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ENHANCING CAPACITY FOR LOW EMISSION DEVELOPMENT STRATEGIES (EC-LEDS)/ CLEAN ENERGY PROGRAM

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Low Emission Development Strategy- Buildings Sector

September 2016

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September, 2016

This report was prepared under the technical assistance provided to the Government of Georgia for development of the Low Emission Development Strategy in the framework of the "Enhancing Capacity for Low Emission Development Strategy" (EC-LEDS) project.

The report presents the Building Sector chapter of the Low Emission Development Strategy. Its Georgian version was submitted to the buildings sub working group for consideration and comments on August 9 , 2016. No comments have been received from sub-working group by September 27, 2016.

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Abbreviations and Symbols

PJ	Petajoule (10^{15} Joule)
Gg	Gigagram (10^9G=10^3T)
GWh	Gigawatt-hour (10^9 W.h)
MW	Megawatt (10^6 W)
BAU	Business As Usual
EBRD	European Bank for Reconstruction and Development
CO_2	Carbon dioxide
CH_4	Methane
N_2O	Nitrous oxide
GJ	Gigajoule (10^9 Joule)
TJ	Terajoule (10^{12} Joule)
NO	Nitrogen monoxide
NO_x	Nitrogen oxides
EC-LEDS	Enhancing Capacity for Low Emission Development Strategies
N_2	Molecular nitrogen

1 Buildings sector in Georgia

The buildings' fund in Georgia is sufficiently diverse in respect of construction types and functions and includes XX century Soviet era, preceding epoch and recent period constructions. As 53% of country population is living in urban regions and 47%- in rural areas, this correspondingly is reflected in multiplicity of residential houses. In Georgia there is yet no complete register of buildings fund. However definite information and data for cities has been obtained in the process of developing Sustainable Energy Action Plans and Low Emission Development Strategies[1]. Based on this information and using other sources the number of buildings at the territory of Georgia and their total area has been assessed.

65% of buildings in Georgia are predominantly multi-storey buildings constructed in the period of 1950-2000 (Fig. 1):

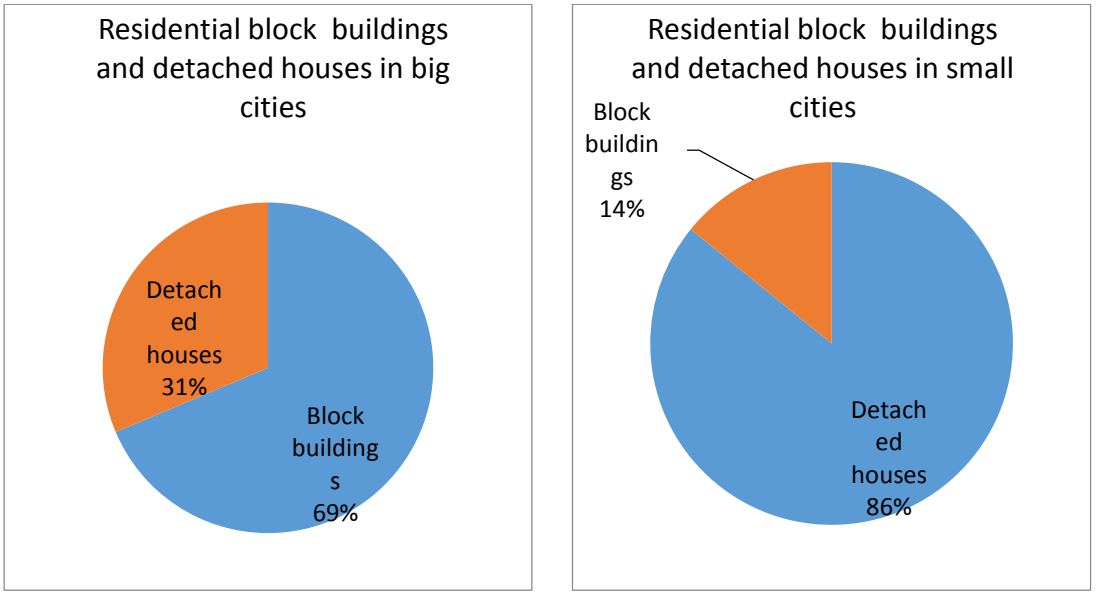

Fig. 1. Distribution of total areas of multistory buildings and detached houses in large and small cities

Since 1960s intensive construction of 5-storey multi-apartment buildings, so called "Khrushchev houses" was started. Their engineering and construction criteria were proceeded from the government policy of that time, aimed at satisfying the minimum requirement of population's living conditions. The exploitation term for Khruschev period buildings was determined to be 25 years, and majority of them has been built 50 years ago[2]. Each type of these buildings was designed using different construction materials with the endurance to 7- force earthquake. Initially these houses were built of bricks, subsequently substituted with big construction blocks and panels. Later on, using the same design, construction of 8-storey buildings has started. The thermal resistance of structures built in this period

[1] Information is mainly based upon questionings conducted in Georgia's 15 municipalities under the EC-LEDS project. 6 large self-governing cities (Tbilisi, Kutaisi, Batumi, Poti and Gori) and 5 Municipalities (Zugdidi, Telavi, Akhaltsikhe, Zestaphoni and Gori) have been questioned, totaling 4 380 residents.

[2] The most wide-spread design standards in this period were: N1-319C, N1-450C, N1-464AC.

was low as the comfort and sanitary-hygienic criteria were minimal. Their thermal resistance index satisfied the obligatory standard, not exceeding the value of R=0.575 m^2 $^0C/W$[3] according to Construction Code. It has to be noted that eventually this Code was changing in time, but the above mentioned obligatory criterion has been the highest in the Soviet engineering practice.

The majority of detached houses as a residence of one or two families, are constructed in the Soviet period as well and mainly satisfy the requirements of that time. The majority of them are constructed with bricks or cement blocks, the thermal resistance index mainly being in the frames of obligatory value (R= 0.575 m^2 $^0C/W$), indicating the need for excess supply of heat to warm the building[4]. For the time being these norms are still in force in Georgia.

The energy consumption trends in Georgia's Buildings sector statistically are not quite reassuring. Exceptionally notable is the 2012 consumption, being dropped out of general canvas. As it is known, since 1990s the official energy balances in Georgia were prepared fragmentally and after the 2 000 energy balance first official energy balance has been developed for 2013. Up to now Georgia has the 2013 and 2014 official Energy Balances. According to the National Statistics Office of Georgia in future the country will have Annual Energy Balances, which will significantly improve the building sector energy consumption data.

In line with the methodology of statistical energy balance development and preparation of GHG inventory, the total fund of existing buildings is divided into 2 major categories to assess energy consumption and GHG emissions: Residential and Non-residential (Commercial) buildings. According to this classification the category of state and municipal buildings is considered in the commercial buildings category, although aiming the proper planning of energy efficiency measures' implementation commercial buildings in this document in its turn are divided into commercial, state and municipal buildings.

Figures (Fig. 2; Fig. 3) demonstrate fuel consumption trends in residential and non-residential (commercial) sectors in 2000-2014.

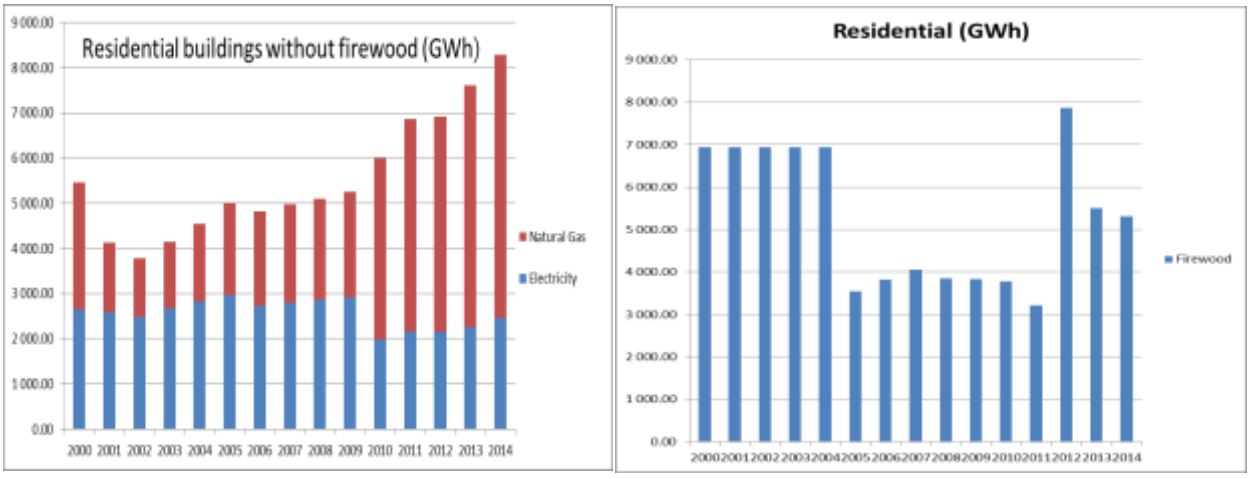

Fig. 2. Fuel consumption trends in residential buildings (GWh)

[3] m^2 $^0C/W$ is the thermal resistance unit, being dependent on climate zone.

[4] In Europe the minimal obligatory index is different according to climate conditions. E.g. the minimum requested value in the city of Split (Croatia) makes 0.83 m^2 $^0C/W$ for wall and 1.33 m^2 $^0C/W$ for roof (www.eurima.org/uvalues-in-europe). At this link minimal requirements by U index (R = 1/U) are given. The given indexes are different for various colors of rooftop as well.

The Fig. 2 shows that wood fuel consumption trend is not typical comparing to the overall increasing trend in energy consumption of Georgia's building sector. Information on fuel wood consumption gathered during the SEAPs preparation shows that despite decrease trends of wood consumption in big cities, the same trend is not observed in small cities and urban areas but in opposite some increase happens in particular years. Most likely this consumption decrease in 2005-2011 is the result of unreliable statistics which was later improved as it is confirmed by local governments. However, in the energy balance of 2014 the wood consumption has decreasing trend compared with 2013.

