but official will serve a basis for scenarios development.

3.3. GDP by Sectors

To be more specific we need not just data on GDP evolution, but data on GDP fluctuations by sectors, and for industrial sector - even by branches of industry.

There are only two statistical sources available to get information for GDP breakdown by sectors. Both of them were used to calculate data, presented in Table 3.3 below.

Table 3.3. Real Annual GDP Evolution by Sectors (%)

	1991	1992	1993	1994	1995	1995	1996	1997
Industry	-25.33	-56.82	-19.58	-30.59	-1.15	-9.60	7.00	8.10
Agriculture	-16.09	-38.22	-40.28	-4.63	-11.23	17.90	5.10	7.10
Construction	-32.95	-44.36	-79.35	21.33	-1.31	14.60	25.10	22.20
Transportation and communication	-21.51	-46.79	-26.37	-94.94	0.90	15.80	0.40	29.70
Trade	-18.92	-88.14	51.37	21.04	144.95	155.10	30.00	12.20
Other branches	-24.48	-59.25	-52.58	5.13	120.03	4.80	6.90	20.60
Total material production	-21.76	-50.59	-37.98	-8.25	5.61	21.20	13.00	11.30
Total non material production	-2.93	-3.01	-6.59	0.72	-46.16	5.60	10.90	1.20
GDP at factor cost	-18.04	-41.61	-32.55	-7.43	0.34	19.00	12.00	9.10

Sources: For 1990-1995: Georgia 1995. State Department of Statistics (factor costs); for 1995-1997: Georgian Economic Trends. Fourth Quarter 1997 (factor costs)

Georgian State Department of Statistics (SDS) provided data on GDP production accounts both at given year current prices and at constant price of previous year

by sectors for each year in the interval 1990-1995. That allows to estimate the annual growth rates by sectors, and then to build chain indexes with the base in 1995 for each sector. The second source of Table 3.3 provided annual rates of growth for 1995-1997. The GDP reconstructed based on those growth rates and broken down by sectors is presented in Table 3.4 in 1995 prices.

Table 3.4. GDP by Sectors in 1995 prices, million GEL

	1990	1991	1992	1993	1994	1995	1996	1997
Industry	2792	2084	900	724	502	454	486	525
Agriculture	3426	2875	1776	1061	1012	1193	1254	1343
Construction	1264	847	471	97	118	135	169	207
Transportation and communication	507	398	212	156	109	126	127	164
Trade	1495	1212	144	218	263	672	873	980
Other Branches	326	246	100	48	50	52	56	68
Total material production	9873	7725	3817	2368	2172	2633	2975	3311
Total non material production	411	399	387	361	364	384	426	431
GDP at factor cost*	***10219***	***8061***	***3990***	***2664***	***2418***	***3017***	***3391***	***3718***
GDP at factor cost**	**8485**	**6955**	**4061**	**2739**	**2535**	**3017**	**3379**	**3687**
Statistical discrepancy, %	20.44	15.90	-1.75	-2.73	-4.61	0.00	0.36	0.85

* Calculated as sum of GDP by Sectors.
** Calculated based on rates of GDP growth.

Sources: Calculated by the authors based on data from tables 3.1.-3.3.

Application of the same procedure to the GDP index as well as GDP indexes by sectors with the following GDP aggregation by separate sectors brings different results. The result of aggregation by sectors is marked bold italic in Table 3.4, while the result received by the aggregated index of GDP - just bold. The discrepancy is about 20% in 1990, falling down to none in 1995 and to 0.85% in 1997.

GDP calculated based on aggregated index (bold) was used for estimation of electricity intensity of GDP, while to do similar calculations for each sector the corresponding data on GDP generated in each sector presented in Table 3.4 were used.

In 1990-1997, industrial value added declined by 5 times, agricultural one - by 2.5; value added in construction fell down by 6 times and in transportation - by 3 times. Uneven decline of value added in separate sectors led to substantial changes in GDP structure.

Presently agriculture and trade together provide for about two thirds of the Georgian GDP. In 1995 about 40% of Georgian GDP was produced in agricultural sector, while it was just 33% in 1990. In addition about 22% of GDP was generated in the trade sector (15% in 1990), while industrial sector accounted for only 15% (27% in 1990).

According to Human Development Report:

> The most important changes in the structure of economy manifested themselves in the rapid growth of the share of trade in the GDP, which is only natural since this is the sector which needs the least capital investment. In addition, the country began to exploit

its favorable geographical position to positive tendencies were more dynamic in Georgia than in other republics of the FSU.

GDP produced in trade sector was the major driving force behind the recent GDP growth. Its contribution to the GDP increase in 1994-1997 equals 55%.

3.4. Industrial Output by Branches

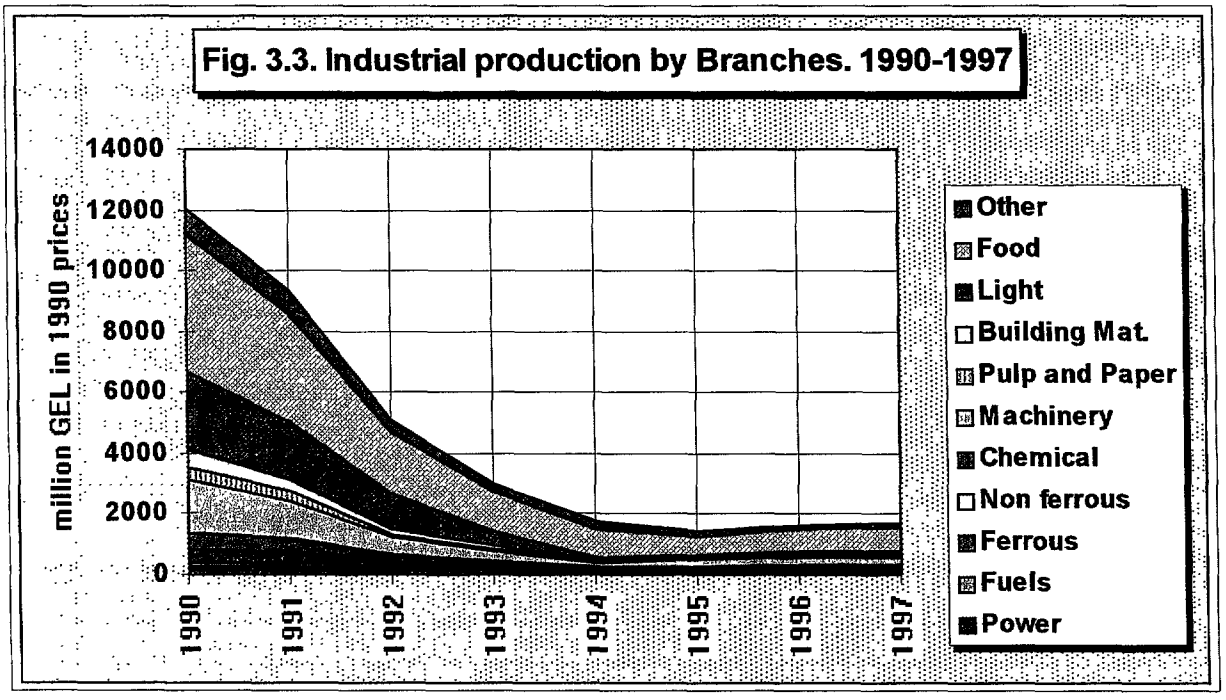
As can be seen from Fig. 3.3 and Table 3.4, the reduction of industrial output was the major contributor to the avalanche like decline of GDP. This sector is very important when someone deals with electricity demand. Therefore the special attention was given to the description of industrial output evolution in 1990-1997.

Georgian Statistical Yearbook (GSY), published in Georgian, provides data on 1990 indexes for different branches of industry for 1990-1996. Human Development Report (HDR) also provides data for 1996 and 1996/1990 indexes. All those sources were used to build the Table 3.5 and to paint Fig. 3.3.

Table 3.5. Industrial Production by Branches (million GEL in 1990 prices)

	1990	1991	1992	1993	1994	1995	1996	1997
Power	278.00	261.32	227.96	202.94	139.00	144.56	147.34	147.34
Fuels	135.00	120.15	32.40	14.85	8.10	4.05	9.45	10.02
Ferrous	416.00	287.04	149.76	79.04	37.44	45.76	37.44	39.50
Non ferrous	38.00	24.32	26.60	17.10	17.48	42.94	50.92	52.19
Chemical	527.00	500.65	189.72	163.37	47.43	42.16	63.24	66.40
Machinery	1730.00	1211.00	588.20	328.70	138.40	224.90	276.80	289.26
Pulp and Paper	401.00	332.83	124.31	68.17	40.10	36.09	48.12	50.53
Building Mat.	618.00	407.88	197.76	86.52	30.90	24.72	30.90	32.91
Light	2555.00	1890.70	1175.30	485.45	153.30	102.20	102.20	109.35
Food	4508.00	3561.32	1983.52	1307.32	901.60	586.04	721.28	753.74
Other	857.00	762.73	419.93	265.67	239.96	179.97	128.55	134.98
Industry	12063.00	9359.94	5115.46	3019.13	1753.71	1433.39	1616.24	1686.00

Sources: HDR 1997 p.25. Table 2.9. GSY, 1997, p.19



There was a seven fold decline registered in industrial output in 1990-1997. If power sector is excluded, the depth of industrial crisis looks even more terrifying.

According to the statistics, there is the only branch of industry which escaped the crisis - non-ferrous metals production. On the other hand, the most significant reductions were registered in building materials production and in light industry.

In 1997 the major contributor to industrial output was food industry (45% in 1997 versus 37% in 1990), followed by machinery (17% versus 14%), power (9% versus 2%), other industries (8% versus 7%), light industry (6% versus 21%). Share of six the most energy intensive industries (fuels, ferrous, non ferrous, chemical, pulp and paper, building materials) felt down slightly from 18% in 1990 to 15%.

Georgian Statistical Yearbook (GSY) and other sources also provide data on major industrial products output. Those data are presented in Table 3.6.

Comparison of Tables 3.5 and 3.6 rises some questions. For example, in 1990-1996 statistics registered coal production decline by 41 times and reduction of petroleum refining by 122 times, while value added in fuel branch reduced "just" by 13 times. Production of paper had reduced by 430 times while output for pulp and paper industry in 1997 was "just" 8 times below 1990 level.

So, from two approaches to estimate industrial production - costs of output by industries versus physical production of major goods - the former approach was selected as the basis for projecting electricity demand.

Table 3.6. Major Industrial Products (10^3 t)

	1990	1991	1992	1993	1994	1995	1996	1997
Electricity, million kWh	14246	13376	11520	10150	7045	7082	7233	7173
Coal	956	698	181	82	45	43	23	23
Petroleum refining	2323	1921	453	309	148	39	19	
Rolled steel	1109	818	430	186	100	75	62	65
Steel pipes	499	453	208	110	39	38	33	
Fertilizers	130	135	77	59	34	43	68	81
Sink electric drives, 10^3 units	11265	8656	2759	2257	950	680	412	
Heavy trucks, units	5735	2658	650	384	137	209	95	82
Paper	69100	27498	5946	2279	1376	1489	164	160
Cement	1290	821	426	278	89	62	85	91
Textile, 10^6 m2	111	66	32	16	3	2	1	0
Dairy products	250	152	24	18	18	4	4	
Meat	76700	31185	6515	3448	378	65	68	363

Sources: HDR 1997 p.25. Table 2.9. GSY, 1997, p.19

Surveys of industry suggest that the rate of industrial capacity use continues to fluctuate at around 8-10 percent.

3.5. Characteristics of Residential Sector

Residential sector is listed among the major consumers of electricity in Georgia. That is why special consideration is to be given to this sector.

Population of Georgia was about 5.4 million people in 1997, of which 56% is urban population. There are about 18 m^2 of living area per person in Georgia.

Table 3.7. Residential sector. Major Indicators

	Units	1990	1991	1992	1993	1994	1995	1996	1997
Population	10^3	5464	5463	5447	5433	5418	5416	5423	5428
Growth rates	%		-0.02	-0.29	-0.26	-0.28	-0.04	0.13	0.1
Urban	10^3	3073	3068	3049	3030	3015	3012	3014	3017
Rural	10^3	2391	2395	2398	2403	2403	2404	2409	2411
Living area	м2 per capita	18.64	18.28	17.03	17.12	17.23	17.55	17.76	17.78
Persons per flat	persons	3.09	3.05	3.06	3.06	3.06	3.06	3.06	3.06
Number of households	10^3	1768	1791	1780	1775	1771	1770	1772	1775
Urban	10^3	994	1006	996	990	985	984	985	987
Rural	10^3	774	785	784	785	785	786	787	789

Sources: CIS in 1996, Moscow, 1998. Human Development Report.

Several major factors drive energy demand in the residential sector: living area and number of habitants, saturation of residential sector with major communal services and appliances, personal income, price for energy and availability of energy.

Evolution of living area is presented in Table 3.8. In 1990-1997 it declined by 5%. About 51% of the total is accounted to urban living area.

Major reason behind such a reduction was substantial amount of decommissioning in 1990-1991 on the background of very weak residential construction activity in 90'es. Statistical data provided by the Georgian Department of Statistics on living area and commissioning of new residential buildings is inconsistent. That is why analytical evaluation of decommissioning for a number of years brings negative values. (See Table 3.8).

It seems that data for additions is only for urban sector. If so, then data on decommissioning of urban living space is always positive. But even calculated by such a way, the decommissioning for 1993 and 1994 left negative. It is clear that data on additions to the living space are not reliable enough, partly due to the fact that part of construction activities, especially for residential housing construction is hidden by shadow economy.

Table 3.8. Evolution of Living Area. 10^3 m^2

	1990	1991	1992	1993	1994	1995	1996	1997
Living area	101824	99842	92736	92988	93357	95048	96336	96502
including urban	50117	49405	47479	47479	48632	49516	49390	
Additions	1005	1327	473	265	132	160	142	166
Decommissioning	2987	8433	221	-104	-1559	-1128	-24	0

Sources: SDS.

As in all other former-Soviet cities the urban living stock was highly dependent on district heating for both heating and hot water purposes. (See Table 3.9). For cooking most families used natural gas.

Table 3.9. Urban Housing Stock: Availability of Energy Supply Infrastructure (% of all households)

	1990	1995	1996
District heat supply	89.20	94.40	97.70
Hot water supply	58.20	60.40	60.20
Electric ranges	14.40	18.70	18.60
Gas supply	83.60	61.60	71.20

Sources: SDS.

3.6. Economic Activity in Agriculture

There was no substantial decline of agricultural production in 1990-1997. Production of grain and vegetables in 1997 exceeded 1990 level, while tea, grapes and citrus production was well below 1990 level.

3.7. Economic Activity in Transportation

The transport sector is potentially of great importance to the Georgian economy. Economic activity in this sector shrunk sharply in 1990-1997. Freight turnover in 1997 was just 7% of that in 1990 and there is no sign of stabilization yet. On

this background the role of railroad transport grew from 19 to 34%. (See Table 3.10).

Passenger turnover decline was less dramatic, but still substantial by any scale. In 1997 it was 28% of 1990 level. In contrast with freight turnover the passenger one is coming up for already four years since 1993. Share of railroad and subway together in 1990 and 1997 was 16%.

Table 3.10. Transport Activity Indicators

	1990	1991	1992	1993	1994	1995	1996	1997
Freight turnover, 10^6 t-km	80005	66663	40967	34630	26680	15519	7413	5986.3
Railroad, 10^6 t-km	15476	12117	3512	1554	955	1246	1141	2006
Share of railroad, %	19%	18%	9%	4%	4%	8%	15%	34%
Passenger turnover, 10^6 pass-km	16113	13724	4588	2694	3098	3045	2957	4505
Railroad, 10^6 pass-km	2457	2135	1210	917	1165	371	380	572
Subway, 10^6 pass-km	183	167	158	182	138	142	155	114
Share of railroad, %	15%	16%	26%	34%	38%	12%	13%	13%
Share of subway, %	1%	1%	3%	7%	4%	5%	5%	3%

Source: SDS.

3.8. Role of energy import in foreign trade

The disintegration of FSU, the break-up of monetary and trade links among the FSU republics, sharp increase in import fuel prices had a dramatic impact on the Georgian economy. Negative external trade balance resulted in the country's dependence on large inflows of humanitarian assistance, especially imports of food.

According to Human Development Report, 1997:

> The situation in external trade is still very weak. There was growth of 29% in recorded exports in 1996, but recorded imports grew even faster at 46%.
>
> There has been some progress on debt rescheduling and in restoring orderly relations with external creditors, which was especially important in the case of Turkmenistan - the major natural gas provider.
>
> However identified foreign debt rose to 1.4 billion US dollars. The absolute amount of Georgian foreign debt as well as its ratio to GDP does not seem to be alarming but the foreign relations of Georgia and prospects of paying out the foreign debt arouses serious anxiety, because exports comprise only 25% of external trade turnover, while the remaining 75% is covered by imports. Georgia's foreign debt was 8 times more than the value of exports in 1996.

To demonstrate the role of energy import, primary energy balance for 1990-1995 is presented at Table 3.11. Several non-balanced data of 1996 are also shown.

In 1990, 87% of primary energy supply was imported from abroad, mainly from Russia and Turkmenistan. Net imports of natural gas, oil and oil products reached 99% of total primary energy supply, coal import accounted for about

one-fifth of its primary supply, and electricity import provided for 22% of final electricity consumption. As domestic economic activity declined and energy import prices rose rapidly up, Georgia's ability to import energy became progressively limited.

By 1995, only 3.9 Mtoe, or 33% of the 1990 level, were imported, while energy consumption fell to 5.8 Mtoe, or 47% of the 1990 consumption. Domestic production of hydropower, coal and oil in the same period significantly declined as a result of accelerated deterioration of production facilities.

In 1995, indigenous energy production even exceeded 1990 level in spite of continuing decline of energy consumption. As can be seen, domestic energy production growth is closely related to a large increase of fuelwood use. The latter gradually substituted other energy carriers, and its share in primary energy production structure increased from 12% in 1990 to 66% in 1995. This is a negative tendency, since spontaneous and uncontrolled fuelwood use damages to forest and the environment.

In the future, Georgia's dependence on energy import may become a serious obstacle to economic development.

Table 3.11. Primary Energy Balance[1] (10^3 toe)

Indicators	Years	Coal	Other solid	Oil and oil products	Gas	Hydro	Nuclear	Geothermal and solar	Electricity	Total
Primary energy	1990	706,0	224,0	186,0	48,0	653,6			x	1817,6
production	1991	333,0	336,0	190	48,0	605,5			x	1512,5
	1992	81,0	525,0	133	40,0	560,3			x	1339,3
	1993	91,0	805,0	42	40,0	629,1			x	1607,1
	1994	28,0	1219,0	50	8,0	438,7			x	1743,7
	1995	29,0	1228,0	42,7	2,7	548,9			x	1851,3
	1996			128	2,7	526,3			x	
Export	1990	309,0		982,0					100,5	1391,5
	1991	175,0		404,0					137,3	716,3
	1992	70,0		295,0					45,7	410,7
	1993	11,0		148,0					29,1	188,1
	1994	7,0		0,0					2,8	9,8
	1995	7		0					0,0	7,0
	1996			0					11,8	11,8
Import	1990	473,0		6797	4407,0				376,2	12053,2
	1991	364,0		4690	3850,0				331,0	9235,0
	1992	307,0		3339	3838,0				133,0	7617,0
	1993	95,0		2766	3073,0				90,4	6024,4
	1994	68,0		2288	2320,0				81,6	4757,6
	1995	13		2068	1812,0				64,8	3957,8
	1996			0					29,6	
Stock changes	1990	23		153						176,0
(+ increase)	1991	8		138						146,0
incl. marine	1992	0		88						88,0
bunkers	1993	0		60						60,0
	1994	-7		42						35,0
	1995	0		35						35,0
	1996			0						
Primary energy	1990	847,0	224,0	5848,0	4455,0	653,6			275,6	12303,2
consumption	1991	514,0	336,0	4338,0	3898,0	605,5			193,7	9885,2
	1992	318,0	525,0	3089,0	3878,0	560,3			87,4	8457,7
	1993	175,0	805,0	2600,0	3113,0	629,1			61,3	7383,4
	1994	96,0	1219,0	2296,0	2328,0	438,7			78,9	6456,5
	1995	35	1228,0	2075,7	1814,7	548,9			64,8	5767,1
	1996	0	0	128,0	2,7	526,3			17,8	674,8

[1] To convert a 1000 toe into natural units, the values presented should be multiplied by the following factors: 11.63 for electricity (in GWh); 1.74 for coal (in 1000 tons), 1.24 for natural gas (in million cubic meters); 1.0 for crude oil and oil products (in 1000 tons); 5.37 for woodfuel (in 1000 cubic meters, solid)

4. Historical Data on Electricity Consumption: 1990-1998

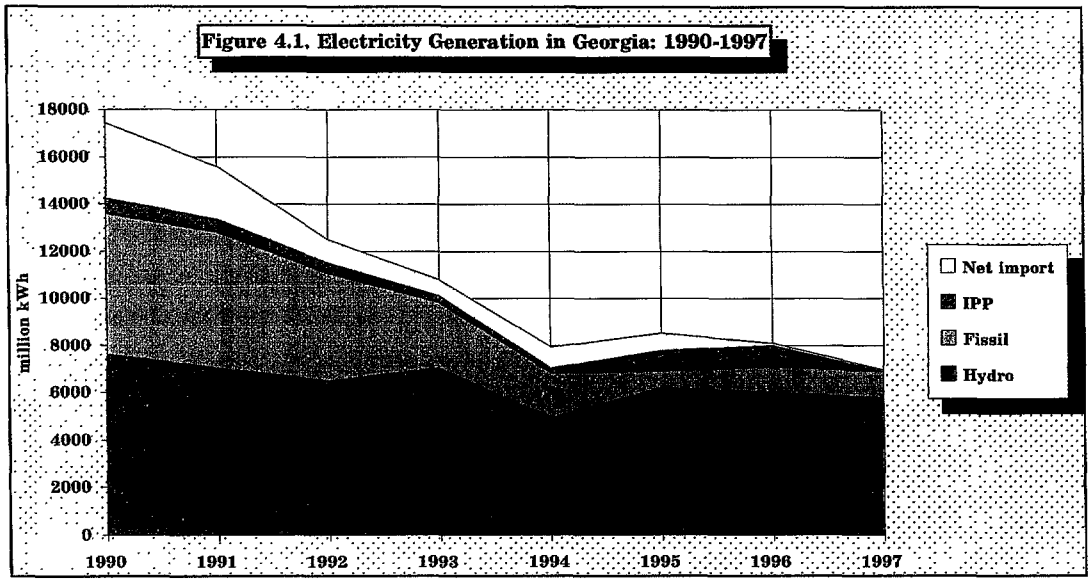
4.1. Electricity Supply

Sources of electricity supply in Georgia are shown at the Fig. 4.1 and Table 4.1. It was not reduction of demand which drew supply down. Growth of import fuel prices, negative trade balance and growing external debt caused the reduction of electricity production at fossil fuel powered stations and reduction of net import of electricity.

As Georgian Economic Trends (third quarter, 1997) reports:

> The hydro plants suffer from lack of water and the thermal plants from lack of fuel. Gardabani has received USD 15 million for the purchase of fuel under the World Bank's Power Rehabilitation loan. This USD 52.3 million loan was approved in June but USD 10 million was disbursed in advance for last winter's needs. The remainder is unlikely to be sufficient for supplies this winter. The prospects for household and business electricity consumers do not look favorable this winter.
>
> The failure to collect payments also led to fuel shortages and under-investment in thermal power, in particular to the Gardabani thermal plant which is one of the main sources of electricity supply during winter. Although the Ministry of Finance has provided several loans to the plant, they do not represent a long-term solution: the only sustainable option seems to be privatization.

As a result, energy is a problem for any business in Georgia. Power cuts are common, as well as low frequency and low voltage. In 1997 there were 104 cases registered of complete power lost in Georgia.



Electricity supply in Georgia in 1997 was just 40% of the 1990 level. The six fold decline of power production at thermal power stations was accompanied by the reduction of net import by 37 times, and only substantial contribution of hydropower stations had provided some stability to the power supply situation.

Hydropower in 1996 provided 74% (44% in 1990) of the total supply, while power stations fueled by fossil fuels - just 14% (35% in 1990), with the rest - provided by the independent power producers (IPP) - 11% (3,6% in 1990) and by net import of electricity - 1,5% (18% in 1990).

Table 4.1. Electricity Supply (million kWh)

	Hydropower	Fossil fuels	IPP	Total generation	Net import	Total supply
1990	7594	6019	625	14238	3205	17443
1991	7037	5782	539	13358	2252	15610
1992	6498	4578	425	11501	1016	12517
1993	7020	2820	285	10125	697	10822
1994	4911	1944	179	7034	919	7953
1995	6206	704	860	7770	752	8522
1996	6010	1105	870	7985	121	8106
1997	5777	1105	0	6882	86	6968

Sources: Statistical Yearbook, p. 3-4; Georgian Economic Trends. TACIS; Sakenergo; World Bank.

4.2. Electricity Demand

There are many sources of statistical information which slightly disagree on the level of total electricity consumption in 1990-1997 (see Table 4.2). Data provide by OECD differ most of all with all other sources (none in Georgia was able to answer who provides information to OECD). All other sources present very similar data.

Two first sources (two issues of "Energy" magazine) presented at the Table refer to the Ministry of Energy as well as data provided by the Energy Research institute. It was suggested that State Department for Statistics provides the most reliable data. Therefore data from this source for 1990-1996 were put in to the right column (final) of Table 4.2, and for 1997 Sakenergo data were taken.

Table 4.2. Estimates of Total Electricity Consumption (million kWh)

	1	2	3	3"	4	5	6	7	8	9	Final
1990	17440		17882	17443			17440		17442	17450	**17450**
1991			15546	15610					15610	15628	**15628**
1992			12514	12517	14288				12517	12536	**12536**
1993		10745	10837	10731	10012				10838	10863	**10863**
1994	7950	7950	7498	7953	10861		7950		7952	7962	**7962**
1995	7830	7831	7679		7605	8522	7830	7831	7830	7836	**7836**
1996	7290	7312	6968		7570	8106	7290	7312		7440	**7440**
1997							7363	7363			**7363**

Sources: 1. Energy. No. 3, 1997, p.7; 2. Energy. No. 2, 1997, p.27; 3. World Bank, p.7; 3". World Bank, 1996 p.14; 4. Energy Balances of Non OECD Countries. IEA/OECD; 5. Georgian Economic Trends. TACIS; 6. B&R Tbilisi office; 7. Sakenergo; 8. Georgian Research Institute of Power Engineering; 9. Statistical Yearbook.

Based on the sample presented in the right column of the Table 4.2 it is clear that electricity demand felt down by 2.4 times in 1990-1997. The most significant reduction was monitored in 1990-1994. Since 1995 electricity consumption is still declining but with very moderate rates. It is important to notice that such decline occurred on the background of growing GDP.

To get real understanding of forces which drive electricity consumption someone should go in more details, by investigating the structure of electricity consumption by major economic sectors and in most important sectors, by branches or even processes.

It is clear that reduction of total electricity consumption occurred mainly due to the reduction of industrial electricity consumption, while electricity consumption in residential sector was relatively stable (see Fig. 4.2 and Table 4.3). Deterioration of statistical reporting and quality of metering is the reason behind the growth of "other" sector contribution to the total electricity consumption.

It is clear that special attention should be given to the investigation of factors driving electricity consumption in industrial sector as the most dynamic component of electricity consumption and to residential sector as to the most stable part of the overall demand for electricity.

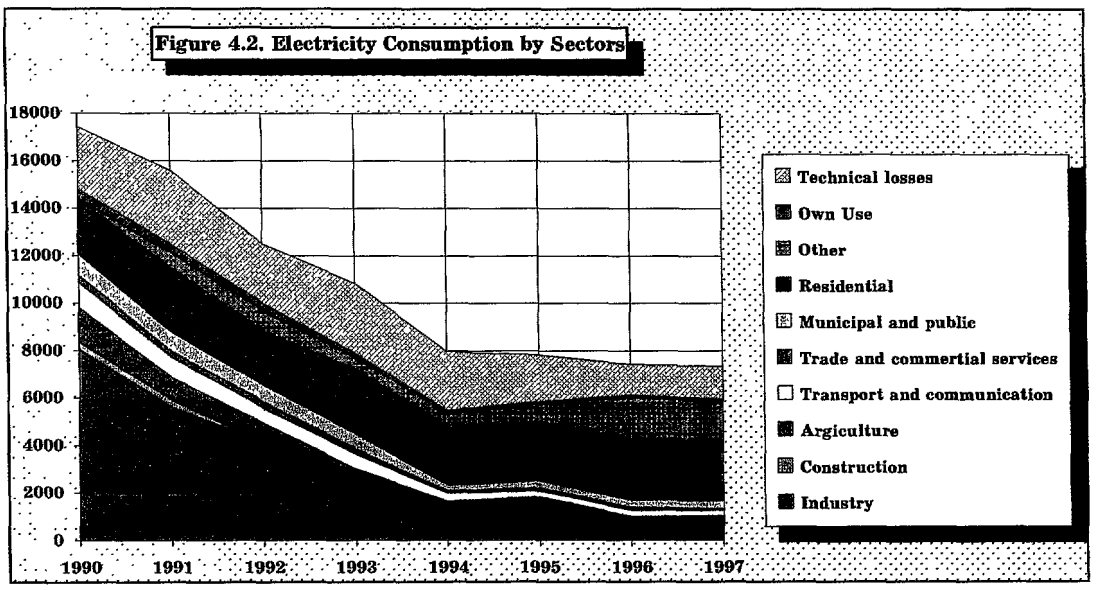


Figure 4.2. Electricity Consumption by Sectors

Table 4.3. Structure of Electricity Consumption by Sectors (10^3 kWh)

	1990	1991	1992	1993	1994	1995	1996	1997
Industry	8054	5609	4135	2552	1434	1518	910	953
Construction	310	280	60	170	73	51	46	38
Agriculture	1460	990	730	317	128	66	26	14
Transport and communication	1040	840	655	608	387	278	275	254
Trade and commercial services	288	259	230	201	78	103	103	64
Municipal and public	912	821	730	636	246	328	326	334
Residential	2320	2680	2250	2772	2410	2464	2547	2593
Other	3	645	895	442	577	948	1768	1590
Own Use	420	382	322	200	136	88	107	113
Technical losses	2643	3122	2530	2965	2494	1993	1332	1411
Final use	14387	12124	9684	7698	5332	5756	6001	5839
Total	**17450**	**15628**	**12536**	**10863**	**7962**	**7836**	**7440**	**7363**

Sources: Calculated by authors based on 1. Energy. No. 3, 1997, p.7; 2. Energy. No. 2, 1997, p.27; 3. World Bank, p.7; 3. World Bank, 1996 p.14; 4. Energy Balances of Non OECD Countries. IEA/OECD; 5. Georgian Economic Trends. TACIS; 6. B&R Tbilisi office; 7. Sakenergo; 8. Georgian Research Institute of Power Engineering; 9. Statistical Yearbook, p. and other sources.

