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Energy Analysis of Lower Rioni Pilot Watershed Area (Khobi and Senaki Municipalities, Samegrelo and Zemo Svaneti Region)

Republic of Georgia

Technical Report Number 22

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Integrated Natural Resources Management in the Republic of Georgia Program

Technical Report Number 22

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List of Acronyms

USAID	United States Agency for International Development
INRMW Program	Integrated Natural Resources Management in Watersheds of Georgia Program
WI	Winrock International
SDAP	Sustainable Development and Policy Center
EE	Energy Efficiency
HH	House Hold
EU	European Union
HPP	Hydro Power Plant
MW	Megawatts
MWh	Megawatt/hours
NG	Natural Gas
PV	Photovoltaic
RE/EE	Renewable Energy/Energy Efficiency
RE	Renewable Energy
SHP	Small Hydropower
kW	Kilowatts
kWh	Kilowatt/hours
PPA	Power Purchase Agreement
NGO	Non-Governmental Organization
GoG	Government of Georgia
MENRP	Ministry of Energy and Natural Resources Protection

Introduction

The following analysis was produced within the framework of the Integrated Natural Resources Management in Watersheds of Georgia (INRMW) Program. It deals with the Lower Rioni Pilot Watershed Area – which is the Rioni River downstream, covering both the Khobi and Senaki municipalities, as selected by the INRMW project in 2011. This analysis is the last in a series of four reports, and deals with the two upstream and two downstream watersheds of the Rioni and Alazani Rivers, respectively.

The Sustainable Development and Policy (SDAP) Center conducted this analysis under a contract signed with the Winrock International Institute for Agricultural Development (Prime Contract # AID-114-LA-10-00004 INRMW, subcontract # 6331-11-01) within Activity 2: Detailed Assessments and Community Stakeholder Engagement. This subcontract defines the SDAP Center task producing a Draft report on Energy Analysis of the Lower Rioni Pilot Watershed Area.

More broadly the SDAP Center activities call for undertaking this Watershed Energy Analysis in order to identify the energy consumption, energy production, and energy resources in the four pilot watersheds. The study also is used to identify potential energy options, and to provide the necessary data for subsequent preparation of watershed energy passports documenting energy inputs and outputs at a watershed level. These will be used by local government agencies and communities in planning for energy-related investments.

The Watershed Energy Analysis goals are as follows:

- Assess local energy resources within 4 pilot watershed areas of the Alazani and Rioni River Basins (with a special emphasis on renewable resources - RE);
- Determine current energy consumption and production patterns;
- Identify opportunities to reduce energy consumption through the adoption of energy-efficiency (EE) investments and practices.

The outputs of the Watershed Energy Analysis will form the basis for Energy Passports of municipalities within the Watersheds (detailed description of energy passports and the methodology to develop them are given in Annex 1). Although such an analytical document as presented here may be used independently, it will provide an instantaneous snapshot of the current energy situation. The Energy Passport can be systematically updated with new data inputs in the future.

Energy planning for a geographical area provides an opportunity for reorganizing the energy consumption and distribution trends so that they can be managed more efficiently in the future.

To reach this goal it was envisioned to develop a software energy planning tool that is not a model of any particular energy system, but rather an instrument that can be used to create models of different energy systems, called in this project “Energy Passports”, where each requires its own unique data structures. It is expected that energy planning software tool will be used for forecasting energy balances and development of the energy action plans for each watershed.

The “Energy Passport” software program proposed will incorporate an overall energy balance – the comprehensive system for presenting and analyzing country level energy system related data. This approach is endorsed and used by a variety of global and regional organizations, as well as national governments as a universal planning tool. Due to its format it is well fitted to serve as a platform for software development. It will be modified as needed in order to accommodate additional analytical and decision-making features to satisfy the future development needs of small territorial units like municipalities and/or regions of Georgia.[1]

It is expected that the Energy Passport will serve several purposes: as a database, that will provide a comprehensive system for maintaining energy information; as a forecasting tool, it will enable the user to make projections of energy supply and demand over a long-term planning; and as a policy analysis tool, it can assess the effects - physical, economic, and environmental - of alternative energy programs, investments, and actions. An “Energy Passport” provides a comprehensive view of the energy system as a whole. It is thus the necessary instrument for understanding energy as part of a larger situation; a present situation, a future “business as usual“ situation, and as an alternative energy scenario, oriented towards sustainability.

At the community level, there will be a strong focus on alternative fuel sources and energy efficient technologies that reduce the need for heating and other energy uses. The program will assess selected energy-related natural resources from the standpoint of their sustainable use, identifying threats to such use, and developing options for optimizing their use in the framework of long-term conservation and broader economic growth. Illustrative subjects for watershed productivity and energy efficiency studies include: hydropower productivity; fuel wood use (and regeneration/silviculture practices); and local alternatives that reduce/substitute fuel wood demand and others.

This analytical document was developed based on a template created and tested during assessments of the Upper and Lower Alazani and the Upper Rioni Pilot Watershed Areas. Here again it was possible to carry out some limited comparative analysis of household energy consumption practices between all four watersheds.

During this study, we expected the pattern of household energy consumption to be different from other watersheds, since the Samegrelo region where this watershed is situated is very different from other parts of Georgia. Here for the first time we deal with a different ethnic and linguistic composition of the population (although still Georgian), as well as subtropical agriculture and a subtropical climate, etc. Still, as a whole, the results of this analytical paper clearly show that despite some important differences in socio-economic development trends and levels, the energy consumption patterns of households are similar in some respect to those in Upper Alazani, Upper Rioni and Lower Alazani Watersheds. The most important item is that just like in Racha, Telavi-Akhmeta, and Dedoplistskaro, there is a heavy dependence on firewood for heating purposes, making it again the single most important energy source for households. On the other hand, Lower Rioni Pilot Watershed Area is almost devoid of fuel wood resources, which makes the necessity of solving the fuel wood dependence problem much more pressing than elsewhere.[2]

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[1] For detailed presentation of energy balance see Annex 1.

[2] For methodology please refer to: Energy Analysis of Upper Rioni Pilot Watershed Area (Ambrolauri and Oni Municipalities, Racha-Lechkhumi and Kvemo Svaneti region).

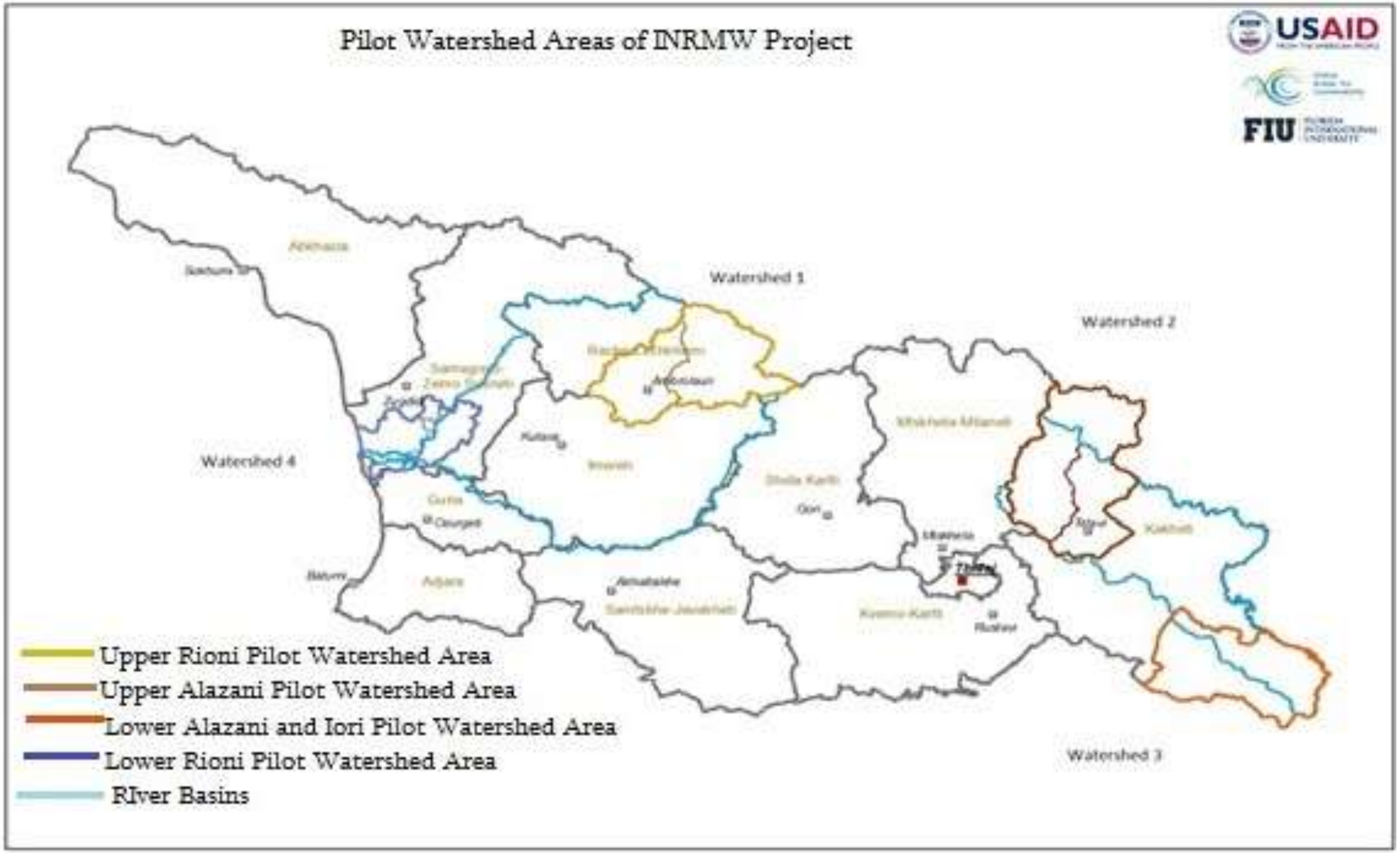
1. Socio-Economic Context

The lower Rioni Pilot Watershed Area is located in the western part of Georgia, in the Samegrelo Zemo-Svaneti region and consists of Khobi and Senaki municipalities. The following maps show the boundaries of Lower Rioni Pilot Watershed Area.

The population in Khobi municipality was 42,096 persons in 2011, according to local municipality data (of these 3,722 are Internally Displaced Persons (IDPs) – 8.8% of the total). The town of Khobi proper has 5,805 persons or 13.8% of the total population. Of these people, 1,213 or 20.1%, i.e., every fifth person, are IDPs. On the contrary, the share of IDPs among the rural population is just 7%, which is easy to explain, since upon arrival these people were housed in relatively large municipal buildings (hostels, hotels, schools, etc.), which were absent in the villages.

There are 15 communities in Khobi consisting of 51 villages, as well as 6 outlying villages, which are not part of any community. There are 3-5 villages per community. The territory of the municipality is very small, even by Georgian standards, at just 676 km^2. The population density is 62.2 persons per km^2.

<u>Figure1.1</u> Map of the relative location of pilot watershed areas of Rioni and Alazani river basins within the territory of Georgia
Developed by: Nutsa Megvinetukhutsesi, GIS expert hired under INRMW program



The population of Senaki is 52,043 persons, of which 8,823 or 17% are IDPs. The town of Senaki has 19,801 inhabitants, or 38% of the total population. The share of the entire urban population in Georgia is 53.2%.[3] This characterizes both municipalities, especially Khobi, as "deep" rural districts and is an exemplary case of pseudo-urbanization, which quite often happens in Georgia when some rural settlement is made in the center of the municipality and granted urban status disregarding its actual functions, economic structure, and people's way of life.

In the town of Senaki, 7,120 or 36% of the population are IDPs. This is an extremely high share, and the majority of these people have not been properly integrated into the local economic and social environment. There are 14 village communities in the municipality and 62 villages. The number of villages per community is usually 5 or 6, although there are isolated cases when there are 1-2 villages per community. There are a few almost de-populated villages, although most villages have from 300 to 700 persons. The share of IDPs in the villages is much lower than in the town of Senaki – just about 7% of the total. The territory of Senaki municipality is even smaller than Khobi, just 520.7 km^2, but with a much higher population, so its density is also higher at 93.8 persons per km^2.

The population of both municipalities has been relatively stable over the past decade, which is not typical for Georgia, where many municipalities underwent sharp population declines, as previously documented in reports on Watersheds 1 and 3. The population of Senaki declined by just 1.1% between 1989 and 2002, while the population of Khobi even increased by 5.5%. In reality though, both municipalities lost some population during that period, but such loss was offset by the influx of IDPs, especially in Khobi.[4]

Much of the information about watersheds comes from the municipal development strategy documents, although these are not universally available. For instance, both Khobi and Senaki municipalities reported the development of their appropriate municipal development strategy documents back in February 2012, although despite persistent efforts of both SDAP/Winrock and INRMW management, no trace of these documents could be found. Thus all (rather scarce) information about the economy of these municipalities comes from their respective web-pages.

Both municipalities, as well as the majority of the Samegrelo region, during the Soviet period specialized in subtropical agriculture, mainly in tea and citrus production, along with associated processing facilities. Today these industries are in a deep decline, with many of the tea plantations abandoned and unfit for cultivation for any crops. Tea and citrus have been replaced mainly by corn and soy, as well as hazelnut, laurel plantations, etc. Since both municipalities are located within former swamps, parts of these agricultural lands are unfit for cultivation due to failing drainage systems. In Khobi, agricultural lands occupy 44% of the total municipality territory; in Senaki they occupy 43% of the territory.

