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Governing for Growth in Georgia

ENERGY AND WATER CONSUMPTION END-USE SURVEY IN COMMERCIAL AND INDUSTRIAL SECTORS

FINAL REPORT

USAID GOVERNING FOR GROWTH (G4G) IN GEORGIA

24 JUNE 2016

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USAID GOVERNING FOR GROWTH (G4G) IN GEORGIA

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ACRONYMS

CRRC	Caucasus Research Resource Center
Disco	Distribution Company
EPI	Economic Prosperity Initiative
G4G	Governing for Growth in Georgia
GEL	Georgian Lari
GEOSTAT	National Statistics Office of Georgia
GoG	Government of Georgia
HIPP	Hydropower Investment Promotion Project
HPEP	Hydro Power and Energy Planning Project
HVAC	Heating Ventilation and Air Conditioning System
kWh	Kilowatt Hour
LED	Light-Emitting Diode
LPG	Liquid Petroleum Gas
M3	Cubic Meter
MARKAL	Long-Term Energy Planning and Optimization Model
MOE	Margin of Error
MoE	Ministry of Energy of Georgia
MoESD	Ministry of Economy and Sustainable Development of Georgia
MW	Megawatt
SME	Small and Medium-Sized Enterprises
SPSS	Software for Statistical Package for the Social Science
STATA	Data Analysis and Statistical Software
USAID	United States Agency for International Development
VOLL	Value of Lost Load
WEG	World Experience for Georgia

CONTENTS

1. BACKGROUND

United States Agency for International Development (USAID) funded project "Governing for Growth (G4G) in Georgia" is designed to improve Georgia's economic governance and leadership, including in the areas of natural resources, the energy sector and human and institutional capacity. G4G is comprised of five components: (1) Support inclusive public-private dialogue (PPD), (2) Strengthen the capacity of the Government of Georgia (GoG) to develop, implement and enforce reforms, (3) Improve water resource management across multiple competing interests, (4) Improve economic governance and leadership of energy trading policy, including cross-border trading of electricity, and (5) Strengthen the capacity of the private sector and civil society actors to advocate for reforms. G4G is a continuation of other USAID projects such as: EPI (Economic Prosperity Initiative), HIPP (Hydropower Investment Promotion Project), and HPEP (Hydro Power and Energy Planning Project), with the objective to increase Georgia's competitiveness in key sectors, such as energy, agriculture, trading, and manufacturing, as well as improving Georgia's business enabling environment. Within the energy planning component of the HPEP project, the MARKAL Georgia model was updated. Namely, the residential sector's data quality was improved through the Household Energy End-Use Survey. Additionally, capacity building of the Analytical Department of the Ministry of Energy of Georgia (MoE) was conducted to enable the MoE with skills for energy planning and energy strategy preparation.

MARKAL is a bottom-up, linear optimization model that represents the Reference Energy System including the whole chain of energy supply, transformation, transmission and consumption, from primary energy supply to final end-use by consumers. The quality MARKAL- generated results solely depend on the quality of input data. Since no reliable statistics and/or end-use surveys on energy consumption in the commercial and industrial sectors exist, data gaps in MARKAL were filled by assumptions and expert inquiries, which affected the quality of the model's outputs. Therefore, it was decided to conduct the energy consumption survey of non-residential consumers and World Experience for Georgia (WEG) was selected to perform the task. Water consumption is not a part of MARKAL based analysis. However, due to the importance of water supply for social and economic growth and due to the need for optimization, G4G has requested to cover water consumption through the survey as well.

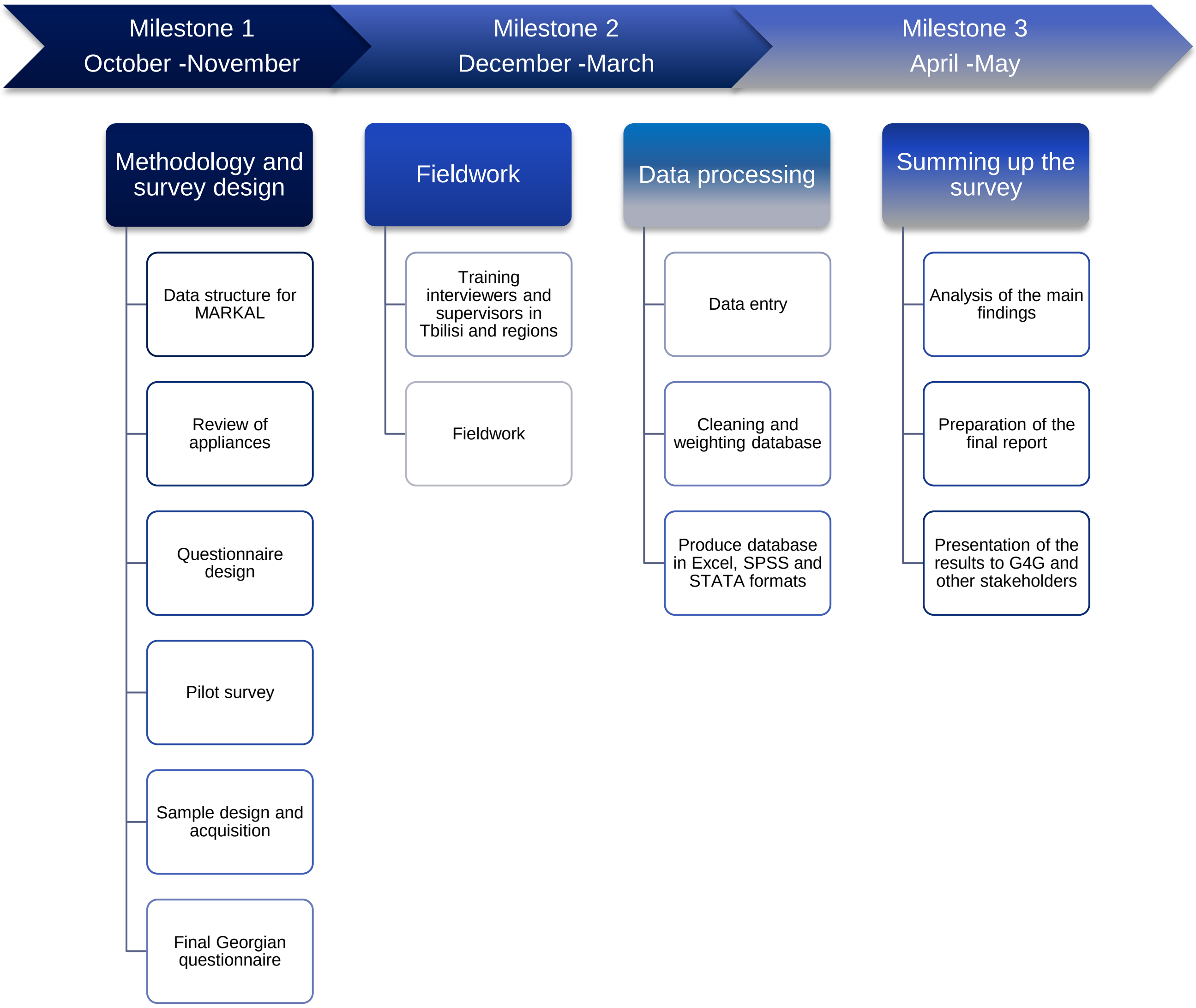
Within the defined timeframe, WEG has conducted an end-use energy and water consumption survey in the commercial and industrial sectors, results of which are organized in an electronic database. The results of the survey will be used for updating data for the commercial and industrial sectors in MARKAL, contribute to better quality of model results, create a better understanding of water consumption patterns and help design effective water policies.

The survey, along with valuable raw data for MARKAL improvement, provides the material for research in energy planning, demand projections, energy efficiency and energy saving, water consumption planning and other fields. It indicates the need for further more detailed studies and energy audits in certain subsectors as well as areas where improved data handling is needed. After further analysis and processing, the survey results can lead to more informed policies and better planning in the energy and water sectors.

2. SUMMARY OF SURVEY PROCESSES

The survey began in October 2015 and lasted for 7 months. The process was divided into 3 milestones (see Figure 1). In the first milestone, WEG developed the data structure in accordance with MARKAL Georgia data sets, reviewed and classified appliances used in the commercial sector, reviewed and classified industrial processes and designed the sample selection and survey processes. The results were incorporated into sector-specific questionnaires. The wide variety of enterprises surveyed, whose energy and water consumption might be drastically different, had to be taken into account along with the varying complexity of technological processes, ranging from high sophistication to simple heating and lighting consumption. This wide diversity in the sample population was drastically different from the previous residential survey. It was therefore critical to carefully design the survey sample and process.

Figure 1: Survey process scheme



Two options were considered for selection of the survey sample: GEOSTAT's (National Statistics Office of Georgia) database of legal entities and electricity distribution company (Disco) consumer databases. It was decided to use electricity consumption as a proxy for sample selection, with preference given to Disco databases where selection based on energy consumption was possible.

WEG has developed two questionnaires: One designed for a more in-depth survey of large and medium industrial enterprises that use complex technological processes in production, and another designed for the entities with relatively simple end-use technologies, requiring less survey detail. The differentiation served to accurately describe technological processes and capture large enterprise energy and water consumption details, with engineer/auditor assistance, while also ensuring comprehensiveness. By request of G4G, water consumption questions were also added to the questionnaire. To cover the large industrial enterprises and conduct in-depth surveys in both the industrial and commercial sectors, WEG hired qualified engineers. Due to the large number of small and medium-sized enterprises (SMEs), WEG subcontracted the Caucasus Research Resource Center (CRRC)-Georgia to conduct a wider, but less detailed survey in commercial and industrial enterprises. Once the questionnaire was designed, WEG conducted a pilot survey to test questionnaire effectiveness. After the analysis of pilot survey results, minor changes were made to the final questionnaires.

WEG, together with CRRC, conducted training for interviewers. The training included basics of energy, typical energy consumption devices and appliances, water consumption and discharge basics, and an explanation of the survey questionnaire. The 71 trained interviewers conducted interviews in all regions of Georgia based on the survey samples obtained from the Discos. In parallel, three engineers conducted the detailed survey in selected large industrial and commercial, as well as some medium-size entities. Throughout the process, the fieldwork supervisor provided interviewers with technical support, ranging from energy-related issues to behavioral guidelines. The data collected was then compiled into a database. Since two questionnaires were developed, two corresponding databases were created accordingly. One database includes commercial and industrial energy and water consumption data for those entities interviewed by the trained interviewers while the other contains data obtained by qualified engineers. The databases were consolidated by removing inaccurate data to ensure sample validity and weighted for analysis. The databases were produced in three formats: Excel, STATA (Data Analysis and Statistical Software) and SPSS (Software for Statistical Package for the Social Sciences)-compatible versions.

Analysis of the main findings was followed by preparation of the final report and the results were presented to G4G and other stakeholders.

3. METHODOLOGY

The main goal of the energy consumption end-use survey in commercial and industrial sectors is to collect the necessary information for better representation of energy consumption in respective sectors according to the MARKAL structure. The survey collected information on other variables apart from energy to provide the grounds for different types of energy and water consumption analysis for the commercial and industrial sectors.

The industrial sector in MARKAL is represented by the following 6[1] subsectors:

- Iron and steel industries;
- Chemical industry;
- Non-metallic minerals industry;
- Construction industry;
- Food, beverage and tobacco industries;
- And other manufacturing industries.

Under the MARKAL model, the commercial sector classification is quite broad, including public and private entities that are not divided into subsectors.

Initially, the Discos were asked to divide the selection of industry entities by the categories listed above. The number of selected enterprises per each subcategory was determined by the following formula:

$$n_{ix} = P_{ix} n_i$$

Where:

- P_{ix} is the share of non-residential customers in each subcategory of a particular Disco in its total number of non-residential customers;
- n_i is the total number of non-residential customers to be selected by particular Disco.

However, the Disco billing systems do not divide non-residential customers by the categories listed above or by more generalized ones, such as industry and commercial customers. Therefore, the Discos were not able to provide the information by required subsectors.

Therefore, two questions were added to the questionnaire to determine the sectors that the particular respondent represented, to separate industrial and commercial results. Additionally, a question on primary and secondary fields of activity was used to further divide industrial enterprises into industry subcategories in accordance with MARKAL classification.

The MARKAL industry subsector classification was used in selecting the sample of large and medium sized commercial and industrial entities to be surveyed by engineers-interviewers. Large enterprises were selected in such a way that each subcategory was represented by at least two large entities. Additionally, descriptive information was collected from large enterprises to gather the data that cannot be captured by the quantitative survey and standardized questionnaire. Overall, after fieldwork completion three datasets were compiled:

- A large database with quantitative data for 1610 commercial and industrial enterprises surveyed by trained interviewers, including the necessary information quantitative analysis;
- A small database with quantitative data for 57 large and medium sized commercial and industrial entities, surveyed by qualified engineers using the more complex and detailed questionnaire. The database was used to cross-check the large database and to better understand energy and water consumption for large and medium entities;

[1] Previously there were 7 subsectors, where non-ferrous metals manufacturing was represented as a separate subsector. This subsector was eliminated because there is no production of non-ferrous metals in Georgia. Ferric alloy manufacturing is included in the iron and steel industry.

- A descriptive database with narrative data on large industrial enterprises, used in conjuncture with the quantitative survey in order to better depict the energy and water consumption of large industrial enterprises and their specific energy-consuming technological processes.

As MARKAL requires energy consumption data to be portioned by end-use technology—which cannot be obtained directly from the survey—additional work is required for effective analysis within the MARKAL model. The survey results contain information on end-use technologies, including their working load, capacity and type of energy sources used. Based on this, the proportion of energy used to satisfy different types of energy demand can be estimated. The report contains some preliminary analysis of key parameters of interest.

4. SAMPLE DESIGN

Due to a wide variety of non-residential energy consumers, ranging from small kiosks to large industrial or commercial entities, the concept of a non-residential consumer was not clearly defined. Therefore, since the main focus of the survey is on energy and water consumption, larger energy consumers were prioritized to show the main patterns of non-residential energy consumption. Non-residential customers were sampled using electricity consumption as a proxy for size and overall energy consumption, using Disco databases rather than the GEOSTAT business registry for selection.

With MoE support, the Discos "Telasi," Energo-Pro" and "Kakheti Energy Distribution" were contacted and requested to send a set of non-residential customers with the following information structure:

Organization name	Contact information	Region	Activity type	Annual electricity consumption (kWh)

If sampling was conducted using the business registry, the likelihood of selecting any entity would have been even, thus potentially excluding large energy consumers. However, using the electricity consumption data, it was possible to select candidates with "probability proportional to size"[2] so that large consumers of energy were more likely to be chosen. However, only Telasi provided the consumption data as the other Discos considered the data confidential. As a compromise, these Discos conducted the sampling procedure themselves based on the specifications provided by CRRC (details of selection can be found in ANNEX C).

Each of the Discos provided their list of non-residential customers, which were incorporated in the sample. However, since response rates differed across the Discos' customers, corresponding weights were calculated based on the numbers of non-residential customers per Disco so that neither Disco is inaccurately represented in the sample. Any analysis of the results must take into account the fact that three biased samples were consolidated in one survey. However, if adequately weighted, the survey results of a summary sample (3289 non-residential customers) can be analyzed to derive accurate conclusions on energy and water consumption patterns.

The interviewers' skills and knowledge of energy basics, consumption appliances and consumption patterns were key limiting factors. Therefore, surveyors were trained and a more specialized survey by engineering specialists on a set of large and medium-sized commercial and industrial entities was conducted to provide (a) a description of energy and water consumption by major largest industry consumers and (b) a typical pattern of consumption for medium industrial and commercial energy consumers that would allow generalization for certain consumer categories. Three qualified engineers with experience in energy auditing were hired for this task to ensure quality of content. This second set of information would be complementary to the survey results delivered by other, non-specialist surveyors.

Two main criteria were used for this set of large and medium consumers: The size and the readiness of entities to participate in the survey. Since large industrial entities were not always eager to take part in similar surveys, personal contacts were used to persuade the selected enterprises to participate. In several cases, letters from Ministry of Economy and Sustainable Development of Georgia (MoESD) were requested by the management of the surveyed enterprise. Medium size entities were selected randomly, however, in some cases refusal to participate in the survey made it necessary to add more entities with more collaborative management.

In total, 65 enterprises were selected resulting in 57 successful surveys. This second set of information contains quantitative energy and water consumption data, as well as qualitative data describing complex technological processes, additional energy consumption related data (e.g. tariffs) and other specifics, for 27 large industrial enterprises from six industry subsectors and similar information for 30 other medium size entities. This second sample and descriptive information can be used to fill information gaps of the first survey sample while deriving an understanding of energy and water consumption in the commercial and industrial sectors.

[2] Measure of "size" is determined by annual electricity consumption

5. SURVEY RESULTS

Presented below are key parameters of interest in the preliminary analysis of the results of the survey. A more detailed analysis and preparation of MARKAL inputs was outside the scope of this assignment.

