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Sustainable Energy Action Plan for Kutaisi

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Sustainable Energy Action Plan for Kutaisi

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1 Introduction – Covenant of Mayors and City of Kutaisi

At the Covenant of Mayors Conference held in Georgia in October 2010, the role of cities as complex systems having significant capacity to reduce greenhouse gas emissions was stressed. Municipalities have been identified as a main driving force in guiding the development and implementation of the Sustainable Energy Action Plan (SEAP) within EU energy efficiency priorities.

In 2011, by signing the Covenant of Mayors, Kutaisi City Hall joined an initiative under which Kutaisi should achieve reduction of greenhouse gas emissions by 20% by 2020 - a goal that will be achieved along with social and economic development of the city.

In order to achieve this goal, Kutaisi City Hall elaborated on the **Sustainable Energy Action Plan for Kutaisi**. The process of development of the SEAP was conducted within the frame of the project Capacity Building in Low Emissions Development / Pure Energy Program, supported by USAID and implied:

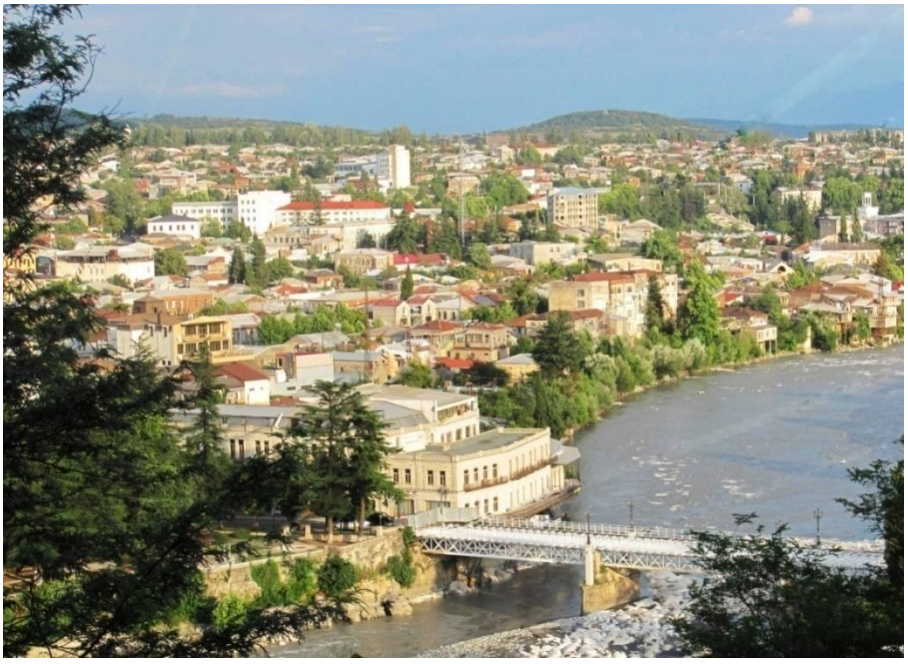
- Development of a Baseline Emissions Inventory (BEI) in transport, outdoor lighting, waste, and greening sectors
- Development of a so called Business as Usual (BAU) Scenario for these sectors
- Defining mitigation measures for greenhouse gas emissions in these sectors for 2020 and assessment of their efficiency
- Monitoring plan
- Development of strategy on local capacity and raising of public awareness

2 City of Kutaisi – Brief Overview

Fast economic development of Kutaisi, the population growth rate and increasing GDP per capita were taken as main assumptions while developing the BAU scenario for 2020 and planning concrete measures in order to reduce the energy consumption and CO2 emissions of the city. Implementation of the actions proposed in the AP will ensure reduction of the overall CO2 emissions by at least 22, 9% for the mentioned sectors in Kutaisi to compare with the 2020 baseline emissions (BAU).

Kutaisi, by its population number and area, is the second largest city in Georgia after Tbilisi. Kutaisi is located along both banks of the Rioni River. It is an area, where the river comes out of the narrow and deep gorge to the Kolkheti Lowland. The city lies at an elevation of 80–120 meters above the sea level and its total area is 70 km^2. To the northeast, Kutaisi is bounded by the Okriba Plain, to the north by the Samgurali Range, and to the south-east by the Kolkheti Lowland. The city population lives mostly in lowlands. Northern parts are located at the elevated banks of the river, while the southern part – at Sapichkhia Hill. The city has a strategic location, connecting East and West parts of Georgia by main highway. Kutaisi lays on the way to Sokhumi, Batumi, and Poti. North-Caucasian Road connects the city also to Samachablo, while Kutaisi railway (Brotseula – Tskaltubo and Rioni – Tkibuli lines) connects it with the main lines of the Caucasus. The distance between Kutaisi and Tbilisi is 220 km.

The climate in Kutaisi is humid subtropical. The summers are generally hot, while the winters are mostly dry and warm. Average annual temperature in the city is 14.5°C. Average annual precipitation is around 1730 mm[1].



Pic. 1. View of the central part of the city

Two thirds of the city territory is residential. Kutaisi is divided into 12 municipal units: City-museum, Avtoqarkhana, Uqimerioni, Dzelkviani, Kakhianouri, Vakisubani, Sapichkhia, Sulkhan-Saba, Nikea. Mukhnari, Gumati, and Gamarjveba.

By the state of 2012, population of Kutaisi was 196 600. After the World War II population was constantly increasing (on average 2.28% yearly growth), but since 1989 it started decreasing (on average 1.73 % yearly growth). Since 2005 it showed increasing trend again, though at lower rates (0.86% on average) (Fig. 1**Error! Reference source not found.**). During 2005-2012 population increased by 6,2% in total. Correspondingly, the population density in the city increased significantly and reached a rather high level of 2 800 persons per square kilometer, exceeding the corresponding value for Tbilisi (2000 persons/km^2) by 40% and the average value for the country (67 persons/km^2) 40 times[2].

[1] http://www.kutaisi.gov.ge/kutaisi-city/

[2] http://nala.ge/uploads/kutaisi.pdf

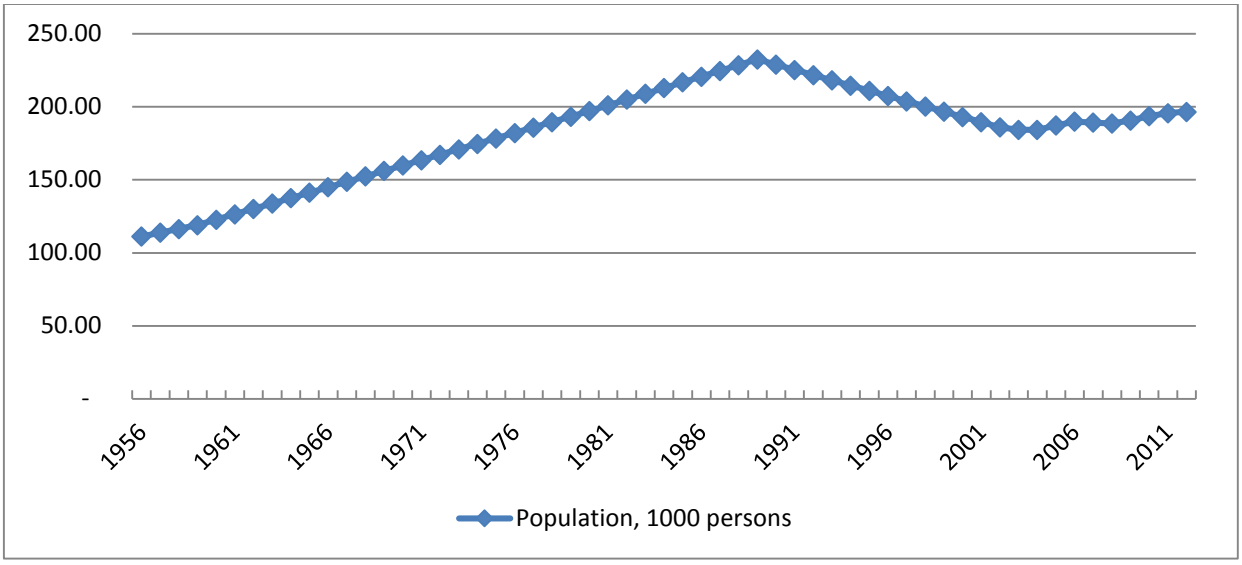


Fig. 1. Kutaisi population, 1000 persons

Despite population growth, migration rate in Kutaisi is rather high, which can be explained by high level of unemployment (22-25%). Though unemployment in Kutaisi is below the average, compared to other cities, it still is the main socio-economic problem of the city.

Table 1. Labor force composition (thousand persons)[3]

	2009	2010	2011
Economically active population	**81.10**	**82.80**	**83.90**
Employed	**61.10**	**63.00**	**65.20**
Hired	47.00	48.30	49.30
Self-employed	14.00	14.50	15.80
Unclear	0.10	0.20	0.10
Unemployed	**20.00**	**19.80**	**18.70**
Population beyond labor force	49.60	50.10	50.20
Unemployment level %	**24.70**	**23.90**	**22.30**

Currently, self-employed segment is rather large and comprises about 16 -18% of population actively involved in economic activities. Main factors contributing to the decreasing trend of unemployment rate during last period, are: significant investments in the economy of the city; attractive environment for

[3] Source: Kutaisi City Hall

investments; introduction of new technologies; favorable environment for tourism, etc. Following actions/activities can be considered as examples of above mentioned factors: reconstruction of Kutaisi Airport, designation of Kutaisi as the Parliament city, moving the Georgian National Energy and Water Supply Regulatory Commission, the Chamber of Control, Government of Georgia, Public Service Halls and Roads Department of Georgia to Kutaisi.

In 2010 a Free Industrial Zone was established in Kutaisi. In 2012 there were operating up to ten companies but taking into account the size of the city, the effect on unemployment rate was negligible. It is planned to attract more foreign investments in order to increase the scale of this effect.

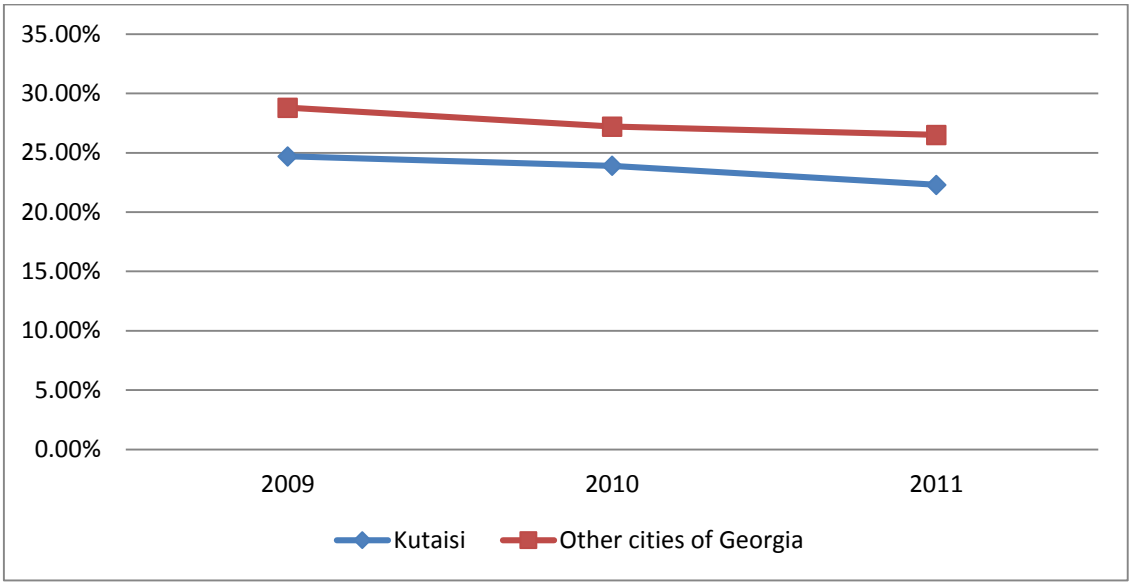


Fig. 2. Unemployment level, %[4]

During the Soviet time, several large industrial enterprises, having high capacity for that period, operated in Kutaisi. Up to 50 thousand people were employed. During 1990-1995, deindustrialization process lead to drastic decrease of production level and consequently, to significant decrease of the industrial sector share in the city's domestic product. Some positive changes in the economy were observed during 1995 – 2001, though the situation remained uneasy. Capacity of industrial plants in Kutaisi was extremely low. A tangible improvement of the situation, observed in 2012, can be explained by gradual increase of the production volume, as well as of the total turnover since 2002.

Number of registered business entities also indicates the increased business activity. In particular, if in 2009 there were registered 17 452 business entities, by 2011 their number reached 24 860. Increased business activity had positive reflection on employment rates as well. In 2009, 33 271 people were employed, while according to 2011 data, the number of employed population reached 36 747. Positive changes in the industry field and certain steps towards regulation of macroeconomics, related to liberalization of economic course of the country, had positive effect on the following indicators as wll:

For the last three years (2009-2011):

[4]Source: Kutaisi City Hall

- Value added increased by 49% (from 610,4 million GEL to 911,7 million GEL)
- Business sector production increased by 41% (from 472,6 million GEL to 666,3 million GEL)

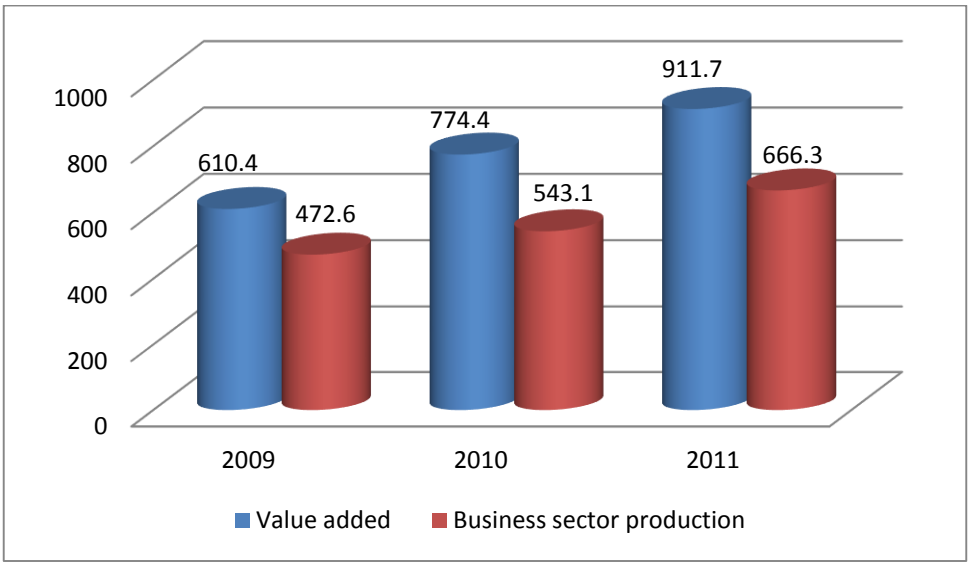


Fig. 3. Dynamics of industrial activity in 2010-2011(million GEL)[5]

Positive dynamics showed in (Fig. 3) is mainly stipulated by mini-factories and small and medium size business companies operating in the city.

Industry lost its dominant position in the city's economy during the last decades. This fact, alongside with transition to the market economy, lead to basic changes in production structure. Main load has been shifted to the service sectors. In particular, for the time being, the industry sector represents only 17% in the production output, whereas the share of trade is 36,5%; education, healthcare and sport are represented by 7,5%, and construction sector – by 12%. (**Error! Reference source not found.**).

[5]Source: Kutaisi City Hall

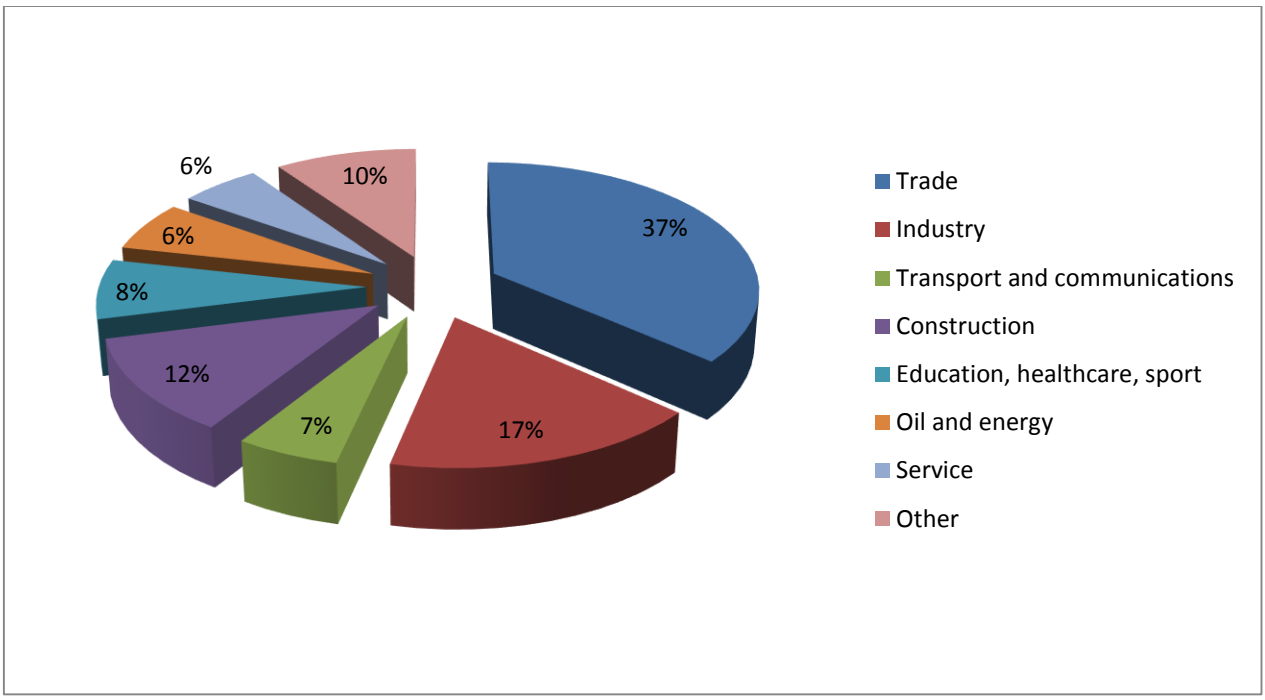


Fig. 4. Composition of economy sectors of Kutaisi, %

Among new economy sectors tourism should be separately noted, as the city has a big potential in this direction. Tourism development program aimed at designation of Kutaisi as a touristic center of Imereti Region has been developed with the support of foreign experts. The city is surrounded by over 500 unique historical and cultural monuments and various mineral springs. Taking into account, that an adventure travel and cultural tourism becomes rather popular, the region having mountains and woodlands of 250 000 ha and rich historical heritage, has exceptional opportunity for developing these types of tourism. Following touristic activities are already available: eco-tourism, rafting on Riony River, mountain hiking, mountain riding and speleo-tourism.

A proper state of environment is an essential precondition for development of tourism and adds more value to the Sustainable Energy Action Plan development and implementation. The city environment and energy efficiency is very important not only for tourists, but for local population as well. In order to turn Kutaisi into a city, favorable for living and development of tourism, the service sector should be appropriately developed: there are up to 20 restaurants, private hotels and tens of cafés, bars and catering services. Up to a thousand of trade and service centers, retail and wholesale markets, several agricultural markets and large modern trade centers are already operational in Kutaisi.

The city infrastructure, including state of roads, has been significantly improved during the last several years. Partial rehabilitation of water supply and sewage systems is ongoing, supported by European Bank for Reconstruction and Development (EBRD), Swedish International Development Cooperation Agency (SIDA) and Millennium Project. Most of the city is supplied by natural gas, while Electric power is available for the whole city.

All measures undertaken during the last period directed to the improvement of exterior view of the city, its infrastructure, animation of industrial activities, serve as a base for gradual transformation of Kutaisi into a modern, well developed city. It should be noted that according to Country Basic Data and Directions

(BDD) document, the priority document of the self- governing city - Kutaisi represents one of the main documents for the city development, reflecting a medium term action plan. The priority document takes into consideration the fact, that regardless certain success, many citizens still live in heavy social conditions. That is why the following tasks have been identified as main goals for the next 5 year period:

- Stabilization of the business sector and rapid development of small and medium size business segment;
- Well-ordered infrastructure;
- Reduction of unemployment rates;
- Further improvement of investment environment.

Special directions, listed below, have been identified for the period of 2013-2017:

- Infrastructure projects and programs (lightening, water supply, public gardens, parks);
- Support small and medium size business;
- Development of modern municipal transport;
- Support of tourism development;
- Educational programs;
- Healthcare and insurance;
- Social projects;
- Sport and Culture programs.

Almost all projects/measures related to the above mentioned priorities will directly or indirectly influence the sustainable development of the city energy sector and, hence, while planning these measures, it is necessary to take it into consideration.

3 Sustainable Energy Strategy

Main goal of the Sustainable Energy Action Plan is to reduce CO_2 emission caused by energy consumption in Kutaisi. At the same time, it is planned to diverse and develop natural sources able absorb the emissions, such as existing city parks, public gardens, and green areas.

While implementing the Sustainable Energy Action Plan, it is necessary to ensure preservation of cultural and historical heritage of the city, involvement of all interested parties (private sector, state, municipal authorities) into planning and implementation processes. In order to succeed, while introducing low carbon technologies to the energy consumption sector, increase of public awareness becomes essential for motivating actual consumption behavior change.

At the current stage, Kutaisi SEAP considers three main sectors, related to the greenhouse gas emissions: transport, buildings and infrastructure (landfills, outdoor lighting, and green spaces).

The Kutaisi Sustainable Energy Action Plan was prepared in 2014 and covers six years period until 2020. Emission reduction strategy defines measures in each sector for short (2014-2017) and long term (2018-2020) periods. Measures, defined for the short term period are tangible and detailed, while measures, planned for the long term period are more strategic and need some additional investigation, planning and feasibility study. Such approach thoroughly complies with thr guidelines for the development of SEAP.

Within the framework of Kutaisi SEAP, the strategy for each sector has been developed based on the inventory data of emissions for basic 2012 year and CO_2 emission growth rates for the period until 2020. As a result, following directions have been identified:

Transport Sector:

Measures considered for public transport development in short term strategy:

- Improvement of public transport service that includes:
  - Elaboration of optimal schemes for regular local routes within the city;
  - Introduction of modern payment systems for public transport;
  - Development of automatic system for public transport management;
  - Installation of electronic information boards at the bus stops;
  - Public transport promotion campaigns, intended for awareness increase and behavior change.

To achieve these goals a detailed public transport strategy should be developed. The strategy should define various activities to improve service quality in municipal transport and increase its attractiveness;

Besides above mentioned activities, following measures are planned in the short term strategy:

- Upgrade and renovation of fleet;
- Establishment of the municipal transport enterprise. At the first stage the fleet will consist of 70-80 new Bogdan type buses for 20-30 passengers, equipped with GPRS system.

Measures, considered for public transport development in long term strategy:

- Moving from the established municipal motor transport fleet to the bio-diesel which will be produced from the used edible oils, collected from restaurants and hotels;
- Introducing fast public transport service that includes:
  - Arranging a tramline system on Nikea street, covering the whole street (5.5 km single direction segment) up to the by-pass road;
  - Providing Bus Rapid Transit (BRT) for central routs, ensuring fast and safe transportation.

Measures, considered for private transport development in short term strategy:

Construction, rehabilitation and maintenance of road infrastructure that imply the following:

- Maintenance of existing renovated central roads, as well as rehabilitation of new/minor roads and inner tracks; Installation of new traffic lights for improving safety and better traffic management.
- Construction of Kutaisi by-pass road and adjustment of whole road system to it.

Measures, considered for private transport development in long term strategy:

- Development of footway and bikeway routs together with program on behavior change;

- Elaboration and enforcement of relevant parking policy – introduction of parking fee and restriction of parking in central districts of the city;
- Facilitation of the development of standards for fuel quality and maintenance checkup.

Buildings Sector:

Short term strategy of Kutaisi identifies several measures to be carried out for reduction of greenhouse gas emissions from municipal and residential buildings. Those are measures, directed to decrease the consumption of energy resources: use of energy efficient electric light bulbs, improvement of thermo-insulation of roofs, entrances, and areas of common use, repair or change of roofs, windows, and doors that allows to avoid significant heat losses. On the other hand, these measures are rather advantageous in terms of affordability.

Transition to energy efficient light bulbs implies replacement of old type bulbs with new fluorescent lamps, which are more feasible considering their price, energy consumption and lifecycle. Evidently, prior to conducting above mentioned activity, educational trainings and campaigns should be conducted for rising public awareness and acceptance rate.

Use of renewable energy sources is one of the most effective ways to reduce carbon dioxide emissions. As it is well known, energy resources in buildings are consumed mainly for heating and hot water supply. Usage of biomass and solar energy as of the renewable energy sources for heating and hot water supply in buildings would significantly decrease the consumption of natural gas and consequently – carbon dioxide emissions. Implementation of these measures, for instance, in 16% of private houses, would reduce the carbon dioxide emissions by 20% at the city level.

Taking into consideration all the above-mentioned, the long term strategy of Kutaisi on greenhouse gas emissions covers production of residual biomass briquettes for using in local heating systems, as well as installation of solar collecting panels in municipal and residential houses. Implementation of the mentioned measures would provide not only hot water supply and heating, but also will facilitate introduction of non-traditional renewable energy to the heat supply sector.

Measures, considered for implementation in Kutaisi buildings sector within the frames of short and long term strategies:

2014-2017

- Replacement of old type bulbs with fluorescent lamps;
- Heat insulation of roofs at day nurseries and kindergartens;
- Installation of fluorescent bulbs in common use areas of residential buildings;
- Thermal insulation of common use areas and entrances in residential buildings;
- Heat insulation of roofs in private houses;
- Energy efficient and cheap houses for refugees (pilot project);
- Program for thermal insulation and roofing for 41 families, having status of a 'poor family'.

2018-2010

- Installation of solar collecting panels for hot water supply in private houses (investor);
- Usage of pallets and briquettes made of wood biomass in municipal and private buildings (pilot projects);
- Usage of solar energy collecting panels in day nurseries and kindergartens.

Municipal Infrastructure Sector

Municipal infrastructure development strategy covers three sub-sectors. It is aimed at: catching and burning of methane (CH4) from municipal landfills (long term); increasing energy efficiency in the street lighting sector (gradually during the whole period); and widening of green spaces in the city. The greening measures are defined as: green planting in different recreation zones of the city; greening of the city street curbs (short term); and planting of recreational forest stands in Botanical Garden (long term).

Summary of the Sustainable Energy Action Plan (SEAP):

Methodology for the development of Kutaisi SEAP does not imply the use of the fixed basic year, as this method contains high risks and can hinder the cities in their efforts to comply with their obligations. The method, which was used, took into consideration normal development perspectives of the country and the city - emissions (caused by increased demand on energy carriers) are supposed to increase by 2020, which is considered as a traditional development scenario (BAU). SEAP suggests different measures and project proposals for reducing emissions compared to the mentioned traditional scenario. More detailed description of the methodology for the Business As Usual (BAU) scenario is given in Transport chapter.

Summarized inventory data for 2012 and 2020 and assessment of the reduced emissions after carrying out the measures reflected in the Sustainable Energy Action Plan are given below, in Table 2 and Table 3.

Table 2. Greenhouse gas emissions in Kutaisi in 2012 and 2020 (t CO_2 eq)

Sector	2012	2020 (BAU)
Transport	152 252	262 069
Buildings	70 606	145 693
Street lighting	1 280	1 604
Waste	36 960	28 350
Total	**261 098**	**437 717**

Table 3. Emissions reduced in different sectors according to the Kutaisi Sustainable Energy Action Plan

Sector	Reduction (t CO2 eq)
Transport	43 548
Buildings	30300
Street lighting	911

Waste	25 192
Greening	178
Total	**100 128**

Fig. 5 shows distribution of emissions according to sectors in basic year of 2012 and 2020 in case of Business As Usual scenario. Increased emissions in different sectors for BAU and the Sustainable Energy Action Plan (SEAP) scenarios are showed in Fig. 6 - Fig. 9.

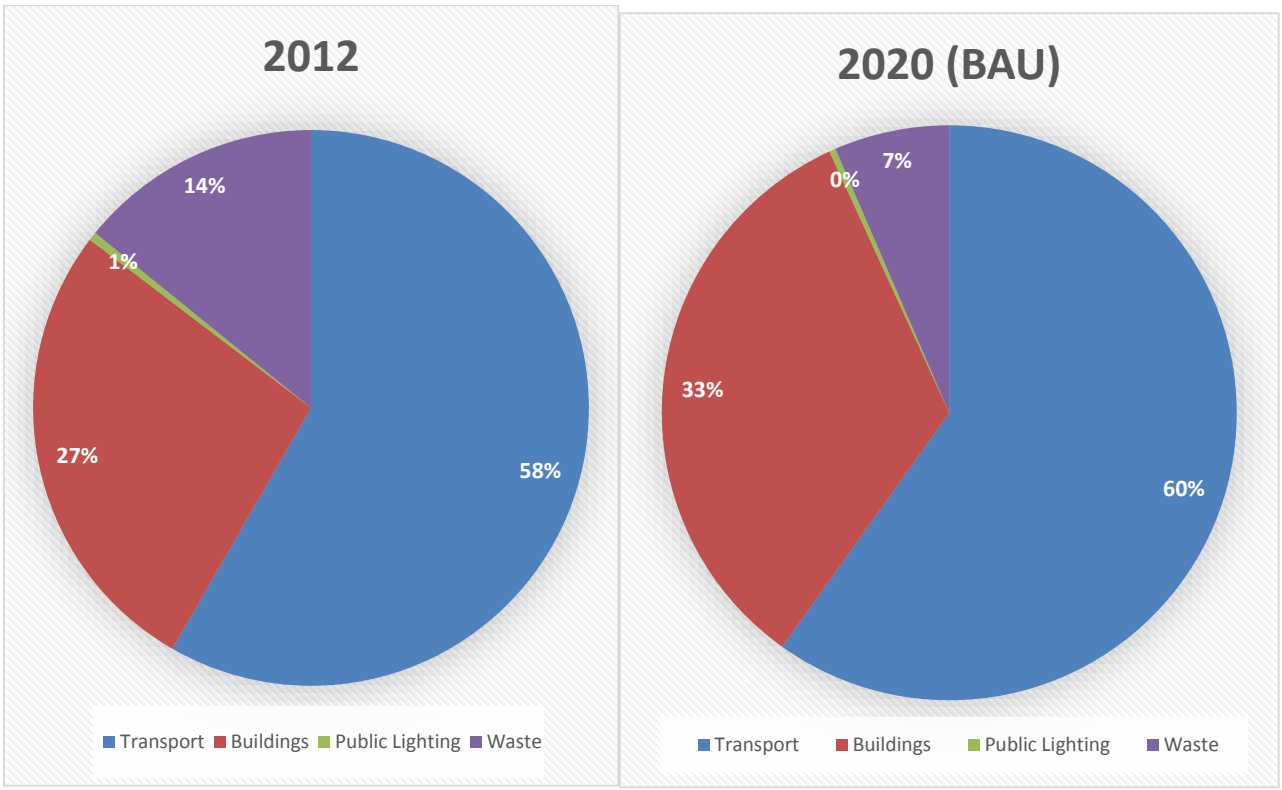


Fig. 5. Emissions distribution according to sectors in 2012 and 2010

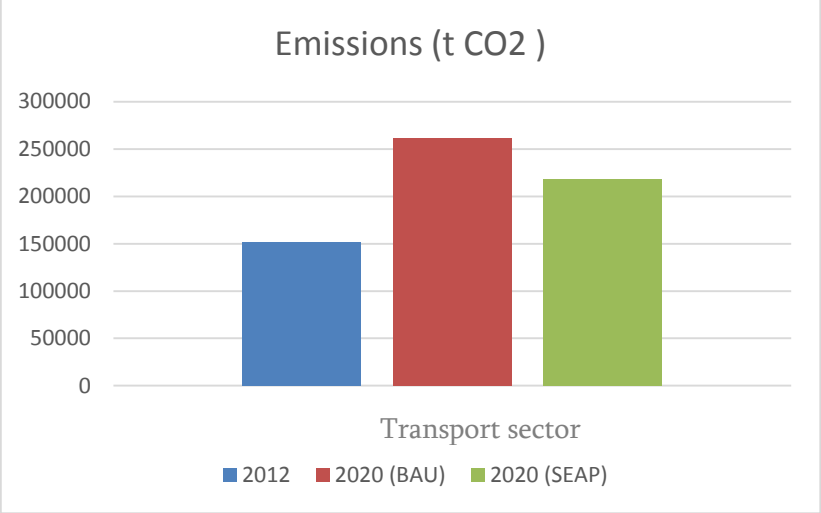


Fig. 6. Emissions in BAU and SEAP scenarios in transport sector

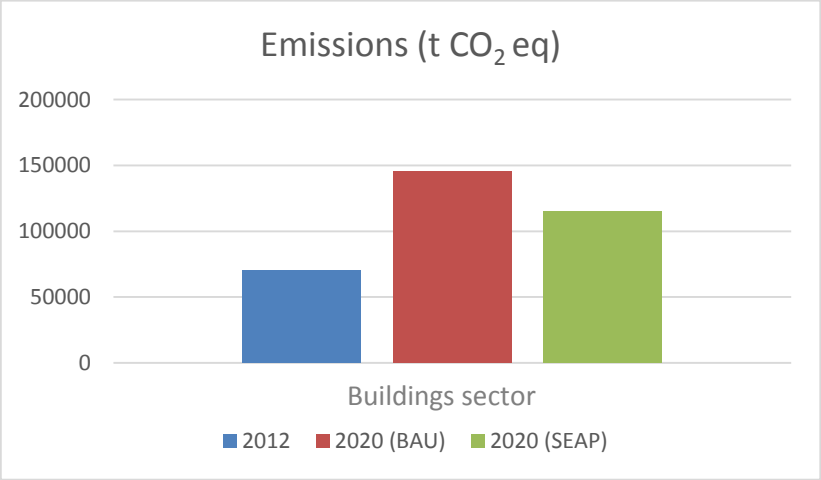


Fig. 7. Emissions in BAU and SEAP scenarios in buildings sector

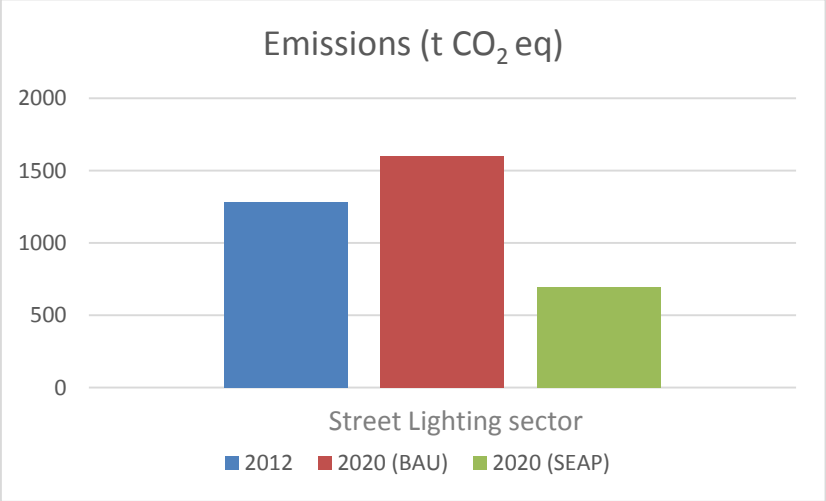


Fig. 8. Emissions in BAU and SEAP scenarios in Street Lighting sector

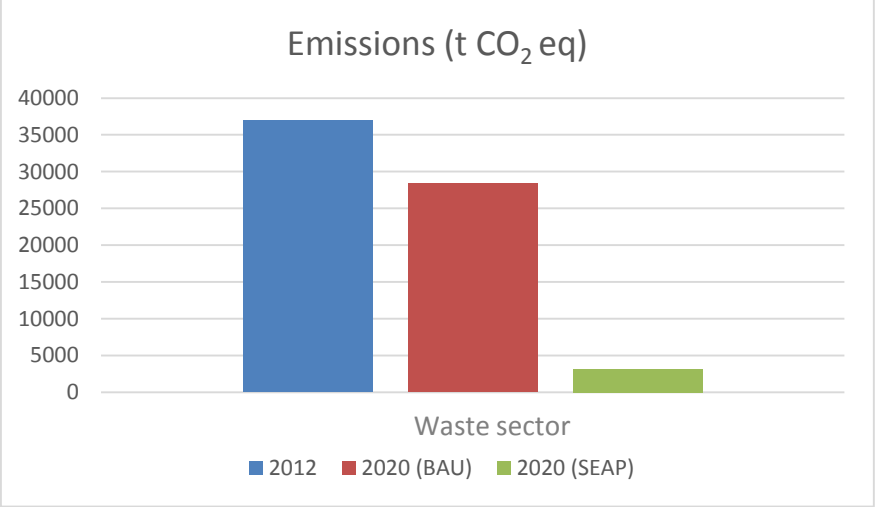


Fig. 9. Emissions in BAU and SEAP scenarios in Waste sector

4 Transport and Road Infrastructure

4.1 Sector overview

Among state functions of Georgia, transit function plays one of the most crucial roles. Due to its geopolitical location, Kutaisi became an important part of the transport corridor between Europe and Asia as well as between Western and Eastern regions of Georgia. Being part of this corridor for Kutaisi means increase of transport stream in the city and related emissions. Therefore, Zestaponi – Kutaisi –Samtredia highway, being currently under construction, is particularly important. One of the most significant parts of this highway is Kutaisi's bypass road. After its completion, transit traffic will be redirected from the city territory to the highway.

Fig. 10. shows Kutaisi layout. The total lengths of the city roads is 414 longitudinal kilometers, including 78 km road bends and deadlocks, 44% of the 336 km of main road is asphalt-paved.