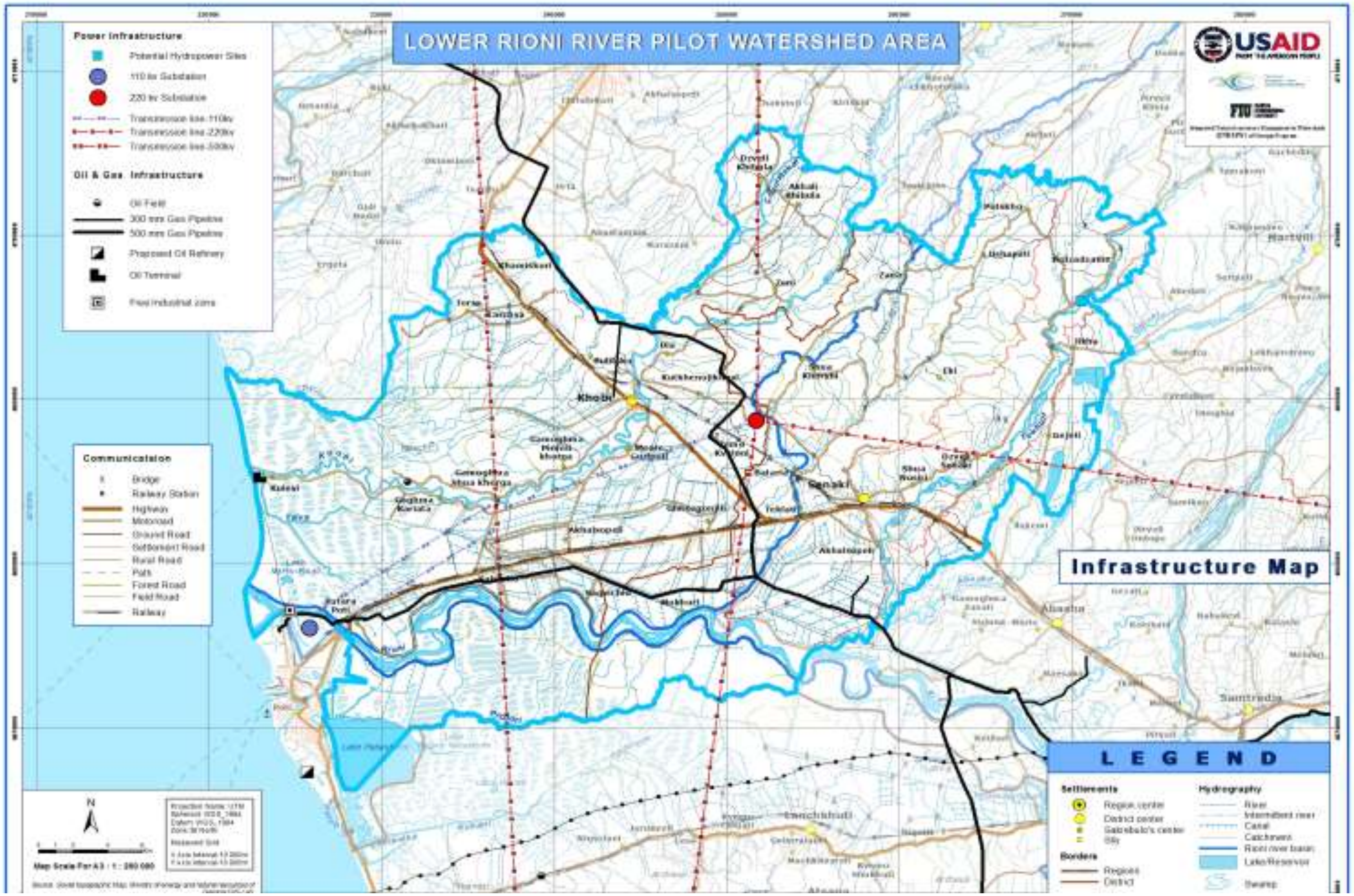
Khobi is the only municipality among all reviewed so far that is situated on the Black Sea coast. Thanks to this fact its territory is located near one of the largest enterprises in all of Georgia –the Black Sea terminal LLC, which belongs to Socar – the Azerbaijan state oil company. The Kulevi Marine Terminal and Port is designated for the transshipment and storage of oil and oil products, as well as for the loading of ships. The overall storage capacity of Tank Park is 320,000 m^3 with the potential to increase storage up to 380,000 m^3. For loading operations there are two berths for

[3]Calculated from: http://www.geostat.ge/?action=page&p_id=151&lang=geo
[4]http://geostat.ge/cms/site_images/_files/georgian/census/2002/I%20tomi%20-%20saqarTvelos%20mosaxleobis%202002%20wlis%20pirveli%20erovnuli%20sayovelTao%20aRweris%20Sedegebi.pdf

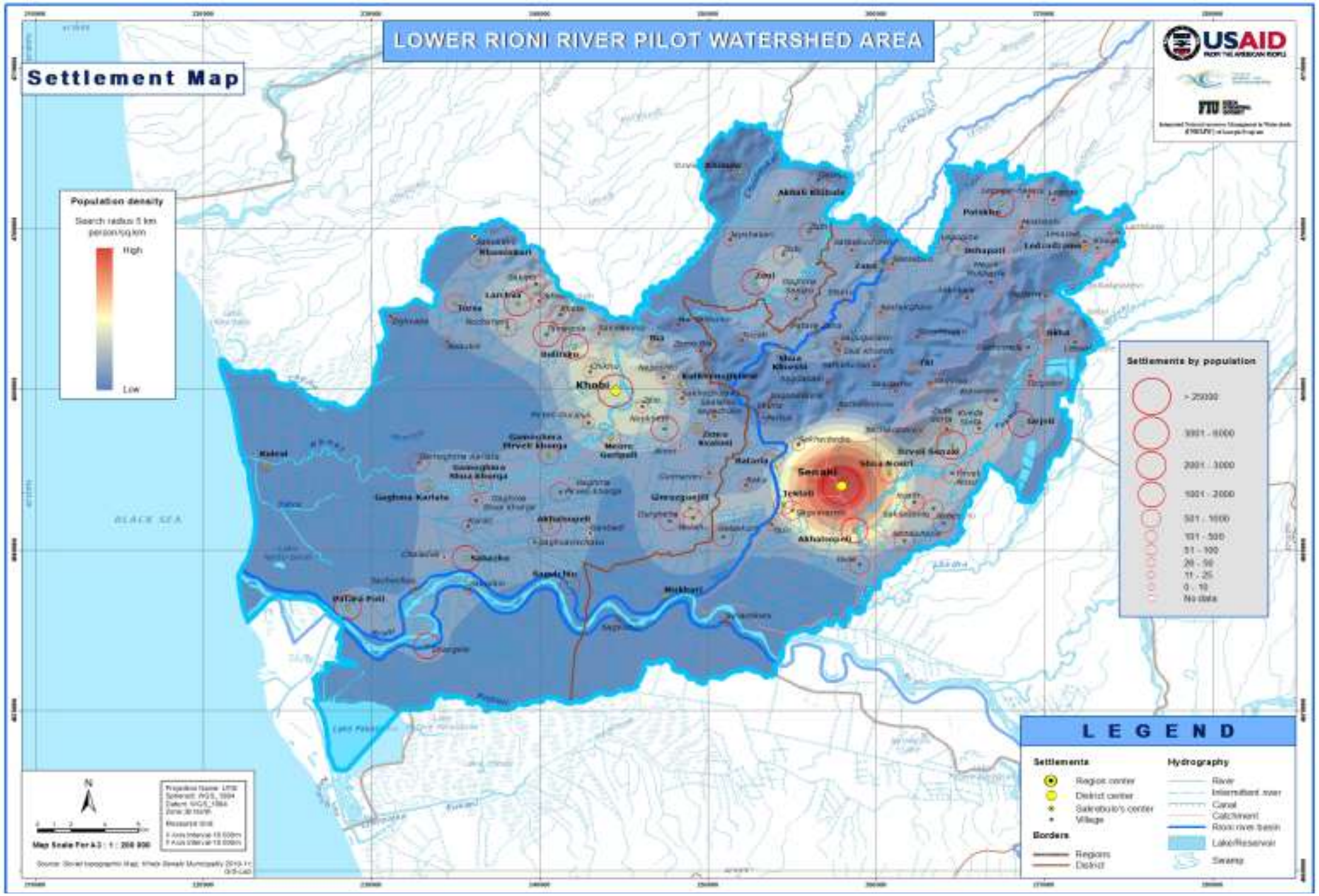
receiving tankers with tonnages of up to 100,000 tons. The loading capacity is from 1,000 to 8,000 m^3/hr. The terminal has its own railway station, where 180 oil tank cars at a time can fit for unloading. The trestles make possible the simultaneous discharge of up to 168 oil tankers.[5] This facility plays a key role for Khobi municipality development, since it provides 65-70% of its overall tax revenues. On September 18, 2012 the President of Georgia announced plans to build a carbamide factory in the same region by the Socar Georgian Investment Company. This enterprise will occupy 24 ha. The problem is that both the terminal and the future factory are located inside the delicate Kolkheti National Park, with the terminal motor-car and railway access roads already cutting it in half. This park is formally protected by both Georgian law and a number of international legal acts agreed to by Georgian authorities. Adding one more chemical factory inside this already badly undermined national park essentially would mean its complete environmental collapse.

[5] http://www.kulevioilterminal.com/index.php?option=com_content&view=article&id=98&Itemid=77&lang=en

Figure 1.2 Map of the Lower Rioni Pilot Watershed Area
Developed by: Nutsa Megvinetukhutsesi, GIS expert hired under INRMW program



<u>Figure 1.3</u> Lower Rioni Pilot Watershed Area – Population map and settlements
Developed by: Nutsa Megvinetukhutsesi, GIS expert hired under INRMW program



2.Energy Resources

General considerations about the factors influencing the utilization of energy resources as well as their applicability in Georgia were previously discussed in the report on upper Rioni pilot watershed, thus these are not repeated here.

In the case of the Lower Rioni Pilot Watershed Area (similar to the Upper Rioni and Alazani Pilot Watershed Areas), mineral energy resources (including geothermal water) have not been discovered. There are, however, other potential renewable energy resources such as wind, solar, biogas, hydro, and biomass.

Wind Power. According to the *Wind Power Atlas of Georgia*, as well as information on the MENR website (http://www.menr.gov.ge/4501), the territory of Lower Rioni Pilot Watershed Area as a whole does not possess substantial and verified wind power potential for the feasible operation of commercial wind power plants. The average annual wind speed in this area is below 2 m/sec; both Racha and Kakheti fare better in this respect (2-4 m/sec).

The only limited area that possesses such power potential is located near the city of Poti, which is directly adjacent to Khobi municipality. According to the MENR, the installed wind farm power potential at this location is 50 MW, with an annual energy potential generation of 110 GWh. The ISET Policy Institute meanwhile provides alternative data for the same location as 90 MW installed capable of producing 210 GWh/year.[6] Still, despite long-running discussions about the necessity of building a wind farm here, no active steps have been taken so far.

The solar energy potential is approximately 1,590 kWh per m^2 on a horizontal surface per year for Khobi, and 1,560 kWh/m^2per years for Senaki.[7] This is the approximate equivalent of 195 kWh of electricity or 1,231 kWh of thermal energy (hot water) annually for Khobi, and 191 kWh and 1,208 kWh respectively for Senaki. This is a little higher than the Georgian average, enough to substantially contribute to the reduction of commercial energy dependence by producing hot water throughout the year on ahousehold,small business, or public building level.[8]

The solar energy power transformers systems are an optimal solution in terms of different aspects of Georgian life, especially in the mountainous, sparsely populated region villages; as well as for geological parties' scientific research, shepherds, military conditions, and telecommunication stations and emergency conditions centers. http://www.menr.gov.ge/en/4760

Biogas, which can be produced from animal waste, is a viable alternative to commercial fossilized fuels, although a biodigester needs at least 4 head of cattle to produce enough gas to justify the capital investment for the equipment. Currently in Lower Rioni Pilot Watershed Area there are not enough cattle on average per household engaged in agriculture to meet this minimum threshold. Previous biogas utilization experience in Georgia shows that this type of energy generation is not popular and is unlikely to become so in the near term.

[6]See: http://www.aypeg.ge/wp-content/uploads/2012/05/Seasonality.pdf
[7]Calculated from: სამშენებლონორმები და წესები, სამშენებლოკლიმატოლოგია, სნდა წ პნ 01.05-06, ოფიციალურიგამოცემა, საქართველოსეკონომიკურიგანვითარებისსამინისტრო, თბილისი, 2006, pp.11-13. There is no data for Khobi, thus we took the averaged potential for Poti and Senaki.
[8]The average solar resource for Georgia is 1,550 kWh/year of solar energy, equivalent to about 190 kWh/yr of electricity and 1,200 kWh/yr of thermal energy, as presented in the *Rural Energy Potential in Georgia and the Policy Options for its Utilization*, prepared by World Experience for Georgia for Winrock International under Sub Agreement 5708-07-04, in February 2008, p.20 http://www.nateliproject.ge/files/02-re_prospects.pdf. All of these estimates are approximate and are used for general illustrative purposes only.

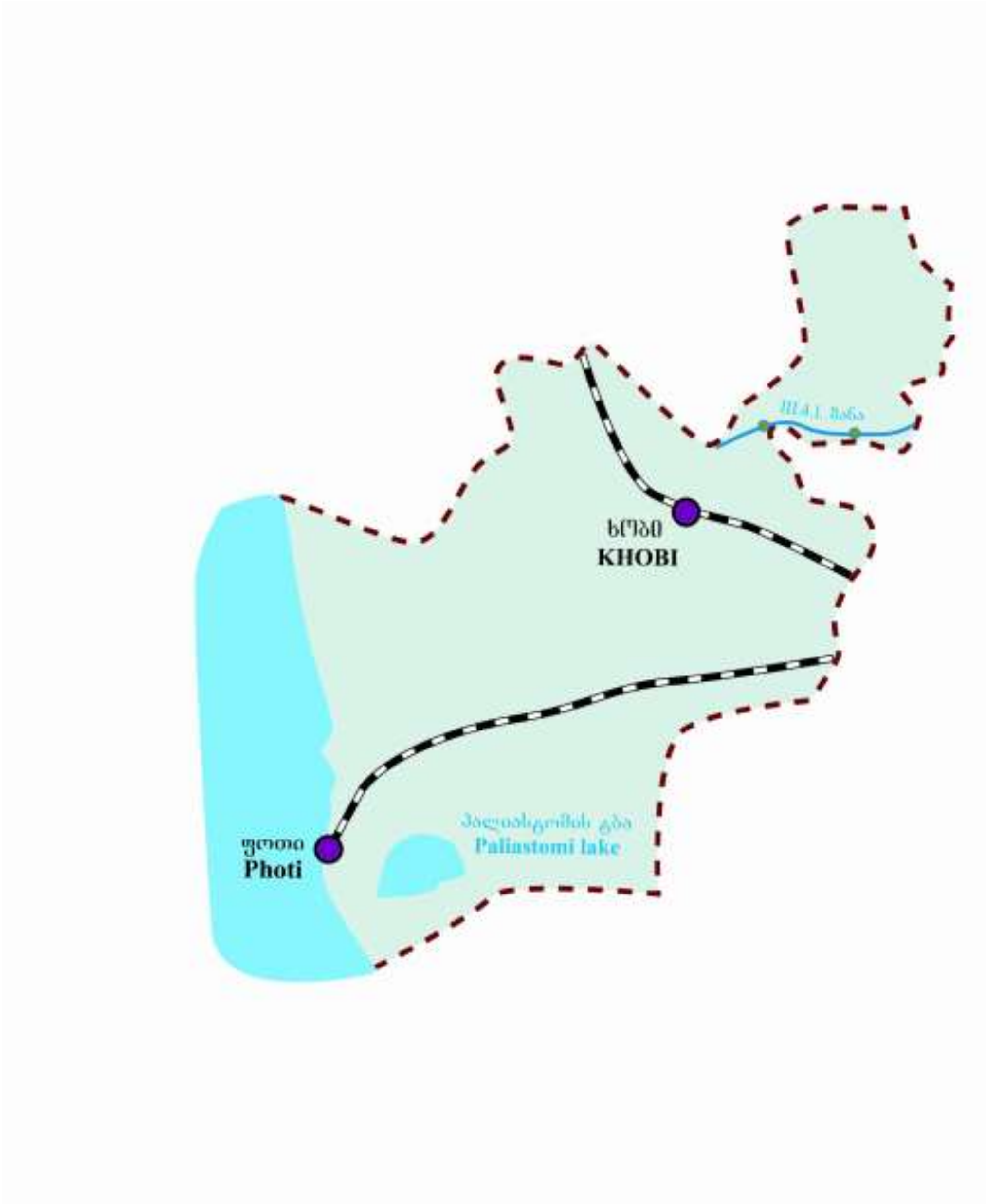
Both hydro resources and fuel wood are also relatively sparse in this watershed.

