Integrated Biodiversity Management, South Caucasus

Energy demand assessment in the municipalities of Dedoplistskaro and Akhmeta

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Executive summary

In November 2015, 753 households in the municipalities of Dedoplistskaro and Akhmeta were interviewed with regard to their energy consumption. The questions addressed energy used for space heating, cooking and hot water supply, as well as the consumption of natural gas and electricity. Special attention was given to the supply and consumption of firewood, as the overall objective of this assessment was to derive recommendations for forest management planning in the two project areas of the GIZ program Sustainable Management of Biodiversity, South Caucasus.

The assessment showed that the mean annual energy demand per household is 75GJ for both regions. The largest share of this energy is supplied by firewood (47%), followed by natural gas, with bottled gas and electricity providing significantly smaller amounts. It should be kept in mind that no current figures for the number of households per municipality could be made available. Most of the energy is used for space heating (82%), followed by cooking (7%) and warm water supply (7%). The specific heat demand per m^2 was calculated to be 395 kWh, which corresponds to values found in neighboring countries such as the Russian Federation with 382 KWh/m^2 but is rather high compared to the EU average lying between 150 and 300 Kwh/m^2. Electricity represents the smallest sector of energy consumption with 4%. As most of the energy is needed for space heating, it is significant that the findings uniformly show housing is not thermally insulated, the conversion technology is inefficient and the quality of the firewood is low. 90% of the firewood is burnt within the first three months after purchase.

On average, about 8m^3 of firewood are needed per household, whereas the mean consumption of firewood equals about 9 m^3 and in Akhmeta only about 7.5 m^3. The majority spends between 350 and 700 GEL for firewood per year, which corresponds to 1-2 months of average household income (350 GEL). This leads to a demand for firewood of ≈ 59,000m^3 and 51,000m^3 in Dedoplistskaro. These figures lead to questions regarding the official timber harvest amounts, which are 10,000m^3 in Akhmeta, for instance. The amount of registered harvest is less than a fifth of what the actual demand of firewood is estimated to be. On the other hand, local wood sellers estimated that 70,000m^3 of firewood are purchased per year in Akhmeta, which exceeds this assessment's estimate, but is closer to the actual amount than the official figures.

As a consequence, the following recommendations could be derived from this assessment:

1. **Develop a market for qualitative biomass products**
2. **Support forest management with emphasis on harvest monitoring**
3. **Promote thermal insulation and energy efficient combustion of biomass**

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The energy demand assessment also showed that the current demand for energy is very high, given the relatively small variety of energy services consumed. The largest share is provided by firewood. However, the relevant authorities do not know how much firewood is actually needed in the municipalities. This survey showed that the public figures of those responsible for managing the forest differ considerably from those calculated by this energy demand assessment. Room for improvement exists.

1. Introduction and background

Thermal energy consumption within the Georgian residential sector is dominated by biomass. This biomass is used primarily in the form of firewood; however, it is generally burned very inefficiently due to lack of prior drying and low-efficiency stoves, wasting significant amounts of energy while putting additional pressure on local forest resources. This leads to deforestation and land degradation, reduction of biodiversity, and contributes to greenhouse gas emissions. Energy efficiency of the buildings in rural areas is extremely low and even simple and cheap measures for improvement of the energy situation are not undertaken.

The program "Sustainable Management of Biodiversity, South Caucasus" is active in the district of Dedoplistskaro with funding from Austrian Development Agency (ADA). The local forest is planned as a pilot region for the implementation of Sustainable Forest Management (SFM) in degraded forest areas. In order to secure the forest's long-term future and prevent further stress on the degraded forest, options for a sustainable provision of firewood are being investigated. In the district of Akhmeta, GIZ is planning to set up a second pilot area for SFM. The region is rich in forest resources, but no exact data on the stocking volume or timber and firewood extraction exist. The local population depends heavily on the forest resources for multiple uses, such as firewood and timber extraction. In order to determine how high the demand for wood products is, regional use of firewood shall be examined and included in the forest management plan.

Since existing information is incomplete, a baseline study for the use and supply of wood and other resources was carried out. Part of the input data for the baseline scenario can build on existing information, e.g. statistics from GeoStat, the National Forest Agency, administrations (*gamgeoba*) of local municipalities and reports of other international and national projects in the field of energy and firewood use, forest management plans and forest management maps for Akhmeta and Dedoplistskaro. Most of the information about the energy consumption was collected via a questionnaire in both pilot regions.

1.1 Objective of the study

The objective of this energy demand assessment is the analysis of energy consumption (e.g. firewood, other types of biomass, gas and electricity) in the districts of Akhmeta and Dedoplistskaro in order to provide baseline information for the development of appropriate Forest Management Plans for the respective forest areas. The specific tasks include:

1. Design of questionnaire and training of enumerators.
2. Assessment and processing of the information obtained on energy consumption in the two pilot regions.
3. Development of recommendations on how the supply of firewood can be ensured over the long term under given framework conditions.
4. Preparation and presentation of the methodology and results of the demand for firewood to the local and national forest management institutions.

2. Methodology

2.1 Framework conditions

The study was prepared in October 2015 in cooperation with CENN. A preliminary questionnaire was designed and presented to GIZ and the enumerators from CENN. The methodology of the assessment and underlying reasoning behind the sampling procedure were explained and discussed. The enumerators' feedback and opinions were incorporated into the questionnaire based on prior regional experience. The questionnaire addressed various aspects of energy consumption, such as:

- Household status
- Energy demand for space heating, water heating and cooking
- Electricity and gas consumption
- Wood consumption and trade as well as forms/shapes and storage

The complete questionnaire is attached to this study (see Annex 1). The group of enumerators and the international consultant visited the target regions over a four-day period. The enumerators were trained on sampling methodology, the appropriate manner of approaching the household inhabitants and the procedure for asking questions. Measurements of heated living space, amounts of stored firewood and estimation of relevant indicators were practiced, initially as a group and then individually over the following days. Throughout the testing period the enumerators were trained in filling out the questionnaires and the Excel sheets with the entry data. At the end of the testing phase all of the enumerators had a full understanding of the assessment's objectives and their responsibility in measuring and estimating the relevant indicators in order to assess the energy demand of the sampled households. The interviewers were equipped with a measuring tape, camera, questionnaire (see Annex), pen and dice.

2.2 Confidence, margin of error and sample size

The level of confidence was chosen to be 95% and the margin of error 5%. Dedoplistskaro has a population of 21,100 and Akhmeta about 31,300, according to information from the statistical office[1]. The last census was carried out in 2013 but the data were not available at the time of sampling. Data from the 2003 census were found to be insufficiently reliable to carry out random sampling based on household listings.

In order to determine the number of households it was assumed that on average four persons live in one household, which results in 5,275 households for Dedoplistskaro and 7,825 for Akhmeta. Based on the equation as presented by Krejcie & Morgan[2], the sample size of 365 households per municipality was determined. In total, 732 interviews were carried out in the two municipalities during November 2015.

2.3 Random walk method

[1] www.geostat.ge

[2] Krejcie & Morgan, 1970: Determining Sample Size for Research Activities. *Educational and Psychological Measurement*, #30, pp. 607-610.

The sampled households were selected by the random walk method[3]. The two municipalities were divided into 10 segments each, with each segment containing at least 40 households. Figure 1 shows six segments and the numbered starting points. In each segment, six starting points were set randomly, keeping in mind the limitations of accessibility, time and overall scope of the assessment. Each interviewer threw a die in order to identify his or her starting point, numbered from 1-6. The driver transported the interviewers to the starting point, from which the next eight households were visited and interviewed. If there were no people present in a household, the interviewer would choose the next household and continue until the desired number of interviews per segment had been achieved.

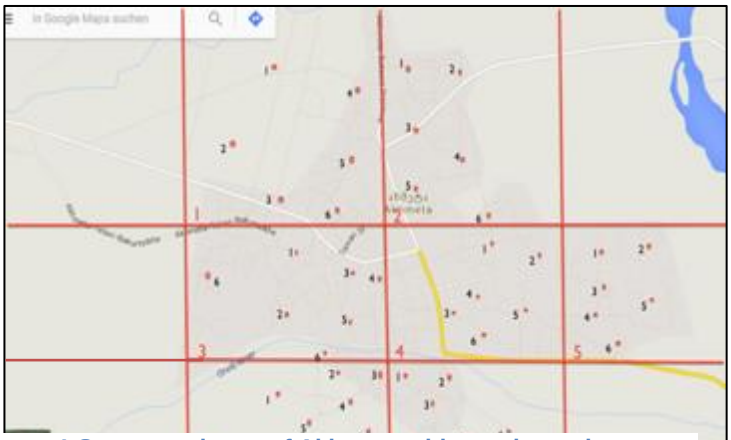

Figure 1 Segmented map of Akhmeta with starting points.