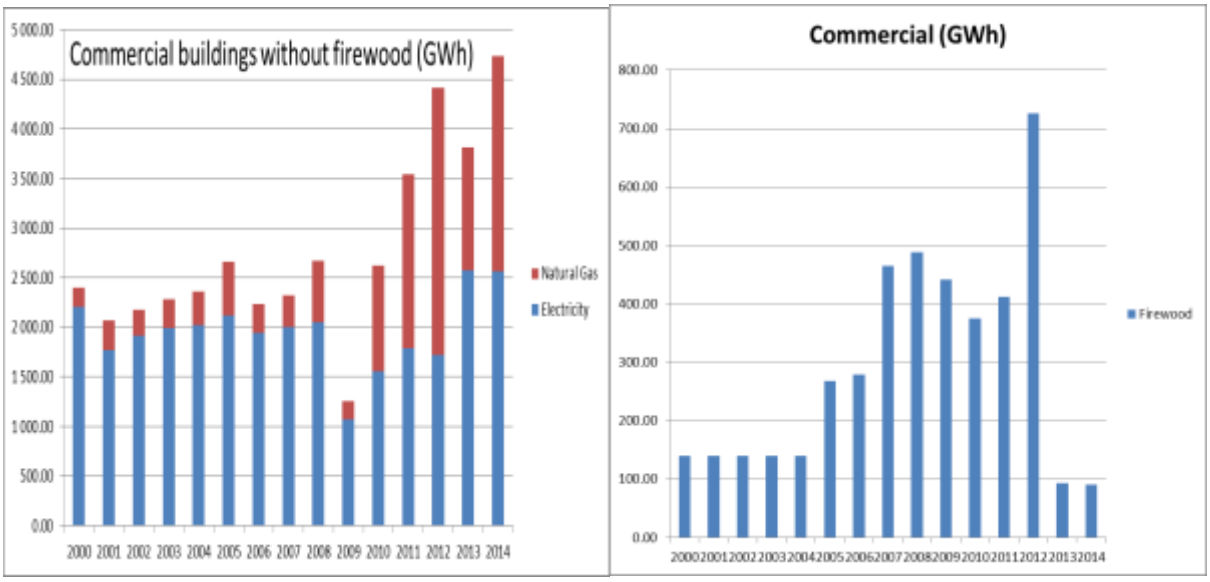

Fig. 3. Fuel consumption trends in non-residential (commercial) buildings (GWh)

The Fig. 3 represents fuel consumption by non-residential (commercial) buildings (comprising of state and municipal buildings as well). Energy consumption fall in 2009 could be explained by decreased economic activities in post 2008 August war period.

Considering the year 2012 when fuel wood consumption in both residential and in non-residential sectors was very high compared with other years, the climatic parameters of heating season in this year[5] were checked with the National Environmental Agency (NEA) and it was confirmed that it was one of the coldest seasons in 2007-2014, when air temperature fell by 1-3 ^0C[6] compared to the mean, leading to the increase in energy consumption (particularly firewood, Fig. 2 and Fig. 3) and this increase was particularly high in small cities and rural areas using mainly wood fuel for heating and having more severe climate. According to different sources[7] the firewood consumption in 2012 reached almost 4 million m^3, that is 0.3 million m3 more than the annual wood demand (3.7 million m^3)[8] officially confirmed by the Minister of Environment and Natural Resources Protection.

[5] Heating season of 2012 comprises 2 last months (November, December) of 2011 and 3 months (January, February, March) of 2012.

[6] The Third National Communication of Georgia to the UNFCCC; NEA of the Ministry of Environment and Natural Recourses protection. http://moe.gov.ge/index.php?lang_id=GEO&sec_id=141

[7] IEA

[8] CENN, http://forestry.cenn.org/index.php/news/gigla-agulashvili-sheshis-mothkhovna-mitsodebis-shesadzleblobaze-gatsilebith-maghalia.html

Results of comparing heating season temperature and buildings sector energy consumption are provided on the Fig. 4.

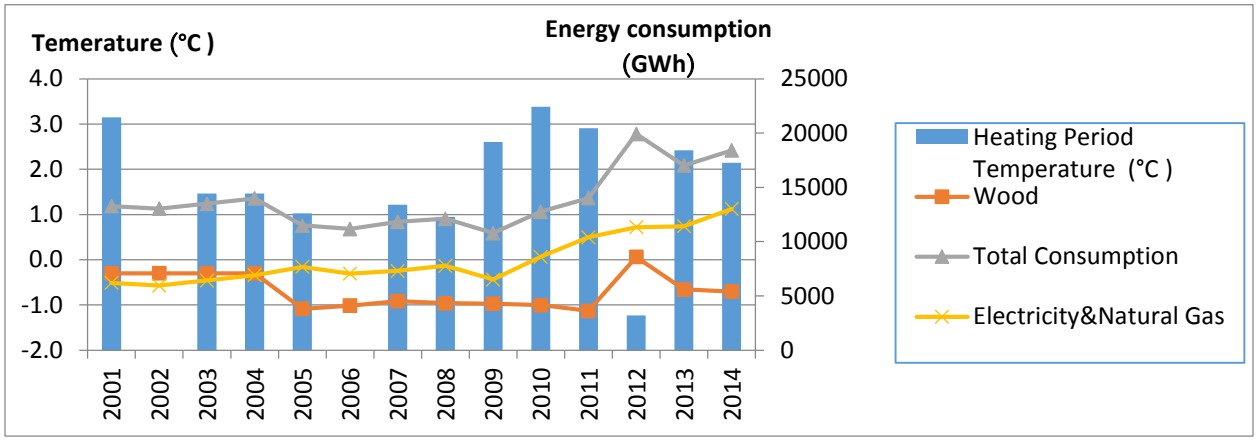

Fig. 4. Impact of heating season average temperature on energy consumption

Fig. 4 demonstrates significant sensitivity of wood fuel consumption to temperature variation (fall in this case), which could be explained by several reasons but among them the most important one is that wood stoves in Georgia are less efficient than gas and electricity consuming heating technologies and in addition coldest heating seasons in Georgia are in regions, where more than 80% of households are using wood stoves. More detailed analysis is not relevant till more reliable statistics is not available.

According to the Energy Balance Sheets, energy consumption in 2014 was 8% higher than in 2013. Fig. 5 presents changes in energy consumption shares (in %) of residential and non-residential sectors.

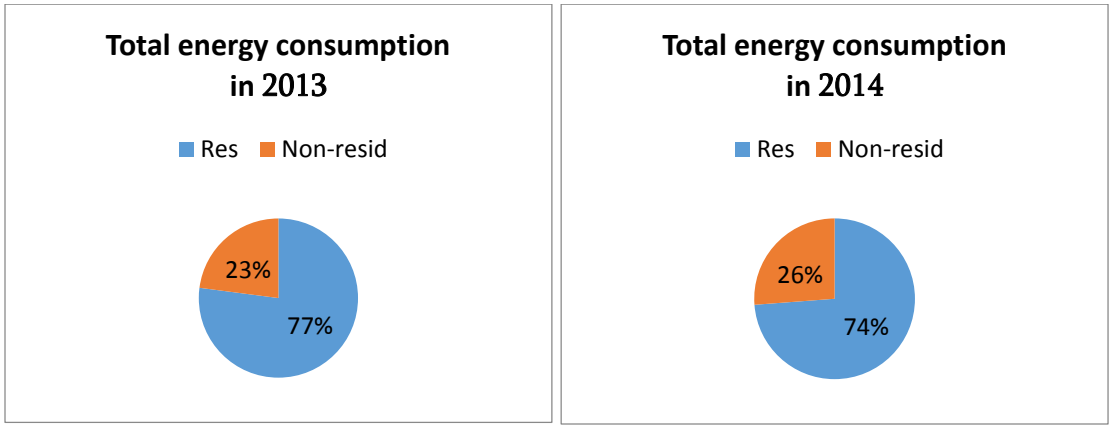

Fig. 5. Shares in energy consumption of residential and non-residential sectors in 2013-2014

Fig. 6 represents CO_2 emissions by fuel types from residential and non-residential buildings.

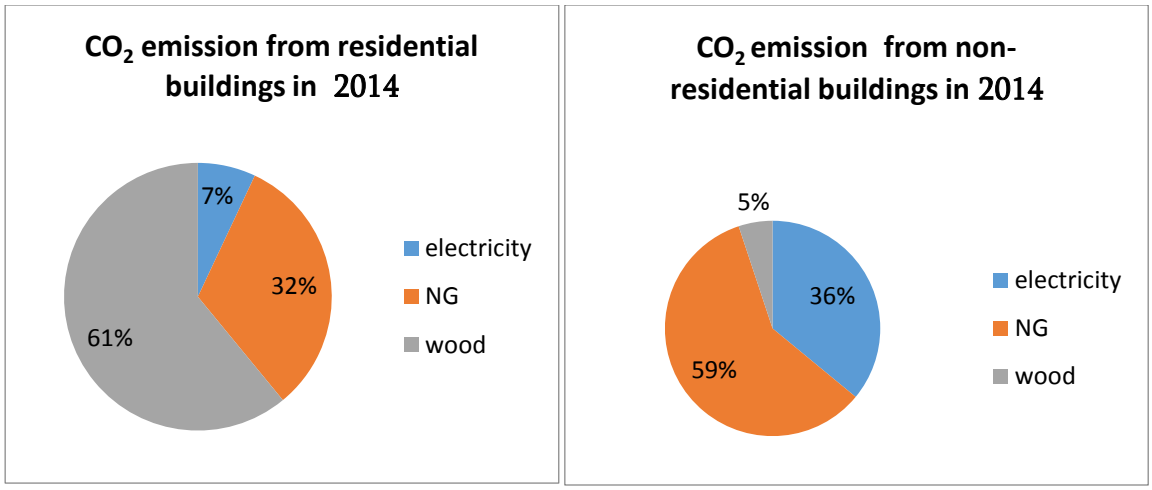

Fig. 6. Distribution (in %) of CO2 emission by fuel type and building ownership

Fig. 6 demonstrates that wood fuel emission[9] has highest share in total emission from residential sector that was relevantly taken into consideration when emission reduction measures for buildings sector were planned.

In the Buildings (Housing) sector of Georgia the total fund of buildings has been grouped and assessed by different criteria, aimed at the introduction of energy efficiency measures and the increase of renewable energy application (or provision of low emission buildings sector). These are:

- Ownership form (7 types);
- Location according to climate zone (3 zones);
- Location according to technological zone (5 zones);
- Functionality of buildings;
- Types of buildings according to construction design;
- Specific and overall energy consumption by the building.

According to the analysis of different estimations, it has been revealed that total area of buildings existing in Georgia makes up 126.7 million m^2, from which about 75.97 million m^2 (59%) are heated. As there are no exact data on the dwelling fund in the country, the assessment of this value was made using various sources (questionings under LEDS project[10], the SEAP data of the cities[11]) and different methods of estimation (Annex I). The overall residential area in Georgia approximately equals to 110.1 million m^2 (Annex I). The estimates also revealed that commercial and state owned areas correspondingly make 10.7 million m^2 and 5.9 million m^2 (Fig. 7).

[9] According to the IPCC Guideline emission from biomass fuel is calculated in GHGs National Inventory but is not summed up with total emission as this emissions considered to be 0 because the biomass fuel is neutral (it emits the same amount which was absorbed in its lifetime) under sustainable forest management and it's assumed that in most countries fuel wood is produced in sustainable way. However, under the unsustainable management of forests and production of firewood it is the same type emission source as other fuels and in particular in long-term perspective.