The initial expectation of the response rate for the survey of commercial and industrial entities by CRRC was approximately 30%. Therefore, in order to achieve the agreed sample size of 1000, 3289 interview attempts were made. However, the actual response rate was substantially higher and after database cleaning, the final sample size was larger than expected: 1610 vs. 1000.

Together with the results of specialized surveys conducted by WEG, the final number of valid survey responses (1667) is 67% higher than initially planned, representing both the commercial and industrial sectors. Information was collected for 471 industrial, 1102 commercial and 37 agricultural entities. The latter were identified at the analysis stage and were excluded from the final results.

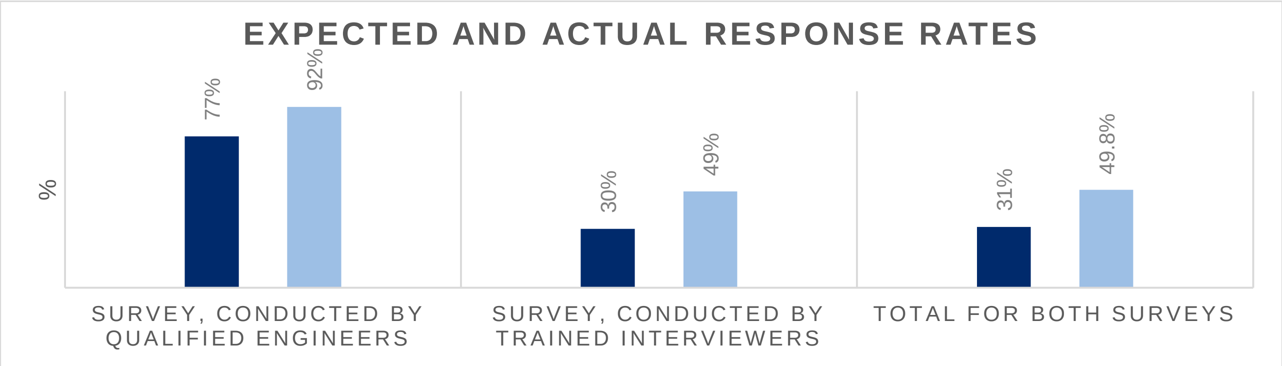
Table 1: Expected and actual survey results

	Targeted responses	Interview attempts	Actual responses
Surveys of large and medium size entities, conducted by engineers	50	62	57
Surveys of small and medium-sized entities by trained interviewers	1000	3289	1610
Total for both sectors	1050	3354	1667

The response rate to the questionnaires can also be considered high: The average response rate for all questions was 88%. However, due to the reluctance or ignorance of respondents, some questions turned out to be difficult to fill in. These are mainly: 1. Cost of manufactured products (response rate 60%); 2. Company turnover (response rate 58%); 3. Monthly electricity consumption in kWh (average response rate 33%); 4. Annual consumption of water in m^3 (average response rate 34%) and; 5. Capacity of appliances - computers, elevators and TV (average response rate 54%) and some others.

For large and medium size entities, surveys conducted by the engineers also had a high response rate, due to personal contacts and support letters from the MoE used to persuade the enterprises to take part. Still, five targeted enterprises could not be surveyed and the final response rate was 92%.

Figure 2: Expected and actual response rates



6. MAIN FINDINGS

There are some general key messages that can be drawn from the survey results:

- Lack of planning. Only a few entities answered positively to the question on whether they plan water consumption. Similarly, only a few entities reported plans to replace existing technologies with energy efficient ones;
- Energy price elasticity. None of the large and medium industrial entities surveyed reported a plan to switch to cheaper energy sources, which implies that they are not sensitive to price change of the type of energy that they use;
- Electricity is the primary energy source for heating in the commercial sector (see Figure 3). This is explained by the fact that the majority of commercial entities use split-system conditioners for both cooling and heating needs. This is true not only for small entities (e.g. shops, small offices), but also for large commercial entities (e.g. restaurants). The share of those that use heating, ventilation and air conditioning systems (HVACs) is small, even though the HVAC system is a much more efficient way of cooling and heating;
- The majority of large and medium industrial enterprises surveyed reported that they have no water purifying systems and others lacked the capacity to ensure quality water purification.

Below we present the initial findings of the survey for the characterization of energy and water consumption by end-use technology.

COMMERCIAL SECTOR

ENERGY USE

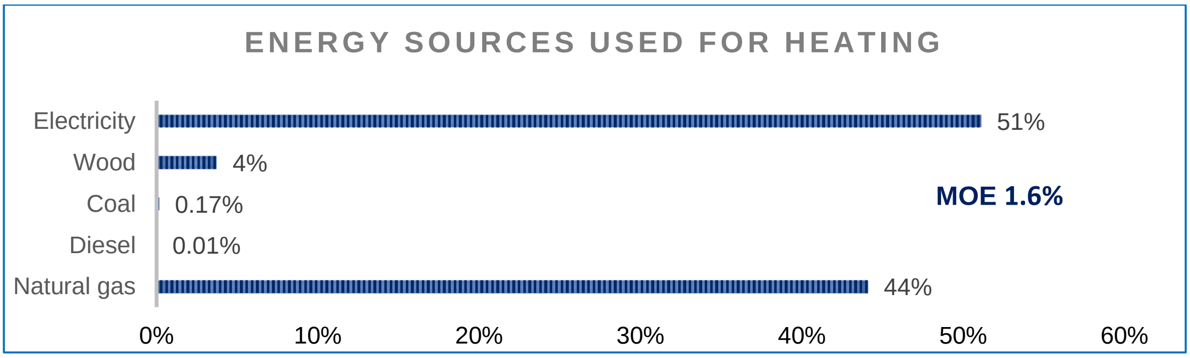
To better describe energy usage, each graph contains, apart from data visualization, an indication of the margin of error (MOE). A bar chart was used to represent a summary of question responses and therefore displays proportions that do not equal 100%. In contrast, a pie chart was used to represent the real proportions of responses within each category. The data was processed with STATA software.

Figure 3 shows that the main energy source for heating in the commercial sector is electricity. The second most used energy source for heating is natural gas. The proportion of those who use other energy sources for heating is statistically insignificant. The main categories that prefer heating with electricity rather than with natural gas are: Restaurants and restaurant complexes,[3] hospitals, shops, drugstores, commercial bank service centers and others. The MOE of the dataset was found to be 1.6%.

Note that the data in these figures represent patterns for the sample (3289 commercial and industrial entities). See section "Sample Design"

[3] Restaurant complex that consists of several independent buildings.

Figure 3: Energy sources used for heating

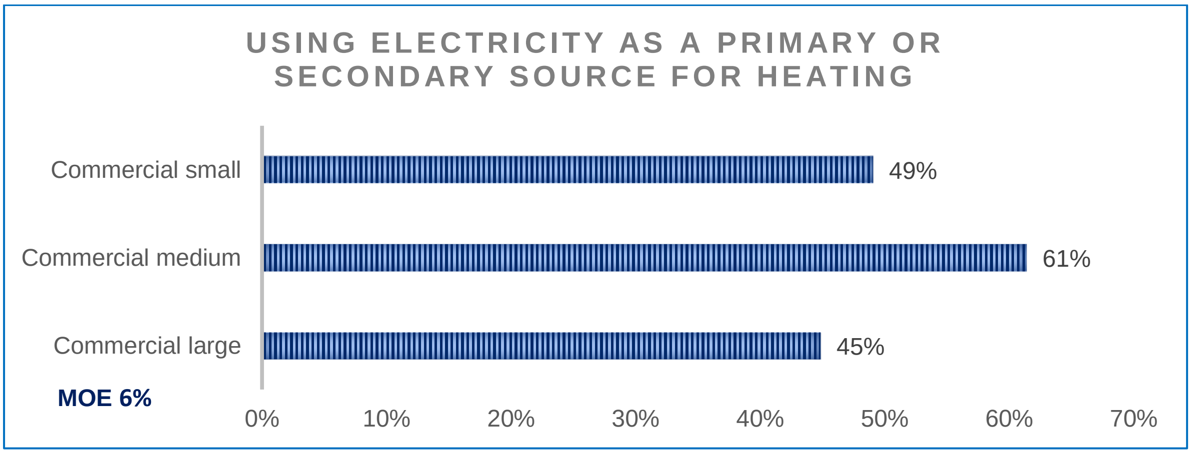


Note: responses were not mutually exclusive

There were high response rates for questions on electricity consumption. However, many enterprises found it difficult to answer how many kWh of electricity they consume monthly or annually, preferring instead to provide total electricity costs, in Georgian Lari, on their utility bills. Electricity consumption in kWh was later calculated, at the analysis stage, based on known electricity tariffs for non-residential customers of three Discos. Based on this variable (annual electricity consumption), the commercial sector can be divided into three subsectors within the sample. These subsectors are: Large (non-residential large electricity consumers), medium (entities with medium electricity consumption) and small. Since the commercial sector is represented by different enterprises with contrasting activities, size and electricity consumption, analyzing proportional distribution of responses per subcategory separately will help better depict the commercial sector electricity consumption structure.

Figure 4 depicts electricity consumption among large, medium and small consumers. The share of electricity as a primary or secondary source for heating is quite substantial for all three groups. The most commonly used electric conditioning technology is the split-system wall conditioner, used for both heating and cooling needs.

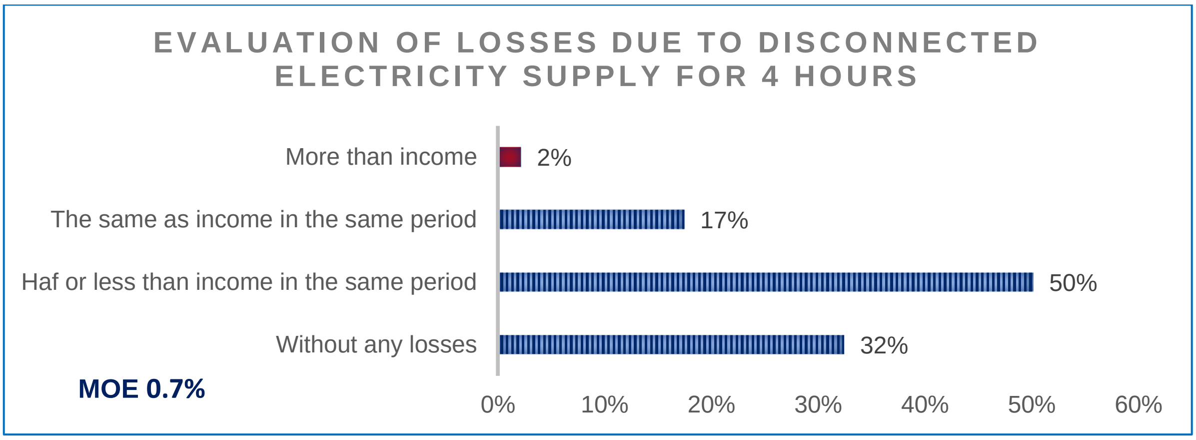
Figure 4: Using electricity for heating



Note: Proportions represent shares per each subcategory (large, small and medium commercial)

Figure 5 shows respondents' estimation of their potential losses in case of electricity supply disruption. The majority of respondents who did not predict a loss in case of electricity supply disruption reported an alternative source of energy, such as a diesel generator, which can substitute electricity from the grid for the duration of the disruption period. This data can be used to estimate the potential value of lost load (VOLL).

Figure 5: Estimation of losses due to disconnected electricity supply



Note: Blue bars represent proportions of responses within one question, while the red one is taken from the separate question.

Figure 6 shows the main energy sources used for water heating. As can be seen, similar to space heating, the water is heated mostly with electricity. A substantial proportion of commercial sector consumers do not use hot water, judging by the proportion of enterprises that did not report using either natural gas or electricity for water heating. These enterprises are mainly representatives of the trade subcategory (e.g. shops, drugstores) including commercial bank service centers, offices and transport services (e.g. bus stations).

Figure 6: Energy sources used for water heating

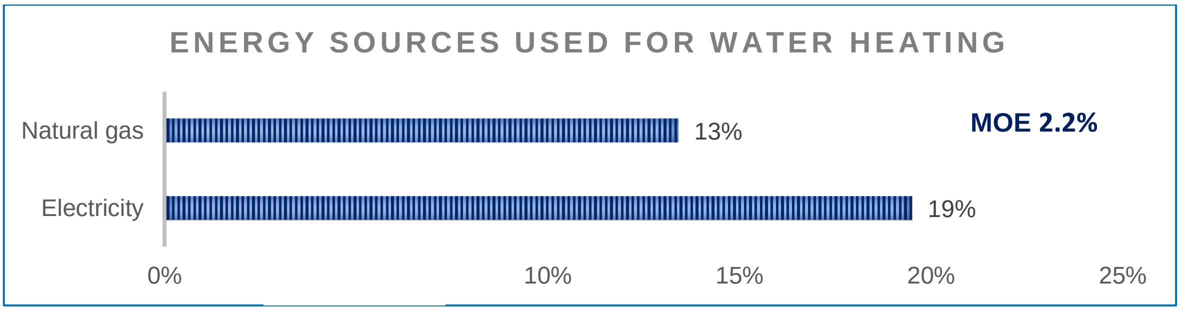


Figure 7 shows the distribution of responses on possible economic losses in case of short term natural gas supply disruption. A high share of respondents responded with negligible losses. The main reason is that taking into account activity type, specifically natural gas disruption, does not affect operation of those entities. Additionally, some enterprises use alternative sources of energy, with which they can substitute natural gas consumption for the period of disruption. This alternative source is primarily either electricity or liquid petroleum gas (LPG). This data can be used for estimation of VOLL.

Figure 7: Estimation of losses due to disconnected gas supply

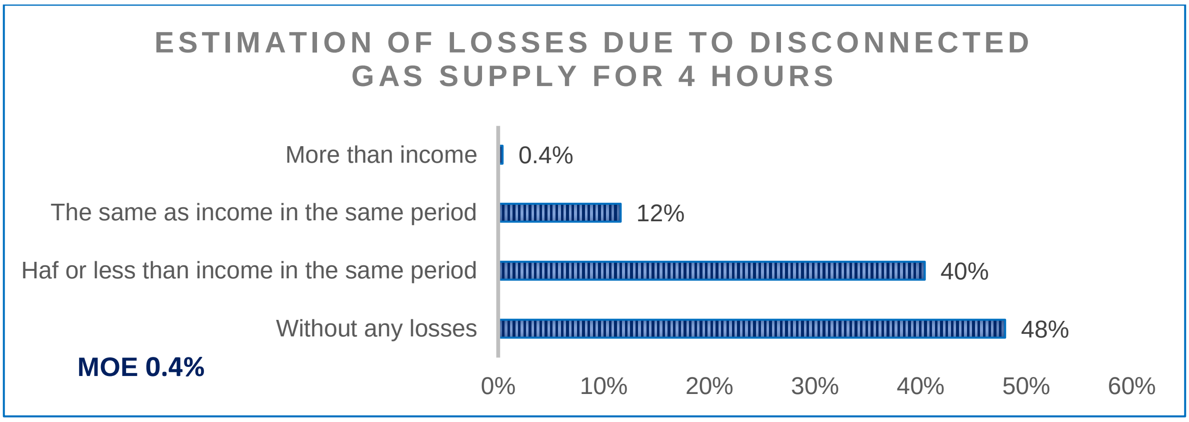


Figure 8 shows the penetration rate of cooling technologies. As can be seen, 80% of commercial enterprises have cooling devices. It should be noted that only heat pumps are considered as cooling technology in the questionnaire. There was no option of reporting other technology (e.g. fan which actually does not decrease the indoor temperature[4]).

Figure 8: Penetration rate of cooling technologies

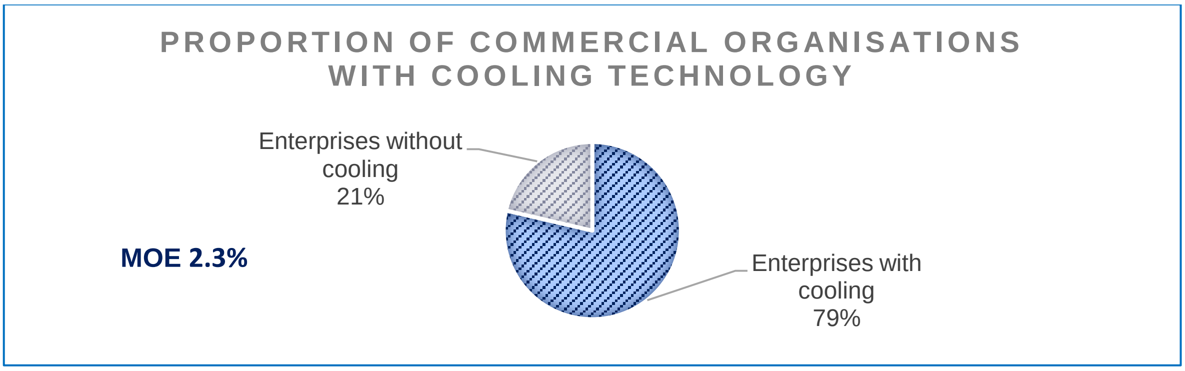


Figure 9 shows types of air pumps (conditioners) used in the commercial sector for cooling purposes. The most widely used technology is the split system conditioner that provides only local cooling. Almost one-fifth of commercial entities have central cooling systems installed to cool to the entire work space.