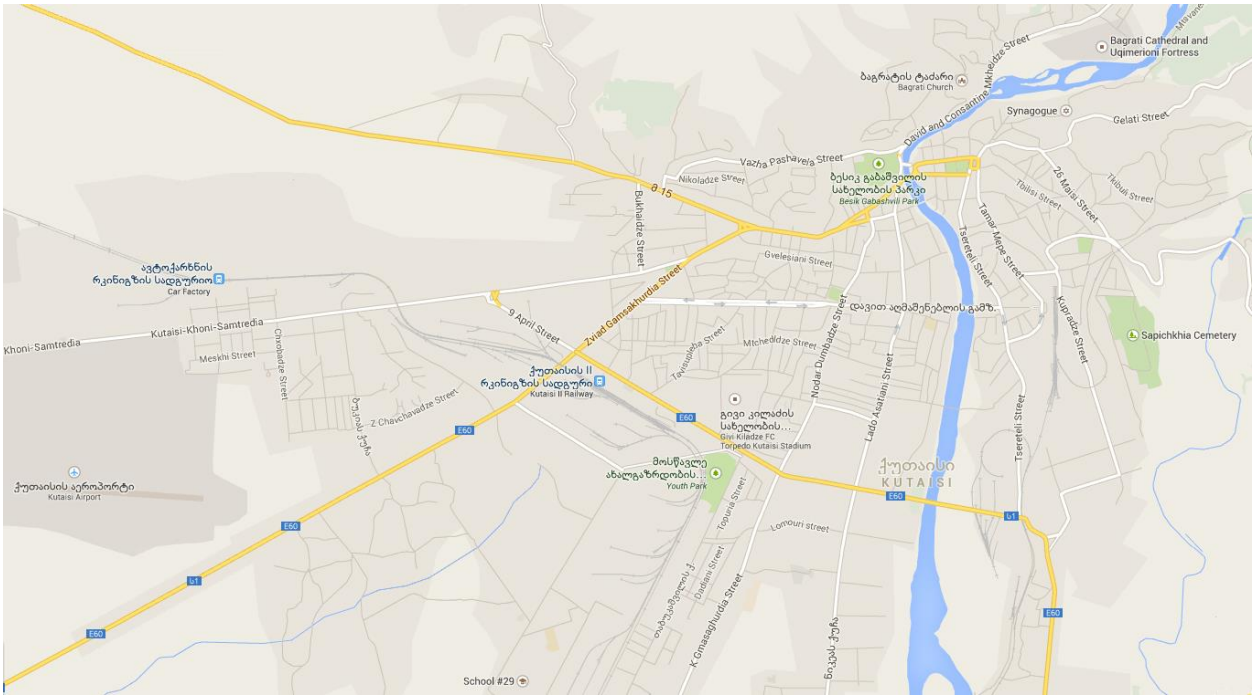


Fig. 10. Kutaisi layout

The city's road infrastructure is almost entirely amortized nowadays. Thoroughly rehabilitated roads are already damaged and need at least hole repairs, though in most of the places fundamental reconstruction is required. Poor condition of roads impedes vehicle movements and increases CO_2 emissions. Considerable amount of funds are spent annually from budget for road construction and pavement rehabilitation activities. 225.1 thousand m^2 asphalt was laid down during 2008 - 2012 in Kutaisi, costing 18,9 million GEL, additional 230 thousand GEL was spent on rehabilitation of bridges.Water sewers and sidewalks have also been repaired on some of the streets.

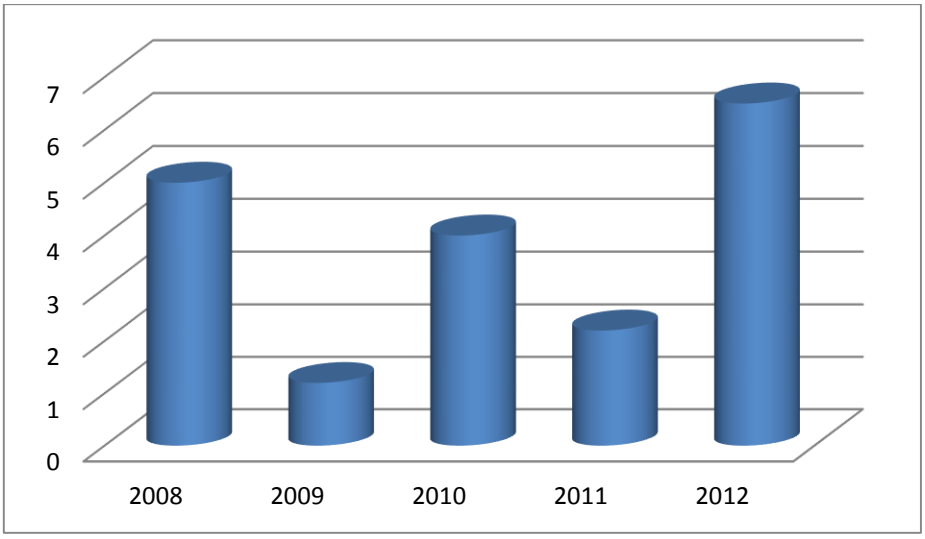


Fig. 11. Amounts, spent on Kutaisi roads rehabilitation (million GEL)

The situation is better in regards to traffic lights. There are 29 well-functioning traffic lights in the city, which is sufficient to ensure uninterrupted flow of traffic.

130 projects have been sent to the Regional Development and Municipal Development Funds (RDF, MDF) from Kutaisi City Hall in 2014 to improve road infrastructure. At the moment, issue of funding for projects is unknown yet and depends on the Funds' decision.

Positive dynamics as of the population of Kutaisi, as well as number of employed people, have increased the demand for public transport and showed the need for planning of new routes. According to the current statistics, about 32 million passengers are carried by public transport annually, therefore, this number is expected to rise, along with growing tendency of emissions due to additional vehicles. That is why improvement of the energy efficiency in transport sector is one of the most crucial tasks in terms of sustainable energy development. Table 4 shows types of vehicles registered in Kutaisi, quantity and fuel consumption for 2012.

Table 4. Transport Registered in Kutaisi and their Characteristics

Vehicles	Cars (except for Taxis and municipal vehicles)	Kutaisi Municipality Service and other Vehicles	Buses	Minibuses	Taxi	Small Trucks (up to 2 ton carrying capacity)	Big Trucks
According to Fuel							
Gasoline powered	31 121	45			93	217	
Diesel powered	7 836	8	194	587	121	1 208	853
Natural-gas powered	6 348				479		
Sum	**45 305**	**53**	**194**	**587**	**693**	**1 425**	**853**
Annual mileage (km/vehicle)	9 000	8 000	40 000	60 000	50 000	30 000	15 000
Average fuel consumption of gasoline (l/100 km)	10.00	8.00			10	16	
Average fuel consumption of diesel (l/100 km)	8.00	35.00	38	15	9	14	30
Average fuel consumption of natural gas (cub. m/100 km)	10.00				11		
Total gasoline consumption (liter)	28 008 900	28 800	1 280	0	465 000	1 041 600	
Total diesel consumption (liter)	5 641 920	22 400	2 948 800	5 283 000	544 500	5 073 600	3 838 500
Total natural gas consumption (cub. m.)	5 713 200				2 634 500		

Up to 2007 population of Kutaisi was served by municipal transport enterprise, which was shut down due to outdated vehicles. Private transportation companies were given permission for regular city routes. Currently there are 12 active companies, which complicates timely and proper management of energy efficiency improvement measures and may require creation of additional control mechanisms. As there already exists transport service control group, responsible for permission and violation monitoring, their usage for monitoring energy efficiency improvement measures will be reasonable.

Main violations, revealed by the control group nowadays (violation of traffic schedule, arbitrary stops and unsufficient number of vehicles, especially at nights) have negative impact on the popularity of public transport, making private vehicles more attractive to use. Restoration of municipal transport should be considered as one of effective measures to decrease emissions, along with other activities.

Table 5 shows vehicles, serving the city. In terms of energy efficiency, it is worth mentioning, that permits, issued for the city bus routes, include an obligation to replace vehicles with new and technically improved buses one year after issuing the permit. As for mini-bus autopark, it has been upgraded and currently consists of vehicles, manufactured in 2000 - 2006.

Table 5. Public transport of Kutaisi

	Working Daily	Inventory Quantity
Bus	67	97
Minibus	153	321
Sum	225	428

According to Table 4, total fuel consumption in Kutaisi reached about 29.5 million liters of gasoline, 23.4 million liters of diesel and 8.3 m^3 of gas. Not all vehicles, described in Table 5 travel within the city (e.g. some buses and minibuses work intercity), but due lack of accurate information, including transit flows, Greenhouse gas inventory was performed based on Table 4 data.

4.2 Methodology

2012 is a baseline year for transport sector similar to other sectors. Greenhouse gas emissions are calculated with formula adapted for intergovernmental council's (IPCC) methodology level 1 sector approach for local level which is based on actual fuel consumption data.

Carbon Dioxide emissions $_j$ ($GgCO_2$)=

$\square_i${Actual fuel consumption $_{ji}$ (unit)x caloric value of $fuel_i$(MWh[6]/per unit)

x carbon emissions factor (TC/MWh)/1000x oxidized carbon share i}x 44/12,

Where lower index refers to sector and lower index *i* - type of fuel.

[6]Basic energy unit in IPCC methodology is Terajoule, while according to the SEAP methodology it is MW/h, that is why MW/h is used here everywhere

Emissions for other gases with sector approach were calculated via following formula:

Greenhouse gas emissions $_j$ (GgGas)=

$\square_i$[Actual fuel consumption $_{ji}$ (unit)

x caloric value of fuel$_i$(MWh/per unit)

x Gas emissions factor $_{ji}$(TGas/MWh)/1000].

IPCC typical values of carbon emission factors (carbon emission per energy unit) and transfer coefficient (fuel's heat of combustion, i.e. caloricity) have been used for calculations since 1996.

Table 6. Transfer Coefficients and Carbon Emission Factors for Different Types of Fuel

Type of Fuel	Unit	Transfer Coefficient (MW/h unit)	Carbon Emission Factor (Ton C/ MW.h)
Gasoline	1000 liters	0.01	0.247
Diesel	1000 tons	0.011	0.267
Liquid Gas	1000 tons	0.013	0.227
Natural Gas	1 millionm^3	0.009	0.202
Firewood	1000 m^3	0.002	--

The Average emission factor of grid electricity was used in 2012 - 0. 136 kg CO_2/kWh for the electric power.

A small portion of carbon in fuel is not oxidized during combustion but the largest part of it is oxidized later in the atmosphere. It is calculated that non-oxidized carbon is stored for indefinitely long period. Typical values of oxidized carbon recommended by IPCC and used in 2006-2011 inventory are given below, in Table 7.

Table 7. Share of Oxidized Carbon for Different Fuels

Fuel	Share of Oxidized Carbon
Oil and Oil Products	0.990
Natural Gas	0.995

Different gas emission factors for transport sector are given in

Table 8.

Table 8. Methane and Nitrous Oxide Emission Factors for Transport Sectors (kg/MWh)

Greenhouse Gas	Gasoline	Diesel	Natural Gas
CH_4	0.072	0.018	0.18
N_2O	0.002	0.002	0.0004

Global warming potential values (GWP) of mentioned gases are used for converting methane and nitrous oxide into carbon dioxide equivalent.

Table 9. Global Warming Potential of Methane and Nitrous Oxide

Gas	Life Expectancy, Years	100-year GWP
CH_4	12±3	21
N_2O	120	310

Guidance document[7] has been developed by the Joint Research Centre (JRC) specially for the Eastern Partnership member cities, according to which these cities are given a choice to determine mandatory reductions of emissions through three alternative approaches:

1. Reduction for full emissions of fixed base year;
2. Per capita emissions reduction for fixed year emissions;
3. Reduction by Business As Usual (BAU) scenario for prospective emissions of 2020.

Sustainable energy development plan of Kutaisi uses emissions reduction calculations for the BAU scenario. Abovementioned guidance describes two possible versions of scenario construction:

1. The city can develop its own methodology, which later will be evaluated by the JRC.
2. The city may use national ratios indicated in the guidance. These ratios have been developed for the Global Atmosphere Research (EDGAR) project CIRCE[8] employing emissions database. There has

[7]"HOW TO DEVELOP A SUSTAINABLE ENERGY ACTION PLAN (SEAP) IN THE EASTERN PARTNERSHIP AND CENTRAL ASIAN CITIES" – GUIDEBOOK, European Commission Joint Research Centre, Institute for Energy and Transport, Luxembourg: Publications Office of the European Union © European Union, 2013

[8]

also been used POLES (Prospective Outlook for the Long-term Energy Systems)[9]method, considering growth of energy consumption due to population and economic growth. According to the baseline year, the BAU scenario calculates level of emissions for 2020 assuming that current trends of population, economy, technologies and human behavior will continue and no national measures will be taken towards reduction of emissions.

The first approach has been used in case of Kutaisi, i.e. its own methodology has been developed that was similar to the second approach. Just as in the second one, national growth ratios are being taken but there are the following differences:

1. The ratios have been obtained not from the research, conducted outside the country, as JRC ratios, but in accordance with the BAU scenario results, based on MARKAL-Georgia model. created on the National level and used for working out low-emission development and energy development strategies of Georgia. Therefore, these ratios reflect the current situation and future plans of the country better.
2. The ratios are available not only at the level of total emissions but also at different fuel consumption level in various sectors, allowing for better planning of mitigation measures.
3. If there are population and Gross Domestic Product (GDP) growth projections at municipal level, mentioned projections may be used for modification of MARKAL-Georgia national ratios.

Using this method, a small, Excel based software muni-EIPMP (municipal emissions' inventory, projection and mitigation measures planning) has been developed by the USAID funded "Enhancing Capacity for Low-Emission Development Strategies Clean Energy Program", based on which the BAU scenario projections, acquired on the basis of MARKAL-Georgia model, may be adapted to specific municipality inventory. The BAU scenario has been developed for Kutaisi via this software. Used ratios are shown in

Table 13.

In addition to greenhouse gases, there have been also evaluated other, namely local pollutants emitted by transport. Special softwareCOPERT IV (Computer Programme to Calculate Emissions from Road Transport) worked out by the European Agency has been used for mentioned purposes and is widely used in Europe.

Information in Georgia and its regions mainly need adaptation toCOPERT IV model, since a substantial part of information does not exist. COPERT IV, on the basis of standard values of properly selected initial data, allows approximate evaluation of emissions. Due to lack of technical inspection of vehicles and information on a quality of fuel, true values of pollutant emissions are likely much higher than

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U.M. Doering, G. Janssens-Maenhout, J.A. van Aardenne, V. Pagliari (2010), CIRCE report D.3.3.1, Climate Change and Impact Research in the Mediterranean Environment: Scenarios of Future Climate Change IES report 62957.

- A. Pozzer, P. Zimmermann, U.M. Doering, J. van Aardenne, H. Tost, F. Dentener, G. Janssens- Maenhout, and J. Lelieveld, Effects of business-as-usual anthropogenic emissions on air quality, Atmos. Chem. Phys. Discuss., 12, 8617-8676, 2012, doi:10.5194/acpd-12-8617-2012

[9]Russ, P., Wiesenthal, T., van Regenmorter, D., Ciscar, J. C., 2007. Global Climate Policy Scenarios for 2030 and beyond. Analysis of Greenhouse Gas Emission Reduction Pathway Scenarios with the POLES and GEM-E3 models, JRC Reference report EUR 23032 EN. http://ipts.jrc.ec.europa.eu/publications/pub.cfm?id=1510

the values shown here. As for the number of vehicles and consumed fuel, they are tailored to specific locations. COPERT usage has made it possible to regulate database and create the precondition to calculate emissions from transport sector and fully exploit the software. There will be necessary to build certain category collecting data, undoubtedly. These results may be used only to see emission trends to determine which are most likely to grow and which will be reduced as a result of measures.

- The following pollutants have been additionally assessed through the COPERT:
- Heavy metals: Lead (Pb), Cadmium, Copper, Chromium, Nickel, Selenium, Zinc;
- Volatile: Volatile Organic Compounds (VOC), Non-methane Volatile Organic Compounds (NMVOC); Non-volatile: Carbon Monoxide (CO), Nitrogen Oxides (NOX, NO, NO2, NH3), PM, OM, EC, FC;

Direct greenhouse gas emissions have also been assessed (C02, N2O andCH4) of all vehicles registered in Kutaisi (according to Table 4) and compared with the results of inventory.

4.3 Base Year Inventory and Greenhouse Gas Emissions Baseline Scenario (2013 - 2020)

Kutaisi transport sector and base year inventory is based on 2012 data and includes the following kind of transportation:

- Municipal service vehicles;
- Public transport (buses, mini-buses and taxis);
- Private and commercial transport.

According to the Sustainable Energy Plan Development Methodology, fuel consumption is not considered by navigation, air traffic and railway, since travel with above-mentioned facilities expands outside the territorial limits of the city.

Fuel consumption of Kutaisi transport sector reached about 609 thousand MWh in 2012.

Table 10. Final Energy Consumption of Kutaisi Transport Sector (MWh) - 2012

Subsector	Natural Gas	Diesel	Gasoline	Total
Municipal Vehicle Fleet	0	240.2	273.63	513.83
Public Transport	24 583.32	94 108.97	4 417.85	123 110.14
Private and Commercial Vehicles	53 312.75	156 065.24	276 015.78	485 393.77
Sum	**77 896.07**	**250 414.41**	**280 707.26**	**609 017.73**

Emission of greenhouse gases from the transport sector reached about 152.3 thousand ton CO_2 equivalent in 2012.

Table 11. Greenhouse Gas Emissions from Kutaisi Transport Sector in CO_2Equivalent - 2012

Subsector	Natural Gas	Diesel	Gasoline	Total
Municipal Vehicle Fleet	0	63.65	68.17	131.83
Public Transport	5 035.29	24 938.88	1 100.69	31 074.86
Private and Commercial Vehicles	10 919.81	41 357.29	68 768.47	121 045.56
Sum	**15 955.09**	**66 359.82**	**69 937.33**	**152 252.25**

Emissions of other local pollutants of 2010-2012 is given below, in Table 12:

Table 12. Total Pollutants and Percentage Difference in 2010 - 2012

№	Title	Year			Difference between 2010 - 2012
		2010	2011	2012	
1	PB	0.02	0.02	0.02	**10%**
2	Cadmium	0.0005	0.0005	0.0008	**57%**
3	Copper	0.24	0.25	0.26	**9%**
4	Chromium	0.01	0.01	0.01	**9%**
5	Nickel	0	0	0	**8%**
6	Selenium	0	0	0	**7%**
7	Zinc	0.1	0.1	0.1	**8%**
8	VOC	1 213.71	1 237.68	1 251.48	**3%**
9	NMVOC	1 165.20	1 187.24	1 198.76	**3%**
10	CO	10 308.85	10 479.46	10 573.79	**3%**
11	CH4	48.53	50.4	51.41	**6%**
12	NOX	1 104.02	1 179.32	1 205.49	**9%**
13	NO	1 027.21	1 105.61	1 119.65	**9%**
14	NO2	75.97	83.47	86.45	**14%**
15	N2O	3.4	3.56	3.62	**6%**
16	NH3	1.77	1.79	1.88	**6%**
17	PM	46.28	50.37	51.74	**12%**
18	OM	14.92	16.24	16.58	**11%**
19	EC	21.63	23.71	24.26	**12%**
20	FC	45 995.98	48 834.00	49 812.38	**8%**
21	CO2	143 379.38	152 183.00	155 189.00	**8%**

Growth ratios of different fuel consumption in transport sector according to the MARKAL-Georgia National Model are given below**:**

Table 13. Fuel Consumption Growth Ratios of Different Transport Types according to the BAU Scenario

Fuel| Year	2012	2013	2014	2015	2016	2017	2018	2019	2020
Passenger Cars									
Gasoline	1	1.06	1.11	1.17	1.25	1.32	1.4	1.47	1.53
Diesel	1	0.93	0.87	0.8	0.73	0.67	0.6	0.53	0.47
Gas	1	1.37	1.73	2.1	2.58	3.06	3.54	4.07	4.61
Municipal Transport (buses, mini-buses)									
Gasoline	1	0.92	0.83	0.75	0.67	0.58	0.5	0.42	0.33
Diesel	1	1.09	1.17	1.26	1.35	1.43	1.52	1.61	1.69
Gas	1	1.15	1.31	1.46	1.61	1.77	1.92	2.07	2.23
Big Trucks									
Gasoline	1	0.92	0.83	0.75	0.67	0.58	0.5	0.42	0.33
Diesel	1	1.16	1.33	1.49	1.69	1.9	2.1	2.28	2.46
Gas	1	0.92	0.83	0.75	0.67	0.58	0.5	0.42	0.33
Small Trucks									
Gasoline	1	0.92	0.83	0.75	0.67	0.58	0.5	0.42	0.33
Diesel	1	1.05	1.09	1.14	1.2	1.27	1.33	1.39	1.44
Gas	1	0.92	0.83	0.75	0.67	0.58	0.5	0.42	0.33

In the absence of local projections of gross domestic product and population growth, national projections without modifications have been used for Kutaisi. According to the baseline scenario, fuel consumption will increase by 80%, reaching about 1095 thousand MW/h for 2020.

Table 14. Final Energy Consumption in Kutaisi Transport Sector (MW/h) - 2020

Subsector	Natural Gas	Diesel	Gasoline	Total
Municipal Vehicle Fleet	0	368.01	368.62	736.63
Public Transport	113 242.94	152 196.32	6 768.63	272 207.89
Private and Commercial Vehicles	245 579.64	165 908.47	411 001.65	822 489.76
Sum	**358**	**318**	**418**	**1 095**

	822.58	**472.80**	**138.90**	**434.28**

Greenhouse gas emissions from the transport sector reached about 262 thousand tons of CO_2 equivalent by 2020 according to the same scenario.

Table 15. Greenhouse Gas Emissions of CO_2 equivalent from Kutaisi Transport Sector – 2020

Subsector	Natural Gas	Diesel	Gasoline	Sum
Municipal Vehicle Fleet	0	97.52	91.84	189.36
Public Transport	23 195.03	40 332.03	1 686.38	65 213.44
Private and Commercial Vehicles	50 300.95	43 965.74	102 399.77	196 666.47
Sum	**73 495.98**	**84 395.29**	**104 178.00**	**262 069.27**

Growth of emissions in different subsectors of transport sectors are given below:

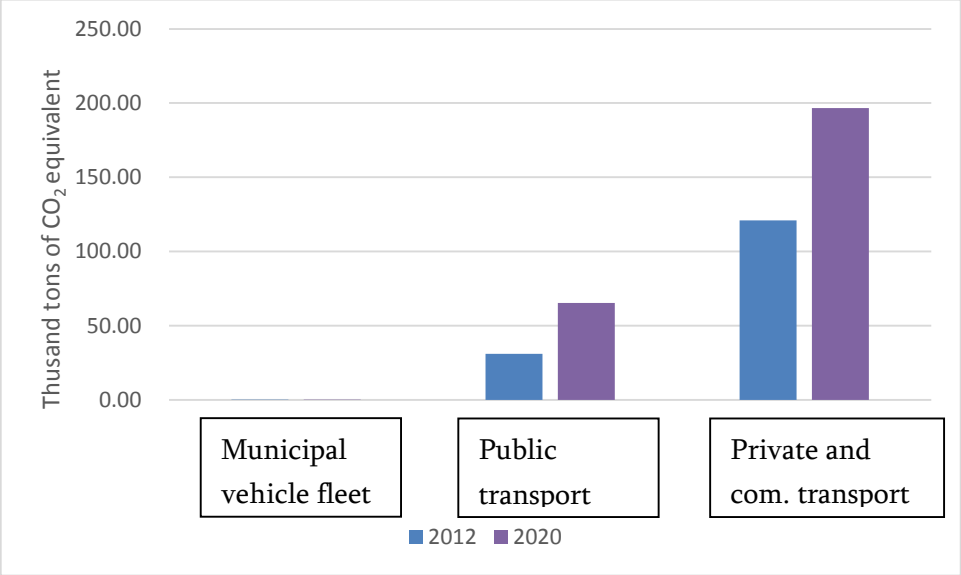

Fig. 12. Trends of Emissions from the Transport Sector according to the BAU Scenario

The following table shows values of local pollutants from vehicles, registered in Kutaisi

Table 16. Total Amount of Pollutants in Tons and Percentage Difference between 2010 – 2020

#	Title	Year								Difference between 2010 - 2020
		2013	2014	2015	2016	2017	2018	2019	2020	

1	Pb	0.02	0.03	0.03	0.03	0.03	0.03	0.04	0.04	**59%**
2	Cd	0.0006	0.0006	0.0006	0.0007	0.0007	0.0007	0.0008	0.0008	**45%**
3	Cu	0.27	0.3	0.31	0.33	0.36	0.38	0.4	0.42	**53%**
4	Cr	0.01	0.01	0.01	0.01	0.01	0.02	0.02	0.02	**55%**
5	Ni	0.005	0.005	0.005	0.005	0.006	0.006	0.006	0.007	**46%**
6	Se	0.0006	0.0007	0.0007	0.0007	0.0008	0.0008	0.0009	0.0009	**41%**
7	Zn	0.11	0.12	0.12	0.13	0.14	0.15	0.16	0.17	**51%**
8	VOC	1 253.47	1 385.31	1 452.80	1 544.29	1 636.33	1 726.93	1 807.82	1 888.03	**51%**
9	NMVOC	1 199.28	1 326.11	1 389.52	1 475.98	1 562.77	1 648.55	1 724.52	1 799.94	**50%**
10	CO	10 565.84	11 708.64	12 279.93	13 058.53	13 841.24	14 613.50	15 299.61	15 981.22	**51%**
11	CH4	53.39	59.32	63.17	68.18	73.44	78.23	83.15	87.89	**65%**
12	NOX	1 244.30	1 343.94	1 422.73	1 509.25	1 595.99	1 680.74	1 759.91	1 836.38	**48%**
13	NO	1 153.58	1 250.96	1 320.23	1 400.87	1 481.74	1 560.69	1 634.34	1 705.58	**48%**
14	NO2	90.85	98.15	102.66	108.62	114.49	120.33	125.88	131.12	**44%**
15	N2O	3.77	4.16	4.43	4.75	5.08	5.39	5.68	5.97	**58%**
16	NH3	2.59	2.99	3.37	3.84	4.38	4.81	5.32	5.84	**125%**
17	PM	54.33	53.94	56.37	58.22	60.06	61.81	63.49	65.01	**20%**
18	CO2	17.39	17.32	17.64	18.04	18.44	18.82	19.16	19.44	**12%**
19	Pb	25.58	25.5	26.01	26.61	27.2	27.79	28.33	28.79	**13%**
20	Cd	52 554.33	57 455.03	60 858.23	65 393.43	70 075.78	74 416.65	78 855.60	83 204.75	**58%**
21	Cu	163 382.28	178 285.77	188 226.93	201 824.56	215 828.22	228 869.31	242 090.79	255 029.14	**56%**

4.4 Emission Reduction Action Plan from Kutaisi Transport Sector

Transport plays a key role in society. It takes people to workplaces and schools, shops and medical facilities. It delivers agricultural products to markets, row materials to factories, office inventory to organizations and finished products to shops. It bonds families and friends to socialize and help each other. It allows politicians and businessmen to establish direct contacts, solve problems and grow business relations.

Transport consumes significant amount of energy to operate and, fossil fuel, mainly used for its production, nowadays is associated with greenhouse gas emissions into the atmosphere. The world's environmental, social and economic challenges require switching to public transport, electric or other, more sustainable private vehicles, going on foot, use of bicycles and better territorial planning. Starting positions of various countries, in terms of overcoming mentioned challenges, are different. In highly developed countries, overcoming the habit of dependence on cars is necessary. Developing countries are more trying

to improve city planning and use of public transport for making this sector more sustainable. Developing countries often face serious traffic congestions, air pollution and insufficient quality of public transport infrastructure and services. Abundance of vehicles is not as acute in developing countries nowadays as in developed ones, but fast speed of economic growth in many countries of the developing world and corresponding increase in private vehicles require appropriate measures to be taken. Traffic overcrowding, noise, security, air pollution and greenhouse gas emissions make such cities less attractive for investors, forcing them to transfer their capital to other cities.

Kutaisi, as well as other towns, is between these two realities in some way. There are 230 privately owned cars per 1000 people, which is approximately twice lower than figures of Western European cities, though increase in number of private vehicles has been observed lately. Kutaisi residents prefer to use large, inefficient vehicles like in other parts of Georgia, thus, traffic overcrowding and air pollution caused by lack of mandatory technical inspection and fuel quality, pass ahead greenhouse gas emission rates. Therefore, action plan on reduction of greenhouse gas emissions from the transport sector shall primarily include measures, improving traffic management, transport infrastructure and public transport services and only later followed by such measures as restriction for private vehicles and deployment of more effective technologies.

SEAP of Kutaisi is developed in 2014 and covers remaining 6 years until 2020. Therefore, emission reduction strategy for both major sub-sectors (public transport and private transport) of transport sector considers two periods only: short–term period (2014 – 2017) and long-term period (2018 – 2020). Short-term measures are specific and detailed, while long-term ones are considered in terms of strategy and require additional research-planning and economic-technical justification. This approach is fully consistent with the guiding methodology of Sustainable Energy Plan development.

The following actions are being considered for the public transport within short-term strategy:

- Public transport service improvement, that includes:
  - Scheming of optimal regular local passenger transportation routes of the city;
  - Implementation of modern payment system for the city transportation;
  - Creation of automated system for public transport management in Kutaisi;
  - Implementation of electronic information boards on public transport stops and their operating software;
  - Promotion of public transport services and conduction of behavior change programs;
  - Development of detailed public transport strategy and implementation of mentioned plans, aiming at improving and popularization of public transport services.
- In addition, transport fleet upgrade and foundation of municipal transport enterprise, planned within the short-term strategy, which primarily will include 70-80 new Bogdan buses with 20-30 passenger seats and GPRS system.

The following actions are being considered for the public transport within long-term strategy:

Fast public transport service, which includes:

- Building a tram system on 5.5 km one-way road from Nikea street up to bypass road (highway) in Kutaisi;

- Creation of express bus routes (Bus Rapid Transit -BRT) for central routes, ensuring quick and safe movement of buses;
- Converting some municipal transport fleet to biodiesel, which will be made by used cooking oil from restaurants and hotels.

In order to influence private transport sector, both implementation of land and urban planning measures and scheduling of high-emission restricting and low-emission encouraging activities are required, which should be carried out with joint efforts of state agencies. Among the priority projects, planned for the period of 2014-2017, construction-rehabilitation of road infrastructure and development of transport infrastructure are especially important. Long-term strategy, in turn, combines measures, aiming at decrease of interest in private cars among city population and promotion of low-emission public transport use. Considering the fact, that greenhouse gas emissions from private vehicles, per passenger are significantly higher than from the public transport, reduction of private car usage and their replacement with public transport is especially important. Such an approach would enable the city to attract more tourists and more residents as well, as overcrowded streets has become chronical problem for health and economy. Transition from private cars to public transportation significantly reduces overall level of traffic. Therefore, action plan of Kutaisi includes measures that may not reduce private car use, but its growth will slow down, enabling the transport sector to achieve commited goals. Measures to limit use of private vehicles will be effective only in case if other types of transportation, in particular the pubic one is well developed, comfortable and available for the population. Mentioned measures are just part of wider transport strategy and needs farther elaboration.

Therefore, the following actions are being considered for the private transportation within short-term strategy:

- Road infrastructure rehabilitation and maintenance, including the following activities:
- Maintenance of existing rehabilitated central roads of the city and rehabilitation of new/secondary, inter-block roads; streets and holes fixing activities;
- Installation of new traffic lights in terms of traffic management and safety;
- Construction of Kutaisi bypass highway and the whole city road system adjustment to this highway.

Long-term strategy for the private transportation includes the following measures:

- Development of walking and cycle routes parallel to people's behavior change programs;
- Conducting parking policy setting parking prices and restricting parking in central districts of the city;
- Working out technical inspection and fuel quality standards.

Feasibility study, determination the effectiveness of such measures, shall be prepared before their implementation.

Implementation of the Sustainable Energy Action Plan measures of Kutaisi, will reduce CO_2 emissions from the transport sector by 43 548 tons of CO_2 equivalent by 2020.

Transport Sector Action Plan of Kutaisi

Sectors and Activity Fields	Main Activities per Sector	Department/Person or Company in Charge/ if the third party is involved	Start/End Date	Cost	Expected Energy Savings (MW/h) from an Activity	Expected CO2 Emission Reduction from an Activity (T)
Transportation total					**88 892**	**43 548**
Public Transport	T1 Activity: Improving Public Transport Services T1.1. Optimal Transportation Scheming of Regular Local Passenger Transportation Routes of the City T1.2 Implementation of Modern Payment System in the City Transport T1.3. Development of Urban Transport Management Automated System in Kutaisi T1.4. Implementation of Electronic Information Devices and Operation Software at Urban Transport Stops T1.5. Public Transport Promotion and Behavior Change Programs	Kutaisi City Hall Transportation Service	2014-2017	5 000 000 USD	34 054	7 968
	T2 Activity : Municipal Transport Upgrade	Kutaisi City Hall Transportation Service	2014-2017	Estimation needed	82	22
	T3 Activity : Municipal Transport Conversion to Biodiesel	Kutaisi City Hall Transportation Service	2018-2020	70 000 GEL		29

	T4 Activity: Fast Public Transport Service Activities T4.1: Tram System Development T4.2: Bus Rapid Transit System Development	Kutaisi City Hall Transportation Service	2018-2020	Estimation needed	43 801	10 249
Private and Commercial Transport	T5 Activity: Construction-Rehabilitation of the Road Infrastructure and Transport Infrastructure Development	Kutaisi City Hall Infrastructure Service, Ministry of Regional Development and Infrastructure	2014-2017	Estimation needed	10 954	2 621
	T6 Activity. Development of Walking, Cycle Routes	Kutaisi City Hall	2018-2020	Estimation needed	8 539	2 721
	T7 Activity. Parking Policy Development	Kutaisi City Hall Transportation Service	2018-2020	Estimation needed	6 811	1 594
	T8 .Technical Inspection and Fuel Quality Standards Elaboration	Government of Georgia, Kutaisi City Hall	2018-2020	Estimation needed	76 680	18 345

Description of Activities

T1 Activity - Public Transport Service Improvement and Popularization includes the following activities:

T1.1. Optimal Transportation Scheming of Local Regular Passenger Transportation Routes

Due to lack of passengers, formation of direct transport links in Kutaisi between "Avtokarkhana Settlement - Sulkhan-Saba Settlement" ,"Avtokarkhana Settlement - Tabukashvili Street", "Sulkhan-Saba Settlement – Nikea Settlement", "Sulkhan-Saba Settlement – Tabukashvili Street", "Nikea Settlement – Tabukashvili Street" etc. via existing routes of local regular passenger transportation has not been feasible, therefore, only taxis and private vehicles have become means of transportation for these directions. Increase in industrial and commercial activities at mentioned settlements is a reason to assume that they will become important industrial and commercial centers of the city, thus - demanded destinations. Respectively, review and modification of existing transport routes and addition of new ones should be seriously considered.

In addition, traffic relief of Kutaisi Center and direct links between city districts will result in reduction of transfers, travel convenience and safety, reduction of travel time and financial expenses, improvement of traffic flow in the city center and increased environmental safety.

T1.2. Implementation of Modern Payment System in the City Transport

Transportation fee in Kutaisi currently is paid to drivers by cash. Such form of payment is not convenient and contains significant deficiencies, namely: difficulties in exact count of passengers and income, increasing time of parking duration of buses, causing violation of schedule and large number of passengers at stops, traffic delays and safety deterioration. Due to cash payments, drivers cannot adequately control passengers' safe boarding and getting off the bus. Thus, implementation of modern electronic ticketing system is necessary in urban transport to solve these problems.

Implementation of electronic fare payment system will enable to develop automated system of transportation and revenue control. Operating logic of this system is following: electronic fare payment system transfers information to fleet management device, installed in each vehicle and having positioning and trecking capability via GPS, as well as information transfer capability via GSM connection to the main server of Kutaisi City Hall Transport Office.

After processing received information via special software, development of passenger flow parameters' database will become possible, which is necessary for the optimal planning of routes. In addition, drivers, after deployment of electronic payment system, will be concentrated only on safe driving and boarding/getting off passengers at stops.

Hence, determination of optimal values of bus transportation schedule, reduction of transportation time, bus schedule observance, precise control of number of passengers and revenue, increasing transport security and service quality level are expected.

T1.3. Development of Urban Transport Management Automated System in Kutaisi

Regular control of public transport at present is performed by route dispatchers and transport service team at main passenger gathering points. Proper trecking on whole routes is impossible due to limited resources. Absence of control causes violation of traffic schedule, increased duration of standing at the bus stops and other disorders. Therefore, development of public transport's GPS – aided automated dispatch software for distanced monitoring of vehicles is necessary.

Via GPS/GSM onboard devices and remote monitoring system trecking of city buses will become possible. This process will cover: observation of current location of buses; adherence to bus motion schedule; detecting bus service interruptions and taking measures to eliminate them; accumulation and systematization of database information, enabling to discover violations, implement administrative actions and organizational – controlling measures.

Consequently, unauthorized stops and willful violations are supposed to be eliminated while adherence to traffic schedule, passengers' safe boarding/getting off the buses, prompt elimination of delays and improving level of transportation services are expected.

T1.4. Implementation of Electronic Information Devices and their Operating Software at Public Transport Stops

Public transport stop amenities – modern design and construction, equipped with electronic information displays is an important issue. Some steps in this direction have already been taken, in particular, bus stop setting project has been selected by transport service in accordance with international standards. Kutaisi City Council approved the project in 2009 by the Resolution № 216 as of June 25. Now, due to ongoing changes in street names and addresses, the projects' modernization activities are being carried out. Moreover, modern bus stops were placed on main streets of the city. It is necessary to continue works and equip them with electronic information displays as there is no other unified e-system, providing information about routes and schedule of buses.

Installation of electronic information displays on public transport stops in Kutaisi and their operation software would provide passengers with electronic information in two languages (Georgian and English) about bus routes, frequency, stops and intervals. Inclusion electronic displays into the public transport's unified on-line monitoring GPS/GSM system (remote control system) would allow automated transmission of information about specific routes to the electronic devices.

In addition to described measures, simplification of boarding/getting off process for physically disabled persons in public transport (installation of special equipment - ramps, elevators) is required.

Due to improved service, public transport will be more actively used by the city residents and visitors.