Hydropower. Both municipalities are situated within the Rioni River basin and its tributaries' sub-basins, but they do not possess any considerable hydro resource potential (see Figures3.1 and 3.2). The potential installed capacity (P) of rivers situated within the Khobi municipality is estimated at about 1.9 MW with an annual electricity generation potential (E) of 10.1 million kWh per year; for Senaki municipality there is a potential of 0.4 MW with 12.2 million kWh per year. The total for both municipalities within the Lower Rioni Pilot Watershed Area is 2.3 MW hydro potential with 12.2 million kWh per year of energy generation. This potential is barely large enough to justify its inclusion in the Hydro Energy Technical Potential Cadastre of Rivers of Georgia. None of this potential is currently being utilized by any hydro power plants; nor are there any plans to utilize it in the foreseeable future. Besides, it's worth mentioning that, even though it is assumed that the small hydropower run-of-the river schemes tend to have relatively modest environment impacts, some site specific effects arose from these schemes might be significant. Generally, unsustainable planning of hydropower can result in environmental impacts such as changes in the flow regime of the river, impact on downstream populations, ecosystems and biodiversity. Environmental degradation associated from hydropower cascades (even for small schemes).might be higher than that caused by large hydropower. Hence, Georgia should invest in research into potential environmental and social problems from hydropower and proceed with caution.

Table 2.1 Small Hydro Power Potential of the Lower Rioni Pilot Watershed Area

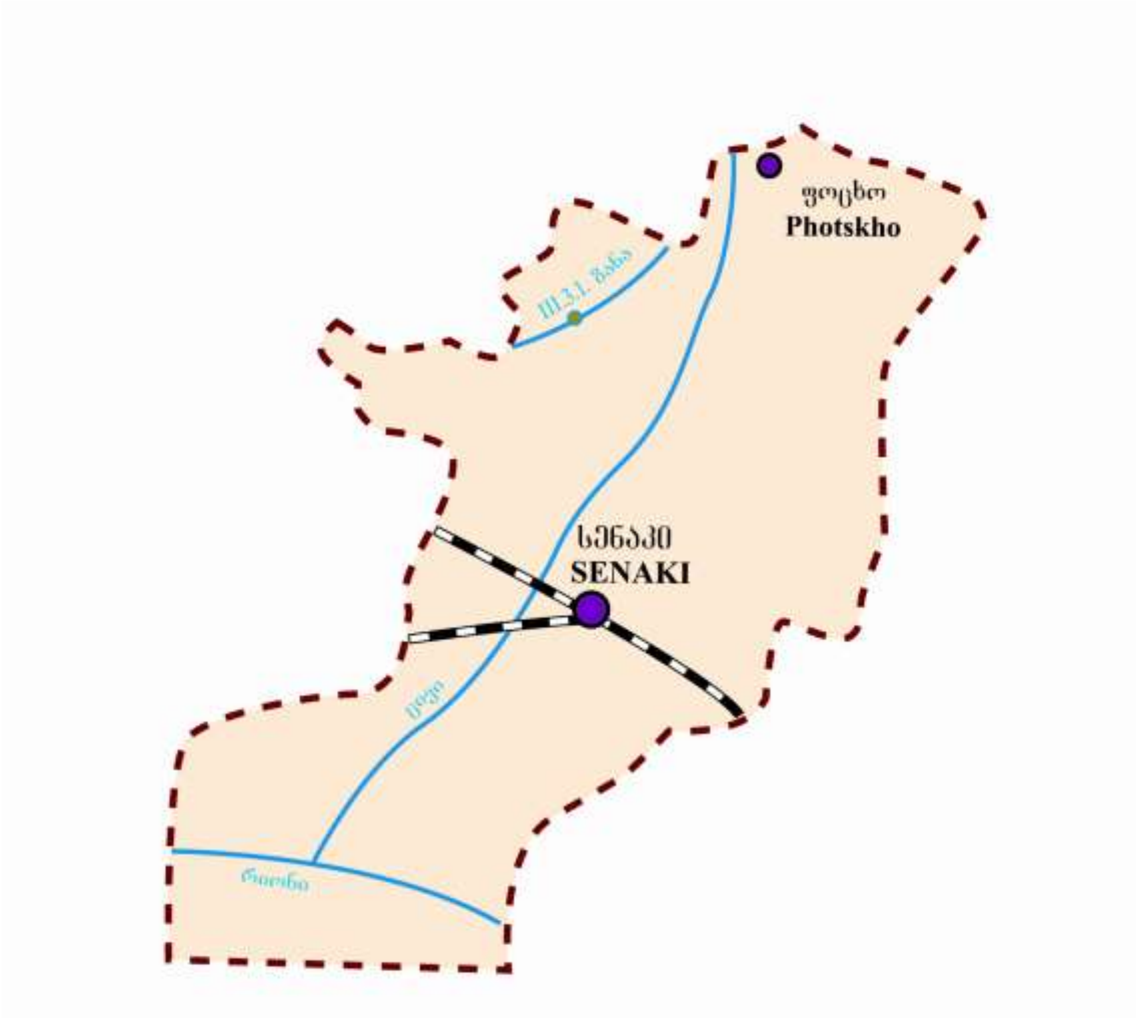
	River	Installed Capacity - P MW	Annual electricity generation – E million kWh
Khobi	III.4.1 Zana		
	I	0.8	4.2
	II	1.1	5.9
	∑	1.9	10.1
	TotalKhobi	1.9	10.1
Senaki	III.3.1 Zana		
	I	0.4	2.1
	Total Senaki	0.4	2.1
	Total Khobi and Senaki	2.3	12.2

<u>Figure 2.1</u> Schematic of the Khobi Municipality River System



<u>Source:</u> Ministry of Environment and Natural Recourses of Georgia

<u>Figure 2.2</u> Schematic of the Senaki Municipality River System



<u>Source:</u> Ministry of Environment and Natural Recourses of Georgia

Fuel wood is formally defined as - trees that will yield logs of suitable size and quality for the production of firewood logs or other wood fuel.[9] The other wood fuels include wood chips, wood pellets, wood briquettes, bark, sawdust and shavings. In Georgia, only firewood is formally recognized, inventoried, and requires permission for logging.

Firewood has provided almost 50% of the population's energy demand during the past 15 years, which has created significant environmental problems. Georgian forestry, the main firewood source, can sustainably satisfy only 15% of Georgia's energy demand. Therefore, the present use of forestry at such a wasteful pace can result in environmental catastrophes such as landslides, desertification, and river sedimentation. (Rural Energy Potential in Georgia and the Policy Options for its Utilization, Prepared by World Experience for Georgia for Winrock International under Sub Agreement 5708-07-04, February 2008, p.20, http://www.nateliproject.ge/files/02-re prospects.pdf, p.109). According to "Wood Energy Resources of Georgia and Their Efficient Utilization", which was produced within the Energy Capacity Initiative Project in 2010 (Contract No. ECI-GA-20) the share of firewood in an annual

[9] http://www.websters-online-dictionary.org/definitions/FUELWOODthe

wood production of Georgia is similar to the same share in less developed African countries (p. 28).

According to the Agency of Natural Resources of the Ministry of Energy and Natural Resources of Georgia (letter # 08-05/246 of 30January, 2012), the forest resources for Khobi municipality were defined as 10,880 ha, while for Senakiwere defined as 13,927 ha (Decree #299 of August 4, 2011). But in the same letter the Agency acknowledges that the logging potential in these municipalities is so small that it does not possess any relevant data; moreover, there are no authorized licensees for forest development located here. On the other hand representatives of this same Agency in Lower Rioni Pilot Watershed Area provided SDAP with data about allocated and procured firewood (see 4.1.4), although with no data on logging potential. This again characterizes the situation existing for the fuel wood sector, which is considered as one of the least organized and transparent in Georgia, and is an object of constant controversy.

3.Energy Sector

3.1 Consumption

3.1.1 Electricity

Electricity in the Lower Rioni Pilot Watershed Area is supplied by JSC ENERGO-PRO Georgia, which is wholly owned by the ENERGO-PRO, a Czech based company. This company serves 2/3 of Georgian electricity customers, both for households, as well as for commercial and government organizations.

In Khobi, the municipality company serves 9,983 residential customers, of which 4,740 (47.5%) are metered; 454 customers are commercial and government organizations (all of these have individual meters). In Senaki there are 15,865 residential customers, of which 13,732 (86.6%) are metered. There are 865 commercial and government customers, all of whom have individual meters. It is important to stress that the absence of individual metering among residential users usually leads to confusion and often to conflicts, since the exact amount of consumption by each individual household is unclear. This is especially true in such cases where small businesses are also hiding themselves among households, and obviously passing along the rebated cost of their electricity consumption to other customers.

The electricity tariff for the population is GEL 0.1298 ($ 0.08) per KWh, if the amount of electricity consumed is less than 100 kWh/month, GEL0.1652 ($ 0.1) for 101-300 kWh/month and GEL0.1750 ($ 0.11) for 301 kWh or more/month.

On average households account for about 46% of all electricity consumed in both municipalities.[10] In Khobi households consumed 51% of all energy, and in Senaki relatively less at about 44%.

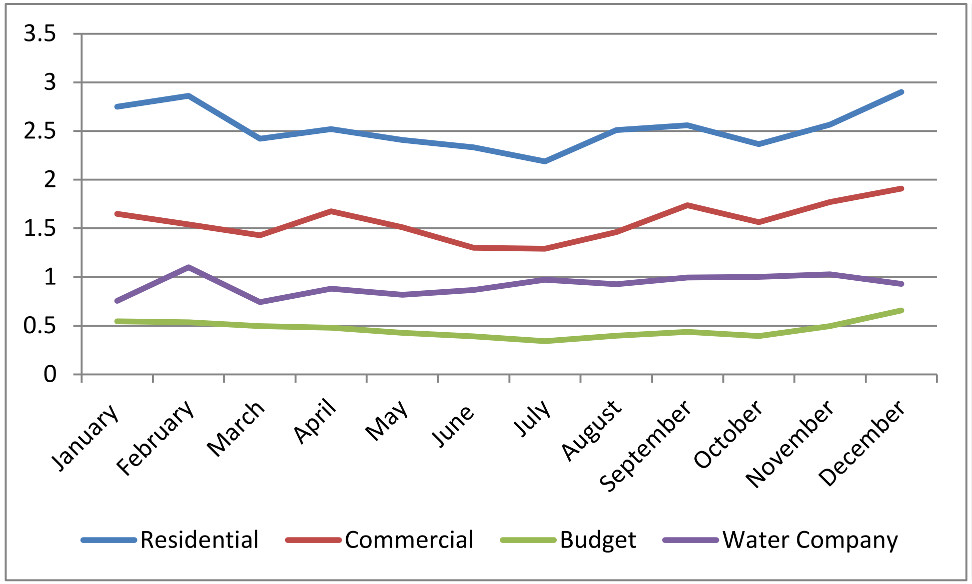
There is an important conclusion that can be drawn from the data provided from the charts below, including a comparative analysis of population and Energo-Pro residential customers data. There are approximately 14,521 households (about 42,096 people) residing in Khobi, while electricity is supplied to 9,983 residential customers. Judging by this, only approximately

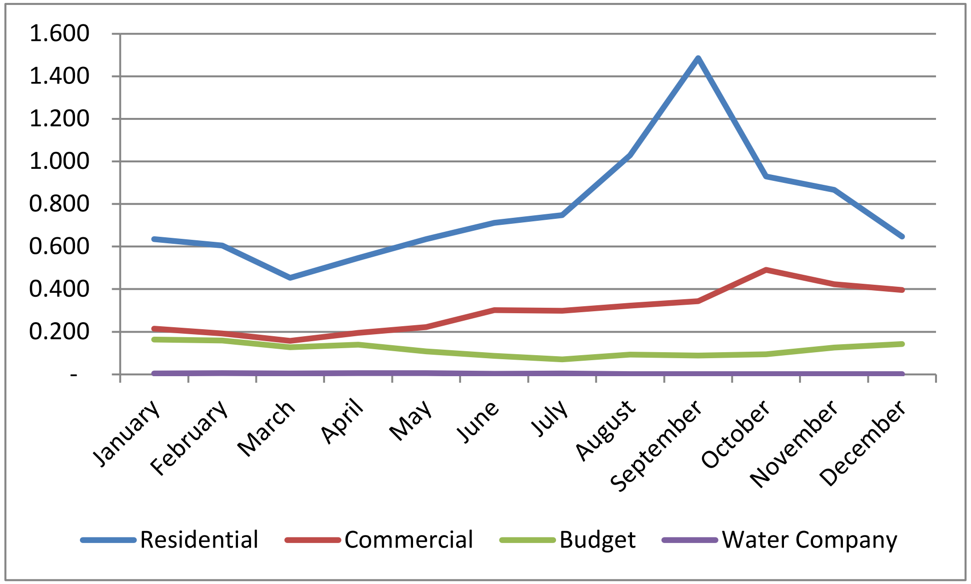
[10]This strongly differentiates Lower Rioni pilot watershed from upper Rioni pilot watershed, where population accounted for 2/3 of all electric energy consumed.

69% of households are supplied with electricity. Such a situation is utterly impossible and probably indicative of the total chaos within the electricity supply organization and the inadequate coverage of customers by individual meters. In Senaki there are 17,945 households (HHs), with electricity supplied to 15,865 customers, or approximately 88%. Considering that of the HHs 3,062 are represented by Internally Displaced Persons (IDP), who often live in so called “collective centers” and are not supplied with electricity individually, but rather as groups, this data appears to describe the existing situation more or less accurately.

On the other hand the annual electricity consumption charts of residential and commercial sectors rather accurately reflect expected trends with minimums in March and in early summer, and a small peak in August-September (which is expected in this primarily agricultural region) and a maximum in the winter. It is very different from the Upper Rioni Pilot Watershed Area (see figure 3.1 below) where every year since 2007, residential electricity consumption increases sharply in August, then peaks in September, before it again recedes to approximate August levels in October and continues to recede until its minimum in March-April. This trend is also maintained in the commercial sector, although it is not as sharply pronounced. Residential sector consumption maximum is almost 3 times higher than the minimum. On the contrary, in the Lower Rioni Pilot Watershed Area the residential consumption maximum is only 1.3 times higher than the minimum. Among other things this is in an indicator of the relative stable local economic situation indicative of only a minor seasonal population migration, unlike for the Upper Rioni Pilot Watershed Area where such migration is well pronounced.