2.4 Statistical analysis and assumptions

The collected data were entered into an Excel sheet that was provided to the enumerators prior to sampling. The data were then cleaned of anomalies in order to be suitable for statistical analysis. R was used for statistical analysis. All fuel and end-use categories were derived using conversion factors on the response data (see table 1). Unrealistically high or low amounts and prices were disregarded from calculation of mean amounts. For the sake of clarity the results are given in rounded figures without the standard deviation and margins of error.

[3] Magnani, R., 1997: Sampling Guide. Food and Nutrition Technical Assistance, USAID.

Table 1 Basic assumptions, units and conversion factors.

	Amount	Unit	Energy content [MJ]
Price of 1kWh electricity	0.14	GEL	-
Price 1MJ electricity	0.04	GEL	-
Price of 1 cubic meter gas	0.5	GEL	-
Traded units of wood			
1 space cubic meter (scm)	0.7	m^3	6552
1 "Piri" (One load of wood 4x2x0.5m^3)	2.0	m^3	18720
1 piece of chopped wood (30 cm)	0.0012	m^3	11.115
1 piece round wood (30 cm)	0.0095	m^3	88.92
1 truck	4.0	m^3	37440
large delivery	5.0	m^3	46800
medium delivery	2.0	m^3	18720
small delivery	1.0	m^3	9360
Energy carriers			
1 bottle LPG	0.02	m^3	510
1 minute gas 8l/min cooking	0.0080	m^3	0.33
1kg coal	0.00077	m^3	0.02
Natural gas	1.0	m^3	40
Amount of gas for 1 GEL	2.0	m^3	80
1kg gas (density ~ 0.6kg/m^3)	1.6667	m^3	66.67
1kg gas LPG (density 493 kg/m^3)	0.0020	m^3	46.33
1kg wood 35% moisture (density ~ 650 kg/m^3)	0.0015	m^3	14.4
1 piece branch (1.5m length and <8 cm diameter)	0.0080	m^3	54.14
1kg wooden residue (35% H_2O)	0.0007	m^3	14.4
1 piece residue	0.0012	m^3	11.12
Beech (35% H_2O)	1.0	m^3	9180
Beech (25% H_2O)	1.0	m^3	9540
Beech (15% H_2O)	1.0	m^3	9878

3. Results

3.1 Interview data

The chart on the left illustrates the distribution of interviews conducted per enumerator. In total, six enumerators conducted 732 interviews, 366 in each of the two municipalities (see figure 2). In the time period between November 9th and 27th, two enumerators submitted 62 questionnaires each and another two handed in 122, with 182 being submitted by the third pair. Every day the group of enumerators visited between 40 and 60 households. In total, the two municipalities were each divided into 10 segments for sampling, leading to a total of 20.

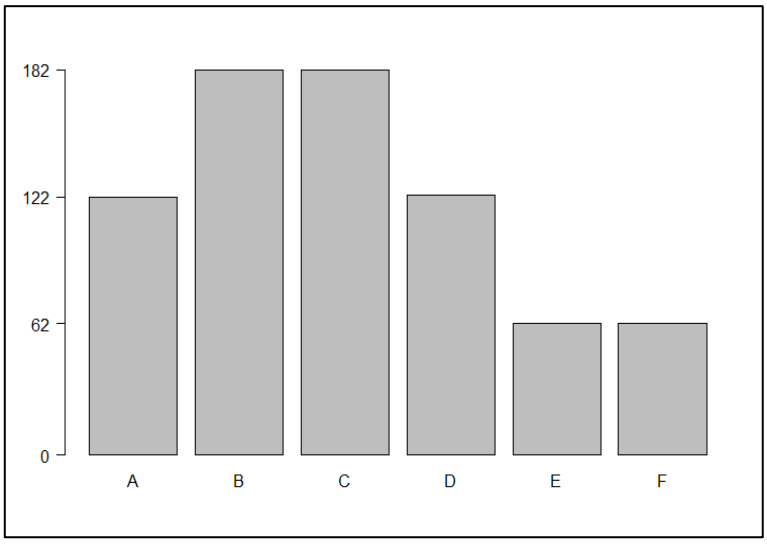

Figure 2 Interviews per enumerator.

Akhmeta and Dedoplistskaro are municipalities that comprise a total of 58 settlements. A collection of all the maps including the segments and starting points is attached in the Annex of this assessment. The two municipalities are marked by the red squares as can be seen in figure 3. The total forest area of Akhemta (64,952ha) is much higher than in Dedoplitskaro, where only 12,587ha is covered with forest. These two target areas were deliberately chosen in order to be able to obtain an understanding of the energy supply in the municipalities of differing natural resource availability in their immediate periphery.

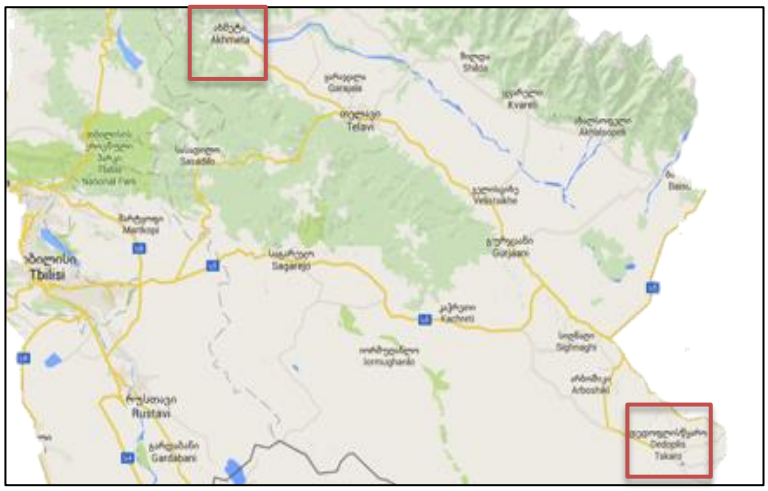

Figure 3 Map of Akhmeta and Dedoplistskaro.

3.2 State of housing

The vast majority of the 732 interviewed households were standalone, single-family houses that were used for residence. 51 multi-family houses and 29 flats were part of the sampled households, while eight households were used either for purely commercial or commercial and residential purposes. Most of the businesses provided some kind of service.

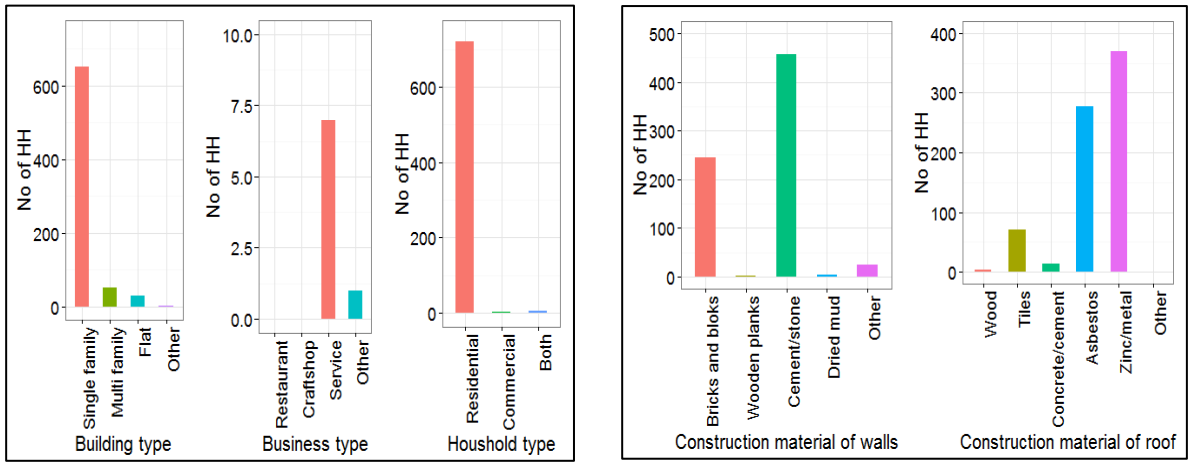

Figure 4 Building, household and business type (left). Construction material walls and roof (right).