T1.5. Public Transport Promotion and Behavior Change Programs

Usage of public transport is sometimes interpreted as an indicator of low social status, as if such persons cannot afford their own cars. This view is rapidly changing is developed world and therefore it is important in Georgia to raise people's awareness about benefits of using mass transportation as well: residents should be sure that public transport is reliable, fast, comfortable, safe, inexpensive and available mean of transmission. Citizens should be given accurate information about all benefits of public transportation, compared to the other means of transport. Besides, marketing and branding activities is

important to be implemented to make its services more reliable and attractive. For that reason, working with various target groups, public transport branding etc. are required. Marketing strategy should become systematic tool, allowing traffic managers to identify market requirements and level of service quality, that is acceptable to customers. There should be actively used such marketing and customer experience components as sales promotion, advertising, networking, branding, product specification, claim management and customer service. All the above-mentioned will contribute to sustainable development of public transportation. Special website will be developed for residents and tourists to allow passengers to get detailed information about transports operation (lines, routes, schedules and prices). Information brochures will be prepared and distributed for local residents and especially tourists as a guide and a map of the public transport service. They will be delivered to airports, hotels railway, travel agencies, cafes and restaurants, souvenir shops etc.

Consequently, rates of public transport use will relatively improve and city residents, as well as guest will take advantage of this service more frequently.

Such activities, as improvement of public transport services and public awareness campaign do not have direct influence on energy consumption and CO_2 emissions, but they are real tools for supporting, accelerating and increasing effectiveness of other activities. Awareness growth and behavior change programs alone have reduced private car use rates by 10% in developed countries; and their return for one spent USD is 30[10] USD. Since in Georgia, as in developing country, share of public transport is relatively high, there has been assumed that after taking adequate measures to all five directions, rate of private cars use will be reduced by 10% before 2020. Transition from private cars to public transport will reduce emissions by half[11]. According to the baseline scenario, private vehicle (only passenger) emissions in Kutaisi will reach 159361 tons by 2020. If 10% of the abovementioned start to use public transport, emissions of this 10% will reduce by half i.e. total emissions will be reduced by 5%, which, in turn equals to 7968-ton reduction in CO_2equivalent compared to the BAU. Total price of described activities is 5 000 000 USD.

Activity T2: Municipal Transport Upgrade

Initially the measure includes setting up of municipal transport enterprise equipped with 70-80 new 20-30 passenger Bogdan type buses, that will replace old buses and have about 10% improved efficiency.

Activity T3: Municipal Transport Conversion to Biodiesel

The measure means conversion of part of municipal transport fleet to biodiesel. Biodiesel is made by used oil from Kutaisi restaurants and hotels collected and handed in by them. In return, their ads will be put on buses.

Ilia State University and Non-Governmental Organization "Altera" have launched a pilot project within the framework of which biodiesel-making machine for fuel from waste cooking oil is being tested and

[10] I Ker, Preliminary Evaluation of the Financial Impacts and Outcomes of the TravelSmart Individualised Marketing Program, ARRB for Department for Planning and Infrastructure, Perth, Western Australia, 2002.

[11] Technologies for Climate Change Mitigation – Tranport Sector, UNEP Risoe Center, 2011. http://tech-action.org/

a project proposal is prepared. According to the proposal, ½-ton capacity biodiesel equipment can provide 15-20 buses with biodiesel that will save about 29 thousand tons per year costing nearly 70 thousand GEL.

In order to carry out the measure properly, assessment of accumulative oil storage and implementation of their storage/collection systems are required as well, which need additional expenses.

Activity T3: Fast Public Transport Service, considered within the long-term strategy, includes:

Activity T3.1: Tram System Development

Advantages of modern tram compared to other means of transportation:

- Safety (approved by the examples of many developed countries);
- Minimum amount of pollution and CO_2 emissions;
- Comfortable for elderly and disabled passengers;
- Large capacity – 3000-15 000 passengers per hour to one direction;
- An average speed 25 – 30 km/h;
- Small energy consumption;
- Attractive for tourists.

Sustainable Energy Action Plan involves 5.5 km tramline from the beginning of Nikea Street up to bypass road (highway), which will replace buses and microbuses. Marketing research conducted in Europe and 50-year North-American Experience has revealed that even private car owners prefer to replace vehicles by tramcars rather than by buses. According to statistics, 30-40% of tram passengers had their own cars[12] before.

Activity T3.2: Bus Rapid Transit – BRT Development

Bus Rapid Transit has become widely used in many countries for faster transportation of passengers in medium distances. It is possible to transport 10-20 thousand passengers an hour by one BRT line. In some cases this number could increase up to 40 thousand causing traffic jams. BRT lines have been successfully implemented in many cities including Bogota, Mexico City, Jakarta, Beijing, Istanbul, Paris, Los Angeles, Boston etc. Bus Rapid Transit systems will have an advantage if the country/city government provides them separate lines that will be isolated from other vehicles and will be equipped with necessary infrastructure (stops, shelters, information posters/displays). Public Transport should be significantly cheaper in comparison with private vehicles encouraging citizens to use public transportation and all related advantages.

Initially, feasibility study and pilot projects should be implemented to determine effect on overall passenger turnover. According to the Mitigation Measures Manual for transport sector [13] trams use about 4,6 times less energy per passenger-kilometer than private cars, while buses consume 2.4 times less. Based

[12]Sustainable Light Rail – professor Lewis Lesley. Claverton Energy Group Conference, Bath October 2008, claverton-energy.com

[13] Technologies for Climate Change Mitigation – Tranport Sector, UNEP Risoe Center, 2011. http://tech-action.org/

on the conservative assumption if at least 3% of private car turnover switch over to trams and 7% to rapid buses it could reduce 10249 ton of emissions.

Activity T4: Construction-rehabilitation of Road Infrastructure and Transport Infrastructure Development. This activity plays an important role among priority projects for the years 2014 – 2017. Road infrastructure construction-rehabilitation and maintenance include the following activities:

- Maintenance of current rehabilitated central roads and rehabilitation of new/secondary and internal roads. Hole repairs and street rehabilitation;
- Installation of new traffic lights to organize traffic and ensure safety;
- Bypass road construction and adjustment of city transport system of Kutaisi to this road.

Bypass road construction will be directly linked to reduction of transportation distances and therefore reduction in emissions. Besides, this measure would relieve the congested traffic and traffic jams in the city. In general, realization of greenhouse gas emission reduction opportunities associated with traffic management (as well as road infrastructure improvement) is complex and contradictory process. Reduced traffic overcrowding (by such measures as traffic lights management, green line etc.) would lower greenhouse gas emissions from individual cars, as they would run more efficiently. However, it may not lead to overall emission reduction as overcrowding lessening makes private vehicles more attractive to use causing an increase in emissions. One of the measures is to ensure moving with uniform velocity that may be more effective than the regular "stop-start" mode of cars. Nevertheless, if this uniform motion leads to increase in number of vehicles, greenhouse gas emissions growth will be inevitable. Therefore, if reduced traffic is accompanied by private car use limitations, reduction of greenhouse gas emissions will actually be achieved. So, these measures and associated emission reduction could be considered only as a part of wider transport strategy along with other measures described herein. Therefore, after carrying out all abovementioned measures annual energy consumption by transport can be reduced only by 1% for 2020 leading to 2621 tons CO_2 equivalent reduction in emissions.

Activity T5: Development of Walking and Cycle Routes

Bycicle is one of the most popular transports in the world. 130 million bikes were produced worldwide in 2007, while only 69 million cars were manufactured during this period. Due to energy crisis and air pollution problems in the 1970s, many European countries decide to promote more sustainable transportation forms – public transport, walking and cycling.

Barriers to wider use of cycling can be overcome via following measures:

- ❖ Ensuring safe walking roads for bikes;
- ❖ Consideration of this issue among other urban planning activities;
- ❖ Increase availability of bicycles;
- ❖ Providing technical services and spare parts;
- ❖ Increase level of bicycle protection;
- ❖ Increase level of public awareness and cycling status.

One of the examples of bicycle use promotion is bicycle race held in Kutaisi in Aghmashenebeli ave. on the occasion of energy efficiency day from 21 to 27 June. Government representatives themselves were

among attendants and participants along with youth volunteer groups, local residents, students and the media.

Walking area development also has great importance along with bicycle use. This represents a combination of practices and technologies, enabling the city to turn into future-oriented society with the following features: better functionality, safety, sustainable development, socializing among people, more healthy and attractive environment. Walking areas have well-planned, well-connected pedestrian road network, making it easier for residents to reach destinations safely, comfortably and on time. This measure also includes so-called "environmental islands" in which transportation via private cars is prohibited. Appropriate feasibility study should be prepared before implementation of these measures determining cycling and walking routes and location of so-called "environmental islands".

According to the Mitigation Measures Manual for Transport Sector[14], a 2-kilometer long distance walk or cycling can reduce emissions by 417 grams. Germany reached the following through carrying out adequate measures: only 15% of 1-3 km distance is covered by cars, 55% - on foot, 30% by bikes while the number of private vehicles is high in Germany and the country is quite rich. According to the conservative assumption, at least 30% of 1-3 km distance will be covered on foot or by bike by 2020; mentioned movement is about 5% of total amount of transportation. Based on the baseline scenario, private passenger cars and public transport will cover nearly 870 million km for 2020 that allows to save about 13 million km travelled by private cars and public transport, which is decrease of 2 720 tons CO_2 equivalent compared to the BAU.

Activity T6: Parking Policy Development

Parking policy has a great importance in terms of reducing emissions. Paid parking increases car maintenance expenses and parking limits make car use less attractive. Many cities use parking policies to reduce congestions in central areas and improve traffic safety at the same time. Parking measures planning requires development of relevant legislation; establish municipal parking companies collecting parking fees and using them to finance public transport, purchase/installation of parking meters and urban planning review to mark areas for parking.

It is quite difficult to estimate parking policy efficiency separately, without other measures, however, according to the Mitigation Measures Manual for Transport Sector[9], 10% increase in the cost of cars leads to car ownership decrease (3%). It has been conservatively assumed that parking policy will decrease car ownership by 1% only, saving about 1594 tons CO_2-equivelent emissions.

Activity T7: Technical Inspection and Fuel Quality Standards Elaboration

It is expected that technical inspection of vehicles will become mandatory in Georgia since 2015 but details about inspection type has not been fully determined. Kutaisi City Hall will collaborate with national structures to develop vehicle and fuel standards in line with European ones. Eventually, as fuel consumption so greenhouse gas emissions and local pollutants will be reduced, helping to improve living conditions and health status. Technical inspection will promote better maintenance and adequate technical equipping of cars. According to the Mitigation Measures Manual for Transport Sector[9] well maintained car's fuel consumption can be reduced by up to 3-7% leading to reduction of emissions as well. Since most of vehicles

[14]Technologies for Climate Cahnge Mitigation – Tranport Sector, UNEP Risoe Center, 2011. http://tech-action.org/

in Georgia are outdated and less effective, emissions of private cars will reduce at maximum 7% leading to 18 345 tons of CO_2 equivalent emissions reduction.

5 Buildings

5.1 Sector overview

Development plan of Kutaisi is focused on attracting foreign investments, developing industrial, commercial and tourism sectors, ensuring dynamic economic growth of the city, creating new jobs, increasing incomes of the population, gradualy overcoming poverty and promoting social background improvement activities.

Pic. 2. Kutaisi central square

In such dynamic environment, Building sector of Kutaisi is one of important sectors in terms of emission reduction and sustaianble energy development, that includes municipal and other commercial buildings (offices, shops, hotels etc). One of the significant prerequisits for reducing greenhouse gas emissions is to lessen energy consumption in the buildings. Therefore, measures aiming to increase energy efficiency and renewable energy use need special planning.

According to housing and communal service of Kutaisi City Hall there are 19 214 buildings in Kutaisi now with total area of 3 375 672 m^2. Detailed breakdown of building types is shown below (Table 17).

Table 17. Municipal and Residential Buildings Stock in Kutaisi

Building Type	Quantity	Total Area m2
Residential Buildings		
1-2 Block	271	320 322

3 – 5	337	797 287
6 – 9	300	1 308 152
10 – 16	22	60 455
1 – 2 Private	18 284	889 456
Municipal Buildings		
Kindergartens	35	47 707
Non municipal, Commercial and Governmental Buildings		
Public Schools	38	187 555
Medical Centers	28	81 626

Residential buildings are generally 1-2-storey houses, in relatively good condition, as their absolute majority is private property. Multi-storey housing are also privately owned but the vast majority of buildings needs capital repair. Roofs, entrances, stairs, elevators, utility facilities etc. are in extremely poor condition. 19 condemned high-rise buildings in the city and 14 apartment houses situated on the right bank of the River Rioni need urgent rehabilitation.

Kutaisi City Hall is implementing measures aiming at improving conditions of buildings. Some of the measures (roof repairs, entrances rehabilitation, roofing works) have energy efficiency characteristics. Following list describes measures, carried out before 2014 and projects planned for 2014 with respective budgets:

- Condominium communities were provided with 442 448 m^2 various types of roofing materials within the framework of programme "Korpusi", additional 87376 m^2 roofing (waterproofing material 51 948 m^2, galvanized corrugated roof – 35 428 m^2, galvanized corrugated sheets – 1 191 m^2) with total amount of 700 000 GEL will be given in 2014.
- 477 elevators out of 943 ones have been refurbished (3 absolutely new elevators have been installed in newly constructed houses), technical condition of 310 ones have been maintained by residents themselves, 156 elevators still need repairs. Rehabilitation of 44 elevators is planned through co-financing and 467 656 GEL is allocated for this purpose.
- Total amount of entrances in residential blocks is 2 358; 79 of them have been rehabilitated within the "Korpusi" programme. Renovation of 76 entrances is planned through condominium co-financing in 2014 costing 440 000 GEL.
- Water and sewer rehabilitation works have been conducted for 106 buildings out of 930 condominiums though co-financing. Water and sewerage pipe rehabilitation is scheduled for 19 apartment houses in 2014 with total budget of 84 525 GEL.

- Damaged connections of panels in 10 panel-type residential buildings have been filled by insulation materials. Upper parts (parapets) of 98 buildings have been fundamentally repaired.
- 772 waste collectors and containers have been demounted in 328 apartment blocks with disinfection and deratization measures and 532 mobile waste containers, made of 1.10 m^2 galvanized steel sheets, have been allocated instead.
- Implementation of a pilot program with total budget of 150 000 GEL aiming at covering of residential houses with condemned roofs through full funding of local government is planned for 2014. This program is for "poor families" whose socio-economic situation is estimated as less than 57 000 rating scores. Project and cost estimation documents will be prepared for 41 private residential houses based on applications of citizens' and municipal territorial bodies.

Despite implemented and planned measures, residential and municipal buildings sector of Kutaisi is one of serious sources of energy consumption, loss and therefore savings. The majority of such buildings were built in Soviet period according to poor standards, considering quick and cheap construction. Most of such buildings do not meet energy saving requirements: open entrances, thin walls, and damaged frame, single glazed wooden windows, low values of buildings thermal resistance coefficient and exterior thermal characteristics; this is an incomplete list of gaps, that lead to high energy losses and therefore high saving potential.

5.1.1 Total Energy Consumption in Kutaisi

Electricity

According to the Kutaisi City Hall the city consumed 280 235 997 kWh of electricity in 2012, including:

- Household sector - 99 439 581 kWh/y;
- Non-residential sector - 180 796 416 kWh/y.

254 272 808.18 kW/h of electricity was consumed in the city in 2013, including:

- Household sector - 98 064 267.63 kWh/y;
- Non-residential sector - 156 208 540.55 kWh/y.

Natural Gas

38 902 599 m3 of Natural Gas was consumed in Kutaisi in 2012, including:

- Industry -11 748 105 m3 natural gas
- Population - 27 154 494 m3 natural gas

38 443 386 m3 of Natural Gas was consumed in Kutaisi in 2013, including:

- Industry -10 669 161 m3 natural gas
- Population - 27 774 225 m3 natural gas

Firewood

Firewood consumed during 2012 in Kutaisi - 3 305 m3;

Firewood consumed during 2013 in Kutaisi - 2 765 m3;

According to expert estimates, firewood consumption is private houses was 30 000–40 000 m3.

Annual consumption of various energy sources in municipal buildings:

Electricity

Total energy consumption of Municipal buildings for 2012 was 13 202 298 kWh.

Total energy consumption of Municipal buildings for 2013 was 14 086 581 kWh.

Natural Gas

Total amount of natural gas consumed by municipal buildings in 2012 was 561 137 m3;

Total amount of natural gas consumed by municipal buildings in 2013 was 477 526 m3;

Liquid Gas

Only Nursery Union N(N)LE of municipal buildings consumed liquid gas amounted to 460 kg. in 2012.

Municipal buildings consumed 554 kg liquid gas in 2013, including: N(N)LE Nursery Union N(N)LE - 494 kg liquid gas; Thanksgiving House of Kutaisi N(N)LE – 60 kg liquid gas.

Firewood

Total amount of consumed firewood by municipal buildings in 2012 was 385.5 m^3.

Total amount of consumed firewood by municipal buildings in 2013 was 770 m^3.

Energy resources consumed by different buildings under Kutaisi Municipality for the years of 2012 – 2013 are given below (Table 18).

Table 18. Annual Energy Consumption

#	Entity	Electricity kWh/y		Natural Gas m^3/y		Liquid Gas kg/y		Firewood m^3/y	
		2012	2013	2012	2013	2012	2013	2012	2013
1	N(N)LE Nursery Union	533 941	690 136	256 925	275 295	460	494	-	-
2	N(N)LE Sporting Institutions Union	235 666	228 981	38 813	41 596	-	-	-	-

3	Cultural, Art and Educational Institutions Union	112 404	109 833	20 498	23 588	-	-	3	
4	Ice Skating Rink	436 200	347 400	17 232	4 376	-	-	-	-
5	Scientific Library	74 914	74 622	-	-	-	-	-	-
6	The Folklore Center,State Danc e and Song Ensemble	17 680	14 871	1 983	7 303	-	-	-	-
7	Students' and Youth Park	21 073	15 000	-	-	-	-	-	-
8	Botanical Garden	-	2 263	-	-	-	-	-	-
9	Thanksgiving House	42 052	6 419	3 522	6 223	-	60	-	-
10	Lado Meskhishvili State Drama Theatre	25 091	19 667	-	30 845	-	-	-	-
11	Opera and Ballet Theatre	68 418	73 785	33 014	37 108	-	-	-	-
12	Puppet Theatre	24 611	19 324	-	-	-	-	-	-
13	Encyclopedia LTD	1 927	2 000	-	-	-	-	-	-
14	Kutaisi Disinfection Station	600	550	-	-	-	-	-	-
15	Georgian Traditions LTD	18 412	7 500	-	-	-	-	-	-
16	"Kutservicegroup" LTD	18 719	18 549	-	-	-	-	-	-
17	Kutaisi Elevator LTD	1 200	1 110	-	-	-	-	2.5	2
18	Uckimerioni LTD	182	90	-	-	-	-	-	-
19	Gumati Medical Ambulatory LTD	1 037	3 275	-	-	-	-	-	-

20	Kutaisi Mixed Polyclinic #4 LTD	49 166	45 040	-	-	-	-	-	-
21	Green Kutaisi LTD	4 600	2 787	-	-	-	-	-	-
22	City Hall Administration Building and City Territorial Bodies	11 514 405	12 346 376	189 150	51 192	-	-	380	768
	Sum	**13 202 298**	**14 086 581**	**561 137**	**477 526**	**460**	**554**	**385.5**	**770**

5.2 Methodology

Methodology for CO_2baseline (2012) emission inventory and future trends (up to 2020) in builing sector is the same as described in the transport sector. There are also given carbon dioxide emission factors and transfer coefficients; methane and nitrous oxide emission factors resulted from incomplete combustion of fuel have been taken from IPCC 1996 are shown below (Table 19).

Table 19. Methane and Nitrous Oxide Emission Factors for Buildings (kg/MW/h)

Greenhouse Gas	Natural Gas	Oil Products	Firewood
CH_4	0.018	0.036	1.08
N_2O	0.00036	0.002	0.014

As for the emission reduction potential after energy saving measures, it has been assessed through selecting buildings typical for Kutaisi, carrying out energy audit and evaluating energy efficiency measures and then extending these results to other buildings. Methodology in more details is described below.

Buildings, such as residential houses, schools, hospitals, kindergartens, hotels, educational institutions, shops, offices etc. have significant potential for energy conservation. Determination of actual potential of energy conservation requires optimal methods and means to conduct energy audit, which, in turn includes building studies, situation assessment and evaluation as well as other measures to be taken to reduce energy consumption and improve buildings' microclimate. Results are reflected in the energy audit report that shall describe recommended measures with appropriate investments, savings and profits. Energy audit has to be conducted by trained and experienced energy auditors.

It is impossible to assess energy-saving potential in a building just through simple accounting/fixing annually consumed energy quantities (e.g. 700 000 kWh/y). This figure does not show if the building is big or small. A clear picture on energy efficiency of buildings is given by specific energy consumption i.e. used energy per square meter, e.g. 130 /m^2 annual. However, there are also many other factors such as building type (Administrative, hospital, school etc.), climate conditions, building insulation levels, etc. influencing

over energy consumption rates and therefore specific energy consumption of buildings that should be compared with "standard" key numbers of the country.

Key numbers should reflect model values of specific energy consumption taking into account all mentioned factors. Comparison of measured and calculated values with key numbers enables to evaluate energy efficiency and energy-saving potential of buildings quickly. Specific energy consumption rates also indicate energy efficiency of the building, as, for example, fuel consumption per a mile defines energy efficiency of a car.

Significant reduction of energy expenses in buildings is possible by realizing various measures. Energy consumption requirements management, hole filling quality improvement, automatic regulation of administration, automatic hydraulic balancing of heating system, installation of thermostatic valves on radiators, additional insulation of constructions and other measures reduces emissions along with reducing energy consumption and significantly improves deteriorated ecological situation as locally so on a global scale.

In order to assess buildings' energy saving potential conduction of energy audit is required. Energy audit oversees all the factors influencing energy consumption:insulating constructions of buildings (walls, windows, roofs, floors), heating system, ventilation system, hot water supply system, automated management system, lighting, miscellaneous equipment and air-conditioning system.

Overall process of energy audit is divided into six important steps: project identification, scanning, energy audit, business plan, implementation (realization) and exploitation.

In order to develop a single document on energy consumption of buildings energy and power consumption budget standards have been carried out. It is based on eight articles: heating, ventilation, hot water supply, fans/pumps, lighting, miscellaneous equipment, cooling and outdoor equipment.

Budget division into 8 articles facilitates energy and power consumption modification analysis in a year (period). There have to be determined annual energy consumption (kWh/y) and specific annual energy consumption values (energy consumption for 1 m^2 space heating. kWh/m^2y).

Budget for residential and household buildings may be simplified to three articles: heating (including natural ventilation) hot water supply and household (lighting, control of farm equipment, etc.).

Energy audit of typical buildings of Kutaisi has been conducted via **"Key Numbers" of the ENSI software.** A Norwegian Consulting Company ENSI, founded in 1992, has developed a simple software "Key Number" for a quick calculation of energy characteristics, applicable as for projecting of new buildings and reconstruction activities so for assessing energy-saving measures of existing buildings.

Key figures reflect model values of specific energy consumption of buildings, taking into account all mentioned factors. Comparison of measured and calculated values of energy consumption with key numbers enables to assess energy efficiency and energy saving potential of buildings quickly.

ENSI software provides database for each energy budget article and reflects data obtained after carrying out energy-saving measures. For example, ENSI software format in energy budget article "Heating" looks as follows: the first column contains the most important "parameters", affecting energy consumption required for heating. The second column shows model values of each parameters based partly on

construction standards, rules and regulations and partly on experiences gained from various projects (Fig. 13. ENSI Software format for Energy Budget Article "Heating"

The third column "condition" includes real technical conditions of a building selected for energy audit and so called "measured energy consumption" required for heating (kWh/m^2 y).

Real exploitation conditions of buildings in Georgia nowadays substantially differs from project/normative conditions. Thus, measured energy consumption may be higher than calculated one (e.g. due to water leaks or improper operation of a heating system) or less (e.g. due to heating or ventilation system shutoff). Besides, along with energy-saving measures, an owner might need to improve microclimate in the building, install forcedair ventilation system and increase productivity of existing system. All the above mentioned will lead to an increase in energy consumption.

Due to the fact that in most cases "measured energy consumption" does not coincide with "estimated energy consumption", calculated values of energy consumption provided in the fourth column of ENSI software have to be used as a "basic line", to get accurate values of energy economy.

"ENCON measure" contains alternative energy saving solutions and energy-saving measures and "after ENCON" column (saving by each parameter/measure) lists the savings.

Parameter	Reference	Condition	Baseline	Sensitivity kWh/m²y	ENCON measure	After ENCON
1. Heating	**46,4** kWh/m²y					
U - wall	0,30 W/m²K	0,45	0,45	+ 0,1 W/m²K = 6,76	0,30	-9,51
U - window	2,40 W/m²K	3,00	3,00	+ 0,1 W/m²K = 1,56	1,30	-24,77
U - roof	0,20 W/m²K	0,20	0,20	+ 0,1 W/m²K = 1,71	0,20	
U - floor	0,30 W/m²K	0,30	0,30	+ 0,1 W/m²K = 1,71	0,30	
Form - factor	0,31 -	0,31	0,31		0,31	
Window area	15,1 %	15,1	15,1		15,1	
Total solar gain	0,55 -	0,55	0,55		0,55	
Infiltration	0,25 1/h	0,40	0,40	+ 0,1 1/ h = 11,23	0,25	-15,76
Indoor temperature	21,0 °C	21,0	21,0	+ 1 °C = 5,92	21,0	
Setback temperature	18,0 °C	18,0	18,0	+ 1 °C = 4,49	17,5	-2,11
Contribution from						
Ventilation	kWh/m²y	-2,01	-2,01		-1,41	
Lighting	kWh/m²y	21,32	21,32		19,98	
Various equipment	kWh/m²y	12,71	12,71		11,91	
Sum 1	**kWh/m²y**	**73,5**	**73,5**		**24,6**	
Distribution losses	2,0 %	2,0	2,0		2,0	
Automatic control	98,0 %	Modern	Modern	Poor +3 %, Manual +5 %	Modern	
Sum 2	**kWh/m²y**	**76,5**	**76,5**		**25,6**	
O & M / EM	98,0 %	95,0	95,0		98,0	-2,32
Sum 3	**kWh/m²y**	**80,6**	**80,6**		**26,1**	
Energy supply efficiency	100,0 %	100,0	100,0		100,0	
1. Heating corrected	**kWh/m²y**	**80,6**	**80,6**		**26,1**	

Fig. 13. ENSI Software format for Energy Budget Article "Heating"

A similar structure is used for other articles as well (ventilation, hot water supply, fans and pumps, lighting, other equipment, cooling and outdoor equipment). Obtained results are collected in "energy budget" table (Fig. 14).

Energy Budget | Power Budget | ENCON Measures | ET curve | Annual consumption

Project
test714

Reference building: Office
Reference condition: 1987
Climatic zone: Oslo
Heating season: 15.9 - 15.5

Budget item	Reference	Condition		Baseline before ENCON		After ENCON	
	kWh/m²	kWh/m²	kWh/y	kWh/m²	kWh/y	kWh/m²	kWh/y
1. Heating	46,4	80,6	191 755,4	80,6	191 755	26,1	62 149
2. Ventilation	33,5	44,2	105 148,1	44,2	105 148	42,0	99 901
3. DHW	9,9	19,8	47 012,5	19,8	47 013	10,4	24 784
4. Fans and pumps	20,2	23,0	54 676,0	23,0	54 676	17,3	41 071
5. Lighting	31,5	31,5	75 072,0	31,5	75 072	31,5	75 072
6. Various	24,0	24,0	57 066,4	24,0	57 066	24,0	57 066
7. Cooling	0,0	0,0	0,0	0,0	0	0,0	0
Total	165,5	223,0	530 730,6	223,0	530 731	151,3	360 043
8. Outdoor			0		0		0

Fig. 14. „Energy Budget“

Carbon Dioxide Emissions Assessment

As mentioned above, in order to assess emission reduction potential, energy audit of typical buildings has been conducted and obtained results have been expanded to other buildings. To determine appropriateness of such expansion, energy consumption has been compared through three scenarios.The first scenario is based on the annual energy data, second one – on data about buildings and the third scenario is based on population's data.

According to the first scenario, it becomes possible to estimate an annual energy consumption on the basis of annual statistical data of consumed natural gas, electricity and firewood (E1, kW*h/y).

The second scenario needs detailed energy audit of different type of pre-selected buildings (typical buildings) and estimation of specific energy expenditures (energy consumption per m^2, kW*h/m^2y) on heating, cooking and electrical equipment. Energy audit conducted via optimal methods and the software format would allow us to determine actual potential of energy-savings, which, in turn, involves situation assessment and analyses and other measures to be conducted to reduce energy consumption and therefore carbon dioxide emissions.

After clarification specific energy consumption, estimation of annually consumed energy on heating, hot water, cooking and electrical equipment becomes possible (E2, kW*h/y) for various types of buildings.

The third scenario is based on statistical data about the number of people living in the area. Determination of per capita energy consumption (kWh/y per capita) enables to calculate annual energy consumption of entire population (E3, kW*h/y).

Finally, inter-comparison of findings makes it possible to determine accuracy of calculation for each scenario under the condition that (E1 = E2 = E3).

5.3 Base Year (2012) Intervention and Greenhouse Gas Emissions Baseline Scenario (2013 – 2020)

The buildings' sector structure of Kutaisi includes three sub-sectors according to the sustainable energy development manual: municipal buildings, residential buildings and other (commercial buildings). The data are based on the energy consumed in the buildings in 2012.

Energy consumption of buildings' sector in 2012 is given below (Table 20).

Table 20. Final Energy Consumption in Buildings' Sector (MWh) - 2012

Subsector	Electricity	Natural Gas	Liquid Gas	Firewood	Total
Municipal Buildings	13 203.35	5 236.14	6.05	803.19	19 248.73
Other (Commercial) Buildings	6 370.51	202.41	0	0	6 572.92
Residential Buildings	99 447.54	253 386.78	0	83 340.00	436 174.32
Sum	**119 021.40**	**258 825.34**	**6.05**	**84 143.19**	**461 995.98**

Greenhouse gas emissions in CO_2 equivalent from buildings in 2012 amounted to 70.6 thousand tons.

Table 21. Greenhouse Gas Emissions in CO_2 (tons) Equivalent from Buildings Sector - 2012

Subsector	Electricity	Natural Gas	Liquid Gas	Firewood	Total
Municipal Buildings	1 795.66	1 054.68	1.38	21.8	2 873.51
Other (Commercial) Buildings	866.39	40.77	0	0	907.16
Residential Buildings	13 524.86	51 038.10	0	2 262.00	66 824.96
Sum	**16 186.91**	**52 133.55**	**1.38**	**2 283.80**	**70 605.64**

Driving parameters of building sector's energy demand and consumption are an increase in fuel consumption in various sectors projected by the MARKAL-GEORGIA national model, which, in turn is based on population growth, GDP growth and GDP per capita growth of the city. Methodology details are described in "Transport" chapter.

According to the baseline scenario, energy consumption by household and municipal buildings will increase by 84% exceeding 850.2 thousand MWh.

Table 22. Final Energy Consumption in Kutaisi Buildings (MWh) - 2020

Subsector	Electricity	Natural Gas	Liquid Gas	Firewood	Total
Municipal Buildings	15 347.77	9 121.38	0	387.4	24 856.54
Commercial Buildings	7 405.17	352.61	0	0	7 757.78
Residential Buildings	125 094.49	601 727.44	0	90 808.93	817 630.86
Sum	**147 847.43**	**611 201.43**	**0**	**91 196.33**	**850 245.18**

Greenhouse gas emissions is expected to increase by 106%.

Table 23. Greenhouse Gas Emissions CO_2 eq. From Kutaisi Building Sector – 2020

Subsector	Electricity	Natural Gas	Liquid Gas	Firewood	Total
Municipal Buildings	2 087.30	1 837.26	0	10.51	3 935.07
Commercial Buildings	1 007.10	71.02	0	0	1 078.13
Residential Buildings	17 012.85	121 202.16	0	2 464.72	140 679.73
Sum	**20 107.25**	**123 110.44**	**0**	**2 475.24**	**145 692.93**

5.4 Action Plan for Reducing Emissions from Kutaisi Building Sector

A short-term strategy for reducing greenhouse gas emission from municipal and residential buildings of Kutaisi aims at reducing energy resources consumption by such measures as: using energy efficient bulbs, improving heat insulation of roofing, entrance and other spaces of common use, roof leaks and damages repairs, repair or replacement of windows and doors. All the measures save significant amount of thermal energy and at the same time are relatively affordable. Conversion to energy-efficient light bulbs considers replacing incandescent bulbs with fluorescent ones characterized by efficiency and long working ability. There measures, of course, should be accompanied by information campaigns and appropriate trainings helping to raise public awareness.

A promising way of reducing carbon dioxide emissions is the use of renewable energy sources. As is well known, main part of energy resources is used for heating and hot water supply. Therefore, bio-waste and solar energy, as renewable energy sources, in heating and hot water supply systems of buildings will significantly reduce the amount of natural gas and carbon dioxide emissions as well. Implementation of these measures even in 16% of private houses will reduce carbon dioxide emissions by 20% all around the city.

Therefore, a long-term strategy of greenhouse gas emissions in Kutaisi may mean production of waste biomass blocks and their use in local and heating systems as well as installation of solar collectors in municipal and residential buildings. Implementation of mentioned measures will not only serve the purpose of water heating and also promote non-conventional renewable energy sources.

The following measures can be carried out in Kutaisi under the short and long-term strategy:

- Bio-waste pellets utilization in municipal and private buildings (pilot projects);
- Lighting system with fluorescent bulbs;
- Thermal insulation of roofs in kindergartens;
- Solar collectors in kindergartens;
- Installation of fluorescent light in shared residential spaces;
- Warming shared residential areas and entrances;
- Thermal insulation of roofs in private houses;
- House for refugees with reduced energy consumption/pilot project;
- Installation of solar collectors for water heating in private houses/investor;
- House roofing and thermal insulation program for 41 “poor families”.

Detailed energy audit was conducted in buildings sector of Kutaisi on April 10-12, 2014 to determine emission reduction potential through above-mentioned strategy. There have been selected nine different buildings, according to their energy consumption nature.

Pic. 3. Kutaisi Public School #40 (address: #22 Nikea II turn)

Pic. 4. Kutaisi Kindergarten #27 (address: #14 Nikea II turn);

Pic. 5. Leri Khonelidze Clinic Ltd (address #11 Lortkipanidze St.)

Pic. 6. Two-storey Residential Building (address: #24 Marjanishvili St.)

Pic. 7. Three-storey apartment building (address: #6 Zviad Gamsakhurdia I turn)

Pic. 8. Five-storey apartment building (address: #24 Ilia Chavchavadze ave);

Pic. 9. Eight-storey apartment building (address: #38 Zviad Gamsakhurdia ave.);

Pic. 10. Nine-storey apartment building (address: #12 Melikishvili St.);

Pic. 11. Single-family house (address: #6 Freedom St IV turn)

Detailed results of the energy audit conducted for these buildings can be found in the appendix. Actual energy-saving and emission reduction potential from these buildings have been determined under extensive research and described methodology (see Table 24 and

Table 25).

Table 24. Existing Emissions from Residential Buildings and Possible Savings

Energy Expenses	Energy		Emission			
	Basic	Saving	Norm	Existing	Saving	Saving
	kW*h/ y	kW*h/ y	kg/ kW*h	T/y	T/y	%
1-2 Storey Building						
1. On heating	24 344 472.00	6 566 601.00	0.20	4 917.58	1 326.45	26.97
2. On hot water						
By natural gas	7 340 713.00	3 670 356.00	0.20	1 482.82	741.41	50.00
By electricity	10 276 998.00	5 138 499.00	0.14	1 397.67	698.84	50.00
3. On Electrical equipment	13 197 266.00	2 504 918.00	0.14	1 794.83	340.67	18.98
Sum	**55 159 448.00**	**17 880 374.00**		**9 592.91**	**3 107.37**	**32.39**
3-5 Storey Buildings						
1. On heating	54 215 516.00	15 945 740.00	0.20	10 951.53	3 221.04	29.41
2. On hot water						
By natural gas	9 966 088.00	1 993 218.00	0.20	2 013.15	402.63	20.00
By electricity	13 952 523.00	2 790 505.00	0.14	1 897.54	379.51	20.00
3. On Electrical equipment	27 905 045.00	3 986 435.00	0.14	3 795.09	542.16	14.29

Sum	**106 039 171.00**	**24 715 897.00**		**18 657.31**	**4 545.33**	**24.36**
6-9 Storey Buildings						
1. On heating	75 273 385.00	19 160 498.00	0.20	15 205.22	3 870.42	25.45
2. On hot water						
By natural gas	13115817,08	2 281 012.00	0.20	2 649.40	460.76	17.39
By electricity	18362143,92	3 193 416.00	0.14	2 497.25	434.30	17.39
3. On Electrical equipment	32 846 568.00	5 707 091.00	0.14	4 467.13	776.16	17.38
Sum	**139 597 914.00**	**30 342 017.00**		**24 819.00**	**5 541.65**	**22.33**
Private Houses						
1. On heating	107446284.8		0.20	21 704.15		
By Natural gas		28 907 320	0.20		5 839.28	
By Biomass		37 606 200	2.20		7 596.5	
2. On hot water						
By Natural Gas	5 781 464.00	5 781 464.00	0.20	1 167.86	1 167.86	100.00
By Electricity	8094049,6	8 094 050.00	0.14	1 100.79	1 100.79	100.00
3. On Electrical Equipment	14320241.6	3 709 032.00	0.14	1 947.55	504.43	
Sum	**135 642 040.00**	**55 190 745**		**25 920.35**	**16 208.81**	**62.5**

Table 25. Emissions from Non-residential Buildings and Possible Savings

Energy Expenses	Energy		Emission			
	Basic	Basic	Norm	Existing	Saving	Saving
	kW*h/ y	kW*h/ y	kg/ kW*h	T/y	T/y	%
Kindergartens						
1. On heating	1 264 236.00	190 828.00	0.20	255.38	38.55	15.09
2. On hot water						
By natural gas	178 901.00	178 901.00	0.20	36.14	36.14	100.00
By electricity	250 462.00	250 462.00	0.14	34.06	34.06	100.00
3. On Electrical equipment	310 096.00	78 717.00	0.14	42.17	10.71	25.38
Sum	**2 003 694.00**	**698 908.00**		**367.75**	**119.45**	**32.48**
Public Schools						
1. On heating	1 856 794.50	375 110.00	0.20	375.07	75.77	20.20
2. On Electrical Equipment	656 442.50	146 293.00	0.14	89.28	19.90	22.29
Sum	**2 513 237.00**	**521 403.00**		**464.35**	**95.67**	**20.60**
Hospitals						

1. On heating	8 840 096.00	979 512.00	0.20	1 785.70	197.86	11.08
2. On hot water						
By natural gas	795 854.00	795 854.00	0.20	160.76	160.76	100.00
By electricity	1 114 195.00	1 114 195.00	0.14	151.53	151.53	100.00
3. On Electrical equipment	4 595 544.00	1 428 455.00	0.14	624.99	194.27	31.08
Sum	**15 345 688.00**	**4 318 015.00**		**2 722.99**	**704.42**	**25.87**

The tables above reflect full potential of energy-saving under these measures involving all buildings.