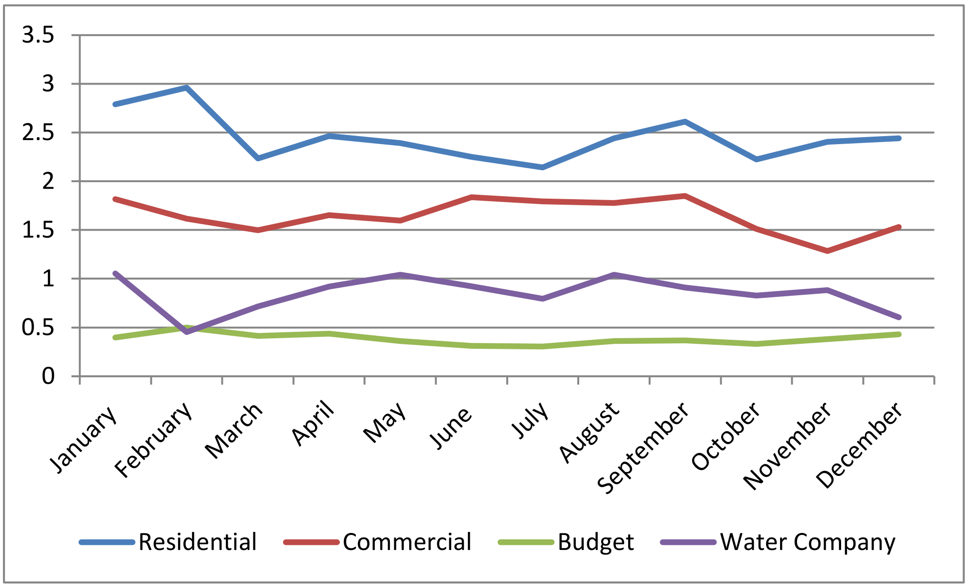
<u>Figure 3.1:</u> Side by side comparison of electricity consumption in the Lower and Upper Rioni Pilot Watershed Areas in 2011 (GWh)





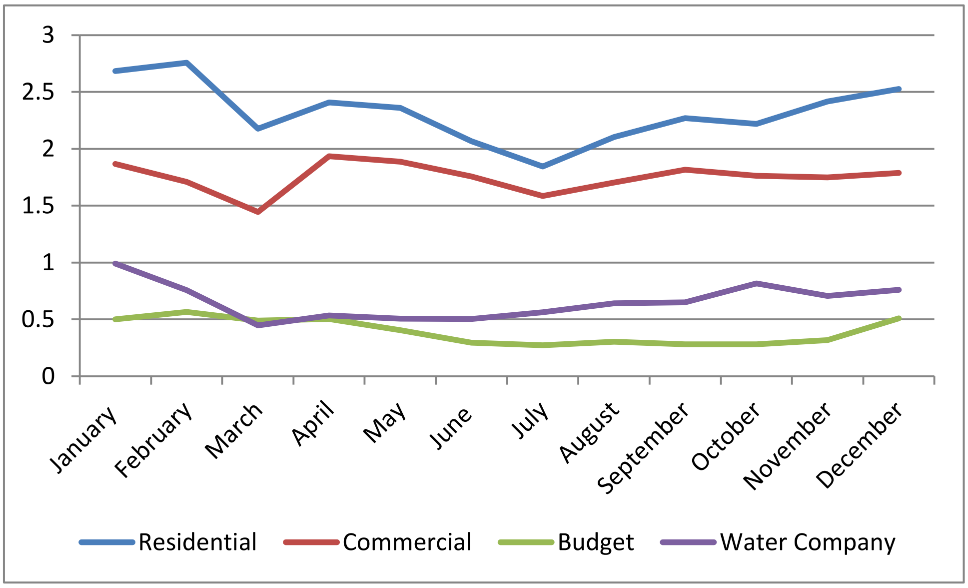
<u>Source</u>: JSC ENERGO-PRO Georgia

Figure 3.2: Electricity consumption in the Lower Rioni Pilot Watershed Area in 2010



***Source:* JSC ENERGO-PRO Georgia**

Figure 3.3: Electricity consumption in the Lower Rioni Pilot Watershed Area in 2009



***Source:* JSC ENERGO-PRO Georgia**

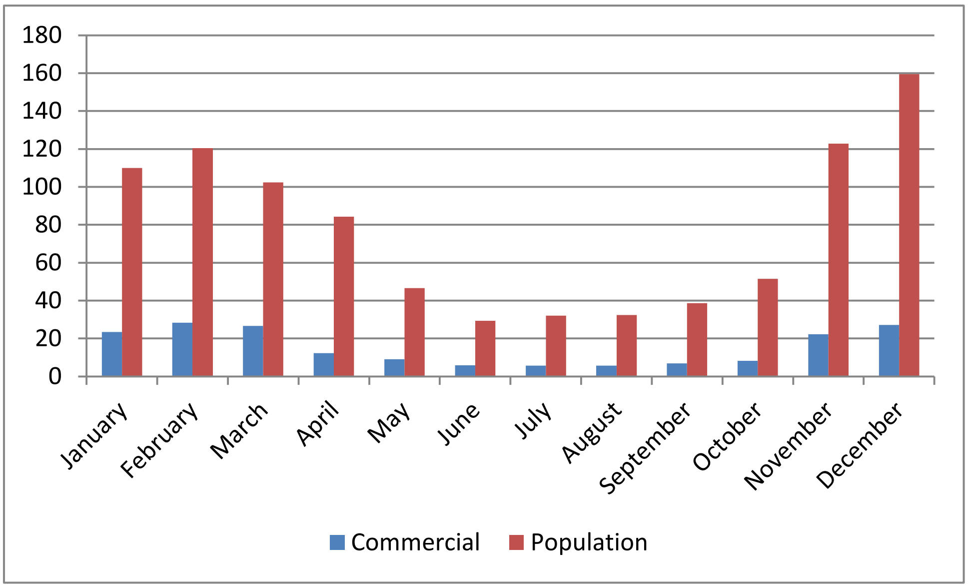
3.1.2 Natural Gas

Natural gas is supplied only to the town of Senaki by JSC Gasko. The number of its customers was 2,200 in 2011, of which 40 were commercial customers. Gas supply was reinstated in Senaki after a long interruption and now is provided to approximately 32% of households.[11]

[11]Excluding IDPs.

Gasko plans to increase the number of customers to about 800-1,000 by the end of 2012. The chart below of natural gas consumption by the types of customers in Senaki shows a typical distribution according to seasonal demand variations with a winter peak and minimum in June (see Figure 3.4 below).

<u>Figure 3.4</u>Natural gas supply trends to the Senaki town residential and commercial consumers in 2011 (thousands m^3)



<u>Source</u>: Gasko JSC

<u>Figure 3.5</u> Gasko office in Senaki

3.1.3 Liquid Fuels

Liquefied propane gas is only sold by two outlets in Khobi. Both are represented by individual entrepreneurs. They both sell approximately 600-700 kg's per month in summer, and 1 ton in winter at a price of about $ 2.10 per kilogram. In Senaki, there are also three individual entrepreneurs, one of whom sells approximately 250 kg per month in summer, and 500 kg in winter; while the other two sell 170 and 250 kg and 300 and 500 kg respectively. The price is the same as in Khobi – $ 2.10 per kilogram. There is also a Socar Energy Georgia outlet in Senaki, with a higher sales volume of about 800 kg per month in summer and 1 ton in winter, at a considerably lower price of $ 1.60 per kilogram.

Figure 3.6 LPG outlet in Khobi

With the price difference mentioned above (and especially the quality of service and fuel), Socar theoretically should have driven smaller entrepreneurs from the market, but this has not happened yet, and these outlets still co-exist.

3.1.4 Fuel wood

As it was mentioned in Chapter 2, the Agency of Natural Resources of the Ministry of Energy and Natural Resources of Georgia in its letter formally confirms that there are not enough firewood resources in Khobi and Senaki municipalities to maintain any information as such. On the contrary, during a field trip to Lower Rioni Pilot Watershed Area, the SDAP team was informed by the local branch of the same agency that in both municipalities fuel wood was allocated and procured. This at least supports the thesis reiterated in all previous reports that the forest sector in Georgia is rather dysfunctional. Here again, as was for instance the case in the upper Rioni pilot watershed, arises a question – where does all the fuel wood needed come from? Even if we do not make our calculations based on the results of the household survey, which indicates on average 14 m^3 of firewood per season per HH, but rather on the “Wood Energy Resources of Georgia and Their Efficient Utilization,” which states that the average household in Georgia consumes 6 m^3 of firewood annually, the population of Lower Rioni Pilot Watershed Area (approximately 30,000 HHs, assuming that none of natural gas consumers use firewood for heating) needs a minimum of 180,000 m^3 of firewood annually.

Table 3.1 Allocated and Procured Fuel wood in Khobi and Senaki Municipalities, Years2010-2011

Year	Wood (m^3)	Khobi	Senaki
2011	Allocated	17,066	4,715
	Procured	11,130	3,418
2010	Allocated	15,403	3,049
	Procured	13,191	2,898

***Source*: Ministry of Energy and Natural Resources of Georgia, Agency of Natural Resources, local branch**

4. Household Energy Consumption Analysis

During afield visit to the Lower Rioni Pilot Watershed Area (Khobi and Senaki municipalities), SDAP Center representatives conducted a household sample survey in order to investigate typical energy consumption patterns on the household level. In order to select households which are representative of a larger population, the SDAP team used the representative sampling method. In this survey a total of 49 households were surveyed, including 7 in the town of Khobi and 14 in two villages located near it (7 in Pirveli Maisi and 7 in Kheta village); as well as 10 in the town of Senaki proper and 18 in two villages of Senaki municipality (9 in Akhalsopeli and 9 in Nosiri).[12] 49 typical residential buildings were randomly selected for survey. The sampling results were extrapolated to make generalization about upper lower Rioni watershed area. The above mentioned methodology allowed estimating typical energy consumption patterns without assessing every single household in the target watershed area.

The survey was conducted using the same questionnaire developed specifically for this purpose, which was also used during the previous surveys, starting with the Upper Rioni Pilot Watershed Area. This questionnaire consists of 6 parts as follows:

1. Household demographics (8 questions);
2. Energy sources used by household (20 questions);
3. Building characteristics occupied by the household (5 questions);
4. Building envelope structure (22 questions);
5. Heating/air conditioning systems (21 questions);
6. Energy expenditures (10 questions).

[12]This report uses the same template as in the Reports 1, 2 and 3 in order to make easier comparisons between different watersheds.

The Lower Rioni Pilot Watershed Area house energy consumption patterns closely resemble those observed in all other pilot watershed areas, although unlike these former areas, which are located in building-climatic zone IIIb (average January temperature -5 to -2^{o} C). The lower Rioni Pilot Watershed Area is located in zone IVb (average January temperature +2 to +6^{o} C).[13] Furthermore, the duration of the heating season in the Lower Rioni Pilot Watershed Area is approximately half of that in Dedoplistskaro or Oni, and is about 2/3 of the duration in the other municipalities reviewed in the previous reports.[14] Nevertheless, in this watershed, like all the three previous watersheds, people say that they heat their houses for six months on average. Of course, one may argue that there may be some exaggerated response of people to the standard questionnaire, although it is hard to imagine such unanimous behavior from 49 randomly selected respondents in 6 different localities. It’s more likely that the standard definition of the heating season duration does not take into account that people begin to feel discomfort when the average daily temperature falls below 10^{o} C for several days. Such discomfort is exacerbated by poorly insulated, un-weatherized houses. In addition for the Lower Rioni Pilot Watershed Area, the majority of house floors are made with concrete pads, sometimes with ceramic tiles, or linoleum lay on top of the concrete, which makes it even more difficult to create comfortable conditions with uninsulated floors during the winter. Again, the poor condition of housing and use of inefficient heaters leads to similar energy consumption patterns during the heating season with the other three watersheds, despite differences found with their climatic conditions. But what is especially important to note is that despite the scarce wood resources in the Lower Rioni Pilot Watershed Area, the population still heavily relies on firewood.

<u>Figure 4.1</u>Typical house (Senaki town)

[13]See სამშენებლონორმები და წესები, სამშენებლოკლიმატოლოგია, სნდა წ პნ 01.05-06, ოფიციალურიგამოცემა, საქართველოსეკონომიკურიგანვითარებისსამინისტრო, თბილისი, 2006, pp. 9-10. Climatic zone is III-B.

[14]op.cit. pp.

Here again the analysis was conducted separately for urban and rural households in order to define similarities and/or differences in household energy consumption more precisely.

Of all households surveyed in the municipality, 36 defined themselves as middle income, while 13 defined themselves as poor. The detailed breakout for urban HHs was 3 poor and 14 of middle income; and for rural HHs the breakout was 10 poor and 22 middle income. Thus, approximately 80% of all urban and 70% of all rural respondents see themselves as in the middle income bracket (about 75% of all HHs). No household ranked themselves as having a high income. Note that out of the 10 poor rural households, 6 lived in a single locality – Nosiri village of Senaki municipality. This situation differentiates Lower Rioni Pilot Watershed Area from all other watersheds, where the share of poor households was much higher. For instance, in the upper Rioni pilot watershed poor households constituted 60% of the total, while in upper Alazani watershed approximately 50% characterized themselves as poor, and similarly in lower Alazani watershed at about 60%.

Unlike the lower Alazani-Iori Pilot Watershed Area, there is just one household in the Lower Rioni Pilot Watershed Area with no permanently employed member among the urban population and there are none as such among the rural HH. Although here too it is evident from the responses to the question about permanent employment that agriculture is normally not considered as such.

Most jobs are found in the public sector, private industry, services, and in agriculture. Here, unlike in the other watersheds, businesses and especially public sector employment strongly outnumbers agricultural employment even for rural settlements. This fact also shows why middle income HHs strongly outnumbers the poor ones in this particular watershed. Note that for all 6 poor HHs reported in Nosiri village, agriculture was reported as their main employment activity.

Figure 5.2 A typical house in Khobi town. Virtually all houses here (as elsewhere in small town and rural Georgia) have stairs connecting the first and second floors outside, which divides these houses into two isolated heating zones during winter.

All households were provided with a guaranteed electricity supply and all had individual meters. The level of consumer satisfaction was high. Out of 17 urban respondents,13 HHs were completely satisfied, 2 were partly satisfied, and 2 were dissatisfied. In the rural area only 2 of the 32 respondents were not satisfied, while 8 were partly satisfied.

Urban households consume approximately 190 kWh electricity per month, although more affluent families use 300 kWh/month or more. Just 1 out of 13 urban households consumed less than 100 kWh/month. Household spending for electric power was about $ 220 annually, although there are exceptions (in the case of higher income families), when this may run above $300. In rural areas an average household consumed about 150 kWh of electricity per month, spending $ 150 per year.[15] Ten of 36 rural HHs consumed less than 100 kWh per month.