[4] Fans do not cool the air, but provide ventilation. However, in Georgia fans are sometimes used for cooling purposes.

Figure 9: Types of cooling technologies used in commercial sector

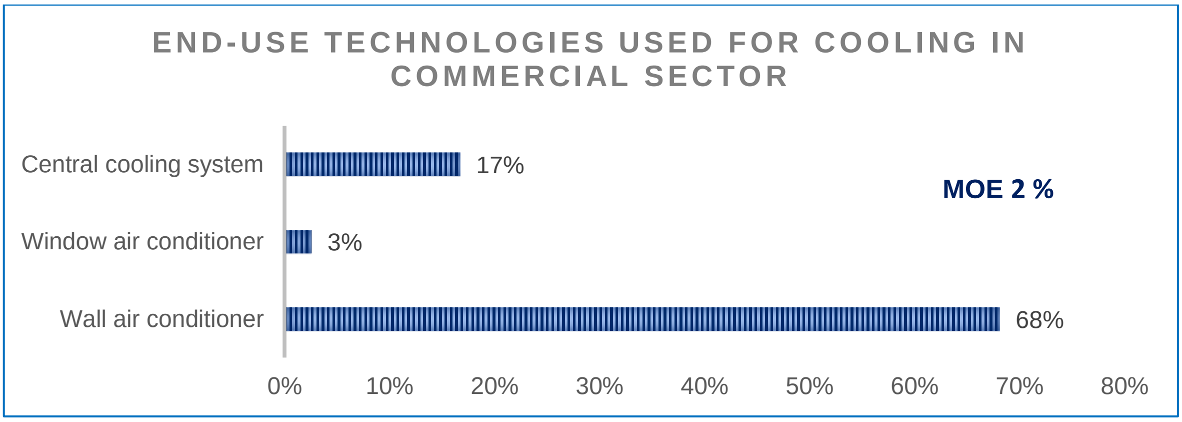
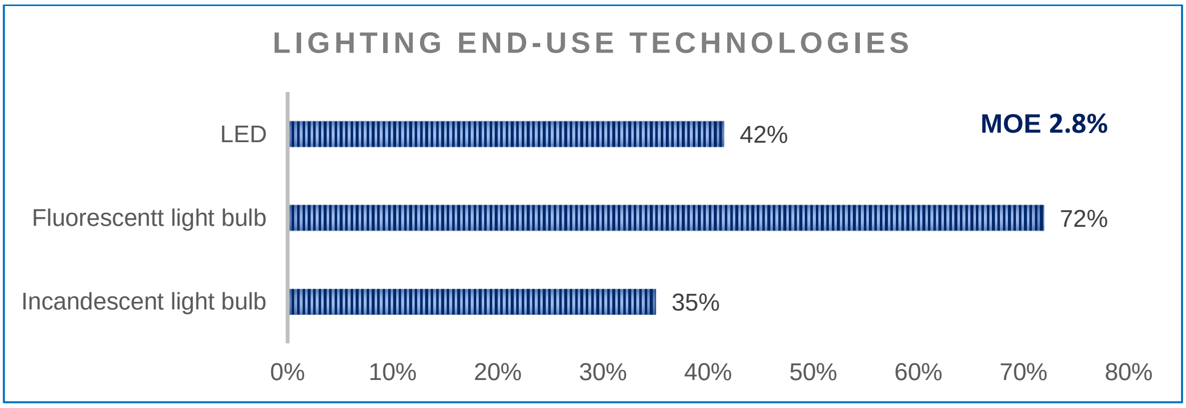


Figure 10 shows penetration of light bulbs by type used in the commercial sector. The biggest share belongs to energy efficient fluorescent light bulbs, while light-emitting diode (LED) is also quite popular. However, inefficient incandescent light bulbs seem to be widely used as well. Since questions are not mutually exclusive, these proportions show that some enterprises use a mix of bulb types for a single entity.

Figure 10: Types of light bulbs used in commercial sector

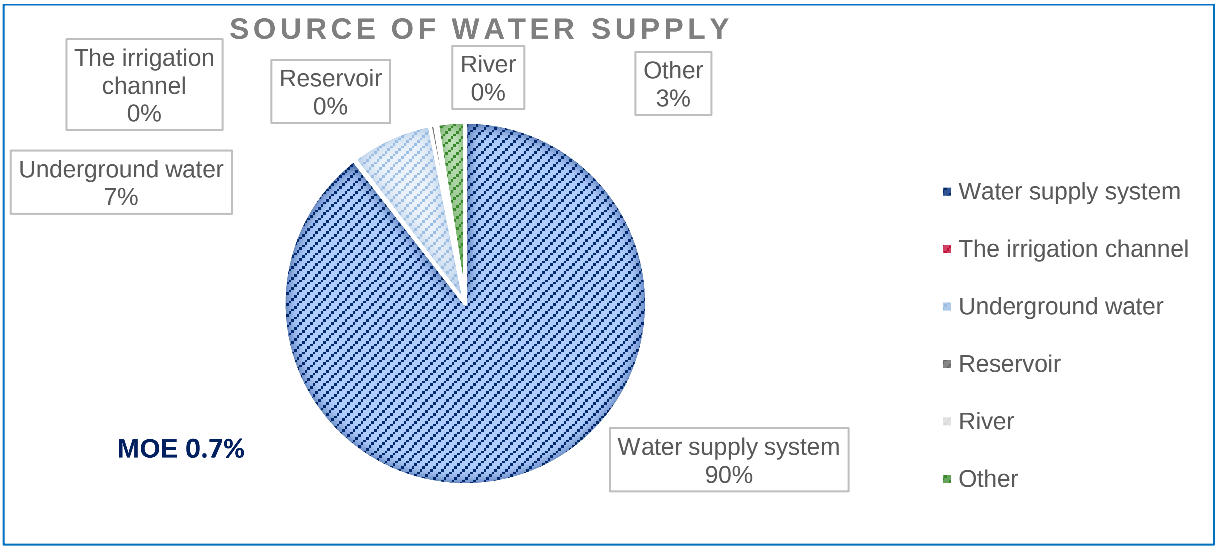


WATER CONSUMPTION ANALYSIS

Water consumption data is not used for energy modeling in MARKAL, however, the respective inquiry was conducted as agreed with G4G. The below charts represent the summary of answers to water related questions and cover the entire set of surveyed consumers.

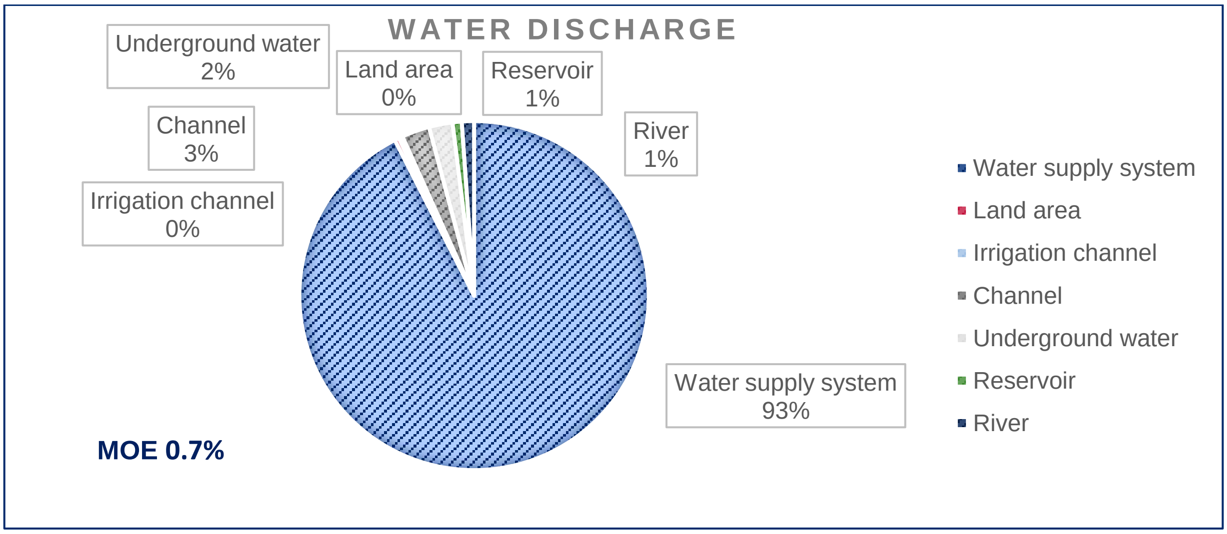
The absolute majority of consumers rely on centralized water supply systems, though some still use underground water sources.

Figure 11: Sources of water supply



In general, water discharge is not monitored or measured by the consumers therefore, no estimates of discharge water volumes were made. Below is the analysis of the types of sinks for discharge of used water.

Figure 12: Water discharge sources



In spite of water treatment conducted by the water supply companies, the survey showed a relatively high percentage of consumers using their own purification systems.

Figure 13: Organizations with water purifying technology

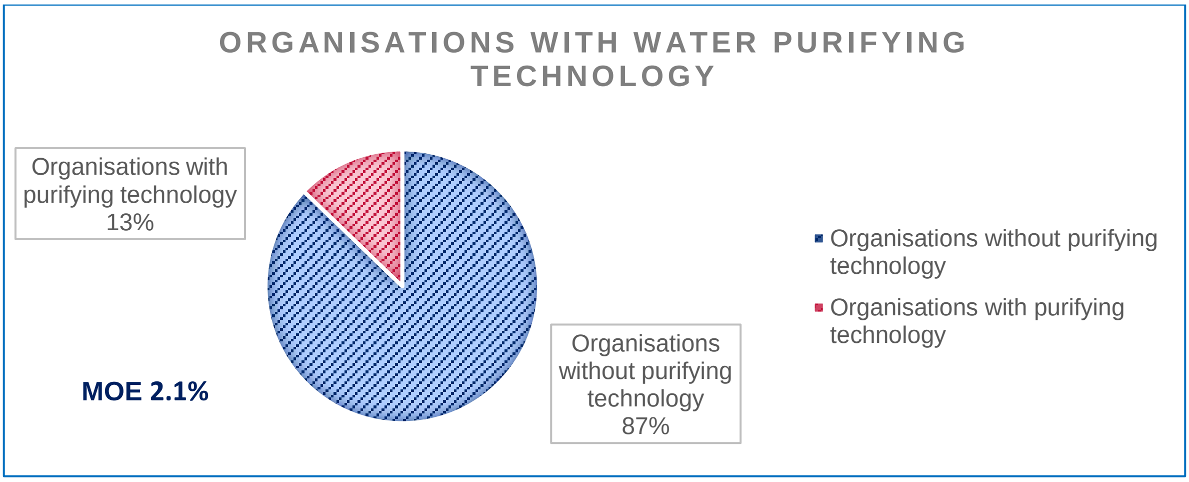
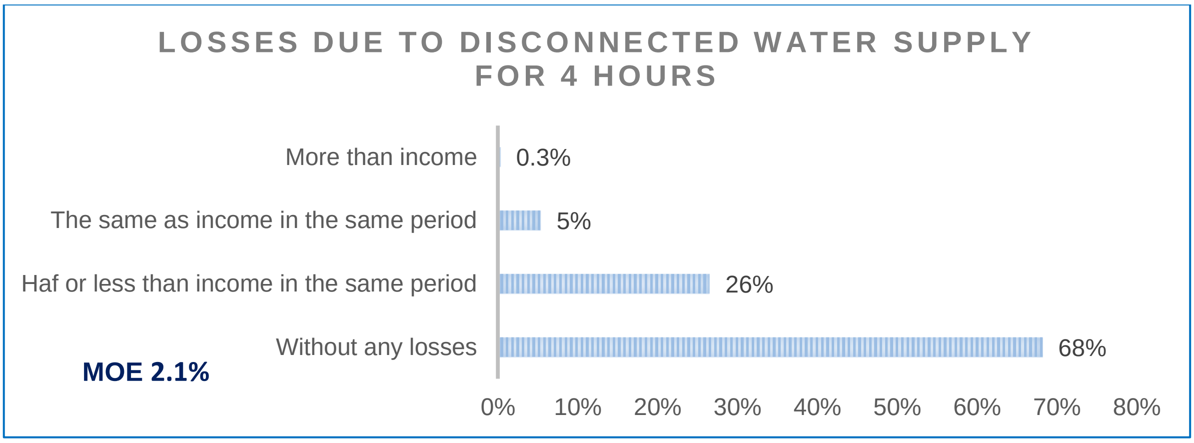


Figure 14 shows reported losses due to disconnected water supply. The majority of respondents replied that they have no losses in case of water supply disruption, implying that water supply disruption for 4 hours does not affect their operation.

Figure 14: Estimation of losses due to disconnected water supply



INDUSTRIAL SECTOR

IRON AND STEEL INDUSTRY

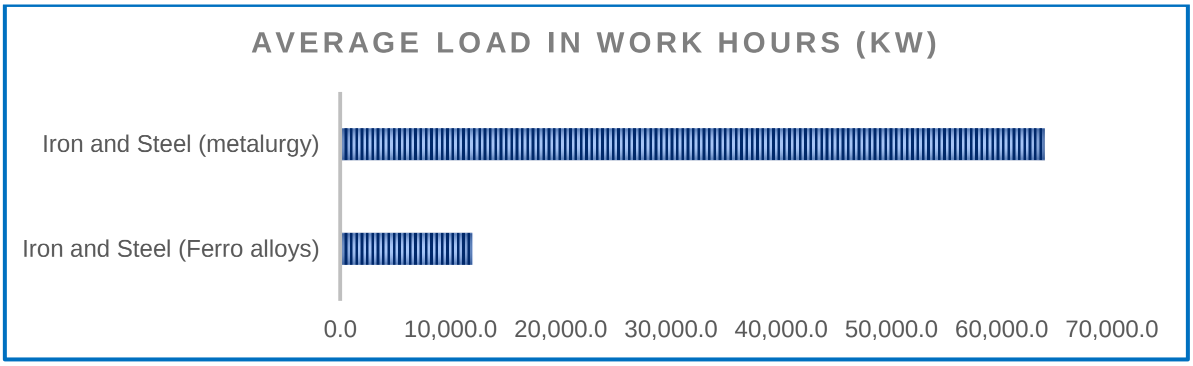
This subsector is characterized by high temperature technological processes, where in most cases electric arc furnaces (rarely Induction furnaces) are used. Manganese ore melting, for example, takes place at a temperature higher than 2000 degrees centigrade. In this case, the ore has been added by the so-called Restoring Cox electric arc furnace, which is a highly energy consuming device. Approximately 90-98% of electricity consumed by these plants is consumed using such technologies. The remaining electricity is consumed by mechanical processes.

In some large factories, both natural gas and electricity are used for manufacturing (e.g. gas furnaces). Other energy sources, such as oil products and coal, are not used. Factories take “technical water” from different sources (the water supply system, rivers, channels, and groundwater), which is mainly used for cooling, circulated in closed construction that does not spill. Despite this fact, most of the factories have laboratories and water purification devices.

There are eight large factories in the iron and steel industry. The metallurgy subsector, which is represented by four large factories, was entirely covered by the surveyors. An additional subsector, ferric alloy plants, is represented by 4 large and several small factories. All large ferric alloy plants were surveyed. Therefore, the data obtained from the iron and steel industry survey provides a good ground for analysis and generalization for the entire industry.

Figure 15 shows average load in work hours for the two subcategories of the iron and steel industry. One can see the scale of electricity consumption by these large factories. Sixty percent of respondents reported the existence of alternative sources of electricity if confronted by electricity disruption. In most cases, the alternative source is a diesel generator or alternative electricity line. Therefore, the majority reported that they have no or insignificant losses in case of electricity disruption.

Figure 15: Average load in work hours



As can be seen from Figure 16, the main source of potable water is the water supply system however, 50% of surveyed ferroalloys reported that they do not use potable water at all.

Figure 16: Potable water sources

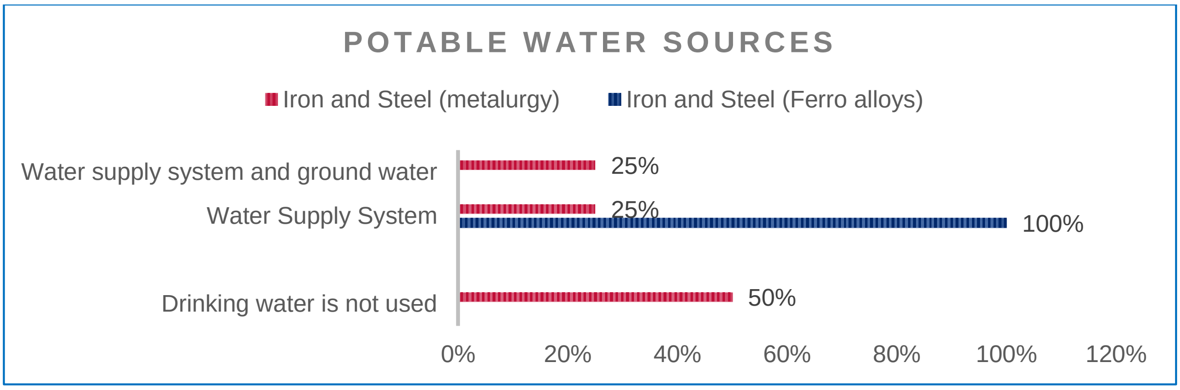


Figure 17 shows sources of “technical water.” As can be seen, the major source is ground water. Some factories also have reservoirs or take “technical water” from rivers or the water supply system.