As for the action plan of the next 6 years, it includes the following measures:

Emission Reduction Action Plan from Buildings

Table 26. Action Plan to Reduce Emissions from Buildings

Sectors and Activities	Key Measures in Activities	Responsible Department, Person or a Company (If the third party is involved)	Implementation Period (Start and End Date)	Expected Energy Saving from each Measure (MWh/y)	Expected CO2 (T/y) Reduction from each Measure	Cost of Measures (GEL)
Municipal Buildings (MB)						
Activity MB1	**Installation of space heating systems in municipal buildings**					
MB 1.1	Bio-waste pellets production and utilization in municipal buildings	Economic Policy Office in Kutaisi City Hall	2015-2017	126	25.45	15 000
Activity MB 2	**Installation of efficient lighting systems is municipal buildings**					
MB 2.1	Fluorescent lamps lighting system	Economic Policy Office in Kutaisi City Hall	2015	161.73	22.05	14 000
Activity MB 3	**Renovation of municipal buildings**					
MB 3.1	Thermal insulation of roofs in kindergartens	Economic Policy Office in Kutaisi City Hall	2015-2018	57.42	11.5	35 000

Activity MB 4	**Utilization of renewable energy sources for hot water supply**					
MB 4.1	Installation of solar collectors in kindergartens	Economic Policy Office in Kutaisi City Hall	2015-2020	126	25.45	78 000
Activity MB 5	**Education/inform/Public-awareness raising campaign**	Economic Policy Office in Kutaisi City Hall	2012-2020			
Activity MB 6	**Implementation of energy management and monitoring program in municipal buildings**		2012-2020			
MB 6.1	Control of energy consumption, behavior norms development	Economic Policy Office in Kutaisi City Hall				
MB 6.2	Municipal buildings' energy database development	Economic Policy Office in Kutaisi City Hall				
MB 6.3	Establish energy efficiency indicators to prepare documents necessary for state procurement of rehabilitation works	Economic Policy Office in Kutaisi City Hall				
Residential Buildings (RB)						
Activity RB 1	**Installation of efficient lighting system**					

RB 1.1	Installation of fluorescent bulbs in common areas of residential buildings	Economic Policy Office in Kutaisi City Hall	2015-2017	223.5	30.4	22 800
Activity RB 2	**Renovation of residential buildings**					
RB 2.1	Warming of common areas in residential buildings – in 76 entrances	Economic Policy Office in Kutaisi City Hall	2014	950	191.9	440 000
RB 2.2	Thermal insulation of roofs in private houses	Investor	2014-2020	35.7	7.2	11 800
RB 2.3	Reduced energy consumptive house for refugees/pilot project/	Investor	2017-2018	150	30	120 000
Activity RB 3	**Utilization of renewable energy sources for hot water supply**					
RB 3.1	Installation of solar collectors for water heating in private houses	Investor	2015-2020	184.2	37	65 000
RB 3.2	Roofing and thermal insulation program for 41 families having "poor family" economic status	Economic Policy Office in Kutaisi City Hall	2014	240	48.5	150 000

RB 3.3	Bio-waste pellets production and use in residential buildings	Investor	2015-2020	147 980	29 890	3 114 000
Activity RB 4	**Public awareness raising/ information campaigns**					
RB 4.1	Trainings about energy efficiency issues in the buildings for various target groups	Economic Policy Office in Kutaisi City Hall				
RB 4.2	Mass media and energy efficiency information campaign	Economic Policy Office in Kutaisi City Hall				
Sum				**150 234**	**30 319**	**4 065 600**

Detailed description of measures:

Measure MB1.1. Utilization of bio-waste pellets in municipal buildings (pilot project)

Bio-waste pellets can be used as fuel instead of natural gas in buildings. Bio-waste pellet is carbon-free fuel enabling 20% emission reduction scheduled for 2020. In order to determine all aspects of this measure implementation of pilot project is desirable.

Market price of one ton of organic waste pellets was 450 GEL due to high cost of sawdust transporting. Now, private companies, making production in the territory of sawdust obtaining, reduce their sales price to 250 GEL. Pellets heat capacity is 16 000 kJ/kg., which means that during 1 kg pellet combustion process 4.44 kWh energy is being released. Price for one kWh such energy is 250 / (1000 * 4.44) = 0.06 GEL/kWh.

An average price of 1 000 m^3 natural gas is 750 GEL for different consumer groups and state buildings. Its thermal capacity is 33 868 kJ/Nm^3. 8.00 kWh of energy released during 1m^3 natural gas combustion process. Thus, cost of 1 kWh energy produced by natural gas burning will be 0.09 GEL/ kWh.

Total amount of energy required for pilot buildings (#27 kindergarten) heating will be about 126 MWh/y, in case of natural gas use. This measure is linked to additional expenses - 15 000 GEL for purchasing and installation of pyrolysis furnace (such furnace was produced by JSC Sarini in 2012 and was installed in Natakhtari public school. In monetary terms, the annual savings will be126 000 x 0.02 = 2520 (0.09-0.07=0.02 GEL/kWh is the difference in prices between pellets and gas).

As mentioned above, bio-waste is carbon-free fuel so conversion to this fuel reduces CO_2 emissions by 126 x 0.202[15]=25.45 tons per year.

It is expected that the pilot project results will be expanded to minimum ten such municipal buildings (kindergartens). Profitability parameters of MB 1.1 measure are given below (Table 27).

Table 27. Profitability parameters of MB1.1 measure

Measure	Investment Cost GEL	Payback *PB	Internal Rate of Return (IRR) *IRR,%	Net Present Value Quotient *NPVQ	CO_2- Reduction T/Y
Central Heating System (F=2 798 ∂2)	15 000.00	6	16	0.61	25.45

**PB – Payback; *IRR – Internal Rate of Return; *NPVQ - Net Present Value Quotient*

Measure MB2.1.- Lighting System with Fluorescent Lamps

In order to assess energy savings potential of this activity data of the same #27 kindergarten have been used.

Energy savings potential has been determined via comparison of incandescent lighting with fluorescent one.

Lamps are switched on in the building for about 20 hours a week.

Basic energy consumption for incandescent bulbs is 11 552 kWh according to ENSI software (see appendixes) and 6931 kWh for fluorescent ones, energy saving of the pilot building will be 4621 kWh, or 4 621 x0.16=739 GEL, in monetary terms. Profitability parameters are presented in Table 28.

Fluorescent lighting is going to be installed in at least 35 kindergartens.

Table 28. Profitability parameters of MB2.1 measure

Measure	Investment Cost GEL	Payback *PB	Internal Rate of Return (IRR) *IRR,%	Net Present Value Quotient *NPVQ	CO_2- Reduction T/Y
Fluorescent lamps lighting system (F=2 798 ∂²)	400	0.5	185	7.47	0.63
In 35 Municipal buildings .	14 000	0.5	185	7.47	22.05

Measure MB3.1. – Thermal Insulation of Roofs in Kindergartens

It is known, that a building and its heating system is one unit. Thermal insulation of roofs reduces heating system's load. The following value has been taken in calculations for ceiling resistance coefficient: R=0.70 m^2deg/W, with further insulation it would be R=1.0 m^2deg/W, ceiling area is 1400m^2.

Resulted energy saving under this measure is 11484 kWh/y according to ENSI.

In case of natural gas use, the savings would be: 11 484/8.00 =1 435 m^3 or 1 435 x 0.75 = 1 076 GEL. Investment cost of the measure is 7000 GEL; CO_2reduction - 11 484 x 0.202= 2.30 t/per year. Profitability parameters of the measure are given below (Table 29).

Installation of roofs' thermal insulation is planned for at least 5 kindergartens with the same ceiling areas.

Table 29. Profitability parameters of MB 3.1 measure

Measure	Investment Cost (GEL)	Payback PB	Internal Rate of Return (IRR)	Net Present Value Quotient *NPVQ	CO_2- Reduction t/y
Thermal Insulation of Roofs (F=2 798 ∂²)	7 000	6.5	14.4	0.48	2.3
5 Kindergartens	35 000	6.5	14.4	0.48	11.5

Measure MB 4.1. Solar Collectors Utilization in Kindergartens

Solar collectors convert radiation into heat energy and then give the heat to water, which is provided to buildings. Described measure aims at using solar collectors for hot water supply in such municipal buildings as Kindergartens.

About 4000 liters of hot water (40 degrees) a day is consumed in #27 kindergarten (295 children and 45 employees) heating of which needs 25 123 kWh energy per year.

It is known that solar energy received on the horizontal surface in Kutaisi is approximately 1200 kWh per year. The solar energy collector surface can be oriented at 90-degree angle leading to 25% increase of solar radiation amounting to 1500 kWh/m²/y. Taking into account the fact that solar energy collector efficiency is 70%, 1050 kWh/m² energy would be available.

In case of using solar vacuum collectors, that are installed on roofs, we will get 25 200 kWh energy from 24 m² total area per year. Standard solar energy collector surface is 2m² and costs 1300 GEL with installation. 12 pieces of such collectors are needed for 27 kindergartens with total investment cost of 15600 GEL.

To take mentioned energy (25 200 kWh/y) from natural gas burning, the following amount of gas is required: 25 200 /8.00 =3 150 m³, or 3 150 x 0.75=2 362 GEL. Reduction of CO_2 emissions, in case of conversion from natural gas to solar energy, will be 5.09 per year. Profitability parameters of this measure are given below (Table 30).

Solar water heating is considered for five kindergartens.

Table 30. Profitability parameters of MB 4.1 measure

Measure	Investment Cost (GEL)	Payback PB	Internal Rate of Return (IRR)	Net Present Value Quotient *NPVQ	CO_2- Reduction t/y
Hot water supply though solar energy	15 600	6.6	14	0.45	5.09

(F=2 798 ∂²)					
5 Kindergartens	78 000	6.6	14	0.45	25.45

Measure RB1.1. Installation of Fluorescent Bulbs in Common Areas of Residential Buildings (76 Entrances)

Mentioned measure includes replacement of incandescent bulbs with fluorescent ones. For example, if we consider a common space F=389 m² of 9-storey building with stairs its minimum energy consumption is 3.5 W/m², in case of lighting with incandescent lamps. This corresponds to total consumption of 1.36 kW. Assuming that work duration of incandescent bulbs is 55 hours a week, the annual consumption would be 1.36*55/7 *365= 3900 kWh. Their replacement with fluorescent lamps will save 2 941 kWh energy (2 941 x 0.16 = 471 GEL) (economic bulbs consume 3-4 times less energy).

Total amount of replaced bulbs will be 45 pieces (9 floors, 5 entrances) costing about 360 Gel. CO_2 emission reduction from a building will be 0.40 t/y. Result of this example can be used for other buildings assuming that this change will reach energy savings of 7.56 kWh/m² in common spaces per year. Profitability parameters of the measure are given below (Table 31).

Table 31. Profitability parameters of RB 1.1 measure

Measure	Investment Cost (GEL)	Payback PB	Internal Rate of Return (IRR)	Net Present Value Quotient *NPVQ	CO_2– Reduction t/y
Lighting with fluorescent bulbs	360	0.8	129.7	4.98	0.4
In 76 entrances	22 800	0.8	129.7	4.98	30.4

The forecast considers replacing of incandescent bulbs with fluorescent ones in 76 entrances.

Measure RB 2.1. – Warming of Common Spaces and Entrances of 9-storey Residential Buildings

The measure involves installation of metal-plastic windows on each floors. Warming of buildings and minimization of heat losses will save up to 950 MWh energy. Corresponding natural gas saving is about 950 000/8.00=118 750 m³ and emissions reduction - 191.90 t/y i.e. 118 750x0.45 = 53 437 GEL per year.

There will have to be installed about 3 826m3 metal-plastic windows in 76 entrances under this measure with total investment of 115 USD / m 2 = m 2 x 3 826 440 000 GEL. Profitability parameters of the measure are presented below (

Table 32).

Table 32. Profitability Parameters of RB 2.1 Measure

Measure	Investment Cost (GEL)	Payback PB	Internal Rate of Return (IRR)	Net Present Value Quotient *NPVQ	CO_2- Reduction t/y
Warming of common spaces of 9-storey 15 residential buildings (76 typical entrances)	440 000	8.3	12	0.36	191.9

Measure RB2.2 – Thermal Insulation of Roofs in 2-storey Private Houses

Additional thermal insulation of private house roofs i.e. raising of roofs' thermal resistance coefficient from R=0.70 m^2deg/W to R=1.00 m^2deg/W will save up to 1 788 kWh energy resulting CO_2 emissions reduction of 0.36 t/y or 1 788 x 0.056 = 100 GEL per year. Investment and installation cost is 5 GEL per square meter and the total investment will be 118 m 2 x 5.00 USD / m 2 = 590 GEL. Profitability parameters of the measure are given below (Table 33).

Table 33. Profitability Parameters of RB 2.2 Measuere

Measure	Investment Cost (GEL)	Payback PB	Internal Rate of Return (IRR)	Net Present Value Quotient *NPVQ	CO_2- Reduction t/y
Roofs thermal insulation in 2-storey private houses	590	5.9	16.6	0.76	0.36
Roofs insulation in 20 analogous houses	11 800	5.9	16.6	0.76	7.2

Measure RB 2.3 – Reduced Energy Consumptive House for Refugees/pilot project

Expected energy saving after implementation of the measure is 150 MWh and CO_2 emissions reduction from residential buildings will be 30 t/y.

According to City Hall, 17 000 refugees live in Kutaisi nowadays and development of compact housing is being considered for them.

Improvement of thermal characteristics of at least one building external walls (3000 m^2) along with installation of efficient lighting and new heating equipment with solar hot water supply system. Profitability parameters of the measure are given below (Table 34).

Table 34. Profitability Parameters of RB 2.3 Measure

Measure	Investment Cost (GEL)	Payback PB	Internal Rate of Return (IRR)	Net Present Value Quotient *NPVQ	CO_2- Reduction t/y
Energy Efficient Building (3000 m^2 external walls)	120 000	8.5	11.7	0.39	30

Measure RB 3.1. – Installation of Solar Collectors for Water Heating in Private Houses/Investor

This measure concerning municipal buildings is described in paragraph MB 4.1. Its results are applied to residential buildings as well. It is necessary to launch a pilot project with participation of investors to determine optimal technical solutions.

Annual demand for hot water supply per private house is 3 685 kWh/y. CO_2emissions reduction in case of conversion from natural gas to solar energy will be 0.74 tons per year.

The results presumably will involve 10 000 residential houses. This would allow using solar energy and increasing the share of renewable energy in final energy consumption rates. Profitability parameters of the measure are presented below (Table 35).

Table 35. Profitability Parameters of RB 3.1 Measure

Measure	Investment Cost (GEL)	Payback PB	Internal Rate of Return (IRR)	Net Present Value Quotient *NPVQ	CO_2- Reduction t/y
Installation of solar collectors for hot water supply	1300	6.2	15	0.55	0.74
For 50 residential buildings	65 000	6.2	15	0.55	37

Measure RB 3.2. Roofing and Thermal Insulation Program for 41 Families Having "Poor Family" Economic Status

Additional insulation of roofs of residential buildings i.e. raising of roof thermal resistance coefficient from R=0.70 m^2deg/W to R=1.00 m^2deg/Wwill save 1788 kWh energy, resulting CO_2emissions reduction - 0.36 t/y.

Roofs' insulation of residential buildings i.e. raising of roof thermal resistance coefficient from R=0.70 m^2deg/W to R=1.00m^2deg/W will save up to 240 000 kWh energy. Such energy savings will be followed by CO_2emissions reduction - 48.50 t/y i.e. 240 000 x 0.056= 13 440 GEL per year. Investment and installation cost is 5 GEL and total investment will be 6 000 m^2x25.00 Gel/ m^2 = 150 000 GEL. Profitability parameters of the measure are presented below (Table 36).

Table 36. Profitability Parameters of RB 3.2 Measure

Measure	Investment Cost (GEL)	Payback PB	Internal Rate of Return (IRR)	Net Present Value Quotient *NPVQ	CO_2- Reduction t/y
Roofs insulation	150 000	11.2	8	0.01	48.5

This is not a social program and we do not pay attention to low NPVQ in implementation of measures.

Measure RB 3.3. – Bio-waste Pellets Utilization in Private Houses/pilot project

This measure on municipal buildings is described in the paragraph MB 4.1. Obtained results are applied to residential buildings as well. It is necessary to launch the pilot project with participation of investors to determine optimal technical solutions.

Annual demand on heating per house is 28 513 kWh/y, CO_2 emissions reduction in case of conversion from natural gas to biomass will be 28 513 x 0.202=5.76 t/y.

This measure corresponds to 600 GEL investment to buy pyrolysis furnace. In monetary terms, the annual savings will be 28 513 x 0.02 = 570 GEL (0.09-0.07=0.02 GEL/kWh is price difference between pallets and gas).

Pilot project results should propably involve 5 190 residential buildings. It will increase share of renewable energy in total energy consumption rates. Profitability parameters of the measure are given below (Table 37).

Table 37. Profitability Parameters of RB 3.3 Measure

Measure	Investment Cost (GEL)	Payback PB	Net Present Value Quotient *NPVQ	CO_2- Reduction t/y

Per House	600	1.1	6.98	5.76
5 190 Houses	3 114 000	1.1	6.98	29 890

6 Street Lighting

6.1 Sector Overview

Kutaisi is one of the oldest cities in the world. During its history it was keeping a status of the biggest city in the West Georgia. Now it is second largest city in Georgia as by its population, as by its political and economic importance.

Pic. 12. Historical area, International airport, and Palm alley in Kutaisi

During the last years several significant developments took place in Kutaisi, such as construction and opening of Kutaisi International Airport, rehabilitation of a historical part of the city, and moving of the Parliament of Georgia to Kutaisi. All these lead to significant increase of expenditures for street lighting. In 2012 more electric power was consumed for fountains, traffic lights, and illumination of different buildings.

Table 38. Energy consumption and expenditure in street lighting sector in 2012

Infrastructure init	Electricity consumption (kWh)	Expenditure (GEL)
Traffic lights	86 620.00	13 859.89
Kutaisi street lighting*	9 412 671.32	1 506 102.97
Total	**9 499 291.32**	**1 519 962.86**

*Expenditures for illumination of buildings, cultural monuments and similar objects are included into street lighting expenditure.

As it is shown in the table, electricity consumption in Kutaisi in 2012 was nearly 9.5 million kWh that corresponds to the expenditure of over 1.5 million GEL per year. There are 13 635 lighting units in Kutaisi, the types and energy consumption for which are given in Table 39 below.

Table 39. Bulb types and energy consumption

Bulb type	Unit number	Mean consumption /per unit	Sum kW/h
Diode	42.00	0.015	0.63
Economy	1044.00	0.05	52.2
Halogen	142.00	0.37	52.6
Metal-halide	388.00	0.174	67.65
Sodium	11 971.00	0.175	2 091.43
Spiral	48.00	0.25	12.00
Total	**13 635.00**		**2 276.51**

6.2 Methodology

Methodology described in Transport Sector chapter was used for the inventory on CO_2 baseline emissions (2012) and future trends (until 2020). According to MARKAL-Georgia baseline scenario, energy consumption by the street lighting sector will increase by 25% in 2020 (approximately 3740 new non-efficient sodium bulbs). Mean grid emission factor -0.136 t of CO2 /MWh in 2012 was taken as electric energy emission factor and it was assumed that it has not been changing during the discussed period.

6.3 Baseline year inventory (2012) and greenhouse gas emissions baseline scenario (2013-2020)

In 2012 the electric power consumption by street lighting sector was 9412671 kWh and the emissions from this sector equaled correspondingly to 1280 t of CO_2 eq.

In the baseline scenario it was assumed that the increasing of number of lighting units in public areas would be conditioned by increasing lighting and widening of the city area. According to a standard assumption, additional lighting would be undertaken by using of cheap and non-efficient sodium bulbs. According to baseline scenario, street lighting energy consumption will increase in future and reach 11.8 thousand MWh by 2020, while CO_2 emission from this sector by that time will reach 1.604 thousand t per year.

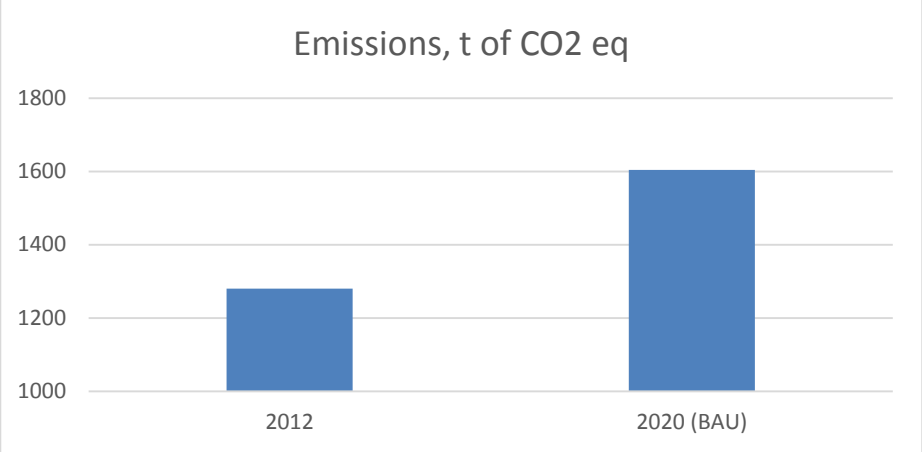

Fig. 15. Emissions from street lighting sector in 2012 and 2020

6.4 Action Plan for reduction of emissions from Kutaisi street lighting sector

Action Plan for street lighting sector envisages following measures:

Activity PL1.

Modernization of Kutaisi street lighting system implies following activities:

- Equipping the city street lighting system and parks with ECO-LAMPS that would allow saving expenses from local budget
- Elaboration of Kutaisi Street Lighting Audit and Development Master Plan
- Establishment of centralized intelligent management system for street lighting
- Providing software for management and monitoring of street lighting system
- Elimination of energy losses in street lighting system.

Among the mentioned activities replacement of non-efficient bulbs with ECO-LAMPS (fluorescent lamps) will have the most significant effect. Economic lighting is one of the latest saving technologies.

ECO-LAMPS have many advantages, such as:

- High luminance and wide spectrum of colors;
- Water resistance and dust resistance;
- Energy efficiency;
- Long life time.

ECO-LAMPS life time is minimum 20 000 hours, while halogen and luminescent lamps have only 4 000 hours life time. Though ECO-LMAPS demand higher investment initially, in the end these investments together with electricity consumption expenditures turn to be lower. According to these plans, 85% of lamps should be replaced by ECO-LAMPS that means that 14 700 new ECO-LAMPS must be installed. Thanks to these measures, about 6.7 thousand MWh electric power will be saved and 911 t CO2 eq will be reduced. Taking into account that purchasing and installing of one such lamp costs 270 GEL, the total cost

of this measure will be 4 million GEL. Replacement should be conducted gradually and, if it is conducted over a period of eight years, then the cost will comprise a half a million per year.

The graph given below shows greenhouse gas emissions in case of baseline scenario and in case of installation of energy saving lamps on light poles that represents the highest priority measure in sustainable energy action plan for this sector.

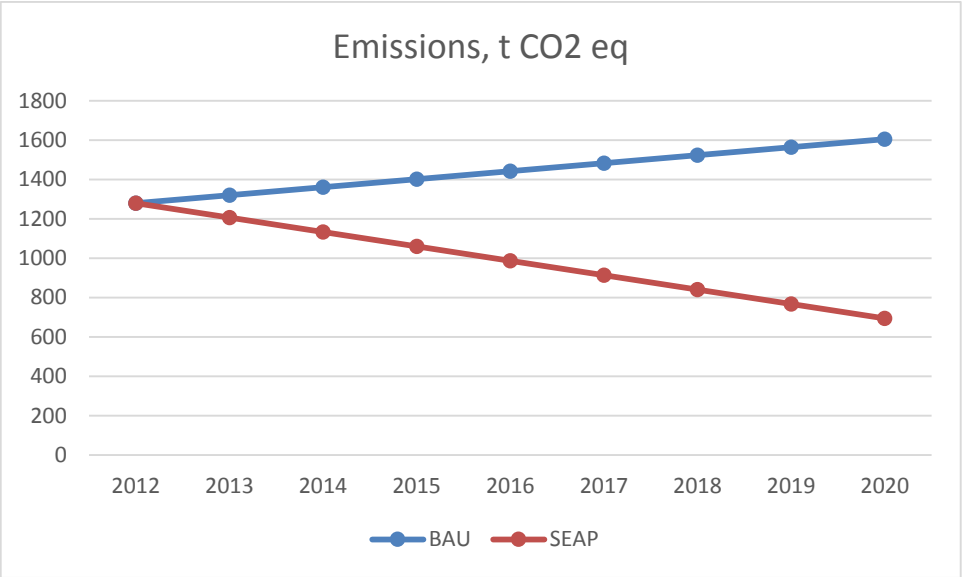

Fig. 16. Emissions from street lighting according to BAU scenario and in case of implementation of the measures envisaged by Sustainable Energy Action Plan.

The following graph clearly indicates the benefits for the Kutaisi Municipality derived from implementation of the above mentioned measures:

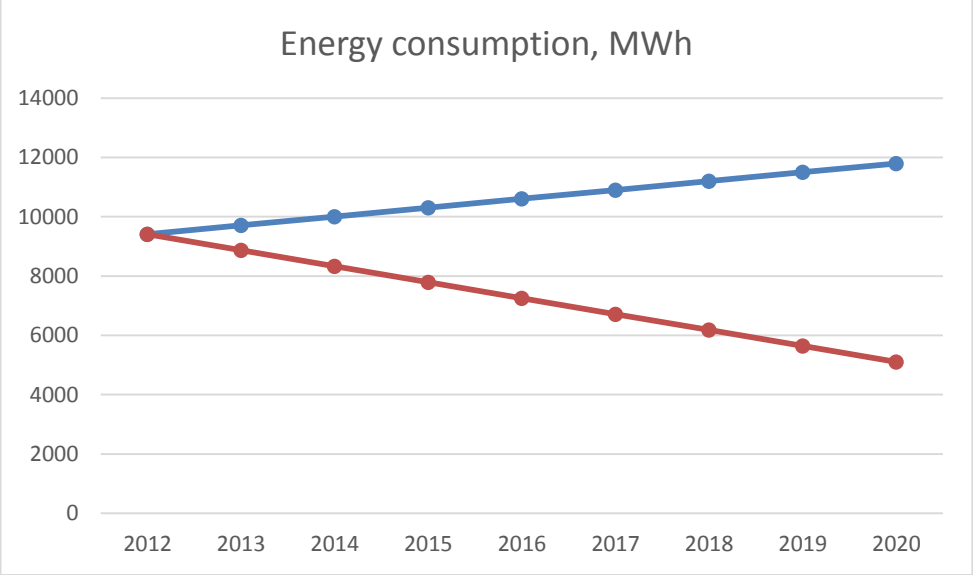

Fig. 17. Energy consumption by the city street lighting according to BAU scenario and in case of implementation of the measures envisaged by Sustainable Energy Action Plan

It is supposed that other measures, mentioned above would also reduce energy consumption and emissions, though for the time being the relevant assessments have not been conducted.

7 Waste

7.1 Sector Overview

Solid waste

Infrastructure of Kutaisi has been intensively developing during the last period.There are numbers of new constructions, cultural and recreational zones being developed, and consequently, energy demand is constantly increasing. Amount of waste produced within the city and its suburbs is also increased. One of the priorities for development of Kutaisi and the whole region for 2014-2016 is the improvement of waste management that implies closing of old landfills and creation of new landfills for disposal of municipal solid waste (MSW), as well as reconstruction of the existing municipal water treatment facilities[16] that would be a significant step towards country's sustainable development.

For calculation of emissions from the waste sector the guidelines for greenhouse gas inventories of the Intergovernmental Panel on Climate Change (IPCC) supported by United Nations Framework Convention on Climate Change have been used. According to these guidelines there are following categories in the sector:

- Solid waste disposal (6A)
- Wastewater treatment (6B1, 6B2)

[16] http://static.mrdi.gov.ge/52b312180cf2f9b6fab6b48d.pdf

- Waste incineration (6C)
- Other waste – municipal waters (6D)

Waste inventory in Kutaisi has been conducted only for two categories – solid waste disposal (6A) and for municipal and commercial wastewater treatment (6B1). Other IPCC categories have not been discussed, because waste incineration does not take place in Kutaisi, as well as inventory and disposal of other waste (industrial, medical and radioactive). It should be noted also that approximately 50 000 m^3 of construction waste in Kutaisi is disposed to the landfills every year together with municipal waste, which was not taken into account while calculating general emissions from landfills, as the construction material practically does not contain organic carbon and hence does not release methane. Sub-category 6B2 Industrial wastewater is also not discussed, because no official data on yearly production of industrial enterprises are available[17].

Solid waste disposal

There is one waste disposal landfill in Kutaisi operational since 1956. It covers area of 15 ha (150962.28 m^2). The landfill is located close to Kutaisi-Gudauta highway, along the Nikea Street in the distance of 0.5 km from a population settlement. The landfill borders Rioni River to the east. To the north, within the limits of the landfill, an area of 50 m is illegally planted with hazelnut, while in the rest of the northern part of the landfill an area of about 1 ha is naturally covered by small shrubs. The landfill is expanding toward the south. From the west it is limited by a concrete wall separating the area from Geguti highway[18] (Fig. 18).

[17] National Statistics Office of Georgia http://geostat.ge/

[18] http://geonews.ge/category/23/regions/news/193231/murgulia_qutaisis_nagavsayreli.html

Fig. 18. Kutaisi active landfill

Kutaisi landfill is one of the most problematic landfills in Georgia. Several unsuccessful attempts have been undertaken to improve its parameters and local population still suffer from its proximity. Plastic bottles and bags can be seen all over the adjacent area. Decomposition smell is spread over the settlements and there are frequent cases of methane natural inflammation, which runs uncontrolled and creates certain threat to local population[19].

Kutaisi landfill, located at Rioni river was not even fenced until 2004. Even for the time being, the river waters wash out the waste during each flood. Rioni river has washed out a considerable part of the landfill area little by little and now the landfill initial area of 18 ha is decreased to 15 ha[20]. Leakage waters from the landfill cause pollution of the abundant ground waters of the city which are actively used by a part of population. It should be noted that the mentioned part of population independently provides water supply from the ground water sources for their household needs, though the relevant monitoring on ground waters within the city area is not conducted[21].

[19] http://regions.ge/Imereti&newsid=5874&year=2012&position=news_main

[20] http://newpress.ge/index.php?page=4&staties_id=884&rub_param=8

[21] http://nala.ge/uploads/kutaisi.pdf

Waste disposal is conducted chaotically and the whole area is almost fully covered with the waste. The depth of the waste layer reaches 12-15 m in some points (correspondingly, the landfill can be considered as a deep (>5) landfill). The circular road along the landfill perimeter is covered with the waste. Inappropriate exploitation leads to pollution of an irrigation channel within the territory (the channel is arranged by population for irrigation of 5 adjacent villages). Population has to clean the channel at their own expenses. Cleaning is conducted every year (last cleanings were conducted in 2013 and 2014) and often it becomes necessary to clean it within the landfill territory. Cases of self-inflammation, as well as intensive combustion sites have been frequently reported[22].

Since September 2013 the Kutaisi landfill is under responsibility of the Ministry of Regional Development and Infrastructure of Georgia, where the Solid Waste Management Company has been established[23]. According to information, received from the municipal department responsible for waste collection, the yearly disposal of waste has been increased 1.5 times[24]. At the Nikea landfill, which except for Kutaisi also serves Tskaltubo and Bagdadi, amount of disposed waste, starting from its opening and until today, comprises 7.5 million m^3, or expressing in mass units – 1.5 million tons (1 m^3– 0.2 t[25]). In future increasing amounts of solid municipal waste is expected, because for the time being, only 60% of waste, including the waste disposed by commercial users, is disposed in an organized way at the landfill. This tendency underlines importance of introduction of modern waste management and utilization systems in the city, which addressed both, waste managemnt at generation sites (e.g. sorting out of waste by population, treatment at place), as well as at landfills. This would significantly reduce amount of waste disposed at landfills, improve waste management process at landfills, and enhance effective use of energy, obtained from the waste.

Waste management system in Kutaisi needs to be improved. There are many illegal landfills in the suburbs, where construction and municipal waste is disposed together.

The Solid Waste Management Company responsible for the Kutaisi landfill, planned to conduct following activities starting from 2013: to transfer the waste disposed at landfills to preliminary designated sites, to ram it and cover by an insulating soil layer; to collect and transfer all waste scattered around the landfill and to install check-point booths; to arrange storm-water inlet systems, to fence the landfill, to install weighing machines, to establish sanitary points and to install a fire shield[26]. Kalasi Ltd, a sub-contracting company of the Solid Waste Management Company, carries out the above mentioned work. For the time being it conducts ground flattening works. The channel in landfill area is already cleaned up; Waste is being disposed only at the back area of the landfill. After completing the ground flattening works the landfill area will be divided into zones (squares) and waste will be disposed into the divided cells. It will be rammed and covered by an insulating soil blankets. The whole landfill will be surrounded by a fence[27]; A watch house, as well as garage for machinery and foundation for a weighing machine are already installed. Internal roads are

[22] http://geonews.ge/category/23/regions/news/193231/murgulia_qutaisis_nagavsayreli.html

[23] Aim of the company is to reduce the impact of waste disposal and waste treatment; to avoid or minimize waste generation; to reduce hazardous waste and to close all landfills which do not comply with the EU Directiv; to provide safe and effective disposal and to arrange relevant infrastructure for waste separation and treatment http://www.mrdi.gov.ge/ge/structure#

[24] http://nala.ge/uploads/kutaisi.pdf

[25] Sanitary cleaning in settlements, 1990, p. 6

[26] http://waste.gov.ge/index.php?a=main&pid=103&lang=geo

[27] http://www.newpress.ge/index.php?page=4&staties_id=884&rub_param=17

arranged; Cells are being arranged; A coast protective dam is being constructed at Rioni River side to avoid washing out of the waste into the water[28].

According to the project of the Solid Waste Management Company of Georgia, 'Kutaisi Integrated Solid Waste Management', after conservation of the old Kutaisi landfill, a new sanitary landfill[29] will start to operate. Construction works will begin in 2014. By 2016[30] it will serve not only Imereti, but also Racha-Lechkhumi region (Fig. 19). According to the project, the new Imereti landfill will be arranged near the Kutaisi entrance, at the territory, adjacent to Terjola region[31] in 1.5 km from populated settlements that fully complies with the international standards. In addition, it is planned to plant green cover that would create better environment for local population[32].

Fig. 19. Model of a new Kutaisi landfill[33]

Waste waters

Municipal waste waters are mostly generated at sanitary sites, in service sector, industrial and housing facilities, and municipal engineering sector. During different stages of treatment process, such as physical, chemical, physical-chemical, bio-chemical or complex treatment, some residues - solid admixtures are produced. Sewerage residues represent one of the most significant polluters of environment, which after decomposition generate huge spectrum of different harmful substances, including significant amount of greenhouse gases.

Centralized sewerage systems are operational only in 45 cities of Georgia. Most of them are constructed in 80s and do not meet technical standards due to frequent system malfunctions. Only 33 cities of Georgia have sewage treatment plants operational with total estimated capacity of 1640.2 thousand m^3/day, and most of them are also outdated. Only 26 cities have biological treatment facilities with total

[28] http://www.mrdi.gov.ge/ge/news/press/53871b3f0cf2f176b8222cf3
[29] http://waste.gov.ge/admin/editor/uploads/files/2013%20-%20Six%20Month%20amosabechdi.pdf
[30] http://www.ambebi.ge/regionebi/78825-quthaisshi-akhali-nagavsayreli-2016-tslidan-amoqmeddeba.html
[31] http://www.ambebi.ge/regionebi/78825-quthaisshi-akhali-nagavsayreli-2016-tslidan-amoqmeddeba.html
[32] http://www.mrdi.gov.ge/ge/news/press/52a3534be4b073169dbbb7ac
[33] http://www.waste.gov.ge/admin/editor/uploads/files/prezentacia%20parlamentistvis.pdf

estimated capacity of 1476.6 thousand m³/day, but with the exception of Batumi and Gardabani, are out of order and ceased (including Kutaisi[34]).

Share of sectors, polluting waste waters are ranged as following: water supply and sewage system – 344.1 million m³/sec (67%); thermal energy generation – 163.8 million m³/sec (31%); industry – 9.6 million m³/sec (2%)[35].

Central sewerage collection system collects sewage waters in Kutaisi, while treatment is carried out at Patriketi treatment plant. The treatment facility occupies 14 ha and is operational since 80s[36]. It serves only Kutaisi.

One of the most acute problems of Kutaisi is pollution of surface waters with municipal, industrial, and drainage waters[37].

In any of enterprises operational in Kutaisi the waste waters are not sufficiently treated, that leads to pollution of rivers with municipal and industrial waste. The most significant polluting factors for river Rioni - main sanitary artery of the city -is the Kutaisi municipal waste waters. The municipal waters flow to the Patriketi treatment plant, but due to its flawed operation, the waters from the collector flow directly to the river through the emergency drain inlet. River Rua crosses the city districts not equipped with sewerage system. Municipal waters discharged to the river through the drain system cause significant pollution. Besides that the river is polluted with municipal waste.

82% of Kutaisi is provided with sewage system, though 40% of the system needs rehabilitation[38].

Municipal waste water treatment plant of the city located in village Patriketi of Tskaltubo municipality has not been properly operating for years (only mechanical treatment takes place) that causes pollution of Rioni river[39].