Unlike the Lower Alazani-Iori Pilot Watershed Area, for the Lower Rioni Pilot Watershed Area natural gas was supplied to only 2 of the urban households in Senaki. Khobi as a whole and rural Senaki have no natural gas supply. Based on this limited data, it is not possible to draw any useful conclusions, especially since one of these households consumes only about 35 m^3 of gas per month (on par with other urban households in other watersheds) and heats just one room (20 m^2) with a wall-mounted gas heater. While the other HH has central heating, which serves the entire ground floor (116 m^2). This household consumes about 130 m^3 of gas per month on average, with corresponding annual expenses of $ 480 per year.[16]

All other urban and rural households were using liquefied gas (LPG) for cooking. LPG gas costs about $ 2 on average per kilogram, although it was reported to be more expensive in the town of Khobi at $ 2.14/kg. Urban households consumed about 9.5 kg LPG per month, with corresponding annual expenses of $ 237. The rural household reported using 7.3 kg/month with annual expenses of $ 172. Both urban and rural HHs in this watershed consumed (and spent) considerably more on LPG than elsewhere.

The largest single household expense is related to energy. It is mainly used for heating during the winter, for at least 6 months per year. Almost all surveyed households used firewood as their main source of energy. Unlike in the other watersheds, here the share of HHs that obtains firewood through their own logging is relatively high. In rural Senaki there are 4 such HHs out of 18 total; in urban Senaki there are 2 out of 8 (two HHs did not use firewood at all-see above); in rural Khobi there there are 4 of 14; and in urban Khobi there there are 2 out of 7. The problem is that in this watershed –depending on the data provider (see 3.1.4), there is no or very little wood set aside for logging. In all cases for the other watersheds, people who did their own logging in areas with good firewood resources, complained that this was a (sometimes very) difficult undertaking. Here, on the contrary, many said that such logging was *very easy* and if there was a complaint, it was only about the difficulty of transportation over a long distance (reported as about 18-20 km). Such a situation raises a number of questions about the origins of this wood, as well as its legality.

[15] Formal calculations led us to the annual spending of US$ 175 per year, although this results from the extremely high (by the Georgian standards) consumption of the single household in Khobi municipality (Kheta village), which consumed approximately 700 kWh of electricity per month for an annual cost of US$ 840.

[16] These expenses are the highest ever registered in all 4 Watersheds for all surveys. These people also consumed about 400 kWh electricity per month and in the end paid about US$ 960 for energy per annum (also the highest amount observed), while allocating only about 20% of the household budget.

One HH in Nosiri village (Senaki municipality) used hazelnut shells for heating, which were obtained from the local hazelnut processing factory, where one of the HH members worked. They used about 3 tons of such shells for heating 2 rooms (50 m^2) for 6 months of the year. One ton costs approximately $ 90. After a long internet search we were able to approximately calculate that the kilogram per kilogram energy value of hazelnut shells is approximately 1.7 times higher than this of beech firewood, the most widespread in Georgia. Still, this same HH cannot use this obviously better fuel more efficiently than other HHs that use firewood due to inefficient heaters and uninsulated houses. On the other hand, hazelnut shells, especially after carbonization and briquetting, are used in Turkey for instance (as well as other hazelnut producing countries) as highly efficient fuel.[17] Considering this, the organization of the same kind of hazelnut processing in Georgia can be highly recommended, especially that this is the waste product, which if properly used can replace plenty of firewood.

Again, as different from the Upper Alazani and Rioni Pilot Watershed Areas, there was one urban household which had a natural gas fired central heating system and hot water supply system installed for the whole floor of the house; 1 urban household used a wall mounted natural gas space heater; 3 urban and 8 rural households used a supplementary electric space heater; 1 urban household had a natural gas water heater; and 6 urban and 6 rural households had electric water heaters. 1 rural household used a split air conditioning system.

Still 15 urban households used firewood, as well as all 32 rural households. Urban households that purchased firewood at the market spent on average $330 per year, while rural households spent $385. Urban households spent approximately $26 per m^3 of firewood, which is considerably cheaper than for the other watersheds, while rural households spent about $ 30, which is also cheaper than in Watersheds 1 and 2. Rural households reported using 13m^3 on average per heating season, while urban households used 15 m^3 on average, which is much more than in other watersheds. Although respondents in the Senaki municipality (both urban and rural) reported consuming approximately 10-11 m^3 of firewood (i.e., on par with other watersheds), while respondents in Khobi claimed to annually consume about 17 m^3, which is suspiciously high, although it is difficult to verify whether this reflects the actual situation.

People who obtained firewood through their own logging efforts annually consumed approximately 17 m^3 in urban and 15 m^3 in rural areas. This cost them considerably less than that purchased on the open market – depending on the locality – 3.5 to 5 times less. While the majority of HHs which bought firewood on market complained about its availability, the majority of those who did their own logging were satisfied with the process and availability. Although, once again, no HH reported the difficulties of the type which people experience in Dedoplistskaro, where all respondents, both poor and relatively affluent, characterized firewood as very expensive and difficult to access.

Questionnaire–*Does your existing heating system creates comfortable conditions?* Just 2 urban respondents answered – Yes, Always. Eleven (more than half) said that it creates comfortable conditions from time to time. Four said that they are dissatisfied. Fourteen rural respondents answered that heating always created comfortable conditions, 19 (out of 32) answered from time to time, and 6 were dissatisfied.

[17] http://www.iaeng.org/publication/WCECS2010/WCECS2010_pp739-741.pdf

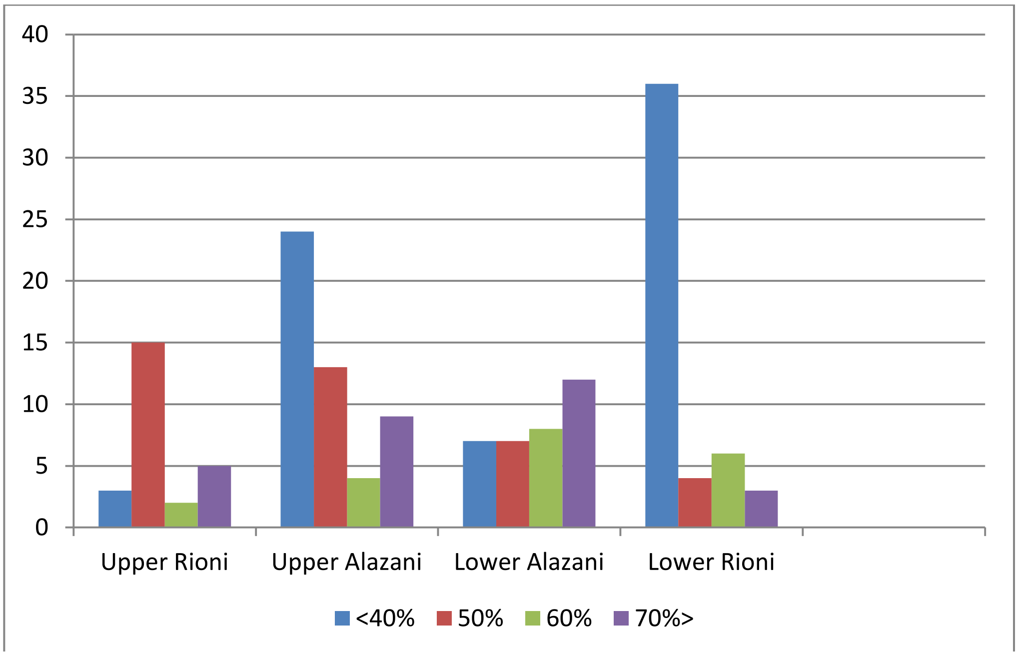
Total or partial dissatisfaction for heating was primarily ascribed either to poor insulation of buildings or inefficient heating systems, or both. The wide dispersion of opinions of this kind is considerable depending on the watershed, as well as if it is an urban or rural locality. Considering that almost all households used the same kind of heating and live in similar houses, the above answers may be mostly ascribed to subjective perceptions, rather than to real differences.

Questionnaire- *Are heating expenses justified from the household budget expenditures point of view?*
Three urban households said no; five said yes. For the remaining 9 HHs (i.e., half), these expenditures were only partly justified mainly because they only heated parts of their homes. Among rural respondents 14 consider such expenses as justified, just 2 as unjustified and for the remaining 16 as partly justified, i.e. unlike the other watersheds, here the subjective level of justification of expenses is rather high.

Only 5 households intentionally replaced some incandescent bulbs with modern fluorescent bulbs and were interested in energy efficiency (these people use 2-3 energy efficient bulbs maximum). In all other cases people live under self-enforced saving conditions. They simply switch off lighting throughout the house save for a single room, where they use old incandescent bulbs.

Questionnaire- *What part of the household annual budget do you spend on energy?* Among 17 urban households the vast majority, 13 answered less than 40%; 1 as 50%; 2 as 60%; and 2 answered 70% or more. Among 32 rural households 23 (again the vast majority) spent less than 40%; 3 as 50%; 5 as 60%; and just 1 as 70% and more.[18]When a household reports that more than 70% of their annual budget is spent on energy this may look somehow exaggerated, and appears inflated.

Figure 4.3 comparative energy budgets spending by pilot watershed areas (number of HHs)

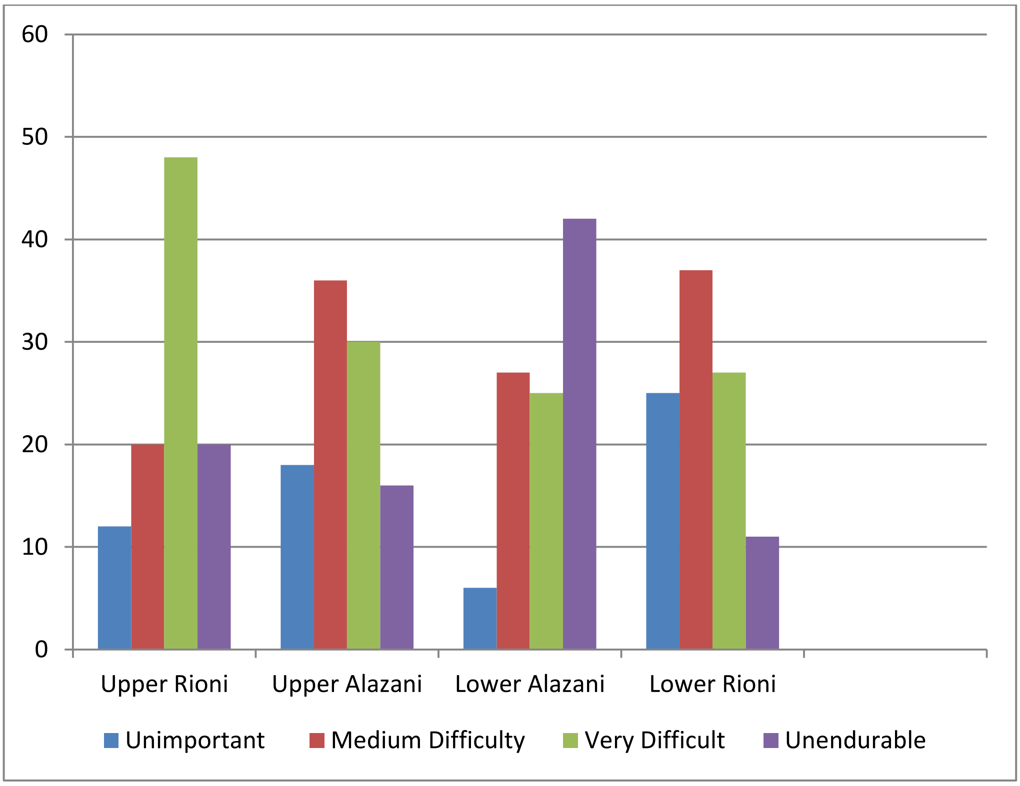


[18]In this watershed, unlike the others, when people report that they spend less than 40% of their budget on energy, in the majority of cases this means that they spend 15% or less.

Of 17 urban households 4 households rated *energy expenditures* as not a problem; 4 respondents described energy expenses as medium difficulty; 5 HHs rated as very difficult, and 4 HHs as unendurable. Among the rural households, for 8 energy expenditures posed no problem, 14 considered them as of medium difficulty, 8 as very difficult and 2 as unendurable. That is, in the Lower Rioni Pilot Watershed Area more people considered such expenses difficult to unendurable among urban households than in rural ones.

In this respect the Lower Rioni Pilot Watershed Area and the Upper Alazani Pilot Watershed Area considerably differ from the other watersheds, since the share of HHs for which energy expenditures pose no problem to medium difficulty is about 50%, while in Watersheds 1 and 3 2/3 of HHs found such expenditures as very difficult or unendurable (see Figure 4.3). Among other things such a distribution of energy expenditure perceptions clearly helps establish the relative level of population incomes and well-being within the watersheds.

Figure 4.4 Comparative perceptions of energy expenditures in different pilot watershed areas (as % of total HHs)



The type and state of housing, which these households occupy also plays an important role from an energy consumption point of view. As discussed before, heating is the main consumer of energy for any given household, and its effectiveness is to a large extent reduced due to poor or no building envelope insulation.

Here as well as almost anywhere in Georgia during the winter people vacate all rooms in the house, save one or two (rarely more), in which a wood stove is installed (sometimes supplemented by electric heater(s). They live there, often cook, and sometimes (depending on the size and composition of the family) they retire to unheated rooms during the night under heavy bed covers, sometimes not. As it was stated in comments for Figure 4.2, the outside stairs virtually divide the houses into two semi-independent parts; and second floors are not usually used in the colder part of the year. All households use heating only during the daytime hours.[19] This is absolutely the same as was found in all the other watersheds, irrespective of income and social status of respondents.

By heating premises only during the daytime, homeowners simply endure a situation of expensive discomfort. Among urban households in 14 cases families used heating for only 1 or 2 rooms with an average area of 15-35 m^2; in two cases there were 4 heated rooms with more than 100 m^2 area; and in 1 case the family heated 3 small rooms with a total area of 55 m^2. In rural areas out of 32 total HHs, 27 of them heated 1-2 rooms with an average area of 20-40 m^2. In 2 cases 3 rooms were heated and in 2 more cases – 4 rooms (although in one such case 120 m^2 of area was heated and in another just 70 m^2 due to varying room size).

Many houses are built from common cement blocks or stone, which are characterized by a heavy thermal mass, and since they have no insulation they also suffer from high heat losses. It is very difficult to provide comfortable conditions in such housing due to the high thermal inertia and low wall R values, especially using inefficient traditional wood stoves. Window frames are made of wood with single glazing, again thermally inefficient, characterized by low R-values and large heat losses. Uninsulated doors are not much better than the windows only with sturdier frames. Roofs and ceilings generally are without adequate or any insulation, and are also characterized by high heat losses. Furthermore, houses are not designed to take advantage of basic passive solar design concepts that could further reduce heating needs by 20% or more.