The buildings were predominantly built out of cement and stone or bricks and blocks. Only a small number of houses were built of other materials, such as wooden planks or dried mud. The roofs of the houses were mostly constructed with zinc or metal sheet or asbestos plates, less commonly tiles or concrete, with wooden roofs representing a small minority (see figure 5). Most of the houses had an insufficient thermal performance. It can be expected that the values for thermal insulation are very low and produced heat does not remain in the heated living space for long.

Figure 5 Example of stand-alone single family house in Akhmeta.

Figure 6 shows that 86% of the respondents did not have any form of additional insulation. 11% of the houses have insulated windows. Some of the respondents insulated the shielding of their house, such as the roof, walls, door or their veranda. Asked about the type of windows, 16% have double-glazing and 83% single-glazed windows.

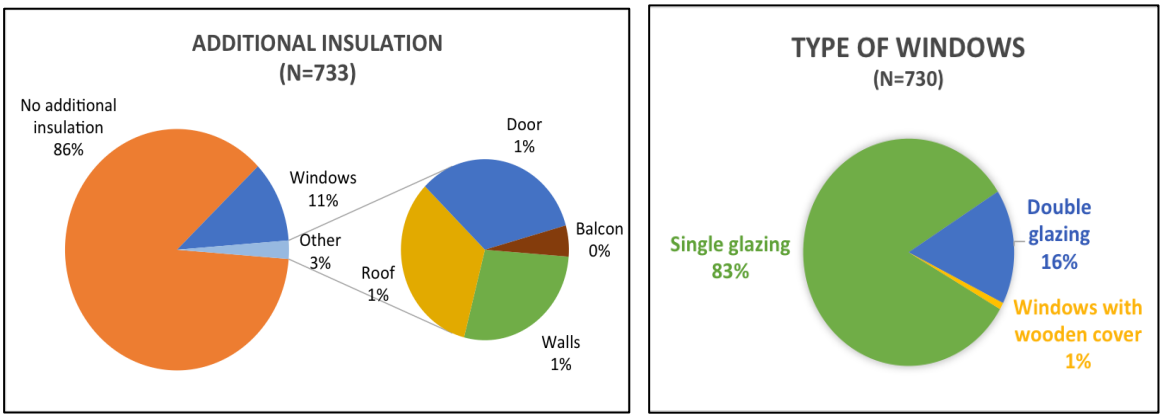

Figure 6 Additional insulation (left) and type of windows (right).

3.3 Energy demand overall, per district, household and capita

Energy demand was assessed in three categories: space heating, water heating and cooking. In addition, the consumption of gas and electricity of the households was assessed. The total energy demand is the sum of energy of those categories. Figures 6 provide an overview of energy demand per month divided into the three sectors. Firewood is the most commonly consumed natural resource for energy supply throughout all sectors but natural gas plays an almost equally important role. 72% of households are connected to the local gas grid but most of the households use it mainly as a supplement to firewood for space heating, hot water supply and cooking; roughly 6,000MJ is supplied by gas and 7,500MJ is estimated to be provided by the combustion of biomass per household per month, assuming a calorific value of 6,768MJ per m^3 for firewood.

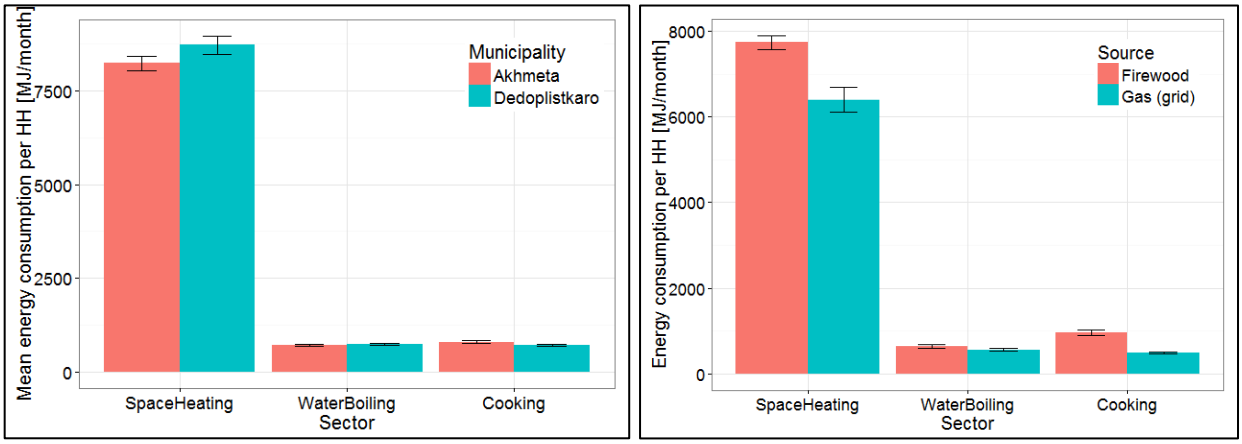

Figure 7 Energy consumption per household in MJ per month per municipality (left) and energy consumption per household in MJ per month and natural resource of energy (right)

The assessment shows that the total energy demand for both municipalities varies roughly in line with the different numbers of households. In Akhmeta, the total energy demand was calculated to be 873TJ per year, whereas in Dedoplistskaro the demand is slightly lower with 657TJ per year. The energy demand is dominated by the energy needed for space heating, with water heating and cooking requiring almost equal shares of energy. Overall, 82% of consumed energy is needed for space heating, followed by hot water supply (7%) and cooking (7%). 4% of the total energy demand can be associated with the use of electricity.

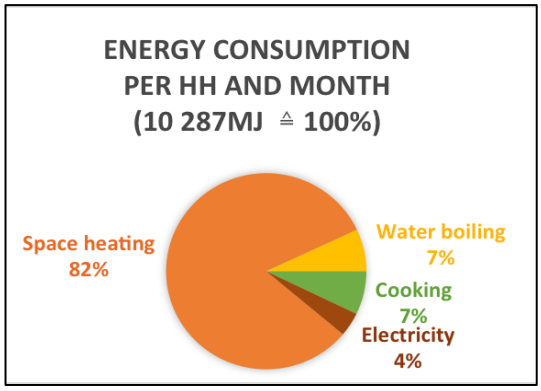

Figure 8 Distribution of energy consumption for space heating, water boiling, cooking and use of electricity in MJ per month per household.

The energy demand of 75GJ per household per year supplies an average of 3.4 inhabitants. This leads to the conclusion that the mean energy demand per capita and year corresponds to about 22GJ per year. Table 2 gives an overview of the energy demand per municipality, household and capita. These figures correspond roughly to the official figures for the mean

energy demand per capita of 34.6GJ per year in Georgia[4] but are considerably lower than the national mean energy demand per capita. For comparison, this energy demand per capita is 160GJ per year in Germany and as much as 218GJ per year in the Russian Federation[5]. The conclusion can be drawn that the energy demand is below average due to the widespread poverty in the rural areas of Akhmeta and Dedoplistskaro.

Table 2 Total energy demand in GJ per year for municipality, household and per capita.

	Municipality [in GJ per year]				Household [in GJ per year]	Capita [in GJ per year]
	Space	Water	Cooking	Total	Total	Total
Akhmeta	369,369	60,713	62,367	528,074	75	22
Dedoplistskaro	278,346	45,751	46,998	396,524	75	22

3.3.1 Space heating

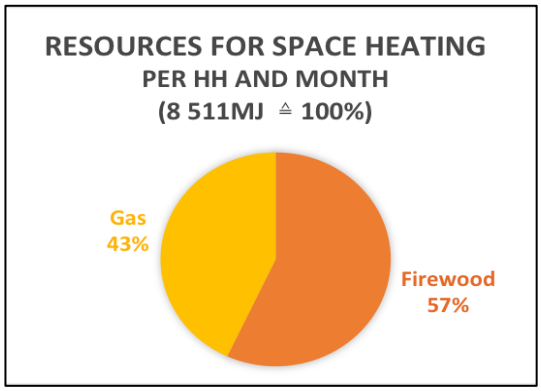

Figure 9 Resources for space heating in MJ per household per month.

The length of the heating season in the two municipalities is 6.2 months. On average 2.7 rooms, covering an area of about 40m^2, are heated. The mean total energy associated with heating of living space is 57.2GJ per year. This leads to a mean heat demand of roughly **395kWh per m^2** per year for space heating. 64% of this energy is generated by the combustion of firewood. In Russia, for example, the average energy consumption equals 382kWh per m^2, whereas in the European Union values vary between 150 and 300kWh[6].