[10] Enhancing Capacity for Low Emission Development Strategies/EC-LEDS Clean Energy Program, Knowledge, Attitude and Behavior Baseline Survey: Annex #1- Summery Findings by Target Municipalities

[11] http://remissia.ge/index .php/ka/2014-12-09-16-12-09/seaps

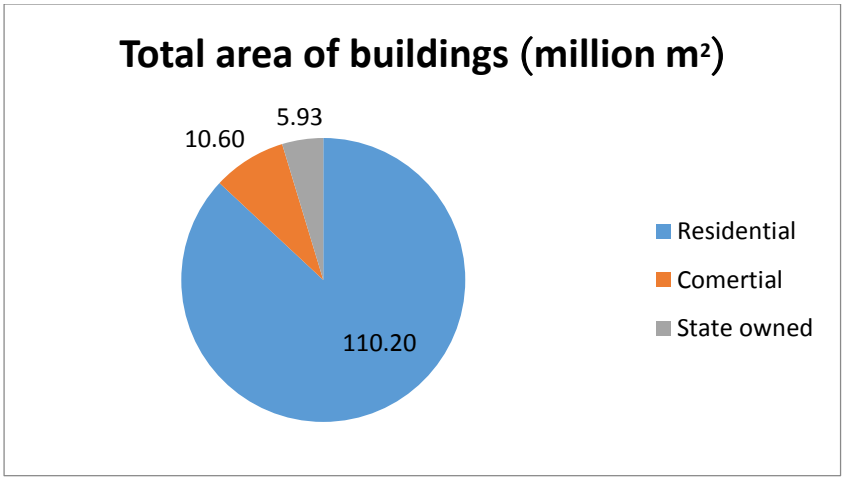

Fig. 7. Distribution of areas by the form of ownership.

The 44% of buildings' total area and 38% of residential area is concentrated in large cities and 46% of overall area is congregated in Tbilisi.

In the Residential buildings sector, according to ownership form 4 main types may be singled out among which, despite important similarities, nevertheless exist some differences which should be accounted for during the introduction of large-scale energy efficiency programs and implementation of buildings' complete rehabilitation activities.

Box 1. Residential buildings

- Buildings having common areas are block buildings. According to Georgia's Legislation the buildings are managed by flat owners associations[12].
- Multi-apartment buildings also include "Social-houses", mainly constructed by local authorities for critically low income families, eco-migrants and internally displaced persons (IDPs).
- Residential houses having the status of cultural heritage mainly are located within large cities. This 1-3 storey buildings are in private ownership, though their owners are restricted to make significant changes during the rehabilitation that especially concerns the reconstruction of façade.
- Energy audits undertaken during the development of SEAPs have revealed that the 1-2 storey private houses possess the highest potential of energy saving in case of their complete heating.

[12] This Low regulates homeowner associations common property management process, determines forms of homeowners association and forms of homeowners property, as well as main juridical conditions for the creation, formation, activity and liquidation of such associations. The Low (Article 7, Paragraph 3) obliges flat owner to maintain common property and make financial contribution to the building exploitation, determining in some aspects the execution mechanism, consisting of debt of flat owner to association in case of rejecting to make contribution, which may be recorded in the Public Register (if the sum exceeds 500 GEL) on behalf of that flat. In case of selling the flat new owner will be responsible for the debt, though this approach is not usually in use. In the process of maintaining the building important barrier is the fact that association is not a legal entity that weakens its responsibility and makes it unable to get a credit, the more as, according to the same Low, the association is not responsible for the individual debt of flat owner.

Non-residential/commercial buildings consist of state edifices and commercial constructions, while state edifices are divided into buildings being under municipal ownership and premises under central or Autonomous Republic's possession, among them public buildings.

Box 2. Non-residential/Commercial buildings

- **Buildings under the state possession**, belonging to the Ministry of Economy and Sustainable Development or sectorial Ministries.
- **Buildings under the Autonomous Republic's possession**, belonging to the Ministry of Economy and sectoral Ministries of Autonomous Republic.
- **Municipal buildings**
- **Public buildings**[13] occupy yet important part of state belongings and make about 40% of total property[14].According to present policy the Authority attempts to ensure maximum privatization of state property, first of all of public buildings and to minimize the number of premises necessary to perform administrative functions by the State.
- **Commercial buildings** include constructions used in private services (private schools, kindergartens, Universities, private utilities of medical service and all other commercial edifices in the frames of private sector).

Distribution rate of state owned buildings by ownership and residential buildings by age class are presented in Figures below (Fig. 8 and Fig. 9).

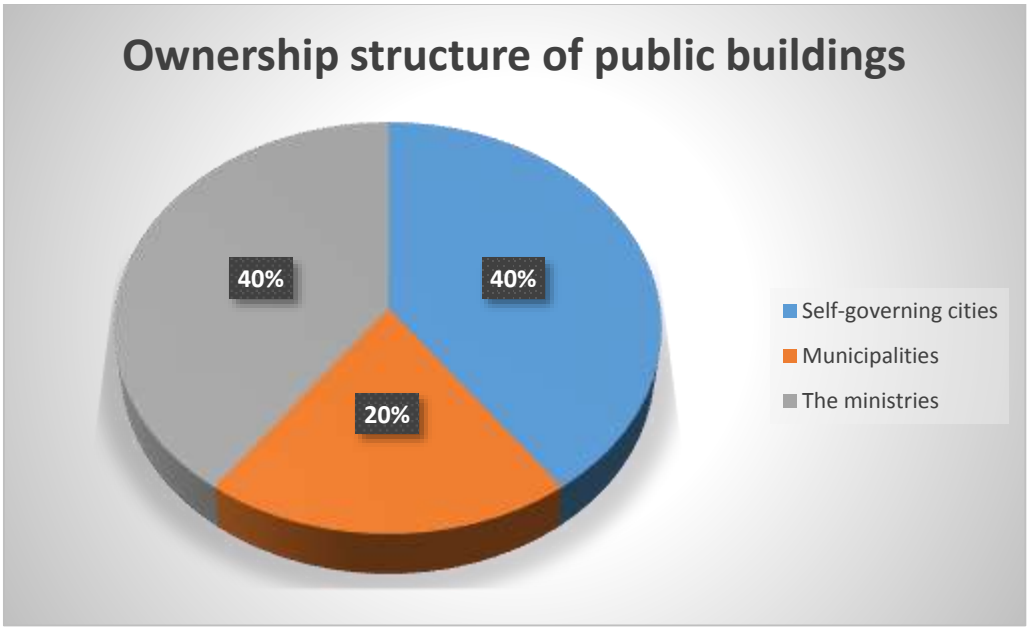

Fig. 8. Share of state buildings according to ownership form.

The share of administrative buildings makes by an area 1% in Georgia's buildings sector. 3 main types of administrative constructions could be singled out: historical buildings being under the possession of

[13] Schools, kindergartens, sporting and music schools, clinics and hospitals.
[14] SEAPs of Georgia's 10 cities and Municipalities

Municipalities or the State, but still requiring special permit to conduct rehabilitation works, soviet area buildings and modern constructions, trimmed predominantly with glass, which were constructed in 2005-2012 and are in small number.

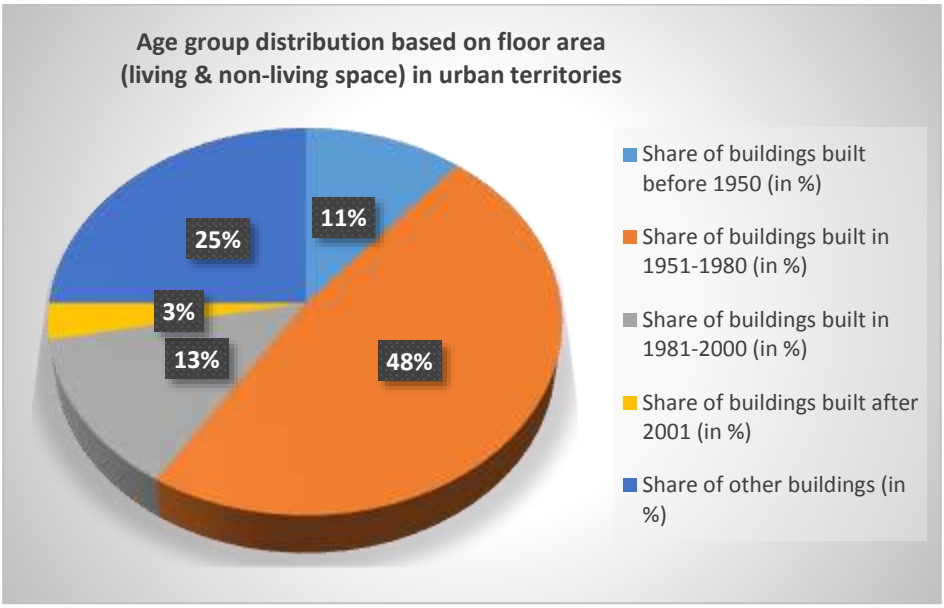

Fig. 9. Distribution of buildings by the age, in the frames of EC-LEDS project survey

For the assessment of different features of Georgia's buildings sector energy efficiency and energy consumption total area of the country was divided into 3 climate zones[15]. This division is based upon such important for heating and cooling parameter as the Heating and Cooling Degree-days[16].

In each of this climate zone, according to population number significantly defining applied technologies, additionally could be singled out two types of zones, conventionally called as Fourth and Fifth zones. Hence, accounting for technologies and fuel consumption, altogether 5 technological zones are discussed. In the Fourth zone the settlements are amalgamated having population more than 2 000, and in the Fifth zone 5 big cities are united (Tbilisi, Batumi, Kutaisi, Rustavi and Poti). The climate conditions (in particular heat degree-days), fuel availability and heating/cooling technologies are just those parameters which determine the duration of heating season in these zones, energy efficiency of the buildings, applied technologies and the energy consumption efficiency in general. Below each zone is described in more detail.

[15] Design Technical Regulations "Construction Climatology" http://gov.ge/files/382_40062_363410_71-5.pdf. These norms are in force under the Decree No. 1-1/1743 of the Minister and Economy and Sustainable Development dated 25 August 2008. https://www.matsne.gov.ge/ka/document/view/79210

[16] Heating degree-day is the amount of heat required during the heating season and it depends on climate zone.

Fig. 10. Climatic-Technological zones in Georgia

Brief descriptions of climate-technological zones in relation to the building sector energy consumption are provided in boxes 3-7.

Box 3. First technological zone

- The First technological zone coincides with the first climate zone, although it includes settlements having population less than 2 000 inhabitants. In this zone the number of Heating Degree-days is less than D= 2 000 and it includes the lowland territory of West Georgia with elevation not exceeding 300 m a.s.l. This zone is marked in green.
- This climate zone all-year-round is characterized with stabile moderate temperature, humid subtropical warm climate, hot summer and mild winter, sufficient number of sunny days.
- In this technological zone the majority of buildings are one- or two-storey, thickness of walls equals to 20-40 cm, material-concrete blocks or bricks, attics-thermally non-insulated.
- Total area of this climate zone is 10 thousand km^2 and the number of population makes 460 000.
- Number of buildings makes 144 thousand with total area of 15.6 million m^2.
- Heat consumption per m^2 equals to 0.082 kW. Annual energy consumption is 1 855 GWh and annual per capita energy consumption 4.03 MWh.
- Shares in total energy consumption: wood- 64%; NG- 21%; electricity – 14%.