In this case it was decided to approximately estimate (for demonstration purposes) how much the typical household spends on average to heat 1m^2 if only using firewood. It turned out that the average urban HH heats about 20 m^2 and spends about $ 16 per m^2 of heated area (during a 6-month long heating season) if firewood is purchased on the local market and $ 5 if the firewood is self-logged. The average rural HH heats about 24.5 m^2 and also spends about $ 16 per m^2 of heated area if firewood is purchased on the market and $ 3.5 if the firewood is self-logged. On the other hand, based on actual observations, a HH in Tbilisi, living in a typical Soviet era apartment block in the flat of approximately 100 m^2 area, outfitted with double glazed metal-plastic windows and balcony doors, with a modern central heating, spends for the same purposes about $ 4 per season. In summary, firewood heating for uninsulated homes is extremely inefficient from a purely financial point of view, even without taking into consideration all of the other associated factors like reliability, safety, ease of use and improved comfort conditions, which are altogether absent for traditional wood stove heating. This also means that relatively less well-to-do HHs are financially punished for the inability to install and use more efficient heating implements and properly weatherize their homes.

Since the amount of firewood used by HHs in the Lower Rioni Pilot Watershed Area is higher than for other watersheds (a case, which obviously needs further research), it was decided to compare it with upper Alazani watershed, which shares some characteristics (see above) with the former. In this latter it costs the average HH about $ 8 to heat per m^2 of area (i.e. half of what it costs in the Lower Rioni Pilot Watershed Area), but it is still much higher than if the home is well weatherized, insulated and outfitted with modern central heating.

A summary of a typical household (HH) survey results for Lower Rioni Pilot Watershed Area is as follows:

[19]Obviously save the one, which has central heating.

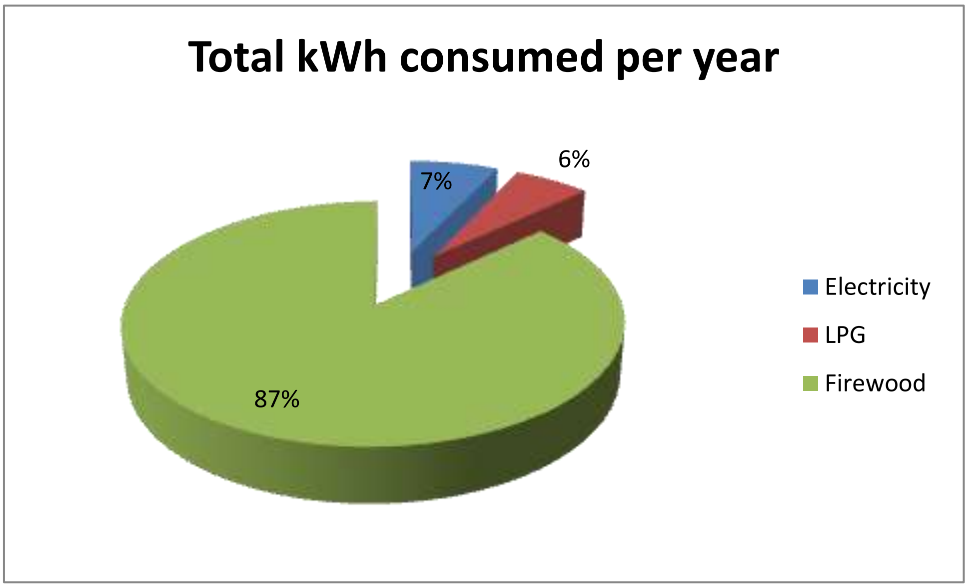
An average urban household consumes about
~2,130kWh of electric energy per year
~1,499 kWh of liquefied gas (LPG)[20]
~29,014 kWh of firewood

Thus, an average total of about 32,643 kWh of energy is consumed annually for a typical household without natural gas supply.

Table 4.1 Annual Urban Household Average Energy Expenses

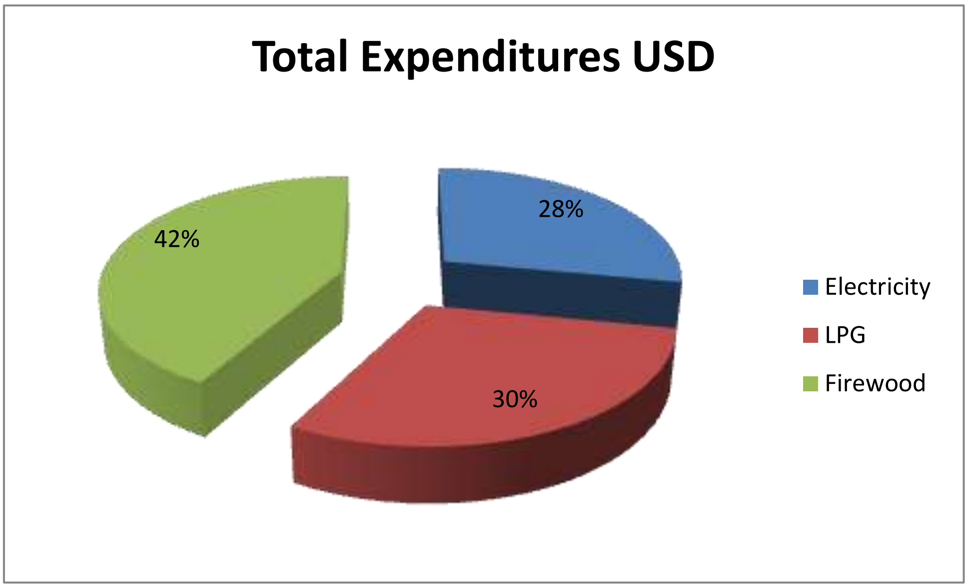
Fuel Type	Total kWh Consumed per year	Price per kWh $	Total Expenditures $
Electricity	2,130	0.102[21]	218
LPG	1,499	0.17	237
Firewood – purchased on market	28,803	0.015	425
Firewood– self-logged	29,815	0,004	105
All energy-			
Households with Firewood – purchased on market	32,432	-	880
Households with Firewood -self logged	33,444		560

Figure4.6 Annual Urban Household Average Energy Consumption(HH without natural gas)



[20] We deliberately excluded 2 households with a natural gas supply from these calculations due to a large difference in consumption patterns that are not deemed representative.
[21] Weighted average price.

Figure 4.7 Annual Urban Household Average Energy Expenses (HH without natural gas)



This data were arrived at through the following calculations, similar to those used for the Upper Rioni Pilot Watershed Area:

Electric energy – measured in kWh by metering as provided by the local electric power company;

1 m^3 of natural gas supplied to Georgia has an energy content of about 9.36 kWh on average;

LPG – 1 kg of LPG – 12.87 kWh;[22]

The firewood caloric value was calculated for beech firewood, which is the most widespread. Depending on moisture content it varies between 1,672 and 1,888 kWh for m^3 of stacked logs, or1,780 kWh on average.[23] We used this average since the moisture content of air dried beech logs is not available.

An average rural household in the Lower Rioni Pilot Watershed Area consumes about

~1,800 kWh electric energy per year
~1,126 kWh of liquefied gas (LPG)
~25,092 kWh of firewood

Thus, an average total of about 28,018 kWh of energy is consumed annually for a typical household without natural gas supply.

[22] http://www.volker-quaschning.de/datserv/faktoren/index_e.php
[23] http://nuke.biomasstradecentres.eu/Portals/0/D2.1.1%20-%20WOOD%20FUELS%20HANDBOOK_BTC_EN.pdf

Table 4.2 Annual Rural Household Average Energy Consumption and Expenses

Fuel Type	Total kWh Consumed per year	Price per kWh $	Total Expenditures $
Electricity	1,800	0.097	175
LPG	1,126	0.12	172
Firewood – purchased on market	24,528	0.016	384
Firewood - self logged	26,700	0.003	85
All energy-			
Households with Firewood – purchased on market	27,454	-	731
Households with Firewood -self logged	29,626		432

Figure4.8 Annual Rural Household Average Energy Consumption(HH without natural gas)

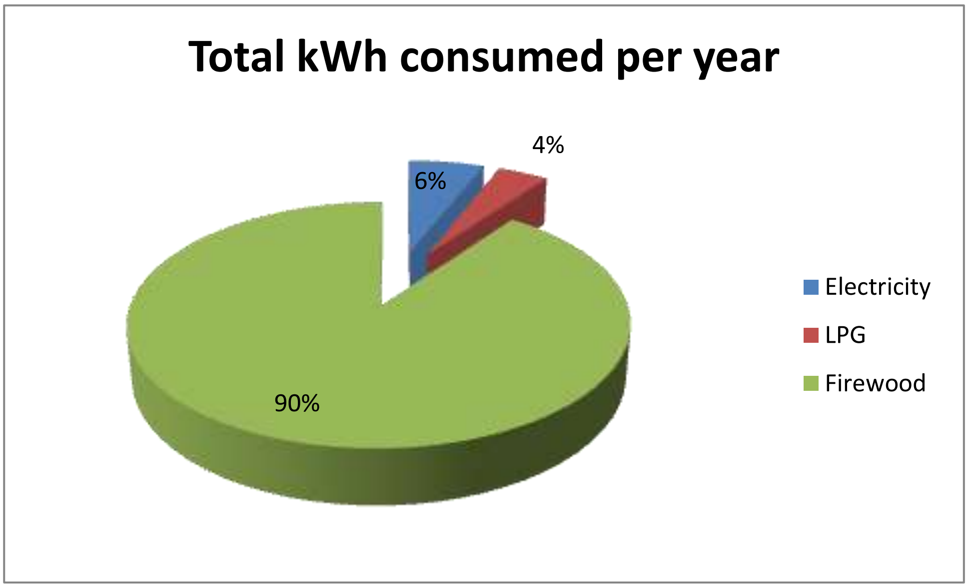
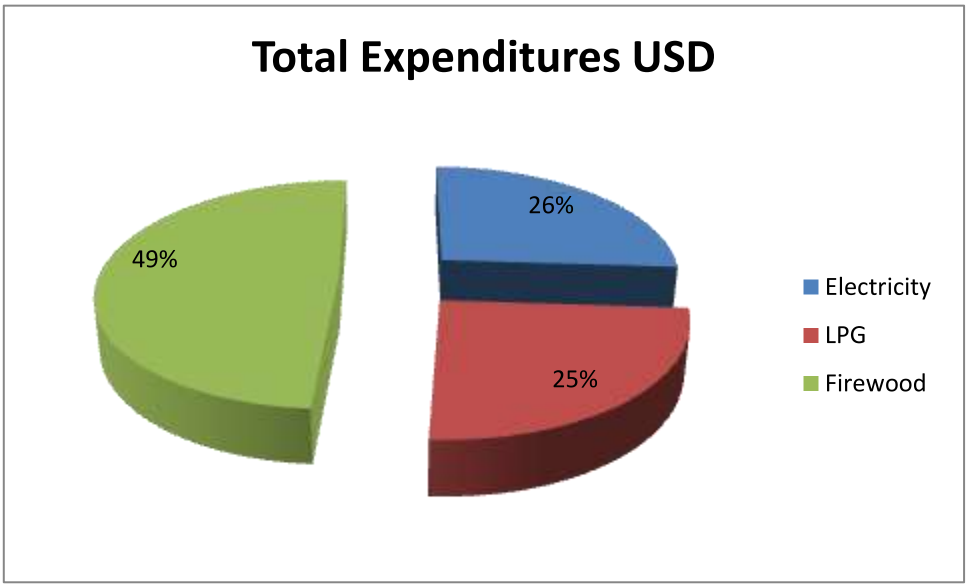


Figure 4.9 Annual Rural Household Average Energy Expenses(HH without natural gas)



A comparison of urban and rural households' energy consumption shows that an average rural household consumes 85% of the electricity as consumed by the average urban household; it also consumes 75% of the LPG, and 85% of the firewood purchased on market and 82% of self-logged firewood, i.e., an average rural household consumes about 85% of all energy consumed by the average urban household. Obviously, the ramifications of not having a natural gas supply network in this watershed is a huge drawback, which precludes the population at large from installation of more efficient heating implements using such fuel. Thus the most important issue that emerges here (as well as in the case of HHs in other watersheds without a natural gas supply), is the provision of basic weatherization and replacement of existing inefficient woodstoves with more efficient ones. For now the replacement of firewood by much more efficient wood pellets does not seem viable due to an undeveloped market chain. It turns out that there appears to be just one small scale pellet producer in Georgia; pellets require absolutely different kinds of special stoves, which are very expensive by Georgian standards (and not readily supplied to the country). The US consumer guides or specialized shops' advertisements for instance, put retail prices of such stoves at $ 1,100 minimum, and $ 1,400-3,000 on average.[24]

Table 4.3 Annual Household Average Energy Expenses

Energy Type	Total kWh Consumed per year	Price per kWh US$	Total Expenditures US$
Electricity	1,965	1.0	175
LPG	1,312	0.15	172
Firewood – purchased on market	24,528	0.016	384
Firewood - self logged	26,700	0.003	85
All energy-			
Households with Firewood – purchased on market	27,454	-	731
Households with Firewood -self logged	29,626		432

Comparison of energy consumption and expenditures of the Lower Rioni Pilot Watershed Area, relative to the Upper Rioni and Alazani Pilot Watershed Areas (households with LPG and firewood purchased on the market), shows many similarities despite considerable differences in natural-geographic and socio-economic conditions.[25] Nationally, firewood for winter heating dominates both energy consumption and spending again and emerges as the main issue for the watershed (i.e., municipal) level energy sector in Georgia. The summary tables and charts also confirm again the thesis that energy provision and consumption are where the poorest HHs suffers the most. In the Upper Rioni Pilot Watershed Area, which is among the least developed and poorest among all Georgian regions; firewood provides considerably more energy and consumes more money (as compared to other kinds of energy expense) than elsewhere.

[24] See for example http://www.woodpelletstoves.net/buying.html, http://www.homedepot.com/webapp/catalog/servlet/ContentView?pn=KH_BG_HF_Wood_Pellet_Stoves

[25] lowerAlazani-Iori Pilot Watershed Area did not fit into this comparison since almost all HHs interviewed there were supplied with natural gas.