4.3. Electricity Consumption in Industry

The level of statistical uncertainty of electricity consumption in industry is much larger then that of the total electricity consumption. As in the case of economic statistics, electricity consumption statistics for industry is neither consistent nor reliable. The OECD again provides data which are too far from being consistent with Georgian statistics. But even Ministry of Energy in its magazine "Energy" provides the data which differ substantially from the data provided by the SDS. Statistical uncertainty is large even for 1990, but it is especially large for 1992-1995. Another problem is different coverage of branches by different sources. For example, figures may differ depending on whether own use or losses are accounted within the industrial sector, or separately.

Table 4.4. Estimates of Electricity Consumption in Industry (million kWh)

	1	2	3	4	5	6	7	8	9
1990	8360		5910			5937		8054	8054.0
1991			4480			4483		6780	6780.0
1992			2520	6420		2522		5452.2	5452.2
1993		1720	1720	4128		1939		3846.2	3846.2
1994	1430	950	926	2767				1882.5	1882.5
1995	1510	837	1177	2942			837	953.2	953.2
1996	810				983		805	812.2	812.2
1997					1033		768	767.7	767.7

Sources: 1. Energy. No. 3, 1997, p.7; 2. Energy. No. 2, 1997, p.27; 3. World Bank, p.7; 3. World Bank, 1996 p.14; 4. Energy Balances of Non OECD Countries. IEA/OECD; 5. Georgian Economic Trends. TACIS; 6. Hydro Rehabilitation Report; 7. Sakenergo; 8. B&R Tbilisi office; 9. Statistical Yearbook, p. 3.

Based on the official statistics, electricity consumption in industry, or more correctly speaking electricity supply to the industrial sector, felt down by 10.5 times in 1990-1997. Table 4.5 and Fig. 4.3 provide evidence to the fact that there is no branch of industry managed to avoid substantial reduction of supply. This table was build based on three sources. Electricity consumption by several major industrial enterprises is also shown in this table to check the quality of statistics, on the one hand, and to demonstrate that there are few (about ten) large industrial enterprises which consume the lion share of electricity within the industrial sector. Therefore, revival of such enterprises is crucial in determining the volume of electricity consumption by branches of heavy industry.

For some branches the line "other" has negative numbers. That means two things: low quality of statistical data, and the fact that some of diversified large scale enterprises produce products, which are counted by statistics as products for another branches of industry. The Chief energy manager of the Chemical Combinat (which formerly called the Azoti Fertilizer), claimed that electricity consumption in 1997 was equal 180 million kWh, while data presented gives the value 79 million kWh for the whole chemical industry in 1997.

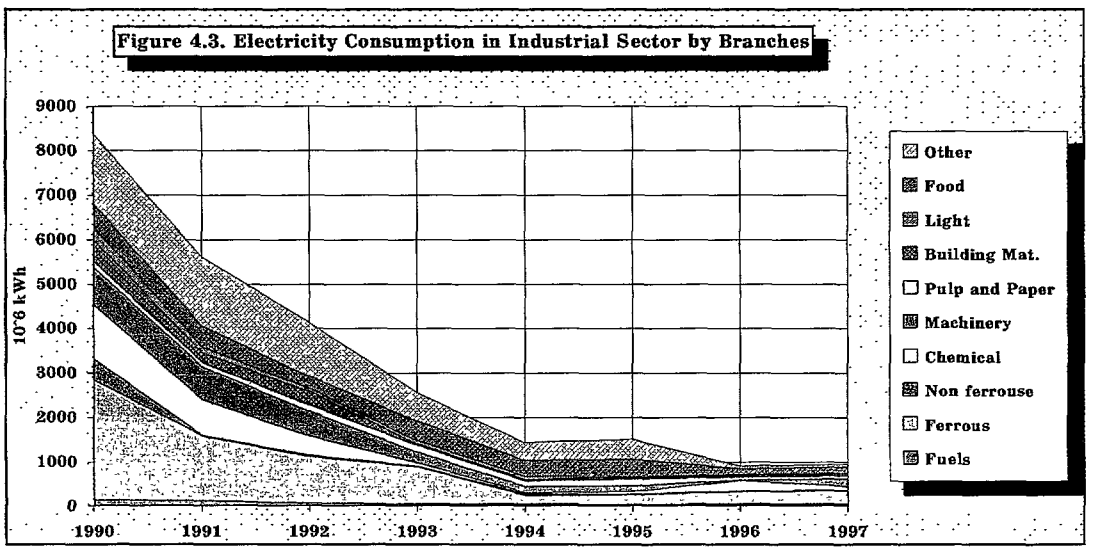
Table 4.5. Industrial Electricity Consumption by Branches (10^6 kWh)

	1990	1991	1992	1993	1994	1995	1996	1997
Fuels	130	119	70	52	50	40	50	53
Tkibuli Coal	*70*	*66*	*44*	*39*				
Tkvarcheli Coal	*28*	*24*	*9*	*0*				
Others	*32*	*29*	*17*	*13*				
Ferrous	2715	1460	1060	840	204	223	280	295
Zestaponi Ferro	*1244*	*802*	*322*	*310*				
Rustavi Metallurgical	*533*	*560*	*446*	*330*				*280*
Chiatura Mananese	*3*	*3*	*3*	*2*				
Others	*935*	*95*	*289*	*198*				
Non ferrous	465	20	20	20	20	20	20	20
Chemical	1230	800	440	70	40	50	230	79
Azoti Fertilizer	*666*	*537*	*347*	*310*				*180*
Chemical Fiber	*139*	*108*	*106*	*78*				
Others	*425*	*155*	*-13*	*-318*				*-101*
Machinery	830	745	552	244	140	140	20	180
Kutaissi Truck	*310*	*212*	*99*	*39*				
Electrical Motor	*542*	*454*	*261*	*213*				
Others	*-22*	*79*	*192*	*-8*				
Pulp and Paper	140	100	140	150	130	145	60	63
Building Mat.	490	220	300	38	20	20	40	43
Kaspi Cement	*70*	*58*	*37*	*19*				
Rustavi Cement	*89*	*85*	*54*	*39*				
Others	*331*	*77*	*209*	*-20*				
Light	280	130	70	70	70	30	20	21
Food	520	470	285	443	360	400	130	136
Other	1560	1545	1198	625	400	450	60	63
Industry (sum by branches)	**8360**	**5609**	**4135**	**2552**	**1434**	**1518**	**910**	**953**
Industry (official data)	**8054**	**6780**	**5452**	**3846**	**1883**	**953**	**812**	**768**

Sources: Georgian Research Institute of Power Engineering; "Energy". No. 3 1997, p. 7; Sakenergo; Hydro Rehabilitation Report.

The two last lines in Table 4.5 demonstrate the gap between the official statistics, provided by the SDS, and table's totals for each year. The statistical discrepancy is pretty large for all years considered. Such a gap can be found even in the same source. The "Energy" magazine N 3, 1997 gives total industrial electricity consumption equal to 812 million kWh, and then provides data by the branches of industry. When the consumption is summed up by branches the result is 910 million kWh.

The upper line "industry (sum by branches)" of Table 4.5 was used in this work as a basis for analysis and projections.



Another important peace of information is the distribution of electricity consumption by industrial processes. That is important to know when issue of possibilities to improve energy efficiency is to be discussed. The provocative approach was used to get this information. Similar information provided by the "Tools and Methods for Integrated Resources Planning. Improved Energy Efficiency and Protecting the Environment" by J. Swisher, G. Jannuzzi and R. Redlinger published by UNEP on November 1997 for several countries was presented to Georgian Chief energy managers for review. They have made corrections in the table and results of that exercise are presented in Table 4.6 below. They are pretty much in line with foreign statistics while do reflect the Georgian specifics.

Table 4.6. Structure of Electricity Consumption by Processes (%)

	Motor	Process heat	Direct heat	Illumination	Others	Total
Fuels	85	5	0	5	5	100
Ferrous	15	0	80	5	0	100
Non ferrous	1	0	98	0	1	100
Chemical	85	5	0	10	0	100
Machinery	90	5	0	5	0	100
Pulp and Paper	90	0	0	5	5	100
Building Materials	70	10	15	5	0	100
Light	90	5	0	5	0	100
Food	10	70	15	5	0	100
Other	70	10	15	5	0	100

Source: Calculated by authors, based on results of energy managers survey.

4.4. Electricity Consumption by the Residential Sector

Residential sector in recent years became the major consumer of electricity. According to some estimates in winter its share reached 75% of overall consumption. As in case of industry there is no agreement of different statistical sources on the volume of electricity consumption in the residential sector. (See Table 4.7). There are a number of historical explanations for such a situation. In the Former Soviet Union electricity consumption was, as a rule, shown for population and commercial sector together. Separate statistics also existed. But there were many confusions of what is accounted and what is not when residential sector alone was monitored. For example, electricity consumption in agricultural sector was presented in some cases with, while in others without electricity consumed by households for non production purposes.

Namely such accounting problems led to the significant differences in data on residential electricity consumption in 1994-1995 provided in two consequent issues of "Energy" magazine (No. 2 and No. 3, 1997).

Table 4.7. Residential Electricity Consumption (10^6 kWh)

	1	2	3	4	5	7	8	Final
1990	2800		2320				2800	**2320**
1991			2680				2800	**2680**
1992			2250	1284			1873	**2250**
1993		2772	2770	1023			3050	**2772**
1994	3250	2410	2818	686			3250	**2410**
1995	3230	2464	2452	733		2404	3250	**2464**
1996	2660	2640			2504	2639	3226	**2547**
1997					2414	2593		**2593**

Sources: 1. Energy. No. 3, 1997, p.7; 2. Energy. No. 2, 1997, p.27; 3. World Bank, p.7. World Bank, 1996 p.14; 4. Energy Balances of Non OECD Countries. IEA/OECD; 5. Georgian Economic Trends. TACIS; 6. B&R Tbilisi office; 7. Sakenergo; 8. Georgian Research Institute of Power Engineering.

Careful analysis of available data led authors to the selection of time series for the electricity consumption in the residential sector shown in the final column of Table 4.7.

To make reliable projections of electricity demand it is necessary to have more information on electricity consumption patterns by separate processes. That is especially important when limitations of electricity supply provide a meaningful effect on the structure and intensities of electricity consumption by households.

An important contribution to understanding the situation in the residential sector was provided by the survey conducted by the State Department for Statistics of Georgia on December 1997 ("Georgia Statistical Review. January-February 1998").

Two important blocks of information were provided by the survey. The first one informs on the availability of electricity. (See Table 4.8). Rationing of electricity was introduced since 1997. The second one shows the role of electricity in covering energy demand by different processes. (See Table 4.9).

Table 4.8. Distribution of Families in Tbilisi by the Availability of Electricity by the Time of the Day

Time of the day	Number of families receiving electricity	%	Number of families not receiving electricity	%	Number of families receiving electricity only for that time interval	%
morning	379	84	70	16	0	0
day	70	15	379	84	0	0
evening	443	98	6	1	50	11
night	36	8	413	91	0	0
morning and day	51	11	398	88	1	0
morning and evening	373	83	76	17	308	68
morning and night	35	8	414	92	5	1
day and evening	69	15	380	84	19	4
day and night	15	3	434	96	0	0
evening and night	31	7	418	92	1	0
morning, day and evening	50	11	399	88	35	8
morning, day and night	15	3	434	96	0	0
morning, evening and night	30	7	419	93	15	3
day, evening and night	15	3	434	96	0	0
morning, day, evening and night	15	3	434	96	15	3

Source: Georgia Statistical Review. January-February, 1998 Tbilisi. State Department for Statistics of Georgia. pp. 23-27.

It is clear that rationing is the daily practice of 85% of families in Tbilisi and probably even larger percentage of families throughout country. Eleven percent of families have electricity available only at evenings. Only 3 percent of families have electricity available at any time of the day. The most common situation is an availability of electricity at mornings and evenings, average duration of electricity supply within that time intervals is 2.3 and 3.7 hours correspondingly.

The first four lines of the Table 4.8 can be also used as proxy for the shape of load curve for residential sector under suggestion that percentage of consumers represents the capacity used. There is no other data available on that subject. Load is not monitored for separate groups of customers in Georgia. Therefore, there is no other information on shapes of load curves for the residential sector.

In addition to rationing frequent accidents are responsible for switching some residential consumers off for 2-3 days. As can be seen from Table 4.7 rationing didn't led to noticeable reduction of electricity consumption in the residential sector.

The reason behind such a situation is about complete failure of the district heating system. Only 3-4% of families in Tbilisi are supplied by the district heating system. In many Georgian families young children wonder what for are radiators installed in their flats. They never touch them warm.

As a result electricity in much degree had substituted district heating and partly natural gas. (See Table 4.9). According to the data presented electricity is consumed for heating by 45% of families and 22% of families have only electricity as a heating source. The corresponding numbers for cooking are 62% and 16%.

Table 4.9. Distribution of Families by Energy Sources Used for Different Processes

Space Heating	**100.0**
only electricity	22.0
only kerosene	21.2
only fuelwood	8.5
only natural gas	3.4
electricity+kerosene	28.8
electricity+fuelwood	11.5
electricity+natural gas	4.6
electricity +smth.else	45
Cooking	**100.0**
only electricity	16
only kerosene	9.7
only fuelwood	2.7
only natural gas	9.7
electricity+kerosene	27.3
electricity+fuelwood	7.5
electricity+natural gas	27.3
electricity +smth.else	62
no electricity	22

Source: Calculated based on Georgia Statistical Review. January-February, 1998 Tbilisi. State Department for Statistics of Georgia. pp. 23-27.

Information presented in Tables 4.8 and 4.9 as well as data on countries similar to Georgia by climate and economic development was used to estimate the structure of electricity consumption by processes.

Residential electricity consumption for 1990 was desegregated by end-uses based on data for Russia in 1990: 12% was prescribed for space heating, 2% - for water heating, 12% - for cooking, 26% - for lighting, and the remaining 48% - for appliances. (See Table 4.10). Electricity consumed by appliances is shared between refrigerators/freezers and other appliances in almost equal parts. An assumption was made that rural residents consume 30% of electricity allocated for lighting and appliances. All the rest was corresponded to urban residents. Russia's residential electricity consumption structure of 1992 was used as a basis for allocation by processes in Georgia for 1994, although some corrections were made:

1. It was assumed that share of electricity consumption by appliances declined by 2-fold, taking into account frequent cut-offs in winter time preventing from normal use of appliances, especially refrigerators. Refrigerators are probably used mainly at summer time
2. The share of electricity consumed for space and water heating was estimated as a difference between total consumption and that for appliances, lighting and cooking. As a result, this share increased significantly from 13,5% in 1990 to 44% in 1994. As Georgian experts confirm, electricity is covering the shortage of district heat supply.

3. Electricity consumption for water heating was assumed 3-fold larger than that of 1990, and the rest electricity was allocated to space heating.

Estimates of residential electricity consumption by the end-uses for Georgia in comparison with the Russian data are presented at Table 4.10.

Table 4.10. Structure of Residential Electricity Consumption by End-Uses (%)

	Russia 1990	Georgia 1990 estimates	Russia 1992	Georgia 1994 estimates
Space heating	13,5	12,0	16,9	40,0
Water heating		1,5		4,3
Cooking	11,9	11,9	12,9	12,9
Lightning	25,9	25,9	24,1	24,1
Appliances	48,7	48,7	46,1	23,1
Total	100,0	100,0	100,0	100,0

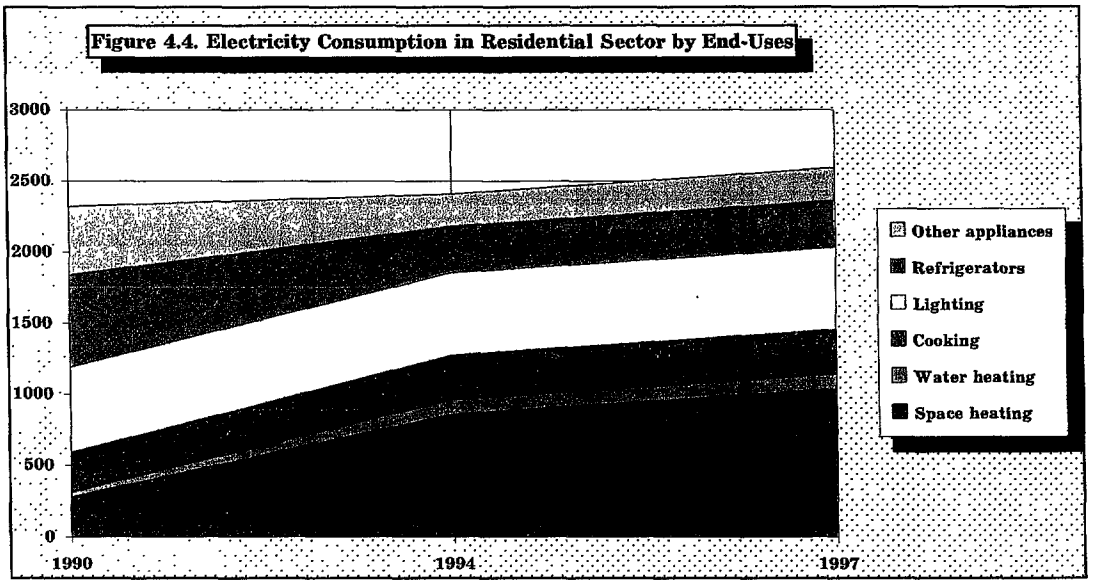
Source: Calculated by the authors.

Based on such data the breakdown of residential electricity consumption was made. (See Table 4.11 and Fig. 4.4). Estimate for 1997 residential electricity consumption was made under an assumption that all end-uses except space heating were kept unchanged as compared to 1994. An increase of total electricity consumption was allocated to space heating.

Table 4.11. Residential Electricity Consumption (10^6 kWh)

	1990	1994	1997
Space heating	279	859	1039
Water heating	35	105	105
Cooking	275	311	311
Lighting	601	580	581
Refrigerators	650	322	323
Other appliances	480	234	234
Total	**2320**	**2410**	**2593**

Source: Calculated by the authors.



4.5. Electricity Consumption by Other Major Economic Sectors

4.5.1. Agriculture

Data on agricultural Electricity Consumption are shown in Table 4.11. It is clear that reliability of data for this sector is not high by any standards. Different sources are in agreement only for two years - 1996 and 1997. Comparison with production in agricultural sector provided the basis for selecting data from the World Bank report and Sakenergo to build time series for this sector (see column final of Table 4.12).

Table 4.12. Agricultural Electricity Consumption (10^6 kWh)

	1	2	3	4	5	6	7	Final
1990	2000		1460	870	2000		2000	**1460**
1991			990				2985	**990**
1992			730				2700	**730**
1993		380	317		380.4		1700	**317**
1994	720	130	128		720		720	**128**
1995	670	65	245		670	65.6	670	**66**
1996	26	30			26	25.9		**26**
1997					14.4	14.4		**14**

Sources: 1. Energy. No. 3, 1997, p.7; 2. Energy. No. 2, 1997, p.27; 3. World Bank, p.7; 3. World Bank, 1996 p.14; 4. Georgian Economic Trends. TACIS; 5. B&R Tbilisi office; 6. Sakenergo; 7. Georgian Research Institute of Power Engineering.

4.5.2. Construction

Authors identified only four sources which provide information on electricity consumption in construction sector. There are more agreement among them on the volumes of consumption comparing with agriculture. But still there are significant differences for the 1993 and 1994. Sakenergo data were used for

1995-1997, data from the "Energy" No. 2 for 1993-1994, and from Georgian Research Institute of Power Engineering for 1990-1992.

Table 4.13. Electricity Consumption in Construction (10^6 kWh)

	1	2	3	4	Final
1990	310			310	**310**
1991				280	**280**
1992				60	**60**
1993		170		100	**170**
1994	160	73		160	**73**
1995	80	51	51.3	80	**51**
	50	40	45.5		**45.5**
1997			37.6		**37.6**

Sources: 1. Energy. No. 3, 1997, p.7; 2. Energy. No. 2, 1997, p.27; 3. Sakenergo; 4. Georgian Research Institute of Power Engineering.

4.5.3. Transport and Communication

Data for electricity consumption in this sector is the most consistent among all sources available. The main reason for some differentiation among them is inclusion or exclusion of electricity consumption in communication sector to the aggregate. Final time series presented in the final column of the Table 4.14 does include communication for all years.

Table 4.14. Electricity Consumption on Transport and Communication (10^6 kWh)

	1	2	3	4	5	9	Final
1990	1000		1040.1		1000	1040.11	**1040.1**
1991			840		1000	840	**840**
1992			654.7		660	654.7	**654.7**
1993		431	607.6		900	607.6	**607.6**
1994	230	311	386.6		233	386.6	**386.6**
1995	210	278	253.6	253.5	212	253.6	**278**
1996	260	270	249.8	275.2		249.8	**275.2**
1997			230.7	253.5			**253.5**

Sources: 1. Energy. No. 3, 1997, p.7; 2. Energy. No. 2, 1997, p.27; 3. B&R Tbilisi office; 4. Sakenergo; 5. Georgian Research Institute of Power Engineering; World Bank, p.7.

4.5.4. Services

According to the statistical definition electricity consumption in so called commercial sector accounts for consumption by all entities providing services. For the purpose of this study two major groups of consumers were separated from this sector:

- trade and commercial services
- municipal and public services.

Quality of data on commercial services is not high even in developed countries with good statistical and accounting systems, not to speak about Georgia.

The electricity consumption data for the total services sector are taken from the "Energy" No. 2. Data on municipal and public services were provided by Georgian Economic Trends. Results are presented in Table 4.15.

Table 4.15. Electricity Consumption by Commercial Sector (10^6 kWh)

	Total Services	Municipal and public services	Trade and commercial services
1990	1200	912	288
1991	1080	821	259
1992	960	730	230
1993	837	636	201
1994	324	246	78
1995	431	328	103
1996	429	326	103
1997	398	334	64

Sources: 1. Energy. No. 3, 1997, p.7; 2. Energy. No. 2, 1997, p.27; 3. B&R Tbilisi office; 4. Sakenergo; 5. Georgian Research Institute of Power Engineering; World Bank, p.7.

As in the residential sector there is no district heat available for municipal and public services. In schools heat is provided by fired stoves, or own school boilers burning mazut or natural gas. Parents are responsible for acquiring fuel for schools.

Many commercial enterprises have their own generators which they use when power is not available from the grid.

4.5.5. Own use

There are two other important items of electricity balance - own use and losses. The first item sometimes is shown as a part of electricity consumption by industrial sector, but usually it is separated in the electricity balance.

There is not too much disagreement on the level of "own use" item provided by the four statistical sources. (See Table 4.16). To select the right source the comparison of own use ratio to volume of generated electricity was used. Growing role of hydro in the generation balance should lead to the reduction of that ratio. Based on such criteria time series for own use was evaluated (column final of the Table 4.16).

Table 4.16. Own Use of Electricity by Power Stations (10^6 kWh)

	1	2	3	4	Final
1990	432		420	432	**420**
1991	419		382	419	**382**
1992	312		322	312	**322**
1993	228	240	200	121	**200**
1994	230	227	136	230	**136**
1995	225	110	88		**88**
1996		120	107		**107**
1997					

Sources: 1. Hydro Rehabilitation Report; 2. Energy. No. 2, 1997, p.27; 3. World Bank, p.7; 3. World Bank, 1996 p.14;

4.5.6. Losses

According to the available sources about one fifth of all electricity supplied to the system is lost. (See Table 4.17). Losses are of two kinds: technical and commercial. Below only technical losses are discussed. Technical losses can be separated as those in transmission and distribution lines. The World Bank made an effort to evaluate the latter item. It equals to about one sixth of the total consumption.

Real loads are often 3-4 times exceeding the normative one. As a result losses are high. In Tbilisi every week in winter about 15 transformers are burned out and replaced. Technical university did some measuring of technical losses. According to the results they are 16%. There is an evidence that in winter sometimes one can see a vapor rising from underground electric cables.

As in about all other cases discussed above, the sources disagree on the level of technical losses. Georgian official statistics provide data on losses. Namely this source was taken as a basis for following calculations.

Table 4.17. Electricity Losses (10^6 kWh)

	1	2	3* trans.	3* distr.	3	4	8	9	**Final**
1990	2550		1827	693	2520		2552	2643.3	**2643.3**
1991			1668	660	2328		2543	3121.9	**3121.9**
1992			1463	518	1981	2478	2802	2529.5	**2529.5**
1993		2560	1383	383	1766	1760	2288	2965.2	**2965.2**
1994	2024	2230	1046	277	1323	2690	2019	2493.5	**2493.5**
1995	2042	2122	1063	269	1332	2133	2041	1992.5	**1992.5**
1996	2123	1980	1065	269	1334	1742		1332.4	**1332.4**
1997									**1411.2**

Sources: 1. Energy. No. 3, 1997, p.7; 2. Energy. No. 2, 1997, p.27; 3. World Bank, p.7; 3. World Bank, 1996 p.14; 4. Energy Balances of Non OECD Countries. IEA/OECD; 5. Georgian Economic Trends. TACIS; 6. B&R Tbilisi office; 7. Sakenergo; 8. Georgian Research Institute of Power Engineering; 9. Statistical Yearbook, p. ;

4.6. Evolution of Electricity Prices

1994-1997 electricity tariffs are shown in Table 4.18 below. For major production sectors tariffs expressed in dollars are lower in 1997 as compared to 1994. In 1996-1998 tariffs were relatively stable. Only tariffs for residential sector grew up. In order to increase revenues tariffs for household have been raised by up to 3.3 tetri per kWh at the beginning of 1997.

Another step to rise tariffs was planned for the 1st of April, with the target to equalize tariffs for households and industry at the level of 4.5 tetri. It was postponed to July and later to the 1st of August.

As the Georgian Economic Trends -(third quarter 1997) states:

> Electricity tariffs for all consumers were unified in August, 1997, so that household consumers will now be charged the business rate of 4.5 tetri/kWh. This represents a move towards cost recovery but still does not provide for an investment or maintenance program. New tariffs can be negotiated with the Regulatory Commission if investment funds are attracted to the sector.

Table 4.18. Electricity Tariffs Dynamics, USc/kWh

	since Sept. 1994*	1 June-1 October 1995 (seasonal tariffs)*	1995 winter season*	1996**	1997 (9 months)**	since Sept. 1997**
Industrial enterprises	4,6	3,46	3,60	3,31	3,38	3,46
Agriculture	4,6	3,46	3,60	3,54	3,29	3,46
Transport	4,6	3,46	3,60	3,54	3,29	3,46
Budget organizations	4,6	3,46	3,60	3,54	3,46	3,46
Population	4,6	1,9 for the first 100 kWh per month; 3,46 for the consumption above 100 kWh	1,98 for the first 100 kWh per month; 3,60 for the consumption above 100 kWh	1,80	2,58	3,46
Other	4,6	3,46	3,60	3,54	3,29	3,46
Distribution companies	N/A	2,1	2,5	N/A	N/A	N/A
Telasi distribution company (Tbilisi)	N/A	1,6	2,5	N/A	N/A	N/A
Tbilisi Interbank currency exchange rates, GEL/USD	1,40	1,3	1,25	1,27	1,3	1,3

Sources: *) Georgia Energy Sector Memorandum. The World Bank, 1996
**) Georgian Economic Trends TACIS third quarter 1997 report

In 1995 there were some experiments with tariffs: seasonal tariffs an block tariffs. Then tariff setting system was simplified. Even large industrial consumers do not have capacity charge. All customers are paying only power charge. On 27th of June 1997 the Parliament ratified a law on electricity. The law defines the functions of the Regulatory Commission which is to set electricity tariffs.

So far the tariffs in electricity are set as follows: generators sell a kWh of electricity to Sakenergo at the average price of 1.55 tetri (however the average price of a kWh produced by hydro-power plants is 0.5 tetri, while by thermal it is 4.3 tetri); distributors buy a kWh from Sakenergo at the average price of 2.7 tetri. There are 5 categories of distribution areas and in the big cities the price is the highest - 2.8 tetri. The Commission is to work out different methods of setting tariffs.

4.7. Collection Rates

Collection rates are crucial parameters for the present and future of Georgian power sector. Average rates felt down from 72% in 1990 to 9% in 1994. Then they grew up to 64% in 1997. (See Table 4.19). Payment discipline was improved both in residential and in commercial sectors.

Table 4.19. Collection rates, %

	1990*	1991*	1992*	1993*	1994*	1996**	1997 (9 months)**
Average collection rates, of which:	72,0	91,0	70,0	24,0	9,1	40,1	63,6
Industrial enterprises		97,0	84,0	64,0	16,0	89,2	81,5
Residential sector			5,0	3,6	12,5	20,0	40,5

Sources: *) Georgia Energy Sector Memorandum. The World Bank, 1996
**) TACIS third quarter 1997 report

To rise collection rates for the residential sector the separation of special portion of salaries was introduced to pay for electricity. For those who work in the government sector it was set at 2.5 lari per month. For pensions of retired persons it was set at 1.8 lari per month. This portion is directly transferred to Sakenergo. That improves payment discipline, but provides no incentive to use power more efficiently. While power supply is still under rationing, the collection problem is more significant then incentives for efficiency.