The total energy demand for space heating is roughly 369GJ in Akhmeta and 278GJ in Dedoplistskaro per year.

Figure 10 Typical application of heating stoves for space heating.

[4] National Statistics Office of Georgia. Retrieved in January 2016.
[4] USAID, 2014: Household energy end-use survey.
[5] Worldbank Energy Use: *World Development Indicators*, World Bank. Retrieved January 2016.
[6] UNECE United Nations Human Settlement Programme, 2013: Good Practices for Energy Efficient Housing in the UNECE Region.

3.3.2 Water heating

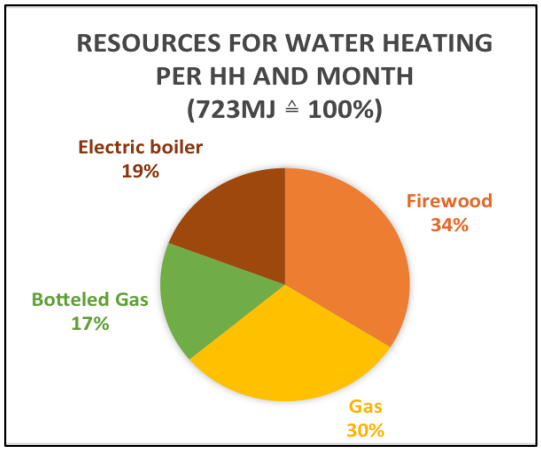

Figure 11 Resources for water heating in MJ per household per month.

Hot water is supplied by the use of two additional energy sources, bottled gas and electric boilers, which represent 17% and 19% of the energy demand, respectively. Most of the water is heated by the combustion of biomass (34%); the second-largest share is provided by natural gas from the grid (30%) as can be seen in figure 10. In total, the energy that is associated with the supply of hot water amounts to 723MJ per household and month. It should be remarked that it was not easy for many of the respondents to distinguish between firewood use for space heating and for water heating, as in many cases a pot with water that is to be heated is placed on the heating stove. The total annual energy demand for water heating was calculated to be 60.7TJ in Akhmeta and 45.7TJ in Dedoplistskaro.

Figure 12 Examples of heating devices for water heating.

3.3.3 Cooking

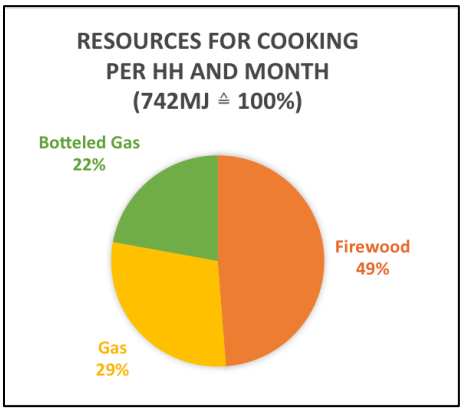

Figure 13 Resources for cooking in MJ per household per month.

Resources for cooking energy are comprised of three energy carriers: firewood (49%), gas from the grid (29%) and bottled LPG (22%). In total, 724MJ was associated with the supply of energy for cooking purposes, about as much as for heating water. Hence, most of the cooking in the sampled households is done on the stove that is also heating the room. The total annual energy demand for cooking is 62TJ in Akhmeta and 47TJ in Dedoplistskaro.

Figure 14 Examples of cooking on heating stoves.

3.3.4 Electricity

When asked to name the top three priorities for consumption of electricity, the respondents uniformly stated that the main use is related to lighting in the house. The second most important use of electricity is multimedia and the third is for the operation of other electrical appliances, such as machinery (see figure 15).

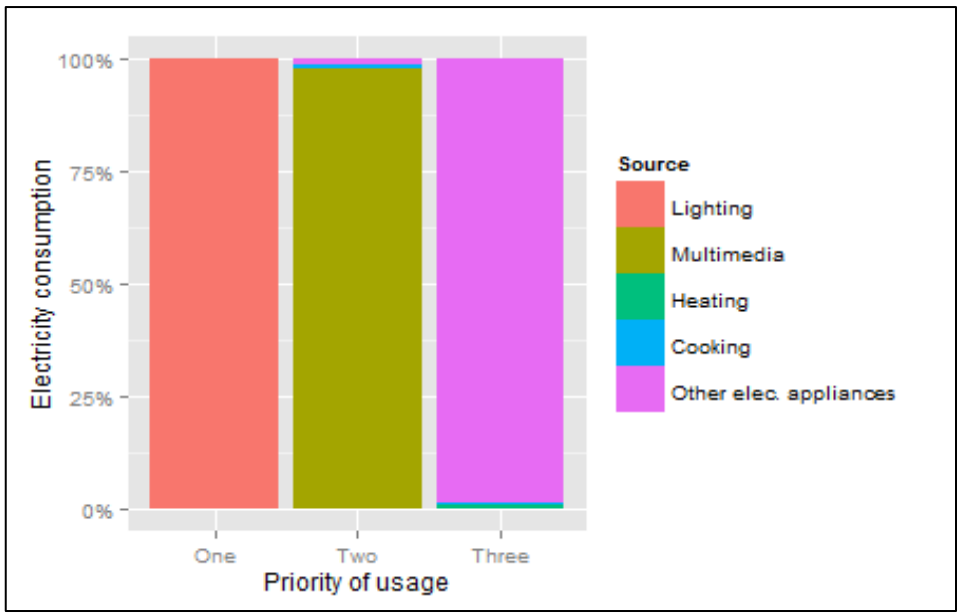

Figure 15 Prioritization of appliances that consume electricity.

On average, a household consumes about 114kWh per month, with slight variations between the two municipalities. In total, the annual energy amounts consumed in the form of electricity are 35,625GJ for Akhmeta and 25,429GJ per year for Dedoplistskaro. This means that 1,413kWh per household in Akhmeta and 1,233 kWh per household in Dedoplistskaro are used per year. Costs for electricity amount to 16.2 GEL per month, or 194.4 GEL per year.

4 Natural resources for energy demand

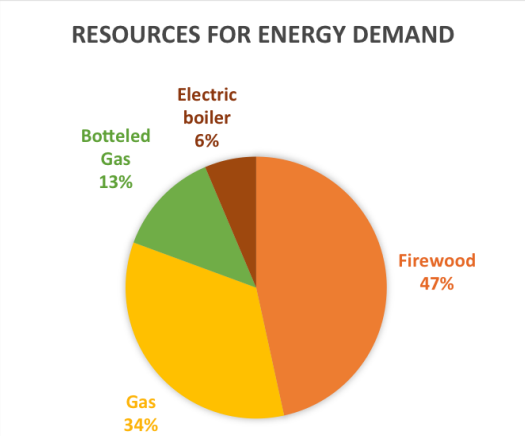

Figure 16 Shares of natural resources for the supply of energy.

In the two municipalities, two natural resources are the most important: firewood (47%) and natural gas (34%). LPG (13%) and electricity (6%) form part of the energy mix but are mostly relevant for cooking, electrical appliances and to some extent hot water supply. Table 3 gives an overview to the natural resources needed for the supply of energy in Akhmeta and Dedoplistskaro. 58,687m^3 of firewood are consumed in Akhmeta and 51,525m^3 in Dedoplistskaro. The amount of natural gas that is used amounts to roughly 3.7 million m^3 for the two municipalities.

Table 3 Amounts of natural ressources in m^3 per household and municipality and year.

	Household	Municipality
	Total [m^3]	Total [m^3]
Akhmeta		
Firewood	7.5	58,687
Natural gas	220	2,270,000
Dedoplistskaro		
Firewood	9	51,525
Natural gas	200	1,475,000

4.1 Gas grid connection and consumption

About 80% of the population in Akhmeta is connected to the gas grid, according to statements from the municipal authorities. The figures provided by officials report that in 2015 2,000,000m^3 gas was consumed in Akhmeta. In Dedoplistskaro, only 56% of the population is connected to the gas grid, with a consumption of about 2,900,000m^3 of gas, according to the local gas supplier.

Figure 17 Examples of gas grid connected gasometers.

The results of the interviews support the figures of gas grid connection, with 72% of the sampled households connected to the natural gas grid. Based on the answers from the respondents, a mean consumption of gas of 220 m^3 in Akhmeta and 200 m^3 in Dedoplistskaro per household per month (of a heating season) could be derived. Multiplied with the number of households and gas grid connection, a total gas consumption of 2,270,000 m^3 for Akhmeta and 1,475,000m^3 for Dedoplistskaro. These results are significantly lower than those provided by official figures. According to the information obtained by the enumerators, using gas is more expensive than using firewood, for which reason many households prefer the latter.