Figure 17: "Technical water" sources

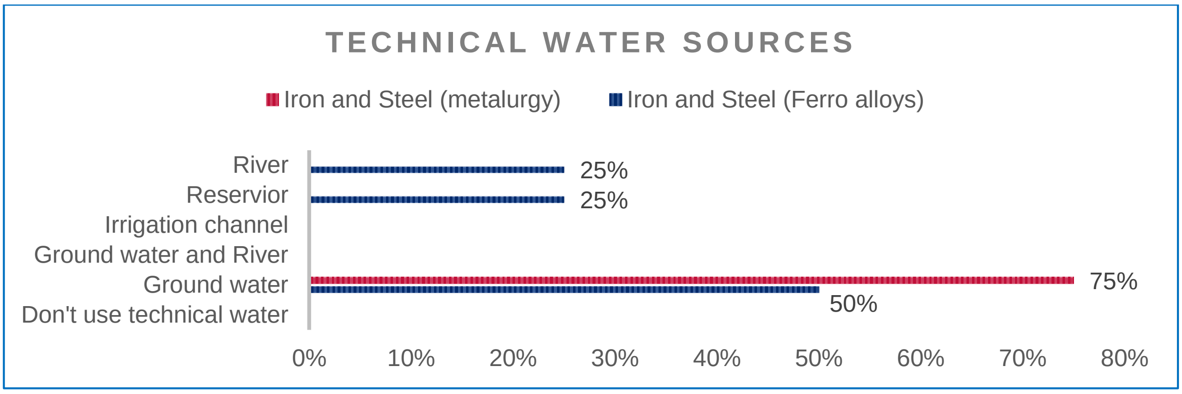


Table 2 shows water consumption volumes in the iron and steel industry. As can be seen, water is mostly used for cooling. The data only represents the consumption of those plants surveyed by engineers. The question had a 100% response rate among these plants, therefore representing the factual water consumption of large iron and steel plants.

Table 2: Water consumption volumes of surveyed plants

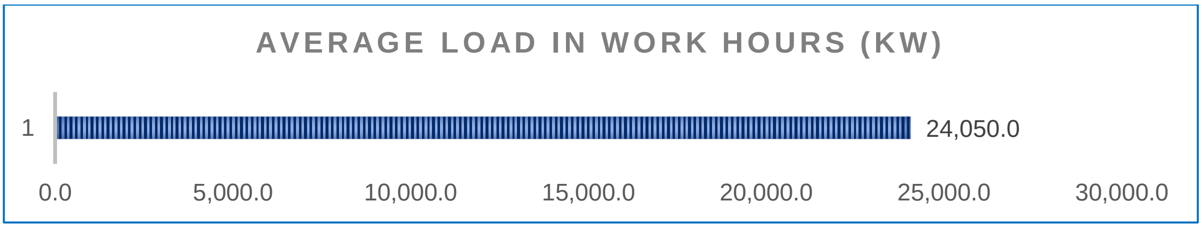
m3	Year	Water supply system	Irrigation channel	Underground	River	Reservoir
Water intake	2014	180,067		304,800		7,730,201
	2015	284,453		887,400		8,375,570
Water consumption	2014	180,067		304,800		7,730,201
	2015	284,453		887,400		8,375,570
Polluted water discharge	2014	950				
	2015	35,790				
Clean water discharge	2014					
	2015					
Water for cooling	2014	120,000		239,100		7,730,201
	2015	90,000		818,100		8,375,570

CHEMICAL INDUSTRY

Large chemical plants use electricity and high pressure natural gas (10-12 atmospheres). Electricity is used in mechanical processes (compressors, feed water pumps) and gas is used in both high-pressure (contact device, natural gas conversion device, ammonia catalytic reactor) and low pressure (cryogenic machinery, rotary ovens) processes. Other sources of energy (oil products, coal) are not used.

The largest consumer of energy in the chemical industry is the Azoti plant, whose natural gas consumption is higher than the natural gas consumption of both the commercial and industrial sectors. The plant was surveyed by engineers/auditors. Apart from the Azoti plant, another large chemical plant, Manganum Chemical, was also surveyed by the engineers. There are also relatively small chemical companies that produce pharmaceuticals and paints. However, their share of energy consumption is small compared to large chemical plants.

Figure 18: Average load in work hours



All respondents also reported that they consume natural gas. However, Azoti consumed natural gas for both energy and non-energy use.

Table 3 contains water consumption volumes reported by large chemical plants. Since the question has a 100% response rate among large plants, the data in the table represents the factual water consumption volumes of large chemical plants.

Table 3: Water consumption volumes in large Chemical plants

m3	Year	Water supply system	Irrigation channel	Underground	River	Reservoir
Water intake	2014	37,475	470,000			
	2015					
Water consumption	2014	36,412	438,000			
	2015					
Polluted water discharge	2014	1,063				
	2015					
Clean water discharge	2014	24,000	146,000			
	2015					
Water for cooling	2014					
	2015					

NON-METALLIC MINERALS INDUSTRY

Electricity is mainly used for mechanical processes in this subsector. One exception is JSC “Mina” where 50% of electricity is used for high-temperature processes (glass producing furnaces). Natural gas (on medium pressure) is used for high-temperature processes as well as for low-temperature technologies.

“Technical water” is mainly taken from rivers and does not require water purification procedures.

Overall, since there are only a few large plants in the non-metallic minerals industry in Georgia, and all large ones were surveyed by qualified engineers, analysis of the results can be used for generalizing the trends and patterns of energy and water consumption in the entire non-metallic minerals industry. The share of energy consumption of large surveyed plants in the total energy consumption in the non-metallic minerals industry is 72% for electricity and 75% for natural gas, which indicates high coverage of the survey.

Figure 19: Average load in work hours

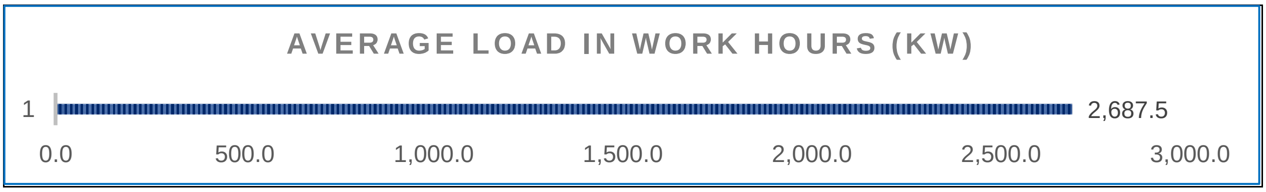
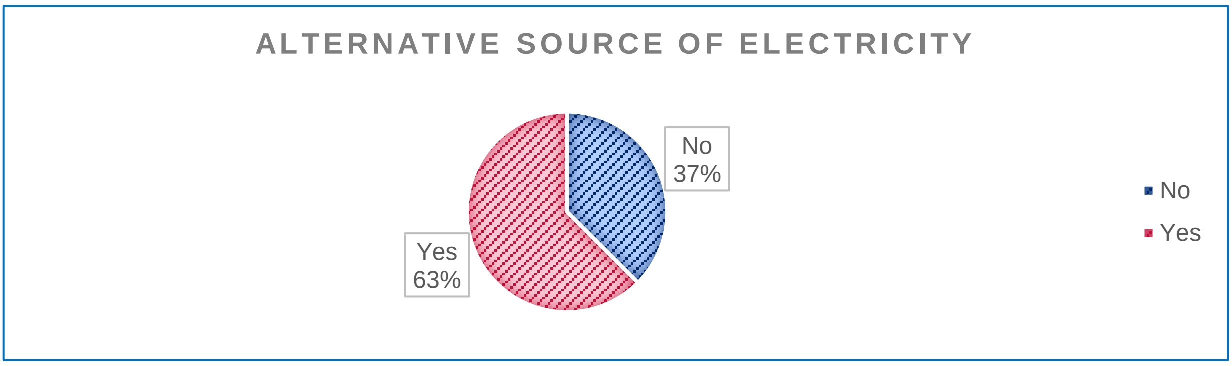


Figure 20: Portion of plants with alternative source of electricity



The main sources of alternative electricity supply are diesel generators and reserve lines.

Figure 21: Portion of plants that consume natural gas

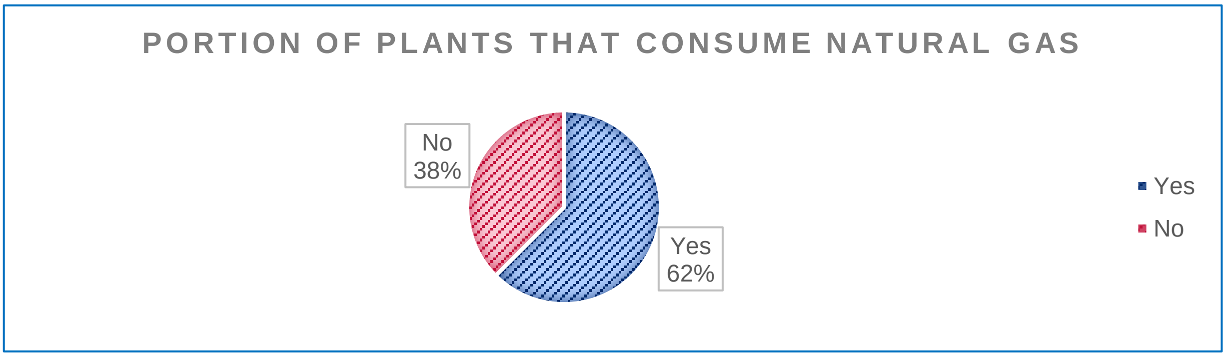


Table 4: Proportion of responses on water consumption of large non-metallic minerals plants

m3	Year	Water supply system	Irrigation channel	Underground	River	Reservoir
Water intake	2014	50.0%		12.5%	25.0%	
	2015	62.5%		12.5%	12.5%	
Water consumption	2014	50.0%		12.5%	37.5%	
	2015	62.5%		12.5%	25.0%	
Polluted water discharge	2014	12.5%			25.0%	
	2015	12.5%			25.0%	
Clean water discharge	2014					
	2015					
Water for cooling	2014				12.5%	
	2015				12.5%	

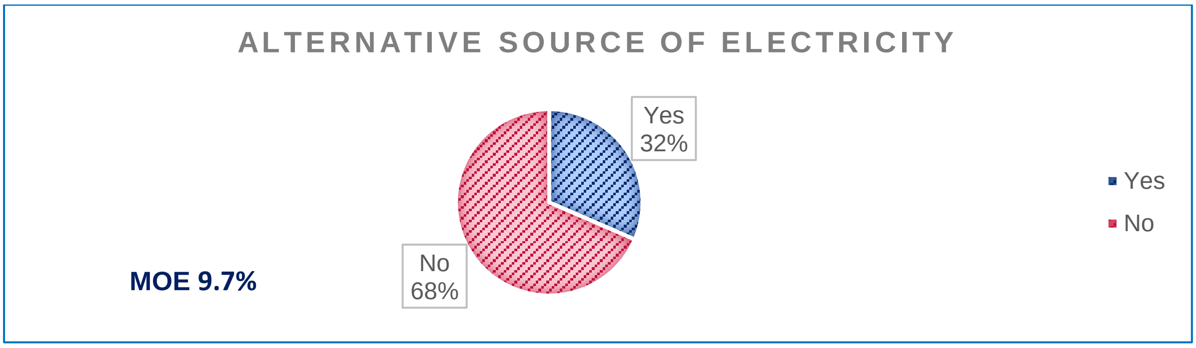
Since not all surveyed plants reported water consumption volumes, Table 4 represents the distribution of the responses by types of water supply and discharge sources. The distribution shows the reported sources of potable and technical water as well as the type of water discharge.

CONSTRUCTION INDUSTRY

In this subsector, electricity is used for mechanical processes. The majority of organizations within the construction industry do not have an alternative source of energy (electricity and natural gas).

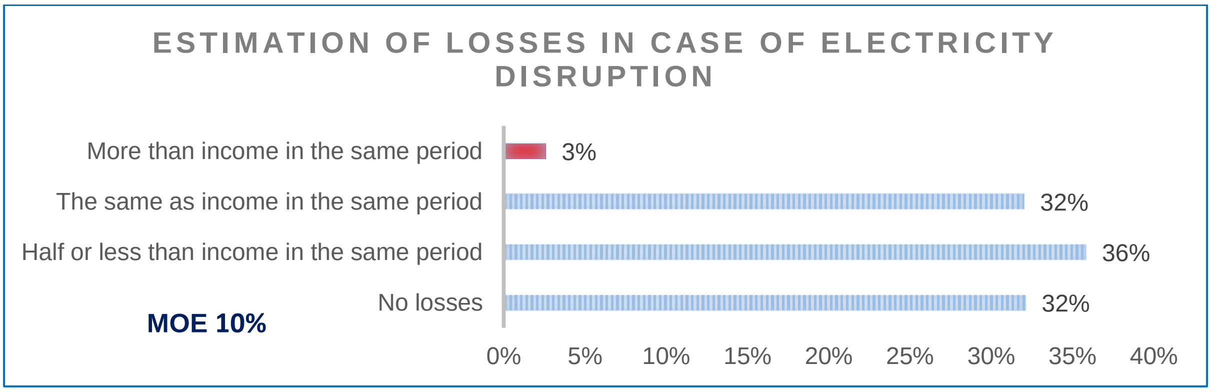
Some plants use natural gas. The plants get water mostly from the water supply system and underground water. The majority of plants do not have water purification devices. Considering the small amount of consumed water, water losses are mostly insignificant.

Figure 22: Portion of plants with alternative source of electricity



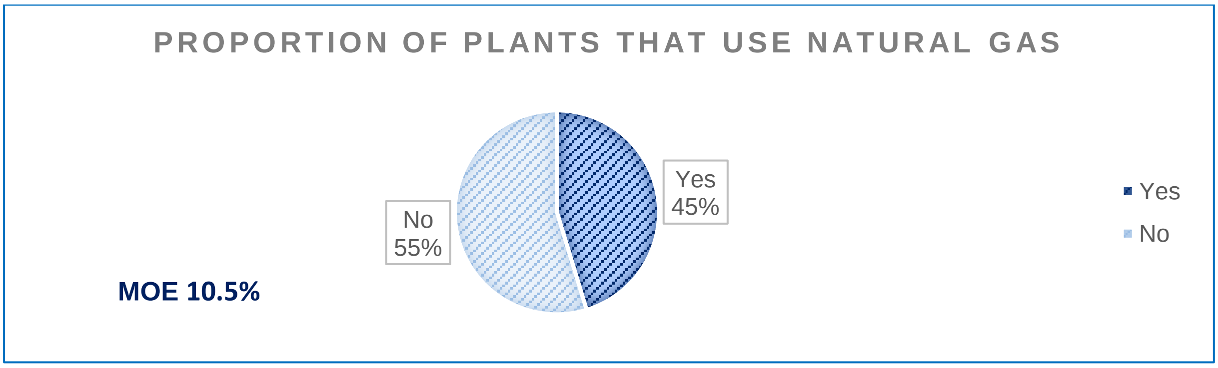
Only 3% of respondents reported losses that are higher than income in the same period. Although the majority of plants do not have alternative sources of electricity, almost a third of all respondents reported no losses in case of electricity disruption.

Figure 23: Estimation of losses in case of electricity disruption



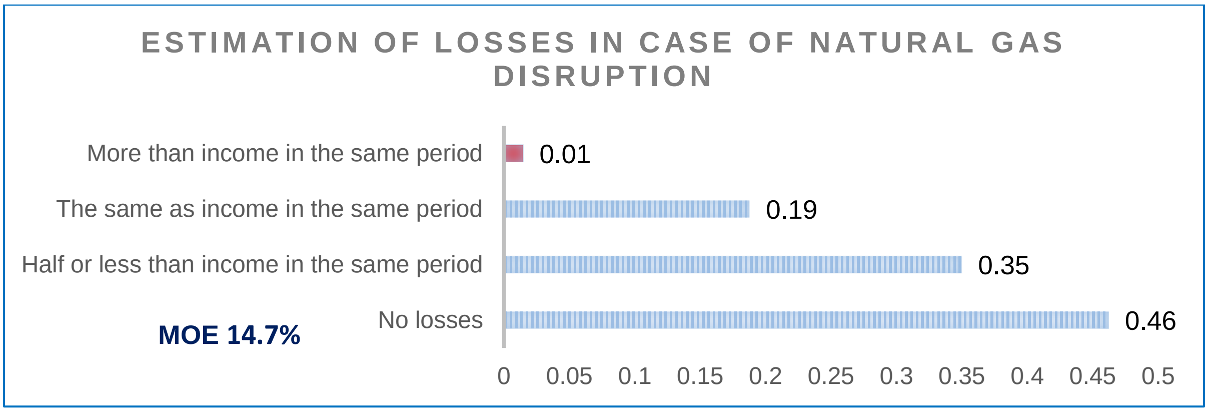
Note: The red bar indicates an answer from a separate question.