Metering of electricity consumed is a very serious problem to be solved in Georgia. According to experts from "Telasi", about 80% of individual electric meters are out of order.

Another innovation which seems to provide a negative impact on the collection rate is transition from the system of reading meters by inspectors to the system when readings will be made by residents themselves. Such a system is used for a long time in Russia. In Georgia it was introduced only from the April 1998.

Experts from "Telasi" expect significant reduction of collection rates due to the introduction of new system. It should be noted that in Russia the collection rate with this system is 85-95%.

The failure to collect payments lead to:

- fuel shortages;
- under-investment in thermal power, in particular to the Gardabani thermal plant which is one of the main sources of electricity supply during winter period;
- a hindrance to any potential investors.

5. Modeling Complex for Forecasting Electricity Demand in Georgia

5.1. Uncertainty of Electricity Demand Projections

There were several efforts made by different institutions to dismiss the mist of uncertainty which cover the future growth of electricity consumption in Georgia. Those are very important exercises keeping in mind that shortage of electricity is already a barrier to the economic revival and it will be an obstacle to future economic development if situation with electricity supply does not change. To change the situation it is important to know electricity demand and load patterns of future economic growth in order to allocate scarce resources by such a way which allows to eliminate a negative impact of electricity shortage slowing the economic growth.

High uncertainty of future electricity demand is a derivative of high uncertainty of economic evolution in Georgia. A number of specific features produce additional difficulties in projecting Georgian electricity demand:

- the economy is in severe transformation, with major structural changes under way;
- electricity tariffs as price signals have limited impact on consumers' behavior because of poor payment enforcement;
- the pattern and the level of consumption, therefore, have been little affected by price increases and income changes;
- because of the poor state of electric installations, in recent years delivery and consumption infrastructure, was constrained by low supply availability.

Table 5.1 lists the most recent projections of electricity demand made by several institutions or research groups. Analysis of data presented brings to the following conclusions:

- local experts come with higher projections of electricity consumption comparing with foreign ones;
- the more recent are projections made by local experts the lower they are;
- level of uncertainty for future demand is high: projections for 2000 vary in a range from 8225 to 14000 million kWh; for 2005 - from 11457 to 19000 million kWh; and for 2010 - from 15000 to 24000 million kWh.

Table 5.1. Review of Electricity Demand Projections Developed by Different Groups of Experts, GWh

Expert groups	1997	1998	1999	2000	2005	2010
Sakenergo[1)]	10250	11500	12000	14000	18000	
Sakenergo[2)]	7363	7900	9000	9900	12400	15000
IBRD[3)]						
Pessimistic Scenario	7113	8283	9069	9631	11457	
Optimistic Scenario	7322	8824	9999	10987	14767	
EU (TACIS) [4)]:						
Baseline	8900	9755	10846	11689		
Modified	6262	6863	7631	8224		
GRIPE[5)], low				12500	17000	22000
high				14000	19000	24000

1) Actual data up to 1995; projected values are presented from 1996, and only Scenario 1 is taken into account. Projection was made in 1996.
2) Projection dated April 15 of 1997.
3) Georgia. Power Rehabilitation Project. Staff Appraisal Report. page 4.
4) Hydro Rehabilitation Report.
5) D. Zubitashvilli and Arveladze. Georgian research institute of power engineering (GRIPE). Current Georgian power industry situation and the prospects for development. "Energy", No. 3, 1997.

5.2. Review of Forecasting Tools Used by Other Research Groups

It is well known that a result of a projection is a function of two major factors: expectations of authors and quality of model used for projections. When publishing results authors sometimes describe the model which was used to get those results. In such a case the procedure of getting results based on given scenarios is transparent. That is the case with the Georgia Power Rehabilitation Project, Staff Appraisal Report. In cases of Sakenergo and GRIPE projections we do not have any description of models or even logic which was used as a basis for projections.

5.2.1. Georgia Power Rehabilitation Project Model

This model is represented by only one equation. Even this equation parameters were not evaluated based on Georgian statistics, but rather were taken from international experience.

Authors call this equation a dynamic consumption model. There are three factors affecting electricity demand changes in GDP (gross domestic product), price adjustments (including lagged effects), and supply constraints - used to forecast annual demand for electricity for the period 1998-2005.

The authors describe the model approach by the following way:

- over the long-run, the way and speed of economic growth determines largely how energy demand will be supplied and at what price;
- the model implicitly suggests that the economy would stabilize sufficiently (structurally and behaviorally) by the beginning of the period;

- since statistics on household appliances, industrial and commercial energy using electricity are virtually nonexistent in Georgia, the chosen demand model is based on the "partial specification", which introduces a proxy for the user's equipment stock;
- the model states that consumption in year t is explained by the value of all the explanatory variables in that year, plus the lagged base variable (i.e., the energy consumed in the prior year);
- to express the relationship between the dependent and independent variables, a dynamic double-log was used. The key advantage of this model is that it provides estimates of both short- and long-run elasticities;
- the estimated coefficients are the short-run elasticities that measure the proportional change of a dependent variable due to the proportional changes in the independent variables;
- given the absence of an adequate time-series on consumption and tariffs (the available data extended from 1989 to 1995), the estimated electricity demand elasticities are essentially judgmental in nature;
- although regression analysis was performed, the quality of the estimates was so poor, given the low number of observations and the deficient data quality, that we rely more on judgment than on the regression results.

Table 5.2. presents the coefficients used in the projection. The magnitudes of the elasticities are higher for income than for price. Although the estimated demand is very inelastic to price changes in the short-run, the long-run price elasticity is significantly higher.

Table 5.2. Georgian Electricity Demand Model

	Constant	In GDP	In Tariff	In Lagged Demand	Dummy
Coefficients	1.79	0.34	-0.05	0.53	0.20
Long-term elasticities		0.72	-0.10		

Table 5.3 serves as a justification of selected values for model. The justification is very questionable: none of countries presented has price elasticity coefficient close to what was used for Georgia, and only Venezuela has close long ran income elasticity.

Table 5.3. Average Long-run Elasticities of Electricity Demand in Selected Countries

	Georgia	Westley	Brazil	Mexico	Venezuela
Tariff	-0.10	-0.48	-0.83	-0.40	-0.53
Income	0.72	1.18	1.08	1.09	0.79

There are two major points of criticism of the model used by IBRD:

- oversimplification of the situation by projecting just overall electricity consumption without separating it by sectors, where forces driving electricity demand are very different and can not be explained by just two factors: GDP and price;

- arbitrary selection of crucial model parameters, which completely explain the results of the projections;
- separation of situation in electricity consumption from changes in overall energy balance and evolution availability of prices for other energy carriers.

Such model is not capable to incorporate any energy efficiency improvements or integrated resource planning polices.

5.2.2. GRIPE Model

The model used by GRIPE is not strictly described in the text. But the way results are presented gives some ground for logical reconstruction of model used. Projections of electricity demand are given by sectors and within the industrial sector - by branches.

Therefore there was a suggestion made on the rates of GDP growth and corresponding growth of economic activities in all sectors and industrial branches. How that was made is not clear from the publication. Then some suggestions were made on the evolution of energy intensities for each sector. Finally the shares of electricity in the energy balance for each sector were determined and electricity demand for each sector was estimated.

There are several problems with such model:

- no price or other market indicators impact is evaluated;
- energy intensity reductions are arbitrary, they do not depend on both tariffs and energy efficiency improvement activities;
- the evolution of electricity shares in energy balances for each sector are determined basing on a rule of thumb.

Similar approach was used in Russia by Energy Research Institute when projecting energy demand. It always resulted in overestimated the level of electricity consumption.

5.3. The CENEf's System of Models

The system of models for projecting electricity demand in Georgia have to be developed in accordance with the complexity of the factors affecting demand in different sectors and availability of statistics for identification of those factors effects. Seven models were used for making projections of electricity consumption and loads for the years 1998-2020. (See Fig. 5.1).

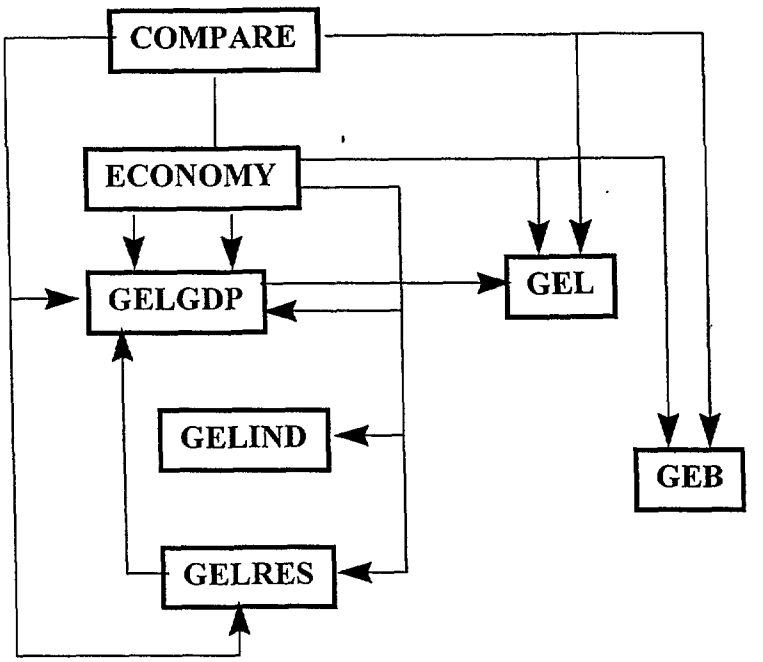


Fig 5.1. System of Models for Projecting Georgian Electricity Demand

Those models are:

COMPARE. This is the model for identification of correct time series from historical data which later are used in all other models. If some corrections of statistical data occur, historical data will be updated in all other models, through connections established. Results of this model were presented in section 4.

ECONOMY. This econometric model was built to estimate rates and proportions of economic growth, when rates of GDP are given. Output of this model is used as economic activity input in all other models.

GELGDP. This model was developed to estimate electricity consumption by different sectors of economy. Own use by the power generation system and technical losses are also considered by this model. Only two sectors are considered separately - industrial sector and residential sector.

GELIND. This model is used to make projections of electricity consumption by branches of industry.

GELRES. This model was built to estimate electricity consumption in residential sector.

GEL. This model was adopted for Georgia to make projections of electric loads and pick demands.

GEB. This CENEf's model was adopted for Georgia. GEB is an energy balance model which provides projections for six prime energy resources, six secondary energy carriers, and ten sectors of energy consumption.

This model allows to evaluate the impact of evolution of energy prices and taxes on energy demand. For this study that model was used to control the quality of results received by the GELGDP. This control is performed in two ways. First, GEB project electricity demand by sectors for the same macroeconomic scenario. Therefore, each scenario has two projections made. The GEB's projections are used only as control numbers for the GELGDP model. Second, when GDP growth rates for the future are selected, some limits of growth are to be taken into consideration. One of them is a lack of foreign currency to pay for energy import. GEB estimates volume and value of energy import and provides indicators of consistency of proposed rates of GDP with foreign trade limitations.

5.4. ECONOMY - model for projecting Georgian economy

As was mentioned above the ECONOMY is an econometric model which was build to estimate rates and proportions of economic growth, when rates of GDP are given.

This models consists from three blocks:

- GDP by expenditures (6 equations);
- GDP by sectors (8 equations);
- Industry by branches (10 equations).

All model parameters were estimated statistically based on the time series of 1990-1998. As a rule, econometric equations include one or two factors. Very limited time series do not allow to build more complex equations. Nonetheless, in all cases correlation was very strong.

Factors included in each equation in every block are shown in Tables 5.4 -5.6. GDP is the major input to the model. Based on it gross fixed capital formation, government consumption, private consumption, export, import, and external debt are estimated.

Table 5.4. Structure of GDP by Expenditures Block of the ECONOMY

	GDP	Gross Fixed Capital Formation	Government consumption	Export	Import	Cumulative saldo
Gross Fixed Capital Formation	+	+				
Government consumption	+		+			
Private consumption	+					
Export	+			+		
Import				+		+
External debt				+	+	

Those parameters later are used to determine value added by the 8 sectors of economy. The first and the second set of variables serve as an input to the block where output by 10 branches of industry is evaluated.

Table 5.5. Block of the ECONOMY: Structure of GDP by Sectors

	Industry	Construction	Agriculture	Transport	Trade	Services	Other	GDP	Gross Fixed Capital Investments	Private consumption
Industry			+					+		
Construction									+	
Agriculture			+					+		
Transport	+		+							
Trade	+									
Services						+				+
Other	+									
GDP	+	+	+	+	+	+	+			

Table 5.6. Block of the ECONOMY: Structure of Industry by Branches

	Chemical	Machinery	Pulp and Paper	Light	Food	Other	Industry	Construction	Agriculture
Fuels							+		
Ferrous		+							
Non ferrous							+		
Chemical	+						+		
Machinery								+	
Pulp and Paper			+				+		
Building Materials								+	
Light				+			+		
Food					+				+
Other						+	+		

Therefore the logic of ECONOMY is reverse to many other econometric models which are structured to identify future GDP.

There is a problem with ECONOMY which is to be mentioned. This model reproduces only relationships of economic variables monitored in 1990-1997. Therefore it should be used very carefully for projecting proportions of economic growth for 1998-2020 for the country which is coming through the transition.

5.5. GELGDP - model for projecting electricity demand by major sectors of economy

GELGDP - the model to estimate electricity consumption by different sectors of economy. Own use by the power generation system and technical losses also are considered by this model. Only two sectors are modeled separately - industrial and residential.

GELGDP includes three blocks with each block developed to evaluate the impact of crucial factors on the evolution of demand:

- economic activity impact block;
- electricity price impact block;
- energy efficiency policy impact block.

The first block was developed to estimate impacts of two major factors:

- the structure of economic growth by sectors, and
- electricity intensities affected by the characteristics of economic growth.

The structure of economic growth by sectors is determined by ECONOMY model. One more exogenous variable - electricity generation - is introduced as an indicator of economic activity to evaluate "Own use". Electricity demand projected as a sum of electricity consumption by sectors then is used as an indicator of economic activity to evaluate Technical losses.

Electricity intensities are affected by many factors. Among them are:

- level of production capacity use;
- limitations on power supply.

The first factor leads to the growth of electricity intensity other things are equal due to substantial portion of non-production related electricity consumption (lighting, ventilation, etc.). Table 5.7 confirms the importance of this factor. In 1990-1993, electricity intensity in many sectors grew up exactly due to the reduction of capacity use.

For "Own use" the intensity is counted as the electricity consumption for own use related to the volume of electricity generation. For technical losses this index is a ratio of technical losses to the amount of total electricity consumption.

The second factor leads to the reduction of electricity intensity, due to utilization of every possible measure to cut down electricity use to meet limits and to keep a production facility alive. In such a situation even electricity use required by technology are cut down (for example, lighting). In 1994-1997, electricity intensities felt down due to both strict limitations of power supply and frequent power cut-offs.

One more observation comes from the Table 5.7: sharp fluctuations of electricity intensities in separate years. It means a low reliability of either data on electricity consumption for those years, or data on value added by sectors.

Table 5.7. Electricity Intensity of GDP by Sectors (kWh/lari in 1995 prices)

	1990	1991	1992	1993	1994	1995	1996	1997
Industry	2.89	2.69	4.59	3.53	2.85	3.34	1.87	1.81
Construction	0.25	0.33	0.13	1.75	0.62	0.38	0.27	0.18
Agriculture	0.43	0.34	0.41	0.30	0.13	0.06	0.02	0.01
Transport and communication	2.05	2.11	3.09	3.90	3.54	2.20	2.17	1.54
Trade	0.19	0.21	1.60	0.92	0.30	0.15	0.12	0.07
Services	2.22	2.06	1.89	1.76	0.68	0.85	0.77	0.77
Other	0.01	2.62	8.92	9.30	11.53	18.09	31.57	23.53
Population	0.42	0.49	0.41	0.51	0.44	0.45	0.47	0.48
Own use	0.03	0.03	0.03	0.02	0.02	0.01	0.01	0.02
Losses	0.18	0.26	0.26	0.39	0.47	0.35	0.22	0.24
GDP	1.71	1.94	3.14	4.08	3.29	2.60	2.19	1.98

Source: Calculated by authors.

Revival of Georgian economy will be accompanied by the growing reliability of power supply and therefore less strict limitation with following complete abolishing of those limitations and steady growth of capacity use in many sectors. That clearly will provide impact on the level of electricity intensity.

It is proposed that when limitations are still in force the average electricity intensities for 1995-1997 will be used to determine the level of consumption. When limitations are removed then average intensities for 1990-1991 are used.

It is assumed that lessons of 1995-1997 limits induced strong energy conservation will be never forgotten and electricity intensities will never reach a level of 1992-1994 even if the production capacities are not fully loaded.

The output of the first block of GELGDP serves as an input to the **second block** which allows to estimate the price impact on electricity demand.

As was correctly mentioned in the IBRD study that there is no statistical base to determine the level of price elasticity using econometric tools. Therefore, some proxies are to be used. As a proxy we used results of CENEf's study for Rostov-on-Don oblast and Krasnodar krai.[1]

Those two regions are located at the similar to Georgia climate conditions, they also have limited availability of power, go through the similar process of transition to a market economy. In other words, those two regions are probably the best proxies for Georgia. MTD-CENEf model was built for those regions to estimate the impact of tariffs policy impacts on a utility's revenue.

Price elasticity coefficients for those two utilities without specification them by names (that is the provision of the contract) are presented in Box 1 below.

Majority of the presented coefficients are negative in the full accordance with the theory of market demand. That is, tariff growth brings along consumption reduction. However, the reduction is different by different groups of consumers.

Box 1

Electricity Price Elasticity of Demand and Debt for Two Russian Electric Utilities

Price Elasticity of Demand	**Utility 1**	**Utility 2**
Large industrial consumers	-0.190	-0.297
Residential sector	-0.204	-0.180
Small industrial consumers	-0.143	-0.175
Public and municipal sector	0	-0.069
Railroads	0	-0.068
In city transport	0	0
Agricultural sector	-0.271	-0.015
Price Elasticity of Debts		
Industrial sector	1.2	
Agricultural sector	1.7	

Source: I. Bashmakov, S. Sorokina. Evaluation of tariff policy impacts on utility's revenues. Energy Efficiency. № 13, 1996. CENEf.

[1] I. Bashmakov, S. Sorokina, A. Perevozchikov. Evaluation of Tariff Policy Impacts on a Utility's Revenues. CENEf. Moscow, 1996. Under the contract with Pacific National Northwest Laboratories.

Based on the results of this study elasticity coefficients were selected and incorporated to the model. (See Table 5.8).

Table 5.8. Electricity Price Elasticity of Demand Used in GELGDP

	1998-2000	2000-2020
Industry	-0.10	-0.20
Construction	-0.10	-0.20
Agriculture	-0.10	-0.20
Transport and communication	-0.05	-0.10
Trade	-0.10	-0.20
Services	-0.08	-0.10
Other	-0.10	-0.20
Population	-0.10	-0.20

Electricity price elasticities in Russian regions are lower than in Western European countries. One of the most resent study for Denmark evaluated average price elasticity equal -0.41, with fluctuations in the range from -0.29 to -0.56 in separate sectors[2]. Therefore, on the one hand, the elasticity coefficients chosen for the model are lower than in West European countries, as it should be, and, there is no much difference in the value of elasticities for branches of industry.

Given scenario of electricity prices fluctuations and presented above elasticity coefficients allow evaluate price impact on electricity consumption by sectors.

The third block of GELGDP accounts for energy efficiency improvement measures (EEMs). Again all measures for industrial and commercial sectors are considered by the corresponding models - GELIND and GELRES. Here EEMs for all the other sectors are considered.

Those sectors were divided by two groups:

1. Construction, agriculture, transport&communication, and own use;
2. Trade, services, and others.

For each of these groups the structure of electricity consumption by processes was evaluated, based on both expert estimates received during the contacts with Georgian experts and on similar data for other countries. (See Table 5.9). That was the only way to get such information.

Table 5.9. Structure of electricity consumption by processes (%)

	Motors	Process heat	Direct heat	Electrochem	Lighting	Others	Total
Construction	60	5	30	2	2	1	100
Agriculture	60	5	30	2	2	1	100
Transport and communication	80	0	10	0	5	5	100
Own use	80	0	10	0	5	5	100

[2] M. Togeby, T. Bjorner, and K. Jonansen. Evluation of the Danish CO2 Taxes and Agreements. Parer presnted at the Industrial Energy Efficiency Policies: Understanding Success and Failure. Urtrecht. 11-12 June 1998.

	Equip-ment	Space heating	Water heating	Refrigeration	Lighting	Others	Total
Trade	8	14	2	12	46	18	100
Services	15	14	2	12	46	11	100
Other	10	14	2	12	46	16	100

Source: Estimated by authors

Based on the shares from Table 5.9 and data on total electricity consumption for 1990 and 1996, volumes of electricity consumed by processes were estimated for 1990 and 1996.

Next step allows to identify energy efficiency improvement potential by processes. To do that the potential for efficiency gains for each process was evaluated (see Table 5.10). Primarily it was estimated as percentage to the level of consumption and then as amount of electricity savings for 1990 and 1996.

Table 5.10. Electricity Efficiency Potential (%)

	Motors	Process heat	Direct heat	Electro-chem	Lighting	Others	Total, 10^6 kWh
1990	25	10	10	10	30	10	2968
1996	25	10	10	10	30	10	971
	Equip-ment	**Space heating**	**Water heating**	**Refrige-ration**	**Lighting**	**Others**	**Total, 10^6 kWh**
1990	25	10	10	10	30	10	107
1996	25	10	10	10	30	10	679

Source: Estimated by authors

Only economically attractive EEMs are to be implemented. The determination of economic parameters for each proposed measure was done based on data presented in Table 5.11 (this Table is used only as an illustrative example).

Motors efficiency improvement can be achieved by several ways, listed in Table 5.11. Each way has different costs and effects. Share and corresponding volume of each measure in the total potential for efficiency improvement are shown in the two first columns of Table 5.11. Based on such data and life cycle cost approach the cost of saved energy (CSE) is evaluated. Similar table was built for 1996.

Table 5.11. Costs of Saved Electricity[3]

	Share in the potential	Volume of savings	Specific investments	Hours	Capacities to apply EEMs	Total investm.	Cost of saved energy
	%	10^6 kWh	$/kW		10^3 kW	10^3 US$	$/1000kWh
Correction of oversizing	10	56	100	3000	18.5	1858	8
Efficient motors	15	84	200	3000	27.8	5575	17
Adjustable speed drives	50	279	200	3000	92.9	1858	17
Control systems on blowers and pumps	25	139	150	3000	46.4	6969	13

Source: Calculated by authors.

If electricity prices are above the CSE, the given measures are implemented. The scale of implementation is determined by two major factors:

- level of capacity use (measured as a ratio of electricity consumption in given year to the 1990 level), and
- technology penetration rate.

The potential determined for 1996 is under utilization since the very beginning. As value added in given sector grows, the rest of the potential (the difference between 1990 and 1996 potentials) is used proportionally to the level of electricity consumption in that year to the level of consumption in 1990. Technology penetration rate depends on the life time of equipment and aggressiveness of the state energy efficiency policy.

An illustrative example of such calculation is shown in Table 5.12.

[3] All calculations for the cost of EEMs were made based on the life cycle cost approach

LCC=Cc+a/CRFtr+SV/(1+r)^t

Cc- initial capital costs

CRF = r/[1-(1+r)^(-t)]

PWF=SV/(1+r)^t

r-discount rate

t -equipment lifetime

SV- salvage value

Table 5.12. Evaluation of Savings for Adjustable Speed Drives

	Units	1998	1999	2000	2005	2010	2015	2020
Economically efficient potential	10^6 KWh	20.33	35.25	51.63	61.69	87.67	142.97	198.56
Penetration rate	%	0.10	0.10	0.10	0.10	0.10	0.10	0.10
Investments	10^6 US$	44	76	111	133	189	308	427
Additional savings	10^6 KWh	2.03	3.53	5.16	6.17	8.77	14.30	19.86
Cumulative savings	10^6 KWh	2.03	5.56	10.72	16.89	25.66	39.95	59.81

Source: Calculated by authors.

Similar calculations are made for each of proposed EEMs which will be described in more details in the section 6. Cumulative electricity savings are then allocated to every sector based on its share in the potential and then are deducted from electricity consumption by the sector adjusted to the price evolution.

Therefore there are three levels of electricity consumption estimated for each sector:

- economic activity driven;
- economic activity and price driven;
- economic activity, price and energy efficiency policy driven.

The final index is the output of the GELGDP model.

5.6. GELIND - Electricity Demand Projecting Model for Industrial Sector

GELIND is used to make projections of electricity consumption by branches of industry. By the concept it is very close to the GELGDP model. In fact the GELIND model was built first and served as a prototype for GELGDP.

GELIND also includes three blocks:

- economic activity impact block;
- electricity price impact block;
- energy efficiency policy impact block.

Below we will stop only on the specifics of GELIND.

Table 5.13 illustrates that in 1990-1994 electricity intensity in many branches grew up due to the reduction of capacity use. And in 1995-1997, it declined under the pressure of limitations and power cut-offs.

For 1998-2020 so called autonomous technological progress parameter is introduced into the model. The reason behind it is the steady replacement of the equipment stock which take place only through acquisition of new equipment. Modern equipment is as a rule more efficient than the replaced one. Therefore just regular replacement of obsolete equipment leads to the reduction of electric intensity. It was proposed that annual rate of such autonomous reduction is 1 percent.

Table 5.13. Electricity Intensity of Industrial Production (kWh/Lari in 1990 prices)

	1990	1991	1992	1993	1994	1995	1996	1997
Fuels	0.96	0.99	2.16	3.50	6.17	9.88	5.29	5.29
Ferrous	6.53	5.09	7.08	10.63	5.45	4.87	7.48	7.48
Non ferrous	12.24	0.82	0.75	1.17	1.14	0.47	0.39	0.39
Chemical	2.33	1.60	2.32	0.43	0.84	1.19	3.64	1.19
Machinery	0.48	0.62	0.94	0.74	1.01	0.62	0.07	0.62
Pulp and Paper	0.35	0.30	1.13	2.20	3.24	4.02	1.25	1.25
Building Mat.	0.79	0.54	1.52	0.44	0.65	0.81	1.29	1.29
Light	0.11	0.07	0.06	0.14	0.46	0.29	0.20	0.20
Food	0.12	0.13	0.14	0.34	0.40	0.68	0.18	0.18
Other	1.82	2.03	2.85	2.35	1.67	2.50	0.47	0.47

Source: Calculated by authors

Price elasticities for all branches are taken equal. They are -0.05 for 1998-2000 and -0.1 for the situation with limitations and correspondingly -0.1 and -0.2 for the situation with no limitation.

The logic of EEMs incorporation into the model is completely similar to the one already described for GELGDP.

5.7. GELRES - Electricity Demand Projecting Model for Residential Sector

GELRES is used to make projections of electricity consumption in the residential sector. It is also very close to both GELIND and GELGDP models and includes the same three blocks:

- population growth driven;
- population and price driven;
- population, price and energy efficiency policy driven.

GELRES projects electricity consumption by end-uses - space and water heating, cooking, lighting, and appliances - for urban and rural residents separately.

Several major factors drive energy demand in the residential sector: living area and number of habitants, saturation of residential sector with major communal services and appliances, personal incomes, price for electricity and availability of energy supply.

Per capita electricity consumption by end-uses, according to the authors estimates, is presented at Table 5.14.

As can be seen, there was a substantial growth of electricity consumption for space and water heating in 1997 as compared to 1990. That was the result of a shortage of district heat supply. Simultaneous reduction of electricity consumption by refrigerators and other appliances was caused mainly by frequent power cut-offs in winter time. As electricity supply becomes adequate, with no cut-offs and limitations, and a problem of space heating is being solved by means of either district heating system recovery, or through decentralization of heat supply, with parallel gas meters installation, and implementation of other measures, the situation is likely to change gradually. Per capita electricity

consumption will approach either 1990 level, or the level achieved in developed countries.

Table 5.14. Per capita residential electricity consumption by end-uses (toe/capita)

End-use	Urban/rural	1990	1997
Space heating	urban	0.0078	0.0296
Water heating	urban	0.0010	0.0030
Cooking	urban	0.0077	0.0089
Lighting	urban	0.0118	0.0125
	rural	0.0065	0.0050
Refrigerators	urban	0.0111	0.0054
	rural	0.0091	0.0047
Other appliances	urban	0.0111	0.0054
	rural	0.0030	0.0016

Source: Calculated by authors

Price elasticities for residential sector are assumed at -0.2 regardless of limitations.

The logic for incorporation of EEMs into the model is completely similar to what was already described for GELGDP.

5.8. GEB - Energy Balance Model

As it was already mentioned, developed by CENEf long-term energy balance model was adopted for Georgia and named GEB. This model has several macroeconomic inputs from ECONOMY. Some model parameters are generalized based on results of model run for GELIND and GELRES. In addition to macroeconomic variables there are several exogenous parameters in the GEB: energy production, energy export by sources, energy prices and energy taxes. GEB's output for each year looks like Table 5.15 presented below for 1990.