- Efficiency of applied technologies is 30-40%, however thermex (efficiency 80-90%) and solar collectors are also used in a very limited number.

- This zone has favorable physical, geographical and economic conditions for broader application of technologies based on alternate (solar, geothermal, biomass, etc.) energy sources.

- The list of recommended technologies to be introduced in this technological zone includes: cooking (multifunctional convection stoves with 80-95% efficiency); water heating (solar collectors+ hybrid heat pump+ multifunctional convection stove with transformation coefficient 300-400%); thermal insulation of buildings. In separate cases, for commercial and state buildings, with an area exceeding 500 m^2, the arrangement of centralized heating hybrid systems is possible.

Box 4. Second technological zone

- The Second technological zone coincides with the second climate zone, but refers only to settlements having population more than 2 000. In this zone the warming requires number of Heating Degree-days in the range of 2 000-3 000. The zone embraces the territory of Georgia with the mean altitude between 300 and 1 000 m a.s.l. This zone is marked in light brown.

- This climatic zone is characterized by cold winter and temperate warm summer.

- Edifices here require intense heating in the winter and application of cooling systems in summer.

- Roofs and attics, as a rule, are not thermally insulated. The part of buildings, constructed in the end of 20th and in the beginning of 21th century, require thermal insulation of walls, while the old historical building need only the improvement of thermal insulation of windows and doors.

- Total area of this climate zone is 13.3 thousand km^2 and the number of population makes 602 000.

- Number of buildings make 188 thousand with total area of 29.3 million m^2.

- Heat consumption per m^2 equals to 0.120 kW. Annual energy consumption is 3 670 GWh and annual per capita energy consumption 6.09 MWh.

- Shares in total energy consumption: wood- 78%; NG- 14%; electricity – 8%.

- Average efficiency of applied technologies is 30-40%, though thermex (efficiency 80-90%) and solar collectors are also used in a very limited number.

- Compared with the first technological zone this one has less favorable economic conditions for broader application of technologies based on alternate (solar, geothermal, biomass, etc.) energy sources. In addition some physical and geographical barriers should be taken into consideration[17].

- In this technological zone traditional energy carriers may be supplemented with solar energy, while the applied technologies should be similar to the first technological zone. Thermal insulation of buildings is strongly recommended and "passive energy consumer" types of buildings should be supported.

Box 5. Third technological zone

- The Third technological zone coincides with the third climate zone, but includes the settlements with less

[17] E.g. steep slopes typical at this altitude is barrier for sustainable biomass and fuel wood management.

than 2 000 population. This zone is characterized by the number of Heating Degree-days D exceeding the value of 3 000 and it embraces regions of Georgia disposed at the elevation higher than 1 000 m a.s.l.., including the skiing resort facilities in the alpine zone. This zone is marked in dark brown.

- This zone is featured by the cold winter and chilly summer.
- Relevant to the climate is the character of buildings, which historically are flat-roofed, using stone as a construction material. The thickness of walls makes 60-70 cm and the area of window is lessened. The population is well aware of the building envelope thermal insulation necessity. Buildings constructed in the end of 20th and the beginning of 21st century, require thermal insulation of walls.
- Total area of this climate zone is 20.0 thousand km^2 and the number of population makes 387 000.
- Number of buildings makes 122 thousand with total area of 9.7 million m^2.
- Heat consumption per m^2 equals to 0.203 kW. Annual energy consumption is 2 021 GWh and annual per capita energy consumption 5.22 MWh.
- Shares in total energy consumption: wood- 82 %; NG- 11%; electricity – 7%.
- Efficiency of applied technologies is 30-40%, though thermex (efficiency 80-90%) and solar collectors are also used in a very limited number.
- This zone has favorable physical, geographical and economic conditions for broader application of technologies based on alternate (solar, geothermal, biomass, etc.) energy sources.
- In this zone, due to the low potential of alternative sources of energy, the main emphasis should be made on the reduction of energy losses from the outer parts of the buildings and the maintaining of high compactness index. The efficient fuel for such regions could be any solid biomass applied with high energy efficiency. Special importance should be credited to the use of fuel briquettes and pellets in the pyrolytic fuel cameras or switching of gas-condensation water heating systems into the networks at those rare territories which are supplied with natural gas.

In each of these three climate/technological zones the sub-zones could be singled out, in which energy consumption by the buildings is performed with different technologies unlike those used at the remaining territory. Conditionally they are named as fourth and Fifth technological zones which are mainly defined by the number of population and availability of natural gas. During the assessment of Fourth and Fifth technological zones climate indexes of the zone mainly coincide with the climate indicators of the zone, in which it is located, though in such zones often the urban effect is added and thus the heating/cooling parameters differ from the general feature of the zone. As a rule, the Degree-days for such settlements are advisable to be calculated separately, specifically for these communities. This is important also mindful of the fact that in the Fourth and Fifth zones technologies spread among the population, their efficiency and dominant energy resource are different from the other part of the zone.

Box 6. Fourth technological zone

- The Forth zone aggregates medium and small size administrative units and small towns with mixed energy consumers and number of population exceeding 2 000. Territories included in this zone may be disposed in any described above 3 climate zones.
- Multi-storey block buildings have appeared in this technological zone. Buildings are not thermally

insulated.[18]

- Number of population makes 631 000.
- Number of buildings is 212 thousand with total area of 27.6 million m^2.
- Heat consumption per m^2 equals to 0.135 kW. Annual energy consumption is 4 037 GWh and annual per capita energy consumption 6.39 MWh.
- Shares in total energy consumption: wood- 42 %; NG- 47%; electricity – 11%.
- Efficiency of applied technologies in this zone is quite high (80-90%). Exceptions are wood stoves with efficiency 35-40%.
- For the Fourth zone the arrangement of centralized co-and Tri energy generation stations is advisable, operating both on fossil fuel and the biomass. The application of renewable energy is recommended in places having sufficient resource potential. From energy sources are considered the biomass, solar energy, electricity and natural gas, while the recommended technologies include: for cooking- multifunctional convection stoves with 80-95% efficiency, energy efficient electric and gas stoves (90-98%); for space heating- the biomass and gas operated energy efficient boilers, solar collectors, multifunctional convection stoves (100-110%); for air conditioning- the hybrid heat pumps; for water heating- solar collector+ hybrid heat pump+ multifunctional convection stove (efficiency 90-100%). The thermal insulation of existing buildings is required along with the enhancement of energy efficiency trends in new constructions.

Box 7. Fifth technological zone

- This zone unites large gasified cities with the population numbering 100 000 and more. The territories included in this zone (mainly big cities) may be positioned in any described above climate zone. These are the following cities: Batumi, Kutaisi, Tbilisi and Rustavi. Despite the fact that self-governing city of Poti according to the number of population is the seventh among the cities of Georgia, ensuing from complicated sea and port infrastructure, it could be considered in the Fifth technological zone as well.
- Besides the residential, commercial and state-owned buildings, the Fifth zone is characterized by premises with specific energy consumption such as: Sea ports, Airports, large Trading Centers, the Subway, substantial railway stations, special military facilities, bridges, tunnels, etc.
- For these cities three-member families are typical, the dwelling area per one family makes on the average 78 m^2 (2 bedrooms, one common room, one kitchen, one bath-room and toilet). Majority of multi-storey block buildings are constructed with thin blocks and are not thermally insulated.
- Number of population makes 1 650 000.
- Number of buildings is 518 thousand with total area of 44.5 million m^2.
- Heat consumption per m^2 equals to 0.107 kW. Annual energy consumption is 7 169 GWh and annual per capita energy consumption 5.02 MWh.
- Shares in total energy consumption: wood- 4 %; NG- 79%; electricity – 17%.
- This zone harbors the most highly developed technologies. The majority of innovation companies

[18] Some cases of energy efficiency and thermal insulation are met in new buildings constructed in tourist zones (Gudauri, Bakuriani, etc.)

registered in Georgia are concentrated here. The developed commercial sector promotes quick adaptation of the market to contemporary technologies. Efficiency of applied technologies in this zone is quite high (80-90%). Exceptions are wood stoves with efficiency 35-40%.

- In these cities it is possible to pick out more populous subzones where the arrangement of centralized co- and tri energy generating stations is advisable, operating both on fossil fuel and on the biomass. In particular, in cities located in the first climate zone (Batumi, Poti) the application of heat pumps integrated with solar systems is recommended as well as the use of secondary recuperated heat and cold, heat and cold buffer storing technologies. In this technological zone, during the equipment of premises with engineering technologies, the priority should be given to energy efficient electric appliances, alternative energy sources generators, as well as the use of dual principles of electric grid permission is expedient[19].

Below figures (Fig. 11; Fig. 12; Fig. 13) present energy consumption and emission features of these zones.

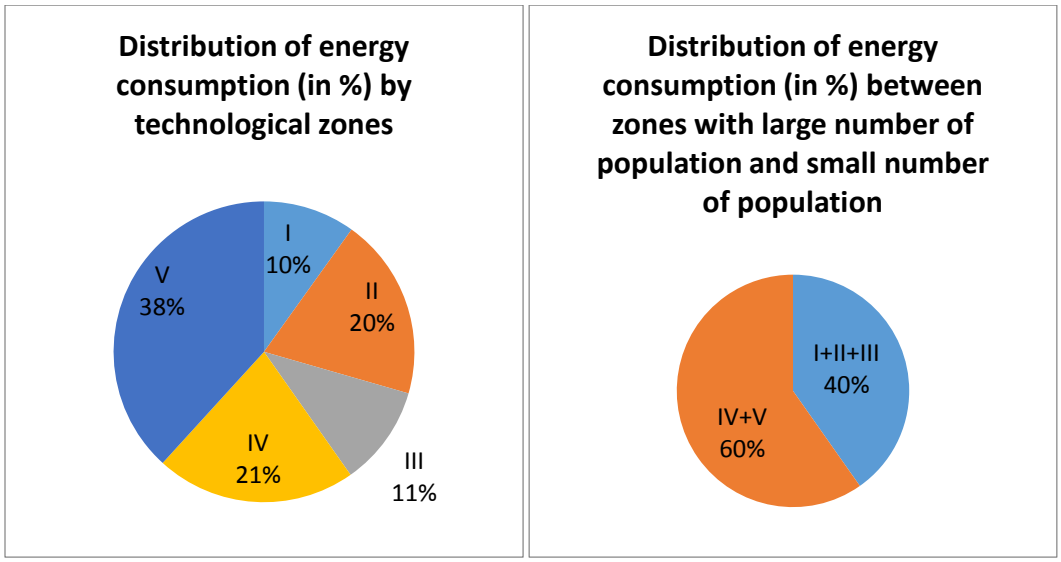

Fig. 11. Total consumption of energy (in %) by technological zones

For the more efficient planning of emissions reduction measures in the Buildings sector, the consumption of energy in the above described climate- technological zones has been assessed. The percentage distribution of energy consumption in Buildings sector in these zones is presented at the Fig. 11, and the relevant emissions are given in Fig. 12.