Length of the Kutaisi sewage network is about 280 km. It is constructed with different materials, such as ceramics, asbestos, ferroconcrete, cast iron, and polyethylene pipes. Diameter of sewage network pipes varies from 150 mm to 1 000 mm. The system is self-flowing (uses gravity). It connects to the ferroconcrete collector of 17 km in length and 1 500 mm in diameter. Water flows to Patriketi treatment plant from the collector.

Until 1990 the mechanical, as well as biological treatment and chlorination was being conducted at the treatment plant (with capacity 110 000 m³/day). For today only mechanical treatment is carried out there. 90 000 m³/day of waste waters are being discharged into Rioni River on average[40].

To reduce impact of residual and commercial waste waters on environment, first of all, it is necessary to reconstruct the waste water treatment plant. From one hand it will increase production of methane, but from the other hand it will decrease pressure on the environment. Taking into account, that without

[34]Only mechanical treatment is carried out in Kutaisi.
[35]http://ekofact.com/2010/05/30/76/
[36]http://ekofact.com/2010/05/30/76/
[37]http://29skola.ucoz.com/news/zedap_39_iruli_ts_39_qlebi/2013-11-14-5
[38]http://nala.ge/uploads/kutaisi.pdf

[39]http://nala.ge/uploads/kutaisi.pdf
[40]ქ. ქუთაისის მერია

reconstruction only small amount of methane is released from the existing waste water treatment plant, the first priority recommendation would be a full reconstruction of it to mitigate the impact on local environment, soil and ground waters, and only in case of reconstruction to recognize it in the Kutaisi Sustainable Energy Action Plan as a methane emission source.

7.2 Methodology

To calculate methane emissions from landfills two methods are suggested by IPCC guidelines: default (level 1) and FOD (level 2) methods. Default method is a simple mass balance calculation which estimates the amount of CH4 emitted from the solid waste disposal sites (SWDS) assuming that all CH4 is released the same year the waste is disposed of. The other method outlined in the IPCC Guidelines is the so-called First Order Decay (FOD) method. The FOD method takes the time factors of the degradation process into account, and produces annual emission estimates that reflect this process, which can take years, even decades. The default method can be successfully used if there is a constant amount and composition of waste disposed to a landfill, or if the variations are insignificant during several decades. In case of rapid changes in waste amount and composition that evidently is connected to carbon content, use of the default method is not recommended.

To calculate methane emissions from the Kutaisi landfill the FOD method (level 2) was applied. The relevant formulas and parameters are given below.

Level 2: First Order Decay Method (FOD)

Level 2: First Order Decay Method

$$M^{G}_{CH4}(t) = \sum_{x=1}^{x=t}[(A \bullet k \bullet MSW_T(x) \bullet MSW_F(x) \bullet MCF(x) \bullet DOC(x) \bullet DOC_F(x) \bullet F \bullet 16/12)] \bullet e^{-k(t-x)},$$

$$M^{E}_{CH4}(t) = [M^{G}_{CH4}(t) - R(t)] \bullet (1 - OX), \qquad (2)$$

Where:

$M^{G}_{CH4}(t)$ = is methane amount produced in t year, while $M^{E}_{CH4}(t)$ - is finally emitted methane amount

$MSW_T = Pop \bullet GR.$

MSW_T - is total Municipal Solid Waste

Pop –population number producing waste disposed to landfill

GR - municipal solid waste production norm

MSW_F - share of the Municipal Solid Waste in total waste disposed at landfill

MCF - methane correction factor

DOC - degradable organic carbon

DOC_F - fraction DOC dissimilated

F-fraction of CH4 in landfill gas

R -recovered CH4

OX-oxidation factor

t – year of inventory

x– previous year (with respect to)

$k=ln(2)/t_{1/2}$ - methane generation speed constant; $t_{1/2}$ - half-life

$\boldsymbol{A=(1-e^{-k})/k}$ - normalization coefficient correcting the sum calculation

Activity data

Waste generation, which is being disposed or used to be disposed to landfills

According to data of the year of 2012, population of Kutaisi was 196 600 persons. After the II World War the city population was constantly increasing (by 2.28% yearly in average), but since 1989 it started decreasing (by 1.73 % yearly in average). Since 2005 it showed a trend of increasing again, though at lower rates (0.82% in average) to compare with the last century data (until 1989) (Table 40). Kutaisi population densityis 2 800 persons per square kilometer, exceeding 40 times the corresponding average

Table 40. **Factual, interpolated (*) and predictedvalues for Kutaisi population (2014 -2020)** provides actual, interpolated and predicted values of Kutaisi population from 1956 to 2020.

Table 40. Factual, interpolated (*) and predicted[41] values for Kutaisi population (2014 -2020)

Year	Population number	Year	Population number	Year	Population number	Year	Population number	Year	Population, persons
1956*	111 269	1969*	156 130	1982*	205 033	1995*	211 028	2008	188 600
1957*	113 846	1970*	159 840	1983*	208 959	1996*	207 447	2009	190 700
1958*	116 423	1971*	163 550	1984*	212 884	1997*	203 867	2010	193 600
1959	119 000	1972*	167 270	1985*	216 809	1998*	200 286	2011	195 700
1960*	122 720	1973*	170 980	1986*	220 734	1999*	196 706	2012	196 600
1961*	126 430	1974*	174 690	1987*	224 660	2000	193 126	2013	196 500
1962*	130 140	1975*	178 400	1988*	228 585	2001	189 545	2014	197 483
1963*	133 850	1976*	182 120	1989	232 510	2002	185 965	2015	198 470
1964*	137 560	1977*	185 830	1990*	228 930	2003	184 300	2016	199 462
1965*	141 280	1978*	189 550	1991*	225 349	2004	184 200	2017	200 460
1966*	144 990	1979	193 258	1992*	221 769	2005	187 300	2018	201 462
1967*	148 700	1980*	197 183	1993*	218 188	2006	189 900	2019	202 469
1968*	152 420	1981*	201 108	1994*	214 608	2007	189 200	2020	203 482

[41] Prediction for 2014-2020 has been made based on assumption of 0.5% increase used also for other sectors.

According to data provided by the Municipality, 48 000 households are registered as users of the Kutaisi landfill. It is approximately 114 000 persons, that comprises 58% of Kutaisi population. Taking into account, that additional 4 300 subscribers are registered in the local cleaning service database as commercial users, total number of city landfill[42] uses reaches 60% of Kutaisi population.

Besides 60% of Kutaisi population, waste from Tskaltubo and Bagdadi has been also disposed to the landfill since 1994. For instance in 2012 the waste amount from Tskaltubo and Bagdadi was 18 000 m^3 and 12 000 m^3 correspondingly. As precise data on population segment, generating the waste, disposed to the landfill is not available, the total population (of those municipalities) data was taken. Based on Kutaisi data, the waste generated per 1 person for 2012 was calculated (200 000 m^3/(114 000+4 300)=1.7 m^3), that equals to 1.7 m^3, i.e. 338 kg[43](1m^3-0.2 t). Based on the assumption that in 2012, waste per person value in the region was the same, the number of population in Tskaltubo (10 588) and Bagdadi (7 058), which disposed the waste to Kutaisi landfill in 2012 was calculated. For Tskaltubo in 2012 it was 14% of total population and for Bagdadi – 24% (Table 41. Population number in Tskaltubo and Bagdadi municipalitiesTable 41). Finall result shows 45% (135 947 persons)of the total population(299500) of all three cities disposed waste to the Kutaisi landfill.

It should be noted that statistical data on population rates in Tskaltubo and Bagdadi municipalities are available only started from 2002 and the data is given below in Table 41.

Table 41. Population number in Tskaltubo and Bagdadi municipalities[44]

Municipality	Year Thousand persons														
	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014
Bagdadi	NDA	NDA	29.2	29	28.7	28.4	29	28.8	28.6	28.5	28.7	28.8	28.8	28.6	28.5
Tskaltubo	NDA	NDA	73.9	73.4	72.9	72.7	73.9	73.6	73.2	73	73.6	73.8	74.1	73.6	73.5

NDA – No Data Available

[42]Commercial users are considered as regular citizens

[43] Equals to 0.9 kg/day/person, that is close the same parameters in South Europeans countries located at the same geographical latitude

[44]http://www.geostat.ge

Characteristics of waste generation and disposal processes

As it was mentioned above, Kutaisi landfill serves city of Kutaisi, Tskaltubo[45] and Bagdagi[46] municipalities. According to 2012 data the Kutaisi landfill receives yearly (population, industrial enterprises, other institutions) around 200 000 m^3 of waste from Kutaisi, 18 000 m^3 from Tskaltubo municipality, and 12 000 m^3 from Bagdadi municipality[47]. According to information received from Kutaisi City Hall, since 1994, the waste from Tskaltubo and Bagdadi was disposed to the Nikea landfill. Based on the above mentioned information, from 1956 until 1994, the landfill received waste generated only in Kutaisi. It was assumed that in 1956 waste generated by only 30% of population was disposed at the landfill. This value increased to 37% in 1993. Besides that, an investigation conducted by GIZ in 2013 showed, that the yearly amount of waste generated per person in Tbilisi in 2013 was 271 kg (less than the European statistic data, according to which the waste amount generated in 2010 was 524kg/person/year[48]. It was assumed that 271 kg of waste per person was a proper value for Kutaisi as well as for the region for the period, including 2003. Based on these assumptions the amount of waste in 1956 – 1993 has been calculated. In 1994 two more cities were involved into this process – Tskaltubo and Kutaisi.

It is also known, that the amount of waste has increased within the last decade by 30% in Tskaltubo, 5 times in Bagdadi and 1,5 times in Kutaisi[49].

Since 2000 the amount of waste, in comparison to 2012, was 1.5 times less (133 333 m^3) in Kutaisi, 30 % less in Tskaltubo (13 846 m^3), and 5 times less (2 400 m^3) in Bagdadi, the total amount in 2000 can be calculated as 149 579.5 m^3 (29 915 897 kg, 1m^3 – 0.2 t). Assuming that for this period a calculation 271kg of waste/person is still valid, the total population number supplying the landfill will be 110 391 persons (29 915 897/271), i.e., 37% of the population of all three cities. Taking into account that 37% of all three cities were connected to the landfill in 2000, an assumption was made that the waste generated by 25% of population of all three cities was disposed at the Kutaisi landfill. Waste per person is assumed to be 271 kg in a year, including 2003. After 2003 the share of population connected to the landfill has increased from 37% in 2003 to 45% in 2012. If in 2003 waste generated per person was 271 kg, in 2012 this parameter is increased to 338 kg, and it is predicted to be the same until 2020.

Since 2003, percentage of population connected to the landfill has been increasing and from 37% in 2000 it reached 45% in 2012, while the amount of waste per person was gradually increasing from 271 kg to 338kg and as it was assumed, will remain the same until 2020.

Increased ratio of population, connected to landfills from 1956 to 2012 is calculated by common interpolation method and taking into account the above mentioned assumption. Changes in percentage of the connected population are given in Table 43, showing that 1.3 million tons of waste has been disposed during 56 years (1956 - 2012).

[45] http://nala.ge/uploads/ckaltubo.pdf
[46] http://nala.ge/uploads/bagdati.pdf
[47] Kutaisi City Hall
[48] The European environment – state and outlook 2010: Synthesis, European Environment Agency, Published: 29 Nov 2010, Copenhagen, p.73 http://www.eea.europa.eu/soer/synthesis/synthesis
[49] Kutaisi City Hall

Table 42. Factual and interpolated amounts of population generating waste disposed at the Nikea landfill and the factual and interpolated amounts of waste disposed at the Nikea landfill

Year	Total population of a city				Population share generating waste disposed at the landfill		Waste, t
	Kutaisi	Bagdadi	Tskaltubo	Three cities	%	Sum	
1956	111 269	0	0	111 269	30	33 381	9 046.17
1957	113 846	0	0	113 846	30.19	34 369	9 314.05
1958	116 423	0	0	116 423	30.38	35 367	9 584.58
1959	119 000	0	0	119 000	30.57	36 375	9 857.75
1960	122 720	0	0	122 720	30.76	37 745	10 228.83
1961	126 430	0	0	126 430	30.95	39 125	10 602.88
1962	130 140	0	0	130 140	31.14	40 519	10 980.74
1963	133 850	0	0	133 850	31.32	41 928	11 362.41
1964	137 560	0	0	137 560	31.51	43 350	11 747.88
1965	141 280	0	0	141 280	31.7	44 790	12 138.01
1966	144 990	0	0	144 990	31.89	46 240	12 531.10
1967	148 700	0	0	148 700	32.08	47 705	12 927.99
1968	152 420	0	0	152 420	32.27	49 187	13 329.55
1969	156 130	0	0	156 130	32.46	50 679	13 734.06
1970	159 840	0	0	159 840	32.65	52 186	14 142.36
1971	163 550	0	0	163 550	32.84	53 707	14 554.47
1972	167 270	0	0	167 270	33.03	55 245	14 971.29
1973	170 980	0	0	170 980	33.22	56 793	15 391.01

1974	174 690	0	0	174 690	33.41	58 356	15 814.54
1975	178 400	0	0	178 400	33.59	59 933	16 241.88
1976	182 120	0	0	182 120	33.78	61 527	16 673.93
1977	185 830	0	0	185 830	33.97	63 132	17 108.88
1978	189 550	0	0	189 550	34.16	64 755	17 548.56
1979	193 258	0	0	193 258	34.35	66 387	17 990.94
1980	197 183	0	0	197 183	34.54	68 109	18 457.43
1981	201 108	0	0	201 108	34.73	69 845	18 927.94
1982	205 033	0	0	205 033	34.92	71 596	19 402.48
1983	208 959	0	0	208 959	35.11	73 362	19 881.15
1984	212 884	0	0	212 884	35.3	75 143	20 363.74
1985	216 809	0	0	216 809	35.49	76 939	20 850.35
1986	220 734	0	0	220 734	35.68	78 749	21 341.00
1987	224 660	0	0	224 660	35.87	80 575	21 835.76
1988	228 585	0	0	228 585	36.05	82 415	22 334.45
1989	232 510	0	0	232 510	36.24	84 270	22 837.17
1990	228 930	0	0	228 930	36.43	83 406	22 602.92
1991	225 349	0	0	225 349	36.62	82 527	22 364.90
1992	221 769	0	0	221 769	36.81	81 636	22 123.31
1993	218 188	0	0	218 188	37	80 730	21 877.95
1994	214 608	29 200	73 900	317 708	25	79 427	21 524.72
1995	211 028	29 200	73 900	314 128	27	84 815	22 984.75
1996	207 447	29 200	73 900	310 547	29	90 059	24 405.89
1997	203 867	29 200	73 900	306 967	31	95 160	25 788.30
1998	200 286	29 200	73 900	303 386	33	100 117	27 131.81
1999	196 706	29 200	73 900	299 806	35	104 932	28 436.60

2000	193 126	29 200	73 900	300 526	37	111 195	30 133.74
2001	189 545	29 200	73 900	296 945	37.75	112 097	30 378.22
2002	185 965	29 200	73 900	293 365	38.5	112 946	30 608.24
2003	184 300	29 000	73 400	291 000	39.25	114 218	30 952.94
2004	184 200	28 700	72 900	290 100	40	116 040	39 221.52
2005	187 300	28 400	72 700	292 700	40.75	119 275	40 315.03
2006	189 900	29 000	73 900	297 100	41.5	123 297	41 674.22
2007	189 200	28 800	73 600	295 900	42.25	125 018	42 256.00
2008	188 600	28 600	73 200	294 700	43	126 721	42 831.70
2009	190 700	28 500	73 000	296 500	43.75	129 719	43 844.94
2010	193 600	28 700	73 600	300 200	44.5	133 589	45 153.08
2011	195 700	28 800	73 800	302 600	45.25	136 927	46 281.16
2012	196 600	28 800	74 100	303 800	45.92	139 748	47 234.82

To define future increase of waste generation, an assumption was made, that besides a yearly 0.5% increase of population, there would be 2% increase of population from all three cities connected to landfills, while waste generated per person would remain 338 kg.

With the mentioned assumption there were discussed two scenarios: 1) the landfill is closed in 2016 and no waste is disposed after 2017, and 2) the landfill is operating until 2020.

Prognosis calculations for both assumptions were carried out for total population of all three cities and the population connected to the landfill separately. Results are given in Table 43 and Table 44.

Table 43. Total population and population connected to the landfill are increasing until 2016, and then the landfill will be closed

Year	Factual (2012, 2013) and predicted population number	Factual (2012) and predicted number of population/user generating waste disposed to landfill	Factual (2012) and predicted waste amount (kg)

		%	People	
2012	303 800	45.92	139 505	46 000 000
2013	303 000	47.92	145 198	49 072 420
2014	304 515	49.92	152 014	51 376 303
2015	306 038	51.92	158 895	53 701 999
2016	307 568	53.92	165 841	56 049 667
2017	309 106	0	0	0
2018	310 651	0	0	0
2019	312 204	0	0	0
2020	313 765	0	0	0

Table 44. Total population and population connected to landfill are increasing until 2020 and the landfill continues operating

Year	Factual (2012, 2013) and predicted population number	Factual (2012) and predicted number of population/user generating waste disposed to landfill		Factual (2012) and predicted waste amount (kg)
		%	People	
2012	303 800	45.92	139 505	46 000 000
2013	303 000	47.92	145 198	49 072 420
2014	304 515	49.92	152 014	51 376 303
2015	306 038	51.92	158 895	53 701 999
2016	307 568	53.92	165 841	56 049 667
2017	309 106	55.92	172 852	58 419 469
2018	310 651	57.92	179 929	60 811 568

2019	312 204	59.92	187 073	63 226 128
2020	313 765	61.92	194 283	65 663 312

Waste composition

Comprehensive/precise data on composition of municipal waste is not available. The only available data is composition percentages, which comes from single survey, conducted in Tbilisi (2013, GIZ) and Batumi (EU) municipalities. There is certain difference between the waste compositions of these two cities, and taking into account, that Batumi is a touristic city and the waste of Batumi and Kutaisi would differ significantly, it was decided to use Tbilisi data for calculations (2003, GIZ). There are some other sources for waste composition, but all of them are based on measurements of 2003. According to some of existing sources waste composition has changed compare to 1989-1990. In particular, fraction of organic waste (paper, carton) and metal has decreased, while plastic fraction is significantly higher[50] (Table 45).

Table 45. Composition of municipal waste in Tbilisi[51]

Fraction	1990	kg	
	m^3 [52]	2003 [52][53]	2010 [52]
Paper	34	5	6
Plastic material	2	6	6
Inert material	4	5.5	5
Mixed	NDA	1	1
Metal	5	3	3
Green waste	NDA	3	3
Hygienic waste	NDA	2	2
Textile/leather	5	3	3
Small/residue fraction	8	27.8	NDA
Organic waste	42	43.7	71

[50] http://geocities-tbilisi.ge/failebi/2388-Introduction.pdf

[51] 2003 - "2003, GIZ" ; 1990 and 2010- "*GEO*-cities Tbilisi: Integrated Assessment of State and Trends in Capital of Georgia"; http://geocities-tbilisi.ge/failebi/2388-Introduction.pdf

[52] Kutaisi City Hall

[53] GIZ, Analysis of waste produced in Tbilisi, 2003

As it is shown in Table 45, there is a waste fraction, consisting most probably of organic substances in the data for 1900 and 2003 (while comparing data of 2003 and 2010, it can be seen that the sum of small/residue fraction and organic fraction in 2003 equals to organic fraction in 2010). Calculations were made based on the assumption, that the small/residue and organic fractions in 1990 and 2003 are united in one - organic fraction in 2010.

Data of 1990[54] given in volume units were transformed into weight units[55], while for the interim years the data were interpolated. Table 46 shows the interpolated data on waste composition for different years that was used for calculation.

[54] http://geocities-tbilisi.ge/failebi/2388-Introduction.pdfandGIZ, Analysis of waste produced in Tbilisi, 2003

[55] Mean density of waste fractions: paper –63kg/m^3; plastic–55kg/m^3;
Inert material- 435kg/m^3; metal–165kg/m^3; textile/leather– 56kg/m^3; organic waste– 330kg/m^3 (GIZ, Analysis of waste produced in Tbilisi, 2003)

Table 46. Waste composition (factual data for 1990, 2003, and 2010 and interpolated data for the rest of the years)

Year	Mass of fraction								
	Paper	Plastic material	Inert material	Metal	Textile leather	Organic waste	Mixed	Green waste	Hygienic waste
1990	10.5	0.5	8	4	1.4	75.6	0	0	0
1991	10.08	1	7.85	3.92	1.52	75.28	0.04	0.23	0.15
1992	9.65	1.4	7.7	3.85	1.65	74.97	0.08	0.46	0.31
1993	9.23	1.8	7.55	3.77	1.77	74.65	0.12	0.69	0.46
1994	8.81	2.2	7.4	3.69	1.89	74.34	0.15	0.92	0.62
1995	8.38	2.6	7.25	3.62	2.02	74.02	0.19	1.15	0.77
1996	7.96	3	7.1	3.54	2.14	73.71	0.23	1.38	0.92
1997	7.54	3.4	6.95	3.46	2.26	73.39	0.27	1.62	1.08
1998	7.12	3.8	6.8	3.38	2.38	73.08	0.31	1.85	1.23
1999	6.69	4.2	6.65	3.31	2.51	72.76	0.35	2.08	1.38
2000	6.27	4.6	6.5	3.23	2.63	72.45	0.39	2.31	1.54
2001	5.85	5	6.35	3.15	2.75	72.13	0.42	2.54	1.69
2002	5.42	5.4	6.2	3.08	2.88	71.82	0.46	2.77	1.85
2003	5	6	6	3	3	71.5	0.5	3	2

2004	5.14	6	5.86	3	3	71.43	0.57	3	2
2005	5.29	6	5.71	3	3	71.36	0.64	3	2
2006	5.43	6	5.57	3	3	71.29	0.71	3	2
2007	5.57	6	5.43	3	3	71.21	0.79	3	2
2008	5.71	6	5.29	3	3	71.14	0.86	3	2
2009	5.86	6	5.14	3	3	71.07	0.93	3	2
2010	6	6	5	3	3	71	1	3	2

Waste management practice in Georgia is at the initial stage. Consequently, there is no reliable information on waste composition in the country, especially data for separate cities. Hence, the best solution is to calculate the Kutaisi greenhouse emissions from solid waste disposal sites, bases on Tbilisi data. High share of organic waste according to Table 46 would increase generation potential of greenhouse gases and consequently, methane generation, if this value is reliable.

Theoretical and practical work conducted by the Institute of Hydrometeorology of Technical University of Georgia at the new landfill in Tbilisi (Norio) showed, that though calculation results of theoretic data were quite high, real measurements of produced methane were even a bit higher[56].

Thus, it can be suggested, that despite the different composition of waste in different countries, the investigation data on composition of waste, generated in Georgia waste and the selected default values are close to actual data.

Emission factors

Different factors are to be used for calculation of methane emission from solid waste:

Methane Correction Factor – MCF - depends on a landfill type. Unmanaged landfills produce less amounts of methane than managed ones, because decomposition of the most of waste in upper layers of that type of landfills runs in aerobic conditions, releasing carbon dioxide. IPCC 1996[57] gives default values of the correction factor which are given in Table 47.

Table 47. Default values of methane emission correction factor (MCF) for different landfill types

Landfill type/landfill	Average thickness of waste (m)	MCF
Managed[58]		1
Managed-thin[59]	Waste thickness <5 m	0.5

[56]Report on greenhouse gas emissions in Georgia, 2006 – 2011

[57]1996 IPCC Guidelines for National Greenhouse Gas Inventories, http://www.ipcc-nggip.iges.or.jp/public/gl/pdfiles/rusch6-1.pdf(p. 6.8)

[58]Managed landfill is an area where waste is disposed and kept under control (waste is disposed at specially prepared areas where it is protected from self-ingition). Waste is covered, rammed and disposed in layers. Good Practice Guidance and Uncertainty Management in National Greenhouse Gas Inventories, 2000, p. 5.9

[59]2006 IPCC Guidelines for National Greenhouse Gas Inventories, http://www.ipcc-nggip.iges.or.jp/public/2006gl (p.3.16)

Unmanaged – deep	Waste thickness>5 m	0.8
Unmanaged – shallow	Waste thickness <5 m	0.4
Uncategorized landfills		0.6
Kutaisi	**15**	**0.8**

Kutaisi landfill, like most of the landfills in Georgia (except Tbilisi and Rustavi landfills), is unmanaged, and it is deep. As it was noted earlier, the depth of waste is 12 -15 m on average. There is no drainage system at the landfill; no systematic treatment of waste, such as covering with soil layer, is conducted (sometimes construction waste from the city is disposed at the landfill). The only treatment measure conducted at the landfill is ramming with Komatsu bulldozers.

Taking into account, that Kutaisi landfill belongs to an unmanaged category of landfills, it is deeper than 5m (>5) and its depth is up to 15m, the methane correction factor 0.8 was taken for calculation (Table 47).

Degradable organic carbon – DOC

Degradable organic carbon - DOC is a constituent part of waste, which decomposes boicemically and is measured in mg C /mg.

Value of DOC- depends on waste composition and climate conditions of a country. IPCC guidelines were used to calculate DOC values for waste component[60].DOC values according to waste composition are given in Table 48.

Table 48. DOC values according to waste composition

Waste composition	DOC
Food waste	0.15
Garden	0.2
Paper	0.4
Wood and straw	0.43
Textile	0.24
Single use pads	0.24

[60] 2006 IPCC Guidelines for National Greenhouse Gas Inventorieshttp://www.ipcc-nggip.iges.or.jp/public/2006gl (ვა. 2.16)

Fraction of degradable organic carbon dissimilated -DOC_F

Some part of organic carbon does not degrade, or degrades very slowly. IPCC GPG presents recommended values for DOC_F– 0.5 – 0.6 (in this case it is supposed that there are anaerobic conditions at the landfill and DOC_F value contains also lignin[61] carbon). DOC_F value depends on many factors, such as temperature, humidity, pH, waste composition, etc.

According to IPCC GPG, it is recommended to use national values, though they should be based on well documented survey.

For maximum uptaking/degradability of lignin-cellulose containing substances the Van Soest logarithmic-linear relation was used basing on Barla's experimental data[62]. For mixed waste (municipal solid waste) DOC_F was calculated using the formula:

$$DOC_F = (DOC_1 \bullet DOC_{F1} + DOC_2 \bullet DOC_{F2} + \cdots + DOC_N \bullet DOC_{FN}) / DOC,$$

where N is the number of different waste types.

$(DOC_F)_{w/o\ lignin}$ was calculated using the formula [63]:

$$(DOC_F)_{w/o\ lignin} = DOC_F \bullet DOC / DOC_{w/o\ lignin}.$$

For calculations we used IPCC 2006 level 2 software, which automatically calculates all necessary parameters.

Content of methane in landfill gas (F)

According to IPCC 2006, the content of methane in landfill gas is 50% of the volume. Only oil and fat containing material produces bio-gas with a higher content of methane.

Oxidation coefficient (OX) denotes the quantity of methane produced in the material used for covering the waste (soil, or other). In case of managed landfill (where waste is covered by oxidizing substances – soil, compost) OX equals 0.1, while in unmanaged landfills OX = 0[64]. Accordingly, for the Kutaisi landfill it was assumed that OX = 0.

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[61]Plant cells contain three significant components: cellulose, lignin, and hemicellulose. Lignin supplies cell walls and connects cells. Decomposition of lignin is aerobic process. Lignin decomposition in anaerobic conditions is a very long process.

[62]Chandler, J.A., W.J. Jewell, J.M. Gossett, P.J. Van Soest, and J.B. Robertson. 1980. Predicting methane fermentation biodegradability. Biotechnology and Bioengineering Symposium No. 10, pp. 93-107; Richard T. The Effect of Lignin on Biodegradability."Cornell Composting - Science & Engineering, 1996, www.css.cornell.edu/compast/calc/lognin.htme

[63]Chandler, J.A., W.J. Jewell, J.M. Gossett, P.J. Van Soest, and J.B. Robertson. 1980. Predicting methane fermentation biodegradability. Biotechnology and Bioengineering Symposium No. 10, pp. 93-107; Richard T. The Effect of Lignin on Biodegradability."Cornell Composting - Science & Engineering, 1996, www.css.cornell.edu/compast/calc/lognin.htme

[64]Good Practice Guidance and Uncertainty Management in National Greenhouse Gas Inventories, 2000, p. 5.10. http://www.ipcc-nggip.iges.or.jp/public/gp/english/index.html (p.5.10)

7.3 Baseline year inventory and greenhouse gas emissions base scenario (2012-2020)

According to the project of the Solid Waste Management Company, the Kutaisi landfill will be closed in 2016, and methane emissions will consequently be decreased. Table 49 shows methane emission prognosis after closing of the Kutaisi landfill (2016). The mentioned calculations have been conducted based on an assumption, that the existing waste would remain at the landfill and methane would not be utilized.

Table 49. Nikea landfill and methane emission in 2012 – 2036 (in case of closing in 2016)

Year	Gg/Year	Kg/Year	m^3/Year	m^3/day
2012	1.76	1 757 700.00	2 441 250.00	6 688.36
2013	1.82	1 818 000.00	2 525 000.00	6 917.81
2014	1.88	1 882 600.00	2 614 722.22	7 163.62
2015	1.95	1 953 400.00	2 713 055.56	7 433.03
2016	2.03	2 029 600.00	2 818 888.89	7 722.98
2017	2.11	2 110 600.00	2 931 388.89	8 031.20
2018	1.81	1 809 300.00	2 512 916.67	6 884.70
2019	1.56	1 555 800.00	2 160 833.33	5 920.09
2020	1.34	1 342 200.00	1 864 166.67	5 107.31
2021	1.16	1 162 000.00	1 613 888.89	4 421.61
2022	1.01	1 009 700.00	1 402 361.11	3 842.09
2023	0.88	880 700.00	1 223 194.44	3 351.22
2024	0.77	771 200.00	1 071 111.11	2 934.55
2025	0.68	678 100.00	941 805.56	2 580.29
2026	0.6	598 800.00	831 666.67	2 278.54
2027	0.53	530 900.00	737 361.11	2 020.17
2028	0.47	472 700.00	656 527.78	1 798.71
2029	0.42	422 700.00	587 083.33	1 608.45
2030	0.38	379 600.00	527 222.22	1 444.44
2031	0.34	342 300.00	475 416.67	1 302.51

2032	0.31	309 800.00	430 277.78	1 178.84
2033	0.28	281 600.00	391 111.11	1 071.54
2034	0.26	256 800.00	356 666.67	977.17
2035	0.24	235 100.00	326 527.78	894.6
2036	0.22	215 900.00	299 861.11	821.54

Accoring to obtained data (Table 49), it can be suggested that in case of implementation of the project and if the landfill is closed in 2016, then methane emission from the closed landfill in 2020 will be 1.34 Gg. If the landfill will continue operating, methane emission from the operational landfill will be 2.38 Gg by 2020 (Table 50).

Table 50. Methane emission from Nikea landfill in 2012 – 2016 (in case of operation)

Year		Kg/Year	m^3/Year	m^3/Day
2012	1.76	1 757 700.00	2 441 250.00	6 688.36
2013	1.82	1 818 000.00	2 525 000.00	6 917.81
2014	1.88	1 882 600.00	2 614 722.22	7 163.62
2015	1.95	1 953 400.00	2 713 055.56	7 433.03
2016	2.03	2 029 600.00	2 818 888.89	7 722.98
2017	2.11	2 110 600.00	2 931 388.89	8 031.20
2018	2.2	2 195 700.00	3 049 583.33	8 355.02
2019	2.28	2 284 700.00	3 173 194.44	8 693.68
2020	2.38	2 376 900.00	3 301 250.00	9 044.52
2021	2.47	2 472 200.00	3 433 611.11	9 407.15
2022	2.58	2 577 000.00	3 579 166.67	9 805.94
2023	2.69	2 690 600.00	3 736 944.44	10 238.20
2024	2.81	2 812 400.00	3 906 111.11	10 701.67
2025	2.94	2 942 100.00	4 086 250.00	11 195.21
2026	3.08	3 079 300.00	4 276 805.56	11 717.28

2027	3.22	3 223 800.00	4 477 500.00	12 267.12
2028	3.38	3 375 300.00	4 687 916.67	12 843.61
2029	3.53	3 533 800.00	4 908 055.56	13 446.73
2030	3.7	3 699 100.00	5 137 638.89	14 075.72
2031	3.87	3 871 300.00	5 376 805.56	14 730.97
2032	4.05	4 050 200.00	5 625 277.78	15 411.72
2033	4.24	4 236 000.00	5 883 333.33	16 118.72
2034	4.43	4 428 700.00	6 150 972.22	16 851.98
2035	4.63	4 628 400.00	6 428 333.33	17 611.87
2036	4.84	4 835 100.00	6 715 416.67	18 398.40

7.4 Action Plan for decreasing emissions from the solid waste sector in Kutaisi

In the Kutaisi Sustainable Energy Action Plan only one measure is envisaged in the landfill management sector – establishment of a system for collection and burning of methane at the existing landfill. Implementation of this measure would replace emissions of methane (CH_4) with releasing of carbon dioxide (CO_2) into the atmosphere, which has less dangerous features of a greenhouse gas. The decreased amounts of emissions are calculated for the above mentioned two cases: closing of the landfill in 2016 and continuing operation. It was assumed, that the establishment of a system for collection and burning of methane would take place in 2016.

Table 51. Amount of saved CO_2 in case of implementation of the project.

Year	Gg/Year							
	Closingin in 2016				Operation continues			
	CH_4	CO_2eq	CO_2 produced by burning of 80% of CH4	Saved CO_2	CH_4	CO_2eq	CO_2 produced by burning of 80% of CH4	Saved CO_2
2012	1.76	36.96	0	0	1.76	36.96	0	0
2013	1.82	38.22	0	0	1.82	38.22	0	0
2014	1.88	39.48	0	0	1.88	39.48	0	0
2015	1.95	40.95	0	0	1.95	40.95	0	0

2016	2.03	42.63	0	0	2.03	42.63	0	0
2017	2.11	44.31	4.64	39.668	2.11	44.31	4.64	39.66
2018	1.81	38.01	3.98	34.028	2.2	46.2	4.84	41.36
2019	1.56	32.76	3.43	29.328	2.28	47.88	5.01	42.86
2020	1.34	28.14	2.94	25.192	2.38	49.98	5.23	44.74
2017-2020 Total	6.82	143.22	15	128.21	8.97	188.37	19.73	168.63

In case of development of first scenario, CO_2 emissions will be decreased by 25 Gg (89%), while if second scenario takes place, CO_2 will be decreased by 45 Gg (89,5%). During calculating this data, two assumptions have been made: first, that actually only 80% of methane can be collected and second, that while burning of 1 t of methane, 2.75 t of CO_2 would be released into the atmosphere. In case of implementation of the project (closure of the landfill in 2016), 128 Gg of CO_2 will be reduced in 4 years in total, that corresponds to 89.5%.

Table 52. CO_2 equivalent of the methane emitted from Kutaisi landfill in 2012 – 2020 (without measures undertaken) and CO_2 amount (in case of measures undertaken) according to two scenarios

Measure	**CO_2, Gg**		
	2012	**2020**	
	Operation	**Scenario1** **Closed in 2016**	**Scenario 2** **Operating**
Not undertaken	36.96	28.14	49.98
Undertaken		2.94	5.23

8 Green Spaces

8.1 Sector Overview

State of Kutaisi environment has been significantly worsening during the last period. One of the reasons is a continuing loss of green cover starting from 90s of last century. The city traffic is overloaded, especially downtown, that causes additional problems to the environment.

Kutaisi recreational zone covers 221.4 ha. There are public gardens with total area of 4 ha (4 units), squares with total area of 20.4 ha (107 units), one park of 7 ha, lawns of 21.4 ha and one Botanical Garden with the area of 14.7 ha. Green cover at the city cemeteries occupies 88.8 ha. Green areas adjacent to private houses, living buildings, different offices and institutions, occupy in total 65.1 ha. About 140 thousands wood plants are distributed in the mentioned recreational areas. Most frequently there can be seen following species: Platan, Aspen, Zelkova, Cedar, Cypress, Willow, and Palm. Major part of trees were planted in 50 – 60s of last century. Comprehensive inventory of these plantings has not been conducted and data available for today is not precise. It should be noted, that data on Botanical Garden is more or less full, while data on other recreational areas is poor and scattered. Taking into account this non-comprehensive data, the percent values of high wood trees, where significant part of biomass is concentrated, were used for calculations. Percent values for dominating wood tree species in Kutaisi recreational zones (except Botanical Garden) are given below[65]:

- Platan (Platanus orientalis) - 34%, 70 ha;
- Aspen (Populus)- 19%, 39 ha;
- Cedar (Cedrus deodara)- 13%, 27 ha;
- Pine (Pinus pinaster)- 10%, 21 ha;
- Cypress (Cupressus sempervirens)- 9%, 18 ha;
- Other wood trees- 15%, 31 ha.

As regards to the Botanical Garden, it covers two separately registered areas - one area is located in 2, Leselidze Street (7.5 ha) and another one – near Hotel Khvamli (7.2 ha). Core area of the Botanical Garden is the area at Leselidze Street. It is located on the right bank of Rioni river and occupies three terraces, adjacent to the river. First of the terraces is not planted, because there was no dam for protecting the Garden area from the river. The river used to flood the first terrace periodically. As a result, Rioni washed out part of the terrace and initial 70 m buffer between the Garden and the river decreased to 15 - 20 m.

Main part of the Botanical garden covers 7.05 ha (See Fig. 20) About 5 ha of the whole territory is planted. The rest of the territory is occupied by administrative buildings, amphitheatre, orangery, nursery, squares, pathways, etc. Core area of the Garden is surrounded by some frees (along the river), where it is planned to create a forest-park of about 5 ha.

[65] According to Kutaisi City Hall data

Fig. 20. Ortho-photograph of Botanical Garden with contours of planted areas

Among all plants represented in the Kutaisi Botanical garden, 160 species are evergreen trees and bushes and 518 species are deciduous plants.