Figure 24: Proportion of plants that use natural gas for energy



Majority of the plants in the construction industry do not use natural gas, and majority of those who do, reported no losses in case of natural gas disruption.

Figure 25: Estimation of losses in case of natural gas disruption



Note: The red bar indicates an answer from a separate question.

The main source of potable water is from water supply companies however, 26% of respondents use underground water as a source of potable water. Water discharge is also done through water supply company systems and only a few plants use other sources, such as reservoirs, underground channels, rivers, etc.

Figure 26: Water supply sources

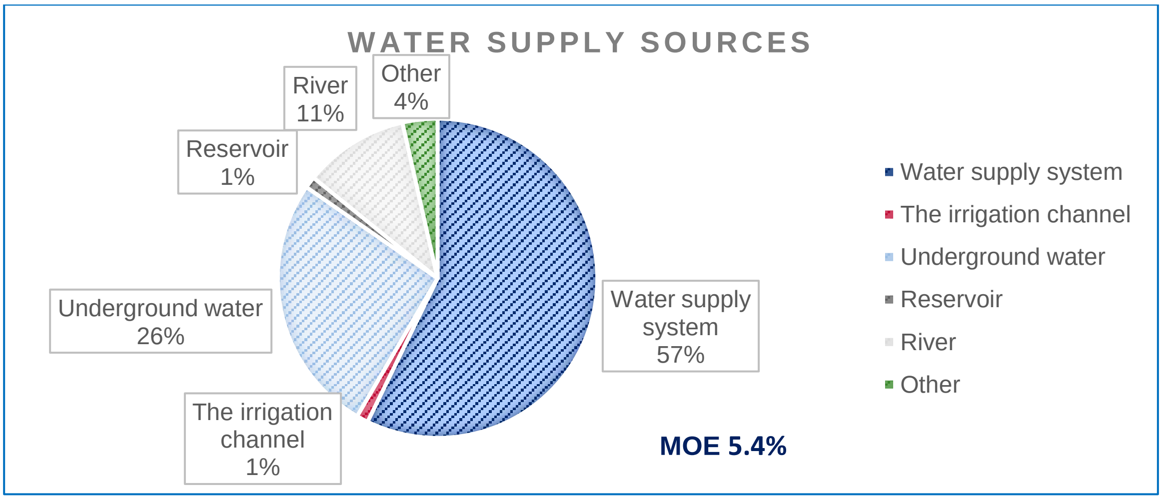


Figure 27: Water discharge sources

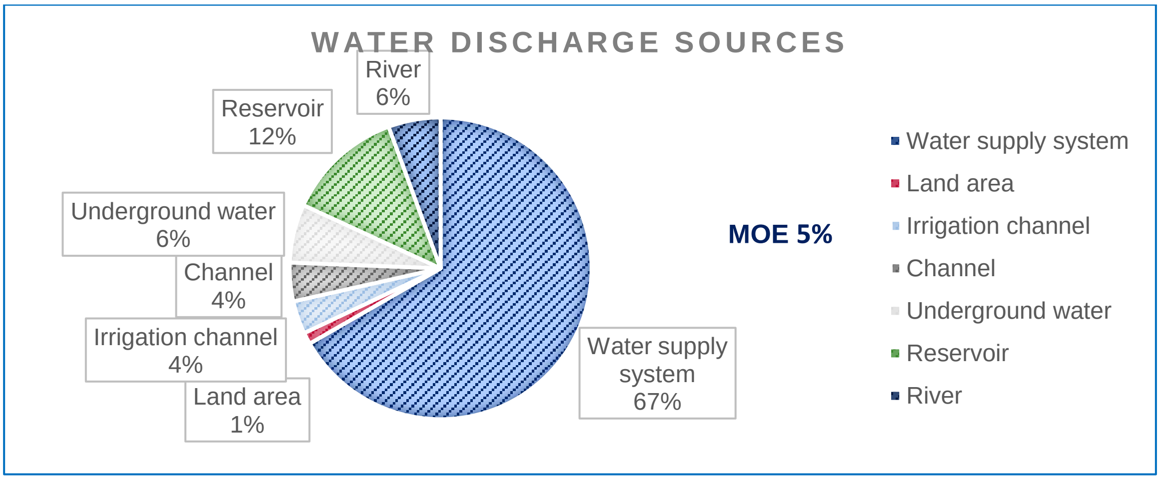
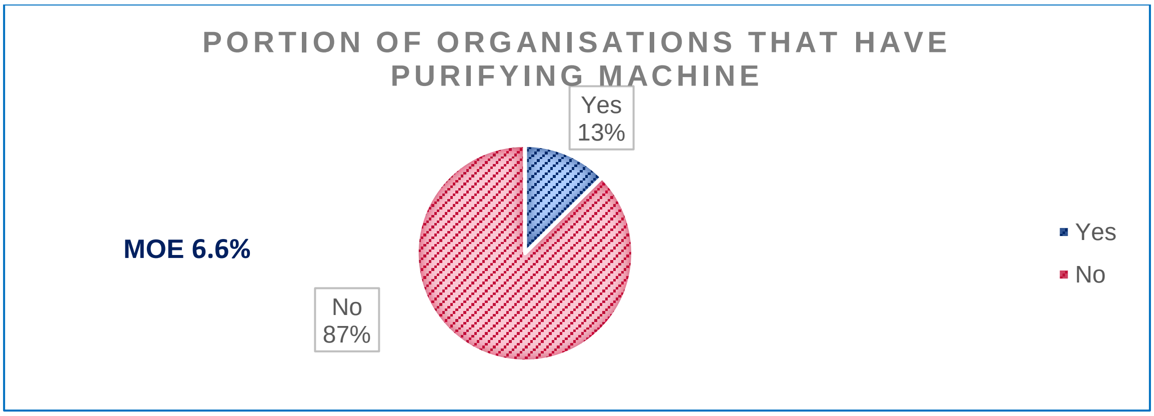
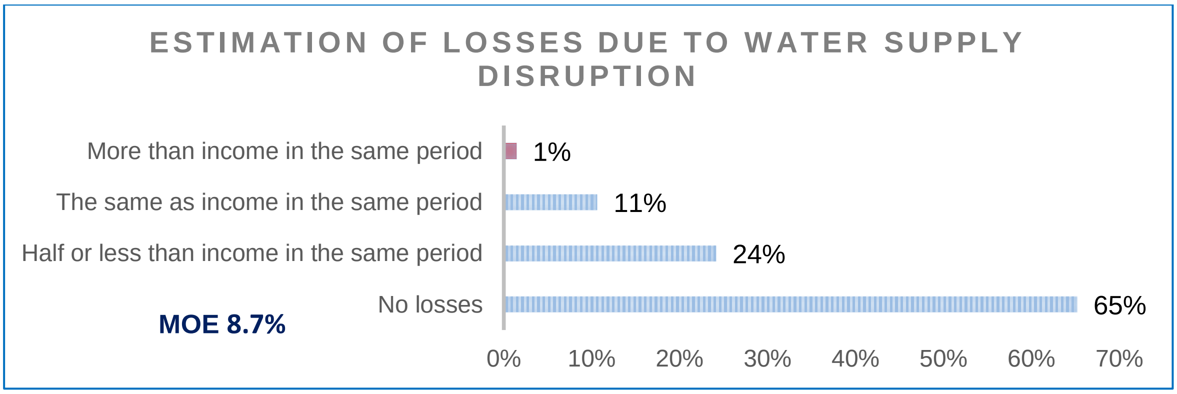


Figure 28: Portion of plants that have water purifying machine



Only a few surveyed plants have a water purifying machine and even fewer reported that they have the capacity to ensure quality water purification.

Figure 29: Estimation of losses due to water supply disruption



Note: The red bar indicates an answer from a separate question.

The majority of respondents reported to have no losses in case of water supply disruption even though few respondents have alternative sources of water.

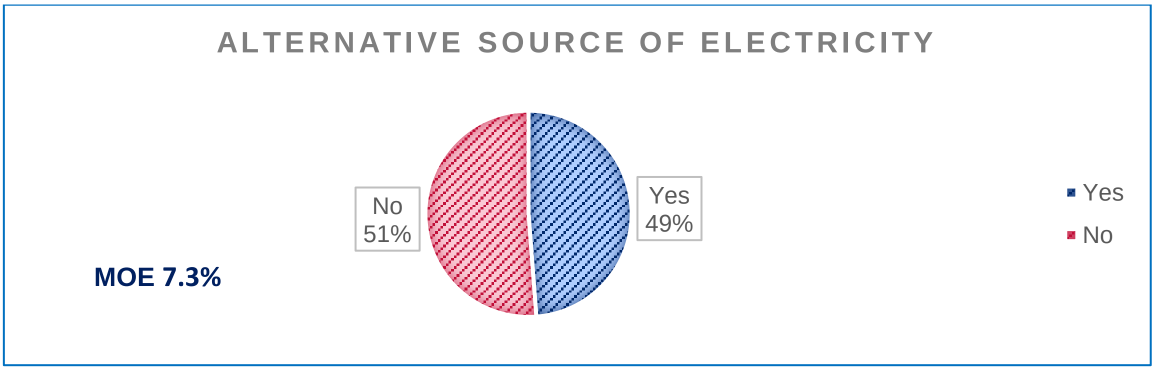
FOOD, BEVERAGES AND TOBACCO INDUSTRY

The food, beverages and tobacco industry uses electricity as well as natural gas. Electricity is primarily used in mechanical processes. The primary alternative source of electricity is mainly diesel generators. Therefore, in case of electricity supply termination, losses are associated with diesel consumption, which is more expensive.

Natural gas is mainly used in low-temperature processes (Bakery ovens, steam boilers). The majority of factories use potable water. They do not perform water purification activities.

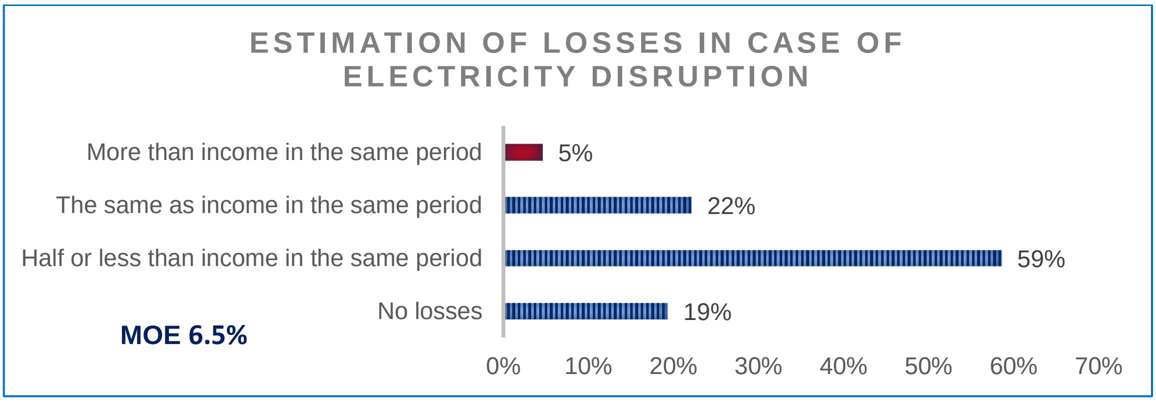
About half of the entities have alternative sources of energy as can be seen from Fig. 30.

Figure 30: Portion of factories with alternative source of electricity



Only a few of the entities assess losses due to electricity disruption to be higher than earnings in the same period of time. The majority of respondents reported that they have losses which are half or less than income in the same period.

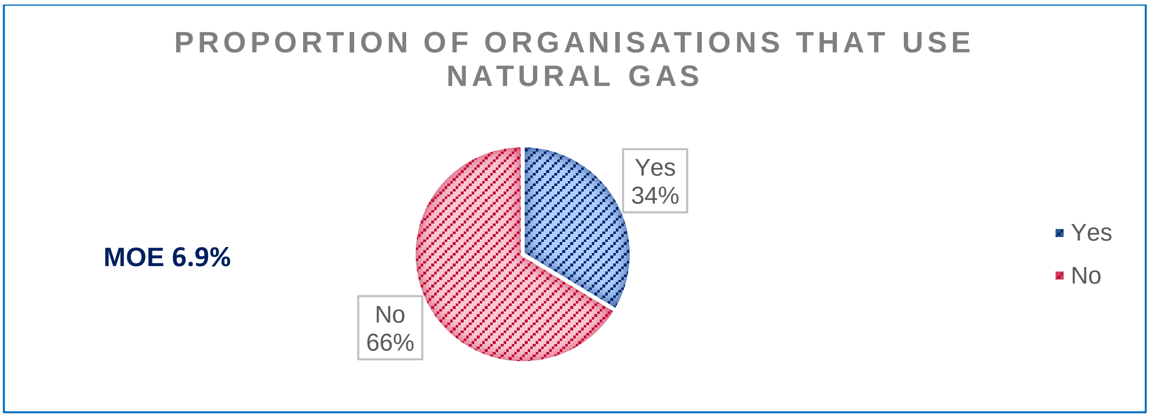
Figure 31: Estimation of losses in case of electricity disruption



Note: The red bar indicates answers from a separate question.

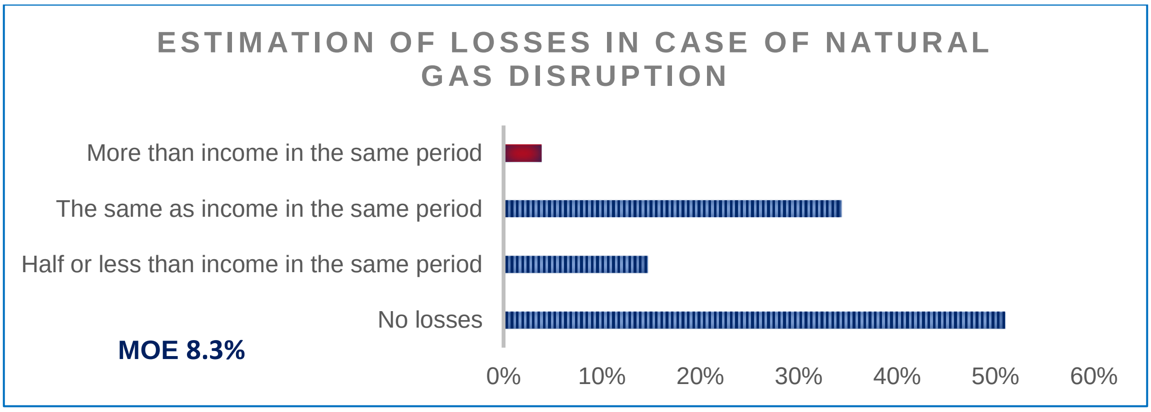
Sixty-six percent of respondents claimed that they don't consume natural gas however, it is mainly consumed by food manufacturing facilities, mainly in bakeries.

Figure 32: Proportion of factories that use natural gas



The sensitivity to interruption of the gas supply is not high as can be seen from Figure 33 below.

Figure 33: Estimation of losses due to natural gas disruption



Note: The red bar indicates answers from a separate question.

About 65% of surveyed entities rely on water supply systems and 25% utilize ground water (Figure 34).