Table 5.15. Georgian Energy Balance for 1990 (10^3 toe)

Parameter	Coal	Other solid fuels	Oil	Natural Gas	Hydro	Solar	Electricity	Heat	Total
Primary energy production	706	224	186	48	654	0	0	0	1818
Export	309	0	982	0	0	0	101	0	1392
Import	473	0	6797	4407	0	0	376	0	12053
Stock change	23	0	153	0	0	0	0	0	176
Primary energy consumption	849	225	5845	4455	654	0	276	0	12303
Electricity generation	0	0	0	0	-654	0	654		0
District heat boilers	-232	0	-1010	-1379	0	0	0	1390	-1231
Combined cycle	0	0	-1519	-542	0	0	571	250	-1240
Own use and losses	0	0	-294	-70	0	0	-263	-408	-1035
Final energy consumption	617	225	3022	2464	0	0	1237	1233	8798
Industry	538	0	639	1169	0	0	719	788	3853
Agriculture	14	21	349	154	0	0	126	45	709
Transport	11	0	1301	32	0	0	89	7	1440
Residential and commercial	54	204	622	955	0	0	303	393	2531
Non-energy and other use	0	0	111	154	0	0	0	0	265

Source: Calculated based on "Georgia Energy Sector Memorandum". The World Bank. January 16, 1996

Historical data for energy balances are limited by data presented by the World Bank. Those data are not always consistent and presented only for 1990-1994 with limited data available for 1995-1997. Application of model based on such statistical base for 1998-2020 is very questionable. Therefore, GEB calibrated on the very limited statistical basis was used by the authors only as a control model to get double check of the quality of results received by the GELGDP.

This control is performed in two ways. First, GEB projects electricity demand by sectors for the same macroeconomic scenario. Therefore for each scenario two projections were made. The GEB's projections are used only as control numbers for the GELGDP model. Second, when GDP growth rates for the future are selected, some limits of growth are to be taken into consideration. One of the major limits is lack of foreign currency to pay for energy import. GEB estimates volume and value of energy import and provides indicators of consistency of GDP proposed rates growth with foreign trade limitations.

This model allow to evaluate the impact of energy prices and taxes evolution on energy demand.

6. Energy Efficiency Improvement Opportunities in Georgia

6.1. Energy Efficiency From Rhetoric to Actions

Energy efficiency impact on the electricity demand is evaluated in the special block of three models - GELGDP, GELIND and GELRES. Specific part of the section 5 was devoted to the logic through which efficiency is incorporated into each of those model. Below the most promising energy efficient technologies applicable in Georgia as well as the scale of their application are shortly described. It should be noted that the more detailed investigation of energy efficiency improvement potential is required.

The special study on how to promote energy efficiency in Georgia, which later can become the basis for development of the Presidential Program "Energy Efficiency in Georgia for 1999-2005" is required as well.

Historically, in the former USSR ,energy efficiency was a subject of much rhetoric and little concrete action. And it is still in Georgia. There is a very strong process of energy conservation by the switching consumers off, but there is a very weak process of improving energy efficiency.

Strong programs linked to sectoral and regional activities are critical. Energy efficiency objectives should be carefully integrated with industrial, social, fiscal and other policies that affect energy use.

Often, Georgians equate energy efficiency with energy technologies. An important development over the last few years has been production and distribution of metering equipment. Technology must be appropriate and integrated with policy and practice in the location where it is used and with the users. The least-cost approach to energy efficiency improvements requires integrated solutions.

In developing its approach to energy policy, Georgia should make energy efficiency a priority. Russian and western practices show that the resolution of present-day energy related problems requires a well-formulated energy efficiency improvement policy. So as to develop and implement this policy, federal and regional authorities need to be formed to administer activities in this field.

Without institutional measures, converting Georgian economy to the energy efficient path will be an extremely difficult task. Energy saving potential will only remain a potential if no institutions are created to initiate its practical emplementation.

To spur energy efficiency there is a need of an appropriate economic environment: economic incentives and motivation of market agents to reduce production costs by investing in energy efficiency. Energy price reform and privatization process provide such motivation. Growing energy efficiency reduce production costs and, therefore, provide basis for further economic growth.

All those problems are to be risen and solved to clean the entrance for efficient technologies penetration.

Below we will concentrate only on technological aspects of energy efficiency improvements, just to get understanding: whether it is worthwhile to develop a Presidential energy efficiency improvement program or potential effects are too small to do anything.

Estimates of potential for some technologies should be based on the understanding of the electricity consumption structure by industrial processes.

To provoke discussion CENEf prepared a table based on data for other countries. Those tables were discussed with Georgian experts including energy managers of large industrial plans and the result of such an effort is presented in Table 6.1. This table served as a basis for determination electricity consumption by processes for both 1990 and 1996. Results of evaluation of electricity consumption by processes were then used to estimate electricity efficiency improvement potential.

Table 6.1. Structure of Electricity Consumption by Industrial Processes

	Motor	Process heat	Direct heat	Electrochem	Illumination	Others	Total
Fuels	79	5	4	9	3	0	100
Ferrous	55	0	43	0	1	1	100
Non ferrous	1	0	98	0	0	1	100
Chemical	79	5	4	9	3	0	100
Machinery	98	0	0	0	2	0	100
Pulp and Paper	95	0	0	0	5	0	100
Building Mat.	58	1	39	0	2	0	100
Light	89	4	1	0	5	1	100
Food	6	77	16	0	1	0	100
Other	58	1	39	0	2	0	100
Industry	**59.67%**	**5.98%**	**30.66%**	**1.46%**	**1.82%**	**0.41%**	**100.00 %**

Source: result of the pull conducted by CENEf's experts.

6.2. Energy Efficient Technologies in the Industrial Sector

Only several crucial technologies were considered in this section. (See Table 6.2). In reality much more opportunities to improve efficiency do exist, but for the proper identification of those much deeper research is required.

Variable (Adjustable) Speed Drives (VSD) are capable of controlling the speed of AC induction motors- the most commonly used electric motors in industrial processes and utility operations. About 20% of Georgian electrical consumption used to drive AC electric motors. Application of VSD has a potential to save about 30-40% of electric energy of motors which work with variable load. VSDs provid several benefits:

- save electricity;
- improve system efficiency;
- improve equipment reliability by permitting soft start and smooth slowdowns;
- reduce the noise and save working space.

VSDs can be used to improve the process control in the metallurgical, chemical, food, building materials industries, etc.

Table 6.2. EEMs for the Industrial Application

Measure	EEMs	Specific costs $/kWe	Where to be implemented	Pay back period (years)
Independent energy source	Due to high efficiency reducing of 1kWh cost from 0.35$ to 0.15-0.18$	600-800	Azot Fertilizer plant - 30 MW (electricity consumption - 180 million kWh). Metallurgical plant- 30 MW (electricity consumption - 280 million kWh). Ferrous alloy plant - 60 MW	3-5
Installation of the input transformers with the optimal capacity	savings are 10-12% of electricity consumption	30-40	Azot Fertilizer plant, Metallurgical plant and others, where big transformers are installed	1-1.5
Motor savers (overloading and overheating protection)	prolong the lifetime of motors up to 50%	10	average motor capacity for Georgian industrial motors is 15-20 kW. About 5000 motors need to be equipped	2
Variable speed drives (VSD)	electricity savings 30-40%	130-170	Food, pulp and paper, cement, chemical, consumer good industries, electricity generation	1.5-2
Motors switching off during the idle run period	electricity savings up to 50% of existing losses of idle run period	10	Food, pulp and paper, cement, chemical, consumer good industries, electricity generation	1.5-2
Decentralization of compressed air supply	electricity savings up to 50% from compressor consumption	300	Ferrous and chemical industry (compressors consume 10% of electricity)	1
Compensators of reactive power	electricity savings up to 10%	25-40 $/KVA	metallurgical plant, Ferroalloys plant	2-3
Electricity demand control systems (energy monitoring)	savings up to 10% of energy consumption	50-100	Every enterprise with the electric capacity more than 2000 kW	2

Transformers. Underloaded input transformers (110/6.3 KV and 6,3/0,4 KV) actually work in the regime of idle run which leads to overheating of equipment and significant energy losses. Additional installation of rather low capacity transformers can solve this problems and save about 10% of electricity.

After the transition to design consumption regime new installed transformers could be used to supply electricity to separate workshops.

Compressors. Oversizing of main energy consumers in Georgian industry as a result of production reduction leads to inefficient use of electricity. For example huge compressors at the metallurgical plant work at about 10% of design capacity. The decentralization of compressed air supply network and installation of small compressors can decrease electricity consumption up to 50%.

Compensators of reactive power. The main consumers of reactive power are: induction motors, transformers, voltage stabilizers. To eliminate electrical losses special capacity type compensators should be installed. Compensators could be categorized by: individual (for each motor), group and centralized. In conditions

of underloaded equipment the role of compensators are significant. Electricity savings up to 10% could be achieved.

Motor savers and idle run of motors. Average motor's capacity in Georgian industry is 15-20 kW. At least 5000 motors need to be equipped by special low cost devices with the common name of motor savers. This microprocessor based device prevents the overheating, phase loosing and overloading. This device prolongs the motor life time up to 20-30%.

Motors switching off during the idle run period could save up to 50% of existing electricity losses caused by idle run.

Control systems. Proper monitoring, recording and analysis lead to corrective actions that produce the desired result of reducing energy per unit of production or per service performed. Ultimately up to 10% reduction of energy consumption can be achieved when metering is tied directly to the process through a programmable logic controller. Experience shows that 2-3% reduction in energy use can be achieved after meters are installed just by letting users know that they are been monitoring. Georgian industry has no experience in such of systems. This measure can be recommended to every enterprise with the electric capacity more than 2 MW.

Lighting. Sodium high pressure lamps for streets and industrial territory lighting is the most promising for Georgian industry.

Independent energy sources. Non reliable, expensive and low quality electricity from Georgian utility enforced energy managers of large enterprises to think about installation of independent power sources. There are at least two projects to build 30-50 MW power stations with gas turbines. Actual specific consumption by existing power stations in Georgia is about 450-650 gce/kWh, comparing with the specific consumption of new gas turbine - 200-250 gce/kWh.

In Tables 6.3 and 6.4 below electricity efficiency improvement results of GELIND model run are shown under the following assumptions:

- electricity prices will grow from 34.6 $/1000 kWh in 1998 to 67.4 in 2020;
- capital recovery factor is 0.33 (discount rate 0.2 and lifetime 5 years);
- penetration rate for motor systems is 0.2 (that is only 20% of potential is used on practice).

Table 6.3. Motors efficiency potential

	Share		Specific investm.	Hours		Capacities		Cost of saved energy	
	%		$/kW			kW		$/1000kWh	
	1990	1996		1990	1996	1990	1996	1990	1996
Decentralization, correction of oversizing, and switching off	20	35	310	3000	2000	111464	31724	34.55	51.83
Compensators and motor savers	10	10	180	3000	2000	55732	9064	20.06	30.09
Adjustable speed drives	50	30	170	3000	2000	278660	27192	18.95	28.42
Control systems on blowers and pumps, transformers	20	25	140	3000	2000	111464	22660	15.60	23.41
Total	0	0	0	0	0	557320	90640		

Source: Calculated by authors by using GELIND

Table 6.4. Motors efficiency potential utilization

		1998	1999	2000	2005	2010	2015	2020
Decentralization, correction of oversizing, and switching off								
Economically efficient potential	10^6 kWh	3.68	9.05	27.75	64.53	161.03	245.84	315.64
Penetration rate	%	0.2	0.2	0.2	0.2	0.2	0.2	0.2
Investments	$	76	187	573	1334	3328	5081	6523
Annual savings	10^6 kWh	0.74	1.81	5.55	12.91	32.21	49.17	63.13
Cumulative savings	10^6 kWh	0.74	2.55	8.10	21.00	53.21	102.37	165.50
Compensators and motor savers								
Economically efficient potential	10^6 kWh	20.15	23.11	33.39	53.63	71.82	118.47	156.88
Penetration rate	%	0.2	0.2	0.2	0.2	0.2	0.2	0.2
Investments	$	416	478	690	1108	1484	2448	3242
Annual savings	10^6 kWh	4.03	4.62	6.68	10.73	14.36	23.69	31.38
Cumulative savings	10^6 kWh	4.03	8.65	15.33	26.06	40.42	64.11	95.49
Adjustable speed drives								
Economically efficient potential	10^6 kWh	65.00	80.49	134.42	240.53	335.89	580.52	781.87
Penetration rate	%	0.2	0.2	0.2	0.2	0.2	0.2	0.2
Investments	$	1343	1663	2778	4971	6942	11997	16159
Annual savings	10^6 kWh	13.00	16.10	26.88	48.11	67.18	116.10	156.37
Cumulative savings	10^6 kWh	13.00	29.10	55.98	104.09	171.27	287.37	443.75
Control systems on blowers and pumps, transformers								
Economically efficient potential	10^6 kWh	49.25	54.98	74.92	114.17	149.43	239.91	314.38
Penetration rate	%	0.2	0.2	0.2	0.2	0.2	0.2	0.2
Investments	10^3 $	1018	1136	1548	2359	3088	4958	6497
Annual savings	10^6 kWh	9.85	11.00	14.98	22.83	29.89	47.98	62.88
Cumulative savings	10^6 kWh	9.85	20.84	35.83	58.66	88.55	136.53	199.41
Total for motor systems								
Additional savings	10^6 kWh	27.62	33.52	54.10	94.57	143.63	236.95	313.75
Cumulative savings	10^6 kWh	27.62	61.14	115.24	209.81	353.44	590.39	904.14

Source: Calculated by authors by using GELIND

Similar calculations were made only for one more process - lighting. The most important information used in calculating electricity efficiency improvement potential for lighting is presented in Table 6.5. Those data was used to conduct calculations similar to what was presented in Table 6.4.

Table 6.5. Motors efficiency potential

	Share		Specific invest-ments	Hours		Capacities		Cost of saved energy	
	%		$/kW			kW		$/1000 kWh	
	1990	1996		1990	1996	1990	1996	1990	1996
Incandescent	20	20	135	2000	2000	13688	1680	2.77	22.57
Fluorescent	70	70	180	3000	3000	31938	3920	2.46	20.06
High pressure discharge	10	10	27	3000	3000	4563	560	0.37	3.01

Source: Calculated by authors by using GELIND

6.3. Energy Efficiency in the Residential Sector

One of the first things to do in the residential sector is to set right metering and billing system to provide incentives for efficient use of electricity and to improve collection rate as a basis for stable economic position of electricity suppliers.

But even in present conditions there are incentives to use electricity more efficiently. They are comfort requirements and reduction of total capacity of appliances to the design level per flat to keep electricity supply reliable. Equipment with higher efficiency as well as some measures to reduce heat losses (when electricity was used as heat source) will produce better indoor comfort while reducing per flat load and amount of electricity consumed. In addition new efficient appliances perform given functions faster or better. That is important when power supply can be cut off each minute.

There are two sets of measures for the sector: building level and flat level. Watt-stoppers (electric current limiters) -- very simple devices to disconnect overloaded buildings or industrial objects, and building level metering electronic system (with split-core current sensors) are from the first group. There are many measures in the second group. ' In addition to regular measures directed to lighting or appliances efficiency improvements, there is a set of measures to reduce heat losses (because electricity became very important heating source) and measures to replace electricity as a heat or hot water source.

Several technologies for improving the efficiency of electricity use in the residential sector are presented in the Table 6.6.

Table 6.6. EEMs for the Residential Application

Measure	EEMs	Specific cost	Pay back period (years)
Watt-stoppers (electric current limiters) very simple device to disconnect overloaded buildings or industrial objects	Prevent the overloading of transformers. Reduce non-payment	10$/Amp	0.5
Building level submetering electronic system (with split-core current sensors)	Upgrade billing system. Reduce nonpayment	500$/building input	0.5
Double glazing	Reduce heat loses up to 30%	10$/sq.m with wooden frame	1.5
Weather stripping	Reduce heat loses up to 10%	0.2$/ sq.m	1.5
Effective lighting (compact fluorescent lamps)	Reduce electricity consumption by 5 times. Prolong life time by 5 times	10$/item	2.5 (3.5C/kW)
Using of renewable energy	Solar panels save 0.05 tce/sq.m/year	Solar water heater 200$/sq.m	
	Micro-GPS (total) 80 MW can produce 300 million. kW heat	800$/kW	
	Wind power stations (total) 300 MW can produce 700 million. kWh/year	1000$/kW	

Electricity efficiency improvement measures

To provide incentives for energy efficiency the building level submetering electronic systems are to be installed. Such system is a microprocessor based device, which consists of metering unit and several split-core current sensors. Main advantages:

- high accuracy;
- low cost;
- full range of communication options;
- automated billing.

Electricity efficiency improvements in following devices were considered:

- Effective lighting;
- Refrigerators;
- Electric ranges.

Together they are responsible for two thirds of electricity consumption in the residential sector. The most important information used in calculating electricity efficiency improvement potential for lighting is presented in Table 6.7 below.

Table 6.7. Electric Devices Efficiency Improvement Potential

	Share		Specific investments	Hours		Capacities		Cost of saved energy	
	%		$/kW			kW		$/1000 kWh	
	1990	1994		1990	1994	1990	1994	1990	1994
Incandescent	95	95	90	1000	1000	171264	165263	30.09	30.09
Fluorescent	5	5	120	1000	1000	9014	8698	40.13	40.13
Refrigerators	100	100	983	8760	4000	22254	24145	24.02	52.60
Electric ranges	100	100	112.50	700	500	78586	124460	38.57	54.00

Source: Calculated by authors by using GELIND

Heat losses reduction measures

Heat Reflecting Films for Window. Single glazing is very common in Georgian residential buildings. The best way to save heat up to 30% is the installation of additional window. It is expensive. Instead the special heat reflecting films can be installed, which are much cheaper. Heating season in Georgia is 152 days. Average temperature during the heating period is 4.2 °C.

Weather stripping. Weather stripping program is a low cost and reliable measure, and is a very common solution for residential buildings. Usually it saves up to 10% of heating consumption.

Table 6.8. Heat Losses Reduction Potential

	Share		Specific investments	Hours		Capacities		Cost of saved energy	
	%		$/kW			kW		$/1000kWh	
	1990	1994		1990	1994	1990	1994	1990	1994
Weather stripping	30	30	46.67	1540	405	11959	139746	11.82	44.89
Double window	70	70	60.00	1540	405	27904	326074	15.19	57.71
Solar panels*	100	100	200.00	1000	1000	13951	41854	48.00	48.00

* This is the measure to replace electricity in heating water.

Source: Calculated by authors by using GELIND

Electricity substitution measures

Using renewable energy. Solar panels for water heating could save annually 0.05 tce/m^2. For one sunny day one m^2 of solar panel provides 0.5 kW of capacity, that is enough to heat 80 l of water up to 65°C.

Total potential of wind power is 300 MW (700 mln kwh/year). Potential of total micro hydro stations is 80 MW (300 million kWh/year).

At this moment the model does not account for potential for replacing network electricity with renewable energy. Additional work should be done to do that properly.

6.4. Energy Efficiency in the Other Sectors

In the section 5 of this report is was already explained how the third block of GELGDP accounts for energy efficiency improvement measures (EEMs).

6.5. Success Stories from Russia[1]

Pessimists will keep saying that it is too difficult to do anything with energy efficiency potential. Optimists will keep telling success stories to convince pessimists. This section presents three such stories from Russia, a country which is in the situation similar to Georgian one.

Where there is a will there is a way. Many obstacles are still there. They are to be removed and road shall be paved. Obviously, people with a strong will are needed to overcome them and go beyond limits to make Russia's industry rational.

In Russia energy tariffs are high. That makes energy efficiency a priority, when production costs reduction strategy is addressed. Production costs reduction is the basic means to improve the competitiveness of Russia's economy. Energy costs reduction is the basic means to reduce production costs. Bringing together knowledge and efforts of energy consumers and manufacturers of energy efficient equipment is the basic means to reduce energy costs.

There are clear signs that top management of Russian industrial corporations realized the importance of effective energy management in the corporation

[1] This section is borrowed from: Igor Bashmakov. Russian Industry: Paving Road to Rationality. International Workshop on Industrial Energy Efficiency Policies: Understanding Success and Failure. June 11-12, 1998. Utrecht, The Netherlands

strategy on production costs reduction. Chief energy managers of many industrial enterprises were required to develop energy costs reduction programs. While this requirement is set there are not enough experience at the enterprises in developing and implementation of such programs.

There are more and more examples in Russia when due to very aggressive programs and efficient energy management in a very short time frame energy related costs felt down by 15-20%.

Magnitogorsk Metallurgical Plant

Magnitogorsk Metallurgical Plant is gigantic industrial enterprise located at Urals. In 1996-1998 special energy consumption was reduced from 9.82 to 7.83 Gcal/t crude steel, or by 20%. That is mainly a result of Center for Energy Efficient Technologies activities. This Center was created three years ago and presently employs 170 people. It has four departments:

- metering bureau;
- control group;
- adjustment group;
- design group.

The most important starting point was the development of wide spread metering system all around this gigantic industrial facility. This is the responsibility of metering group. Presently readings from more than 700 devices are collected and analyzed daily. Based on this information, energy balances of the whole enterprise as well as for separate energy carriers and separated shops were reconstructed and norms for specific energy consumption, and limits of consumption are set for each of major production departments. One of the main task is to reduce peak loads for morning and evening maximums, introducing more flexible production regimes.

The control group is responsible for identification of losses as well as for checking the implementation of technical rules for energy consuming equipment.

Adjustment group is responsible for turning equipment parameters (burners, furnaces etc.) to get highest possible efficiency for given production regime.

The design group is responsible for designing implementation of proposals which leads to the reduction of energy consumption.

Among the most important measures are:

⇒ utilization of coke oven gas and blast furnace gas;

⇒ utilization of secondary heat;

⇒ decentralization of the compressed air production;

⇒ reconstruction of own power sources (three power stations with total capacity 400 MWt.

The whole four years energy efficiency improvement program (1998-2001) costs 480 million US$. The Magnitogorsk Metallurgical Plant will invest 30% of funds required, and the rest 70% are to be mobilized outside.

Moskabelmet

This is electric cables manufacturing plant located in the center of Moscow. The share of energy costs in production costs grew from 4% in early 90'es to 7% in 1997. The negative impact of high energy prices on production costs was neutralized by permanent energy efficiency improvement activities promoted by the top management of the enterprise. All measures were implemented for Moskabelmet own expense.

Metering again was the departure point for the whole program. It was followed by the introduction of peak demand management system. Next step was installation of steam traps, which allowed to save 20% of consumed heat. All heat supply pipes were replaced or insulated. All water supply system was reconstructed.

District heat for the utility is very expensive. Moskabelmet installed its own boiler house (3.7 million US$ worth), which generates heat for just 60% of utility price.

Based on collected statistics specific energy consumption by each shop were estimated and enforced in line with the introduction of economic incentives for complying with those norms. General director personally monitor on regulatory basis the work of that system.

Ekaterinburg Machinery Building Plant

This plant started from low cost measures. Introduction of strong control allowed to reduce water consumption by 35% and electricity consumption for lighting - by 50%. Due to the reduction of internal shops temperature heat consumption felt down. Low capacity load was the reason for conservation of several shops and warehouses. That measure brought significant savings. The production from conserved shops was transferred to another ones.

Another set of measures is related to the decentralization of heat, compressed air. Small efficient local boilers replaced large one. Such action provided basis for the substantial reduction of heat losses. Decentralization of compressed air supply was accompanied by the reduction of electricity consumption by 40%.

7. Electricity Demand in Georgia: 1998-2020

7.1. Scenarios for projecting electricity demand in Georgia

In 1995-1997, average annual rate of GDP growth accounted for 13%, and by 1997, GDP achieved 43% of 1990 level. According to Georgian State Department of Statistics, the growth remains strong. Nevertheless, obstacles for accelerated economic growth still remain. That raises questions about the economic sustainability of double-digit GDP growth.

One of the major obstacle is strong Georgia's dependence on energy import and large external debt. *Georgian Economic Trends* for the third quarter of 1997 states:

> Imports are growing much faster than GDP; exports are growing more slowly. To sustain further widening of the deficit would require an expansion of official support from foreign governments and international financial institutions, and/or much higher inflows of private investment into Georgia.

Human Development Report for 1997 also pointed:

> Despite the growth of GDP and the low inflation rate, a rapid growth of foreign debt is observable. The total foreign debt amounts to 1 billion 400 million US dollars, 52% of which are debts to the CIS countries.

In 1990, 87% of primary energy supply was imported from abroad, mainly from Russia and Turkmenistan. Net imports of natural gas, oil and oil products reached 99% of total primary energy supply, coal import accounted for about one-fifth of its supply, and electricity import provided for 22% of final electricity consumption. As domestic economic activity declined and energy import prices rose rapidly up, Georgia's ability to import energy became progressively limited.

Therefore, different scenarios of the future economic growth are to be developed. For the purposes of this study three scenarios of GDP growth were selected:

1. SlR-SlG scenario - Slow Recovery (6% per year GDP growth in 1998-2000) - Slow Growth (4.5% GDP growth per year in 2001-2020);
2. StR-StG scenario - Strong Recovery (10% per year GDP growth in 1998-2020) - Strong Growth (6.5% per year GDP growth in 2001-2020);
3. StR-StG-StC scenario - Strong Recovery (10% per year GDP growth in 1998-2020) - Strong Growth (6.5% per year GDP growth in 2001-2020) with Structural Changes of GDP in favor of services.

In addition to the rates of GDP growth evolution of electricity prices is an input to the model. The following assumption were made relative to the price of electricity:

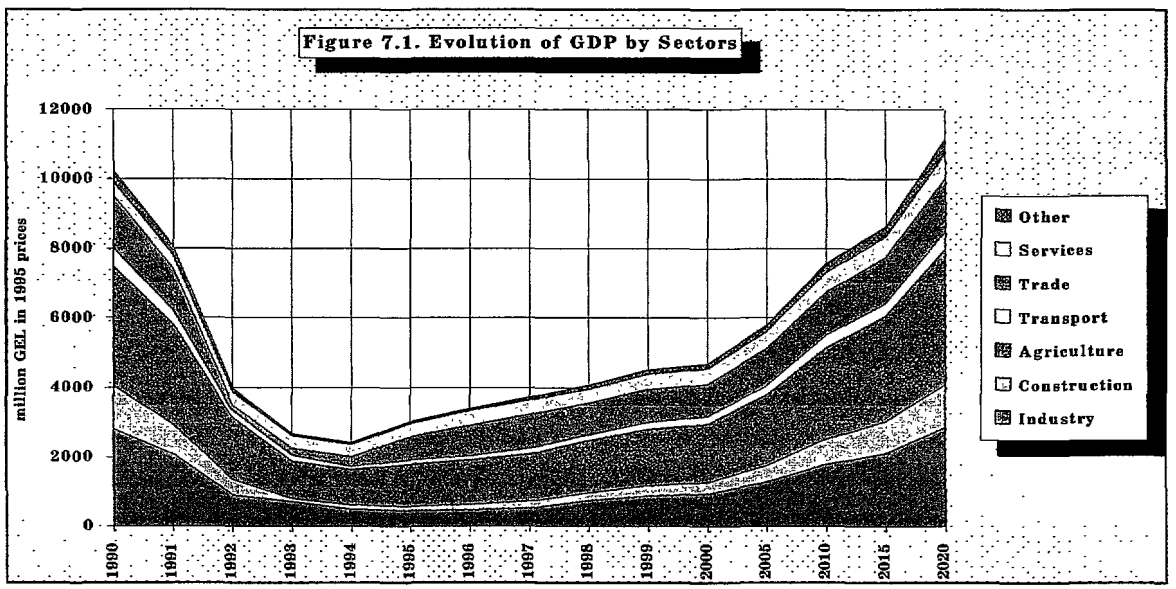
1998	1999	2000	2005	2010	2015	2020
38.06	41.87	46.05	50.66	55.72	61.30	67.43

It was proposed that electricity prices are equal for all sectors in 1998-2020, and since 2001 prices for the residential sector are 20% above the level in other sectors.

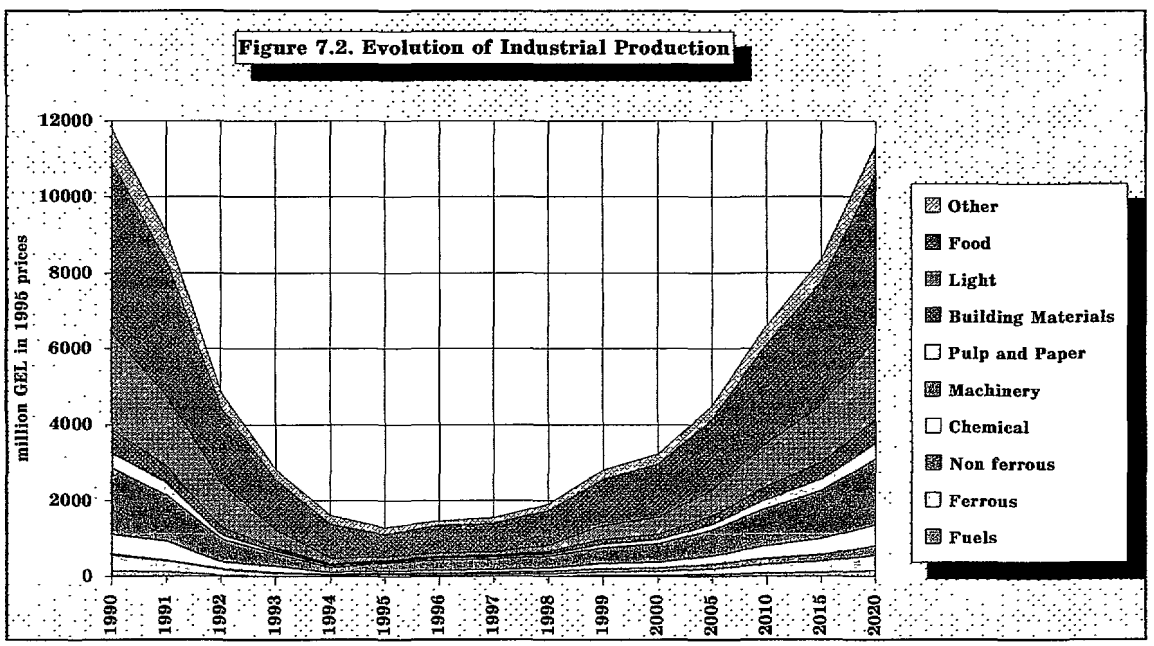
7.2. Slow Recovery - Slow Growth Scenario

7.2.1. Proportions of Economic Growth

Slow Recovery - Slow Growth (SlR-SlG) scenario - propose 6% per year GDP growth in 1998-2000 and 4.5% in 2001-2020. As a result, GDP in 2020 is 25% over the 1990 level and 2.9 times of the 1997 level. Construction (growth in 1998-2020 by 6.2 times), industry (5.4 times) and Other sectors (5.9 times) are most dynamic components of GDP, while the least rates are attributed to trade and services. (See Fig. 7.1).