[19] The dual principle of free permission to grid implies direct selling of excess energy produced by electricity sources to grid distributor or neighboring area, or the exchange with the possibility of further reimbursement in the peak hours.

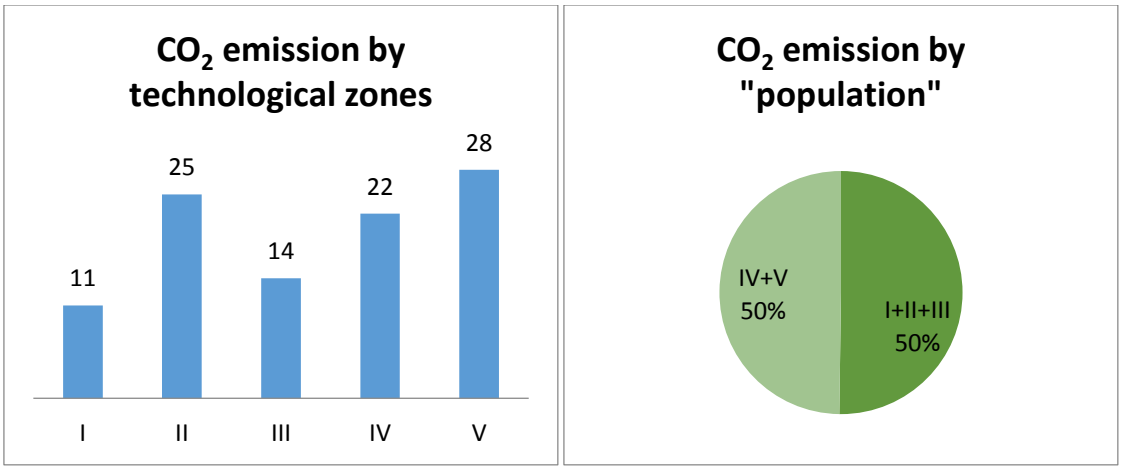

Fig. 12. Distribution of CO_2 emission[20] by technological zones (in %)

As it could be seen from Fig. 11 and Fig. 12, the CO_2 emissions from the I, II and III zones, featured by the high consumption of firewood, is similar to IV and V zones taken together, despite the fact that energy consumption in them is higher by 20%. **Consequently, in the emissions reduction strategy from buildings in Georgia the main priority in the first three zones should be given to the decrease in the use of firewood.**

Fig. 13 demonstrates the summary picture of characteristic parameters of the zones, from which it could be found that in the II zone emissions are by 3% less than in the V zone, where the majority of population lives and, correspondingly the consumption of energy is the highest. In this case it is caused by significant unsustainable use of firewood in the II zone and relatively long and chilly heating period characteristic to this zone.

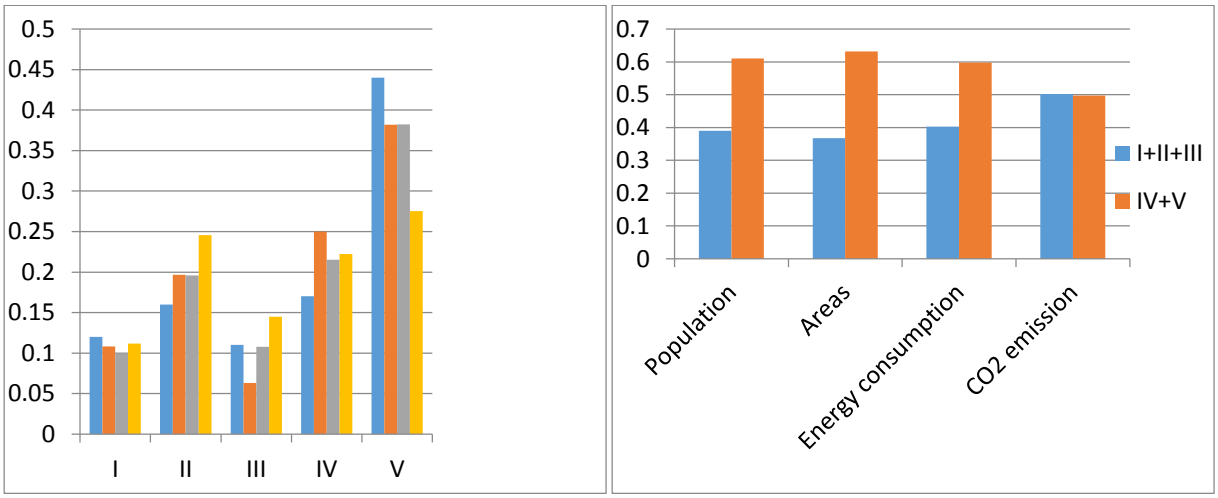

Fig. 13. Distribution of CO_2 emission and other features by technological zones (in %)

[20] GHGs emissions from unsustainable fuel wood consumption is also accounted.

2 Buildings Sector Low Emission Development Strategy Till 2030

Taking into consideration the fact that at this stage the country has not formulated yet the Buildings sector development strategy that should be a basis for its low emission evolution pathway, the latter mainly takes into account policy practiced in the Energy and Forestry sectors, ensuing from the fact that according to official statistics[21] in the Georgian Buildings sector about 30-40% of total energy consumption goes to firewood[22], natural gas is an imported fuel, and electricity is sufficiently clean regarding the GHG emissions. Eventually Georgia's Buildings sector low emission development strategy is in full compliance with Georgia's Forestry policy, Energy Efficiency National Action Plan and the EU Buildings sector policy, mainly defined by 2 Directives (Directive 2010/31/EU on "Buildings' Energy Consumption" approved in 2010 and Directive 2012/27/EU "On the Energy Efficiency" approved in 2012). By means of these two Directives the EU regulates energy consumption in buildings. The necessity of these Directives' requirements' introduction in Georgia is determined by Georgia's Association Agreement with the EU.

Boxes 8-12 demonstrate major conceptual visions, creating the basis for the Buildings Strategy.

Box 8 (The Forestry Sector)

Georgia's Parliament has approved on 11 December 2013 principal document on country's Forestry policy- "Georgia's National Forestry Concept". The document envisages the creation of Forest Sustainable Management System in Georgia.

According to Section 8.1:
The rural population should be provided with the available sources of energy and different means of their use, among them:

a) By assessing potential of energy sources, including in accordance with expenses profitability, the introduction of energy efficient wood stoves, thermal insulation of houses, combined generation of heat and energy, extension of natural gas supply network and by working out Action Plans based upon these assessments;
b) By developing and implementing the program on the provision of rural population with heating firewood;
c) By the rational consumption of firewood at the expense of using more efficient alternatives.

Increasing the responsibility of local rural communities towards local forest resources, including working out and piloting of such mechanisms which will ensure the involvement of these communities in the management of mentioned resources.

Georgia's Association Agreement contains no concrete date for the implementation of mentioned above Directives. The date should be defined in the frames of negotiations on the membership of Georgia in the Energy Union. Despite the fact that the date is not fixed, Georgia is directly committed to implement Directives.

Box 9. The Directive (2010/31/EU) on "Energy consumption by buildings"

[21] According to surveys carried out in the frames of different projects, this number is much higher.
[22] In case of exceptionally serve winter this number goes up to 40-43% due to high consumption in mountain regions, where the temperature significantly drops compared to average value.

The Directive formulates common framework of methodology for the calculation of energy efficiency of buildings. It establishes the minimum criteria of buildings' energy efficiency, at the same time advancing the need for energy- certification of buildings.

Main request of Directive are:

- In case of selling or renting the building, the declaration necessarily must be attended with the building's energy consumption certificate;
- EU member countries should provide the **heating and cooling systems' inspection schemes** or introduce such measures, which ensure the equivalent result;
- EU member countries should establish for the new buildings energy consumption minimum standards for the majority of new buildings and those existing buildings, which will be totally modernized or renovated in regard of such elements as heating and cooling systems, roofs, walls, etc.
- EU member countries should develop at the national level financial measures for increasing the energy efficiency of buildings;
- One of the necessary conditions for the implementation of Directive's requests is the development of Construction Codes at the national level.

By 31 December 2020 all **new buildings** must become almost zero energy consuming (for the state buildings this date is 31 December 2018).

The newest Directive on energy efficiency is the EU Parliament and Council Directive 2012/27/EU dated 25 October 2012.

Box 10. The "Energy Efficiency" Directive (2012/27/EU)

The Directive explains that:

- EU member countries must annually renovate at least 3% of buildings owned by the central authority/Government and occupied by them;
- Government of EU member countries must purchase only the buildings having very high energy efficiency;
- **EU member countries should work out the long-range strategy on the renovation of national buildings bank, being a part of "National Energy Action Plan".** The strategy should mainly include: The overview of Buildings stock; Key political instruments that the country intends to use for the stimulation of renovation process; the preliminary assessment of energy saving, resulting from renovation of buildings.

One more Directive which should be taken into account by the Buildings Strategy is the Directive "On the promotion of using energy from renewable sources".

Box 11. The Directive "On the promotion of using energy from renewable sources" (2009/28/EC)

Main request of the Directive is to increase the use of renewable energies in the buildings:

- The establishment of minimum requirements in the new and renovated buildings;

New state buildings- a model for others.

The strategy is also grounded on the analysis of barriers emerged while studying the sector and given in the Box 12.

Box 12. Barriers prevailing in the sector

- There is no responsible body in the state, determining and carrying out the policy concerning existing buildings (their rehabilitation, conduction of energy efficiency measures, etc.);
- There is no target fund in the state, which will facilitate the co-financing of energy efficient measures;
- The country lacks National body, designated by large international funds (GCF, GEF, etc.) which will introduce in the country huge investments on energy efficiency, cheap loans and grants to fill in the Energy Efficiency Fund for the promotion of renewable energies;
- The country has no common Construction Standards and no monitoring is performed during the process of handing over the buildings. The Standards presumably will vary in different climate zones;
- No Green Purchases policy is practiced in the country;
- There is no formulated policy on maintaining and rehabilitation of multi-storey buildings and the role of residents association is not defined in this process. The existing legislation on association is mainly focused on resident's rights an do not define their duties;
- There is complete chaos at the construction market. In the process of existing buildings' rehabilitation it is impossible to provide necessary quality, that is especially important in case of introducing the energy efficient measures to obtain the relevant result;
- There are no ESCO- type companies (performing complete energy services), which in case of energy efficiency will guarantee actual saving of energy in those buildings, where the level of comfort is already provided;
- On the average 30% of buildings' area (schools, kindergartens, residential houses) is not completely heated, making impossible to save the energy as the rise in comfort brings the reduction of saved energy;
- 60% of existing buildings are constructed in 60-80s of the past century and are depreciated, the introduction of solely energy efficient measures in them brings minimum effect and often is unprofitable;
- The labeling of electric appliances is not obligatory;
- The request on the building's energy consumption certification is not mandatory;
- The local construction materials are not being certified;
- The construction companies are not being certified/licensed.