Below are listed the most common species, represented in the Botanical Garden of Kutaisi [66]:

- Platan (Platanus orientalis)
- Zelkova (Zelkova)
- European spruce (Picea excelsa)
- Evergreen cypress (Cupressus sempervirens)
- Caucasian hornbeam (Carpinus caucasica)
- Japanese spindle (Euonymus japonica)
- Persian ironwood(Parrotia persica)
- Montezuma Cypress (Taxodium mexicanum)
- Evergreen sequoia (Sequoia sempervirens)
- Japanese cedar (Cryptomeria japonica)
- Sweet viburnum (Viburum odoratissimum)
- False Camphor Tree (Cinnamomum glanduliferum)
- Southern magnolia (Magnolia grandiflora)
- Horse chestnut (Aesculus hippocastanum)
- Japanese quince (Chaenomeles japonica)
- Crape myrtle (Lagerstroemia indica)

[66] ბოტანიკური ბაღის ადმინისტრაციიდან მიღებული მონაცემები

Among the above listed plants some long-boled wood trees should be separately noted, because these trees contain significant part of total biomass of the Garden. Those are: Platan, Zelkova, Horse chestnut, European spruce, Evergreen sequoia and Caucasian hornbeam.

8.2 Methodology

Carbon accumulation and absorption potential of the green cover in Kutaisi and Botanical Garden in the baseline year of 2012 is assessed in IPCC Good Practice 2003, using the given methodology[67].

As for the city greening works - in the later years, increase of the carbon accumulation potential was evaluated using the CO2FIX model[68].

IPCC Methodology

Calculations were carried out using the IPCC-methodology in so called living biomass (including underground biomass). In particular, the calculation of the volume of carbon in the accumulated biomass and its subsequent increase area was carried out using the following equations:

1. The equation used to determine carbon reserves accumulated in the live (underground and above-ground live biomass) biomass:

$\Delta C_{F_{LB}} = [V \bullet D \bullet BEF_2] \bullet (1+R) \bullet CF$

where:

V - Wood volume, m3/ha;

D - Volume weight of the totally dry wood, tons of dry mass/m3;

BEF2-Coefficient for converting the commercial wood stock into the total stock of the aboveground wood plants (including crown), for further determination of the aboveground live biomass.

R - Ratio of root mass to the tree sprout;

CF -Carbon portion in dry substance, ton C/ton dry mass.

2. The equation for calculation of annual increment in carbon storeof the biomass:

$\Delta C_{F_G} = (A \cdot G_{TOTAL}) \cdot CF$

where:

[67]Good Practice Guidance for Land Use, Land-Use Change and Forestry, http://www.ipcc-nggip.iges.or.jp/public/gpglulucf/gpglulucf.html

[68] http://dataservices.efi.int/casfor/frontpage.htm

$\Delta C_{F_{G-}}$ is annual increment of carbon store caused by increase of the biomass, t C/year;

A – area covered by wood plants;

G_{TOTAL} – average annual rates of total biomass increment, tone of dry mass/ha/year;

$G_{TOTAL} = G_W \cdot (1+ R)$,

where:

R - is ratio of plant root mass to sprout.

G_W–aboveground biomass increment, t/dry weight.

When G_W–are not avalable, the following eqation should be used for calculation:

$G_W = I_V \cdot D \cdot BEF_1$,

where:

I_V is biomass average annual increment, m^3/ha/year;

D – volume weight of totally dry wood, tone of dry weight/m^3;

BEF_1- coefficient for converting average annual increment into the total aboveground biomass

Model CO2FIX V 3.1

CO2FIX model was elaborated within the CASFOR II project. CASFOR II was funded by the INCO2 Program of the European Commission. Dutch Ministry of Agriculture, Nature and Food Quality and Mexican National Council on Science and Technology (CONACYT) supported the project additionally.

CO2FIX V 3.1 model determines carbon accumulation volumes in nature by using a so-called accounting methodology. In particular, the model calculates changes in carbon stores in all carbon "reservoirs" of the forests within a concrete period of time (carbon "reservoir" is a part of nature where carbon is stored, such as live biomass, ground bulk, organic soils, and also processed wood resources).

Calculations in six main modules of the CO2FIX V 3.1 model are carried out for one year and one hectare:

1. Biomass module;

2. Soil module;

3. Production module;

4. Bio-energy module;

5. Financial module;

6. Carbon credits counting module (for CDM).

According to the model methodology, carbon accumulation volume (CTt) in each (t) period is calculated as follows:

$C_{Tt} = C_{bt} + C_{st} + C_{pt}$ (Mg C/ha)

Where:

C_{b_t}- total amount of carbon in aboveground and underground biomass of a plant (Mg C/ha);

C_{s_t} - carbon stocks in organic soils (Mg C/ha);

C_{P_t}- carbon stocks in the processed wood products (Mg C/ha)

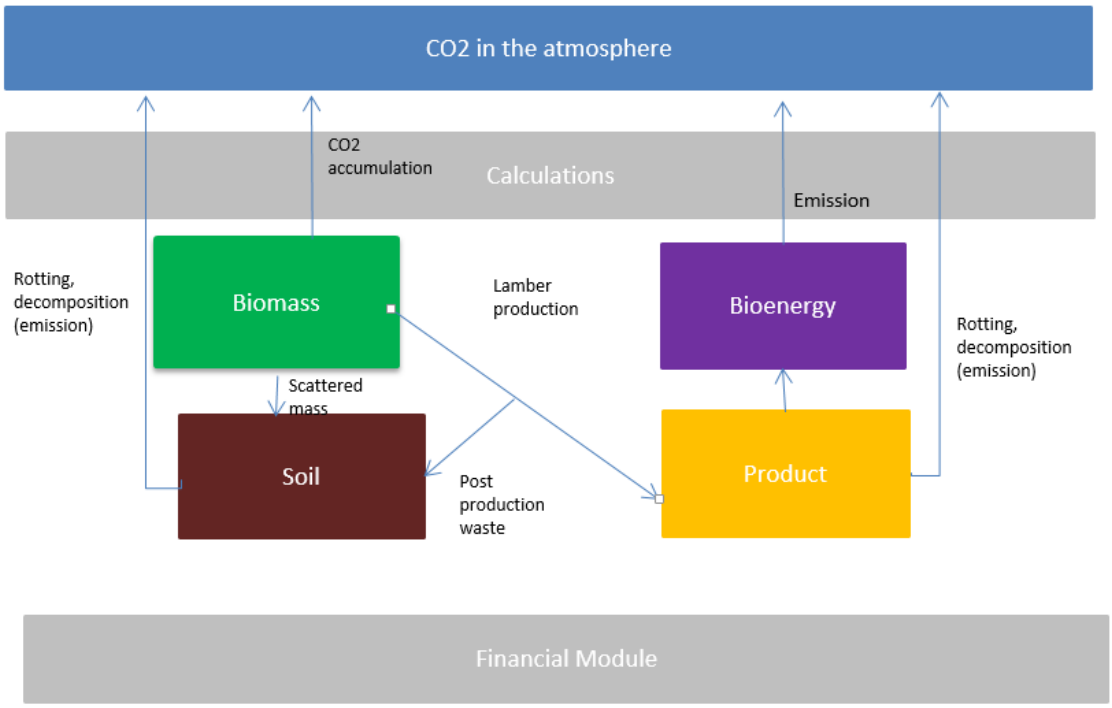

Fig. 21. Model structure

According to the project scenario (rehabilitation/ planting), two modules have been used for calculation: biomass and soil modules.

Biomass module

The biomass module uses a "cohort system", where each cohort consists of one or more wood plant species groups. It is defined as a group of individual trees or as a group of species, which are assumed to exhibit similar growth, drying and other features, and which may be treated as single entities within the model.

Table 53. Necessary and used characteristics in biomass modules according to the project scenario

List of characteristics used in biomass module	Characteristic values
Biomass carbon content	0,5 t C /t dry mass
Wood density, t dry mass	
Poplar	0.353
Cypress	0.542
Paulownia	0.280
Acacia	0.770
Tuya	0.290
Magnolia	0.460
Deer horn	0.620
Oleander	0.255
Initial carbonstock	0tC/ha
Growth correction factor	1.00
Turnover rate	
Conifers	
Needles	0.30
Branches	0.04
Root	0.03
Deciduous	
Leaves	1.00
Branches	0.05
Root	0.08

Soil module

YASSO was chosen as an approach to define carbon dynamics in soil compartment (http://www.efi.fi/projects/yasso/). The model (included in CO2FIX) describes carbon decay and its dynamics in dry soil. It is calibrated for detection of total carbon stock in any soil layers. This model is suitable for coniferous, as well as for deciduous forests and was tested in different countries with different climate zones to describe influence of different climate conditions on decomposition processes of the fallen leaves and branches.

Table 54 Parameters used in soil module

Parameters used in soil module	**Value**
Sum of above zero temperature during the year (C°)	4 150.0
Evapotranspiration (PET,mm)	510.0
Precipitation volume during vegetation(mm);	1 205.0
Monthly average temperature during vegetation period	
March	8.0
April	11.5
May	12.0
June	21.0
July	22.5
August	22.8
September	19.2
October	15.0

8.3 Baseline year inventory

Calculations of carbon reserves and increments, using the mentioned equations, have been conducted for green zones of Kutaisi municipality and Botanical Garden separately.

Some of coefficients for calculations in Kutaisi recreational zones have been taken from data, obtained during the inventory for forest use planning performed in 2009 in forest districts (adjacent to Kutaisi) under administration of the Imereti Regional Forestry Department.

For fragmented planting areas(195.6 ha) within the city recreation zone (221.4 ha) data, corresponding to 50 -60 years old sparse forest stands has been used. While, for the closed canopy stands of recreational zones (11 ha within the city and 5 ha in Botanical Garden, 16 ha in total) medium density forest data has been used (50 – 60 years old trees for the city greening and 80 -120 years old trees for Botanical garden). For calculations, average annual increment and wood plant stock data has been taken, (see Table 54. Coefficients used for calculationsCoefficients used for calculations). For calculation of weighed values / suspended index of the wood volume weight (D), the dominated wood plants stock has been used. Other coefficients (BEF_1, BEF_2, R, CF) were taken from IPCC methodology, specifically, from the standard index list, corresponding to Imereti climate.

Table 54. Coefficients used for calculations

Indexes suitable for calculations	Kutaisi green cover (fragmented and closed canopy stands)		Kutaisi Botanical Garden closed canopy stand
	Fragmented	Closed canopy	
A-Green cover area , ha[69]	195.60	11.00	5.00
V- Wood plants stock m3/ha[70]	47.00	108.00	250.00
D-volume weight of totally dry wood, tone totally dry mass[71] / m^3	0.579	0.590	0.610
I_V- Wood plant mean annual increment, m^3 [72]	1.40	1.80	2.30
BEF_1- Coefficient for conversion of wood mean increment into total aboveground (including crown) mean increment [73]	1.15	1.15	1.15
BEF_2- Coefficient for conversion of commercial wood stock into the total stock of aboveground wood plants (including crown), for calculating further the aboveground living biomass.[74]	1.30	1.30	1.30

[69] Kutaisi City Hall Administration

[70] Imereti Regional Forestry Department, 'Forest Use Plan', 2009

[71] "Global Wood Database"http://datadryad.org; მახვილაძეს.ე. მერქანმცოდნეობა, თბილისი 1962; Боровиков А.М., Уголев Б.Н.. Справочник по древесине. "Лесная Промышленность", Москва, 1989;

[72]ქ.ბათუმის ხე-მცენარეების საშუალო სატაქსაციო მაჩვენებლები; აჭარის ტყის მასივების ინვენტარიზაცია 2004წ.

[73]Good Practice Guidance for Land Use, Land Use Change and Forestry, (IPCC 2003),Table 3A1.10,http://www.ipcc-nggip.iges.or.jp/public/gpglulucf/gpglulucf_files/GPG_LULUCF_FULL.pdf;

[74]Good Practice Guidance for Land Use, Land Use Change and Forestry, (IPCC 2003),Table 3A1.10;

R-Ratio of root mass to sprout[75]	0.24	0.24	0.24
CF-carbon share in dry wood[76]	0.50	0.50	0.50

Calculation data for recreational zones are given in Table 55.

Table 55. Accumulated carbon and annual absorption at the project sites

Kutaisi recreational zones	Recreational zones covered with plantings (ha)	Carbon accumulated in area of 1 ha tC	Carbon accumulated in the city recreational zones tC	Annual deposit of carbon/carbon dioxide		
				Carbon annual sequestration in 1 ha tC	Carbon annual sequestration	Carbon dioxide annual sequestration tCO2
Zones, covered by fragmented planting	195.60	21.60	4 224.90	0.57	112.50	412.50
Zones, covered by closed canopy planting	11.00	51.40	565.40	0.75	8.25	30.20
Botanical Garden	5.00	123.00	615.00	0.95	4.75	17.40
Total weighted average		25.50		0.59		
Sum	211.60		5 395.80		125.50	460.20

Below are given calculations for each site (Botanical Garden, recreational zone, etc.) separately:

Accumulated and annually incremented Carbon in recreation zones of Kutaisi, with fragmented planting (195.6 ha)

[75]Good Practice Guidance for Land Use, Land Use Change and Forestry, (IPCC 2003),Table 3A1.8http://www.ipcc-nggip.iges.or.jp/public/gpglulucf/gpglulucf_files/GPG_LULUCF_FULL.pdf;

[76]Good Practice Guidance for Land Use, Land Use Change and Forestry, (IPCC 2003).http://www.ipcc-nggip.iges.or.jp/public/gpglulucf/gpglulucf.html

Accumulated stocks

$\Delta C_{F_{LB}}$= [V●D●BEF_2] ●(1+R) ●CF =[47●0.57●1.3] ●(1+0.24) ●0.5= 34.8●1.24 ●0.5=**21.6** t**C/**ha**,**

Hence, (195.6 ● 21.6**)=4 225.0tC** is accumulated in Kutaisi recreational zones (fragmented)

Sequestration

Annual carbon sequestration in Kutaisi recreational (fragmented) zones (195.6 ha)

$\Delta C_{F_G}=(A \cdot G_{TOTAL}) \cdot CF$= 195.6 · 1.15 · 0.5=**112.5tC**

$G_{TOTAL} = G_W \cdot (1+ R)$=0.93 ·1.24=1.15;

$G_W = I_V \cdot D \cdot BEF_I$=1.4 ·0.579 ·1.15=0.93;

Hence, annual sequestration in 1 ha recreational zones is **0.57tC/ha**.

<u>Carbon accumulation and annual sequestration in Kutaisi recreational zones, in particular, in closed canopy plantings of 11 ha.</u>

Accumulated stocks

$\Delta C_{F_{LB}}$= [V●D●BEF_2] ●(1+R) ●CF =[108●0.59●1.3] ●(1+0.24) ●0.5= 82.8●1.24●0.5=**51.4tC/ha,**

In recreational (11 ha) zones (closed canopy plantings)is accumulated(11●51.4**) - 565.4 tC.**

Sequestration

Annual carbon sequestration in recreational (11 ha) zones (closed canopy plantings) :

$\Delta C_{F_G}=(A \cdot G_{TOTAL}) \cdot CF$= 11 · 1.5 · 0.5=**8.25tC**

$G_{TOTAL} = G_W \cdot (1+ R)$=1.2 ·1.24=1.5

$G_W = I_V \cdot D \cdot BEF_I$=1.8 ·0.59 ·1.15=1.2

Hence, annual carbon sequestration (closed canopy plantings) in 1 ha of recreational zones is **0.75tC/ha**

<u>Carbon accumulation and annual sequestration in Botanical Garden, in particular, in closed canopy plantings of 5 ha.</u>

Accumulated stocks

$\Delta C_{F_{LB}}$= [V●D●BEF_2] ●(1+R) ●CF =[250●0.61●1.3] ●(1+0.24) ●0.5= 198●1.24●0.5=**123tC/ha;**

Hence, annual carbon accumulation in Botanical Garden (5 ha) is (5●123**)-615 tC**

Increment

Annual sequestration in Botanical Garden (5 ha):

$\Delta C_{F_G}=(A \cdot G_{TOTAL}) \cdot CF= 5 \cdot 1.9 \cdot 0.5=$**4.75tC**

$G_{TOTAL} = G_W \cdot (1+ R)=1.6 \cdot 1.24=1.9$

$G_W = I_V \cdot D \cdot BEF_1=2.3 \cdot 0.61 \cdot 1.15=1.6$

Hence, annual sequestration in Kutaisi botanical garden per 1 ha is **0.95tC/ha**.

Increase of the sequestration potential as a result of greening works, conducted by Kutaisi City Hall in 2014 as well as works, planned for the following years (greening of street curbs (1 ha), forest-park in Botanical Garden (5 ha), and different recreational areas of the city (1 ha)), has been assessed using CO2FIX model.

Preliminary budget has been composed for each work to be carried out within the project proposals. The calculated data has been compared to 2012 baseline year data in the summarizing chapter.

8.4 Kutaisi greening action plan

An annual carbon sequestration potential has been calculated based on the above mentioned data, taking into account works, conducted by the Kutaisi City Hall in 2014, as well as the greening works, planned for the following years.

Activity 1 (Greening of recreational areas planned by the Kutaisi City hall for 2014)

During 2014 it is planned to plant 1250 saplings in different recreational areas of Kutaisi (total area of 1 ha). Detailed budget of the mentioned works is given below in Table 56.

Table 56. Greening works, planned for 2014 in Kutaisi[77].

List of planned works	Quantity	Unit price	Total Price	Total (one year)
Planting of decorative tree saplings	1250	5.00	6,250.00	6,250.00
Spruce. Height 2.2-2.5m	10			805.10

[77]Kutaisi City Hall Public Emenities Service

		80.51	805.10	
Acacia dealbata. Height 2.2-2.5m	30	8.56	256.80	256.80
Cypress. Height 2.2-2.5m	20	53.65	1,073.00	1,073.00
Lagerstroemia nana (pink). Height 2.0-2.2m, with min 3-4 stems	30	27.40	822.00	822.00
Magnolia Stellata. Height 1.5-1.8m	0	-	-	-
Poulownia (decorative). Height 2.0-2.3m	60	28.90	1,734.00	1,734.00
Prunus. Height 2.0-2.2m	0	-	-	-
Tuia (decorative). Height 1.0-1.1m	250	42.37	10,592.50	10,592.50

Carbon accumulation data is given in Table 57. Carbon accumulation dynamics for comming 70 years is shown in graph, plotted according to the model (Fig. 22). It should be noted, that some decrease in accumulation for several species due to necessary trimming (for instance, over 50 years old Poplar trees need trimming) is taken into account.

Table 57. Carbon accumulation and carbon dioxide sequestration indexes after planned greening activities in 2014.

	Sequestered Carbon reforestation	Sequestered Carbon reforestation		Sequestered Carbon reforestation	Sequestered Carbon reforestation		Sequestered Carbon reforestation	Sequestered Carbon reforestation		Sequestered Carbon reforestation	Sequestered Carbon reforestation
year [yr]	carbon [MgC/ha]	CO2 equiv. [MgCO2eq...	year [yr]	carbon [MgC/ha]	CO2 equiv. [MgCO2eq...	year [yr]	carbon [MgC/ha]	CO2 equiv. [MgCO2eq...	year [yr]	carbon [MgC/ha]	CO2 equiv. [MgCO2eq...
1	1.81	6.64	22	74.96	274.84	43	132.01	484.04	64	145.30	532.76
2	4.16	15.27	23	78.42	287.55	44	134.40	492.81	65	144.34	529.25
3	7.03	25.79	24	81.77	299.83	45	135.64	497.33	66	143.74	527.04
4	9.99	36.62	25	85.01	311.69	46	137.73	505.02	67	143.45	526.00
5	12.94	47.45	26	88.14	323.18	47	139.99	513.30	68	143.44	525.96
6	15.93	58.43	27	91.18	334.33	48	142.27	521.65	69	143.62	526.60
7	19.00	69.65	28	94.15	345.21	49	144.53	529.96	70	143.97	527.91
8	22.14	81.17	29	97.03	355.79	50	144.93	531.39			
9	25.47	93.39	30	99.85	366.12	51	146.75	538.09			
10	29.02	106.42	31	102.60	376.21	52	148.83	545.70			
11	32.75	120.10	32	105.30	386.10	53	150.91	553.34			
12	36.63	134.31	33	107.95	395.80	54	153.01	561.02			
13	40.63	148.98	34	110.52	405.23	55	152.64	559.69			
14	44.62	163.59	35	113.02	414.41	56	154.38	566.04			
15	48.58	178.12	36	115.46	423.35	57	156.46	573.68			
16	52.51	192.53	37	117.84	432.08	58	158.55	581.35			
17	56.42	206.86	38	120.17	440.64	59	156.60	574.19			
18	60.31	221.15	39	122.52	449.22	60	151.93	557.07			
19	64.11	235.08	40	124.87	457.85	61	149.55	548.36			
20	67.82	248.66	41	127.24	466.55	62	147.86	542.15			
21	71.42	261.89	42	129.62	475.28	63	146.46	537.01			

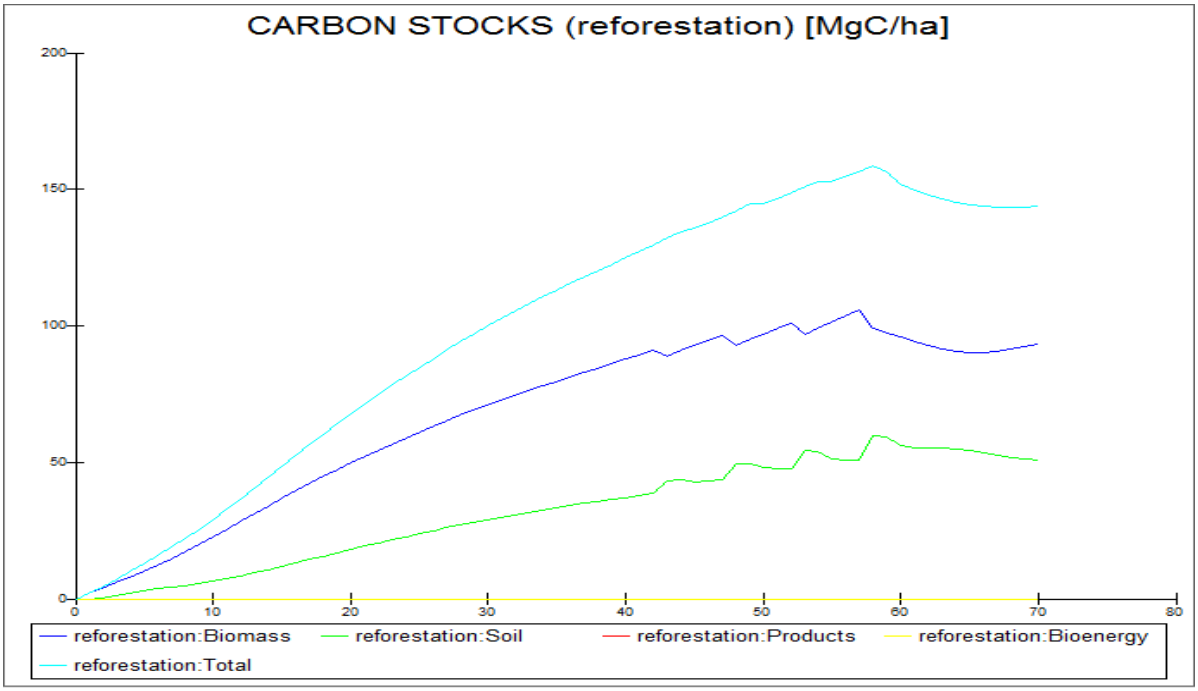

Fig. 22. Carbon accumulation dynamics after planting works (2014)

Summarized data, obtained according to the model, shows that 1.8 t C will be accumulated in 1 ha area during first year of planned planting. Carbon accumulation data until 2020 is given in Table 58.

Table 58. Carbon accumulation annual data at 1 ha after greening works in 2014

	2014	2015	2016	2017	2018	2019	2020
Accumulated carbon t C	1.80	4.20	7.00	10.00	13.00	16.00	19.00
Sequestrated carbon dioxide t CO_2	6.60	15.30	25.80	36.60	47.40	58.40	69.60

Activity 2 Greening of street curbs in Kutaisi

It is planned to carry out greening of the city street curbs in Kutaisi. In particular, 400 wood plants of the first size category will be planted (with a distance of 5 m) at 1 ha (5X2000 m).

Budget of the works is presented in

Table 59, below. Annual accumulation of carbon has been calculated according to the model. (see Table 60 and Fig. 23. Carbon sequestration dynamics).

Table 59. Budget for street curb greening works

№	Expenditure	Unit	Cost per unit (US $)	Total amount	Total cost (US $)
I. Core expenditure					
1	Planting material				
1.1	Wood trees of first size	Piece	95	400	38 000
2	Field works				
2.1.	Marking of area and digging of pit holes	Sapling	0.6	400	240
2.2.	Planting and nurturing	Sapling	0.4	400	160
2.3.	Watering	Sapling	0.1	400	40
	Total				**38 440**

As it is shown in the Table, planting of wood trees will cost 38 440 US dollars, which is equivalent to 67 270 GEL (1 GEL = 1.75 US$).

Table 60. Carbon accumulation and carbon dioxide sequestration.

	Sequestered Carbon reforestation	Sequestered Carbon reforestation		Sequestered Carbon reforestation	Sequestered Carbon reforestation		Sequestered Carbon reforestation	Sequestered Carbon reforestation		Sequestered Carbon reforestation	Sequestered Carbon reforestation
year [yr]	carbon [MgC/ha]	CO2 equiv. [MgCO2eq...	year [yr]	carbon [MgC/ha]	CO2 equiv. [MgCO2eq...	year [yr]	carbon [MgC/ha]	CO2 equiv. [MgCO2eq...	year [yr]	carbon [MgC/ha]	CO2 equiv. [MgCO2eq...
1	0.40	1.48	22	29.59	108.49	43	67.41	247.18	64	65.79	241.25
2	1.01	3.69	23	31.35	114.94	44	69.00	253.02	65	63.38	232.39
3	1.81	6.64	24	33.14	121.52	45	70.56	258.74	66	61.28	224.70
4	2.79	10.22	25	34.97	128.23	46	72.09	264.35	67	59.60	218.53
5	3.91	14.32	26	36.83	135.04	47	73.60	269.86	68	58.29	213.72
6	5.15	18.87	27	38.71	141.94	48	75.08	275.28	69	57.28	210.04
7	6.50	23.84	28	40.61	148.92	49	76.53	280.61	70	56.45	207.00
8	7.96	29.19	29	42.54	155.97	50	77.90	285.62			
9	9.51	34.86	30	44.45	162.97	51	78.95	289.49			
10	11.05	40.50	31	46.34	169.92	52	80.13	293.80			
11	12.56	46.07	32	48.22	176.81	53	81.26	297.95			
12	14.06	51.54	33	50.08	183.63	54	82.32	301.85			
13	15.53	56.96	34	51.92	190.39	55	83.33	305.54			
14	17.01	62.36	35	53.75	197.10	56	84.28	309.04			
15	18.49	67.80	36	55.57	203.75	57	85.19	312.36			
16	19.99	73.28	37	57.37	210.35	58	86.05	315.53			
17	21.50	78.83	38	59.16	216.90	59	86.88	318.54			
18	23.04	84.46	39	60.93	223.40	60	81.43	298.58			
19	24.60	90.18	40	62.66	229.75	61	75.92	278.37			
20	26.21	96.09	41	64.15	235.23	62	71.91	263.65			
21	27.87	102.20	42	65.79	241.22	63	68.61	251.56			

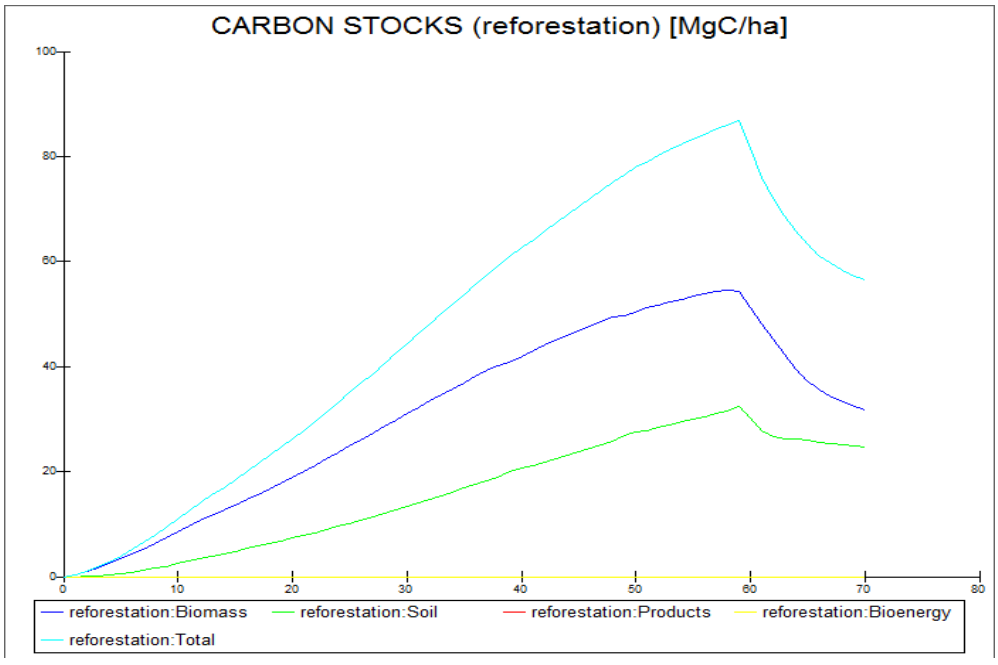

Fig. 23. Carbon sequestration dynamics

Summarized data obtained according to the model show that 0.40 t C will be accumulated in 1 ha area during first year of the planned planting. Accumulation data until 2020 is given in Table 61.

Table 61. Annual carbon accumulation data after conducting the planned greening of street curbs(1 ha)

	2014	2015	2016	2017	2018	2019	2020
Accumulated carbon t C	0.40	1.00	1.80	2.80	3.90	5.20	6.50
Sequestrated carbon t CO_2	1.50	3.70	6.60	10.20	14.30	18.90	23.20

It is also planned to establish a forest-park and a plant nursery in Kutaisi that is described below.

Activity 3. Plan for the development of a free area of the Botanical Garden (5 ha) and establishment of a nursery (2 ha).

The project area of 5 ha of the Botanical Garden is an area, adjacent to the core territory and is extended to the river Rioni bank. It is planed to develop two different types of landscapes on this territory – a classic landscape (with squares and lawns) and an arboterium. The project area should be a natural extention of the Botanical Garden core area and both areas should represent a single dendrological / dendro park. To achieve mentioned goal, plants for the project area should be selected according to their systematic or geographic belonging / characteristics. In particular, it is planned to plant the species according to the classification of floristic districts, with maximum approximation to the natural landscape.

Prior to greening works the planting project should be developed, which includes following components: topographic maps of the park infrastructure, schemes, list of species to be planted, as well as the budget of the intended works. The initial work plan and relevant budget is provided in the mentioned report.

80% of total area has been allocated for planting. The rest of the area (1 ha) will be used for lawns, trials, roads, squares and other infrastructure. Hence, planting will be conducted only on 4 ha area.

Different varieties will be planted in different distances from each other. Distance between the trees of first size category will be 5 m, between the second category trees – 4 m, while the distance between the third category trees – 3 m. The first category (light-demanding) wood trees will be planted at 20% of total area (0.8 ha); second category plants (shade-requiring) will be planted at 35% of total area (1.4 ha); third category trees and bushes will be planted at 45% of total area (1.8 ha). Planting material should be at least 7-10 years old with well developed crown and root system (root system of coniferous plants should be tightly placed in the ground).

Taking into account thr distances between the plants, following number of saplings will be needed:

- First size category wood plants – 97 pieces;
- Second size category wood plants – 880 pieces;
- Third size category wood plants – 1980 pieces.

Totally, 2957 pieces of saplings will be needed to cover 4 ha of the project area. While selecting varieties of species, the habitat requirements should also be taken into account. Budget for planting of wood plants at the project area is given below in the Table 62.

Table 62. Budget for planting works

№	Expenditure description	Unit	Price per unit (US $)	Total amount	Total price (US $)
I. Core expenditure					
1	Planting material				
1.1	Largest wood plant saplings	Pieces	95	97	9 215.0
1.2	Second large wood plant saplings	Pieces	35	880	30 800.0
1.3	Third large plant saplings	Pieces	25	1 980.0	49 500.0
Subtotal 1:				2 957.0	89 515.0
2	Field works				
2.1.	Cleaning of area (from thicket, coppice, etc.)	ha	110	5	550
2.2.	Marking of area and digging pit holes.	Sapling	0.5	2 957.0	1 479.0
2.3.	Planting of saplings	Sapling	0.2	2 957.0	591
2.4.	Watering the planted saplings	Sapling	0.1	2 957.0	296
Subtotal 2:					2 916.0
Total (USD)					**92 431.0**

As it is shown in the Table 62, planting of wood plants at the project area will cost 92 431 US dollars, which is equivalent to 161 754 GEL (1 GEL = 1.75 US$).

It's decided to build two different departments on two different plots, selected for the nursery. One of them (0.7 ha) will serve as a seed/sapling receiver (0.5 ha) and engrafting area(0.2 ha), while another department will be dedicated for seed/sapling re-planting. For instance, two years old saplings, nursed in the first nursery (0.7 ha) will be re-planted to the second department (1.3 ha) with the distance of 1-2 m between them for farther development. Saplings nursed in orangery or containers will also be planted in this department.

Budget for arrangement of the mentioned nursery and planting area (

Table 63) includes main expenditures for the first stage, followed by nurturing works of the second stage. It should be noted, that samplings of some species (eucalypt, palm, etc.) can be received only at greenhouses, where they should stay at least for two years. Only two years old saplings can be planted into an open area and only after that they can be considered as standard, developed / formed saplings.

At current stage, the price for certified seed of only one wood specimen (*Tilia caucasica*) is given in the nursery budget. Planting norm for this species is 450 kg of seeds per 1 ha[78]. In our case we need 225 kg of certified seeds of Tilia (0.5 ha).

For grafting at this stage we have selected also only one specimen - Evergreen privet (*Ligustrum semrevirens*). Grafting norm for this specimen is 75 000 grafts per 1 ha. In our case (0.2 ha) we will need 15 000 grafts.

Table 63. Suggested budget for arrangement of the nursery (0.7 ha)

№	Expenditure description	Size unit	Cost per unit (US $)	Total amount	Total cost (US $)
1	Purchase				
1.1	Seed material (*Tilia caucasica*)	kg	20	225	4 500.0
1.2	Graft material (*Ligustrum semprevirens*)	Pieces	0.08	15 000	1 200.0
Subtotal 1:					5 700.0
2	Field works				
2.1.	Cleaningup the area (from thicket, copies, etc.)	Ha	110	0.7	77
2.2.	Ploughing up the area (autumn)	Ha	100	0.7	70

[78] Tristan Cherkezishvili, Forest planting in Georgia, 1986.

2.3	Harrowing the area (spring)	Ha	50	0.7	35
2.4	Sowing up the area	Ha	55	0.5	28
2.5	Grafting	Peaces	0.15	15 000.0	2 25.0
2.6	Watering of the sown and grafted area	Ha	150	0.7	105
Subtotal 2:					2 565.0
Total (USD)					**8 265.0**

Table 64. Suggested budget for arranging of the planting department

№	Expenditure description	Size unit	Price per unit (US $)	Total amount	Total price (US $)
I. Core expenditure					
I	Field works				
I.1	Cleaning up the area (from thicket, copies, etc.)	ha	110	1.3	143
I.2	Ploughing up the area (autumn)	ha	120	1.3	156
I.3	Harrowing the area (spring)	ha	50	1.3	65
I.4	Planting of two years old saplings from nursery	Pieces	0.1	55 000.0	5 500.
I.5	Watering	Pieces	0.05	55 000.0	2 750.0
Total (USD)					**8 614.0**

Expenditure for planting up the project area is 161 754 GEL; expenditure for nurseries: for the first department (0.7 ha) – 14 464 GEL and for the second department (1/3 ha) – 15 075 GEL (1 GEL – 1.75 US$).

Carbon sequestration data after planting of the 5 ha area is given in Table 65. Sequestration dynamics is shown by curve in Fig. 24. Carbon sequestration dynamics after planting.

Table 65. Carbon sequestration after greening works and carbon dioxide absorption.

	Sequestered Carbon reforestation	Sequestered Carbon reforestation		Sequestered Carbon reforestation	Sequestered Carbon reforestation		Sequestered Carbon reforestation	Sequestered Carbon reforestation		Sequestered Carbon reforestation	Sequestered Carbon reforestation
year [yr]	carbon [MgC/ha]	CO2 equiv. [MgCO2eq...	year [yr]	carbon [MgC/ha]	CO2 equiv. [MgCO2eq...	year [yr]	carbon [MgC/ha]	CO2 equiv. [MgCO2eq...	year [yr]	carbon [MgC/ha]	CO2 equiv. [MgCO2eq...
0	0.00	0.00	21	117.07	429.26	42	193.55	709.69	63	246.69	904.52
1	3.61	13.24	22	121.92	447.05	43	196.34	719.90	64	249.16	913.58
2	8.46	31.03	23	126.64	464.35	44	199.05	729.86	65	251.62	922.61
3	14.49	53.12	24	131.14	480.86	45	201.71	739.60	66	254.08	931.62
4	20.56	75.40	25	135.45	496.63	46	204.31	749.12	67	256.53	940.62
5	26.47	97.07	26	139.56	511.73	47	206.85	758.44	68	258.98	949.59
6	32.30	118.43	27	143.52	526.23	48	209.34	767.57	69	261.37	958.36
7	38.14	139.84	28	147.33	540.22	49	211.83	776.69	70	263.70	966.91
8	44.05	161.52	29	151.06	553.90	50	214.32	785.84			
9	49.94	183.11	30	154.72	567.31	51	216.82	795.00			
10	55.88	204.90	31	158.32	580.50	52	219.32	804.18			
11	61.77	226.49	32	161.86	593.49	53	221.83	813.37			
12	67.58	247.79	33	165.35	606.29	54	224.33	822.55			
13	73.31	268.81	34	168.77	618.81	55	226.83	831.71			
14	79.00	289.66	35	172.10	631.05	56	229.33	840.86			
15	84.65	310.38	36	175.37	643.03	57	231.82	849.99			
16	90.27	330.99	37	178.58	654.78	58	234.30	859.09			
17	95.87	351.53	38	181.72	666.32	59	236.78	868.19			
18	101.46	372.02	39	184.79	677.57	60	239.26	877.29			
19	106.85	391.80	40	187.78	688.54	61	241.74	886.38			
20	112.06	410.88	41	190.70	699.24	62	244.22	895.46			

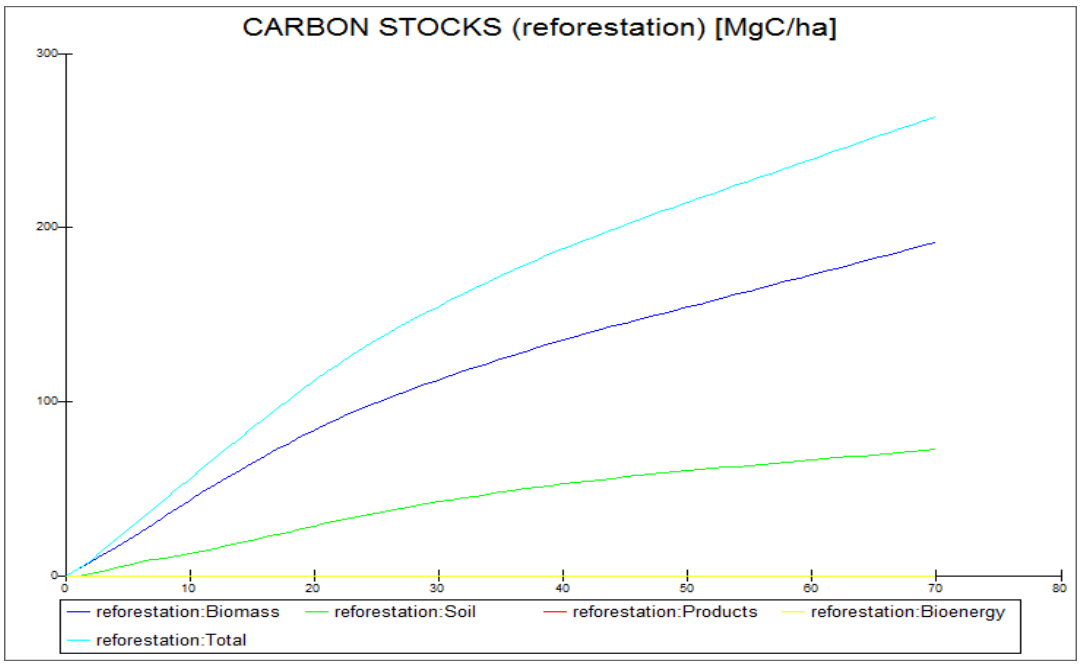

Fig. 24. Carbon sequestration dynamics after planting.