4.2 Firewood consumption

Figure 18 Firewood stored at the wall of a house.

Firewood is the most important source of energy in the municipalities of Akhmeta and Dedoplistskaro. In spite of the majority of households being connected to the gas grid, the consumption of gas is slightly lower than the consumption of firewood. Wood for energy purposes is consumed throughout the whole year since it is needed for hot water supply and cooking; for both sectors about half of the respondents stated that their main source for energy is firewood. Consumption increases during the heating season, which lasts for about 6 months and peaks from November to February.

Figures regarding firewood consumption are based on various assumptions and conversion factors (see chapter Methodology). The reader is encouraged to take a careful look at these assumptions before evaluating the results. Firewood is a very heterogenic energy carrier, which the local population rarely measures by standardized procedures. Accordingly, the assessment of firewood amounts based on the answers of the respondents can only serve as an approximation.

The enumerators asked questions with respect to three time frames, in order to be able to identify the closest approximation of the annual consumption of firewood. The households were asked about their firewood consumption the previous day, during a typical January and for the whole year. By combining the indicators derived from other questions, such as length of heating season, trade of firewood and stored wood amounts, the calculated consumption of firewood was verified.

4.2.1 Firewood consumption in January per household

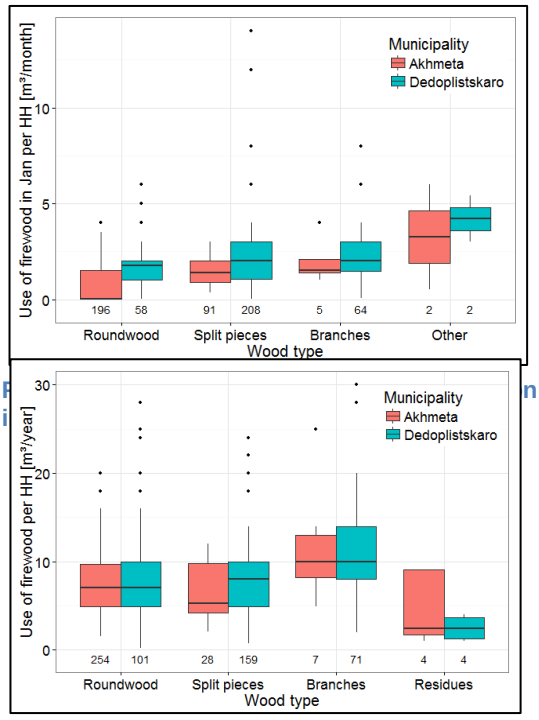

Figure 20 Diagram of firewood consumption in m^3 per year per household.

Asked about their firewood consumption in January, a month in which wood demand peaks, we see that round wood, split pieces, branches and other forms of firewood, such as branches (mostly in Dedoplistskaro) were the preferred units of the respondents. The amounts ranged from 0.01 to 5m^3 after the data had been cleaned of unrealistic values. The mean firewood consumption in the coldest month of the region is 0.9m^3 in Dedoplistskaro and 2 m^3 in Akhmeta.

4.2.2 Annual firewood consumption per household

The yearly consumption was computed using the four most common forms of firewood –round wood. split pieces, branches and other wooden

residues. The two most common forms of firewood are round wood and split wood pieces. Although more than double the number of respondents used round wood in Akhmeta than Dedoplistskaro, the mean annual consumption is the same, at about 7m^3 per household (that obtains wood in this form). In Dedoplistskaro more people seem to receive their firewood already in split pieces. In total, the firewood consumption adds up to 9m^3 in Dedoplistskaro and 7.5m^3 in Akhmeta. These amounts are the result of division of the annual firewood consumption by the estimated number of households per municipality (Dedoplistskaro 5,725 and Akhmeta 7,825).

Table 4 provides an overview of the wood demand (daily, in January and yearly) in the two municipalities. In Akhmeta, the total wood consumption is 58,687m^3 and in Dedoplistskaro about 51,525 m^3.

Table 4 Demand for firewood per day, in January and per year

	Daily (m^3 per hh)	January (m^3 per hh)	Year (m^3 per hh)	per municipality (m^3 per year)
Akhmeta	0.02	2	7.5	58,687
Dedoplistskaro	0.015	0.9	9.0	51,525

Akhmeta and Dedoplistskaro represent about 20% of the population of Kakheti, the easternmost region of Georgia. According to Geostat and the Ministry of Environment and Natural Resources Protection of Georgia, the harvested timber volume amounted to 136,938m^3 in 2013; in addition to about 450m^3 of illegal logging. Since close to 100,000m^3 of firewood is used in one year in two municipalities, as derived in this assessment, more than 70% of the total registered harvest amounts can be associated with only about 20% of the population.

This leads to one or more of the following conclusions:

- The registered harvested amount is an underestimate.
- The share of population that uses firewood is much lower in other municipalities.
- Illegal logging is much higher than the official figures report.
- Firewood consumption in this assessment has been over-estimated.

4.2.3 Sources of firewood

Figure 21 Typical truck that suppllies firewood to households.

Asked to rate the top three sources of firewood, 78% of the respondents gave wood sellers as the first, 20% said direct ticket licenses and 2% said their own sources were the number one source of firewood. The second most relevant source of firewood was direct ticket licensing with 55%, with own sources and friends or neighbors totaling about 40%. Asked for the third most important source, over 90% of respondents mentioned firewood derived from their own sources or friends and neighbors. It can be concluded that most of the firewood is supplied by wood sellers, followed by individually collected wood based on the distributed tickets, and the third most important source of firewood is inhabitants' own sources. A forester from the National Forest Agency (NFA) in Akhmeta stated that up to ten brigades of wood sellers equipped with trucks, chainsaws and winches operate in the local forests.

Figure 22 Prioritization of wood sources.

4.2.4 Forms of traded firewood

70% of the firewood is traded in the form of round wood and is transported directly to the households by the wood sellers. 14% consists of split pieces, with the same percentage being firewood in the form of branches. A small minority (2%) of the firewood is derived from residues, such as old construction wood. Hence it can be concluded that most of the processing is done by the households' inhabitants. There is a slight difference in the purchasing of wood between Dedoplistskaro and Akhmeta: while the majority of pieces purchased in Akhmeta are comprised of round wood, the most popular type is split wooden pieces for Dedoplistskaro.

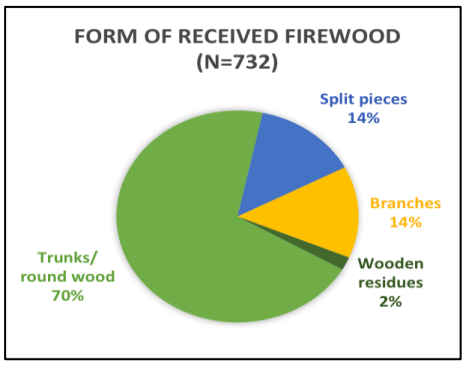

Figure 23 Shares of received forms of firewood.

When looking at each municipality by its own an interesting fact occurs. The population of

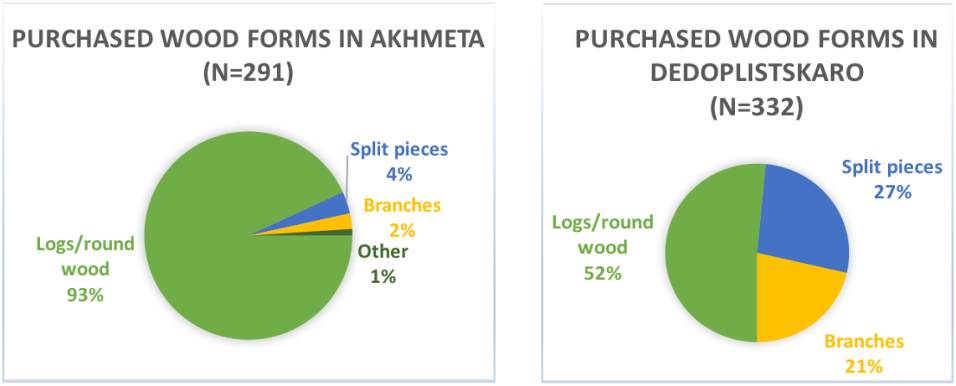

Figure 24 Purchased wood forms in Akhmeta (left) and Dedoplistskaro (right)

Akhmeta, buys in their majority (93%) logs or round wood, whereas in Dedoplistskaro on about half (52%) of the population buy the wood in untreated way. This is most likely linked to the fact, that in Dedoplistskaro very few forest based resources are present. The population relies on the deliveries form wood sellers that offer their biomass most commonly cut or split, already (see figure 24).