Within the industrial sector the largest contribution will be provided by machinery, light, food, and building materials industries. (See Fig. 7.2).



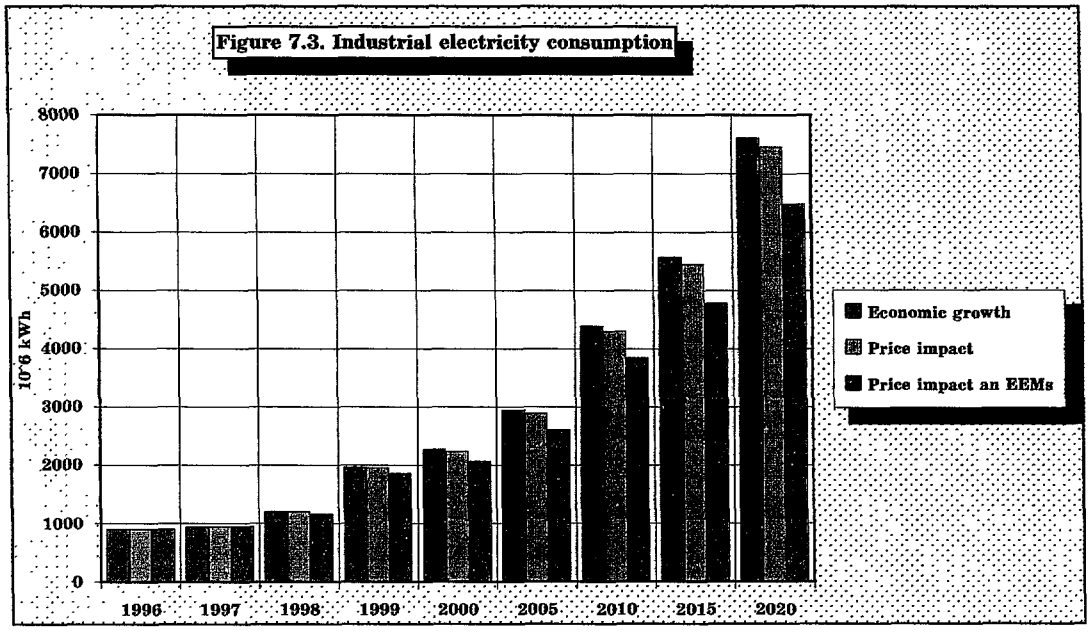
7.2.2. Electricity Consumption in Industrial Sector

For each economic scenario there are three levels of electricity consumption were estimated:

- demand driven by the rates and proportions of economic growth;
- demand with the price impact;
- demand with price and energy efficiency improvements effect.

All those three options are depicted on Fig. 7.3. Economic growth brings industrial consumption up to 7612 million kWh, price impact reduces this number to 7460 million kWh, and realization of EEMs pushes it further down to 6484 million kWh (own use is not counted here). Therefore in 2020, industrial electricity consumption is still below 1990 level.

Evolution of industrial production, electricity consumption and intensity is presented at Fig. 7.4. Levels of electricity consumption by industries are shown in Table 7.1.



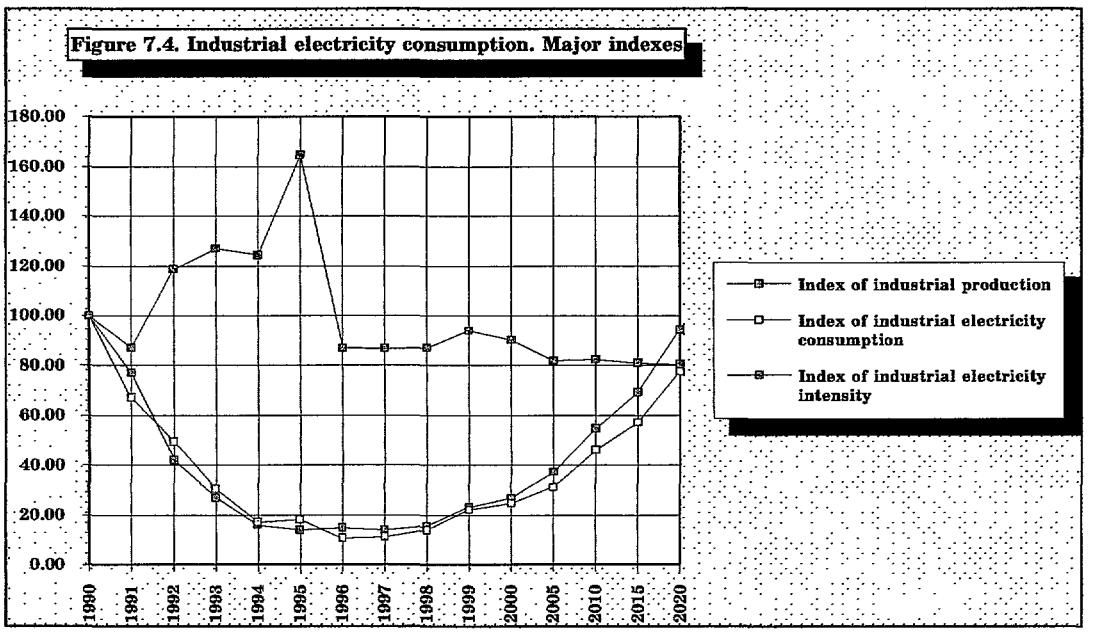


Table 7.1. Industrial energy consumption (SIR-SIG) scenario (10^6 kWh)

	1990	1996	1997	1998	1999	2000	2005	2010	2015	2020
Fuels	130	50	53	86	163	176	44	70	81	116
Ferrous	2715	280	295	385	680	767	853	1268	1625	2251
Non ferrous	465	20	20	15	20	36	41	125	186	240
Chemical	1230	230	79	93	136	139	350	515	605	820
Machinery	830	20	180	187	244	264	314	449	557	756
Pulp and Paper	140	60	63	78	121	133	43	64	74	102
Building Mat.	490	40	43	69	135	155	114	178	229	323
Light	280	20	21	32	63	78	45	73	91	127
Food	520	130	136	158	215	242	215	302	379	503
Other	1560	60	63	67	84	80	587	804	956	1246
Industry	**8360**	**910**	**953**	**1170**	**1862**	**2070**	**2607**	**3848**	**4783**	**6484**

Source: CENEf

7.2.3. Electricity Consumption in Residential Sector

Basic assumptions for the residential sector are presented in Table 7.2.

Table 7.2. Basic Scenario Assumptions for the Residential Sector

	Units	1990	1996	1999	2000	2005	2010	2015	2020
Population	thousand	5464	5434	5439	5445	5499	5555	5610	5667
Growth rates	%		0.10	0.10	0.10	0.20	0.20	0.20	0.20
Urban	thousand	3073	3020	3023	3026	3056	3087	3118	3149
Rural	thousand	2391	2414	2416	2419	2443	2467	2492	2517
M2 per capita	m2	18.64	17.79	17.77	17.76	17.68	17.69	17.91	18.37
persons per flat	persons	3.09	3.06	3.05	3.05	3.05	3.05	3.04	3.00
number of households	units	1768	1779	1782	1785	1804	1824	1844	1889
Urban	units	994	989	990	992	1003	1014	1025	1050
Rural	units	774	790	791	793	802	810	819	839

Source: CENEf.

As in case with the industrial sector there are three major factors impact was evaluated in this sector. (See Table 7.3).

Population, living area and appliances saturation driven level is 3137 million kWh in the year 2020. Growth of prices does reduce this number to 3075 million kWh. Aggressive implementation of EEMs pushes this volume down to 2558 million kWh.

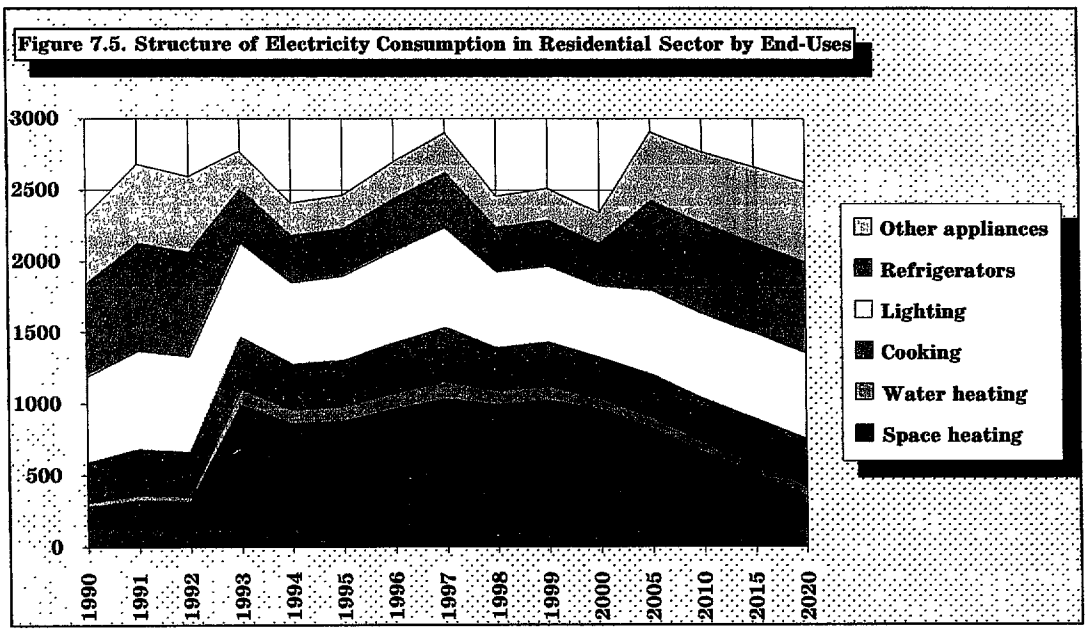
Table 7.3. Residential Electricity Consumption (million kWh)

	1990	1997	1998	1999	2000	2005	2010	2015	2020
Economic growth	2320	2593	2519	2599	2616	3187	3154	3147	3137
Price impact	2320	2593	2475	2547	2448	3124	3091	3084	3075
EEMs	2320	2593	2458	2513	2344	2907	2769	2661	2558

Economic growth - electricity consumption driven only by the factors of economic growth;
Price impact - above electricity consumption after taking into consideration the price impact.
EEMs - above electricity consumption after implementation of EEMs

Source: CENEf.

Practical stabilization of electricity consumption in the residential sector in 1998-2020 is explained by the fact that electricity consumption for heating and hot water is substantially reduced on the background of growth of consumption in other applications. (See Fig. 7.5).



7.2.4. Electricity Consumption in All Sectors

If only economic growth will drive the electricity demand in Georgia it will reach about 20,000 million kWh in 2020. That is 15% above the 1990 level. But price growth effect brakes this growth. As a result, demand about reaches 18,186 million kWh. Finally price and policy induced energy efficiency improvements stop this growth at level 16,488 million kWh, or 94% of 1990 level. (See Table 7.4).

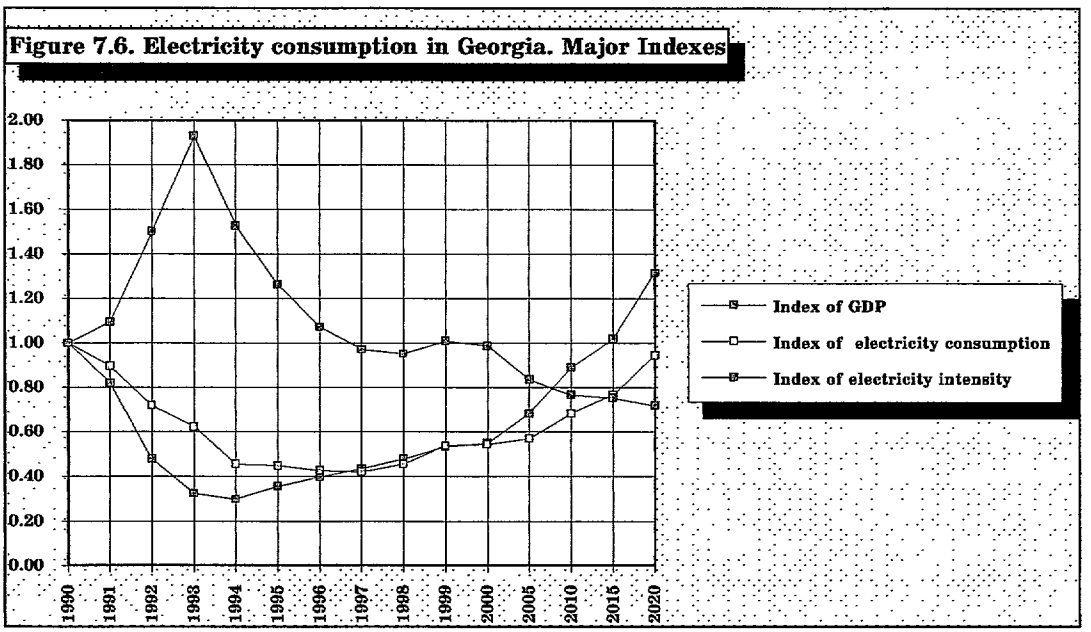
Table 7.4. Total Electricity Consumption (million kWh)

	1990	1997	1998	1999	2000	2005	2010	2015	2020
Economic growth	17450	7363	8219	10023	10497	11334	14069	16071	19976
Price impact	17450	7363	8023	9539	9837	10524	12803	14648	18186
EEMs	17450	7363	7956	9371	9502	9946	11911	13396	16488

Economic growth - electricity consumption driven only by the factors of economic growth;
Price impact - above electricity consumption after taking into consideration the price impact.
EEMs - above electricity consumption after implementation of EEMs

Source: CENEf.

After sharp growth in 1990-1993 and sharp decline in 1994-1997 electricity intensity of GDP is steadily coming down reaching in 2020 72% of 1990 level. Due to that, on the background of GDP growth by 25% over the 1990 level, electricity consumption stays below 1990 level. (See Fig. 7.6).

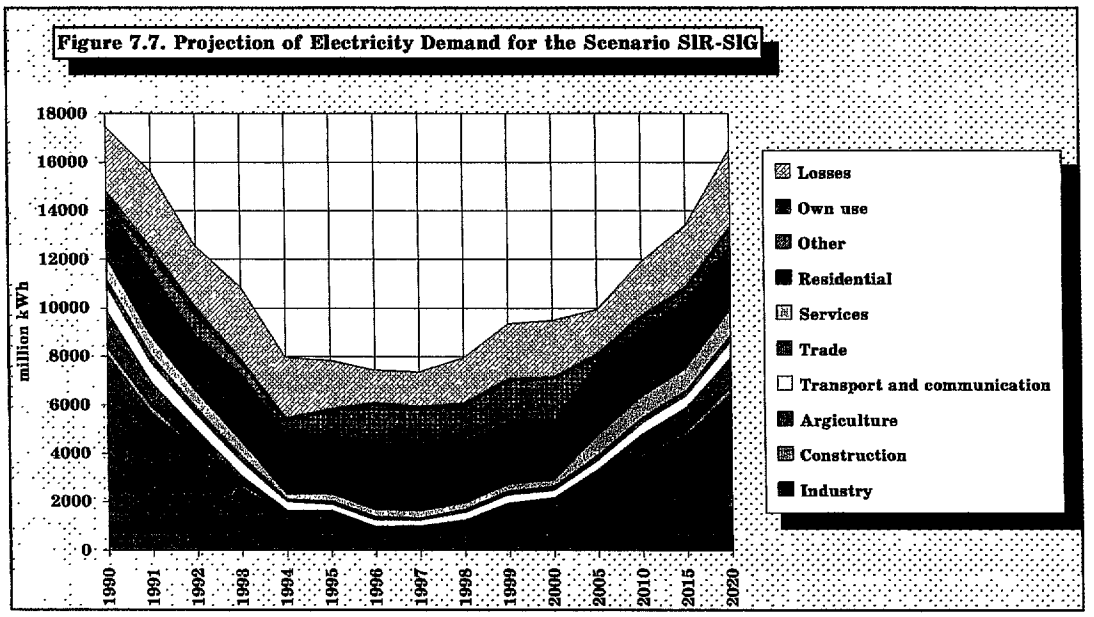


Electricity consumption by sectors is presented in Table 7.5. and its structure is painted at Fig. 7.7. It is clear that growth of demand is mainly driven by the corresponding growth of the industrial and agricultural sectors.

Table 7.5. Projection of Electricity Consumption by Sectors (million kWh)

	1990	1997	1998	1999	2000	2005	2010	2015	2020
Industry	8054	953	1170	1862	2070	2607	3848	4783	6484
Construction	310	38	53	67	73	97	146	188	261
Agriculture	1460	14	20	21	21	637	815	941	1192
Transport and communication	1040	254	321	361	341	421	495	511	679
Trade	288	64	127	133	127	160	186	197	234
Services	912	334	291	305	293	854	870	920	1092
Residential	2320	2593	2458	2513	2344	2907	2769	2661	2558
Other	3	1590	1535	1748	1809	313	440	540	725
Own use	420	113	96	92	84	138	132	124	114
Losses	2643	1411	1886	2268	2341	1811	2209	2531	3149
Final use	14387	5839	5975	7011	7078	7997	9570	10741	13225
Total	17450	7363	7956	9371	9502	9946	11911	13396	16488

Source: CENEf.



7.2.5. Load Evolution

Maximum demand projections are presented in Table 7.6. In 1998-2020 this indicator will grow by 2.2 times.

Table 7.6. Electricity Demand Projections

	1997	1998	1999	2000	2005	2010	2015	2020
Energy (TWh)	7363	7956	9371	9502	9946	11911	13396	16486
Maximum Demand (MW)	1461	1579	1859	1885	1973	2363	2658	3271

7.2.6. Control of Results

Model GEB was used to control projections results. This energy balance model considers electricity on the background of other energy sources. Its calibration was complicated by the lack of data on fossil fuels consumption by sectors. Therefore it is considered as crude instrument capable only to keep authors away from serious mistakes. To compare results of GEB run presented in Table 7.7 with data from Table 7.5 one should keep in mind that industry is presented with construction as one index, as well as residential sector, trade and services, and also own use and losses.

Table 7.7. Projection of Electricity Consumption by Sectors Using GEB Model (million kWh)

	Industry and construction	Agriculture	Transport	Residential and commercial	Final use	Own Use and losses	Total
2000	2813	274	764	3772	8536	2513	11049
2005	3879	325	824	3833	10101	2974	13076
2010	4576	402	931	3918	11157	3285	14442
2015	5437	451	1059	4036	12422	3658	16080
2020	6405	552	1196	4203	13899	4093	17991

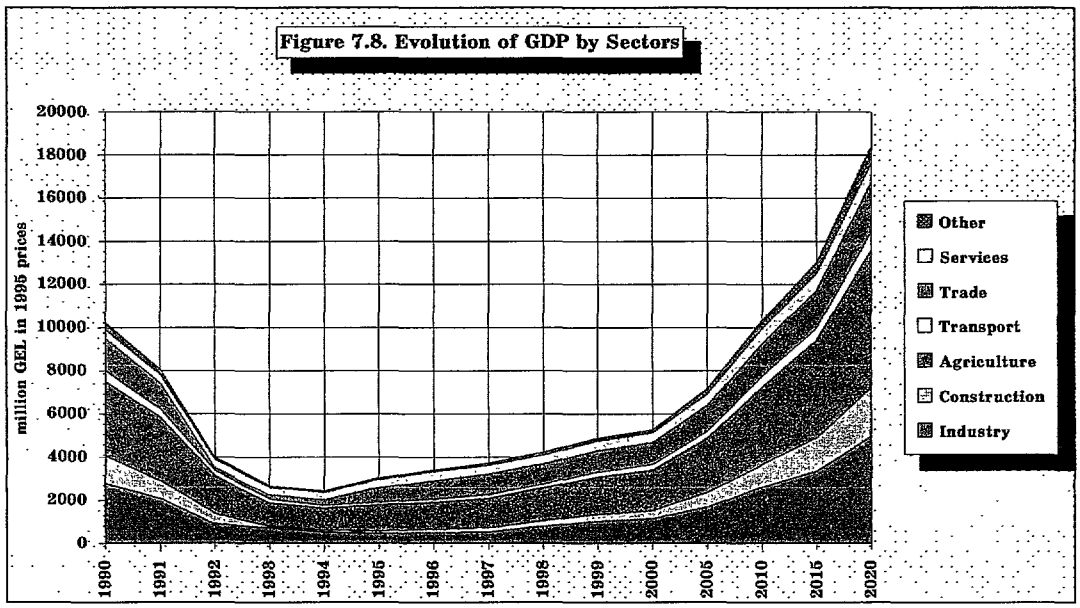
Source: CENEf.

This GEB projection estimates electricity consumption level in 2020 equal 18 billion kWh, or 9% more than model complex gives. Results for industrial sector (including construction) are very close, as well as results for residential and commercial sectors. Substantial differences are received for the agriculture, transportation and losses (including own use).

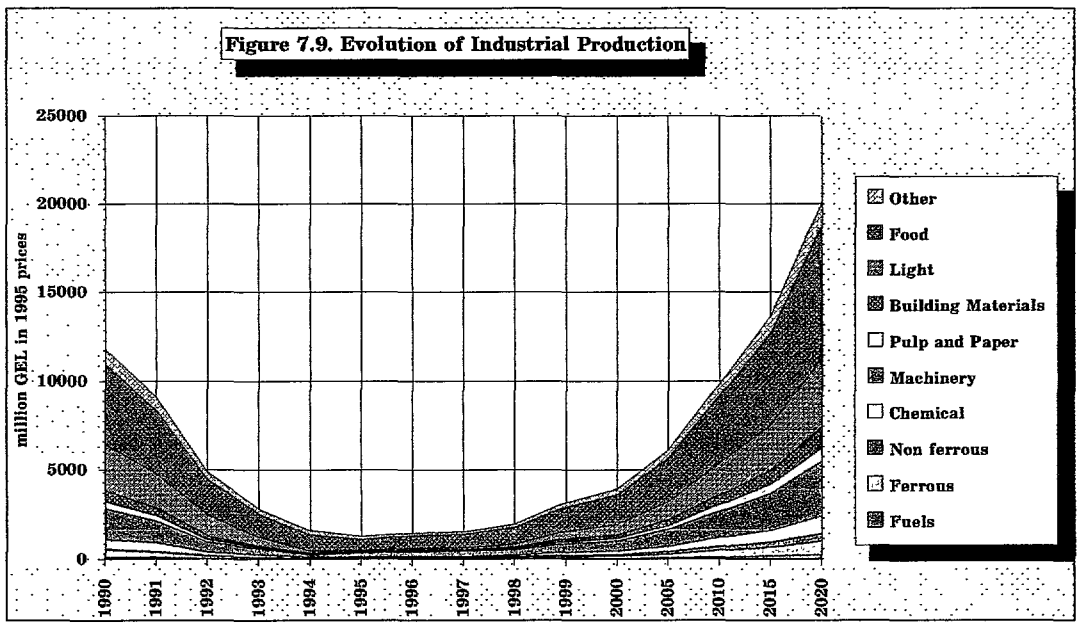
7.3. Strong Recovery - Strong Economic Growth (StR-StG) Scenario

7.3.1. Proportions of Economic Growth

Strong Recovery - Strong Economic Growth (SlR-SlG) scenario - proposes 10% per year GDP growth in 1998-2000 and 6.5% in 2001-2020. As a result, GDP in 2020 is doubled over the 1990 level and is about 5 times of the 1997 level. As in the case of slow growth scenario, construction, industry and other sectors are most dynamic components of GDP. The main contribution to the GDP growth is coming from industry, construction and agriculture. (See Fig. 7.8).



Within the industrial sector the largest contribution is provided by machinery, light, food, and building materials industries. (See Fig. 7.9).



7.3.2. Electricity Consumption in Industrial Sector

Economic growth is substantially driven by the industrial sector. The volume of industrial production in this scenario grows 12 fold in 1997-2020 and reaches in the year 2020 140% of the 1990 level. This growth brings industrial consumption up to 13,461 million kWh (see Fig. 7.3). Price impact reduces this number to 13,192 million kWh. Realization of EEMs pushes it further down to 11,702 million kWh (own use is not included). Therefore in the year 2020 industrial electricity consumption is 46% above the 1990 level. It crosses the 1990 line in 2012.

Evolution of industrial production, electricity consumption and intensity is presented at Fig. 7.10. Levels of electricity consumption by industries are shown in Table 7.8.

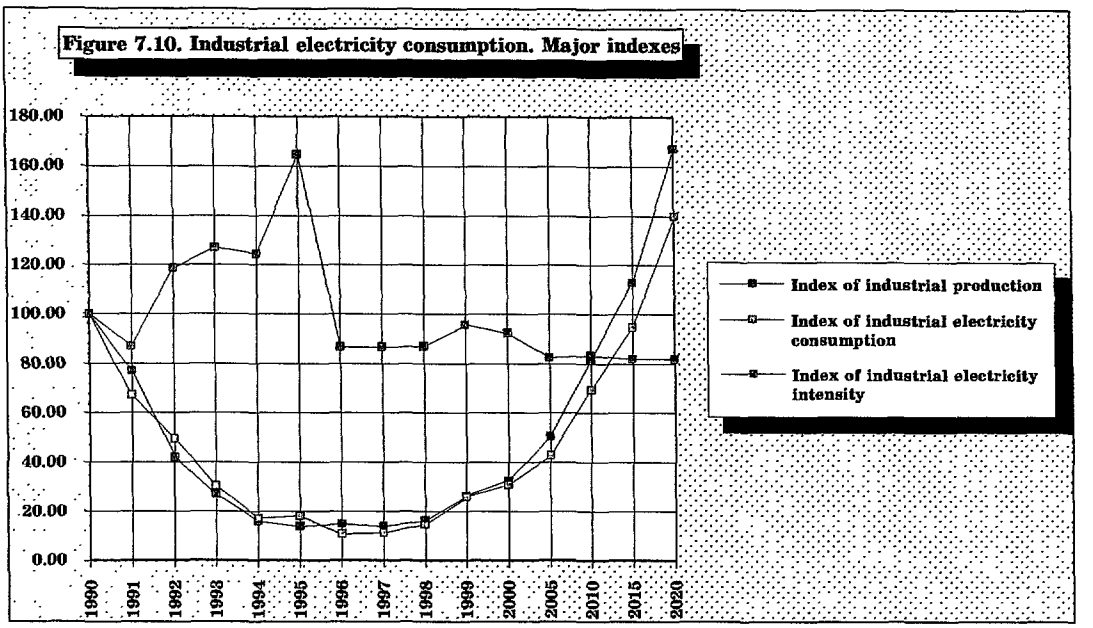


Table 7.8. Industrial energy consumption (STR-STG) scenario (10^6 kWh)

	1990	1996	1997	1998	1999	2000	2005	2010	2015	2020
Fuels	130	50	53	93	197	230	65	112	145	223
Ferrous	2715	280	295	397	797	960	1190	1941	2708	4065
Non ferrous	465	20	20	15	21	42	51	174	284	398
Chemical	1230	230	79	97	158	173	489	795	1036	1532
Machinery	830	20	180	195	282	324	433	685	931	1379
Pulp and Paper	140	60	63	82	141	166	60	99	128	191
Building Mat.	490	40	43	75	166	206	170	289	405	617
Light	280	20	21	35	78	104	68	120	166	250
Food	520	130	136	163	239	287	283	438	605	876
Other	1560	60	63	69	92	93	760	1155	1514	2170
Industry	**8360**	**910**	**953**	**1220**	**2170**	**2586**	**3570**	**5809**	**7921**	**11702**

Source: CENEf.

7.3.3. Electricity Consumption in Residential Sector

As in the case with industrial sector three major factors' impacts were evaluated in this sector. (See Table 7.9).

Population, living area and appliances saturation driven level is 3173 million kWh in the year 2020. Growth of prices does reduce this number to 3122 million kWh. Aggressive implementation of EEMs pushes this volume down to 2600 million kWh. Comparison of presented numbers with those for the SlR-SlG scenario shows that the difference is not substantial.

Table 7.9. Residential Electricity Consumption (million kWh)

	1990	1997	1998	1999	2000	2005	2010	2015	2020
Economic growth	2320	2593	2519	2600	2617	3193	3167	3170	3173
Price impact	2320	2593	2475	2545	2452	3123	3105	3102	3122
EEMs	2320	2593	2459	2511	2348	2906	2781	2677	2600

Economic growth - electricity consumption driven only by the factors of economic growth;
Price impact - above electricity consumption after taking into consideration the price impact.
EEMs - above electricity consumption after implementation of EEMs

Source: CENEf.

Practical stabilization of electricity consumption in residential sector in 1998-2020 is explained by the fact that electricity consumption for heating and hot water is substantially reduced on the background of growth of consumption in other applications. (See Fig. 7.5).

7.3.4. Electricity Consumption in all Sectors

If only economic growth will drive the electricity demand in Georgia it will reach 31,271 million kWh in 2020. That is 79% above the 1990 level. But price growth effect brakes this growth. As a result the demand about reaches 28,480 million kWh. Finally price and policy induced energy efficiency improvements stop this growth at level 26,170 million kWh, or 50% over the 1990 level. (See Table 7.10).