For overcoming all these barriers, first of all the construction and buildings' energy consumption standards are to be introduced.

The questioning of technologies market and the population/consumers has revealed that only the small segment is familiar with the valuable information on technologies.

Box 13. Awareness deficiency

- In relation with cooling-ventilation systems 28 selling companies in Georgia have been questioned, majority of which (64%) operated in the Fifth technological zone, and 22%- only in Tbilisi. The results of the survey demonstrated that the most widely spread (28%) heating- cooling system in this zone is so called Split system and the second and third positions with equal percentage are divided between Chiller-Fanckoil and channel type conditioning systems. Largest part of respondents (29%) can't indicate which system is the most widely used;
- The questionings have shown that only a quarter (25%) of population possesses the information on energy efficient technologies, from which 27% are limited only with the energy efficient lamps;
- Significant part of both consumers and suppliers of heating-conditioning systems is not informed about the efficiency class of systems and gives the preference to cheap alternatives;
- At the same time it should be mentioned that only 33% of companies selling energy efficient and operated on renewable energy production believe that this kind of produce is not highly demanded, 25% consider that the potential of this produce is mainly associated with Georgia's regions (the First to

the Third technological zones), while 25% find difficulty in replying and 17% believe that there are no geographic differences in the demand on the produce.

Based upon the analysis of barriers listed in the Box 12 and the information presented in Boxes 8-11 the main directions of Georgia's Buildings strategy has been formulated:

Working out of State Program on the rehabilitation of existing buildings. This Program should be developed by 2020 in order to make possible for the Government the uninterrupted implementation of programs on energy efficient rehabilitation of existing buildings (NAMA) in 2020-2030. Such Program, first of all, should be developed for the state and municipal buildings and after this- for the multi-storey buildings. For the commercial buildings and 1-2 storey houses the regulations and efficient co-financing mechanisms should be developed. The total energy efficient rehabilitation of constructions brings the largest saving of energy consumption (50-60%) in multi-storey buildings, especially in depreciated edifices.

Approximation of heat consumption efficiency in the buildings to the EU standards[23] in the process of new constructions and rehabilitation of old buildings. To achieve this goal the adoption of Construction Code is necessary, in which the obligatory norms[24] of energy consumption by buildings will be established for the country as a whole or for separate climate zones. This is a mandatory condition without which the certification/licensing of materials and constructions companies, determination of the quality of performed measures and the energy efficiency monitoring will be impossible. According to the Strategy the introduction of Construction Code is supposed by 2018.

The reduction of unsustainable biomass/firewood consumption in the I and II climate zones should be achieved under the assistance of measures, discussed in the National Concept of Forestry Sector. In particular they include: The extension of natural gas supply network, the development and implementation of the Program on the provision of rural population by the firewood, the adoption of energy efficient firewood stoves and solar water heaters, thermal insulation of houses, combined heat and energy generation, application of dry firewood and the reduction of firewood consumption at the expense of the use of more efficient alternatives.

All these activities should be accompanied by increased responsibility of local rural communities towards local forest resources, including the development and piloting of such mechanisms which will ensure the involvement of these communities in the management of mentioned resources.

Increasing of renewable energies share (solar, geothermal) in the buildings power consumption.

By 2030 in the I, II and III climate zones the share of renewable resources (including firewood) in the Buildings sector shall not decrease less than 20% at the expense of maximum spread of solar, geothermal energy and heat pumps application.

[23] For the EU member countries presently this value is 50 W/m^2. Presumably, at the first stage this number in Georgia will be 80 W/m^2, though much more efficient will be the definition of standard values according to climate zones and in this case in the First climate zone the provision of 50 W/m^2 is possible as in this zone nowadays, under the inefficiency conditions, the average heat demand already makes 80 W per 1m^2.

[24] At the time being the application of several international standards is admissible, the majority of which are not published in Georgian and therefore are hardly to be used by both construction organizations and construction certifiers as well.

Further increase of biomass share in heat generation for the long-run perspective (after 2050). After the provision of sustainable management of forests, the firewood/biomass shall become local fuel of strategic importance that should be consumed mainly in the heating sector by applying the highest efficiency technologies.

For the implementation of discussed above strategy, in addition to the mentioned in the third part specific programs, the Government will enact the following activities, which will essentially transform the management of Buildings sector:

- **The Government shall identify the body/structure which will be responsible for the definition of policy** concerning the existing buildings and for the monitoring of implementation;
- **The legislative basis of flat owners associations** should be strengthened regarding the widening of associations' rights and obligations, especially concerning the maintenance of buildings owned by them;
- The **construction market should be regulated** referring to the strengthening of quality demand and control, This means both the certification of locally produced materials by energy efficiency and the admittance to the market of materials only having passed the energy efficiency certification, as well as the licensing construction companies according to international standards.
- The preferential loans and grants should be given to those **developer/construction companies,** which will be encouraged to operate in energy efficiency and renewable energies and to elaborate a conceptual approach, that implies the designing of the building with maximum consideration of concrete environment;
- The **Energy Efficiency Fund** (including the application of renewables in the buildings) should be set up in the country, one of priorities for which, in the first place, should be the state and municipal buildings to facilitate the implementation of EU Directives determined under the Association Agreement;
- The Fund would not be able to perform valuable and efficient operations until the **"Complete energy service" providing companies** are not developed in the country for the heating-cooling- hot water supply sector. At the initial stage, taking into account the state-of-the-art in the Buildings sector, these "Complete energy service" companies could be partly private and partly state owned, or jointly managed with the already experienced operator. However, in the long-run prospective its formation as an independent company is advisable.
- To provide the relevant filling up of Energy Efficiency Fund and in general, to secure the efficient drawing of international co-financing, it is necessary to get in country Accredited National Entity (ies). The primary tasks for the country is the setting up of a new institution or strengthen and facilitate existing relevant national institutions (MDF, banks, etc.) in getting the accreditation for GCF, GEF, etc. In due course the Energy Efficiency Fund itself may be transformed into such accredited body in case of developing appropriate capacities;
- The Government should conduct the **monitoring of energy efficiency processes/projects and energy credit programs,** going on in the country in order to provide complete reporting of energy and GHGs emission savings to the international community.

3 Low emission development of buildings sector

This chapter deals with GHG emissions reduction measures, which, according to assessments, could bring as a result of their implementation in the Buildings sector by 2030 the annual saving of 846 Gg CO_2 eq. GHG emissions produced by fuel combustion. From this amount 641 Gg are saved in the Buildings sector itself, constituting 16.6% of emissions projected to 2030 in this sector. Additionally 205 Gg emissions is saved in the electricity generation sector due to the reduced consumption of electric energy in the Buildings sector, making 9.7% of emissions expected from the electricity generation sector by 2030. Figures (Fig. 14 and Fig. 15) demonstrate emissions growth projections in the Buildings and Electricity generation sectors. From these projections shown at each graph, one curve represents the baseline increase under the BAU scenario and the other-increase in case of adopting the measures planned only for the buildings sector.

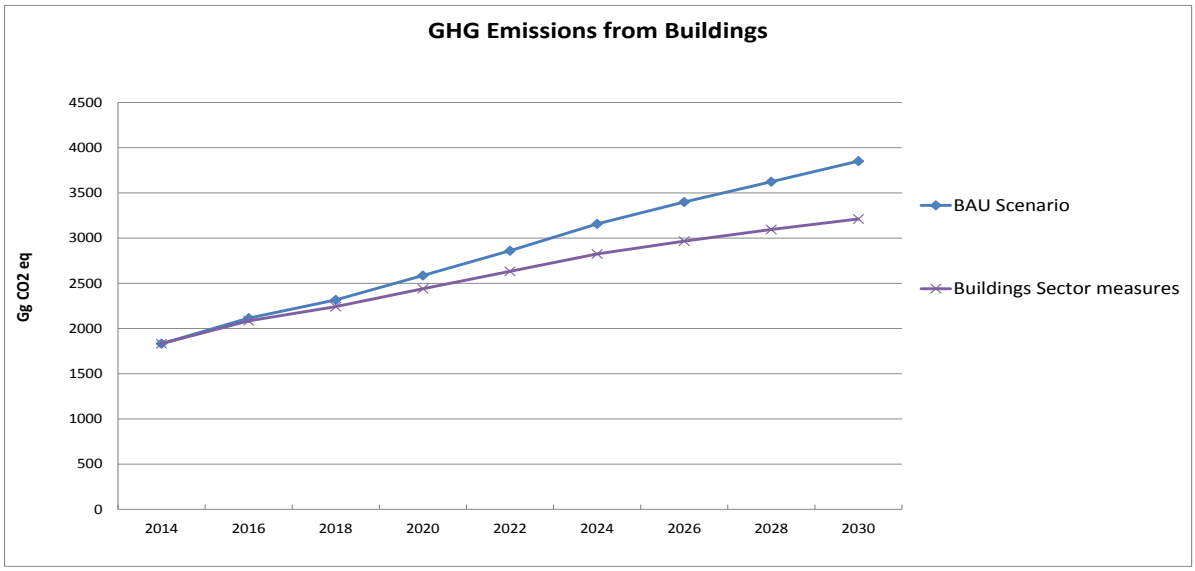

Fig. 14. Projections of GHG emissions from the Buildings sector in case of BAU scenario and under the terms of emissions reduction scenario (2014-2030).