Figure 25 Examples of sold round wood.

4.2.5 Time of purchase of firewood

The population mostly purchases the wood during the heating season, from autumn to spring. This corresponds to the answers given when asked about storage of firewood (see figure 25). However, it can also be observed that some firewood is collected and purchased throughout the whole year.

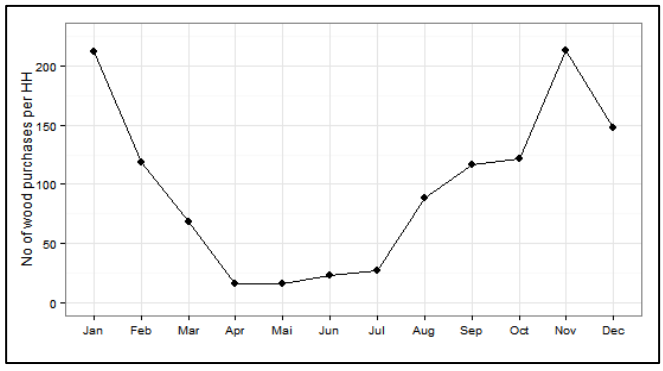

Figure 24 Numbers of purchases of firewood

4.2.6 Annual expenses for firewood

The expenses for firewood varied from 0 GEL to 1,750 GEL per year. On average, 390 GEL is spent per year on purchasing firewood. The distribution of

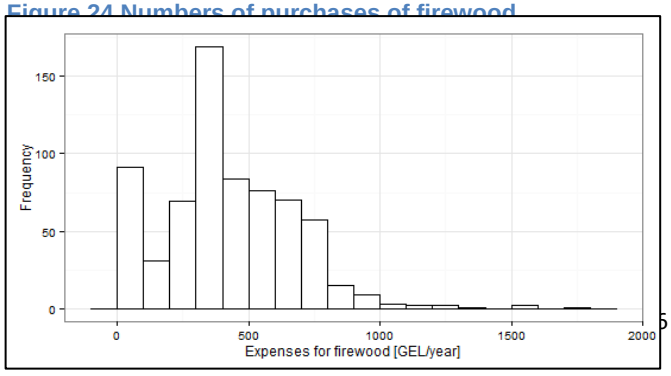

Figure 27 Distribution of annual expenses for firewood.

answers amongst the respondents can be seen in figure 26 It illustrates that most of the households spent between 250 and 750 GEL per year on firewood.

According to the World Bank[7], the monthly average household income in Georgia is about 350 GEL, a figure that is surpassed by annual expenses for firewood alone. The price of one m^3 of firewood was derived to be 59 GEL. This mean value is characterized by a strong deviation from the mean, ranging from 38 to 134 GEL, which can partly be attributed to the imprecise understanding of commonly traded forms of firewood. These units of firewood were sometimes given in truck loads, wood piles, branches or space cubic meters and were commonly difficult for the respondents to quantify.

4.2.7 Storage of wood & mean water content

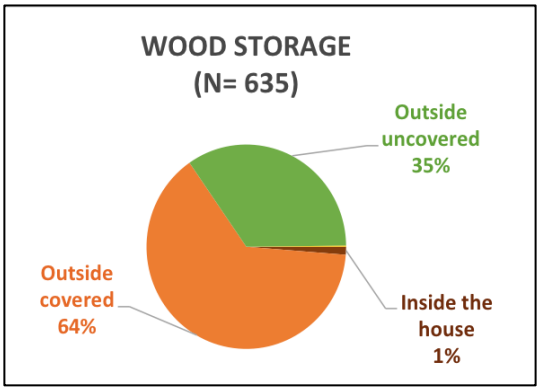

Figure 28 Distribution of forms of wood storage.

64.1% of the inhabitants store and cover their stock of firewood outside, whilst 34.5% leave the firewood without cover. Only 1.3% store it inside the house. A review of the pictures of the households shows that the firewood is generally stored appropriately – in a dry place with air circulation and above the ground. The average amount of stored firewood, which is derived from measurements by the interviewers, is 5.4m^3 in Dedoplistskaro and 6.8m^3 in Akhmeta. Considering that sampling was carried out two months after the start of the heating season, these amounts are in line with our assessment of the annual consumption of firewood.

More than 90% of the firewood is used within the first three months after the purchase. Accordingly, the time of purchase starts in late summer or early autumn and is likely to continue throughout winter. Although the firewood is mostly stored appropriately, it is normally for too little time. It can be assumed that the firewood is commonly burned with water contents of 30-40%, well above the ideal of 15-20%.

Figure 29 Examples of wood storage.

[7] Worldbank Data. Retrieved January 2016.

4.3 Conversion technology

932 ovens were counted during sampling the households, 89% of which had a power ranging from 3-10 kW. 573 of the households have one oven in their living space and 162 have two ovens. According to a German norm (DIN 18893), the living space heating capacity requires approximately 0.1kW per m^2 living space.

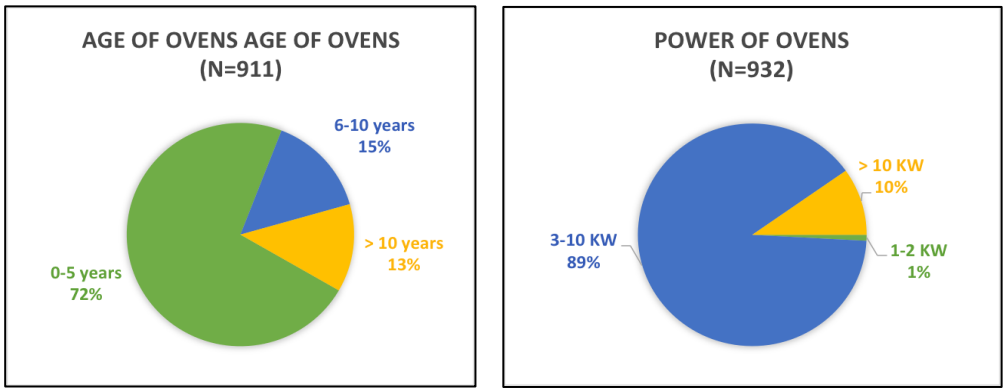

Figure 30 Power and age of ovens.

However, this depends on various factors, such as thermal insulation, firewood quality, size and maintenance of the heating device[8]. The mean heated living space is 40m^2, meaning that the proportions of the ovens are well adapted to the heated living space. Most of the stoves are regularly renewed, with 72% of the sampled stoves not older than five years. The price of one of the most common models is 30-40 GEL and is generally exchanged after a service life of about three years according to the observations of the enumerators. In conclusion, it can be stated that the size of the heating devices is appropriate for the heated living space but poor thermal insulation of housing, the short service life of a stove (3-5 years) and insufficient quality of firewood reduce the overall energy efficiency significantly.

Figure 31 Examples of heating devices.

[8] Fachagentur Nachwachsende Rohstoffe, 2014: Leitfaden Feste Biobrennstoffe.

5. Conclusions

5.1 Housing and energy efficiency

Most of the households in Akhmeta and Dedoplistskaro consist of single-family, standalone houses characterized by poor thermal performance. They generally use decentralized heating systems, normally comprised of one oven that is regularly replaced (every 3-5 years). The oven is placed in the living room and is used for space heating for about 6.2 months per year. The energy of the biomass is converted very inefficiently due to low quality of firewood, high water content and insufficient regulation of combustion rate. However, the size of the heating devices is appropriate for the size of the heated living space. The most common model has a power of about 3-5kW and heats roughly 40m^2. The firewood is mostly bought either shortly before or during the heating season when need is at its highest. The freshly harvested firewood is burnt directly, after a too short storage time, resulting in an energy conversion that is far from optimal. Consequently, the combustion of the biomass is inefficient and could be improved significantly. Improving thermal insulation and increasing the efficiency could reduce the consumption of firewood by more than 50%[9].

5.2 Energy demand

Space heating is the sector of highest energy demand, followed by hot water supply and energy for cooking purposes. The mean annual heat demand per m^2 is 395kWh. This energy demand seems very high, when compared to the average heat demand of the Russian Federation (379 kWh/m^2), Azerbaijan (329 kWh) or a typical, old, uninsulated building in Germany (350 kWh/m^2). This is mostly attributed to the fact that the sampled households use very low quality heating technology and lack thermal insulation.