Figure 34: Water supply sources

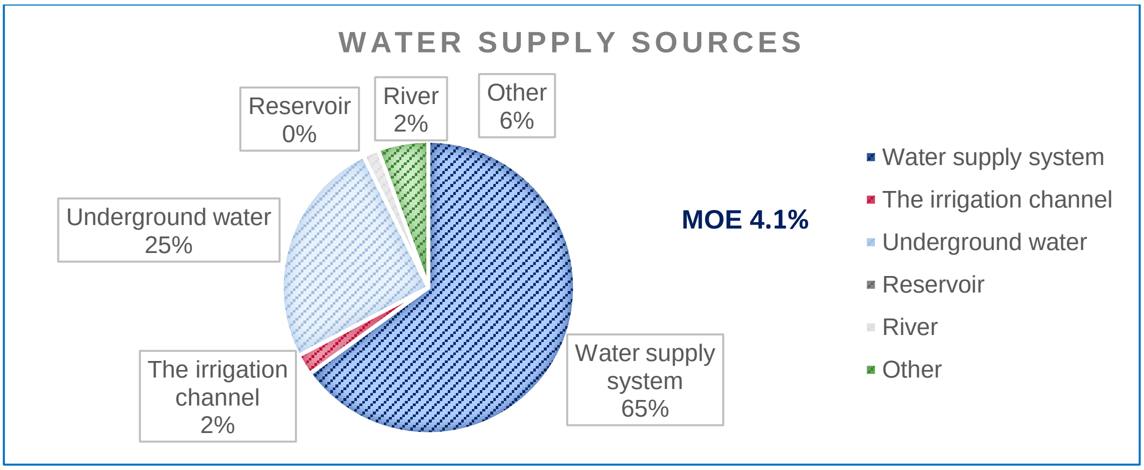
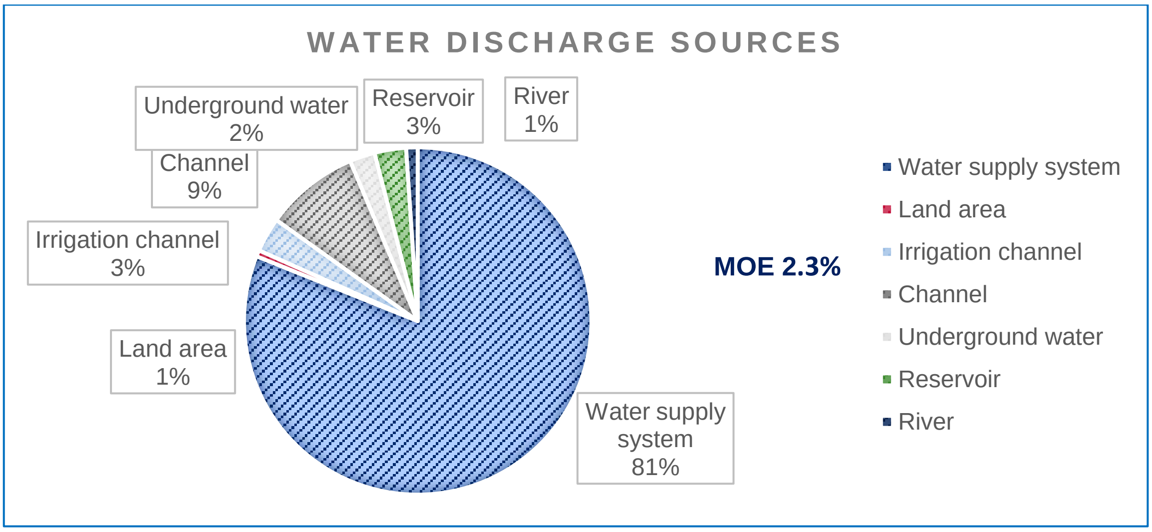
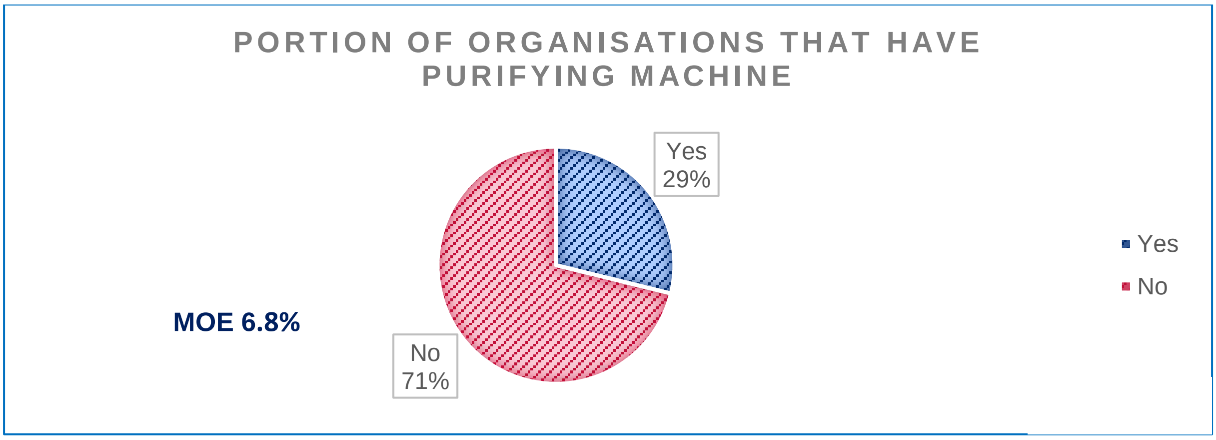


Figure 35: Water discharge sources



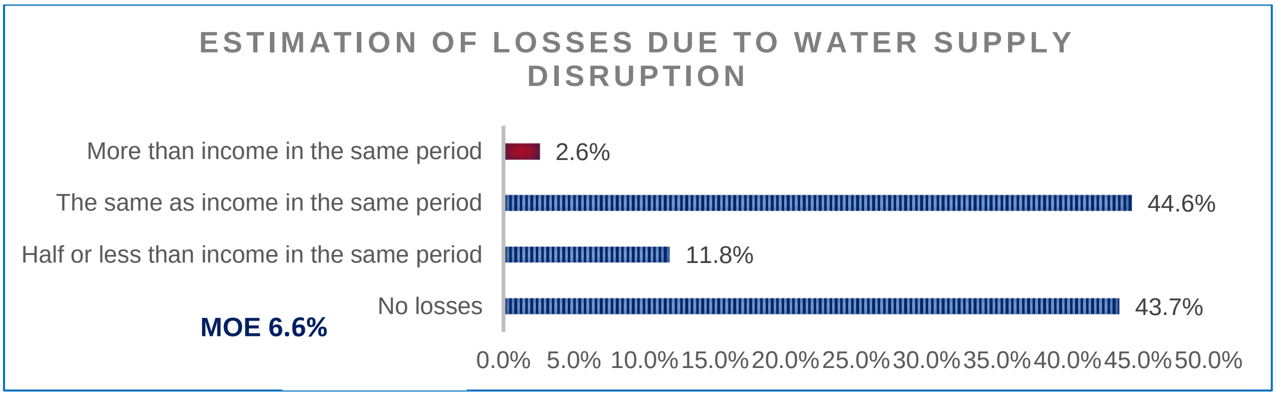
The main source of water discharge is water supply company systems, only a small portion of respondents reported other source of water discharge. Apart from that, only one third of respondents replied to having purifying machines.

Figure 36: Portion of factories that have purifying machine



The majority of respondents reported losses in case of water supply disruption however, in most cases losses are the same or less than income in the same period. Only a small portion of respondents reported that their losses are above income in the same period in case of water supply disruption.

Figure 37: Estimation of losses due to water supply disruption



Note: The red bar indicates answers from a separate question.

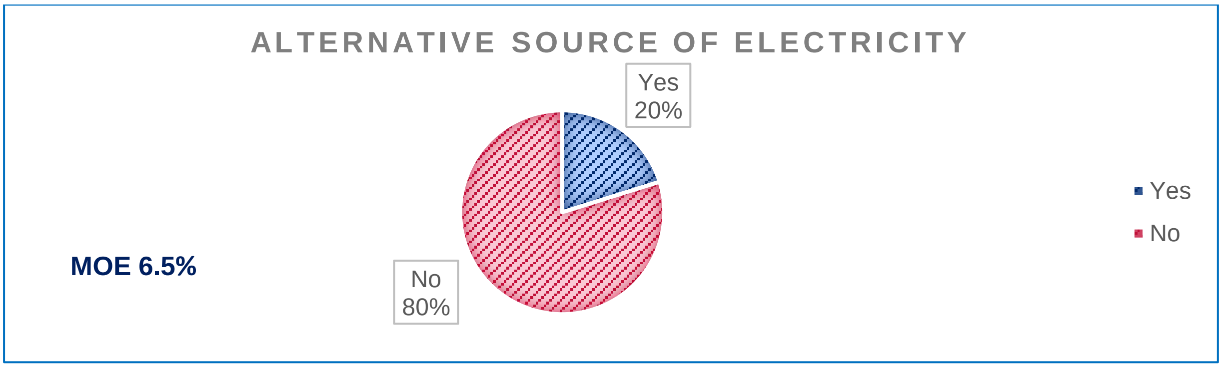
OTHER INDUSTRY

This subcategory contains all production activities that are not included in the categories described above. Thus, procedures used in this subcategory are very different from each other. They use different technologies and energy sources and there is no single rule or tendency for this subcategory.

Most of the factories use electricity. Electricity is used in mechanical processes as well as in low temperature processes. In some cases, electricity is also used in high temperature processes (ovens). Plants that use natural gas in production usually use low temperature technologies (steam boilers).

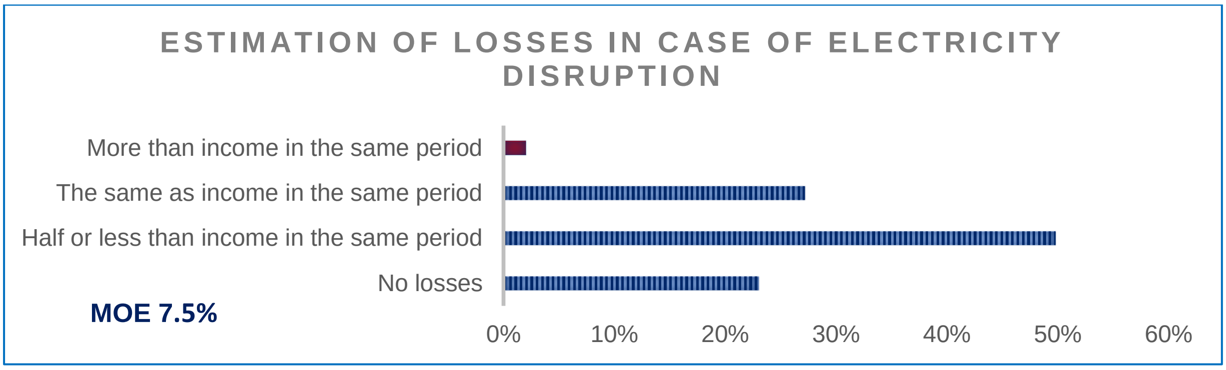
The plants get water from water supply systems and mostly do not have laboratories or water purification devices.

Figure 38: Portion of factories with alternative source of electricity



The majority of surveyed factories have no alternative electricity source. Consequently, most respondents reported losses in case of electricity disruption.

Figure 39: Estimation of losses due to electricity disruption



Note: The red bar indicates answers from a separate question.

The majority of respondents use natural gas. A large portion of respondents reported losses in case of natural gas supply disruption however, very few reported losses greater than income in the same period.

Figure 40: Proportion of factories that use natural gas

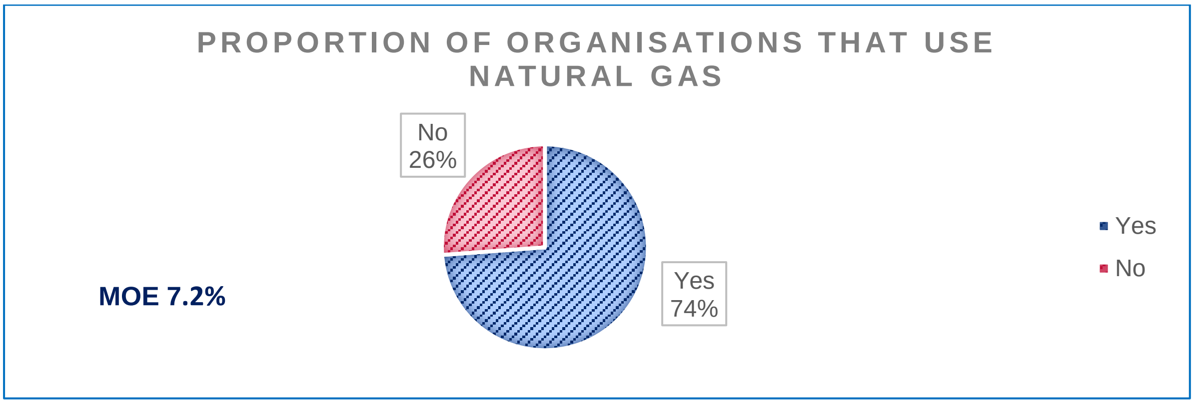
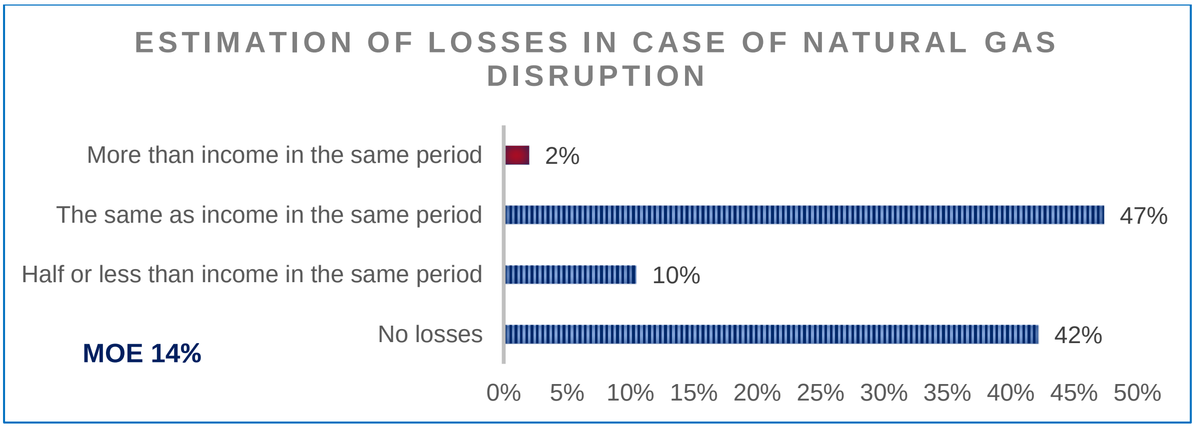


Figure 41: Estimation of losses due to natural gas disruption



Note: The red bar indicates answers from a separate question.

Water supply companies are the main source of potable water, while about 40% of consumers use other sources, mainly rivers and underground water. Water supply companies are also the main source of dischargeable water, though rivers and reservoirs are also used. Most organizations reported losses if water supply was disrupted.