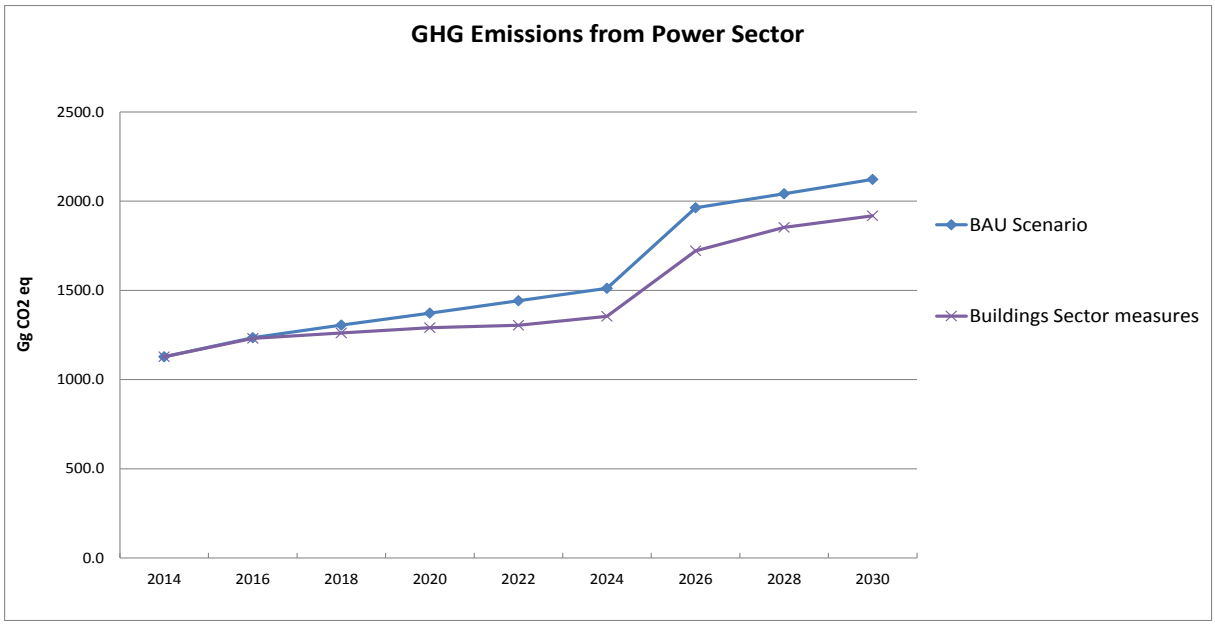

Fig. 15. Projections of GHG emissions from the Electricity generation sector in case of BAU scenario and under the terms of emissions reduction scenario (2014-2030).

As a result of measures taken in the Buildings sector the primary energy decreases by 5.3% compared to the BAU scenario, and the final energy-by 6.4%, while the import of energy carriers is reduced by 5.8% (import of natural gas – by 9.4%). The electricity generation decreases by 2600 GWh (1.4%), consequently demanding 500 less installed capacity of power plants in comparison with the baseline (BAU) scenario.

The most significant effect from the emissions reduction measures in produced by energy efficient rehabilitation of residential buildings.

Measures planned in the scope of till 2020 strategy mainly refer to preparatory phase which includes the perfection of relevant legislative basis, clear definition of responsible structures and their functions, development and implementation/testing of programs and pilot projects, maximum curtailing of all possible barriers and carrying out of all provisional activities necessary for the execution of measures.

Since 2020 begins the implementation of specific programs and projects as well as the actual reduction of GHG emissions and discounting of energy consumption.

While assessing the efficiency of measures, the activities considered in other energy efficient strategies and action plans have been taken into consideration, although in respect to emissions reduction in this strategy more attention has been paid to the heating and hot water supply systems in which 23% of population uses the imported gas and 67%- local unsustainable firewood resource. The downsizing of the consumption of these two energy resources substantially increases the level of power independence, facilities sustainable and efficient consumption of local resources and significantly reduces the GHG emissions. Increasing of efficiency in electricity consumption is significant factor in the development and energy independence process; however, in case of Georgia, it has smaller impact on the GHG emissions reduction due to the sufficiently clean power grid, in which the share of hydropower (82% and more) is remarkably high.

Strategic measures

Name of the measure	**Putting in force the new Construction Code**
Type of the measure	Legislative
Implementing body	Ministry of Economy and Sustainable Development
Years of implementation	Since 2018
Greenhouse gas	CO_2, CH_4, N_2O
Reduction of emissions to 2030 (Gg)	**75**
Description of the measures	The measure implies that the new Construction Code will be put in force in Georgia, to which the energy efficiency standards and renewable energy consumption norms will be added. After the enforcement of the Code energy efficiency of all newly constructed buildings will be improved as minimum by 20% compared to buildings erected under the present technical norms and by 50-60% compared to the rehabilitated buildings. This assumption is based upon the fact that in the buildings now under construction the amount of heat necessary to warm 1 m^2 of area makes 100-130 W, while according to the new Code the maximum requirement on heat per 1 m^2 will be 80 W.
Assumptions and assessments	Putting into force of the new Construction Code from 2018. To 2030 11% of existing residential buildings and 20% of existing commercial buildings will be newly constructed edifices.
Cost of the measure	
Financing source	Government of Georgia

Name of the measure	**Low emission development of state buildings (NAMA)**
Type of the measure	Energy efficiency of buildings
Implementing body	Government of Georgia, Municipalities, relevant Ministries
Years of implementation	2019-2030
Greenhouse gas	CO_2, CH_4, N_2O

Reduction of emissions to 2030 (Gg)	**16**
Description of the measures	The measure considers that at least 50% (maximum 100%) of state buildings existing in 2014 will be completely rehabilitated by 2030. As different audits have indicated a 80% of state and municipal buildings are to some extent rehabilitated, though the whole package of energy efficiency measures (except windows) is not implemented and hence the saving will make 20-30% on the average.
Assumptions and assessments	2019-2020 pilot phase. All state buildings (including municipal structures) existing in 2020-2030 in Georgia. Program- maximum includes 100% of buildings to be rehabilitated and program-minimum- 50% of them.
Cost of the measure	The cost of rehabilitation of medium restorable building taking into account energy efficiency measures makes 280-366 USD. Total area of state buildings including municipal edifices equals to 5.9 million m^2 so as 80% of them are medium restorable, the cost of rehabilitation measure will amount to 1 416 million USD (taking average 300 USD per 1 m^2 of area).
Financing source	Government of Georgia, Energy Efficiency Fund, with co-financing from different donors (GCF, EBRD, etc.).

Name of the measure	**Low emission development of commercial buildings (NAMA)**
Type of the measure	Energy efficiency of buildings
Implementing body	Private sector under the assistance of Government of Georgia
Years of implementation	2021-2030
Greenhouse gas	CO_2, CH_4, N_2O
Reduction of emissions to 2030 (Gg)	**52**
Description of the measures	The implementation of the measure assumes that 50% of medium restorable commercial buildings, existing in 2014 and not covered by energy efficiency measures, will be completely rehabilitated by 2030. The execution of this program is possible only after implementing low emission building NAMA for state and municipal buildings, that will create the market of energy efficient materials, highly skilled constructors and other workforce and "ESCOs", and when the Code will be already enforced.
Assumptions and	By 2030 the energy efficient rehabilitation will be undertaken on the 50% of medium

assessments	restorable commercial buildings. It has been assumed as well that total energy efficient rehabilitation of medium restorable buildings improves the energy efficiency by 20%.
Cost of the measure	The overall area of commercial buildings at the territory of Georgia to 2014 is assessed to be 10.7 million m^2. About 80% of commercial buildings (8 million m^2) in Georgia are relatively well maintained (the remaining 20% include new areas or hard to be rehabilitated areas) i.e. is in a medium restorable condition. The area of medium restorable commercial building makes 4.3 million m^2. The rehabilitation cost of such type of buildings will amount 1 290 million USD (taking 1 m^2=300 USD).
Financing source	Private sector assisted with different incentive programs, offered by local or central Authority.

Name of the measure	**Low emission development of residential buildings (NAMA)**
Type of the measure	Energy efficiency of buildings
Implementing body	Government of Georgia in cooperation with residents associations
Years of implementation	2025-2030
Greenhouse gas	CO_2, CH_4, N_2O
Reduction of emissions to 2030 (Gg)	**434**
Description of the measures	The survey of kindergarden buildings conducted under the Tbilisi city kindergarten buildings energy efficient rehabilitation program development has indicated that 37% kindergarten buildings are to be heavily rehabilitated. Based on this survey and taking into consideration that kindergarten buildings have much more better maintenance against zero maintenance provided to the residential multi-storey buildings (share of multi-storey buildings in big cities is a 69% and in small towns a 14%), the conservative assumption was done that at least 37% of multi-storey buildings to be heavily rehabilitated. EE rehabilitation of heavily damaged buildings can increase the energy efficiency of the contracture by 50%. The measure considers EE rehabilitation up to 40% of heavily damaged buildings in Georgia (44 million m^2) under the terms and special programs offered by the national and local governments with the co-financing from home-owners associations by 2030. To achieve this goal first of all the State Program on Buildings Stock Renovation should be set up and the implementation of NAMAs for the state and commercial buildings will enter into the active phase.
Assumptions and assessments	40% of residential buildings (mainly multi-apartment structures) require heavy rehabilitation and up to 2030 they will be totally restored.
Cost of the measure	The rehabilitation of 1m^2 in the heavily depreciated building accompanied with energy efficient measures requires on the average about 500 USD. The rehabilitation of 44

	million m^2 area demands 22 billion USD.
Financing source	GCF, Energy Efficiency Fund, Government of Georgia with co-financing from residents associations.

Name of the measure	**State program on the spread of solar water heaters and energy efficient stoves in private houses** (In this direction at this stage the NAMA project is developed, which could be regarded as a pilot project of this measure)
Type of the measure	Encouragement of adoption and spread of renewable and energy efficient technologies
Implementing body	Non-governmental sector (the pilot NAMA project is developed by the NGO "Greens Georgia" + :Friends of the Earth"
Years of implementation	2017-2020 pilot phase 2020-2030 Whole territory of Georgia lacking the gas supply
Greenhouse gas	CO_2, CH_4, N_2O
Reduction of emissions to 2030 (Gg)	**62**
Description of the measures	This measure implies the creation by the State of favorable conditions to the rural population, especially those who uses only firewood as a fuel, for the application and dissemination of solar water heaters and energy efficient stoves. The objective of this measure, besides the reduction of GHG emissions from the use of firewood obtained by unsustainable methods, is to support the protection and life-saving of forests, promoting the country to transform the firewood into the long-term energy resource under the conditions of efficient consumption and sustainable management of forests. The implementation of 3 components is planned in the pilot phase: **The first component** entails mounting of solar water heating collectors for about 15 000 families, making 13.2% of total number of householders (114 thousand) living in villages and boroughs. Surveys conducted under the preparation of pilot project indicated that for hot water supply in these regions 12% of total heat supply is used. **The second component** means the installation of energy efficient stoves for 15 000 households living in rural settlements as well. **The third component** of the project implies thermal insulation of houses by different measures, among them: thermal insulation or substitution of windows, thermal insulation of doors, thermal insulation of ceiling and wall. The 15% saving of energy is expected as a result of these measures per one house, in which at this time only 12-15% of total area (1 or 2 rooms) are heated actually.
Assumptions and	It has been assumed that by 2030 this program will cover 80% of rural families (91 200 households) and 30% (188 thousand families) of households living in 1-2 storey houses of

assessments	urban settlements. Energy efficient stoves (having about 70% efficiency) will cover 80% of rural population.
Cost of the measure	The cost of installing solar collector atop one house is on the average 1 200 GEL. Correspondingly the necessary sum for 15 000 houses will make 18 million GEL and for 279 200 houses- 335 million GEL. A large variety of ordinary firewood stoves is produced in Georgia and the cost varies in the range of 25-100 GEL, while the cost of energy efficient stove makes about 600 GEL that requires in total 9 million GEL at the first stage and 54 million GEL at the second stage. The cost of thermal insulation works substantially vary according to the condition of area to be insulated and the degree of insulation. On the average the cost of thermal insulation of 2 rooms (heating space) could vary from 200 to 3 500 GEL. Taking on the median for thermal insulation works 2 000 GEL, it would require 30 million GEL at the first stage and 558 million GEL at the second stage. Till 2020 the piloting of program for 15 000 families requires 57 million GEL and total program till 2030- 974 million GEL.
Financing source	The major source of financing is regarded to be the Green Climate Fund (GCF) which supports programming approaches and modification of behavioral norms among population towards more energy efficient and sustainable (resilient) to climate change way of life. The co-financing (at least 30%) should be considered from the forest sustainable management projects and state programs, while 30% of co-financing from the population.