The overall energy demand is 75GJ per household (22GJ per capita) per year. This corresponds to findings of other studies[10]. Despite only taking place for 6.2 months per year, space heating needs the most energy, followed by hot water supply and cooking, which require about equal amounts and are required throughout the year. The annual consumption of electricity per household in both municipalities is roughly 1,300kWh, much lower than reports suggest: according to a study by GeoStat[11] the average per capita consumption is 1,970kWh.

5.3 Demand for firewood

Regarding the demand for firewood, the results show that in Akhmeta about 58,687m^3 and in Dedoplistskaro about 51,525m^3 are needed for energy supply per year. The annual demand of firewood per household is about 8m^3, in line with the findings of other studies in Georgia[12]. These figures are below the amount of 70,000m^3 for Akhmeta, which was provided by local authorities. However, this demand for firewood is in conflict with the official figures of harvested timber in the region. A share of more than 70% of the total registered harvest amounts is associated with only about 20% of the population of Kakheti. The average price derived from the respondents is roughly 60 GEL per m^3 of firewood delivered to the

[9] UNECE United Nations Human Settlement Programme, 2013: Good Practices for Energy Efficient Housing in the UNECE Region.
[10] ECA Sustainable Cities, 2011: Improving Energy Efficiency in Tbilis, Georgia.
[11] National Statistics Office of Georgia. Retrieved in January 2016.
[12] USAID, 2014: Household energy end-use survey.

household. It is likely that this price is slightly higher due to the difficulties related to the appropriate use of units of firewood and information derived from stakeholder interviews. However, the annual expenses for firewood are most likely accurate, with the majority spending between 350 and 700 GEL per year. From the World Bank's figures, this represents one to two months of average household income (350 GEL), and implies that any financial saving that could be made, due to increased efficiency, for example, would be highly significant to the inhabitants.

The total forest areas in Akhmeta and Dedoplistskaro are 64,952ha and 12,587ha respectively[13]. Considering the shortage of forest resources in Dedoplistskaro, transportation for the supply of firewood is clearly important. Water content, form of the firewood and density are the most important factors determining the efficiency of supply of biomass in terms of transportation. If a mean annual growth of about $10m^3$ per ha per year could be achieved, the annual increase of timber stock would be around $775,000m^3$ in the two municipalities. Consequently, the amount of firewood could be supplied from the regional forests without threatening sustainability under given framework conditions such as population decrease in the rural areas of Georgia.

However, the amount of official harvest grossly differs from the approximate demand calculated for firewood. The official amount of woodcutting in Akhmeta amounts to 10,000 m^3. If $52,892m^3$ of firewood are needed per year and only $10,000m^3$ are given in the public figures then there must be a large amount of unregistered wood consumption in the area. Taking into account that by law, each household has the right to harvest $7m^3$ of firewood, the product of number of households (7,825 in Akhmeta) and supplied tickets for licensed harvest lead to $49,000m^3$ of firewood that should be allowed to cut on a legal basis. The official figures and Forest Management Planning could be improved.

[13] Figures provided by the NFA

6. Recommendations

6.1 Forest productivity and sustainable forest management

Currently, wooden residues of timber harvest that are left in the forest are very high. It is estimated by the NFA that about 4,000m^3 of wooden residues per year accumulate in the forests of Akhmeta alone. In total, about 100,000m^3 are estimated to be available in the forests of Akhmeta. An increased use of this biomass potential would reduce the pressure for utilization on standing volumes. Harvesting wooden residues from timber harvest and production as well as making use of other biomass potential from sources such as vineyards and the forest based industry offer alternatives for the supply of forest-based biomass for energy purposes.

6.2 Forest planning

The assessment showed clearly that there is a large discrepancy between the estimated demand for firewood as derived from the assessment and the official timber harvest figures as available from the NFA. In Akhmeta, for example, the harvested timber amount that is registered is 10,000m^3 but the estimated demand for firewood is roughly 50,000m^3. Distributed ticket licensing and the number of households would lead to an annual legal harvest amount of about 49,000m^3, which roughly corresponds to the amount of firewood needed. However, the forest management does not seem to be implemented in a way that corresponds to the demand and/or administered supply as given by the state. In order for the annual harvest goals to correspond to the demand from the population, firstly the personnel needed for monitoring, and secondly the planning measures need to be considerably improved.

6.3 Increased insulation of buildings and efficiency of conversion technology

Assuming a reduction of the specific heat demand from 390 to 300 kWh/m^2 by improving the thermal insulation, the annual consumption of wood could be reduced from 8 to 6m^3, leading to a 25% saving on energy expenses before even considering a change in storage time. By merely increasing thermal insulation, 30,000-50,000m^3 per year could be saved just for the consumption in Akhmeta and Dedoplistskaro. Clearly, measures for increasing thermal insulation in the heated living space should remain high up on the agenda when developing strategies to reduce the pressure on the local forests.

6.4 Development of a market for quality ensured biomass products

At the current time, 90% of the consumers dry their firewood for 0-3 months, 8% for 3-6 months and 2% for a time >6 months. With these proportions, approximately 176TWh of heat are transferred during combustion. If the shares of firewood could be improved to 5% (0-3 months), 45% (4-6 months) and 50% (>7 months), the amount of energy would increase to 187TWh. Correspondingly, the same amount of energy, 176TWh, could be supplied with about 4,000m^3 less firewood. This is enough wood to supply 500 households, or 10% of Dedoplistskaro's population, merely by increasing the amount of time that the firewood is stored. For one household, the use of only dried wood could lead to a reduction of the annual wood demand of up to 20%, depending on the quality of the wood that is currently used. Combined with increased thermal performance of the building, a higher thermal conversion efficiency and raised consumer awareness, this percentage could be increased even furthe

Annex

Annex 1 Questionnaire

0. To be completed by Interviewer

0.1	Interviewer name **|_____|**	
0.2	**Date: |__|__| / |__|__| / 2015** *Day Month*	
Remarks (Please fill in any additional information that you think might be useful)		
0.3	a. Municipality: |_____| b. Segment number: |____| c. Name of main village (s) visited |_____| d. Starting point: |_____| **(Roll dice to determine starting point.)**	
0.4	**Interview number per day:** |__|__| **(01-10, for each interview day)**	

Introduction to household members:

Dear Sir/Madam,

my name is [**name of interviewer**] and I would like to conduct an interview about the use of energy in the municipality. **The reason for this is that the National Forest Agency of Georgia would like to manage our forests in a way that we can assure we have enough wood for many generations to come**. To do this well, a good understanding of how much wood is needed in our country is necessary. You know that in this region the use of wood for heating and cooking is one of the main services that the Georgian Forests provide. **Your household was chosen randomly.** Everything you say will only be used to derive mean values for the whole population. It is completely anonymous and no one will be able to relate the answers you provide to your household. It will take **about 30 minutes**. After the interview, I would like to **take a picture of your oven and of the stored wood**. We would highly appreciate if you are willing to share this information with us. **Your participation is voluntary.**

The results of the study will be made available to the local administration and accessible for you. Would you like to participate?