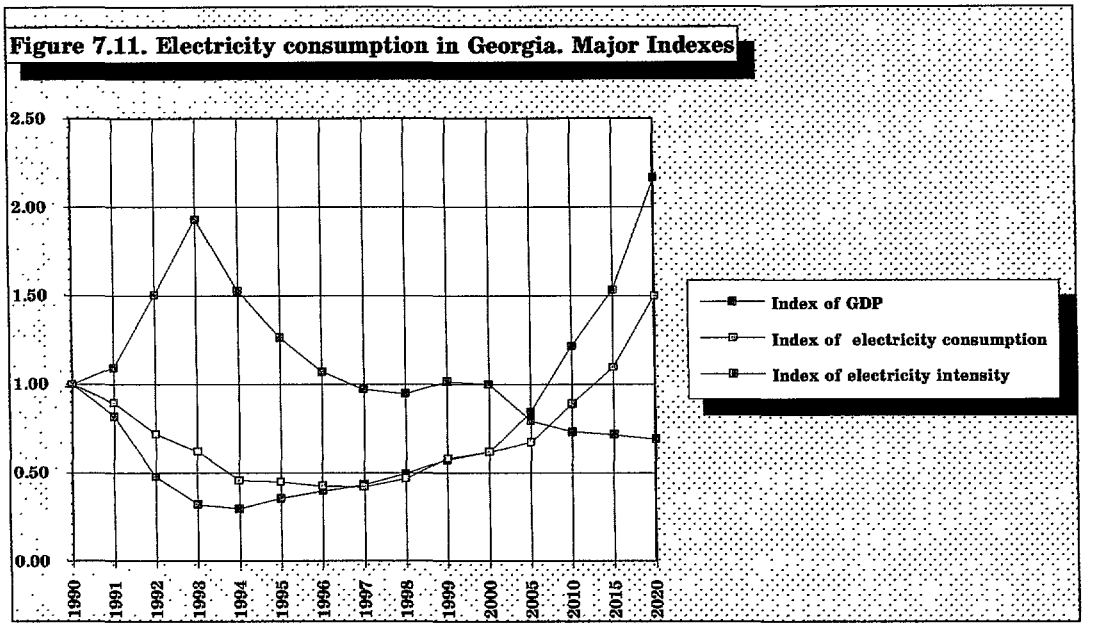
Table 7.10. Total Electricity Consumption (million kWh)

	1990	1997	1998	1999	2000	2005	2010	2015	2020
Economic growth	17450	7363	8462	10910	11931	13420	18296	22831	31271
Price impact	17450	7363	8275	10371	11197	12428	16631	20757	28480
EEMs	17450	7363	8206	10186	10820	11760	15551	19159	26170

Economic growth - electricity consumption driven only by the factors of economic growth;
Price impact - above electricity consumption after taking into consideration the price impact.
EEMs - above electricity consumption after implementation of EEMs

Source: CENEf.

After sharp growth in 1990-1993 and sharp decline in 1994-1997 electricity intensity of GDP is steadily coming down reaching in 2020 69% of the 1990 level. It happens on the background of GDP growth by about 125% above the 1990 level. As a result electricity consumption comes over 1990 level by about 50%. (See Fig. 7.11).



Electricity consumption by sectors is presented in Table 7.11. It is clear that growth of demand is mainly driven by the corresponding growth of the industrial and agricultural sectors.

Table 7.11. Projection of Electricity Consumption by Sectors (million kWh)

	1990	1997	1998	1999	2000	2005	2010	2015	2020
Industry	8054	953	1220	2170	2586	3570	5809	7921	11702
Construction	310	38	57	79	91	136	224	313	474
Agriculture	1460	14	21	23	23	781	1103	1396	1958
Transport and communication	1040	254	336	395	390	535	699	796	1173
Trade	288	64	129	138	135	181	227	261	342
Services	912	334	291	311	305	948	1042	1197	1569
Residential	2320	2593	2459	2511	2348	2906	2781	2677	2600
Other	3	1590	1650	2000	2192	425	662	887	1309
Own use	420	113	96	91	82	134	126	114	98
Losses	2643	1411	1946	2468	2667	2144	2877	3598	4946
Final use	14387	5839	6164	7627	8070	9482	12548	15447	21126
Total	**17450**	**7363**	**8206**	**10186**	**10820**	**11760**	**15551**	**19159**	**26170**

Source: CENEf.

7.3.5 Control of Results

Model GEB again was used to control projections results. To compare results of GEB run presented in Table 7.12 with data from Table 7.11 one should keep in mind that industry is presented with construction as one index, as well as residential sector, trade and services, and also own use and losses.

It should be noted that the GEB model confirms in large degree results obtained from the utilization of modeling complex. Although it gives 6% lower level of

electricity consumption in 2020. GEB gives lower levels of electricity consumption in industrial and agricultural sectors.

Table 7.12. Projection of Electricity Consumption by Sectors Using GEB Model (million kWh)

	Industry and construction	Agriculture	Transport	Residential and commercial	Final use	Own Use and losses	Total
2000	3151	310	836	3790	9062	2668	11730
2005	4495	386	935	3881	11046	3252	14299
2010	5833	531	1141	4012	13046	3841	16887
2015	7621	662	1404	4208	15639	4605	20243
2020	9863	898	1713	4504	18954	5581	24535

Source: CENEf.

GEB was used not only to control the level of electricity consumption, but also to estimate the volume and value of energy import and ability of Georgian economy to import enough energy to fuel fast rates of economic growth. Results of such an estimate are presented in Table 7.13. In 2020 the value of energy import will reach 1860 million US$, or about 14% of the proposed GDP. Georgian economy can afford such energy import only if export oriented industries will be promoted substantially. Otherwise it is not realistic for the country to have such strong sustainable economic growth without adequate export base for covering energy import.

If it is not realistic. then rates of economic growth will be lower as well as levels of electricity consumption.

Table 7.13. Projection of Energy Import for StR-StG scenario

	Coal	Oil	Gas	Total
Net energy import by fuels (10^3 toe)				
2000	88	2718	3357	6162
2010	136	3702	5372	9211
2020	202	5230	8774	14205
Import energy prices ($/toe)				
2000	137	183	99	928
2010	137	183	99	928
2020	137	183	99	928
Cost of energy import (million US$)				
2000	12	497	334	843
2010	19	678	534	1231
2020	28	957	873	1857

Source: CENEf.

7.4. Strong Recovery - Strong Growth with Orientation on Services Scenario

7.4.1. Proposed structure of Georgian GDP

Proportions of economic growth are as important as rates of economic growth. To estimate the sensitivity of the models results to this factor, the following proposal was made: all sectors of economy and of the industry will grow with the same rate as GDP. That is economic proportions registered in 1997 are extrapolated to 1998-2020.

Table 7.14. Sensitivity of Projection Results to Proportions of Economic Growth. Total Electricity Consumption (million kWh)

	2010		2020	
	basic	proportional	basic	proportional
Economic growth	18296	13516	31271	21842
Price impact	16631	11925	28480	18960
EEMs	15551	11219	26170	17627

Source: CENEf.

It is clear from the Table 7.14 that electricity consumption is very sensitive to suggestions on the characteristics of economic growth. If present proportions are extrapolated to the year 2020, then electricity demand will be 8,533 million kWh (33%) lower then in basic StR-StG scenario. It should be noted that there is about zero probability to have such proportional growth. Investment activities in 1997 were very limited. Without pushing up the rate of accumulation it is not possible to have long lasting high rated of economic growth. But the growth of gross fixed capital formation will lead to the growth of electricity intensive industries outputs.

Such analysis as well as discussion of initial results of this study at the Interim Workshop "Least Cost Model for Georgian Power System" held on June 1 and 2, 1998 in Tbilisi rose the issue of additional scenario development for strong economic growth accompanied by the creation of new GDP structure dominated by services, especially trade, restaurants, hotels, recreation, health care and other services.

To develop such a scenario the GDP structure of several countries was estimated (See Table 7.15). Cross-country analysis laid basis for a judgment of the desirable structure of Georgian GDP. It is clear that agricultural sector will contribute substantially to the Georgian GDP in years to come. Therefore, GDP structure of two countries - Greece and Turkey - can be used as a starting point for setting desirable GDP structure for the year 2020.

Table 7.15. Structure of GDP for Selected Countries (percent)

Sector	Georgia			Greece	Spain	Turkey	Portugal	Italy
	1990	1995	2020	1994	1993	1995	1993	1995
Agriculture	31.6	44.4	15.0	14.9	3.5	15.7	3.7	2.2
Industry	24.2	10.1	18.0	16.1	25.2	23.9	23.8	21.1
Electricity, gas, water	2.5	1.8	2.5	2.5	2.7	2.5	4.2	5.8
Construction	9.2	2.4	6.5	6.0	8.1	5.5	5.8	5.1
Trade, restaurants, hotels	7.0	27.7	18.0	12.8	22.3	20.5	18.7	18.8
Transport and communication	7.5	9.0	10.0	6.3	5.5	12.7	6.2	6.6
Finance, insurance	3.8	0.4	7.0	10.9	18.0	7.4	13.6	26.76
Community, social and personal services	9.5	2.3	15.0	17.5	5.3	3.7	7.7	
Government services	4.3	1.9	8.0	11.0	13.3	8.0	15.5	17.0

Sources:

Proposed structure of Georgian GDP in 2020 substantially differs from the one for the strong economic growth scenario. (See Table 7.16). Share of services (if trade is included) is 48% versus 20.5% for the strong economic growth scenario.

Table 7.16. Comparison of GDP Structure in 2020 for two scenarios (percent)

	StR-StG scenario	StR-StG-StC scenario
Industry	27,7	20,5
Construction	12,9	6,5
Agriculture	34,1	15
Transport and communication	4,7	10
Trade, restaurants, hotels	11,3	18
Services	5,2	30
Other	4,0	0

Source: CENEf.

The structural shift in favor of services sector will have electricity demand reduction impact only in case when electricity intensity of services is lower then in many other sectors. Comparison of such intensities presented in Table 5.7 show that in 1990 service sector was the second energy intensive after industry. It was about twelve time as intensive as trade sector. There two possible explanations for such high value of electricity intensity in service sector: low accuracy of data on electricity consumption and value added in services as well as low salaries of those who were working in this sector.

Intensity declined by about three times in 1990-1997 and in 1997 was much below intensities for industrial and transport sectors. If after cancellation of power limitation practice intensity in this sector come back to the 1990 level, then no substantial reduction of consumption comparing with the strong growth scenario is expected. The meaningful impact is possible only in case with conservation of electricity intensity at least at the level of 1997 with some reduction driven by the autonomus technological progress, price impact and implementation of EEMs.

GDP originated from the services sector in 1990-1997 was very stable on the background of overall economic decline. Moreover in 1997 it was 5% above 1990 level and 18% over 1993 level (See Table 3.4). In 1995-1997 both value added and electricity consumption in service sector were stable. Such situation gives some grounds to the proposal that the intensity in this sector will not return to the 1990 level and 1997 electricity intensity for this sector was used to run Strong Recovery - Strong Growth with Orientation on Services Scenario.

7.4.2. Electricity Consumption in all Sectors

Economic growth supplemented by intensive structural changes drives the electricity demand in Georgia to the level it reach 24,542 million kWh in 2020. Price growth reduces this number to 21,795 million kWh. Finally price and policy induced energy efficiency improvements stop this growth at the level 20,156 million kWh, or 16% over the 1990 level and 6 billion kWh lower than in strong economic growth scenario which reproduce the former structure of

economic growth. (See Table 7.17). The later number illustrate the real impact of proportions of economic growth on future electricity demand.

Table 7.17. Total Electricity Consumption (million kWh)

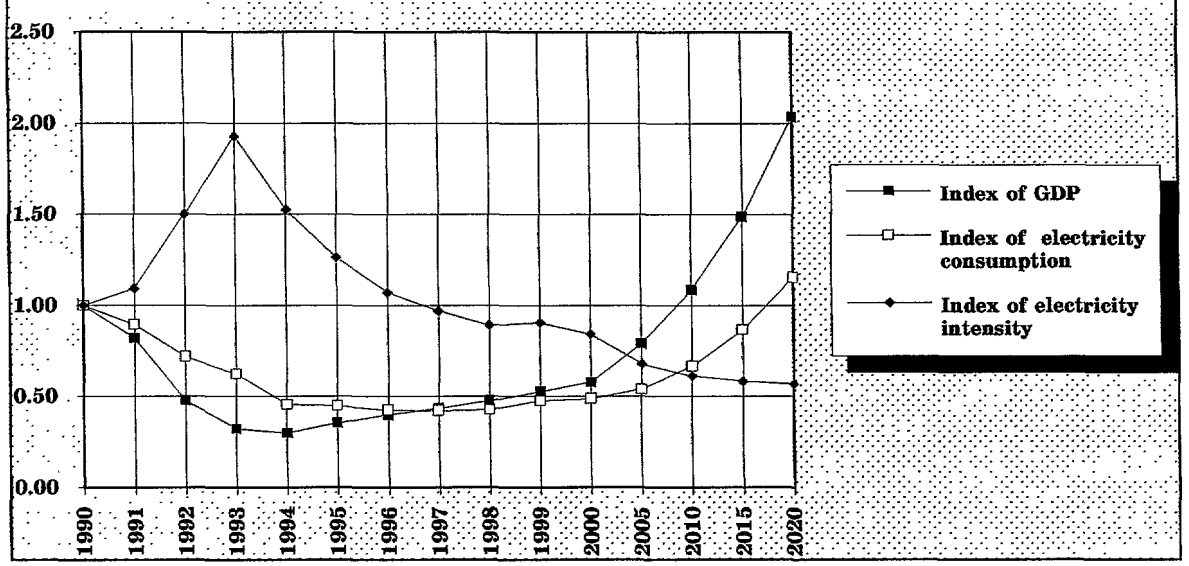
	1990	1997	1998	1999	2000	2005	2010	2015	2020
Economic growth	17450	7363	7614	8878	9404	10706	13826	18255	24542
Price impact	17450	7363	7432	8466	8807	9924	12442	16310	21795
EEMs	17450	7363	7444	8318	8511	9405	11636	15141	20156

Economic growth - electricity consumption driven only by the factors of economic growth;
Price impact - above electricity consumption after taking into consideration the price impact.
EEMs - above electricity consumption after implementation of EEMs

Source: CENEf.

Electricity intensity of GDP is coming down reaching in 2020 57% of the 1990 level. It happens on the background of GDP growth by about 125% above the 1990 level. As a result electricity consumption comes over 1990 level only by 16%. (See Fig. 7.12).

Figure 7.12. Electricity consumption in Georgia. Major Indexes



Electricity consumption by sectors for this scenario is presented in Table 7.18. Comparison of data presented in this table with those given in Table 7.11 shows that electricity consumption in the industrial, agricultural and construction sectors in 2020 is just half of the strong scenario level, while electricity consumption in services sector is about 90% over the strong scenario level.

Table 7.18. Projection of Electricity Consumption by Sectors (million kWh)

	1990	1997	1998	1999	2000	2005	2010	2015	2020
Industry	8054	953	1094	1477	1636	2136	3167	4591	6611
Construction	310	38	54	59	61	79	113	160	228
Agriculture	1460	14	20	21	22	641	728	790	798
Transport and communication	1040	254	325	350	362	657	978	1608	2568
Trade	288	64	149	164	173	246	308	382	468
Services	912	334	313	344	378	706	1089	1822	2949
Residential	2320	2593	2458	2513	2344	2930	2832	2762	2687
Other	3	1590	1173	1287	1356	164	141	80	-47
Own use	420	113	96	93	86	140	134	126	113
Losses	2643	1411	1762	2010	2093	1706	2146	2821	3779
Final use	14387	5839	5586	6214	6332	7559	9356	12194	16264
Total	**17450**	**7363**	**7444**	**8318**	**8511**	**9405**	**11636**	**15141**	**20156**

Source: CENEf.

7.5. Sensitivity Analysis

7.5.1 Crucial exogenous parameters

There are several crucial exogenous parameters which influence e the final result. Among them are:

- rates of economic growth;
- proportions of economic growth;
- prices for electricity;
- rates of major energy efficiency equipment penetration.

To be on the safe side with the projection the sensitivity of final result to the deviation of those parameters from the levels use in given scenario should be evaluated. Sensitivity of results to the proportions of economic growth was already tested in the previous section.

7.5.2. Rates of economic growth

The average rate of economic growth for 1998-2020 in SlR-SlG scenario is 4,9% while in StR-StG it is 7.3%. This additional 2.4% of annual economic growth brings substantial growth of electricity consumption. (See Table 7.14). The level of GDP in 2020 for StR-StG is 63% over SlR-SlG level, while electricity consumption in 59% over SlR-SlG level. Therefore demand elasticity coefficient is slightly below 1.

Table 7.19. Sensitivity of Projection Results to Rates of Economic Growth. Total Electricity Consumption (million kWh)

	1997	1998	1999	2000	2005	2010	2015	2020
SlR-SlG	7363	7956	9371	9502	9946	11911	13396	16488
StR-StG	7363	8206	10186	10820	11760	15551	19159	26170

Source: CENEf.

7.5.3. Prices for electricity

The sensitivity to this factor was already tested. For energy scenario price impact on electricity demand was evaluated. It vary from 1.8 billion kWh in the slow growth scenario to 2.8 billion kWh in the strong growth senario.

7.5.4. Rates of major energy efficiency equipment penetration

If only penetration rates for efficient motor systems for all sectors (excluding industry) grow up from 0.1 to 0.2, then electricity consumption decline by additional 640 million kWh (2%) will be observed.

8. Comparison of Electricity Demand Projections

8.1. Comparison with the WB projection

As was already mentioned the projection developed by CENEf is not the only recent electricity demand projection for Georgia. This section is devoted to the comparison of electricity demand projections. The diapason of CENEf's projection is presented in Table 8.1.

Table 8.1. CENEf's Projections of Total Electricity Consumption (million kWh)

	1997	1998	1999	2000	2005	2010	2015	2020
SlR-SlG	7363	7956	9371	9502	9946	11911	13396	16488
StR-StG-StC	7363	7444	8318	8511	9405	11636	15141	20156
StR-StG	7363	8206	10186	10820	11760	15551	19159	26170

Source: CENEf.

As was already noted, electricity demand is very sensitive to rates of economic growth. World Bank in its report states:

> Given the economic uncertainties, we examined two alternative scenarios. In the pessimistic scenario GDP grows at an average of 4 percent per annum, while in the optimistic one, it grows by 10 percent annually.

World bank results are present in Table 8.2. and Fig. 8.1. As one can see, once the supply shortages disappear after 1997, demand starts growing in tandem with economic expectations, even under the pessimistic scenario.

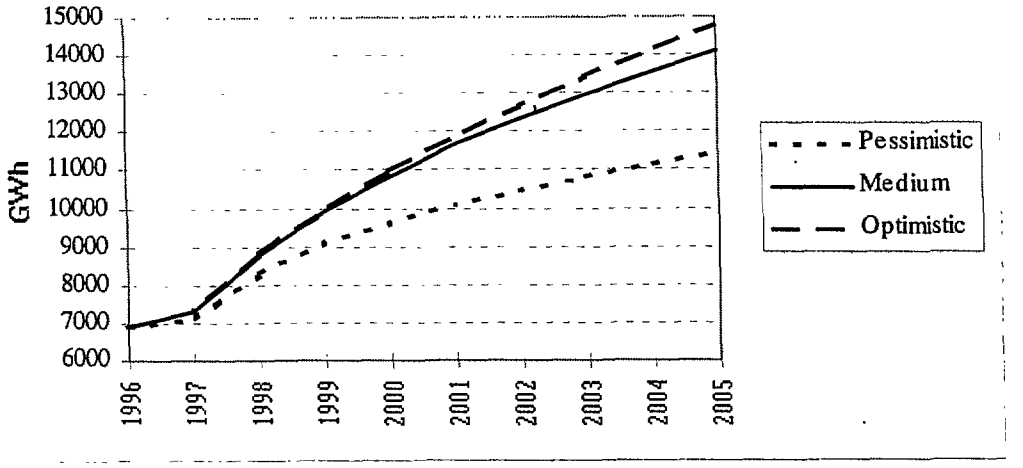
Rates of economic growth used by CENEf are higher then rates for low WB scenario, but CENEf's projection of electricity demand in the year 2005 is 15% lower. Therefore it is possible to state, that oversimplification of the WB model leads to overestimation of electricity demand.

Table 8.2. World Bank Projections of Total Electricity Consumption (million kWh)

Scenarios	1996	1997	1998	1999	2000	2005
Pessimistic	6900	7113	8283	9069	9631	11457
Medium	6900	7299	8782	9910	10832	14096
Optimistic	6900	7322	8824	9999	10987	14767

Source: Georgia Power Rehabilitation Project. Annex 3 - Electricity Demand and Supply Projections. Staff Appraisal Report. World Bank

Fig. 8.1. World Bank Electricity Demand Scenarios



8.2. Comparison with the other projections to the year 2005

Comparison with other projections (see Table 8.3) leads to the similar conclusion: they overestimate demand. Their low boundaries of projection diapasons are close to the high economic growth option of StR-StG scenario.

Table 8.3. Other Total Electricity Consumption projections to the year 2005 (million kWh)

Expert groups	1997	1998	1999	2000	2005
Sakenergo*)	10250	11500	12000	14000	18000
IBRD**): Scenario A	6330	6623	6931	7252	10878
Scenario B	6808	7389	8019	8702	15229
EU (TACIS)***): Baseline	8900	9755	10846	11689	16996
Modified	6262	6863	7631	8224	11957

*) Actual data up to 1995; projected values are presented from 1996, and only Scenario 1 is taken into account. Scenario 2 is infusible.

**) Actual data up to 1995; brutto-production was projected for 2000-2005. These data were used to estimate final consumption. Intermediate values were interpolated

***) Actual data up to 1994; demand was estimated up to 2000 only. Linear extrapolation was applied to estimate the demand for a period of 2001-2005. Modified scenario data for 2001-2005 were estimated with the same growth rates to 1995 as the baseline scenario.

8.3. Georgian Research Institute of Power Engineering (GRIPE) Projection

GRIPE places power use at level 22-24 billion kWh by 2010. (See Tables 8.4 and 8.5). This is much higher than in CENEf's projection for 2010: 12-15.5 billion kWh. In other words, those two authors are substantially overestimating the level of electricity consummation in 2010. They provide projections which are 55-85 % over the level of CENEf' projection.

Table 8.4. GRIPE Electricity Demand Projection, million kWh

Indicators	Years					
	2000		2005		2010	
	min	max	min	max	min	max
Indigenous Production, of which:	12200	13700	16700	18350	21400	23300
thermal power plants	5000	6000	6500	6700	7500	8000
hydropower plants	7000	7500	10000	11000	13000	14000
block-stations	200	200	200	250	300	300
wind	-	-	-	400	600	1000
Import	300	300	300	650	600	700
Demand, of which:	12500	14000	17000	19000	22000	24000
Industry	4550	5200	6870	8400	9000	10000
Construction	300	320	560	560	700	700
Transport	750	820	1300	1300	1900	2100
Agriculture	1300	1350	1570	1640	1800	2300
Residential/ Commercial sector	3300	3700	3800	4000	5000	5200
Own use and losses	2300	2600	2900	3100	3600	3700

Source: Energy, No.3, 1997

Table 8.5. GRIPE Industrial Electricity Demand Projection, million kWh

Indicators						
	2000		2005		2010	
	min	max	min	max	min	max
Industry - total, of which:	4550	5200	6870	8400	9000	10000
ferrous	2020	1550	1820	2300	2450	2750
non-ferrous						
chemical and petrochemical	760	850	1230	1500	1600	1700
machinery	550	600	780	950	1100	1200
building materials	280	300	630	780	800	900
light	160	180	240	250	280	320
fuel	180	190	270	300	340	380
food	400	460	550	680	730	800
wood, pulp and paper	220	250	300	340	380	450
other	730	820	1050	1300	1320	1500

Source: Energy, No.3, 1997

8.4. Sakenergo Projections

Projection of demand made by the Sakenergo does not describe assumption and provide details on the structure of demand. It just evaluate two demand items own use and losses and final consumption. (See Table 8.6).

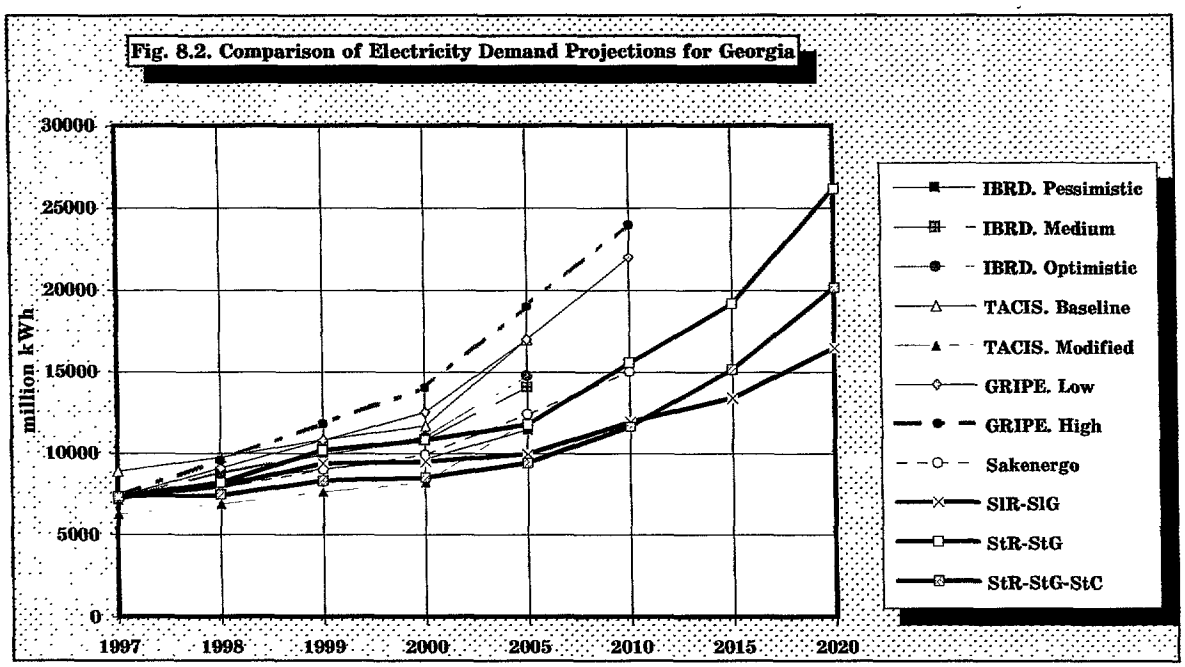
Table 8.6. Sakenergo Electricity Demand Projection, million kWh

	1998	2000	2005	2010
Own use and losses	1440	1500	1550	1500
Final consumption	6460	8400	10850	13500
Total	7900	9900	12400	15000

Source: Sakenergo.

Therefore the Sakenergo projection is much below GRIPE data and fall in the middle of CENEf's range of projections.

Comparison of all projections is shown at the Figure 8.2.



9. Projection of Load Patterns

The GEL Model was adopted for Georgia to make projections of electric loads and pick demands.

9.1. Types of Load Curves and Factors Affecting Them

For planning of power supply companies' future activities, load curves of two types are required - monthly maximum load and daily demand curves. Based on monthly maximum load curve one can determine an optimum structure of generating facilities and reserve margins with an account of requirements to their flexibility. Daily demand curves are used in a practice of a system operating as a basis for distribution of load among generating units.

Experience accumulated in the process of load planning shows that the most significant factors affecting both the level of electricity consumption and the shapes of load curves are:

- outdoor temperature and a continuation of daylight;
- type of a day - weekend, or weekday at the beginning or in the middle of a week, or a holiday, or a day before holiday (curtailed workday);
- season;
- schedule for putting into operation new facilities (under centralized planning it was usually at the end of the year);
- electricity consumption and load structures by sectors and by industries;
- frequency and voltage of electricity supplied.

Daily load pattern depends on the type of a day (Monday, Saturday of weekday, holiday or a day before holiday). This factor causes week cycle fluctuations of the consumption level.

Ignoring other significant factors, the evident tendency can be seen:

- maximum load corresponds to a weekday in a middle of a week;
- the load declines by a weekend to grow up again at a beginning of a new week.

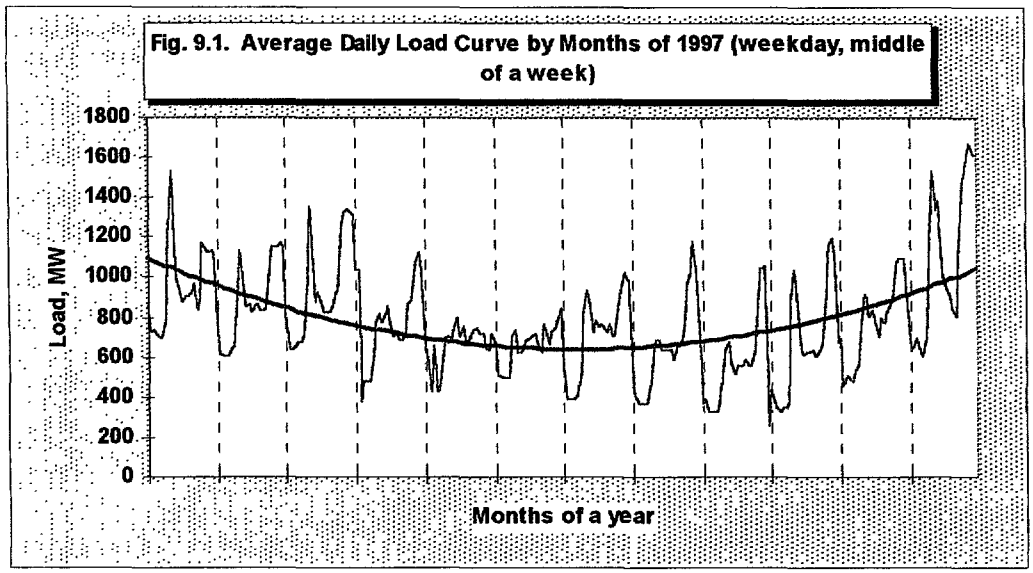
There are Similar fluctuations for holidays and days before holidays. To consider daily consumption fluctuations within a week one usually takes patterns of a weekday, a curtailed workday, Sunday and a holiday. For the purpose of short-term and long-term projections an average weekday is the most representative one. For such a day electricity consumption reaches the maximum level given all other terms equal.