Table 4.4 **Comparative Household Energy Consumption in the Upper Rioni and Alazani Watershed Areas and the Lower Rioni Watershed (Households with LPG)**

Energy Type	Upper Rioni pilot watershed		Upper Alazani Watershed		Lower Rioni Pilot Watershed Area	
	Total kWh Consumed per year	Total Expenditures $	Total kWh Consumed per year	Total Expenditures $	Total kWh Consumed per year	Total Expenditures $
Electricity	1,344	108	1,513	142	1,965	175
LPG	352	53	888	151	1,312	172
Firewood – purchased on market	19,358	581	17,444	366	24,528	384
All energy	21,054	742	19,845	659	27,454	432

Figure 4.10 **Comparative household energy consumption in the Upper Rioni and Alazani Pilot Watershed Areas and the Lower Rioni Pilot Watershed Area (households with LPG) in total kWh consumed per year**

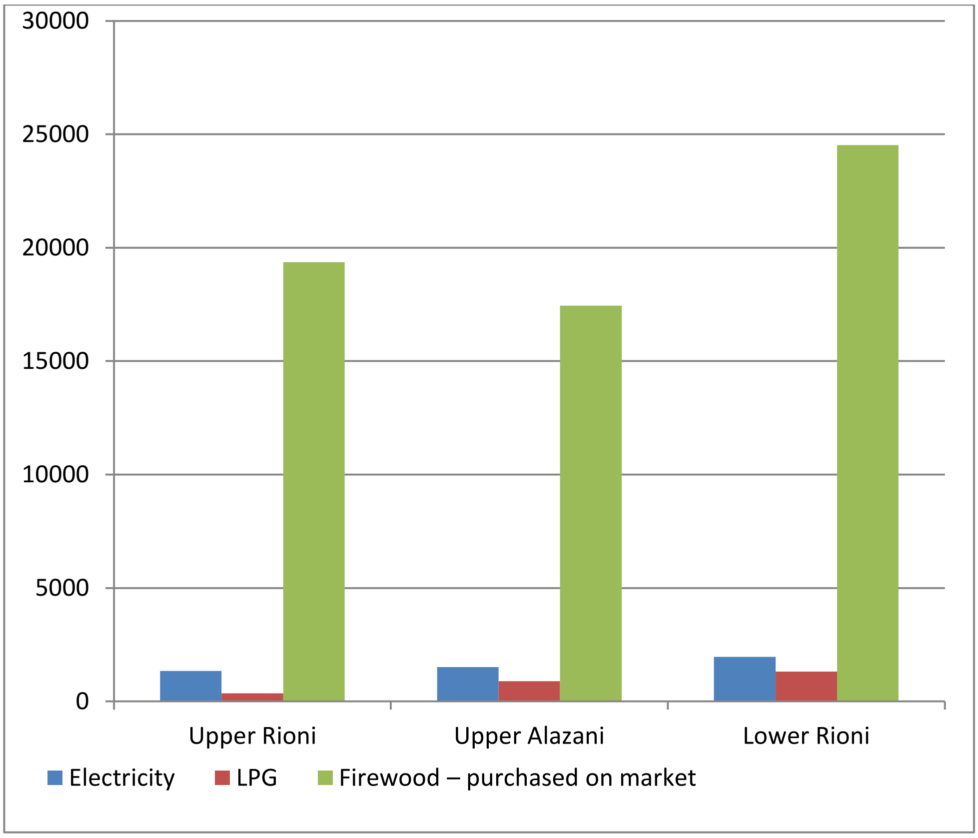
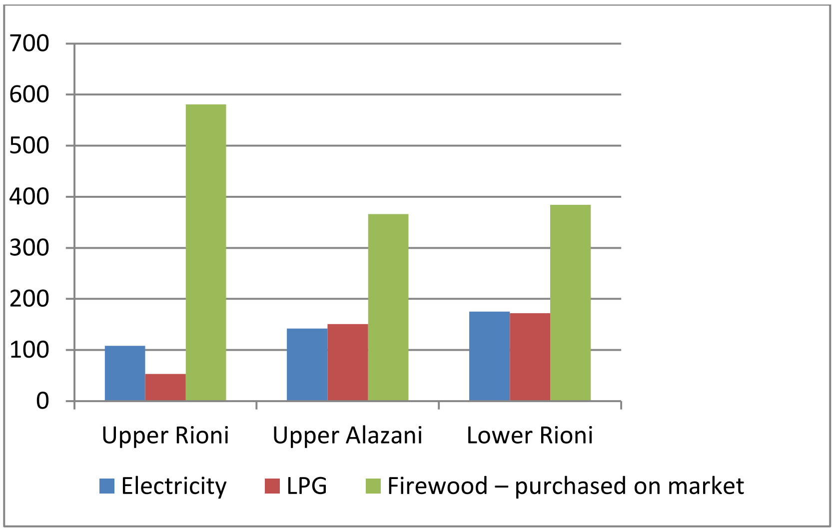


Figure 4.11 **Comparative household energy spending in the Upper Rioni and Alazani Pilot Watershed Areas and the Lower Rioni Pilot Watershed Area (households with LPG) in total $ per year**



5. Local Government and the Energy Sector

As was mentioned in the previous reports for the Upper Alazani and Lower Alazani-Iori Pilot Watershed Areas, there is no apparent legal framework for cooperation between the local municipal governments and the commercial energy sector. Even if Khobi and Senaki municipalities are geographically, culturally, etc. rather far removed from the Kakheti region, they operate on the same template as Akhmeta, Telavi or Dedoplistskaro municipalities. The single most important item of cooperation between the municipal governments with the energy service companies is energy (primarily for electricity), which is provided to various municipal bodies and organizations for administrative buildings, street lighting, etc.

Unlike Dedoplistskaro municipality, which receives almost no positive benefits from the Frontera Georgia oil company operating within its territory, Khobi municipality directly benefits from the presence of the Kulevi Oil Terminal. Although this terminal is one of the most environmentally controversial projects implemented in Georgia during the post-Soviet period, it provides 65-70% of the overall Khobi municipality tax revenue. It provided to the local budget in 2011 3,349 thousand GEL as property tax, 1,678 thousand GEL as land tax, and 1,112 thousand as non-agriculture land tax.[26] In addition, the terminal also participates in local social development projects in Khobi and for instance recently repaired the Kulevi public school during the summer of 2012.[27]

In this report, as in the previous one, it was attempted to establish the energy consumption patterns of municipal facilities. There were 22 facilities at the end of 2011 (municipal administration and village communities' administration buildings, as well as other facilities) in Khobi, as reported by the local authorities. All of these were supplied with electricity (but 4 did not have individual meters). Of these 63% of the energy was consumed by the Khobi municipal building, which is heated and cooled by split air conditioners (see Figure 6.1). 20% of the

[26] http://www.khobi.ge/index.php?location=tree_elements&id=433&slave=316&lang=

[27] http://www.kulevioilterminal.com/index.php?option=com_content&view=article&id=314%3Akulevi-oil-terminal-has-conducted-repair-works-at-the-kulevi-public-school&catid=43%3Aevents&lang=en

electricity was consumed by the local cultural center, which is a rather exceptional phenomenon among all the municipalities reviewed where cultural facilities were usually the last to be provided with electricity.

Figure 5.1Khobi municipal administration building. There are split air conditioners used in almost every office

The village community administrations consumed very little electricity, sometimes less than 40 to even less than 30 kWh/month (as was formally reported). Some did not even report any electricity usage during the summer with the long daylight hours. All use firewood for heating, approximately 4.5 m^3 per administrative building for the heating season. This wood is purchased at a price of $ 30 per m^3, which is close to what the population reported about their own firewood purchase price. This amount of firewood is 2.8 times higher than is used by the Dedoplistskaro municipality for its own facilities.

There are also 23 kindergartens as well as an educational center united under the umbrella of a separate legal entity, as found elsewhere in Georgia, although they all belong to the municipality. Of these 1 did not have an individual electric meter. 12 kindergartens had no electricity for 1 to 2 summer months. Some kindergartens reported consuming 5-10 kWh/month of electricity, which essentially means that they are not supplied power. All together 23 kindergartens consumed just 2/3 of the local cultural center electricity consumption, and just ¼ of the municipal administration building consumption.

All kindergartens used firewood for heating, of which 19 consumed 10 m^3each per heating season. Also all kindergartens used LPG for cooking, usually more than 60 m^3 per year and in 2 cases more than 200 m^3 annually.

One of the main issues which emerged while dealing with the municipal administrations is that despite all the recent efforts to reorganize and improve their activities, their reporting formats differ to a large extent and often are not compatible. Senaki did not provide information about most of its municipal facilities, for instance concerning 15 local libraries, sports schools, and even the vast majority of local administrative buildings. Khobi also did not provide information about 11 libraries, museums, etc. To obtain this additional data would require canvassing each facility and is beyond SDAP's scope.

There is more or less complete data only for the 21 Senaki kindergartens, which are almost totally in compliance with Khobi (as well as Kakheti) data. Nine of these do not have individual meters, two kindergartens consume 7 to 8 kWh of electricity per month on average, and only two consume more than 200 kWh/month, and 3 about 100 kWh/month. Even the highest consumption figures mean that kindergartens minimize use of electricity. On the other hand, all kindergartens consumed more than 100 m^3 of LPG per year, of which 3 consumed more than 300 m^3, and one – 440m^3. These are the highest amounts observed so far among all municipalities. Kindergartens were also rather well provided with firewood for a minimum of 10 m^3 per heating season, with a maximum (in two cases) of 30 m^3.[28] One kindergarten "Otsneba" (Dream) was heated by electric resistance heaters.

Based on the above numbers, it is possible to draw some conclusions about kindergartens, for which it seems are able to provide only a limited amount of comfort and work conditions both for their personnel and pupils.

Conclusions and Recommendations

Not surprisingly, the overall basic conclusions found from the three previous reports on the Upper Rioni and Alazani and Lower Alazani-Iori Pilot Watershed Areas can be applied without much alteration to the Lower Rioni Pilot Watershed Area as well. The most important item is to "wrap up" the results and conclusions for all 4 analyses in order to formulate the local development priorities from the energy sector point of view.

The key point is that currently in Georgia the federal government is firmly committed to maximizing electricity production based on the construction of numerous relatively small HHPs, predominantly in Western Georgia. Even if such an approach is not the optimal from both a technology and economic standpoint, not to mention environmental considerations which have yet to be considered; this is an ongoing process working towards positive improvement in the electricity supply of this country. If any local level interests are taken into consideration in The State Program "Renewable Energy 2008" - (Georgian Government Decree #107 April 18, 2008), they are not explicitly formulated or articulated.

The same consideration might be applied towards the development of a natural gas supply network, which gradually improves natural gas supply in Georgian regions. This process again is "too large" for local governments to be directly involved, although they may lobby gas distribution companies and/or federal government to "streamline" applications for specific communities, as well as to (co)finance gasification, which they are sometimes actually implementing (see the report on Upper Alazani Pilot Watershed Area).

[28] Although this means that such facility uses on average as much fuel as an average household.

On the other hand, as discussed in all 4 watershed reports, the main energy sector issue is not energy supply and distribution *per se,* but rather a shortage of alternative options primarily for the population and local government organizations (especially pre-school, libraries, museums and the like), which is characterized by the inefficient and often wasteful use of available, but rather expensive energy (mainly through firewood for heating). This excessive use of firewood also contributes to deforestation, as well as much higher CO_2 emissions due to inefficient woodstoves.

As was stated in all 4 reports such a situation is caused by inefficient heating equipment, poorly insulated buildings, poor building orientation and design, non-weatherized houses, and an absence of knowledge on viable alternatives.[29] Considering that heating with wood stoves consumes considerably more than half of the household's energy budget, and that the households are in turn the largest energy consumers in all reviewed watersheds, there are tremendous opportunities for improvement at relatively low cost. This thesis is also supported by the finding that the poorer a HH is, the more it is "punished" from both a financial and an operational comfort point of view due to such poor energy system efficiencies.

The above considerations lead to the real need for formulating and implementing comprehensive and integrated energy saving and energy efficiency policies. The issue is that currently the Georgian government has no plans as such, with Georgia remaining almost the only post-Soviet country without any legislative documents dealing with energy efficiency. Moreover Georgia so far does not even have a minimum building code, which defines and imposes energy efficient construction norms.

Thus, on one hand there is a clear need for intervention by the local governments at any level (starting from village communities), since obviously no one else can (nor wishes) to take care of the day to day energy problems of the population; but on the other hand they do not have any formal guidelines and incentives to do so in the absence of formal regulatory instruments and incentives. Moreover, there is little understanding about the type and scope of this problem in general, and it has undergone a partial analysis only through the 4 watershed reports.

These are rather complex socio-economic, energy, and environmental issues, which are not well understood by local decision-makers who are not aware of viable policy alternatives. Stemming from this we see the development of an energy passport electronic program as an instrument to help the local governments and other interested stakeholders evaluate the severity and extent of the existing energy problems in the relevant watersheds, as well as to prioritize these problems in order to develop appropriate instruments to solve, or at least help ameliorate them.

Although even before developing energy passports it is possible (and advisable) to work within the INRMW program to assist local communities in developing and implementing some of the low-cost simple weatherization measures, as well as replace inefficient wood stoves with more efficient ones (possibly even start a local industry to manufacture affordable pellet stoves for widespread use). Similarly, to implement the procurement and installation of efficient natural gas heating equipment where it is possible (see report on lower Alazani watershed). See below the standard set of recommendations applied to every watershed under consideration.

[29] By the way poorly insulated houses are not only a Georgian problem. Examples can be found even in some of the most developed countries, although such problems are normally understood and government energy plans are normally made to fix the situation. See: http://www.france24.com/en/20120914-frances-hollande-outlines-green-energy-policy

The recommendations developed for the Upper Rioni and Alazani Pilot Watershed Areas as well as for the Lower Alazani-Iori Pilot Watershed Area are applicable to the Lower Rioni Pilot Watershed Area Area as well. These are to:

- Organize an **educational campaign** aimed at familiarizing the local population with the most elementary energy saving and energy efficiency measures, which almost every household can implement independently, including trainings for local population on building energy efficiency issues;
- Develop a "simple"/low cost energy efficient **weatherization measures** for low income rural population;
- Develop a **weatherization service center** unit for implementation of the above measures in housing;
- Set up small **wood stove fabrication workshops** in the region for making energy efficient wood stoves to be sold to local population. Such efficient wood stoves reduce firewood needs by 1.5-2 times and would create local cash paying jobs. Additional positive effect of the implementation of this measure will be reduction of fuel logging with associated environmental benefits. This measure also will contribute to safety issues as well as to improvement of the indoor comfort conditions.
- Carry out **wood stove testing** procedures of the energy efficient wood stoves aimed at establishment of a wood stove certification unit as a strategic goal.
- Undertake **inventory of public buildings** within each pilot watershed with corresponding energy audits of select public buildings
- **Organize trainings** for the municipality staff in order to raise awareness on the energy efficiency issues for proper decision making.

In addition, the SDAP considered various off-grid renewable energy solutions to be applicable for use in any of four pilot watersheds. As it was already mentioned in the previous reports, the local population obviously gives priority to such energy technologies which can be run with minimum or even no maintenance and running expenses after installation. Such preferences for instance cast doubt on the feasibility of recommending construction of off-grid HHPs, especially taking into account that the Georgian government is firmly committed to the maximization of hydro energy production in the country to the excess of covering all local electricity needs by such energy. Thus we concentrated on carrying out some kind of feasibility assessment of other kinds of renewable energy, namely solar, biogas and wood pallets. Dr. K. Melikidze provided the following data, based on her findings:

Solar energy. The price of a standard (2 m^2) solar panel on the Georgian market (installation included) is approximately $ 1,000-1,400, depending on the producer, size, and panel model. This is typically for a solar evacuated tube collector that provides about 2,000 kWh of energy per year under average Georgian conditions. This is more than enough to supply hot water to the majority of households in any watershed under consideration, although installation of such panels for any particular site calls for specific calculations depending on family size. Still the initial capital price is the main issue, which definitely cannot be afforded by a majority of local households without outside financing terms assistance. Thus we prefer to recommend such panels initially for use for public buildings such as kindergartens and sports schools, which have problems with providing the basic energy related services for the pupils. It is easier to provide financing to a relatively small number of such institutions through the central government channels and/or some donor organizations than for private homes.