Name of the measure	**Solar water heaters in commercial and state buildings (NAMA)**
Type of the measure	Introduction of renewable technologies
Implementing body	Private sector (ESCO)
Years of implementation	2020-2030
Greenhouse gas	CO_2
Reduction of emissions to 2030 (Gg)	**17** (in generation sector)
Description of the measures	On the basis of different sources it has been assessed that in all 5 zones there are 86 400 commercial and state buildings. The measure implies application of solar heaters in commercial and state edifices. It includes as well the installation of water heaters in municipal buildings from the SEAPs.
Assumptions and assessments	To estimate the cost of the measure it has been assumed that 20% of commercial buildings (hotels, restaurants) and 30% of subscribers to the CoM Municipal Buildings (Kindergartens, municipal hospitals, and Sporting schools) will use solar water heaters by

	2030.
Cost of the measure	For assessing the expenses it has been assumed that one building will require solar collector having at least 2 times more area (4.4 m^2) (actually this would be much more) and in this case one building will cost on the average 2 400 GEL, while the supply of 50% of commercial and state buildings (43 200 buildings) with solar collectors will cost 103.7 million GEL.
Financing source	Private sector and Municipalities under the co-financing from the state programs.

Name of the measure	**Mandatory labeling of electric appliances**
Type of the measure	Promotion of adoption and dissemination of energy efficient technologies
Implementing body	Ministry of Energy, Private sector
Years of implementation	2022-2030
Greenhouse gas	CO_2
Reduction of emissions to 2030 (Gg)	**52** (in Generation sector)
Description of the measures	The measure implies that the EE labeling of electric appliances will become obligatory to 2022 for those electric appliances which are defined by the Association Agreement.
Assumptions and assessments	To assess the efficiency of the measure it has been assumed that resulting from the measure 50% of electric appliances will become more efficient by 2030.
Cost of the measure	
Financing source	Private sector under the assistance of Energy efficiency fund.

Name of the measure	**Removal of incandescent lamps from the consumer market**
Type of the measure	Promotion of adoption and dissemination of energy efficient technologies
Implementing body	Ministry of Energy, Private sector
Years of implementation	2020-2030

Greenhouse gas	CO_2
Reduction of emissions to 2030 (Gg)	**125** (in Generation sector)
Description of the measures	The measure involves the alteration of legislation, according to which the import of incandescent bulbs will be prohibited and accordingly the consumer market will be free of incandescent lamps by 2030. Presumably this will require gradual changes in the electric system.
Assumptions and assessments	In the frames of the measure it has been assumed that the ban will come into force in 2022 and by 2030 the market will be filled by only the energy efficient lamps.
Cost of the measure	The measure will prove to be much cheaper, if by this time in Georgia will exist local enterprise producing energy efficient lamps, confirming to European standards and quality.
Financing source	Government of Georgia, Private sector.

Name of the measure	**The increase of energy efficiency in geothermal hot water supply**
Type of the measure	Promotion of adoption and dissemination of energy efficient technologies
Implementing body	Private sector
Years of implementation	2020-2030
Greenhouse gas	CO_2
Reduction of emissions to 2030 (Gg)	**6**
Description of the measures	Maximum use of geothermal hot water supply potential in Tbilisi both in residential and commercial buildings. Presently in total only a 49% of heat is used from 6 wells existing in Tbilisi. In the frames of the measure a 80-90% utilization development of existing potential should be planned and ensured.
Assumptions and assessments	It is assumed that by 2030 the whole potential of geothermal resources will be utilised both in technical and economic terms.
Cost of the measure	12-15 million USD with the setting up of GCS.
Financing source	Private sector with co-financing and maximum use of existing grants and technical assistance for developing renewable energies. Grants existing in the frames of CoM.

Name of the measure	**Shifting of street lighting to the LED lanterns**
Type of the measure	Promotion of adoption and dissemination of energy efficient technologies
Implementing body	Municipalities
Years of implementation	2019-2030
Greenhouse gas	CO_2
Reduction of emissions to 2030 (Gg)	**7 (in Generation sector)**
Description of the measures	The measure implies the complete shifting of street lighting to the LED lamps (existing and future SECAP measure). The activity considers that in the scope of CoM the Municipalities have already actively initiated the introduction of this measure, being sufficiently profitable for them. Here it should be mentioned as well that Municipalities need technical assistance for the installation of high efficiency systems. Sensor based and other remote control systems as well as solar energy utilization in outdoor lightening are also envisaged.
Assumptions and assessments	By 2030 the 90% of street lighting system will be provided with the LED lamps.
Cost of the measure	
Financing source	

4 Annex I: Applied parameters, their sources and the assessment methodology

Table 1. General and energy features of technological zones

Technological zone #	1	2	3	4	5	Total
Population (thousand person)	460	602	387	631	1 650	3 730
Area of the zone (thousand km^2)	10	13	20			
Number of buildings (thousand)	144	188	122	212	518	1 184
Total area of residential buildings (million m^2)	13.5	26.6	8.0	24.1	38.0	110.1
Total area of commercial buildings (million m^2)	1.3	1.7	1.1	1.8	4.7	10.7
Total area of state and municipal buildings (million m^2)	0.8	1.0	0.7	1.6	1.8	5.9
Overall area of buildings (million m^2)	15.6	29.3	9.7	27.6	44.5	126.7
Total heated area of buildings (million m^2)	7.7	14	4.5	17.8	27.2	71.2
Rated energy consumed for heating of 1 m^2 of the building (KWh/m^2)	0.082	0.120	0.203	0.135	0.107	
Per capita annual consumption of energy (MWh)	4.03	6.09	5.22	6.39	4.3	5.02
Total annual energy consumption (GWh)	1855	3670	2021	4037	7169	18 752
Use of firewood in total energy consumption (%)	64	78	82	42	4	
Use of natural gas in total energy consumption (%)	21	14	11	47	79	
Use of electric energy in total energy consumption (%)	15	8	7	11	17	

Applied initial data and their sources

1. Year of data application- 2014;
2. Population of Georgia (except occupied territories)- 3 730 million;
3. Average number of residents living at one dwelling- 3.4 persons;
4. Average living area per one family for different zones has been assessed by surveys conducted in the frame of EC-LEDS project and using the SEAPs information, adjusted further through the

data obtained from surveys of Municipalities. Only the Fifth zone is estimated by the number of population;

5. The percentage share of basically heated area in residential buildings to total area is assessed through the survey conducted in the frames of EC-LEDS project (Annex 2: Winrock Outputs municipality version 01) and on the basis of information gathered in SEAPs;
6. Armed Forces of Georgia- 37 000 persons (source: Ministry of Defense);
7. Persons in the Penitentiary system- 11 000 persons (source: Ministry of Low Enforcement and Probation);
8. Annual number of foreign visitors- 5 493 492 persons (source: National Statistics Department);
9. Average number of nights spent by the visitors at the territory of Georgia- 2.16 days (source: National Statistics Department);
10. Distribution of average monthly number of visitors according to dwelling place for the First zone is 40% (source: National Statistics Department). For remaining zones it was calculated proportionally to the number of local population taking into account the touristic potential of a zone;
11. Average area of restaurants, bars and other facilities of public catering in Tbilisi- 170 m^2 (source: Tbilisi/Real Estate Market Report 2014, Colliers International);
12. Number of restaurants, bars and other facilities of public catering in Tbilisi, Batumi and Kutaisi- 1 168 (Georgia/Entertainment Industry Report 2014, Colliers International), is being recalculated in proportion to the number of population both in other cities of the Fifth zone and for other zones;
13. Area of commercial buildings in Tbilisi- 3.21 million m^2 (source: Tbilisi/Real Estate Market Report 2014, Colliers International), is being used to calculate commercial area in other cities and zones (proportionally to population);
14. Percentage share of basically heated area in total area of commercial buildings is defined by the selected questioning and expert assessment;
15. The area of state buildings according to zones was estimated by the following way: for the V zone- from the SEAPs of cities entering in the zone; for other zones- according to SEAP data of cities located in the IV zone, under the proportional recalculation accounting to the number of population;
16. Average area of state buildings, corresponding to selected questioning, was taken equal to 200 m^2. This area does not represent total area of the state building, rather it implies area, occupied by different entities (departments, services, LLC-ies, etc.) disposed in the building. This data is used to calculate energy, consumed for the hot water supply and cooking in the state building.
17. The percentage share of basically heated area in the total area of state buildings was determined according to selected questioning and expert judgments;
18. The energy spent on the heating 1 m^2 of the building (KWh/m^2) for different zones was calculated on the basis of buildings audits, undertaken in these zones in the frames of SEAPs.
19. The shares of fuel consumption by fuel types and zones are taken from the EC-LEDS questioning results (Annex 2: Winrock Outputs municipality version 01.);
20. Average consumption of energy for lighting 1 m^2 of area- 10.37 KWh/yr (source: Energy audits of buildings carried out in the frames of SEAPs);
21. Average consumption of energy per 1 m^2 for various purposes (except of heating, hot water supply, cooking and lighting): 14 KWh/yr for residential sector, 10 KWh/yr- for commercial and state sectors (source: Buildings energy audits conducted under the SEAPs);

22. Average dwelling area per capita in Tbilisi- 23 m^2 (source: Tbilisi/Real Estate Market Report 2014, Colliers International) is used to calculate living area in the V zone. The calculation of residential area in other zones is described in the Chapter 4.
23. Emission factors per 1 KWh according to fuel types: natural gas- 0.202 kg, electric energy- 0.104 kg, firewood- 0.202 kg.

Methodology of other data assessment

1. The number of residential buildings by zones is calculated through dividing the number of residents in each zone by the average number of dwellers living in one building;
2. The number of commercial buildings in each zone is calculated through dividing total commercial area in the zone by the average area of commercial entities in this zone;
3. The number of state buildings for cities entering in the V zone is taken from SEAPs developed for this zone;
4. For the cities in the IV zone, having the SEAPs, the number of state buildings is calculated according to data developed for the Fourth zone. For the cities having no SEAP, the calculation was performed proportionally to the number of population, based upon the information concerning those cities in the IV zone which have developed the SEAP;
5. The number of buildings for the I, II and III zones was calculated proportionally to the number of population in the same way as in case of cities belonging to the IV zone lacking the SEAPs.