Substantial changes of electricity consumption regimes result from fluctuations of outdoor temperature and of an intensity of daylight. Power supply company monitors these parameters separately and collects a relative statistics. However, separate accounting of these factors leads to groundlessly high requirements to

the quality of statistics for the long-term forecasting. For this reason both parameters are combined and input into the model as a season factor.

Fig. 9.1 presents data on an average weekday aggregated load in 1997 by months. Dotted lines mark ends of workdays. This figure also contains a curve corresponding to an average daily consumption which reflects an aggregated consumers' reaction to outdoor temperature and an intensity of a daylight as well as seasonal business-cycle of consumption. This graph obviously shows how these factors affect a load: average daily load varies 1.9-fold from 1095 MW in December to 566 MW in June-July.

Besides, a high morning peak in autumn-winter season can be observed. It reaches 91 percent of a maximum consumption. Anomalous high morning consumption was registered in January and March, but the shortage of corresponding data on outdoor temperature prevents from making a detailed analysis of this phenomenon.



To eliminate an influence of a temperature, daylight factor and seasonal factor the model performs in relative units - real consumption is related to an average daily one. Figure 9.2 presents relative load curves. Analysis of curves shows that graph's consistency (maximum load related to an average daily one) and unevenness (maximum load related to a minimum one) decline in summer and increase in winter, and real data display that rates of these alterations of maximum, average and minimum loads do not coincide.

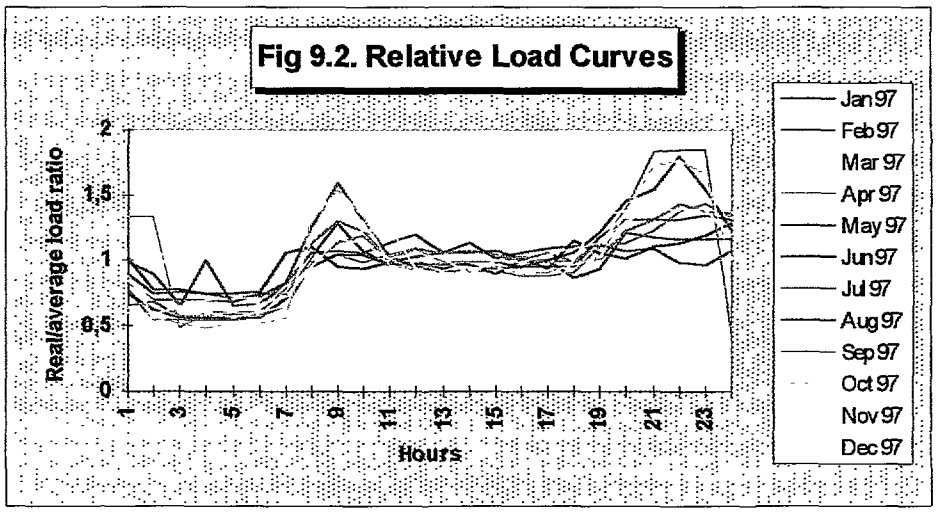
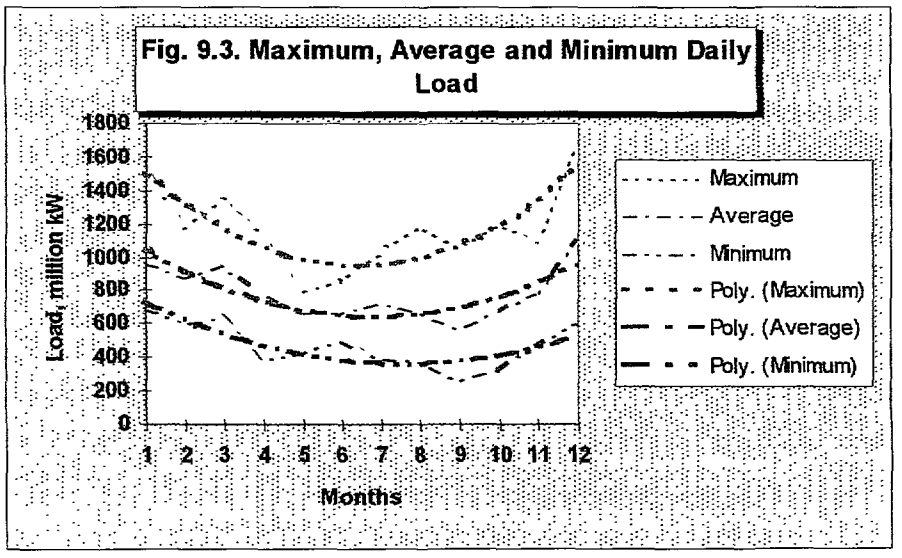


Fig. 9.3. displays curves of maximum, average and minimum daily loads together with their interpolation by 2-d order polynoms. Two upper curves present maximum daily load and the result of its interpolation, two middle curves present average load, and two lower curves show minimum load.



9.2. Procedure of Load Curve Modeling

The resulting load curve drawing with an account of all the factors mentioned above is performed by several steps.

The **first step** is building equations to estimate maximum, average and minimum loads by months. Those equations are listed below:

$$Nmax^i = 18,891*i^2 - 243,3*i + 1728,9 \quad (1)$$

$$Naver^i = 11,744*i^2 - 160,8*i + 1191,5 \quad (2)$$

$$Nmin^i = 8,5492*i^2 - 129,82*i + 850,84, \quad (3)$$

where

i - a serial number of a month.

These equations allow to estimate average annual values of maximum ($N^{aver}max$), average ($N^{aver}aver$) and minimum ($N^{aver}min$) levels of the system load:

$$N^{aver}max = \sum_{i=1}^{i=12} Nmax^i /12 \quad (4)$$

$$N^{aver}aver = \sum_{i=1}^{i=12} Naver^i /12 \quad (5)$$

$$N^{aver}min = \sum_{i=1}^{i=12} Nmin^i /12. \quad (6)$$

The **second step** is drawing a relative load curve. To do this, average daily consumption is calculated, and real values are adjusted by this factor:

$$Naver^i = \sum_{t=1}^{t=24} N_t^i / 24, \quad (7)$$

$$Nrel_t^i = N_t^i / Naver^i, \quad (8)$$

where N_t^i - real registered consumption, hour **t** of the month **i**;

$Naver^i$ - average daily load in a weekday of the month **i**;

$Nrel_t^i$ - relative load, hour **t** of the month **i**;

$t = 1,2,...,24$;

$i = 1,2,...,12$.

The **third step** is selecting the pattern of the system load from real load curves by consumers of Kubanenergo or USSR. This approach was suggested because of the shortage and low quality of statistical data received from Georgia. Using real data for Kubanenergo on December 15, 1993, the relative load curve patterns for construction, agriculture, transport and communications, trade, budgetary organizations, residential sector, other consumers, own use and technical losses were built. For industrial consumers, the USSR average load pattern was applied (see Table 9.1).

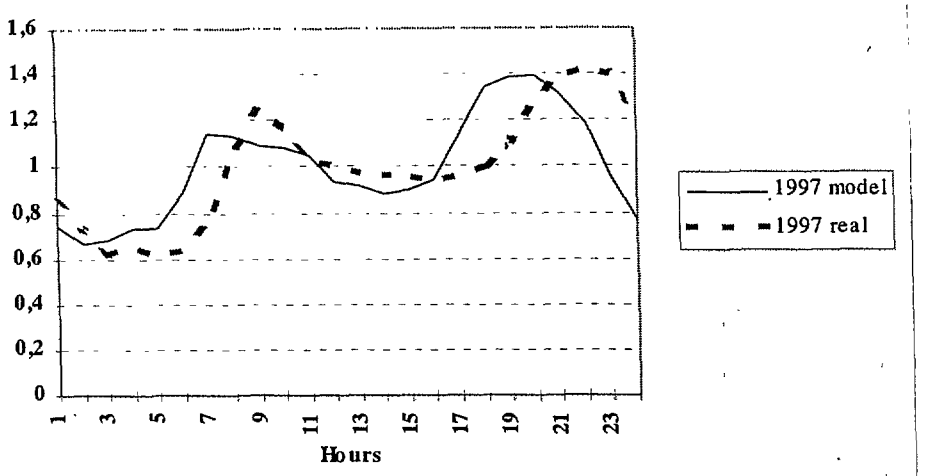
Table 9.1. Relative Consumption Pattern by Customers

	Hours											
	1	2	3	4	5	6	7	8	9	10	11	12
Industry	0,853	0,831	0,821	0,853	0,874	0,885	0,906	0,959	1,012	1,108	1,108	1,098
Construction	0,787	0,769	0,762	0,781	0,775	0,800	0,882	1,039	1,329	1,342	1,317	1,247
Agriculture	0,822	0,824	0,820	0,824	0,918	0,948	0,963	1,016	1,161	1,155	1,118	1,093
Transport and communication	0,822	0,906	0,844	0,754	0,907	0,962	1,090	1,115	1,116	1,052	0,901	0,981
Trade and commercial services	0,744	0,723	0,775	0,769	0,832	0,863	0,977	1,113	1,185	1,227	1,217	1,196
Municipal and public	0,768	0,662	0,733	0,744	0,610	0,867	1,539	1,167	0,976	0,975	0,992	0,693
Residential	0,615	0,492	0,492	0,615	0,689	0,886	0,985	1,231	1,182	1,132	1,058	0,985
Other	0,768	0,662	0,733	0,744	0,610	0,867	1,539	1,167	0,976	0,975	0,992	0,693
Own Use	0,908	0,908	0,908	0,908	0,908	0,908	0,908	0,908	1,058	1,058	1,058	1,058
Technical losses	0,838	0,832	0,831	0,832	0,851	0,921	1,075	1,068	1,101	1,095	1,069	1,014

	Hours											
	13	14	15	16	17	18	19	20	21	22	23	24
Industry	1,076	1,098	1,098	1,098	1,087	1,076	1,066	1,066	1,044	1,034	0,991	0,959
Construction	1,134	1,361	1,348	1,235	1,159	0,989	0,920	0,894	0,850	0,781	0,712	0,787
Agriculture	1,060	1,113	1,105	1,105	1,090	1,055	1,041	1,009	0,989	0,969	0,905	0,897
Transport and communication	0,917	0,946	0,995	0,993	1,052	1,172	1,101	1,102	1,072	1,167	1,044	0,990
Trade and commercial services	1,139	1,237	1,253	1,159	1,097	0,998	1,024	0,889	0,920	0,936	0,910	0,816
Municipal and public	0,743	0,564	0,436	0,542	1,117	1,724	1,858	1,826	1,654	1,271	0,931	0,607
Residential	0,935	0,935	1,083	1,132	1,231	1,280	1,329	1,378	1,329	1,280	0,985	0,738
Other	0,743	0,564	0,436	0,542	1,117	1,724	1,858	1,826	1,654	1,271	0,931	0,607
Own Use	1,058	1,058	1,058	1,058	1,058	1,031	1,031	1,031	1,031	1,031	1,031	1,031
Technical losses	1,003	1,012	0,985	0,993	1,078	1,170	1,169	1,150	1,094	1,028	0,937	0,854

In accordance with the level of consumption by consumer groups, the system relative load was calculated. Obviously, the real and model curves do not coincide (see Fig. 9.4.), deviations by minimum and maximum daily consumption account for 7% and 2%.

Fig. 9.4. Real and Model 1997 Load Curves



To simulate different scenarios of development the primary relative load pattern was compiled of consumers' load patterns proportionally to their share in the structure of electricity consumption.

The **fourth step** is further transformation of an average daily load curve in order to account seasonal fluctuations - changes in load consistency and unevenness. In the course of this transformation the average graph is extended along vertical axis as follows:

$$\text{Nrel mnth}_t^i = \begin{cases} \text{Nrel}_t^i * \text{Nmax}^i / \text{N}^{aver}\text{max} & \text{given } 0{,}2 <= (\text{Nrel}_t^i + -1) & (9) \\ \text{Nrel}_t^i * \text{Naver}^i / \text{N}^{aver}\text{aver} & \text{given } -0{,}2 <= (\text{Nrel}_t^i + -1) <= 0{,}2 & (10) \\ \text{Nrel}_t^i * \text{Nmin}^i / \text{N}^{aver}\text{min} & \text{given } (\text{Nrel}_t^i + -1) <= -0{,}2. & (11) \end{cases}$$

The transformation (9)-(11) means that if a deviation from an average value (i.e., 1) does not exceed 0.2, the current point of the graph belongs to the group of points changing in the same way as the average load changes. If the deviations exceed 0.2, the points vary correspondingly to the maximum of load. If the deviations are below -0.2, the points correspond to the minimum load variation. The transformation (9)-(11) reflects seasonal changes of the load curve.

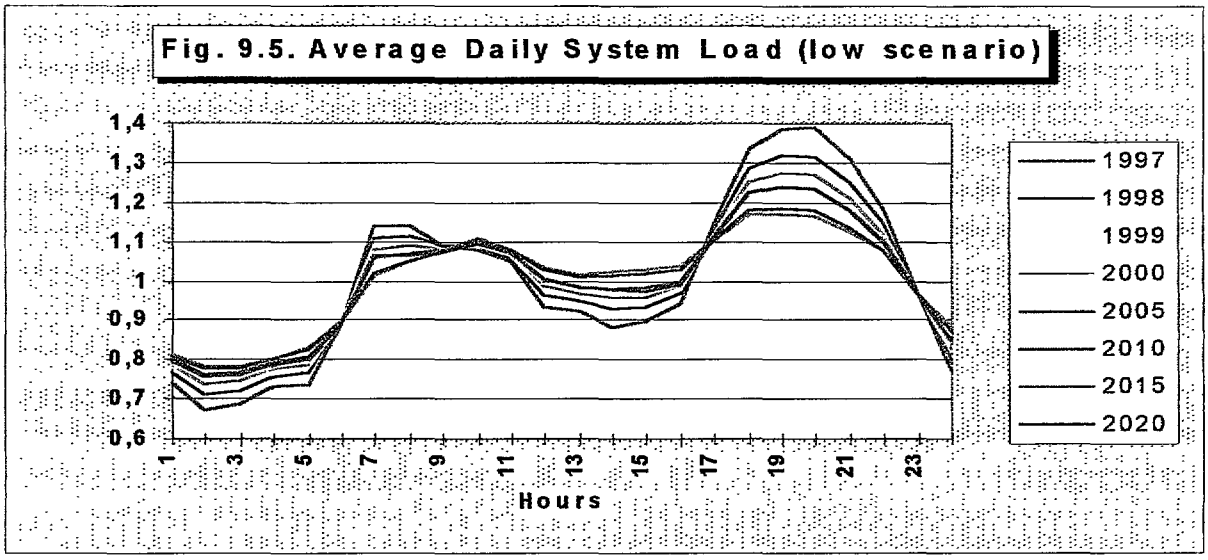
The **last step** is moving the relative load curve correspondingly to the level of electricity consumption. Electricity consumption in 1997 is assumed as 1. The related transformation is as following:

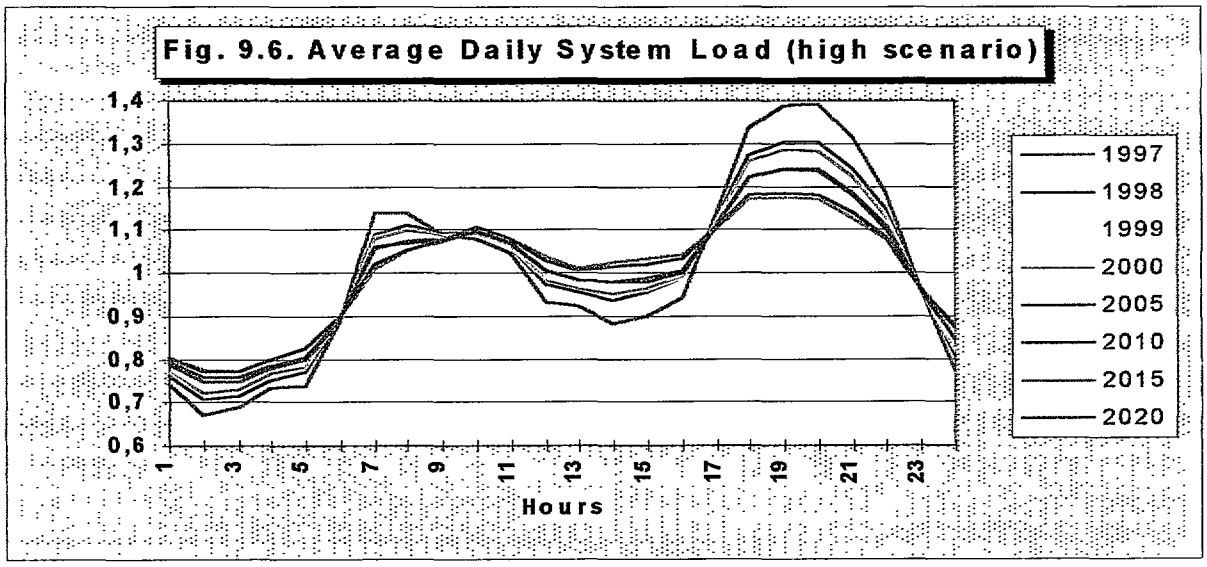
$$N_t^i = \text{Nrel mnth}_t^i * E_t' / E_{1997} \qquad (12)$$

9.3. Results

Consumption mix by users and levels of consumption were input from CENEf's GELGDP, ECONOMY and COMPARE models.

Based on these data the weather adjusted average daily load curves were built for both low and high scenarios (see Fig. 9.5 and 9.6). These are relative load curves, the average daily load is equal to 1.





Then for each year the annual load curves were constructed. These average daily system load curves served as a basis for average system daily load modeling by months. Results of the forecasting are presented at Tables 9.2 and 9.3.

Table 9.2. Load forecast - low scenario (million kW)

	1997		low																					
	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24
January	902	814	833	890	894	928	1187	1185	1133	1125	1091	973	960	919	935	982	1191	1344	1393	1397	1319	1234	1004	934
February	773	698	714	763	767	816	1044	1042	997	989	960	856	844	808	822	863	1048	1177	1220	1223	1156	1085	883	801
March	666	601	614	657	660	725	927	926	886	879	853	760	750	718	731	614	931	1044	1082	1085	1025	964	784	689
April	579	522	535	572	574	655	838	837	800	794	771	687	678	649	660	693	841	945	979	982	928	871	709	600
May	514	463	474	507	509	606	775	774	740	735	713	636	627	600	611	641	778	880	911	914	863	806	656	532
June	469	424	433	463	465	578	739	738	706	701	680	606	598	572	582	612	742	848	879	881	832	769	625	486
July	446	403	412	441	443	571	730	729	697	692	671	598	590	565	575	604	733	850	881	883	834	759	617	462
August	444	401	410	439	441	585	748	746	714	709	687	613	605	579	589	618	750	886	918	920	869	777	632	460
September	464	418	428	458	460	619	792	791	756	750	728	649	640	613	624	655	795	955	990	993	938	823	670	480
October	504	455	465	497	500	675	863	861	824	818	793	707	698	668	680	714	866	1059	1097	1100	1039	897	730	522
November	565	510	522	558	561	751	960	959	917	910	883	787	777	744	757	795	964	1196	1239	1242	1174	999	812	586
December	648	585	598	640	642	848	1085	1083	1036	1028	998	889	877	840	855	898	1089	1367	1416	1420	1341	1128	918	671
	1998		low																					
	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24
January	1068	990	1004	1054	1072	1073	1326	1333	1304	1303	1264	1154	1135	1108	1120	1160	1352	1484	1523	1521	1444	1374	1152	960
February	915	849	861	904	919	943	1166	1173	1147	1146	1112	1015	998	975	985	1020	1189	1300	1334	1333	1265	1208	1013	844
March	788	731	741	778	791	838	1036	1042	1019	1018	988	902	887	866	875	741	1057	1153	1183	1182	1122	1074	900	750
April	685	636	644	677	688	758	936	942	921	920	893	815	802	783	791	819	955	1044	1071	1070	1015	970	813	678
May	608	564	572	601	610	701	866	871	852	851	826	754	742	724	732	758	883	972	997	996	945	898	752	627
June	556	515	522	549	558	668	826	831	812	812	788	719	707	690	698	723	842	936	961	960	911	856	717	598
July	528	490	497	522	530	660	816	820	802	801	778	710	698	682	689	713	832	939	963	962	913	845	708	590
August	526	488	495	520	528	676	835	840	822	821	797	727	715	698	706	731	852	978	1004	1003	952	865	725	605
September	549	509	516	542	551	716	885	890	870	869	844	770	757	739	747	774	902	1055	1082	1081	1026	917	768	640
October	596	553	561	589	599	780	964	969	948	947	919	839	825	806	814	843	983	1169	1199	1198	1137	999	837	698
November	669	621	629	661	672	868	1073	1079	1055	1054	1023	934	919	897	906	939	1094	1321	1355	1353	1285	1112	932	777
December	767	711	721	757	770	981	1212	1219	1192	1191	1156	1055	1038	1013	1024	1060	1236	1509	1548	1547	1468	1256	1053	877

Table 9.2. continued

	1999		low																				
	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24
January	1273	1195	1207	1259	1278	1253	1523	1530	1513	1527	1488	1372	1349	1327	1332	1371	1568	1700	1736	1732	1647	1577	1346	1149
February	1091	1024	1034	1079	1096	1102	1340	1346	1331	1343	1309	1206	1187	1167	1171	1205	1379	1489	1521	1517	1443	1387	1184	1011
March	939	882	890	929	943	979	1191	1196	1183	1193	1163	1072	1055	1037	1041	890	1226	1321	1349	1346	1280	1232	1052	898
April	817	767	775	808	821	885	1076	1081	1068	1078	1051	969	953	937	941	968	1108	1196	1221	1218	1158	1113	951	811
May	725	680	687	717	728	819	995	1000	988	997	972	896	882	867	870	895	1025	1113	1136	1133	1078	1030	879	751
June	663	622	628	655	665	781	949	953	943	951	927	855	841	826	830	854	977	1073	1095	1093	1039	982	839	716
July	630	591	597	623	632	771	937	941	931	939	915	844	830	816	819	843	965	1075	1098	1095	1042	970	828	707
August	627	589	595	620	630	789	960	964	953	962	937	864	850	836	839	863	988	1121	1144	1141	1086	993	848	724
September	654	614	620	647	657	836	1017	1021	1009	1019	993	915	900	885	889	914	1046	1209	1234	1231	1171	1052	898	767
October	711	667	674	703	714	911	1108	1112	1100	1110	1082	997	981	964	968	996	1140	1339	1367	1364	1298	1146	979	835
November	798	749	756	789	801	1014	1233	1238	1225	1236	1204	1110	1092	1074	1078	1109	1269	1513	1544	1541	1466	1276	1089	930
December	915	858	867	904	918	1146	1393	1399	1383	1396	1360	1254	1233	1213	1218	1253	1434	1729	1765	1761	1675	1441	1231	1050
	2000		low																					
	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24
January	1286	1209	1220	1272	1292	1259	1518	1529	1518	1537	1501	1388	1365	1346	1351	1387	1575	1696	1729	1724	1642	1576	1353	1163
February	1102	1037	1046	1091	1108	1107	1335	1345	1336	1352	1320	1221	1201	1184	1188	1220	1385	1485	1514	1511	1439	1386	1190	1023
March	949	892	900	939	953	984	1187	1195	1187	1202	1173	1085	1067	1052	1056	900	1231	1318	1343	1340	1276	1232	1058	909
April	825	776	783	817	829	889	1072	1080	1072	1086	1060	981	964	951	954	980	1112	1192	1216	1213	1155	1113	956	822
May	732	689	695	725	736	822	992	999	992	1004	980	907	892	880	883	906	1029	1110	1131	1129	1075	1030	884	760
June	669	629	635	662	672	784	946	953	946	958	935	865	851	839	842	864	981	1070	1091	1088	1036	982	843	725
July	636	598	604	630	639	774	934	941	934	946	923	854	840	828	831	853	969	1072	1093	1091	1039	969	832	716
August	633	596	601	627	637	793	957	963	957	968	945	875	860	848	851	874	992	1118	1139	1136	1082	993	852	733
September	661	621	627	654	664	840	1013	1020	1013	1026	1001	926	911	898	901	926	1051	1205	1229	1226	1167	1051	903	776
October	718	675	682	711	722	915	1104	1112	1104	1118	1091	1009	992	979	982	1009	1145	1336	1362	1358	1293	1146	984	846
November	806	758	765	798	810	1019	1229	1238	1229	1244	1214	1124	1105	1090	1093	1123	1274	1509	1538	1534	1461	1275	1095	942
December	924	869	876	914	928	1151	1388	1398	1388	1405	1372	1269	1248	1231	1235	1268	1440	1724	1758	1753	1670	1441	1237	1064

Table 9.2. continued

	2005		low																					
	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24
January	1711	1627	1635	1693	1485	1654	1958	1978	1991	2029	1981	1855	1819	1810	1813	1849	2057	2181	2211	2201	2181	2039	1778	1564
February	1467	1395	1402	1451	1306	1455	1722	1740	1751	1785	1743	1632	1600	1592	1594	1626	1809	1910	1937	1928	1919	1793	1564	1376
March	1262	1201	1207	1249	1161	1293	1530	1546	1556	1586	1549	1450	1422	1415	1417	1207	1608	1694	1718	1710	1705	1594	1390	1223
April	1098	1045	1050	1087	1049	1168	1383	1397	1406	1433	1399	1310	1285	1278	1280	1306	1453	1533	1555	1548	1540	1440	1256	1105
May	974	927	931	964	970	1081	1279	1292	1301	1326	1295	1212	1188	1183	1184	1208	1344	1427	1447	1441	1425	1332	1162	1022
June	890	847	851	881	925	1031	1220	1232	1240	1264	1234	1156	1133	1128	1129	1152	1282	1376	1395	1389	1359	1270	1108	975
July	847	805	809	838	914	1018	1205	1217	1225	1248	1219	1141	1119	1114	1115	1138	1266	1379	1398	1392	1342	1255	1094	962
August	843	802	806	834	935	1042	1233	1246	1254	1278	1248	1169	1146	1140	1142	1165	1296	1437	1457	1451	1374	1285	1120	985
September	879	836	840	870	991	1104	1306	1320	1328	1354	1322	1238	1214	1208	1210	1234	1372	1550	1572	1564	1455	1361	1187	1044
October	956	909	913	945	1080	1203	1423	1438	1447	1475	1440	1349	1323	1316	1318	1344	1495	1718	1741	1734	1586	1482	1293	1137
November	1072	1020	1025	1061	1202	1339	1585	1601	1611	1642	1604	1501	1472	1465	1467	1496	1665	1940	1967	1958	1765	1650	1439	1266
December	1229	1169	1175	1216	1358	1512	1790	1808	1820	1855	1811	1696	1663	1655	1657	1690	1881	2217	2248	2238	1994	1864	1626	1430
	2010		low																					
	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24
January	2056	1961	1972	2033	1778	1976	2348	2353	2369	2420	2366	2213	2173	2159	2152	2194	2449	2607	2643	2627	2602	2427	2122	1872
February	1763	1681	1690	1743	1564	1738	2065	2069	2083	2128	2081	1946	1911	1899	1893	1930	2154	2284	2315	2302	2289	2134	1867	1647
March	1517	1447	1455	1500	1390	1544	1835	1839	1851	1891	1849	1730	1698	1688	1682	1455	1914	2026	2053	2042	2034	1897	1659	1463
April	1320	1259	1266	1305	1256	1395	1658	1662	1673	1709	1671	1563	1534	1525	1520	1550	1730	1833	1858	1848	1838	1714	1499	1322
May	1171	1117	1123	1158	1162	1291	1534	1537	1548	1581	1546	1446	1419	1411	1406	1434	1600	1706	1730	1720	1700	1586	1387	1223
June	1070	1021	1026	1058	1108	1231	1463	1466	1476	1508	1474	1379	1354	1345	1341	1367	1526	1645	1667	1658	1621	1512	1322	1167
July	1017	970	976	1006	1094	1216	1445	1447	1457	1489	1456	1361	1337	1328	1324	1350	1507	1649	1671	1662	1601	1493	1306	1152
August	1013	966	971	1002	1120	1245	1479	1482	1492	1524	1491	1394	1369	1360	1356	1382	1543	1718	1742	1732	1639	1529	1337	1180
September	1057	1008	1013	1045	1187	1318	1567	1570	1581	1615	1579	1476	1450	1441	1436	1464	1634	1853	1878	1868	1736	1619	1416	1249
October	1149	1096	1101	1136	1293	1436	1707	1711	1722	1759	1720	1609	1580	1570	1564	1595	1781	2053	2082	2070	1892	1764	1543	1361
November	1289	1229	1236	1274	1439	1599	1901	1904	1917	1958	1915	1791	1758	1748	1742	1776	1982	2319	2351	2337	2106	1964	1718	1515
December	1477	1409	1416	1461	1626	1806	2147	2151	2166	2212	2163	2023	1986	1974	1967	2006	2239	2651	2687	2671	2379	2219	1940	1712