As it is shown in summarized Tables (Table 66-

Table 68), 3.6 t C/ha will be sequestrated during the first year of the planned planting works.

Table 68 below shows the sequestration data until 2020.

Table 66. Annual sequestration data after planting of forest-park (1 ha) in the Botanical Garden

	2014	2015	2016	2017	2018	2019	2020
Sequestrated carbon, t C	3.60	8.50	14.50	20.60	26.50	32.30	38.10

Carbon dioxide absorption, t CO_2	13.30	31.00	53.10	75.40	97.10	118.40	139.80

Outcome

Table 67. Carbon sequestration potential after the planned greening activities in Kutaisi

Planned activities	Annual carbon sequestration t C						
	2014	2015	2016	2017	2018	2019	2020
Carbon sequestration after the planned greening activities conducted by the City Hall (2014); project budget: 6 250 GEL	1.80	4.20	7.00	10.00	13.00	16.00	19.00
Carbon sequestration due to greening of street curb (1.3 ha in total); project budget: 67 270 GEL	0.40	1.00	1.80	2.80	3.90	5.20	6.50
Carbon sequestration after arranging forest-park in Botanical Garden (4 ha); project budget: 161 754 GEL	14.40	34.00	58.00	82.40	106.00	129.20	152.40
Total	16.60	39.20	66.80	95.20	122.90	150.40	177.90

Table 68. Carbon sequestrated in Kutaisi recreational areas and carbon sequestration potential developed due to the planned greening works.

	Annual carbon sequestration t C								
	2012	2013	2014	2015	2016	2017	2018	2019	2020

Carbon sequestration in the city recreational areas without conducting any greening activities	5,395.80	5,396.30	5,396.90	5,397.50	5,398.10	5,398.70	5,399.30	5,399.90	5,400.50
Annual carbon sequestration after conducting greening activities	-	-	16.60	39.20	66.80	95.20	122.90	150.40	177.90
Total carbon sequestration after conducting proposed measures in recreational areas of the city	5,395.80	5,396.30	5,413.50	5,436.70	5,464.90	5,493.90	5,522.20	5,550.30	5,578.40

9 The strategy on awareness raising and education among population and target groups on perspectives of the sustainable energy development in Kutaisi and its economic and social outcomes

Sustainable development of the energy sector in a country or region/municipality is a field where involvement of state and community structures is equally important and where both parties should be equally interested in success. To raise public awareness on renewable energy sources, mix of energy efficiency and energy saving activities, with multilateral approach should be applied. Relevant communication strategy represents one of the most significant integrated parts of the Action Plan (SEAP).

SEAP preparation process within the framework of the Covenant of Mayors (CoM) revealed main barriers, which could create significant obstacles to the strategy implementation. It is important to evaluate all identified barriers and develop relevant strategy to overcome them.

The processes of evaluation has revealed three main barriers, namely:

1. Barriers, existing on the country level / scale, that are remnants of the past practices (especially in awareness field); current economic and social difficulties; deficiency in technology knowledge;
2. Barriers, which are specific to Kutaisi;
3. Barriers, connected with the given project proposals and technologies.

Barriers for implementing sustainable energy development strategy in Georgia

Wasteful consumption in energy sector
Takes origin from Soviet times, as energy was very cheap and consumption was almost unlimited;

Insufficient awareness on sustainable development in general
A very small part of population involved in this field is aware of the concept;
Absence of common vision on relatively long term perspectives of energy sector development (different target groups still have significantly different stand points, which often are not based on relevant and solid calculations);

1**. Absence of common, well analysed and extensive view on the role of energy efficiency and renewable energy resources in short and long term perspectives of energy sector development in Georgia.** It should be noted, that 10% averagen annual increase in energy demand is registered. General potential, as well as development directions are not defined (except hydro). Relevant legislative base is not develope; Goals are not set, as for instance it is done in the fields of gasification or hydropower.

2. Innovation / new technology market is imperfect and holds high risks. An operational failure of every new technology or a pilot project has significant impact on further development perspectives. Availability of technologies is not taken into account while planning long term tasks in energy sector.

3. Several NGOs work on energy efficiency and renewable energy (except hydro) in an uncoordinated and untargeted way. However, there are some positive shifts in energy efficiency in the country, though in a chaotic way. It can be explained by introduction of modern technologies (mostly household appliances) and international energy standards to Georgia market in general.

While identifying mentioned barriers, certain circumstances have been taken into account. Although Kutaisi municipality administration has its vision on further perspectives for sustainable energy development, frequent changes in Kutaisi authorities slow down whole process.

<u>Barriers for Kutaisi sustainable energy development:</u>

1. One of the main barriers in Imereti region is common for all the regions and municipalities of Georgia, including self-governing cities, such as Kutaisi. **This is full dependence on central energy supply in electricity sector and full dependence on private sector with regard to other energy carriers.** This dependence is partial in the gas supply sector, where municipalities mainly depend on processes, planned by the central authorities. Petrol, diesel, and other fuels are a prerogative of private importers.

2. Kutaisi municipality does not collect the statistical data on energy consumption in the city, that would allow to plan an increasing energy demand. There is no vision and strategy developed in case of failure of any of the city energy supply system components. There is no proper awareness on the necessity of energy efficiency and its role in sustainable social-economic development of the city. No relevant vision exists on possible problems, which can appear along with economic growth of the country.

3. Kutaisi municipality does not have sufficient **experience, knowledge and human resources** either for planning, or for managing the processes of sustainable energy development.

4. **Absence of additional free funds** also creates a significant barrier (main part of the budget resources is directed to infrastructure development and social projects).

5. Energy consumption field is unmanaged and chaotic at the municipal level, as well as at the country scale. All mentioned barriers, common for the whole country, are relevant for Kutaisi at different extend.

Apart from the above mentioned barriers, connected to development (local), import and distribution of technologies, there are some specific barriers with regard to each separate technology, which should be taken into account while assessing the selected and applied technologies during the implementation of SEAP.

Barriers connected to technologies :

1. **Lack of knowledge in modern energy efficient and renewable technologies, existing and available at the international market.** Possibilities of adaptation to Georgian conditions are assessed only for few technologies, that significantly increases the risks, related to their introduction. Neither private banks, nor private sector are willing to take mentioned risks. Hence, only the non-governmental sector and those investors, who benefit from expanding coverage for their own technologies have possibilities to introduce and deploy new technologies. correspondingly, among imported technologies, share of high quality technologies is very small, compared ot low quality ones. In most of the cases it can be explained by low prices, though in a short term perspective.

2. **Lack of knowledge on local environment**, where the given technology is to be introduced (for instance, energy efficient lamps are totally ineffective and disadvantageous in case of old and improperly operating electric network). There should be some additional funds allocated to conduct relevant assessments.

3. **Lack of knowledge on environmental and social contra-indications.** The receiving party should have good knowledge about introduced technology to assess technical risks, avoid and minimize them.

4. **Lack of properly educated local human resources,** who would be able to select appropriate technologies, adaptable to local conditions, and deploy them. Lack of such resources is even more specific for municipalities and self-governing cities.

5. **Most of renewable technologies are not sufficiently flexible and easily adaptable to different kinds of environments.** Most of them are not marketable and some additional funds and knowledge are needed for adapting them to the given environment.

Analysis conducted to reveal interested parties within the frames of Kutaisi sustainable energy action plan showed the following target groups in awareness raising and retraining. The target groups should be intensively educated for being able to deal with the above mentioned difficulties. It should be mentioned again, that there are still some barriers common for the whole country and it will be very hard to solve them without significant involvement of the central authorities.

The target groups considered in the present strategy are following: Kutaisi municipality staff and Kutaisi city council members; Kutaisi population and private sector. Special attention should be paid to the industry sector.

Information campaign to raise public awareness is a crucial measure for successful implementation of the Action Plan. Population should well understand aims of development and implementation of the sustainable energy action plan, as well as positive social and economic consequences in case of its successful implementation. At the stage, when it becomes necessary to change certain habits and behavior for obtaining maximum support from population, they should be involved in the process of development of the action plan. According to world practice, higher involvement of population at earlier stages, results in easier implementation management and stronger support of the project.

At the initial stage of development of SEAP, meetings and consultations with Kutaisi population and the representatives of different sectors (where the higher need for change of behavior is expected) should be organized. Advantages of implementation of the action plan and benefits for the city and its population should be clearly explained at these meetings. Consultations are useful for gathering new ideas and project proposals as well (for instance, assessment of attitude of Kutaisi population or behavior change trends), which can be even used for modification of planned activities.

The strategy on awareness raising and training of specialists and future experts for Kutaisi SEAP implementation includes following steps:

Short term strategy (2014-2018)

1. Provide local authorities with the information on advantages of sustainable energy consumption and social and economic benefits of this initiative.
2. Trainings for municipality staff and external resources for achieving successful implementation of the sustainable energy action plan and its monitoring.
3. Assessment of behavior, attitude and information awareness of Kutaisi population; identification, planning and development of recommendations on behavior change trends for successful implementation of the information-education campaign.
4. Information-education campaign, aimed at awareness rising among the population. Preparation of information/education/illustration material on successful experiences and modern technologies, recommended for the green development of cities; demonstration of advantages of energy efficient measures and technologies for population.
5. Ensure involvement of private sector in implementation of the sustainable energy action plan by presenting energy saving and economically profitable technologies and by proposing cooperation programs with the public sector.

Long term strategy (2018-2020)

1. Initiate consultations with interested parties (city population, private sector, non-governmental sector) on restriction measures and standards to be complied by the municipality in different sectors (construction, transport, waste generation) to identify barriers, which may appear during the process of introduction of the mentioned restrictions and standards.

2. Development and implementation of awareness raising and incentive programs for different target groups to ensure smooth introduction of the standards (e.g. energy efficiency).

Strategy of Kutaisi Municipality in the field of education and awareness rising for successful implementation of SEAP

Main strategic goals	Main target groups	Measures to be implemented	Potential leading organization(s)	Outcome	Potential donors
Short term strategic goals (2014-18)	Kutaisi Municipality and City Council	Main goal of short term strategy is to support information awareness of city authorities on perspectives of sustainable energy consumption and its social and economical benefits; to provide maximum information and awareness of the population; to provide assistance to the population for receiving maximum benefit from this initiative; to provide specialists / future experts with relevant education for ensuring proper implementation and monitoring of the action plan.	Kutaisi City Hall	Kutaisi SEAP is successfully implemented	Kutaisi City Hall
	Kutaisi population		Coordinators of the Covenant of Mayors in Georgia (Ministry of Energy and Ministry of Environment and Natural Resources Protection)	Kutaisi City hall continues the same activity after 2020.	Coordinators of the Covenant of Mayors in Georgia (Ministry of Energy and Ministry of Environment and Natural Resources Protection)
			Local and international ongoing programs within the frames of Covenant of Mayors and the initiatives on preparation of low emissions development strategies	Kutaisi population is informed on initiatives, launched by the city authorities	Different local and international programs within the frames of Covenant of Mayors and the initiatives on preparation of low emissions development strategy

					International donors supporting climate change mitigation, renewable energy, energy efficiency and sustainable development processes.

1. Education of specialists				
Education of technical staff for Kutaisi, which would be able to conduct qualified work and to elaborate technical recommendations for successful implementation of the Covenant of Mayors	• Kutaisi City Hall technical group • Special service established by Kutaisi City Hall (it can be the Energy Efficiency Center), which would provide services as for the City Hall, as for population and private sector.	• Establishment of special technical group/service within or outside of Kutaisi City Hall, which will work for the City Hall on implementation and monitoring of the SEAP, as well as on promotion of modern technologies among the city population and private sector. • Development of the program on preparation of the technical group. The program should at minimum reflect requirements of sustainable energy, climate change mitigation measures, EU directives, Covenant of Mayors and analysis of barriers existing for introduction of modern technologies • Preparation of manuals for technical groups • Inserting the technical group	• Kutaisi City Hall • Ministry of Energy • Ministry of Environment and Natural Resources Protection • Representation of the Covenant of Mayors process in Georgia (at current stage – Energy Efficiency Center)	• Program and manual on preparation of specialists for the City Hall technical group are developed • Specialists are prepared and selected on a tender basis • Responsibilities and working program for the selected specialists are clearly defined, which envisage assistance to the City Hall, as well as work with population and private sector • Technical group is actively involved in exchange programs and international networks for obtaining the latest information on modern technologies and approaches in energy sector • Technical group is ready to prepare necessary specialists for the private sector

		members into exchange programs and different information networks for sharing international experience • Possible candidates for the technical group should be involved as much as possible into the development of SEAP at early stages.		

2. Public information and awareness raising					
Maximum public information and awareness rising. Public should receive social and economic benefits due to sustainable energy development process. At first stage of awareness rising, survey on Kutaisi population behavior, attitude and knowledge in this field will be conducted. This survey will identify general attitude of the population and possible involvement trends. Based on the developed recommendations, information campaigns will be planned and implemented. Main working direction of the Municipality will be providing consultations for the city population on energy	• House owners cooperatives • Non-governmental sector • And other public associations	• Preparation of information material for population on those technologies and measures, which will improve the environment and allow to reduce energy consumption • Preparation of information about Kutaisi (e.g. what potential has the city in energy efficiency and green	• Kutaisi City Hall • Non-governmental sector	• TV spots and information booklets for Kutaisi population • TV spots and information booklets are prepared for Kutaisi population on effective technologies, currently represented at the market and their advantages.	Kutaisi City hall USAID GIZ EU

efficiency measures in buildings; latest information on technologies, currently available at the market and the world best practices.		development and how can the population support these processes) • Preparation of information material for city population on energy efficiency measures conducted by signatory cities of the Covenant of Mayors and the relevant outcomes • Regular meetings with population and preparation of PR workers within cooperatives • Involvement of population in preparation and implementation of pilot projects		• Several pilot projects (2 per year) with maximum involvement of local population are implemented	

3. Maximum information of Kutaisi municipality and city council representatives					
Information of local authorities on the advantages and perspectives of sustainable energy	• Kutaisi City Hall • Kutaisi	• Information seminars for the representatives of Kutaisi City Hall and City Council on the advantages and	• Kutaisi City Hall; • Kutaisi City	• Illustration material are prepared for information-education meetings • Information meetings	• EC-LEDS • USAID • EU-COM • GIZ

consumption in the city, on the social and economic benefits of this initiative.	City Council	perspectives of sustainable energy consumption in the city. • Supporting participation of representatives of City Hall and City Council in meetings and conferences connected to the Covenant of Mayor's process at local and international level. • Involving mass media representatives in high level meetings to be held in frames of the Covenant of Mayors and achieving maximum positive publicity about ongoing processes • Ensuring participation of interested parties in decision making process within the frames of the covenant	Council; • Regional Energy Efficiency Center	conducted (at least twice a year) • Experts from EU and other donor countries invited to conduct seminars on modern technologies and approaches • Decisions, considered projects and measures covered by mass media • Representatives from City Hall and City Council fully involved into the current processes at local and international level • Regularly updated information at the City Hall web site on current processes and projects	• Partnership for mitigation • Projects on greenhouse gas emissions reduction • Third national communication of Georgia on Climate Change

Long term strategy (2018-2020)	• Kutaisi City • Kutaisi City Council • Kutaisi • Private sector • Non-governmental sector	Main goal of long term strategy is to attract private sector to the processes of SEAP implementation and overcome revealed barriers; carry out information campaign for awareness rising in private sector and population on worldwide standards and necessity and role of restriction measures in ensuring sustainability of energy consumption	• Kutaisi City Hall • Kutaisi City Council • Energy Efficiency Center • Private sector initiative group • CoM programs and projects	• Kutaisi authority is ready to meet new standards and enforce certain restriction measures within the processes of supporting the initiative of Mayors and synchronization with EU directives • Population and private sector is aware of necessity of conducting the mentioned measures

1. Involvement of private sector in implementation of sustainable energy action plan goals					
• Enhancing the involvement of the private sector in Sustainable Energy Action Plan implementation through providing them with information about energy efficient and economically beneficial technologies and offering programs on cooperation between public and private sectors	• Private sector • Private sector initiative group	• Establishment of annual exhibition/festival of innovations and technologies. One of the main goals of the mentioned festival is to help private sector to enhance knowledge in innovative technologies • To insentify private sector for using innovative	• Kutaisi City Hall • Energy Efficiency Center • Private sector • Non-governmen	• Events conducted every year • Incentive mechanisms to ensure involvement of private sector into the processes of introduction and development of new technologies are elaborated. • Energy efficiency and	• Kutaisi City Hall • Private sector • EU COM • GEF • UNFCCC • programs

		technologies (for instance, by reducing some local payments and taxes for those companies, which would introduce energy efficient technologies) • Stimulate research work in educational institutions and private sector • Consulting service for private sector to reduce possible risks • Establishment of different funds for facilitation of introduction of new technologies, for reduction of risks connected with adaptation • Support private sector initiative groups, which would facilitate maximum involvement of the sector into the processes of Covenant of Mayors	tal sector	Technologies Center established to provide consulting service on new technologies • Risk insurance fund(s) established for private sector to manage risks connected to technologies • Initiative groups are established in different sectors which would act as the main link between the government and the private sector • Representatives of the private sector are involved in international processes, associations and professional networks	

2. Intensification of consultations with interested parties in the process of introduction of restrictive measures and standards					
Intensification of consultations with interested parties (city population, private sector, non-governmental sector) on the restrictive measures and standards to be introduces by municipality in different sectors (construction, transport, waste management)	• Kutaisi City Hall • Kutaisi City • Kutaisi residents • Kutaisi private sector • Non-governmental sector	• Ensuring maximum explanatory information on standards and restrictive measures elaborated for the sectors, considered in the city sustainable energy plan - to the city population, private sector and other target groups • Preparation of information points and TV programs explaining social and environmental benefits brought by the mentioned measures • Preparation/training of those activists who would conduct every day work with target groups	• Kutaisi City Hall • Energy Efficiency and Innovative Technologies Regional Center • Private sector initiative groups • Non-governmental sector	• Specialists who would regularly work with target groups are prepared • Explanatory work and consultation on restrictive measures and necessary standards for implementation of SEAP are conducted for population and different target groups by non-governmental sector at regular base • Mass media is actively involved in explanatory work on social and environmental benefits of the mentioned measures (clips, discussions, etc.)	• Kutaisi City Hall • Kutaisi City Council

3. Identification of barriers through consultations with the interested parties					
Identification of barriers which can arise by introduction of restrictive measures and different standards through consultations with the interested parties	• Kutaisi City Hall • Kutaisi City Council • Kutaisi residents • Kutaisi private	• Revealing barriers during the process of consultations with population on restrictive measures and standards, developed for the sectors in the Sustainable Energy Action Plan • Development of measures for overcoming the revealed barriers based on consultations with different	• Kutaisi City Hall • Kutaisi City Council	• Groups (private sector initiative group, non-governmental sector, mass media) are prepared to conduct consultations • Barriers in each sector, considered within the SEAP, are revealed	• Kutaisi City Hall

	sector • Non-governmental sector	target groups		• Measures to overcome the revealed barriers are developed together with the target groups	

4. Awareness of decision makers, public and private sector representatives on the role of restrictive measures and standards in ensuring sustainable energy consumption					
Development and implementation of awareness rising and incentive programs for different target groups to ensure smooth introduction of the restrictive measures and standards (for instance, energy efficiency). This part would be more effective for decision makers and implementators to raise awareness and to prepare them for the mentioned processes.	• Kutaisi City Hall • Kutaisi City Council • Kutaisi residents • Kutaisi active private sector	• Informing of decision makers and persons, responsible for implementation about successful and unsuccessful international practices • Participation of decision makers and persons responsible for implementation in the processes related to the Covenant of Mayors and international low emissions development. • While preparing information on restrictive measures and new standards for decision makers and implementators,special attention should be paid to the necessity of sustainable consumption of energy in Georgia to ensure the independence of energy supply • While highlighting the decisions,	• Kutaisi City Hall • Programs and projects within the frames of Covenant of Mayors	• Decision makers and implementators are involved and well informed about current international processes, about the obligations of Georgia, related to climate change and energy efficiency • Information packets containing clear analysis of compliance of the process of Covenant of Mayors with EU Directives are prepared • Good practices manuals are developed • Involvement of foreign consultants is	• Government of Georgia • EC-LEDS • EU-CoM • GIZ • Clima East • And other proposed future programs

		made on restrictive measures and new standards for population, mass media should pay special attention to social, environmental and tourism issues and its long term economic effect		necessary	

Implementation strategy

- Kutaisi City Council shall adopt the present strategy and monitor its implementation as of the integral part of the City Development Action Plan.
- Kutaisi City Hall is responsible for updating and implementation of the strategy.
- Energy Efficiency and Innovative Technologies Regional Center is responsible for preparation of local specialists for the strategy implementation and monitoring. For this purpose, current international and local programs, conducted within the frames of Mayors Initiative, shall be used.
- Awareness raising and information materials should be prepared using some external resources (non-governmental sector).
- Kutaisi City Hall in cooperation with external bodies shall organize conferences , technology exhibitions, or/and trainings and seminars.

10 Monitoring, Verification and Reporting on Execution of Kutaisi Sustainable Energy Development Plan and Greenhouse Gas Emissions Reduction

For planning and implementation of monitoring measures on execution of Kutaisi SEAP and greenhouse gas emissions reduction, significant importance is engaged in the way local self-government reforms are fulfilled, as well as internal organizational structure of its executive body(complience to legislative amendments). The Parliament approved a new self-government code on February 6, 2014 and its implementation is expected to begin after local self-government elections in 2014. According to the new self-government code, 8 out of 12 self-governing cities in Georgia are the Covenant of Mayors' signatories. Effectiveness of local financial and human resource development and growth will have great importance in progress of self-governing units. Lack of these resources and appropriate technical skills and knowledge is one of the biggest barriers for preparation and execution of the Sustainable Energy Development Plan by cities.

Therefore, in this transitional phase, monitoring plan may consider several options. Nevertheless, proper distribution of functions and clear separation of rights and responsibilities between internal structural units of municipalities as well as external resources seems to be the most effective one. Thus, proposed approach implies joint use of internal and external resources for monitoring purposes.

The Action plan development process showed that one of the most important problems of Kutaisi, Batumi and other cities of Georgia is obtaining data from various sectors on energy consumption that is necessary for the base year emissions inventory. In many cases, no data accounting system, needed for assessment of emissions, exist at all, as they are not used for evaluation of economic parameters. Sometimes, existing database information requires additional processing that can be made only by data owners of the source, because there is always some additional commercial information, which is confidential for external access. Generally, collection of necessary data requires significant time and human resources, as municipalities (except for several large city municipalities) do not possess well organized statistical/analytical tools and analytical departments. This obstacle destructs the action plan development process, as well as monitoring process.

One of the main parts of National Communications of Georgia on Climate Change is greenhouse gas inventory; this document, covers emissions across the country from energy, transport, industry, agriculture, changes in land use and management of waste and wastewater sectors, but emissions from such sectors as buildings, tourism, etc. are not considered. Calculations of disaggregated emissions at municipal level are also

missing. Some steps were taken in this regard during preparation of the Third National Communication (2012 - 2014), where emissions baseline scenario was calculated for two municipalities (self-governing cities - Batumi and Poti) for 2011. Main emphasis was placed on transport, building and waste sectors during disaggregation process.

In order to reduce data collection related risks, "Monitoring" section of the action plan contains monitoring performance methodology, intended for maximally avoiding existing barriers. One of such measures is creation of data register, necessary for the baseline scenario monitoring. The register will be regularly updated with collected, summarized and systemized info by the group[79]responsible for Kutaisi Sustainable Energy Action Plan implementation monitoring. Monitoring, verification and reporting shall be carried out without significant waste of time based on regular updates of available data.

For internal monitoring and analysis responsible department/division within Kutaisi City Hall should have a software (easy to use even for users without deep knowledge of the field) calculating baseline scenario emissions and quantity of reduced emissions, as for different measures, so for combined data based on the BAU (traditional way of scenario development) approach. Local staff will require mentioned software training for ensuring usage effectivness.

During preparation of periodic reports on the Action Plan Implementation monitoring, commitments of which are based on the "Covenant of Mayors" initiative conditions, involvement of invited experts into the monitoring process may be considered (at least for the first mandatory reporting process).

Main activities included in the Monitoring and Reporting process of Kutaisi:

1. Regular update of the Baseline Scenario (BAU);
2. Assessment of emissions reduced after taken measures and implemented projects;
3. Development of final report.

At the current stage, parties, responsible for these processes under the current action plan are:

1. Kutaisi Municipality is responsible for accumulation of statistical information (GDP, population, per capita income, share of economic activities/economic sectors in GDP, etc.) about main KPIs, describing city development processes. As for the calculation of the baseline scenario, it could be done by external resources as well, if they are accredited in advance by the municipality for conducting this work . The Baseline scenario calculation and its subsequent renewal methodology will be sent to the City Hall under the "Low Emission Development Strategy" by Georgian Government coordinated with the EU "Covenant of Mayors". Used emission factors have to be agreed with responsible authority of the UN Framework Convention on Climate Change in Georgia and low emission development process.
2. Necessary information for calculation of reduced emissions after implemented measures and projects shall be collected straight by the implementing unit/project owner. Municipality should provide the executors with the data collection methodology and ensure periodic verification. Municipality is responsible for calculation and verification of final emissions, though the work can be done by the Municipality, or external resources accredited by the "Covenant of Mayors". Periodic verification of activity data provided by the project executor is a responsibility of the Municipality as well.

[79] Employees of appropriate City Hall offices or Energy Manager specially appointed by the City Hall.

3. The City Hall is responsible for preparation of the final report; its approval is City Council's prerogative after which it will be submitted to the EU.

This document describes the following: monitoring elements, general parameters that have to be monitored during the SEAP implementation, quality control and quality assurance (QA/QC) procedures for different-type and emission factors, based on which a specific year baseline scenario is updated and reduced emissions are calculated.

Unit, Responsible for Monitoring in Kutaisi Municipality

Overall responsibility for preparing – implementation of the "Covenant of Mayors" and the Action Plan (SEAP) as well as their systematic update in accordance with new circumstances and development plans is being taken by the Strategic Planning, Investment and Economic Development Department. The same department is responsible for carrying out monitoring, analyzing its results, considering the results in action plan updating process, verification of activity and monitoring data, preparation and submission of final report on monitoring for approval to the City Council before submission to EU. Strategic Planning, Investment and Economic Development Department is also responsible for organizing process of data collection, supporting data quality improvement, their systematic update and mobilization of new sources. In this process, Strategic Planning, Investment and Economic Development Department may use other divisions and LLC-s under the municipality as well as certified external resources. The municipality plans to rehabilitate former administrative building, located on the territory of botanical garden and establish training – demonstrating center for energy-efficient and renewable technologies. In case of project implementation, it will become an incubator for developing staff to support the municipality to update and monitor Sustainable Energy Development Plan, prepare project offers, mobilization of investments and advertise new, efficient technologies.

There are five main sectors considered within the Sustainable Energy Action Plan of Kutaisi: energy consumption in building sector, energy consumption in transport sector, street lighting energy consumption, methane emissions from waste sector and increasing emission absorption source by green area development. In order to evaluate each sector's baseline scenario, monitoring of different-types of activity data is necessary. This data is described below. In addition to the activity data, it will be necessary to monitor each implemented project and measure, based on which a quantitative estimation of emissions reduction and comparison of total emission savings with the baseline scenario will be made. Amount of final reduction will be determined on basis of result comparison analysis.

Thus, at this stage, Kutaisi City Hall is considering two options of monitoring and collection of sector related data: collection and provision of statistical data by corresponding City Hall department or data archiving and primary processing at energy-effective and renewable technologies training-demonstrating center. The first option seems easily implementable at this stage, but there has not been clearly decided yet whether a common data archive of all sectors will be created, or the data will be archived in the departments, responsible for the sector management.

Fig. 25 shows City Hall offices and LCC-s, responsible for data collection.

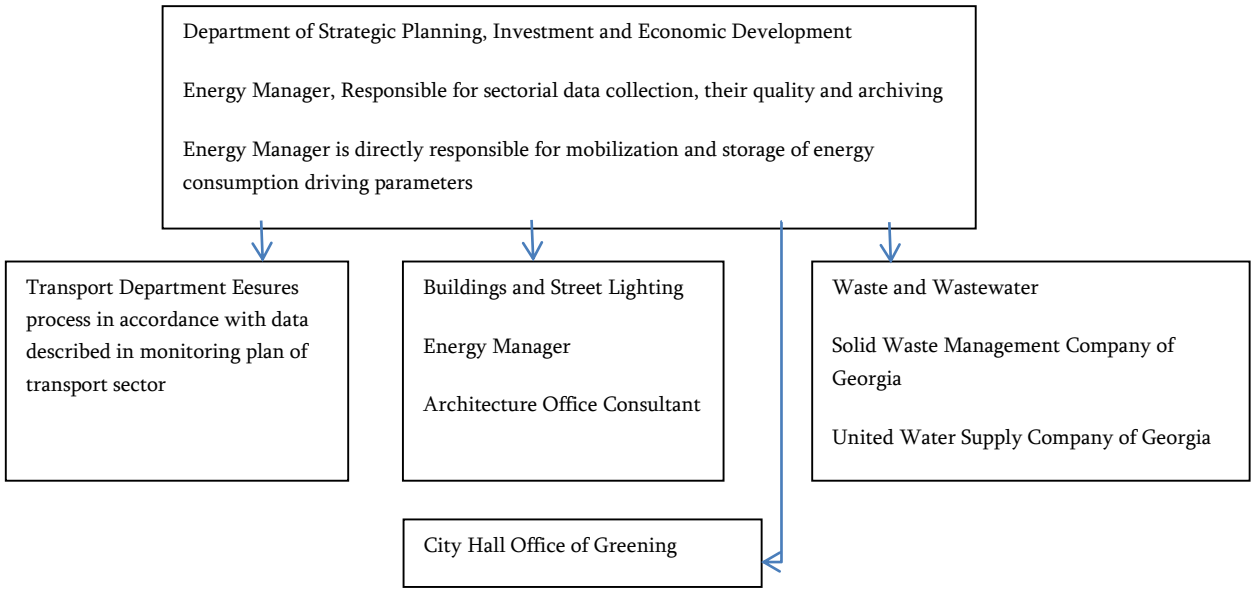

Fig. 25. Monitoring Process Management

The following four types of data shall be collected and evaluated to prepare monitoring report for each sector:

- Annual emissions in CO_2equivalent;
- Measures and projects implementation statuses and emission savings for monitoring time;
- Driving parameters (KPIs) of the baseline scenario (for example: in case of transport sector – population, GDP, or income growth and allocation of passenger-kilometers to transport types;
- Economic and social effects of the measures taken.

In addition to these types, there are considered primary parameters in monitoring process being taken from different sources and secondary data, automatically calculated via MUNI_EIPMP software.

Certified monitoring group of Kutaisi Municipality will be responsible for annual monitoring reporting, being submitted (compiled analysis of recent 2 years) to an independent third party for verification every two years[80]. This party is likely to be provided by the EU Covenant of Mayors. Reporting structure of mentioned monitoring will be worked out by the monitoring group and it should not be in conflict with a common format developed and proposed by the Covenant of Mayors.

[80] Monitoring reports frequency is determined by the "Covenant of Mayors" Office

General and Sector Related Driving Parameters

Purpose of this parameter is to update baseline scenario taking into account current significant social and economic changes in Kutaisi.

Data/ Parameter # 2.1	**Population quantity through the monitoring year**
Dimension:	Quantity
Description:	Primary data; Annual Monitoring
Used Source:	Statistical annual (www.Geostat.ge) and local statistics
Value used in the SEAP:	**196 600 (2012)**
The Rationale for using these data, or measure/assessment method	If generated emissions can not be measured through the waste sector (measurements usually do not happen without project implementation) the annual methane emissions shall be recalculated in accordance with annually observed and measured parameters.
Additional Comment	Population quantity through the monitoring year is used to re-verify different values, data control and monitor trend of per capita emissions

Data/Parameter # 2.2	**Population Growth Rate (percentage)**
Dimension:	%
Description:	Calculated data; Annual monitoring. This parameter is mainly used in case of Business as Usual (BAU) scenario development to assess emission growth based on electricity, fuel, waste, waste water, industry and other fields.
Used Source:	The Source is a parameter, evaluated at a national level, made on behalf of the Ministry of Energy of Georgia. There have been taken national level data used in MARKAL model reduced to the city scale, based on statistical data about past population growth.
Value used in the SEAP:	0.5
The Rationale for using these data, or measure/assessment method	Population is one of the leading parameters for emissions prediction under the IPCC social-economic development scenarios. In addition, in order to assess and forecast energy consumption along with amount of waste and their emissions, knowledge of population size change forecast is necessary.
Additional Comment	For the SEAP forecast preparation, the same number (annual 0.5%) has been taken that is being used by the Ministry of Energy to plan energy sector based on the MARKAL model. This parameter will be defined during the low-emission strategy development process. The Forecast is annual up to 2020, inclusive. Size of population during the monitoring year is enough for the monitoring. This parameter is necessary in case of the BAU update only.

Data/Parameter # 2.3	**Gross Domestic Product (GDP) in the monitoring year**
Dimension:	Million GEL
Description:	Calculated data; Annual monitoring
Used Source:	Statistical annual (www.Geostat.ge)and local statistics. This SEAP source

	was Kutaisi Municipality.
Value used in the SEAP:	This value hasn't been used in SEAP, because did not exist. But for future monitoring should be evaluated.
The Rationale for using these data, or measure/assessment method	
Additional Comment	The National Statistics Office provides information about the region's annual GDP. In this case, Imereti region's GDP and total amount of Imereti population make it possible to determine per capita GDP in Imereti region and then, during the monitoring year to estimate GDP of Kutaisi by multiplying by the number of city population. This is one of the methods of assessment. There also may be used other, more accurate and properly described one. The size of the GDP in the monitoring year is used for additional testing of different values and their observation; to control data and monitor emission trends per GDP unit; to estimate emissions intensity during the economic development process.

Data/Parameter # 2.4	**Gross Domestic Product (GDP) Growth Rate Forecast (%)**
Dimension:	%
Description:	Calculated data; This is calculated by the Ministry of Economy and Sustainable Development of Georgia, Analytical Department of the Ministry of Energy and other international monetary structures (World Bank, IMF, etc.)
Used Source:	Source is a parameter evaluated at the national level and made on behalf of the Ministry of Energy of Georgia. There have been taken national level data used in MARKAL model that have been corrected in accordance with the city scale.
Value used in the SEAP:	5% before 2018, 6 afterwards
The Rationale for using these data, or measure/assessment method	These data are needed to estimate future emission trends and are used in case of the BAU scenario update necessity, only.
Additional Comment	

Emission Factors

Data/ Parameter # 2.4	**Grid emission factors CO2 t/MWh**
Dimension:	T **CO2**/MWh
Description:	Primary data. Calculated at the national level and provided to municipalities
Used Source:	Calculated specially for using in the SEAP but there is a value calculated for the Kyoto Protocol's Clean Development Mechanism projects (Ministry of Environment and Natural Resources Protection of Georgia)
Value used in the SEAP:	0.136
The Rationale for using these data, or measure/assessment method	The emission factor is calculated by dividing annual emissions from power sector by annual electricity generation.
Additional Comment	This emission factor will be calculated centrally in order to monitor low emission development strategy monitoring and will be delivered to municipalities to use it in the SEAP-s. During the SEAP preparation process, used grid emission factor is calculated via average method

	because Kutaisi does not produce electricity independently. The city receives it from centralized energy system of Georgia.

Data/ Parameter # 2.5	**Natural Gas (NG) emission factors**
Dimension:	T/TJ, or Kg/TJ
Description:	Primary data
Used Source:	At this stage, the IPCC calculated typical value is being used (exploited for level 1 calculations)
Value used in the SEAP:	55.78 CO2 T/TJ; 5 CH4 Kg/TJ; 0.1 N2O Kg/TJ.
The Rationale for using these data, or measure/assessment method	
Additional Comment	It is desirable to exploit the country's calculated value, depending on the natural gas calorific value (NCV). Mentioned value should be updated constantly during monitoring process in case of information about used gas caloricity.