Figure 42: Water supply sources

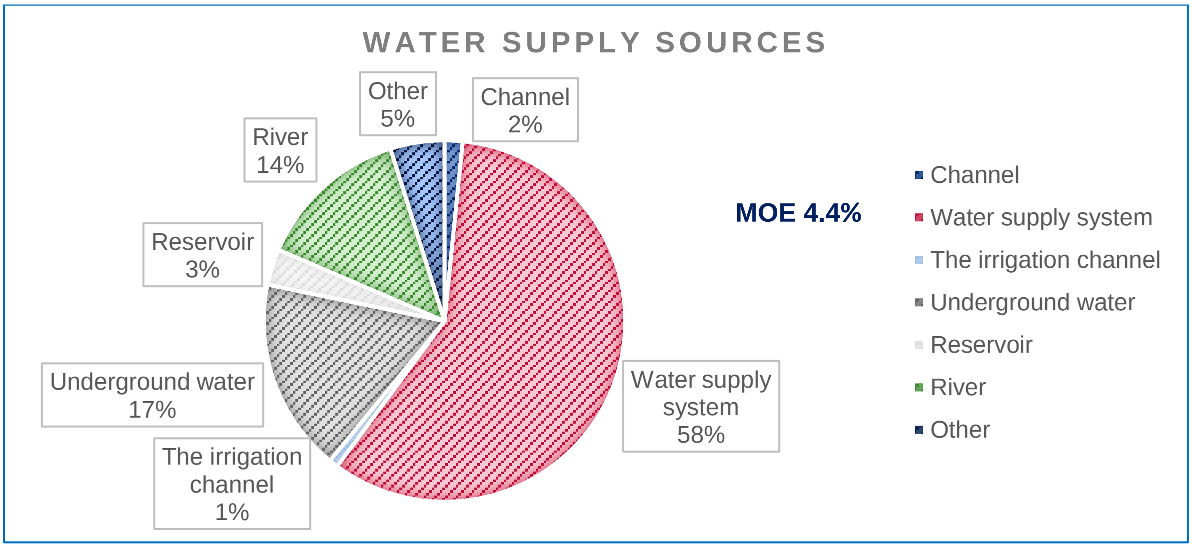


Figure 43: Portion of factories that have purifying machine

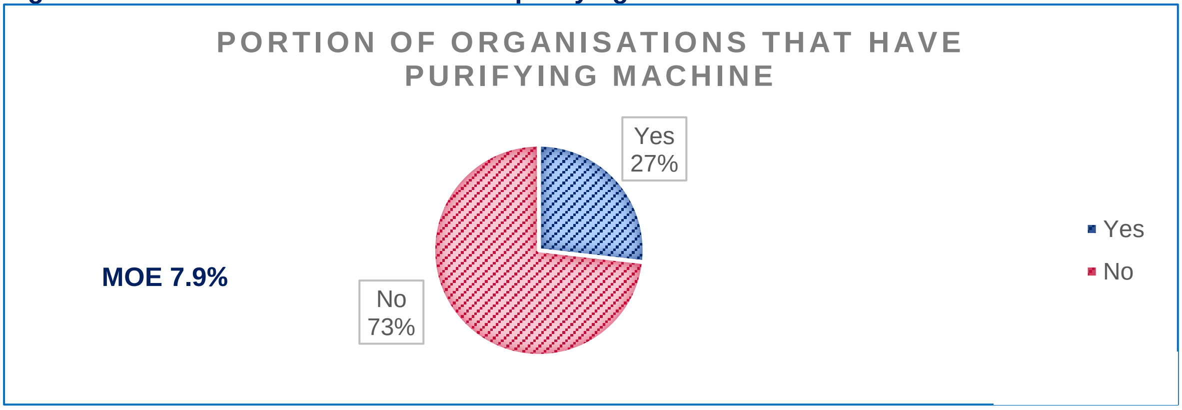
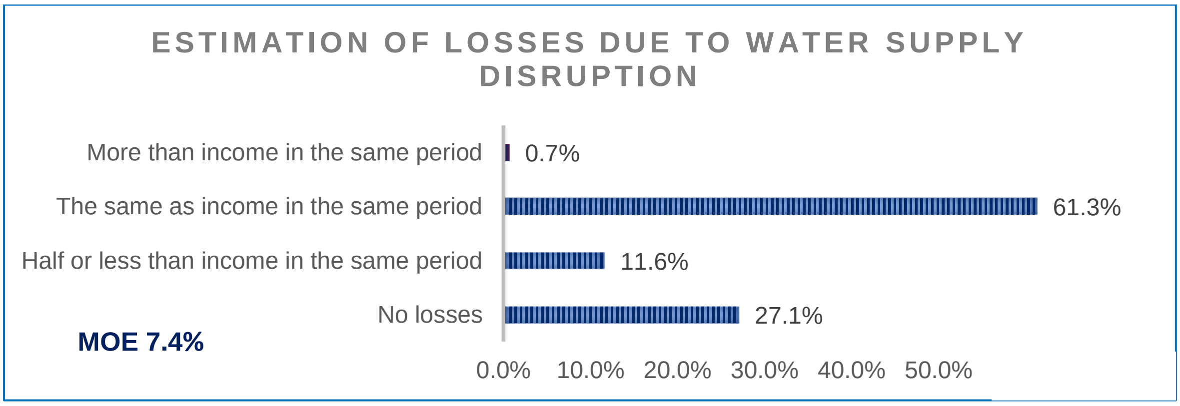
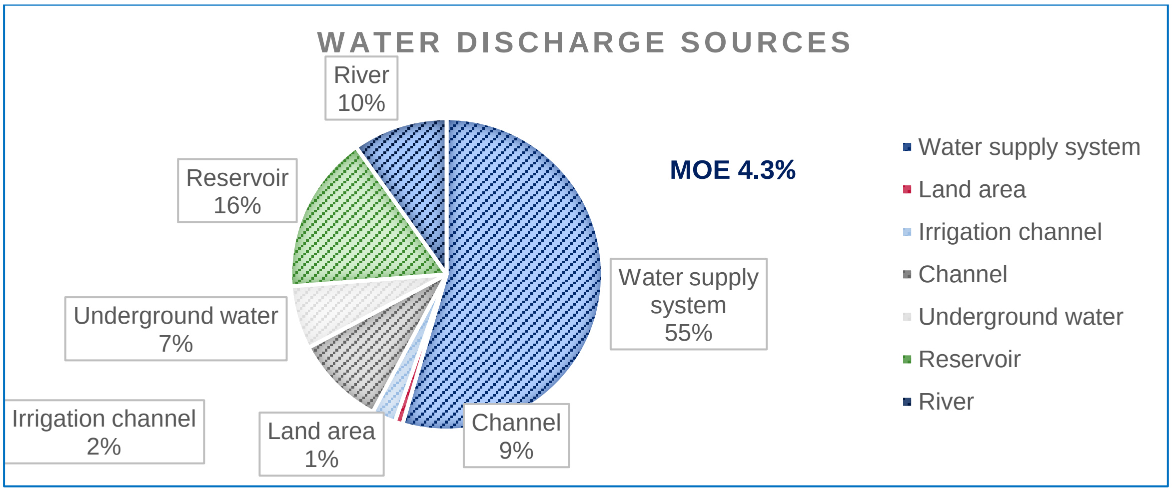


Figure 44: Estimation of losses due to water supply disruption



Note: The red bar indicates answer from a separate question.

Figure 45: Water discharge sources



NON-ENERGY USE

Rustavi nitrogen plant, "Azoti," represents the only plant in Georgia that uses natural gas for non-energy use. Ninety percent of natural gas is used for ammonia production and 10% is used for nitric acid production. In ammonia production itself, 60% of natural gas is used as raw material (non-energy use) and 40% as fuel. Natural gas consumption in 2014 was 93,187,539 m^3 and 139,781,309 m^3 accordingly. The data obtained on non-energy use differs significantly from GEOSTAT information and the latter needs to be adjusted.

The plant, which has water processing equipment, a laboratory, and a 10-hour water supply, takes "technical water" from an irrigation channel.

7. OUTLOOK AND LESSONS LEARNED

Further application of the survey results requires further analysis and processing for input into the MARKAL model to improve the representation of the commercial and industrial sectors. The same information can be processed for input into other energy planning models as well.

- The survey provides a large set of raw information that can serve as a basis for different research and policy articles analyzing consumption patterns, energy demand projections, energy efficiency and energy saving options as well as improvements needed for water supply and consumption systems. It can be used by different energy sector stakeholders including MoE, research and analytical organizations.
- Survey results may be useful for the improvement of national statistics on energy balances. For example, cross-checking this with the official energy balance showed a discrepancy in the patterns of gas use by the chemical industry. Our assessment shows that the use of natural gas for energy in the major chemical plant Azoti is around 36% of total gas volume, while national energy balance indicates this volume to be close to 1%. At the same time, the total volumes of gas consumption are consistent with the survey results. This issue will be raised with GEOSTAT to correct energy balance input.
- The data structure in MARKAL Georgia can now be improved and previous assumptions in the commercial and industrial sectors may be verified and/or improved with factual data. Since no energy consumption end-use surveys have been conducted in the commercial and industrial sectors so far, the data gaps in MARKAL were filled by assumptions and expert inquiries. For example, currently the use of electricity and gas for low temperature heat is set to zero in MARKAL Georgia. However, the survey showed that many industrial factories use electricity and gas for generating steam and hot water for technological processes. This observation has to be incorporated into MARKAL. Likewise, the assumption of gas being the main heating source for commercial sector has to be changed, as the survey revealed a high share of electricity use for this purpose.
- The survey can also assist in splitting the commercial sector in MARKAL into subsectors for more relevant analysis for policymakers. For instance, the commercial sector can list the state sector and commercial sector separately. This will help to better plan and analyze energy efficiency or mitigation measures. However, it will also require data on total energy consumption from energy distribution companies by these subsectors. Currently, electricity distribution companies are not able to split their non-residential customers in required commercial and industrial subsectors.
- The commercial sector in MARKAL Georgia comprises various public and private entities. This study included a detailed survey of some typical consumers (restaurant, hotel, grocery store, etc.) along with the detailed energy audits conducted under other USAID programs in schools, kindergartens, hospitals etc. These results can be used expanded upon to draw the picture of energy consumption in certain subsectors. However, some subsectors (e.g. Tourism and entertainment, budget buildings) require more detailed treatment.
- The conducted study can serve as a good starting point for more in-depth surveys in the commercial and industrial subsectors. Below, we provide some lessons that we learned during the survey process, which need to be considered in further surveys in the field.

The survey process proved to be much more complex than the survey of the residential sector and showed that:

- Large commercial and industrial entities show little willingness in taking part in surveys. A high rate of rejection should be anticipated in these categories unless personal contacts and careful persuasion are used. Official letters from the government had only a minor effect;
- The billing systems of distribution companies do not contain sufficient information to conduct the sectorial study of energy consumption. Consumer categories in the Disco databases only separate residential and non-residential consumers and roughly big and small non-residential consumers. However, they do not contain organized information about consumer activities. There

is a need for regulation to oblige the Disco's to have more detailed information about consumer subcategories;
- Respondents were very sensitive to financial questions, such as those relating to annual turnover or cost of production and some even rejected to take part in the survey. There was a high non-response rate for these particular questions. For the future, financial and economic questions should be shifted to the end of the questionnaires to at least allow collection of technical data;
- Questions on technology specification, such as equipment capacity, were found to be difficult for the majority of respondents. In case the entity was interviewed by an engineer, the capacity was estimated by the interviewer, however, in case the interviewer had no corresponding background, the questions were left unfilled;
- Similarly, respondents found questions on energy consumption volumes difficult to answer. In most cases, they could provide only utility bill costs, but not in energy units. The main reason is that in most cases only financial costs were reported and archived, while volumes in energy units were not saved. The same issue was observed with water consumption.

In summary, the conducted survey provides valuable raw data for MARKAL Georgia improvement, for research in energy planning, demand projections, energy efficiency and energy saving, for water consumption planning and other fields. It indicates the need for further, more detailed studies and energy audits in certain subsectors as well as in areas where improved data handling is needed. After further analysis and processing, the survey results can lead to more informed policies and better planning in energy and water sectors.

APPENDIX A: ENGLISH QUESTIONNAIRE

QUESTIONNAIRE USED BY TRAINED INTERVIEWERS

ENERGY AND WATER CONSUMPTION SURVEY IN ORGANIZATIONS

Number of the organization Interviewed

|____|____|____|____|____|____|____|____|____|____|

(if this organization is chosen from the additional list, please indicate the number of the replaced organization):

|____|____|____|____|____|____|____|____|____|____|

Interviewer code: **|____|____|____|____|**

Interview date **|____|____||____|____||____|____|**

Month/ date / year

Name of the organization and facility visited:

____

Address of the organization

____

If this organization is part of a larger firm or branch, enter the address of the organization which has the biggest energy consumption and where the interview takes place.

____

INTERVIEWER! It is desirable that the interview be conducted with the employee of the technical or logistic unit, who knows the details of the water and energy consumption.

Respondent's name, phone number and e-mail.

Name and Surname:	____
Tel.:	____
e-mail	____

The start time of the interview: **|____|____||____|____|**

Hours / Minutes

A1. Respondent is:

Technical Department Employee	1
Logistics Department Employee	2
Manager	3
Other (please specify)________________________________	4

Section A: General Information

1. [Card 1] Please, tell me, what is your company's organizational and legal form?

INTERVIEWER! Take only one answer

Individual Enterprise	1
Joint Liability Company (JLC)	2
Limited partnership (LP)	3
Limited Liability Company (LLC)	4
Joint Stock Company (JSC)	5
Cooperative	6
Foreign Enterprise Branch	7
Individual entrepreneur	8
Non-commercial legal entity (NELP)	9
Legal entity of public law (LEPL)	10
Foreign legal entity branch	11
*Other (please indicate)*________________________________	12

2. [Card2] What is your company's main field of activity?

3. [Card2] What is your company's additional activities field / fields?

4. What is main type of services delivered or goods produced? Their amount?

Main field of activity
____
Additional field/fields of activity
____
Description of main type of services delivered or goods produced

Amount of produced goods in 2014-2015
2014____201 5____

5. **Please tell me the number of employees in the organization in 2014-2015?**

2014 |____|____|____| NUMBER

2015 |____|____|____| NUMBER

6. **Please tell me what is your organization's annual turnover**

|____|____|____|____|____|____|____| GEL

7. **[Card 7]What is the type of the building where the organization is located?**

Municipal Building	1
State Building	2
Business center / shopping center	3
Part of the residential building	4
Part of the non-residential building	5
Residential building	6
Non-residential building	7
I do not know	-1
(No response)	-2

8. **Please tell me the size of the working space that your organization occupies (Auxiliary buildings and premises excluded)?**

|____|____|____|____|____| **SQUARE METER**

9. **Approximately how many square meters does auxiliary buildings and premises occupy?**

|____|____|____|____|____| **SQUARE METER**

10. **Please tell me how many square meters is heated?**

|____|____|____| **SQUARE METER**

11. Please tell me how many square meters is cooled?

|____|____|____| **SQUARE METER**

12. Please tell me the amount of electricity consumed and paid by months since December 2014?

INTERVIEWER! It is better to write both-GEL and kWh, if he/she does not know both, write one of them. If respondent does not have information about specific month, indicate – I do not know.

Month	GEL	KWH	*I Do Not Know*	*No Response*
December, 2014	|____|____|____|	|____|____|____|____|	*-1*	*-2*
January, 2015	|____|____|____|	|____|____|____|____|	*-1*	*-2*
February, 2015	|____|____|____|	|____|____|____|____|	*-1*	*-2*
March, 2015	|____|____|____|	|____|____|____|____|	*-1*	*-2*
April, 2015	|____|____|____|	|____|____|____|____|	*-1*	*-2*
May, 2015	|____|____|____|	|____|____|____|____|	*-1*	*-2*
June, 2015	|____|____|____|	|____|____|____|____|	*-1*	*-2*
July, 2015	|____|____|____|	|____|____|____|____|	*-1*	*-2*
August, 2015	|____|____|____|	|____|____|____|____|	*-1*	*-2*
September, 2015	|____|____|____|	|____|____|____|____|	*-1*	*-2*
October, 2015	|____|____|____|	|____|____|____|____|	*-1*	*-2*
November, 2015	|____|____|____|	|____|____|____|____|	*-1*	*-2*
December, 2015	|____|____|____|	|____|____|____|____|	*-1*	*-2*
Annual:	|____|____|____|	|____|____|____|____|	*-1*	*-2*

13. Please tell me if you have an alternative energy source IN CASE OF power blackout?

Yes	1	
No	0	Move to the 15th question
I do not know	-1	Move to the 15th question
No response	-2	Move to the 15th question

14. What is this alternative source of energy?

Other electricity lines	1
Diesel generator (____ MW)	2
Other (write down)_______________	3
I do not know	-1
No response	-2

15. How would you assess the losses caused by power DISCONNECTION for 4 hours?

Loss of Income:	
Half or Less of an Income for the Same Period	1
Loss is Equal to Income for the Same Period	2
No Loss	-5
Loss is More than an Income for the Same Period	|____|____|____|- TIMES

16. Please tell me did your organization consume natural gas from December 2014 until today?

Yes	1	
No	0	Move to the 21th question
I do not know	-1	Move to the 21th question
No response	-2	Move to the 21th question

17. Please tell me how much gas your organization consumed by months from December 2014, in cubic meters and GEL?

INTERVIEWER! It is better to write both-GEL and Cubic meters, if he/she does not know both, write one of them. If respondent does not have information about specific month, indicate – I do not know.

Month	GEL	Cubic Meter	*I Do Not Know*	*No Response*
December, 2014	|____|____|____|	|____|____|____|____|	*-1*	*-2*
January, 2015	|____|____|____|	|____|____|____|____|	*-1*	*-2*
February, 2015	|____|____|____|	|____|____|____|____|	*-1*	*-2*
March, 2015	|____|____|____|	|____|____|____|____|	*-1*	*-2*
April, 2015	|____|____|____|	|____|____|____|____|	*-1*	*-2*
May, 2015	|____|____|____|	|____|____|____|____|	*-1*	*-2*
June, 2015	|____|____|____|	|____|____|____|____|	*-1*	*-2*
July, 2015	|____|____|____|	|____|____|____|____|	*-1*	*-2*
August, 2015	|____|____|____|	|____|____|____|____|	*-1*	*-2*

September, 2015	|____|____|____|	|____|____|____|____|	*-1*	*-2*
October, 2015	|____|____|____|	|____|____|____|____|	*-1*	*-2*
November, 2015	|____|____|____|	|____|____|____|____|	*-1*	*-2*
December, 2015	|____|____|____|	|____|____|____|____|	*-1*	*-2*
Annual:	|____|____|____|____|	|____|____|____|____|	*-1*	*-2*

18. Please tell me if you have an alternative energy source in case of natural gas interruption?

Yes	1	
No	0	Move to the 20th question
I do not know	-1	
No response	-2	

19. What is this alternative source of energy in case of gas interruption?

Electricity	1
Coal	2
Diesel	3
Wood	4
Liquid gas	5
Other (write down) _______________	6
I do not know	-1
No response	-2

20. How would you assess the losses caused by natural gas interruption for 4 hours?

Loss of Income:	
Half or Less of an Income	1
Loss is Equal to Income	2
No Loss	-5
Loss is More Than an Income	|____|____|____|- TIMES

21. Please tell me did your organization consume water from December 2014 until today?

Yes	1	
No	0	Move to the 29th question
I do not know	-1	
No response	-2	

22. Please tell me how much water does your organization consume (Use and discharge) annually. GEL and Cubic meters?

INTERVIEWER! It is better to write both-GEL and Cubic meters, if he/she does not know both, write one of them. If respondent does not have information indicate – I do not know.