Signature of Interviewer:

SECTION 1 – HOUSEHOLD STATUS			
1.0	What is the number of persons living in your household?	**1**	|_____|
1.1	How many months of the year do you live in this household?	**1**	Number of Month(s): |_____|
1.2	What type of building do you live in? **(Circle one correct answer)**	**1**	Single family house
		2	Multi family house
		3	Flat/apartment
		4	Other (specify):
1.2.1	Please indicate the type of household. **(Circle all that apply)**	**1**	Residential building
		2	Commercial building
1.2.2	If commercial building, what type of business do you practice? **(Circle one correct answer)**	**1**	Restaurant, bar, café
		2	Craftsmanship (workshop)
		3	Shop / Services
		4	Other (specify):
SECTION 2 – HOUSING AND FACILITIES			
2.1	What is the major construction material of the outside walls? **(Circle one correct answer)**	**1**	Bricks and bloks
		2	Wooden planks / shingles
		3	Cement and/or stones
		4	Other (specify): |_____|
2.2	What is the major construction material of the roof? **(Circle one correct answer)**	**1**	Wood
		2	Tiles
		3	Concrete/cement
		4	Asbestos
		5	Zinc/metal
		6	Other (specify): |_____|
2.3	Of which type are most of the windows? **(Circle one correct answer)**	**1**	Single glazing windows
		2	Double glazing windows
		3	Windows with wooden cover
		4	No glazing
		5	Other (specify): |_____|

2.4	To which part of your house did you install any additional material for insulation? **(Circle all that apply)**	**1**	Windows
		2	Walls
		3	Roof
		4	Other (specify): |_____|

SECTION 3 – ENERGY CONSUMPTION SPACE HEATING READ "FIRST LET US FOCUS ON THE ENERGY USED FOR HEATING YOUR HOUSE/ROOMS ONLY"

3.1	Do you currently have access to the gas grid?	1 = YES	0 = NO
3.2	How long is the heating season?	Months |_____|	
3.2.1	How many rooms do you heat?	Room(s) |_____|	
3.2.2	How many square meters do you heat? **(Measure in case of doubt)**	m^2 |_____| Room(s): a. Length: |_____| Width: |_____| (per room) b. Length: |_____| Width: |_____| (per room) c. Length: |_____| Width: |_____| (per room)	

3.3	How much do you use of the following resources for space heating? **(Circle the most accurately used time unit for reference, pick a unit code and fill in the amount. Fill in for every resource.)**		**3.3.1 Time frame** **1** Week **2** Month **3** Year	**3.3.2 Unit code** **1** Kilogram **2** Piece **3** Liter **4** Minute **5** Gas bottles **6** space cubic meter **7** cubic meter **8** GEL **9** Other |_____|	**3.3.3 Amount**
	1	Firewood			
	2	Gas			
	3	Coal			
	4	Heating oil			
	6	Other_____			

Section 4 ENERGY CONSUMPTION WATER HEATING

4.1	How many resources did you use for water heating? **(Circle the most accurately used time unit for reference, pick a unit code and fill in the amount. Fill in for every resource.)**		**4.1.1 Time frame** **1** Week **2** Month **3** Year	**4.1.2 Unit code** **1** Kilogram **2** Piece **3** Liter **4** Minute **5** Gas bottles **6** space cubic meter **7** cubic meter **8** GEL **9** Other |_____|	**4.1.3. Amount**
	1	Firewood			
	2	Gas (grid connected)			

	3	Gas (bottled)			
	4	Coal			
	5	Heating oil			
	6	Electric boiler			
	7	Other_____			

Section 5 ENERGY CONSUMPTION COOKING (and production of alcohol)					
5.1	How many times do you cook in average per day?		**Number |____|**		
5.2	How many resources did you use yesterday for cooking? **(Circle the most accurately used time unit for reference, pick a unit code and fill in the amount. Fill in for every resource.)**			**5.2.2 Unit code** **1** Kilogram **2** Piece **3** Liter **4** Minute **5** space cubic m **6** GEL **7** Cubic meter **8** Other (specify)	**5.2.3. Amount**
	1	Firewood			
	2	Gas (grid connected)			
	3	Gas (bottled)			
	4	Coal			
	5	Heating oil			
	6	Other_____			

Section 6 ELECTRICITY CONSUMPTION					
6.1	For which appliances do you use electricity? **(Circle the three most important)**	**1**	Lighting		
		2	Multimedia (TV, Radio, Computer)		
		3	Heating		
		4	Cooking		
		5	Other electrical appliances		
6.2	How high is the consumption of electricity per month in average [GEL **or** KWh]?	**6.2.1**	|_____| GEL	N/A=99	
		6.2.2	|_____| KWh	N/A=99	

Section 7 WOOD USE					
7.1	How many times per year do you add firewood to your stock?	**Number |___|**			
7.2	In which month(s) did you	**1**	January	**7**	July

	buy the wood this year? **(Circle all the apply)**	**2**	February	**8**	August	
		3	March	**9**	September	
		4	April	**10**	October	
		5	May	**11**	November	
		6	June	**12**	December	

7.3	What are the most important sources of firewood for your household? **(Circle up to three)**	**1**	Wood seller / forest entrepreneur	
		2	Ticket licensing	
		3	Own sources	
		4	Friends/neighbors	
		5	Other (specify) |_____|	

7.4	Which form of firewood do you receive and how large is their share in the total amount you use? **(Fill out for all that apply)**			**7.4.1 Percentage**
		1	Trunks /round wood	
		2	Split pieces	
		3	Branches	
		4	Wooden residues	
		5	Other (specify) |_____|	
			Sum	**100**

7.5	How many months of the year do you use firewood for cooking mainly?	Month(s) |_____|

7.6	How much firewood did you use yesterday? **(Choose most suitable unit code and fill in the amount. Fill in for every resource.)**	**Unit code 1** Kilogram **2** Pieces **5** Other (specify): |_____|			
			Type	**7.6.1 Unit**	**7.6.2 Amount**
		1	Trunks /round wood		
		2	Split pieces		
		3	Branches		

		4	Wooden residues		
		5	Other (specify) |_____|		
7.7	How much firewood did you use in a typical month during January? **(Choose most suitable unit code and fill in the amount. Fill in for every resource.)**	**Unit code 1** Kilogram **2** Pieces **3** space m^3 **4** Piri **5** cubic meter **6** Other (specify) |_____|			
			Type	**7.7.1 Unit**	**7.7.2 Amount**
		1	Trunks /round wood		
		2	Split pieces		
		3	Branches		
		4	Wooden residues		
		5	Other (specify): |_____|		
7.8	How much firewood did you use last year? **(Choose most suitable unit code and fill in the amount. Fill in for every resource.)**	**Unit code 1** Kilogram **2** Pieces (30 cm) **3** space m^3 **4** Piri **5** Other (specify):			
			Type	**7.8.1 Unit**	**7.8.2 Amount**
		1	Trunks /round wood		
		2	Split pieces		
		3	Branches		
		4	Wooden residues		
		5	Other (specify): |_____|		

Section 8 WOOD TRADE			
8.1	How much do you spend on the purchase of firewood per year?	GEL |_____| N/A=99	
8.2	Of which form is the majority of wood you pay for?	**1**	Logs/round wood

	(Circle one correct answer)	**2**	Split pieces
		3	Branches
		4	Wooden residues
		5	Other
8.3	What is the price of **one** the most common forms of traded units?	**Unit code 1** Kilogram **2** Pieces (30 cm) **3** m^3 **4** Piri **5** Truck **6** Other (specify): |_____| Unit |____| GEL |_____|	
8.3.1	How large is the variation between lowest and highest price in the course of a year for this unit?	GEL |_____|	
8.4	If you use wooden residues, of which kind are they? **(Circle all that apply)**	**1**	Residues from the forest
		2	Residues from your garden
		3	Old furniture /construction material
		4	Other (specify): |_____|
8.5	How far is the wood transported to your household? **(Aim at forest – household distance)**	**1**	Km |_____| **99**=N/A
8.6	Where do you store most of the firewood? **(Circle all that apply)**	**1**	Inside the house
		2	Outside, covered
		3	Outside, uncovered
		4	Other
8.7.1	How long has your wood been stored since you purchased it?	**1**	Month(s): |_____| **99**=N/A
8.7.2	Do you ever consider buying wood one year in advance in order to store it for longer time?	**1=** YES **0=**NO	

SECTION 9 –CONVERSION TECHNOLOGY					
9.1	How many ovens are operating in your household?	Number of ovens |_____|			
9.2	How old is/are the oven/s? **(Fill in the unite code for every oven)**	**9.2.1** Oven 1	**9.2.2** Oven 2	**9.2.3** Oven 3	**9.2.4** Oven 4
		99=N/A			

		Unit codes: 1 0-5 years **2** 6-10 years **3** >10 years
9.3	**(Estimate the power of the oven(s). Only ask for clarification.)**	**9.3.1** Oven 1 | **9.3.2** Oven 2 | **9.3.3** Oven 3 | **9.3.4** Oven 4 | | | | | **Unit codes 1:** 1-2 KW **2:** 3-10 KW **3:** >10 KW
Section 10 MEASUREMENTS and PICTURES		
10.0	After finalizing the interview, check all of the above data. Include file name of the pictures	**Check** Picture wood storage **10.1** Filename of the picture |_____| Picture of main oven **10.2** Filename of the pictures |_____| Measurement of wood pile (length, height, depth) **10.3.1 Pile one** length |_____| width |____| height |____| **10.3.2 Pile two** length |_____| width |____| height |____| **10.3.3 Pile three** length |_____| width |____| height |____|

Annex 2

For the complete selection of pictures from the interviews in the households please have a look at the online storage. Click here.

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