Data/ Parameter # 2.6	**Gasoline**
Dimension:	T/TJ, Kg/TJ
Description:	Primary data
Used Source:	At this stage, the IPCC calculated typical value is being used (exploited for level 1 calculations)
Value used in the SEAP:	68.6 TCO2/TJ; 20 kg CH4/TJ; 0.6 kg N2O /TJ.
The Rationale for using these data, or measure/assessment method	
Additional Comment	It is desirable to exploit the country's calculated value, depending on the carbon content of gasoline. Mentioned value should be updated constantly during monitoring process in case of information about imported gasoline caloricity.

Data/ Parameter # 2.7	**Diesel**
Dimension:	T/TJ, Kg/TJ
Description:	Primary data
Used Source:	At this stage, the IPCC calculated typical value is being used (exploited for level 1 calculations)
Value used in the SEAP:	73.3 T CO2/TJ; 5 Kg CH4/TJ; 0.6 Kg N2O /TJ.
The Rationale for using these data, or measure/assessment method	
Additional Comment	It is desirable to exploit the country's calculated value, depending on the carbon content of diesel. Mentioned value should be updated constantly during monitoring process in case of information about imported diesel caloricity.

Data/ Parameter # 2.8	**Net Calorific Value of Different Fuels (NCV for NG, Gasoline, Diesel)**

Dimension:	
Description:	Primary data. These data shall be collected at the national level from fuel importers.
Used Source:	These data should be collected for each type of fuel used in the country. The information sources are mainly fuel importers and distributors.
Value used in the SEAP:	At this stage, typical values are used in the SEAP provided by the IPCC.
The Rationale for using these data, or measure/assessment method	
Additional Comment	Systematic update is desirable taking into account fuel parameters. It would be better to use these typical data if local data are available.

Activity Data Necessary for Kutaisi Transport Sector Monitoring

Data to be Collected for Municipal Buses

Data/ Parameter # 3.1.1	**Quantity of municipal buses**
Dimension:	Quantity of buses in the monitoring period (annual value)
Description:	Primary data
Used Source:	City bus service company, " Kutaisi Auto Transport" LTD. Provided to the SEAP by Kutaisi Municipality
Value used in the SEAP:	**194**(Diesel-194)
The Rationale for using these data, or measure/assessment method:	
Additional Comment:	

Data/ Parameter # 3.1.2	**Average distance travelled by one bus a year by fuel type (gasoline, diesel, gas)**
Dimension:	Km/y
Description:	Primary data
Used Source:	City bus serving 12 private shipping companies. Provided to the SEAP by Kutaisi Municipality Transport Service.
Value used in the SEAP:	**40 000** km/y
The Rationale for using these data, or measure/assessment method:	
Additional Comment:	This data is desirable to be taken directly by the monitoring group from private shipping companies, that also shows daily kilometrage of buses based on which annual data is calculated. Data validation and verification is a responsibility of Kutaisi Municipality Transport Service. The municipality should verify data as against used fuel expenses.

Data/ Parameter # 3.1.3	**Total distance traveled by all buses annually (by fuel type)**
Dimension:	Trans.Km
Description:	Secondary data, calculated by the MUNI_EIPMP
Used Source:	Data # 3.1.1 and 3.1.2
Value used in the SEAP:	**7760000**
The Rationale for using these data, or measure/assessment method:	
Additional Comment:	This data shall be verified with an amount of fuel used by buses annually

Data/ Parameter # 3.1.4	**Average cost of 1 bus diesel per 100 km**
Dimension:	L/100 km
Description:	Primary data
Used Source:	Bus Service Company –"Kutaisi Auto Transport". Provided to the SEAP by Kutaisi Municipality that also could be an alternative source.
Value used in the SEAP:	**38 L/100 km**
The Rationale for using these data, or measure/assessment method:	
Additional Comment:	This data should be checked with bus registration certificate and interpreted in case of significant difference.

Data/ Parameter # 3.1.5	**Annual consumption of fuel by all buses (by fuel type – gasoline, diesel)**
Dimension:	L/y
Description:	Secondary data.calculated by the MUNI_EIPMP
Used Source:	Provided to the SEAP by Batumi municipality
Value used in the SEAP:	**2 948 800 L (diesel)**
The Rationale for using these data, or measure/assessment method:	
Additional Comment:	The data is calculated by the monitoring group and checked with issued fuel. In case of Kutaisi, only diesel is used by buses as fuel.

Data/ Parameter # 3.1.6	**City bus load factor**[81]
Dimension:	Passenger.km/trans.km
Description:	This parameter should be evaluated by statistical methods and surveys. It could be calculated from 3.1.7. parameter if it is assessed or estimated not through this parameter but via other method

[81] Passenger load factor of transport measures the capacity of utilization of public transport services

Used Source:	For the SEAP it is calculated from # 3.1.7parameter provided by the Kutaisi Municipality
Value used in the SEAP:	**15.05**
The Rationale for using these data, or measure/assessment method:	This parameter is used only for assessment of greenhouse gas emission reductions after measures taken in the sector. Greenhouse gas annual inventory from transport sector is not depended on it.
Additional Comment:	These data can be assessed through surveys, bus tickets sold at public transport stops, etc. If 3.1.7 parameter (mobility) is known, this parameter may be calculated #3.1.7/3.1.1/3.1.2

Data to be Collected for Municipal Minibuses

Data/ Parameter # 3.2.1	**Quantity of municipal minibuses**
Dimension:	Quanity of buses during the monitoring period (annual value)
Description:	Primary data
Used Source:	City Bus Service Company. Provided to the SEAP by Kutaisi Municipality
Value used in the SEAP:	**587** (diesel)
The Rationale for using these data, or measure/assessment method:	
Additional Comment:	

Data/ Parameter # 3.2.2	**Average distance travelled by one minibus a year by consumed fuel type (gasoline, diesel, gas, electricity)**
Dimension:	Km/y
Description:	Primary data.
Used Source:	Minibus companies Provided to the SEAP by Kutaisi Municipality Transport Service
Value used in the SEAP:	**60 000** Km/y
The Rationale for using these data, or measure/assessment method:	This data is desirable to be taken directly by the monitoring group from minibus companies that also shows daily kilometrage of buses based on which annual data is calculated. Data validation and verification shall be a responsibility of Kutaisi Municipality Transport Service. The municipality should verify data as against used fuel expenses.
Additional Comment:	

Data/ Parameter # 3.2.3	**Average distance travelled by all minibuses a year by consumed fuel type (gasoline, diesel, gas)**
Dimension:	km/y
Description:	Estimated data. Is calculated by the MUNI_EIPMP
Used Source:	Data #3.2.1. and 3.2.2.
Value used in the SEAP:	**35 220 000**

The Rationale for using these data, or measure/assessment method:	
Additional Comment:	The Municipality should verify the data relative to consumed fuel expenses, taken from Finance Department

Data/ Parameter # 3.2.4	**Average diesel expenses of one minibus per 100 km**
Dimension:	L/100 km
Description:	Primary data.
Used Source:	Provided to the SEAP by Batumi Municipality
Value used in the SEAP:	**15 l/100 km**
The Rationale for using these data, or measure/assessment method:	
Additional Comment:	This data should be checked with minibus registration certificate and interpreted in case of significant difference.

Data/ Parameter # 3.2.5	**Average fuel consumption by all minibuses according to fuel types (gasoline, diesel, gas)**
Dimension:	L/year
Description:	Secondary data. Shall be calculated by the monitoring group
Used Source:	Calculated by the MUNI_EIPMP Data #3.2.1. ; 3.2.2. and 3.2.4
Value used in the SEAP:	**5 283 000 L (diesel)**
The Rationale for using these data, or measure/assessment method:	
Additional Comment:	This data is calculated by the monitoring group and it should be compared to provided fuel by Transport Service in Finance Department.

Data/ Parameter # 3. 2.6	**Transport's (minibus) Passenger Load Factor**
Dimension:	Passenger.km/Trans.km
Description:	This parameter should be evaluated by statistical methods and surveys. It could be calculated from 3.2.7. parameter if it is assessed or estimated not through this parameter but via other method
Used Source:	Calculated for the SEAP from # 3.2.7 provided by Kutaisi Municipality
Value used in the SEAP:	**8**
The Rationale for using these data, or measure/assessment method:	This parameter is used only for assessment of greenhouse gas emission reductions after measures taken in the sector. Greenhouse gas annual inventory from transport sector is not depended on it.
Additional Comment:	These data can be assessed through surveys, bus tickets sold at public

	transport stops, etc. If 3.2.7 parameter (mobility) is known, this parameter may be calculated #3.1.7/3.1.1/3.1.2#3.2.7/3.2.1/3.2.2

Private Cars (Motor Cars)

Data/ Parameter # 3.3.1	**Amount of private cars registered in Kutaisi (by fuel types)**
Dimension:	Quantity of transport
Description:	Primary data
Used Source:	Ministry of Internal Affairs – Patrol Police Department. Provided to the SEAP by Kutaisi Municipality
Value used in the SEAP:	**45 305 (Sum)** **31 121 (on gasoline) ; 7 836 (on diesel); 6 348 (on gas).**
The Rationale for using these data, or measure/assessment method:	
Additional Comment:	

Data/ Parameter # 3.3.2	**Average annual distance travelled by one vehicle (by fuel type is desirable)**
Dimension:	Km/year
Description:	Primary data.
Used Source:	Provided to the SEAP by Kutaisi Municipality
Value used in the SEAP:	**9 000 km/year**
The Rationale for using these data, or measure/assessment method:	The National Statistics Office and interviews with drivers. Interviews shall reveal average daily kilometrage required for whole- year calculations. Survey results should meet reliability criteria
Additional Comment:	Interviews and surveys for determination of daily kilometrage and the SEAP implementation shall be conducted simultaneously

Data/ Parameter # 3.3.3	**Average distance travelled by all motor cars a year (by fuel types)**
Dimension:	Trans.km/year
Description:	Calculated data
Used Source:	Calculated by the MUNI_EIPMP Data # 3.3.1 and 3.3.2
Value used in the SEAP:	**407 745 000**
The Rationale for using these data, or measure/assessment method:	
Additional Comment:	

Data/ Parameter # 3.3.4	**Fuel consumption per 100 km (by fuel types)**
Dimension:	L/100 km m^3/100 km kW.h/100 km
Description:	Primary data
Used Source:	Taken from the registration certificate of a motor vehicle
Value used in the SEAP:	**Gasoline -10 l/100 km** **Diesel -8 l/100 km** **Natural Gas-10 m^3/100 km**
The Rationale for using these data, or measure/assessment method:	Provided by the Kutaisi Municipality to prepare this SEAP
Additional Comment:	This data is rechecked via registration certificate and surveys

Data/ Parameter # 3.3.5	**Fuel consumption of all motor cars by fuel types (gasoline, diesel, gas)**
Dimension:	L/year
Description:	Secondary data. Shall be calculated by the monitoring group.
Used Source:	Calculated by the MUNI_EIPMP Data #3.3.1. ; 3.3.2. and 3.3.4
Value used in the SEAP:	**28 008 900 l (gasoline)** **5 641 920 l (diesel)** **57 132 000 m^3 (natural gas)**
The Rationale for using these data, or measure/assessment method:	
Additional Comment:	This data is calculated by the monitoring group and is compared to the realized fuel in the city. Significant error is expected, though

Data/ Parameter # 3.3.6	**Transport Load Factor**
Dimension:	Passenger.km/ trans.km
Description:	This parameter should be evaluated by statistical methods and surveys. It could be calculated from 3.3.7. parameter if it is assessed or estimated not through this parameter but via other method.
Used Source:	Calculated for the SEAP from the parameter # 3.3.7 provided by the Kutaisi Municipality
Value used in the SEAP:	**1.64**
The Rationale for using these data, or measure/assessment method:	This parameter is used only for assessment of greenhouse gas emission reductions after measures taken in the sector. Greenhouse gas annual inventory from transport sector is not depended on it.
Additional Comment:	This data can be assessed as a result of a survey if parameter 3.3.7 is known (mobility of private motor cars) this parameter can be calculated #3.3.7/3.3.1/3.3.2

Municipality Owned Fleet

Data/ Parameter # 3.4.1	**Kutaisi municipality service vehicles (by fuel type)**
Dimension:	Amount of transport
Description:	Primary data
Used Source:	Provided to the SEAP by Kutaisi Municipality
Value used in the SEAP:	**total 53** **On gasoline -45; diesel - 8**
The Rationale for using these data, or measure/assessment method:	Kutaisi Municipality transport service is responsible for this data
Additional Comment:	Agricultural Activity Department of the Municipality

Data/ Parameter # 3. 4.2	**Average distance travelled by one vehicle a year (by fuel and transport types)**
Dimension:	km/ year
Description:	Primary data
Used Source:	Provided to the SEAP by Kutaisi Municipality Transport Service
Value used in the SEAP:	**8 000 km/year**
The Rationale for using these data, or measure/assessment method:	Kutaisi Municipality Transport Service is responsible for these data
Additional Comment:	

Data/ Parameter # 3.4.3	**Average distance travelled by the municipality service vehicles annually**
Dimension:	Trans.km/year
Description:	Calculated data.
Used Source:	Calculated by the MUNI_EIPMP Data # 3.4.1 and 3.4.2
Value used in the SEAP:	**424 000**
The Rationale for using these data, or measure/assessment method:	
Additional Comment:	Verification shall be done in accordance with consumed fuel.

Data/ Parameter # 3. 4.4	**Fuel consumption per 100 km (by fuel and transport types)**
Dimension:	L/100 km
Description:	Primary data.
Used Source:	Provided to the SEAP by Kutaisi Municipality
Value used in the SEAP:	**Gasoline -8** **Diesel - 35**

The Rationale for using these data, or measure/assessment method:	Kutaisi Municipality Transport Service is responsible for these data
Additional Comment:	

Data/ Parameter # 3.4.5	**Annual fuel consumption of the entire municipal fleet (by fuel type)**
Dimension:	Litre
Description:	Secondary data.Calculated by the monnitoring group
Used Source:	Calculated by the MUNI_EIPMP Data #3.4.1. ; 3.4.2. and 3.4.4
Value used in the SEAP:	**28 800 (gasoline)** **22 400 (diesel)**
The Rationale for using these data, or measure/assessment method:	
Additional Comment:	Verification shall be done in accordance with consumed fuel

Commercial Transport (Taxi)

Data/ Parameter # 3. 5.1	**Taxi cabs of Kutaisi by fuel type**
Dimension:	Amount of taxis by fuel type
Description:	Primary data.
Used Source:	Provided to the SEAP by Kutaisi Municipality Transport Service
Value used in the SEAP:	**693 (Total)** **93 (on gasoline); 121 (on diesel); 479 (on natural gas)**
The Rationale for using these data, or measure/assessment method:	Kutaisi Municipality Transport Service is responsible for the data
Additional Comment:	Primary verification of these data is a responsibility of Kutaisi City Hall Transport Service but they can control officially registered taxis only. Reliability of the data is very low that is likely to be reflected on total amount of sold fuel.

Data/ Parameter # 3. 5.2	**Average distance travelled by one taxi annually (by fuel types)**
Dimension:	km/year
Description:	Primary data.
Used Source:	Provided to the SEAP by Kutaisi Municipality
Value used in the SEAP:	**50 000**
The Rationale for using these data, or measure/assessment method:	Kutaisi Municipality Transport Service is responsible for the data. These data for officially registered taxis can be obtained via Revenue Service or taxi union.Estimation should be done through drivers' inquiry.
Additional Comment:	Primary verification of the data with different sources (tax) is a responsibility of the City Hall Transportation Service

Data/ Parameter # 3.5.3	**Average distance covered by all taxis annually (by fuel type is desirable)**
Dimension:	Trans.km/year
Description:	Calculated data.
Used Source:	Calculated by the MUNI_EIPMP Data # 3.5.1 and 3.5.2
Value used in the SEAP:	**4 650 000 (on gasoline);** **6 050 000 (on diesel);** **23 950 000 (m3 gas).**
The Rationale for using these data, or measure/assessment method:	
Additional Comment:	

Data/ Parameter # 3. 5.4	**Fuel consumption by transport type**
Dimension:	l/100 km m3/100 km
Description:	Primary data
Used Source:	Registration certificate of a vehicle. Provided to the SEAP by Batumi Municipality
Value used in the SEAP:	**Gasoline 10 L** **Diesel 9 L** **Gas 11 m3**
The Rationale for using these data, or measure/assessment method:	
Additional Comment:	

Data/ Parameter 3. 5.5	**Annual fuel consumption by taxis (by fuel types)**
Dimension:	L/year
Description:	Secondary data
Used Source:	Calculated by the MUNI_EIPMP Data #3.5.1. ; 3.5.2. and 3.5.4
Value used in the SEAP:	**465 000 (gasoline)** **544 500 (diesel)** **2 634 500 (natural gas)**

The Rationale for using these data, or measure/assessment method:	
Additional Comment:	

Data/ Parameter # 3.5.6	**Passenger load factor of taxi cabs (load factor)**
Dimension:	Passenger.km/ trans.km
Description:	This parameter should be evaluated by statistical methods and surveys. It could be calculated from 3.5.7. parameter if it is assessed or estimated not through this parameter but via other method.
Used Source:	Calculated for the SEAP based on # 3.5.7 parameter provided by the Kutaisi Municipality
Value used in the SEAP:	**1.64 correction is needed**
The Rationale for using these data, or measure/assessment method:	The value is calculated within the framework of the SEAP. Mobility of taxi cabs is provided by the Municipality (parameter # 3.5.7)
Additional Comment:	

Commercial Transport Small Trucks (up to 2 tons)

Data/ Parameter # 3. 6.1	**Small trucks moving across Kutaisi**
Dimension:	Small trucks by fuel type
Description:	Primary data
Used Source:	Provided to the SEAP by Kutaisi Municipality
Value used in the SEAP:	**Small Trucks [82] - 1425** **217- on gasoline; 1208- on diesel .**
The Rationale for using these data, or measure/assessment method:	This data is a responsibility of Kutaisi Municipality Transport Service
Additional Comment:	Primary verification of these data is a responsibility of Kutaisi City Hall Transport Service

Data/ Parameter # 3. 6.2	**Average distance travelled by one small truck a year (by fuel type is desirable)**
Dimension:	km/year
Description:	Primary data
Used Source:	Provided to the SEAP by Kutaisi Municipality Transport Service
Value used in the SEAP:	**30 000**

[82] Up to 2 tons load-carrying capacity

The Rationale for using these data, or measure/assessment method:	Kutaisi Municipality Transport Service is responsible for the data.
Additional Comment:	Primary verification of these data is a responsibility of City Hall Transport Service

Data/ Parameter # 3.6.3	**Average distance travelled by small trucks a year (by fuel type is desirable)**
Dimension:	Trans.km/year
Description:	Calculated data
Used Source:	Calculated by the MUNI_EIPMP Data # 3.6.1 and 3.6.2
Value used in the SEAP:	**6 510 000 (on gasoline);** **36 240 000 (on diesel).**
The Rationale for using these data, or measure/assessment method:	
Additional Comment:	

Data/ Parameter 3. 6.4	**Fuel consumption by transport types**
Dimension:	L/100 km
Description:	Primary data
Used Source:	Provided to the SEAP by Kutaisi Municipality
Value used in the SEAP:	**Gasoline 16 l** **Diesel 14 l**
The Rationale for using these data, or measure/assessment method:	
Additional Comment:	This data should be checked with registration certificate of a motor vehicle and interpreted in case of significant difference.

Data/ Parameter # 3. 6.5	**Annual fuel consumption vehicle and fuel types**
Dimension:	L/year
Description:	Secondary data
Used Source:	Calculated by the MUNI_EIPMP
Value used in the	**Gasoline 1 041 600 l**

SEAP:	**Diesel 5 073 600 l**
The Rationale for using these data, or measure/assessment method:	
Additional Comment:	

Data/ Parameter # 3.6.6	**Small trucks load factor (load factor)**
Dimension:	Ton.km/ Trans.km
Description:	This parameter should be evaluated by statistical methods and surveys. It could be calculated from 3.6.7. parameter if it is assessed or estimated not through this parameter but via other method
Used Source:	Provided to the SEAP by Kutaisi Municipality
Value used in the SEAP:	**1**
The Rationale for using these data, or measure/assessment method:	Required to assess emission savings from implemented measures during the monitoring period Evaluation method required here.
Additional Comment:	

Data/ Parameter # 3. 6.7	**Transported freight by all small trucks in a year (annual freight turnover)**
Dimension:	Ton.km/year
Description:	Secondary data
Used Source:	Data #3.6.1*3.6.2*3.6.6.
Value used in the SEAP:	**43 186 770**
The Rationale for using these data, or measure/assessment method:	
Additional Comment:	These parameters can be verified through actually transported freight and kilometrage

Commercial Transport (Big Trucks)

Data/ Parameter # 3. 7.1	**Number of big trucks in Kutaisi (diesel)**
Dimension:	Number of big trucks by fuel type
Description:	Primary data
Used Source:	Provided to the SEAP by Kutaisi Municipality
Value used in the SEAP:	**853 (Total diesel)**
The Rationale for using these data, or measure/assessment method:	Kutaisi Municipality Transport Service is responsible for this data
Additional Comment:	Primary verification of these data is under responsibility of the City Hall Transport Service

Data/ Parameter # 3. 7.2	**Average distance covered by one big truck a year (by duel type is desirable)**
Dimension:	Km/year
Description:	Primary data
Used Source:	Provided to the SEAP by Kutaisi Municipality
Value used in the SEAP:	**15 000**
The Rationale for using these data, or measure/assessment method:	Kutaisi Municipality Transport Service office is responsible for the data.
Additional Comment:	Primary verification of these data is under responsibility of the City Hall Transport Service

Data/ Parameter # 3.7.3	**Average distance covered by all big trucks a year (by duel type is desirable)**
Dimension:	Trans.km/year
Description:	Calculated data
Used Source:	Calculated by the MUNI_EIPMP Data # 3.7.1 and 3.7.2
Value used in the SEAP:	**12 795 000 (diesel)**
The Rationale for using these data, or measure/assessment method:	
Additional Comment:	

Data/ Parameter # 3. 7.4	**Fuel consumption by vehicle type**
Dimension:	L/100 km.
Description:	Primary data
Used Source:	Registration Certificate of a motor car. Provided to the SEAP by Kutaisi Municipality.
Value used in the SEAP:	**Diesel 30 l**
The Rationale for using these data, or measure/assessment method:	
Additional Comment:	

Data/ Parameter # 3. 7.5	**Annual fuel consumption by vehicle and fuel types**
Dimension:	L/year
Description:	Secondary data
Used Source:	Calculated by the MUNI_EIPMP
Value used in the SEAP:	**3 838 500 l diesel**
The Rationale for using these data, or measure/assessment method:	
Additional Comment:	

Data/ Parameter # 3.7.6	**Big trucks load factor (load factor)**
Dimension:	ton-km/ car-km
Description:	Primary data
Used Source:	Provided by the Transport Service of the Municipality now
Value used in the SEAP:	**18**
The Rationale for using these data, or measure/assessment method:	Required to assess emission savings from implemented measures during the monitoring period Evaluation method required here.
Additional Comment:	

Data/ Parameter # 3. 7.7	**Transported freight by all big trucks in a year (annual freight turnover)**
Dimension:	Ton.km/year
Description:	Secondary data
Used Source:	Calculated by the MUNI_EIPMP Data #3.7.1*3.7.2*3.7.6.
Value used in the SEAP:	**230 310 000**
The Rationale for using these data, or measure/assessment method:	
Additional Comment:	These parameters can be verified through actually transported freight and kilometrage

Data/ Parameter # 3. 7.8	**Fuel consumed by Kutaisi transport sector by fuel type**
Dimension:	L/year M^3/year
Description:	Primary data
Used Source:	The National Statistics Office and Kutaisi Municipality Transport Service are responsible for the data.
Value used in the SEAP:	This data has not been used for the SEAP.
The Rationale for using these data, or measure/assessment method:	
Additional Comment:	This data is very important for balance verification

Waste Management

Data/ Parameter # 4.1	**Amount of waste (collected and deposited in a landfill daily) Current landfill in Kutaisi (Nikea)**
Dimension:	m^3 or ton
Description:	Primary data
Used Source:	The data has been provided by Kutaisi Municipality in the SEAP preparation process
Value used in the SEAP:	The landfill has been operating since 1956. 630m^3 ofwaste was deposited daily by 2012. Accumulated waste had to be approximately 6.5 million m^3(1.3 milliont) by 2012.
The Rationale for using these data, or measure/assessment method:	
Additional Comment:	The landfill is currently active and is expected to close in 2016 after opening of a new polygon in Terjola. Methane will continue to flow out for 30 more years maximum, without its collection and combustion.

Data/ Parameter # 4.2	**Nikea landfill parameters (area, depth, waste composition)**
Dimension:	Area -ha Depth -m Waste composition-%
Description:	Primary data. Used for methane quantitative assessment and monitoring will not be necessary, any more
Used Source:	The data has been provided by Kutaisi Municipality in the SEAP preparation process
Value used in the SEAP:	Area -15 ha Depth - 12-157 m Waste composition : Organic waster 71%, Paper 6%, Textiles 3%, Polyethylene 6%, inert material 6%, metal 3% etc. 5%
The Rationale for using these data, or measure/assessment method:	This data is used to estimate annual methane emissions in advance
Additional Comment:	The landfill is currently active and is expected to close in 2016 after opening of a new polygon. There will not be necessary to monitor these parameters after closing. In case of the project proposal implementation, methane measurements will be enough, otherwise theoretical calculations will be considered only.

Data/ Parameter # 4.3	**Amount of collected and burnt methane locally**
Dimension:	m^3
Description:	Primary data. Being obtained through measurements
Used Source:	This data/quantity has been estimated by FOD model of the IPCC in the SEAP preparation process.
Value used in the SEAP:	Assuming that the landfill is closing in 2016 and methane combustion is planned from 2017 an average 30 g CO_2equivalent will be saved from flowing out

	annually, equaling to 128 g CO_2equivalent in 4 years (2016 – 2020), being 89.5% of generated amount.
The Rationale for using these data, or measure/assessment method:	
Additional Comment:	

Data/ Parameter # 4.4	**Generated methane calculation (If closing and project proposal is not performed)**
Dimension:	m^3 or ton
Description:	Secondary data. Generated methane amount shall be calculated through the first-line rotting model. Calculations are under the Monitoring group responsibility.
Used Source:	2006 IPCC Guidelines for National Greenhouse Gas Inventories, http://www.ipcc-nggip.iges.or.jp/public/2006gl (p. 3.36) This is a ready-made software requiring to input parameters
Value used in the SEAP:	Parameters necessary for calculations: Population size Per capita waste (a day or annually) Waste composition (from new evaluations) Methane Emission Correcton Factor (MCF) -1 Rotting-capable organic carbon Waste composition DOC Food waste 0.15 Garden 0.20 Paper 0.40 Wood and straw 0.43 Textile 0.24 Pampers 0.24 Share of Rotting-capable practically rotten organic carbon (DOCF)-0.5-0.6 Share of methane in landfill gas (F)-50% Oxidation factor (OX)-0.1 (on controlled landfill)
The Rationale for using these data, or measure/assessment method:	
Additional Comment:	In case of the landfill closing failure and most importantly the failure of a project proposal about burning of methane, methane measurement is likely to fail as well and abovementioned parameters will be observed through monitoring and generated methane assessment.

Outdoor Lighting Sector

Data/ Parameter # 5.1	**Total amount of electricity consumed for outdoor lighting annually**
Dimension:	kW.h/year
Description:	Primary data
Used Source:	Kutaisi City Hall Infrastructure Service office. The office is responsible for providing a report about amount of electricity consumed for outdoor lighting a year or annually.
Value used in the SEAP:	**9 412 671 kW.h (2012)** **11 800 000 kW.h (2020 year forecast)**
The Rationale for using these data, or measure/assessment method:	
Additional Comment:	The data shall be verified with paid amounts.

Data/ Parameter # 5.2	**Quantity of energy-efficient (ECO-LAMPS) bulbs, which will be partially replaced by inefficient/old lamps and will be used in new installations**
Dimension:	Quantity of ECO-LAMPSlamps
Description:	Primary data
Used Source:	Project/measure implementating unit
Value used in the SEAP:	According to the measure, there will 85% new, ECO-Lamps in outdoor lighting by 2020. **14 700 pieces**
The Rationale for using these data, or measure/assessment method:	
Additional Comment:	If the measure is taken there has to be clarified the follwong: what will happen to the replaced bulbs, are they going to be destructed or handed over to someone, if yes to whom?

Data/ Parameter # 5.3	**Energy saved by one ECO-LAMPS bulb in an hour**
Dimension:	kW.h
Description:	Primary data
Used Source:	Technical passport of the bulb
Value used in the SEAP:	**0.236** kW.h
The Rationale for using these data, or measure/assessment method:	
Additional Comment:	

Data/ Parameter # 5.4	**Emission savings through implemented measures (ECO-LAMPS)**
Dimension:	T $CO_{2equivalent}$
Description:	Secondary data calculated by the monitoring group annually
Used Source:	SEAP developing group
Value used in the SEAP:	Saving of 911 t $CO_{2\ equivalent}$ has been estimated by 2020
The Rationale for using these data, or measure/assessment method:	
Additional Comment:	

Greening of Kutaisi

Data/ Parameter # 6.1	**Annual planting and sprouting (by species)**
Dimension:	Ha Number of plantings by species
Description:	Primary data
Used Source:	City greening service, botanical garden management
Value used in the SEAP:	Due to lack of specific greening plan there has been allowed to cultivate 1 Ha area annually from 2014 (100% sprouting) within the SEAP
The Rationale for using these data, or measure/assessment method:	
Additional Comment:	

Data/ Parameter # 6.2	**Annual cutting of trees (by species)**
Dimension:	m^3
Description:	Primary parameter
Used Source:	City greening service, botanical garden management
Value used in the SEAP:	The SEAP assesses only current accumulation of carbon in Kutaisi and annual accumulation before 2020. Cuttings shall be considered during the monitoring process.
The Rationale for using these data, or measure/assessment method:	
Additional Comment:	

Data/ Parameter # 6.3	**Annual fire or other causes of damages of trees**
Dimension:	m^3
Description:	Primary parameter
Used Source:	City greening service, botanical garden management

Value used in the SEAP:	The SEAP assesses only current accumulation of carbon in Kutaisi and annual accumulation before 2020. Fires, tree and plant diseases and other causes of destruction of trees shall be considered in the monitoring process.
The Rationale for using these data, or measure/assessment method:	
Additional Comment:	

Data/ Parameter # 6.4	**Botanical garden area monitoring**
Dimension:	Ha
Description:	Primary parameter. Annual monitoring of area changes
Used Source:	Botanical garden
Value used in the SEAP:	The SEAP assesses existing condition of botanical garden. Only current accumulation of carbon in Kutaisi and annual accumulation up to 2020. Cuttings shall be considered in the monitoring process.
The Rationale for using these data, or measure/assessment method:	
Additional Comment:	

Data/ Parameter # 6.5	**Garden area changes (fire, diseases and reducing amount of trees)**
Dimension:	m^3
Description:	Primary parameter
Used Source:	Botanical garden
Value used in the SEAP:	Botanical garden's current condition and absorbtion up to 2020 have been assessed within the SEAP.Biomass changes monitoring shall be conducted annually.
The Rationale for using these data, or measure/assessment method:	
Additional Comment:	Typical indicators for the greening sector and characterizing indicators of regional forests for botanical garden have been taken at this stage (biomass increment, dry biomass quantity). Continuous monitoring for all used parameters and relevant changes in calculations required in case of parameters update.

Data/ Parameter # 6.6	**Annual monitoring on CO_2 absorption changes**
Dimension:	T CO_2 a year
Description:	Secondary parameter. Calculated by the monitoring group
Used Source:	Has been calculated by the SEAP developing group for now
Value used in the SEAP:	Greening of Kutaisi covers 211.6 Ha territory (fragmentary covered plantation areas and botanical garden). At the territory now 13 635 t. carbon is reserved

	with annual absorption of 460.2 t CO_2. In 5 Ha of Kutaisi botanical garden 615t carbon has been deposited and annual absorption has been amounted to 17 t CO_2.
The Rationale for using these data, or measure/assessment method:	
Additional Comment:	

Buildings Sector

Data/ Parameter # 7.1	**Annual energy consumption of municipal buildings**
Dimension:	MW.h/Year
Description:	Primary parameter
Used Source:	Kutaisi City Hall Financial Service. Final quality of data is under responsibility of Energy Manager assigned by Kutaisi City Hall.
Value used in the SEAP:	**13 203. 35**
The Rationale for using these data, or measure/assessment method:	
Additional Comment:	This data shall be checked at Energo-pro Georgia and by energy audit estimations.

Data/ Parameter # 7.2	**Annual energy consumption of residential buildings**
Dimension:	MW.h/year
Description:	Primary parameter
Used Source:	Energo-pro Georgia. Final quality of data is under responsibility of Energy Manager assigned by Kutaisi City Hall (or monitoring group)
Value used in the SEAP:	**99 477.54**
The Rationale for using these data, or measure/assessment method:	
Additional Comment:	This data may be checked by a survey of typical buildings or energy audit estimations.

Data/ Parameter # 7.3	**Annual energy consumption of commercial buildings**
Dimension:	MW.h/year
Description:	Primary parameter
Used Source:	Energo-pro Georgia. Final quality of data is under responsibility of Energy Manager assigned by Kutaisi City Hall (or monitoring group)
Value used in the SEAP:	

	6 370.51
The Rationale for using these data, or measure/assessment method:	
Additional Comment:	This data may be checked by a survey of typical buildings or energy audit estimations.

Data/ Parameter # 7.4	**Annual consumption of natural and liquid gas by municipal buildings**
Dimension:	m^3/year; kg/year
Description:	Primary parameter
Used Source:	Kutaisi City Hall Financial Service. Final quality of data is under responsibility of Energy Manager assigned by Kutaisi City Hall.
Value used in the SEAP:	**Natural gas- 561 137 (m^3/year)** **Liquid gas - 460 (kg/year)**
The Rationale for using these data, or measure/assessment method:	
Additional Comment:	May be checked at gas supply company

Data/ Parameter # 7.5	**Annual consumption of natural and liquid gas by residential buildings**
Dimension:	m^3/year; kg/year
Description:	Primary parameter
Used Source:	Gas distribution company, serving Kutaisi. Final quality of data is under responsibility of Energy Manager assigned by Kutaisi City Hall.
Value used in the SEAP:	**Natural gas - 253 386.78** m^3
The Rationale for using these data, or measure/assessment method:	
Additional Comment:	

Data/ Parameter # 7.6	**Natural gas annual consumption by commercial buildings**
Dimension:	m^3/year; kg/year
Description:	Primary parameter. Annual
Used Source:	Gas distribution company, serving Kutaisi. Final quality of data is under responsibility of Energy Manager assigned by Kutaisi City Hall.
Value used in the SEAP:	**Natural gas-202.41 m^3**
The Rationale for using these data, or	

measure/assessment method:	
Additional Comment:	This data may be checked by a survey of commercial buildings or energy audit estimations.

Data/ Parameter # 7.7	**Firewood and diesel annual consumption of municipal buildings**
Dimension:	m^3; l
Description:	Primary data
Used Source:	Kutaisi City Hall Financial Service. Final quality of data is under responsibility of Energy Manager assigned by Kutaisi City Hall.
Value used in the SEAP:	**Firewood - 385.5**
The Rationale for using these data, or measure/assessment method:	
Additional Comment:	

Data/ Parameter # 7.8	**Firewood annual consumption by residential buildings**
Dimension:	m^3
Description:	Primary parameter
Used Source:	Vouchers issued for residents. Final quality of data is under responsibility of Energy Manager assigned by Kutaisi City Hall.
Value used in the SEAP:	**Firewood - 83 340 ∂³**
The Rationale for using these data, or measure/assessment method:	According to experts' estimations, annual consumption of firewood in Kutaisi is about 3000-4 000 m^3.
Additional Comment:	Have to be checked with periodic surveys. Especially firewoodconsumption rate is higher than voucher issuances

Data/ Parameter # 7.9	**Firewood and diesel annual consumption of commercial buildings**
Dimension:	MW.h/year
Description:	Primary parameter. Annual
Used Source:	Commercial buildings survey. Final quality of data is under responsibility of Energy Manager assigned by Kutaisi City Hall.
Value used in the SEAP:	Nothing is being consumed now. But monitoring is necessary.
The Rationale for using these data, or measure/assessment method:	
Additional Comment:	This data may be checked by a survey of commercial buildings

Data/ Parameter # 7.10	**Annual CO_2 monitoring from all three sectors**
Dimension:	T/year
Description:	Secondary parameter. Annual
Used Source:	Calculated by the monitoring group
Value used in the SEAP:	**2012- 70 605.64** **2020- 145 692.93**
The Rationale for using these data, or measure/assessment method:	
Additional Comment:	

Data/ Parameter # 7.11	**Savings through measures carried out in buildings sector**
Dimension:	MW.h/per measure
Description:	Secondary parameter. Annually calculated for each measure.
Used Source:	Project executor (population, municipality, head of commercial building)
Value used in the SEAP:	This parameter is calculated in case of carrying out each specific measure in accordance with the monitoring plan accompanying each measure.
The Rationale for using these data, or measure/assessment method:	Assessment/measurement of energy consumption with corresponding CO2 baseline scenario and actual measurements is required for all buildings and fuel types under the measures
Additional Comment:	Energy consumption can be reduced due to various reasons (technical disconnections, disconnections because of unpaid bills, etc.). Therefore, proving that reduction has actually been resulted from fulfilled measure without involvement of any artefacts is necessary. Emission savings estimation methods within the framework of abovementioned measures shall be described separately for each measure.

Sustainable Development Criteria

Monitoring report should also include results of observations on sustainable development criterias/indicators. The indicators are listed below:

- Increase of the population's comfort and energy expenditure savings (per capita hot water consumption, expansion of heated area, approximation of per area energy consumption to European standards etc.);
- Promotion of residential condominiums;
- Comfort improvement, or energy expense savings in municipal/commercial buildings (heat, electricity, hot water consumption per area unit);
- Implementation of waste recycling technologies;
- Expansion of per capita green areas;
- Reduction of local pollutants (mainly resulted from measures carried out in the transport sector);
- Increase of the number of employees;
- Contribution to the gender processes;

- New technology demonstration and piloting;
- Promotion of the private sector development;
- Municipalities can report on other additional criterias, having been influenced by measures carried out within the framework of the Sustainable Energy Action Plan.
- Main obstacles to the plan, ways to avoid and overcome mentioned barriers and steps towards achieving success.