Annual	GEL	Cubic Meter	*I Do Not Know*	*No Response*
2014	|____|____|____|	|____|____|____|____|	*-1*	*-2*
2015	|____|____|____|	|____|____|____|____|	*-1*	*-2*

23. What is the Primary Source of water?

WSS	1
Irrigation Channel	2
Channel	3
Ground water	4
Reservoir	5
River	6
Other	7
I do not know	-1
No response	-2

24. What is the Alternative Source of water?

WSS	1
Irrigation Channel	2
Channel	3
Ground water	4
Reservoir	5
River	6
Other	7
I have no Alternative Source	-5
I do not know	-1
No response	-2

25. Water discharge?

WSS	1
Land area	2
Irrigation Channel	3
Channel	4
Underground	5
Reservoir	6
River	7

Other	8
I do not know	-1
No response	-2

26. Do you have water treatment facility?

Yes	1
no	0
I do not know	-1
No response	-2

27. Do you have water laboratory facility?

Yes	1
No	0
I do not know	-1
No response	-2

28. How would you asses the losses caused by potable and non-potable water supply failure for 4 hours?

Loss of Income:	
Half or Less of an Income	1
Loss is Equal to Income	2
No Loss	-5
Loss is More Than an Income	|____|____|____|- TIMES

Section B: Heating

#	Device Type	Do they have it or not? (If yes, then move to the next bar)	Capacity (kW). (if there are several devices, write total capacity)	*I do not know*		Duration of work per day (hours)	Days of work per week	Number of months of work per year	holidays for heating season (week-ends excluded)
29	Gas-fired central heating boilers, stationary	YES- 1 NO - 0	|___|___|___|	-1		|___|___|	|___|___|	|___|___|	|___|___|
30	Gas-fired central heating boilers,on the wall	YES- 1 NO - 0	|___|___|___|	-1		|___|___|	|___|___|	|___|___|	|___|___|
31	Diesel-powered central heating boilers, stationary	YES- 1 NO - 0	|___|___|___|	-1	**Diesel Consumed Per Day|___|___|L** **-1 *I Do Not Know***	|___|___|	|___|___|	|___|___|	|___|___|
32	Individual gas heaters KARMA type (using outside air burning)	YES- 1 NO - 0	|___|___|___|	-1		|___|___|	|___|___|	|___|___|	|___|___|
33	Individual gas heaters NIKALA type (using indoor air burning	yes- 1 no - 0	|___|___|___|	-1		|___|___|	|___|___|	|___|___|	|___|___|
34	Air conditionier (so-called. "Summer - Winter")	YES- 1 NO - 0	|___|___|___|	-1		|___|___|	|___|___|	|___|___|	|___|___|
35	Factory made Electric heater (for example: Electric radiator, Electrical Reflector)	YES- 1 NO - 0	|___|___|___|	-1		|___|___|	|___|___|	|___|___|	|___|___|
36	Coal-fired heating equipment Central heating boilers	YES- 1 NO - 0	|___|___|___|	-1	**Coal Consumption Per Day |___|___| Kg** **-1 *I Do Not Know***	|___|___|	|___|___|	|___|___|	|___|___|

#			Wood consumed per day (cubic meter)	I do not know	[redacted]	Duration of work per day (hours)	Days of work per week	Number of months of work per year	holidays for heating season (week-ends excluded)
37	Wood-fired heating equipment Central heating boiler, Traditional direct combustion	YES- 1 NO - 0	|____|____|____|	-1		|____|____|	|____|____|	|____|____|	|____|____|
38	Wood-fired heating equipment Central heating boiler, Pyrolytic burning	YES- 1 NO - 0	|____|____|____|	-1		|____|____|	|____|____|	|____|____|	|____|____|
39	Wood-fired oven, hand made	YES- 1 NO - 0	|____|____|____|	-1		|____|____|	|____|____|	|____|____|	|____|____|
40	Wood-fired efficient oven	YES- 1 NO - 0	|____|____|____|	-1		|____|____|	|____|____|	|____|____|	|____|____|

Section D: Hot water supply

#	Device Type	Do they have it or not? (If yes, then move to the next bar)	Capacity (kW)	I do not know	Work duration per day (hours)	I do not know	water consumed per day (liters)	I do not know	Working days per week	Number of months of work per year	Active holidays per year (excluding weekends)
41	Supplying energy to the high-speed boilers from Central heating	YES- 1 NO - 0	|____|____|____|	-1	|____|____|	-1	|____|____|____|	1	|____|____|	|____|____|	|____|____|
42	Supplying energy to the tank boiler from Central heating	YES- 1 NO - 0	|____|____|____|	-1	|____|____|	-1	|____|____|____|	1	|____|____|	|____|____|	|____|____|

43	Using electric heater (TERMEX TYPE)	YES- 1 NO - 0	|____|____|____|	-1	|____|____|	-1	|____|____|____|	-1	|____|____|	|____|____|	|____|____|

Section E: Air Cooling

#	Device Type	Do they have it or not? (If yes, then move to the next bar)	Capacity (kW). (if there are several devices, write total capacity)	*I do not know*	Work duration per day (hours)	*I do not know*	Working days per week	Number of months of work per year	Active holidays per year (excluding weekends)
44	Wall air conditioner (the so-called "Summer - Winter")	YES- 1 NO - 0	|____|____|____|	-1	|____|____|	-1	|____|____|	|____|____|	|____|____|
45	Window air conditioner (old type)	YES- 1 NO - 0	|____|____|____|	-1	|____|____|	-1	|____|____|	|____|____|	|____|____|
46	Central Cooling System	YES- 1 NO - 0	|____|____|____|	-1	|____|____|	-1	|____|____|	|____|____|	|____|____|

SECTION F: Refrigeration Equipment

#	Device Type	Do they have it or not? (If yes, then move to the next bar)	Capacity (kW). (if there are several devices, write total capacity)	*I do not know*	Refrigeration chamber temperature (0C)	*I do not know*	Work per day (hours)	*I do not know*
47	Industrial refrigeration boxes	YES- 1 NO - 0	|____|____|____|	-1	|____|____|	-1	|____|____|	-1
48	Counter-fridge	YES- 1	|____|____|____|	-1	|____|____|	-1	|____|____|	-1

	დახლ-მაცივარი	NO - 0						
49	Freezer	YES- 1 NO - 0	I____I____I____I	-1	I____I____I	-1	I____I____I	-1
50	Household refrigerator	YES- 1 NO - 0	I____I____I____I	-1	I____I____I	-1	I____I____I	-1

Section G: Cooking

#	Device Type	Do they have it or not? (If yes, then move to the next bar)	Capacity (kW). (if there are several devices, write total capacity)	Gas consumption per hour (m^3)	I do not know	Work per day (hours)	I do not know
51	Electric stove	YES- 1 NO - 0	I____I____I____I		-1	I____I____I	-1
52	Electric cooker	YES- 1 NO - 0	I____I____I____I		-1	I____I____I	-1
53	Gas-fired stove	YES- 1 NO - 0		I____I____I	-1	I____I____I	-1
54	Gas-fired cooker	YES- 1 NO - 0		I____I____I	-1	I____I____I	-1

Section H: Lighting

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#	Device Type	Do they have it or not? (If yes, then move to the next bar)	Total capacity KW	*I do not know*	Work per day (hours)	*I do not know*
55	Incandescent lamp	YES- 1 NO - 0	|___|___|___|___|	-1	|___|___|	-1
56	Fluorescent light bulb	YES- 1 NO - 0	|___|___|___|___|	-1	|___|___|	-1
57	Light-emitting diode (LED) lamp	YES- 1 NO - 0	|___|___|___|___|	-1	|___|___|	-1

Section I: Other Electrical Equipment

#	Device Type	Do they have it or not? (If yes, then move to the next bar)	Amount	*I do not know*	Total capacity KW	*I do not know*	Work per day (hours)	*I do not know*
58	Computers and laptops	YES- 1 NO - 0	|___|___|___|	*-1*	|___|___|___|	*-1*	|___|___|___|	*-1*
59	washing machine	YES- 1 NO - 0	|___|___|___|	*-1*	|___|___|___|	*-1*	|___|___|___|	*-1*
60	Dishwasher	YES- 1 NO - 0	|___|___|___|	*-1*	|___|___|___|	*-1*	|___|___|___|	*-1*
61	Vacuum Cleaner	YES- 1 NO - 0	|___|___|___|	*-1*	|___|___|___|	*-1*	|___|___|___|	*-1*

62	TV	YES- 1 NO - 0	|___|___|___|	*-1*	|___|___|___|	*-1*	|___|___|___|	*-1*
63	Technological equipment---------------------------- --	YES- 1 NO - 0	|___|___|___|	*-1*	|___|___|___|	*-1*	|___|___|___|	*-1*
64	Technological equipment---------------------------- --	YES- 1 NO - 0	|___|___|___|	*-1*	|___|___|___|	*-1*	|___|___|___|	*-1*
65	Technological equipment---------------------------- --	YES- 1 NO - 0	|___|___|___|	*-1*	|___|___|	*-1*	|___|___|___|	*-1*
66	Technological equipment---------------------------- --	YES- 1 NO - 0	|___|___|___|	*-1*	|___|___|	*-1*	|___|___|___|	*-1*
67	Technological equipment---------------------------- --	YES- 1 NO - 0	|___|___|___|	*-1*	|___|___|	*-1*	|___|___|___|	*-1*

QUESTIONNAIRE USED BY QUALIFIED ENGINEERS

Energy and Water Consumption Survey in Industrial Organizations

Survey conducted by: ___________________________

Survey date |___|___| |___|___| |___|___|

Month **date** **year**

Name of the organization:

____

Address of the organization (Site of the facility)

____

Name, phone number and e-mail. Chief engineer or other official responsible for energy and water consumption, related equipment/appliances and water discharge processes.

Name and Surname: ____

Position ____

Tel.: ____

e-mail ____

SECTION A: GENERAL INFORMATION

1. Organization's legal form?

Commercial Enterprise	1
Public entity	2
*Other (please indicate)*____	3

2. Type of the building where the organization is located?

Municipal Building	1
State Building	2
Business center / shopping center	3
Industrial building	4

3. Field of activity at this site?

Main field of activity
____
Additional field/fields of activity
____
Description of production units, main type of services delivered or goods produced
____

4. Initial year of commercial operation

5. Number of employees in the organization in 2014-2015.

2014 |____|____|____|NUMBER

2015 |____|____|____|NUMBER

6. Annual turnover (roughly)

|____|____|____|____|____|____|____|____|

7. The annual amount of manufactured products according to type (Preferably in the last few years)

Type of Product	Unit	Amount

8. Short description/name of main technological processes

____
____
____
____
____
____
____
____
____
____
____
____
____
____
____
____
____
____
____
____
____

9. Sources of Electricity____

____

Voltage ____

Supplying Company ____

Receiving equipment ____

10. Major uses of electricity (Processes)

____
____
____
____
____

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11. Cost and amount of electricity consumed for last 2 years (GEL/KWh)

Year	GEL	KWh
2014		
2015		

12. Electricity daily load schedule

Time	1	2	3	4	5	6	7	8	9	10	11
Load MW											

12	13	14	15	16	17	18	19	20	21	22	23	24

13. Alternative energy source in case of power disconnection?

____

____

14. Recent changes in equipment/appliances – impact on energy consumption and bill?

____

____

15. Possible loss caused by power disconnection for an hour? (GEL)

- Loss caused by time delay |____|____|____||____|____|____|
- Loss caused by loss of material |____|____|____||____|____|____|
- Damage to equipment |____|____|____||____|____|____|
- Other |____|____|____||____|____|____|

16. Possible damage caused by power disconnection for 4 hours? (GEL)

- Loss caused by time delay |____|____|____||____||____|
- Loss caused by loss of material |____|____|____||____||____|
- Damage to equipment |____|____|____||____||____|

- Other |____||____||____||____||____|

17. Source of natural gas ______________________

Pressure level ____

Supplying company ____

Receiving equipment's ____

18. Cost and amount of Natural gas consumed for last 2 years for combustion (GEL/M3)

Year	GEL	M^3
2014		
2015		

19. Cost and amount of Natural gas consumed for last 2 years as feed-stock (GEL/M3)

Year	GEL	M^3
2014		
2015		

20. Alternative energy source in case of natural gas delivery interruption?

____

____

21. Potential loss caused by natural gas delivery interruption for an hour? (GEL)

- Loss caused by time delay |____|____||____|____||____|____|
- Loss caused by loss of material |____|____||____|____||____|____|
- Damage to equipment |____|____||____|____||____|____|
- Other |____|____||____|____||____|____|

22. Potential loss caused by natural gas delivery interruption for 4 hours? (GEL)

- Loss caused by time delay |____|____||____|____||____|____|
- Loss caused by loss of material |____|____||____|____||____|____|
- Damage to equipment |____|____||____|____||____|____|

- Other |____|____||____|____||____|____|

23. **Cost and amount of coal consumed for last 2 years (GEL/T)**

Year	GEL	T
2014		
2015		

24. **Cost and amount of oil products consumed for last 2 years (GEL/KWh)**

Year	GEL	T
2014		
2015		

25. **Source of potable and technical water**____

____

Supplying Organization____

Description of Receiving/Abstraction Equipment______________________________________

____

26. **Annual water consumption/discharge (GEL and cubic meters)**

Annual m^3	WSS	Irrigation Channel	Ground water	River/Impoundment	Artificial Reservoir	Other
1. Intake of fresh water						
2014 Y						
2015 Y						
2.Water Consumption						
2014 Y						
2015 Y						

3. Discharge of Water						
3.1 Polluted						
2014 Y						
2015 Y						
3.2 Clean						
2014 Y						
2015 Y						
3.2 Cooling						
2014 Y						
2015 Y						

27. Existence of treatment and laboratory facility?

Yes ☐ No ☐

Yes ☐ No ☐

28. Potential loss caused by water supply interruption for an hour? (GEL)

- Loss caused by time delay |____|____||____|____||____|____|
- Loss caused by loss of material |____|____||____|____||____|____|
- Damage to equipment |____|____||____|____||____|____|
- Other |____|____||____|____||____|____|

29. Potential loss caused by water supply interruption for 4 hours? (GEL)

- Loss caused by time delay |____|____||____|____||____|____|
- Loss caused by loss of material |____|____||____|____||____|____|
- Damage to equipment |____|____||____|____||____|____|
- Other |____|____||____|____||____|____|

30. **Cost and amount of planned water consumption? (GEL/M3)**

Year	GEL	M^3
2016		
2017		
2018		
2019		
2020		

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Section B: Mechanical Processes

31. Electric motors

Capacity KW	Number	Destination	Time of use - Hours per day	Energy consumption per day KWHs
I____I____II____I____I			I____I____I	I____I____II____I____II____I____I
I____I____II____I____I			I____I____I	I____I____II____I____II____I____I
I____I____II____I____I			I____I____I	I____I____II____I____II____I____I
I____I____II____I____I			I____I____I	I____I____II____I____II____I____I
I____I____II____I____I			I____I____I	I____I____II____I____II____I____I
I____I____II____I____I			I____I____I	I____I____II____I____II____I____I
I____I____II____I____I			I____I____I	I____I____II____I____II____I____I

Section C: High Temperature Heat

32. Description of main processes, name of equipment, model, year constructed, last overhaul

Section D: Low temperature heat

33. Description of main processes, name of equipment, model, year constructed, last overhaul

SECTION E: Other significant consumption

34. Description of main processes, name of equipment, model, year constructed, last overhaul

____

____

____

____

____

SECTION F: Future plans

35. Production increase or beginning of a new type of production (Year, expected capacity and annual consumption)

----

36. Which technologies (production cycles) can be replaced by more energy-efficient technologies?

----

37. What are these new technologies and what will be the estimated cost of such replacement?

----

38. Fuel replacement by a cleaner (cheaper) fuel?

APPENDIX B: CRITERIA FOR SAMPLE SELECTION BY DISCOS

The size of the set to be provided by each Disco was defined as:

$$n_i = \frac{N_i}{N} 3000$$

Where:

- N_i is number of non-residential customers of a particular Disco
- N is total number of non-residential customers in Georgia
- 3000 is the final size of the sample to be achieved.

However, Discos didn't follow the formula exactly and the final size of the sample was 3289 instead of 3000, which only positively affected the quality of the survey.

Additionally, all Disco were requested to select non-residential customers using the following formula:

$$k_{ix} = \frac{\sum_{x=1}^{N_{ix}} MOS_{ix}}{n_{ix}}$$

Where:

- k_{ix} is selection interval
- $\sum_{x=1}^{N_{ix}} MOS_{ix}$ indicates cumulative electricity consumption of non-residential customers in the sample
- n_{ix} is the number of selected customers

Once the selection interval was calculated the next step for Disco was to find selection's starting point that was defined as

$$rndstart_{ix} = rand(0,1) * k_{ix}$$

Where $rand(0,1)$ is random values generator[5] that generates values from 0 to 1.

Once starting point was found the next step was to add to it selection interval (k_{ix}) to get the following selection point value($selection_{ix}$):

$$selection_{ix} = rndstart_{ix} + k_{ix},$$

Then the selection interval is added again to get $n_{ix} - 1$ value of $selection_{ix}$. At the end the number of selection points' values including the starting point was equal to the number of selected customers.

Afterwards selection values were corresponded to Cumulative MOS those values that were higher than the previous value and lower than the current. Finally those non-residential customers were selected whose Cumulative MOS value was corresponded to selection point's value. In this way we got 3 sub samples provided by Disco which were unified in one sample.

[5] This can be done in excel using command „=rand()"

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