Biogas. The price of a standard biodigester (mark BGD-6) on the Georgian market is approximately $ 2,230 (including installation). It is even more expensive in areas with relatively cold winters where additional insulation is necessary to avoid freezing of digester contents. This is pretty expensive for the vast majority of people interviewed during SDAP field trip. They cannot even afford the most readily available wall mounted gas heaters or efficient wood stoves, which are an order of magnitude less in cost. Such gas can only be used for cooking, but not for heating although the heating is universally the part of HH energy consumption, which requires the most energy and thus expense. Thus, such biodigesters can be recommended but only with reservations. There remains the issue of financing installation for biodigesters, which is clearly beyond the reach of almost any private household and calls for special financing schemes.

Wood pellets. Such pellets are relatively more efficient as a fuel source than the log wood (stacked-air dry), which is universally used in Georgia. 1 m^3 of such pellets contains 3,100 kWh of energy,[30] while we operate with energy density by volume of 1,780 kWh on average for watersheds under consideration. I.e. formally the use of wood pellets is 1.74 times more efficient than the use of conventional firewood for Georgia. The problem is that pellets are not by definition an independent product, but rather the byproduct of the woodworking industry. Only in the case of large scale production may such pellets become competitive with conventional firewood. Relatively developed woodworking industry is altogether absent in Georgia, thus there is no appropriate economically viable pellet production as well. Small scale pellet production turns out to be very expensive produce at a price of approximately$ 120 per m^3. This transfers into $ 0.039 per 1 kWh, while on average in all 4 pilot watersheds price of 1 kWh of firewood is $ 0,016 - or 2.4 times less. Accordingly replacement of firewood by wood pallets under the current Georgian conditions can hardly be recommended based on the most elementary cost-benefit considerations. Besides pellets require specialized stoves of a different kind, which are very expensive by Georgian standards (and not supplied in this country). The US consumer guides or specialized shops' advertisements for instance, put retail prices of such stoves at $ 1,100 minimum, and $ 1,400-3,000 on average.[31]On the other hand, we may recommend for consideration of briquetting hazelnut shells, which are produced aplenty in western Georgia as a waste product. This may represent a viable alternative to wood pellets, at least in hazelnut producing areas.

A leading energy planning example from the U.S. is the California Loading Order. The loading order is an approach to decrease growing electricity demand by increasing energy efficiency and demand response, and meeting new power generation needs first with renewables and distributed generation resources, and second with "cleaner" fossil-fuel generation like natural gas. The loading order was adopted in the *2003 Energy Action Plan* prepared by the California Energy Commission. The loading order as the foundation for its recommended energy policies and decisions, with the basic tenants as follows:

Energy Efficiency - *If you don't need it don't use it*
Heat Recovery - *If it's already there – use it*

[30] http://www.biomassenergycentre.org.uk/portal/page?_pageid=75,20041&_dad=portal&_schema=PORTAL

[31]see for example http://www.woodpelletstoves.net/buying.html, http://www.homedepot.com/webapp/catalog/servlet/ContentView?pn=KH_BG_HF_Wood_Pellet_Stoves, see chapter 4 of this report.

Renewable Energy - *If realistic, go carbon free*
Team with Utilities-*Invest where it makes sense*

In order to help solve these issues in Georgia, it is going to take an integrated energy development approach as is commonly used in northern Europe in places like Denmark, Netherlands, Germany, etc. Integrated community energy solutions include looking at all the options and how they can best be combined to maximize energy usage and minimize waste. Some basic steps to modernize Georgia's energy infrastructure and planning could include a multi-pronged approach using a variety energy resources and strategies:

Building efficiency

- Performance certification
- Minimum building codes

District heating and cooling

- Municipal zoning rules
- Expand into new development
- Distributed cogen & heat sources

Energy sources

- Natural gas
- Waste to energy
- Biomass (better wood stoves and/or pellet stoves)
- Expand hydropower use
- Long-term wind strategy
- Industrial heat from plants
- Solar energy

Ultimately, it will take a couple of decades (minimum) to improve the Georgian energy situation adequately for the reviewed watersheds, as well as nationally. There is no single approach that is going to address all the issues. It will take a combination of pathways to address and modernize the energy usage and distribution situation for the country.

Annex 1: Household Energy Consumption Questionnaire

Household Energy Consumption Questionnaire

1. The basic information about household

- Settlement --
- Number of household members (residing permanently) ----------------------------
- Age of household members (0-15, 16-64, 65 or older, gender) ---
- Among them permanently employed --
- Sphere of employment ---
  ____
- Income category (poor, medium income, high income, do not have answer)
- Do they have a car? Yes/No
- If they have, amount of fuel used per month (liters) --

2. Basic information about sources of energy

Electricity, Yes/No

- If yes, is there electricity supply meter? Yes/No
- If yes, what kind of meter is it? – Individual/Common
- How much electricity do they use per month? (kWh) --
- Are they satisfied by energy company service? – Satisfied, Partly satisfied, Not satisfied
- Reason of dissatisfaction – power cuts, quality of electricity, service of company personnel, other reason (indicate) ---
  ----
- Natural Gas Yes/No
- If yes, is there a gas supply meter? Yes/No
- How much natural gas do they use per month? (cubic meters) ---
- Are they satisfied by Natural Gas company service? – Satisfied, Partly satisfied, Not satisfied
- Reason of dissatisfaction – supply cuts, quality of natural gas, service of company personnel, other reason (indicate) ---
  ----
- Firewood, Yes/No
- How much firewood do they use per month? (cubic meters) --
- What is the source of the firewood? – own logging, purchase on the market, other (indicate) --
  ----

- Is firewood easily accessible? – Easily accessible, Quite hard, Very hard
- Reason of dissatisfaction --

- Liquid Gas Yes/No
- How much liquid gas do they use per month? (cubic meters) --
- Other liquid fuels Yes/No
- How much liquid fuel do they use per month? (liters) --

3. Basic information about building

- Year of construction --
- Year of reconstruction/repair --
- What kind of building blueprints can be found? (facade, floors, cross-section)----------------------
  ----
- What kind of building systems' blueprints can be found? (heating systems and etc.) ---------
  ----
- Which system's technical description and documentation can be found? -----------------------------
  ----

4. Data on building structure

- Number of floors --
- Floor height (m) --
- The total floor area (m^2) ---
- The total volume (m^3) ---
- Perimeter of the floor (m) ---

4.1. External walls

1. General condition of the walls - Bad, Acceptable, Good
2. The total area of external walls (m^2) --
3. Wall construction – Basement, Half-basement – Brick, Concrete, Cement Block, Stone, Wood, Other (indicate) --
   ----
4. Wall construction – Ground floor – Brick, Concrete, Cement Block, Stone, Wood, Other (indicate) ---
5. Wall construction – Second floor – Brick, Concrete, Cement Block, Stone, Wood, Other (indicate) ---
6. Facade wall orientation – North, North-East, East, South-East, South, South-West, West, North-West.

4.2. Windows

1. General condition of windows - Bad, Acceptable, Good
2. The total area of windows (m^2) --

3. Window material – Wood, Aluminum, Metal-Plastic, Other (indicate) ---

4. Type of window frame – Single frame, Double frame, Other (indicate) --

5. Glazing type – Single, Double, Triple

4.3. Doors

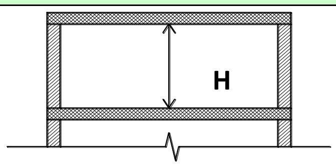
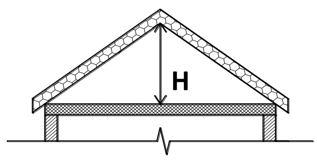
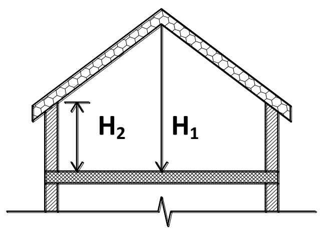
1. General condition of doors - Bad, Acceptable, Good
2. Total area of doors (m^2) ---
3. Door material – Wood, Aluminum, Metal-Plastic, Other (indicate) ---

4. Type of doorframe – Single frame, Double frame, Other (indicate) ---

5. Glazing type – Single, Double, Triple

4.4. Roof

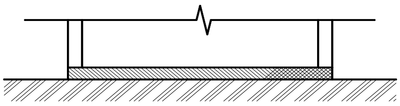
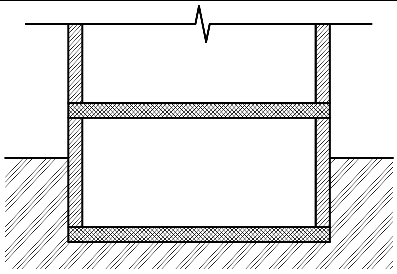
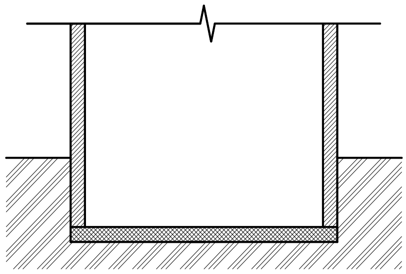
- General condition of roof - Bad, Acceptable, Good
- Total area of roof (m^2) ---

<table>
<tr><td>Roof type RF1</td><td>Attic, Roof Type 2 RF2</td><td>Attic, Roof Type RF3</td><td colspan="4">Attic, Roof Type RF4</td></tr>
<tr><td>Roof on a top of heated area</td><td>
</td><td>
</td><td colspan="4">
</td></tr>
<tr><td>Attic height m</td><td></td><td></td><td>H_1</td><td></td><td>H_2</td><td></td></tr>
</table>

- Roof material ---

4.5. Floor

1. General condition of floor – Bad, Acceptable, Good
2. The total area of floor (m^2) ---
3. Floor material ---

Floor type 1 Floor on ground	Floor type 2 Unheated basement	Floor type 3 Heated basement
		

5. Heating/Air Conditioning Systems

5.1. System Type – Water heating system, individual oven, electric heater, electric air conditioner, other (indicate) --

5.2. Energy sources – Natural gas, Electricity, Liquid gas, other liquid fuel, Firewood, Coal, Other (indicate) --

5.3. Heat systems – Radiator (number), Wood oven (number), Gas oven (number, power output), Electric radiator (number, power output, kW), Electric conditioner (number, power output, kW), Other (indicate) --

5.4. What part of home is heated? – Number of rooms, area (m^2), floor, other (indicate) --

5.5. How long the building is heated during the year? (Months or days) --

5.6. How often do they use heating – Every day, several days per week, from time to time, other (indicate) --

5.7. How do they use heating during the day – All day long, only daytime, several hours a day, other (indicate) --

5.8. Do existing heating systems create comfortable conditions? – Yes all thetime, From time to time, No

5.9. If the answer is no, what you think is the reason of this? – Ineffectiveness of heating systems, Poor insulation of building, Expensive heating systems, Difficult access to fuel, Other (indicate) --

5.10. Are heating expenses justified from the household budget expenditures point of view? Yes, No, Partly

5.11. If the answer is no, what is the reason? --

5.12. Air conditioning systems – Yes/No

5.13. If the answer is yes, then what type of air conditioning systems are used? – Split system (number, power output, kW), window air conditioner (number, power output, kW), Electric ventilator (number, power output, kW), Other (indicate) --

----

5.14. Do they have hot water heaters? – Yes/No

5.15. If the answer is yes, then what kind of heaters do they have? – Connected to heating system, Natural gas boiler (number, power output), Electric boiler (tank, number, capacity, power), “Atmor” type (number, power), Liquid fuel boiler (type, number, power), Coal or wood fired boiler (number, power), Solar Collector (number, power), Other (indicate) ------------------------------

----

5.16. Lighting system. Type of bulbs (Traditional incandescent bulbs, energy efficient) total quantity, power kW --

-----

5.17. What part of home do they use lighting during evening – One room, Two rooms, Room and Storage and etc. (indicate) --

----

5.18. Do they purposely save electricity? Yes/No

5.19. If the answer is yes, then what method do they use? (Indicate) --

----

5.20. Do they know, hat the term “EnergyEfficiency” means? Yes/No

5.21. If the answer is yes, then what do they think it means? (indicate) --

----

6. Energy expenditures

1. How much electricity do they use, how much do they spend on electricity during a year? (If there is an individual meter, please try to get answers from official energy company bills) --

2. How much natural gas do they use, how much do they spend on natural gas during a year? (If there is an individual meter, please try to get answers from official energy company bills) --

3. How much liquid gas do they use, how much do they spend on liquid gas during a year? --

4. How much firewood do they use, how much do they spend on firewood during a year? --

5. How much liquid fuel do they use, how much do they spend on liquid fuel during a year? --

6. How much other fuel do they use, how much do they spend on other fuel during a year? --

7. What part of the household annual budget do they spend on energy? --

8. Do these expenditures create financial problems for them? – Yes/No

9. If the answer is yes, please describe this problem, as - Unimportant, Medium Difficulty, Very Difficult, Unendurable

10. How do you think, what is the reason of these problems? – Expensive energy, Non-effective service, Discrepancy between price and quality of service, Low income, Other (describe) --

Annex 2: Simplified Energy Balance

This is an approximate, first version of the standard simplified Energy Balance downsized to the level of a Georgian municipality. It is drawn primarily to check what could and should be done to turn it into an information organization basis for Energy Passport. It is the very first known attempt of this kind.All data provided here refers to the Lower Rioni Pilot Watershed Area for the Khobi and Senakimunicipalities.

Energy Resources:

Mineral Fuel – Absent
Hydro resources – 2.3 MW potential installed capacity; 12.2 m kWh potential annual electricity generation
Wind – 120-299 GWh per total surface
Solar – 188,528 GWh per total surface annually[32]
Biogas – no data
Fuelwood – n/a

Energy supply:
Local production:
Mineral Fuel – no
Hydro – no
Wind – no
Solar – no data
Biogas – no data
Fuelwood – 43.2 m kWh
Import:
Electricity – no data
Natural gas/LPG – 1111942 m^3; 10.6 GWh app.[33]/84840 kg; 1091891 kWh[34]
Export – no

End use consumption:
Residential buildings: electricity – 30.1 GWh; natural gas/LPG – 10.6 GWh app./n/a fuel wood – 750 GWh app.[35]
Industry and Commercial buildings – electricity –29.8 GWh; natural gas/LPG – n/a; fuel wood – n/a

[32]Considering this surface as horizontal
[33]Calorific value of 1000 m^3 of natural gas used in Georgia is assumed to be 9360 kWh
[34]LPG data is rather approximate due to absence of correct recording by local outlets
[35]Only for demonstration purposes

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