Table 9.2. continued

	2015		low																					
	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24
January	2042	2302	2290	2021	2097	2266	2556	2642	2719	2793	2723	2613	2551	2581	2595	2619	2786	2948	2954	2941	2833	2715	2435	2221
February	1796	1973	1963	1778	1844	1993	2248	2324	2391	2456	2395	2298	2243	2270	2282	2304	2451	2593	2598	2587	2492	2388	2142	1953
March	1596	1698	1690	1580	1639	1771	1998	2065	2125	2183	2128	2043	1994	2017	2028	1690	2178	2304	2309	2299	2214	2122	1903	1736
April	1442	1478	1470	1427	1481	1600	1805	1866	1920	1972	1923	1846	1801	1823	1832	1850	1968	2082	2086	2077	2001	1918	1720	1568
May	1334	1311	1304	1321	1370	1481	1670	1726	1776	1825	1779	1707	1667	1686	1695	1711	1821	1926	1930	1922	1851	1774	1591	1451
June	1272	1198	1192	1259	1306	1412	1593	1646	1694	1740	1696	1628	1589	1608	1617	1632	1736	1837	1840	1832	1765	1692	1517	1383
July	1256	1139	1133	1244	1290	1394	1573	1625	1673	1718	1675	1608	1569	1588	1596	1611	1714	1814	1817	1809	1743	1671	1498	1366
August	1286	1134	1128	1273	1321	1428	1610	1664	1713	1759	1715	1646	1607	1626	1635	1650	1755	1857	1861	1853	1785	1711	1534	1399
September	1363	1183	1177	1349	1399	1512	1706	1763	1814	1863	1817	1744	1702	1722	1731	1748	1859	1967	1971	1962	1890	1812	1625	1482
October	1485	1286	1279	1470	1525	1648	1859	1921	1977	2030	1980	1900	1854	1876	1886	1904	2026	2143	2148	2138	2060	1974	1770	1614
November	1653	1443	1435	1636	1697	1834	2069	2138	2200	2260	2204	2115	2064	2089	2100	2120	2255	2386	2391	2380	2293	2198	1971	1797
December	1867	1653	1645	1848	1917	2072	2337	2415	2485	2553	2489	2389	2332	2360	2372	2395	2547	2695	2701	2689	2590	2482	2226	2030
	2020		low																					
	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24
January	1996	2240	2236	1979	2045	2218	2519	2586	2650	2726	2666	2544	2490	2506	2513	2545	2728	2906	2923	2908	2799	2665	2383	2160
February	1756	1920	1917	1741	1798	1951	2215	2275	2331	2397	2344	2237	2190	2204	2210	2238	2400	2556	2571	2558	2462	2344	2096	1900
March	1560	1653	1650	1547	1598	1734	1969	2021	2071	2130	2083	1988	1946	1959	1964	1650	2133	2272	2285	2273	2188	2083	1863	1688
April	1410	1438	1435	1398	1444	1567	1779	1826	1872	1925	1882	1796	1758	1770	1775	1797	1927	2053	2064	2054	1977	1882	1683	1525
May	1304	1276	1273	1293	1336	1449	1646	1690	1732	1781	1742	1662	1627	1637	1642	1663	1783	1899	1910	1900	1829	1741	1557	1411
June	1244	1166	1164	1233	1274	1382	1569	1611	1651	1698	1661	1585	1551	1561	1566	1585	1700	1811	1821	1812	1744	1661	1485	1346
July	1228	1108	1106	1218	1258	1365	1550	1591	1631	1677	1640	1565	1532	1542	1546	1566	1679	1788	1799	1789	1722	1640	1466	1329
August	1258	1103	1102	1247	1288	1397	1587	1629	1670	1717	1679	1602	1569	1579	1583	1603	1719	1831	1842	1832	1763	1679	1501	1361
September	1332	1151	1149	1321	1364	1480	1681	1726	1768	1819	1779	1697	1661	1672	1677	1698	1820	1939	1951	1941	1867	1778	1590	1441
October	1451	1251	1249	1439	1487	1613	1831	1880	1927	1982	1938	1849	1810	1822	1827	1850	1984	2113	2125	2114	2035	1938	1733	1570
November	1616	1404	1402	1602	1655	1795	2039	2093	2145	2206	2157	2059	2015	2028	2034	2060	2208	2352	2366	2354	2265	2157	1929	1748
December	1825	1609	1606	1810	1869	2028	2303	2364	2423	2492	2437	2325	2276	2291	2297	2326	2494	2657	2673	2659	2559	2437	2179	1975

Table 9.3. Load forecast - high scenario (million kW)

	1997		high																					
	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24
January	902	814	833	890	894	928	1187	1185	1133	1125	1091	973	960	919	935	982	1191	1344	1393	1397	1319	1234	1004	934
February	773	698	714	763	767	816	1044	1042	997	989	960	856	844	808	822	863	1048	1177	1220	1223	1156	1085	883	801
March	666	601	614	657	660	725	927	926	886	879	853	760	750	718	731	614	931	1044	1082	1085	1025	964	784	689
April	579	522	535	572	574	655	838	837	800	794	771	687	678	649	660	693	841	945	979	982	928	871	709	600
May	514	463	474	507	509	606	775	774	740	735	713	636	627	600	611	641	778	880	911	914	863	806	656	532
June	469	424	433	463	465	578	739	738	706	701	680	606	598	572	582	612	742	848	879	881	832	769	625	486
July	446	403	412	441	443	571	730	729	697	692	671	598	590	565	575	604	733	850	881	883	834	759	617	462
August	444	401	410	439	441	585	748	746	714	709	687	613	605	579	589	618	750	886	918	920	869	777	632	460
September	464	418	428	458	460	619	792	791	756	750	728	649	640	613	624	655	795	955	990	993	938	823	670	480
October	504	455	465	497	500	675	863	861	824	818	793	707	698	668	680	714	866	1059	1097	1100	1039	897	730	522
November	565	510	522	558	561	751	960	959	917	910	883	787	777	744	757	795	964	1196	1239	1242	1174	999	812	586
December	648	585	598	640	642	848	1085	1083	1036	1028	998	889	877	840	855	898	1089	1367	1416	1420	1341	1128	918	671
	1998		high																					
	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24
January	1167	1083	1098	1153	1172	1173	1450	1458	1426	1424	1382	1262	1241	1212	1225	1268	1478	1623	1665	1663	1579	1502	1259	1049
February	1001	928	941	988	1005	1032	1275	1282	1254	1253	1216	1110	1092	1066	1077	1115	1300	1422	1459	1457	1383	1321	1107	923
March	861	799	810	851	865	917	1133	1140	1114	1113	1081	986	970	947	957	810	1155	1261	1294	1292	1227	1174	984	820
April	749	695	705	740	752	828	1024	1030	1007	1006	976	891	877	856	865	895	1044	1141	1171	1170	1110	1061	889	741
May	665	617	625	657	667	766	947	953	932	931	903	825	811	792	800	828	966	1062	1090	1089	1033	981	823	686
June	607	563	571	600	610	731	903	908	888	887	861	786	773	755	763	790	921	1024	1050	1049	996	936	784	654
July	578	536	543	571	580	722	892	897	877	876	851	776	764	745	753	780	909	1026	1053	1052	999	924	775	646
August	575	533	541	568	577	739	913	919	898	897	871	795	782	763	771	799	931	1070	1097	1096	1041	946	793	661
September	600	556	564	593	602	783	967	973	951	950	922	842	828	808	817	846	986	1154	1184	1182	1122	1002	840	700
October	652	605	613	644	655	853	1054	1060	1037	1036	1005	918	902	881	890	922	1075	1278	1311	1310	1244	1092	915	763
November	732	679	688	723	735	949	1173	1180	1154	1153	1119	1021	1005	981	991	1026	1196	1444	1481	1480	1405	1216	1019	849
December	838	778	788	828	842	1072	1325	1333	1304	1302	1264	1154	1135	1108	1120	1159	1351	1650	1693	1691	1605	1373	1151	959

Table 9.3. continued

	1999		high																					
	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24
January	1522	1428	1443	1505	1528	1498	1821	1829	1808	1825	1778	1640	1613	1586	1592	1638	1875	2033	2075	2070	1969	1885	1609	1373
February	1305	1224	1237	1290	1310	1317	1602	1609	1591	1605	1564	1442	1418	1395	1400	1441	1649	1780	1818	1813	1725	1658	1415	1208
March	1123	1054	1064	1110	1127	1171	1423	1430	1414	1426	1390	1282	1261	1239	1244	1064	1465	1579	1612	1608	1530	1473	1258	1074
April	977	917	926	966	981	1058	1286	1292	1277	1289	1256	1158	1139	1120	1124	1157	1324	1429	1459	1456	1385	1331	1136	970
May	867	813	821	857	870	979	1190	1195	1182	1192	1162	1071	1054	1036	1040	1070	1225	1330	1358	1355	1289	1231	1051	897
June	792	743	751	783	795	933	1135	1140	1127	1137	1108	1022	1005	988	992	1021	1168	1282	1309	1306	1242	1174	1002	856
July	753	707	714	745	756	921	1120	1125	1113	1123	1094	1009	992	976	979	1008	1153	1285	1312	1309	1245	1159	990	845
August	750	704	711	741	753	944	1147	1152	1139	1150	1120	1033	1016	999	1003	1032	1181	1340	1368	1364	1298	1187	1014	865
September	782	734	741	773	785	999	1215	1220	1207	1218	1187	1094	1076	1058	1062	1093	1251	1445	1475	1471	1400	1257	1074	916
October	850	798	806	841	853	1089	1324	1330	1315	1327	1293	1192	1173	1153	1157	1191	1363	1601	1634	1630	1551	1370	1170	999
November	954	895	904	943	958	1212	1474	1480	1464	1477	1439	1327	1305	1283	1289	1326	1517	1808	1846	1841	1752	1525	1302	1112
December	1093	1026	1036	1081	1098	1369	1665	1672	1653	1668	1626	1499	1474	1450	1455	1498	1714	2066	2110	2105	2002	1723	1471	1256
	2000		high																					
	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24
January	1609	1513	1527	1592	1617	1575	1900	1914	1900	1924	1878	1738	1708	1685	1691	1736	1971	2122	2163	2158	2055	1972	1693	1456
February	1379	1297	1309	1365	1386	1386	1671	1683	1671	1692	1652	1528	1503	1482	1487	1527	1733	1859	1895	1890	1800	1734	1489	1281
March	1187	1117	1127	1175	1193	1231	1485	1496	1485	1504	1468	1358	1335	1317	1321	1127	1540	1649	1681	1677	1597	1541	1324	1138
April	1033	971	980	1022	1038	1113	1342	1352	1342	1359	1326	1227	1207	1190	1194	1226	1392	1492	1521	1518	1445	1393	1196	1028
May	916	862	869	907	921	1029	1242	1251	1242	1257	1227	1135	1116	1101	1105	1134	1287	1389	1416	1412	1345	1288	1106	951
June	837	788	795	829	842	981	1184	1192	1184	1199	1170	1083	1064	1050	1053	1082	1228	1339	1365	1362	1297	1229	1055	907
July	796	749	755	788	800	969	1169	1178	1169	1184	1155	1069	1051	1037	1040	1068	1212	1342	1368	1365	1300	1213	1042	896
August	793	746	752	785	797	992	1197	1206	1197	1212	1183	1095	1076	1061	1065	1094	1241	1399	1426	1422	1354	1242	1067	917
September	827	778	785	818	831	1051	1268	1277	1268	1284	1253	1159	1140	1124	1128	1158	1315	1508	1538	1534	1461	1316	1130	971
October	899	845	853	890	903	1145	1382	1392	1382	1399	1365	1263	1242	1225	1229	1262	1433	1671	1704	1700	1619	1434	1231	1059
November	1009	948	957	998	1014	1275	1538	1549	1538	1557	1520	1406	1383	1364	1368	1405	1595	1888	1925	1920	1828	1596	1371	1178
December	1156	1087	1097	1144	1162	1440	1737	1750	1737	1759	1717	1588	1562	1540	1546	1587	1802	2158	2200	2194	2090	1803	1548	1331

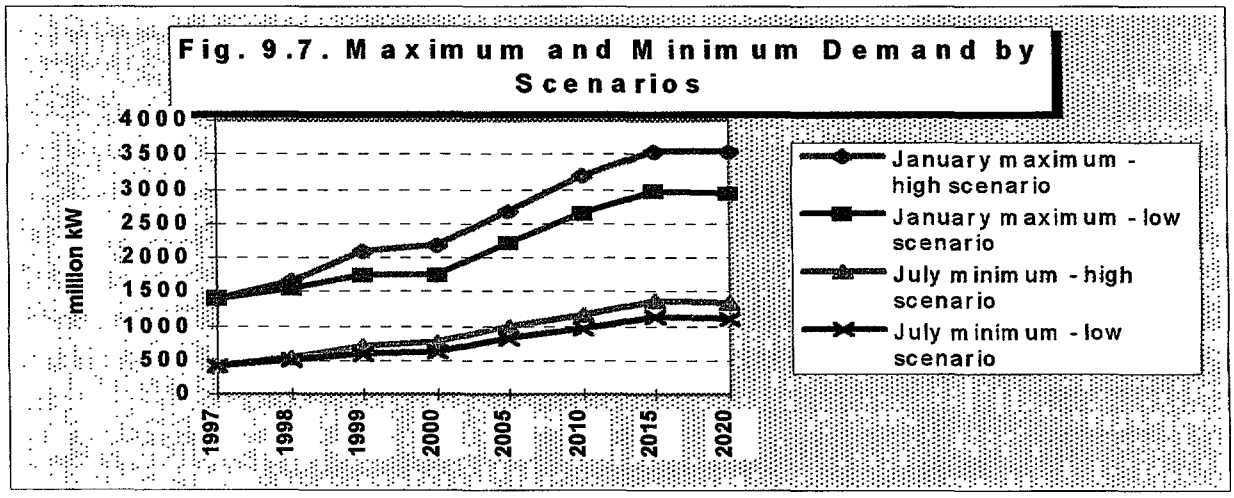
Table 9.3. continued

	2005		high																				
	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24
January	2067	1966	1975	2045	1794	1998	2365	2389	2405	2451	2393	2241	2197	2187	2190	2234	2485	2634	2671	2659	2635	2463	2148	1890
February	1772	1685	1693	1753	1578	1758	2080	2102	2115	2156	2105	1971	1933	1923	1926	1965	2186	2307	2340	2329	2318	2167	1889	1662
March	1525	1450	1458	1509	1402	1562	1849	1868	1880	1916	1871	1752	1718	1709	1712	1458	1942	2047	2075	2066	2060	1925	1679	1477
April	1327	1262	1268	1313	1267	1411	1670	1687	1698	1731	1690	1583	1552	1544	1547	1577	1755	1852	1878	1870	1861	1740	1517	1334
May	1177	1119	1125	1164	1172	1306	1545	1561	1571	1602	1564	1464	1436	1429	1431	1459	1624	1724	1748	1740	1722	1609	1404	1235
June	1076	1023	1028	1064	1118	1245	1474	1489	1498	1527	1491	1396	1369	1362	1364	1392	1548	1662	1685	1677	1642	1535	1338	1177
July	1023	973	977	1012	1104	1229	1455	1470	1480	1508	1473	1379	1352	1345	1347	1374	1529	1666	1689	1682	1621	1515	1322	1163
August	1018	968	973	1007	1130	1259	1490	1505	1515	1544	1508	1412	1384	1378	1380	1407	1565	1736	1760	1752	1660	1552	1353	1190
September	1062	1010	1015	1051	1197	1333	1578	1594	1605	1636	1597	1495	1466	1459	1461	1490	1658	1872	1899	1890	1758	1644	1433	1261
October	1155	1098	1104	1142	1304	1453	1720	1737	1748	1782	1740	1629	1598	1590	1592	1624	1807	2075	2104	2094	1916	1791	1562	1374
November	1296	1232	1238	1282	1452	1617	1914	1934	1946	1984	1937	1814	1779	1770	1772	1808	2011	2343	2376	2365	2133	1994	1739	1529
December	1485	1412	1419	1469	1640	1827	2162	2184	2199	2241	2188	2049	2009	1999	2002	2042	2272	2678	2716	2703	2409	2252	1964	1727
	2010		high																					
	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24
January	2484	2369	2382	2456	2148	2387	2837	2842	2862	2923	2858	2673	2625	2609	2599	2651	2959	3150	3193	3174	3143	2932	2564	2262
February	2129	2031	2042	2106	1890	2099	2495	2500	2517	2571	2514	2351	2308	2294	2286	2332	2603	2759	2797	2780	2765	2579	2255	1990
March	1833	1748	1758	1812	1679	1866	2217	2222	2237	2285	2234	2089	2051	2039	2032	1758	2313	2447	2481	2466	2457	2291	2004	1768
April	1595	1521	1529	1577	1517	1686	2004	2007	2021	2064	2019	1888	1854	1842	1836	1872	2090	2215	2245	2232	2220	2070	1811	1597
May	1415	1349	1357	1399	1404	1559	1854	1857	1870	1910	1868	1747	1715	1704	1698	1732	1933	2061	2090	2078	2054	1915	1675	1478
June	1293	1233	1240	1278	1339	1487	1768	1771	1783	1821	1781	1666	1635	1625	1620	1652	1844	1987	2014	2003	1959	1827	1597	1409
July	1229	1172	1179	1215	1322	1468	1745	1749	1761	1798	1759	1645	1615	1605	1599	1631	1821	1992	2019	2007	1934	1804	1577	1392
August	1224	1167	1174	1210	1353	1504	1787	1791	1803	1842	1801	1684	1653	1643	1638	1670	1864	2076	2104	2092	1980	1847	1615	1425
September	1277	1218	1224	1262	1434	1593	1893	1897	1909	1950	1907	1784	1751	1741	1734	1769	1974	2239	2269	2256	2097	1956	1711	1509
October	1388	1324	1331	1372	1562	1735	2063	2066	2081	2125	2078	1944	1908	1897	1890	1927	2151	2481	2515	2500	2285	2131	1864	1645
November	1557	1485	1493	1540	1739	1932	2296	2300	2316	2366	2313	2164	2124	2111	2104	2146	2395	2802	2840	2824	2544	2373	2075	1831
December	1784	1702	1711	1764	1964	2182	2594	2599	2616	2672	2613	2444	2399	2385	2376	2424	2705	3202	3246	3227	2874	2680	2344	2068

Table 9.3. continued

	2015		high																					
	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24
January	2454	2766	2752	2429	2520	2723	3072	3175	3267	3356	3272	3140	3065	3102	3118	3148	3349	3543	3550	3534	3405	3263	2926	2669
February	2158	2371	2359	2136	2216	2395	2702	2792	2873	2952	2878	2762	2696	2728	2743	2769	2945	3116	3122	3109	2995	2870	2574	2347
March	1918	2041	2031	1899	1970	2129	2401	2482	2554	2623	2558	2455	2396	2424	2437	2031	2617	2769	2775	2762	2661	2550	2287	2086
April	1733	1776	1767	1715	1780	1923	2170	2242	2307	2370	2311	2218	2165	2191	2202	2223	2365	2502	2507	2496	2404	2304	2067	1885
May	1603	1575	1567	1587	1646	1779	2007	2074	2135	2193	2138	2052	2003	2027	2037	2057	2188	2315	2319	2309	2225	2132	1912	1744
June	1529	1440	1432	1513	1570	1697	1914	1978	2035	2091	2039	1957	1910	1932	1943	1961	2086	2207	2212	2202	2121	2033	1823	1663
July	1510	1369	1362	1494	1550	1676	1890	1953	2010	2065	2013	1932	1886	1908	1918	1937	2060	2180	2184	2174	2095	2008	1800	1642
August	1546	1363	1356	1530	1588	1716	1935	2000	2058	2114	2061	1978	1931	1954	1964	1983	2110	2232	2236	2227	2145	2056	1843	1681
September	1637	1422	1414	1621	1681	1817	2050	2118	2180	2239	2183	2095	2045	2070	2081	2100	2234	2364	2369	2358	2272	2177	1952	1781
October	1784	1545	1537	1766	1832	1980	2234	2308	2375	2440	2379	2283	2229	2255	2267	2288	2435	2576	2581	2570	2475	2372	2127	1940
November	1986	1734	1725	1966	2040	2204	2486	2570	2644	2716	2648	2542	2481	2510	2524	2548	2710	2868	2873	2861	2756	2641	2368	2160
December	2244	1987	1977	2221	2304	2490	2809	2903	2987	3068	2992	2871	2802	2836	2851	2878	3061	3239	3245	3231	3113	2983	2675	2440
	2020		high																					
	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24
January	2409	2703	2699	2389	2468	2677	3040	3121	3199	3290	3217	3070	3005	3025	3033	3071	3293	3508	3528	3510	3378	3217	2877	2607
February	2119	2317	2314	2101	2171	2355	2674	2745	2813	2894	2830	2700	2643	2660	2668	2701	2896	3085	3103	3087	2971	2829	2530	2293
March	1883	1995	1991	1867	1929	2093	2376	2440	2500	2571	2515	2400	2349	2364	2371	1991	2574	2742	2758	2744	2640	2514	2249	2038
April	1702	1735	1733	1687	1743	1891	2147	2204	2259	2323	2272	2168	2122	2136	2142	2169	2326	2477	2492	2479	2386	2272	2032	1841
May	1574	1540	1537	1561	1613	1749	1986	2039	2090	2150	2102	2006	1964	1976	1982	2007	2152	2292	2305	2293	2207	2102	1880	1703
June	1501	1407	1405	1488	1538	1668	1894	1945	1993	2050	2004	1913	1872	1885	1890	1914	2052	2186	2198	2187	2105	2004	1792	1624
July	1482	1338	1336	1470	1518	1647	1870	1920	1968	2024	1979	1889	1849	1861	1866	1890	2026	2158	2171	2160	2078	1979	1770	1604
August	1518	1332	1330	1505	1555	1687	1915	1966	2015	2073	2027	1934	1893	1906	1911	1935	2075	2210	2223	2211	2128	2027	1812	1642
September	1608	1389	1387	1594	1647	1787	2029	2083	2134	2195	2147	2048	2005	2018	2024	2049	2197	2341	2354	2342	2254	2146	1919	1739
October	1752	1510	1508	1737	1794	1947	2210	2269	2326	2392	2339	2232	2185	2199	2205	2233	2394	2550	2565	2552	2456	2339	2091	1895
November	1950	1694	1692	1934	1998	2167	2461	2526	2589	2663	2604	2485	2432	2448	2455	2486	2665	2839	2856	2841	2734	2604	2328	2110
December	2203	1942	1939	2184	2256	2448	2779	2854	2924	3008	2941	2807	2747	2765	2773	2808	3011	3207	3226	3209	3088	2941	2630	2383

Maximum and minimum demand levels (of an average January and July weekdays) for both scenarios are presented at Fig. 9.7. As can be seen, by 2015 the maximum demand of high scenario grows up 2.5-fold as compared to 1997 level, exceeding 3.5 billion kW. Low scenario suggests 2.1-fold growth, and the maximum demand in an average January weekday is about 3 billion kW. Simultaneously, summer minimum of the demand increases with higher rates - 3.3-fold and 2.7-fold correspondingly, achieving the level of 1.4-1.1 billion kW.



Important characteristics of the load curves - consistency (maximum load related to an average daily one) and unevenness (maximum load related to a minimum one) for winter and summer seasons are presented at Table 9.4. The values are the same for both scenarios. Obviously, both consistency and unevenness decline by the end of the period considered as compared to 1997. That means, daily load curve fluctuations are being smoothed, and the gap between maximum and minimum is being reduced. This process of load curve gradual transformation was graphically demonstrated by Figures 9.5 and 9.6 above.

Table 9.4. Load Curves Consistency and Unevenness

	Consistency (Max/Aver)		Unevenness (Max/Min)	
	January	July	January	July
1997	1.311	1.396	1.716	2.193
1998	1.248	1.321	1.587	1.966
1999	1.216	1.289	1.511	1.857
2000	1.205	1.277	1.486	1.827
2005	1.177	1.240	1.489	1.737
2010	1.177	1.241	1.486	1.722
2015	1.158	1.175	1.461	1.604
2020	1.171	1.188	1.477	1.625

Attachment

Trip Reports

First data collection CENEf's trip to Tbilisi

April 15-18, 1998

Purpose of the trip. According to the Work Plan for the project the purpose of this trip was to collect statistical information in Tbilisi and interview of Georgian experts on identification of potential to improve energy efficiency.

Team of experts. On this trip two CENEf experts - Igor Bashmakov and Vladimir Zhuze came to Tbilisi.

Schedule of meetings during the trip.

No	Meeting with	Date	Results of the meeting
1	Zurab Menteshashvilli Program Manager, B&R Tbilisi office	16.4	Introduction to the general energy and economic situation in Georgia. Discussion of schedule for the meetings during the trip.
2	Ketino Alatashvilli Expert, B&R Tbilisi office	16.4 and 17.4	Presentation of data collected by B&R Tbilisi office in accordance with the questionnaire sent by CENEf in advance. Translation of some document from Georgian to Russian
3	Temuri Mikiashvili, Senior Engineer, B&R Tbilisi office	16.4	Discussion on technical problems to improve energy efficiency in industrial applications and in municipal sector.
4	Nikolai Dadiany, "Telasi"	16.4	Interview on the situation with electricity supply, demand and payments as well as on energy efficiency improvement measures considered by the local experts. Collection of data.
5	Vassily Metrevely, Chief energy manager of Rustavy Metallurgical Plant, with the participation of his experts	16.4	Technical Problems of running energy facilities at the enterprise and possibilities to improve energy efficiency
6	George Makashvily, First Deputy General Director, Energogeneratia; Goderzy Kiasashvily Chief Engineer; Valery Dzotsenidze, Chief of Production Department	16.4 and 17.4	Management of electricity supply systems, data collection on loads for typical days, data collection on electricity consumption. Interview on the possibilities to improve energy efficiency
7	Andrew Barnard, Georgian Economic Trend, TACIS	17.4	Visit to collect statistical data

8	Otar Vezerishvily, Professor, Tbilisi State University	17.4	Potential and barriers to apply technologies to generate energy from renewable in Georgia
9	Nodar Kereselidze, Director, Georgian Research Institute of Power Engineering Robert Hachiturian, Head of Department in the Institute, with the presence of Tornike Gotsiridze, Expert from the institute as well as TACIS representative	17.4	Data collection on electricity consumption. Introduction to the work on projecting of electricity demand done by the institute,
10	Teimuraz Jugelli, General Director, and Jemal Akhalia, Deputy General Director	17.4	Discussion of the world bank data on energy balances and collection of data
11	Teimuraz Gogishvili, Head of the aggregated statistics and Information Department	17.4	Data collection. Interview on availability of additional data. Presentation of results of the recent survey for identification of residential electricity and fuel use habits

Based on data collected the adaptation of structure of projection models to the situation in Georgia will be accomplished. After that the development of initial versions of electricity demand scenarios will be launched.

Comments. Invaluable assistance was provided to CENEf team during the trip by the Burns and Roe Tbilisi Office staff. CENEf also appreciates the contribution to the data collection process done by the office staff in responding questionnaire send by CENEf's experts in advance.

Trip Report

Second data collection&verification CENEf's trip to Tbilisi

May 18-21, 1998

Purpose of the trip. According to the Work Plan for the project the purpose of this trip was to collect statistical information in Tbilisi and interview of Georgian experts on identification of potential to improve energy efficiency.

Team of experts. On this trip two CENEf experts - Yury Dashevsky and Vladimir Zhuze came to Tbilisi.

Schedule of meetings during the trip.

No	Meeting with	Date	Results of the meeting
1	Goderzy Kiasashvili Chief of technical department of Sakenergo	19.5	Discussion of the situation at Georgian energy market. Technical aspects of energy production at Tbilisi Power plant.
2	Aleksey Zhdanovitch Chief of economics and foreign relations department of Sakenergo	19.5	Data on tariffs, energy production, import and export collection. Introduction to the general energy and economic current situation in Sakenergo.
3	Murman Margelashvili General director of GENECO (Eng&Environmental consultants)	19.5	Discussion of social aspects of energy efficiency measures for industrial applications and in municipal. Introduction to the work on projecting of electricity demand.
8	Otar Vezerishvily, Professor, Tbilisi State University; B&R consultant	19-20.5	Potential to apply technologies to generate energy from renewable in Georgia. Discussion of specific costs of necessary equipment for solar heating, wind power generators etc.
5	Guram Avalishvili Chief energy manager of Caproloctam chemical factory (Rustavi)	18-20.5	Discussion on technical problems to improve energy efficiency in industrial applications and in municipal sector Technical Problems of running energy facilities at the enterprise and possibilities to improve energy efficiency
6	Yury Bedineishvily Director of Chemical combinat (Rustavy)	20.5	The role of chemical industry in future Georgian electricity consumption.
7	David Revia Chief engineer of Energy department of Chemical combinat (Rustavy)	20.5	Management of electricity supply systems, data collection on loads for typical days, data collection on electricity consumption. Interview on the possibilities to improve energy efficiency

8	Dimitry Butorin Chief energy manager of Energy department of Chemical combinat (Rustavy)	20.5	Discussion on motors, transformers and some others enrage consuming equipment improvement opportunities.
9	Levan Robakidze Georgian Energy Efficiency Fund	20-21.5	Visit to collect statistical data on electricity consumption. Discussing the role of EEF in energy situation improvement in Georgia
10	Employees of B&R Georgian office	18-21	Verification of data collected by B&R Tbilisi office. Translation of some documents from Georgian to Russian
11	Visits to Tbilisi shops to collect data on available home appliances efficiency and prices		

Based on data collected the adaptation of structure of projection models to the situation in Georgia will be accomplished. After that the development of initial versions of electricity demand scenarios will be launched.

Comments. Invaluable assistance was provided to CENEf team during the trip by the Burns and Roe Tbilisi Office staff. CENEf also appreciates the contribution to the data collection process done by the office staff in responding questionnaire send by CENEf's experts in advance.

Third trip to Tbilisi to participate in Interium Workshop Least Cost Planning Model for Georgian Power System

May 31 - June 3, 1998

Igor Bashmakov, Executive Director of CENEf came on this trip.

10 copies of Draft report were delivered to Tbilisi.

On May 31 Draft report was presented to Brooks Howell, Adam Krechko and other project participants in English.

On June 1 Electric Power Demand Forecast for Georgia 1998-2020 was presented by I. Bashmakov at the workshop.

On June 3 I. Bashmakov participated at the meeting with Brooks Howell and Adam Krechko to discuss how results can be used by IPM model.

Meeting with Adam Krechko in Moscow

June 24, 1998

Igor Bashmakov and Svetlana Sorokina had a meeting with Adam Krechko in CENEf's office in Moscow. Adam was given all computer models developed and used by CENEf for this study with the condition not to disseminate those models to anyone who is not involved in the project.

Phone consultations

Number of phone consultations were provided:

I. Bashmakov to Bill Dreis;

A. Perevozchikov to B. Howell and A. Kreczko.

Igor Bashmakov
Executive Director of CENEf