Case Studies with Targeted Assistance for Small Businesses in Selected Rural Areas to Introduce Energy Efficiency Measures in Georgia

Tbilisi, Georgia

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Abbreviations

AHS	Autonomous heating system
CoM	Covenant of Mayors
EE	Energy efficiency
EECG	Energy Efficiency Center Georgia
EU	European Union
EXP	Extruded polystyrene
GDP	Gross domestic product
LED	Light emitting diode
PV	Photovoltaic
PVC	Polyvinyl chloride
RE	Renewable energy
SEAP	Sustainable Energy Action Plan
SWH	Solar water heater
UNDP	United Nations Development Programme
UNFCCC	United Nations Framework Convention on Climate Change

Signs and measures

ha	Hectare
kg	Kilogram
kW	Kilowatt
PJ	Picojoules
t	Ton
bcm	Billion Cubic Meters
Mt	Megatonne
Mtoe	Million tonnes of oil equivalent

List of pictures, figures and boxes

Executive Summary

The presented case studies analyse the available biomass resources generated from agricultural operations in selected rural areas of Georgia (Kakheti and Samegrelo-Zemo Svaneti regions) and evaluate their energy potential for heating purposes in buildings.

The case studies are based on the specific implemented demonstration projects, where along with renewable energy (RE) and energy efficiency (EE) carried-out measures, are presented the barriers and challenges faced during the implementation process related to the biomass energy production and utilization.

In order to enhance the full process, particularly, the production of biomass from agricultural residues and the engagement and participation of various stakeholders in these processes, the recommendations to various stakeholders, including the Government of Georgia, are proposed for consideration. This will ensure the introduction of energy-efficient measures and products in Georgia.

Recommendations to the Government

- Create mechanism for alleviation of the tax burden on agricultural residues as current system envisages impose of taxes for users of such resources;
- Adapt legislative initiatives and/or relevant regulatory measures for the generation of thermal energy from agricultural residues;
- Develop innovative financial mechanisms (e.g., combination of loans and grants, guarantees or low-cost credit opportunities) for small businesses and/or farmers;
- Encourage the use of subsidies for biomass (solid fuel) technologies;
- Promote tax exemptions for renewable and energy-efficient energy technologies;
- Ensure the awareness raising campaigns for various stakeholders: business sector, farmers, local authorities, and local population.

Recommendations to Local Authorities:

- Research the full potential of locally available agricultural residues in rural areas for development of relevant strategies and/or action plans and identify local users of produced energy efficient products (as energy source) by mapping.

Recommendations to Small Businesses Sector/Farmers:

- Encourage the establishment of agricultural cooperatives with participation of small businesses and/or farmers for the production and lobbying of energy-efficient products (as energy source);
- Create *Agricultural Residues' Collection Points* for their further processing and/or supply to consumers as energy-efficient products (as energy source);
- Participate in the state and other local programs, as well as in programs announced by international donor organizations for creation of energy efficient products (as energy source).

The aforementioned recommendations will promote:

- Development of the circular economy and creation of green jobs at the local and national levels;
- Reduction of energy dependence on imported fossil fuels at local and national levels;
- Accessibility of clean energy and reduction of energy poverty in rural areas;
- Fulfilment of the international and national commitments made under the Paris Agreement and the Covenant of Mayors.

Introduction

The presented case studies have been developed to assess the available resources of biomass residues from agricultural activities and evaluate their energy potential. The report also provides case studies where the role of small businesses is presented and their involvement in the bioproduction process as well as other stakeholders in a selected rural area for introducing the energy efficiency measures in Georgia.

Background Information

Geographical and Climate Characteristics of Georgia

Georgia, an independent country since 1991, is situated in the South Caucasus region at the crossroads of Western Asia and Eastern Europe. The country is bordered to the west by the Black Sea, to the north by the Russian Federation, to the south by Turkey and Armenia, and to the south-east by Azerbaijan. Georgia covers a territory of 69,700 km^2, and its population is about 3.7 million.[1] The capital, Tbilisi, has population of about 1.2 million. Georgia is divided into 9 regions, 1 capital city, and 2 autonomous republics. These, in turn, are subdivided into 67 districts and 5 self-governing cities.

Picture 1: Administrative Map of Georgia[2]

Source: www.climpartmaps.com

A mountainous landscape determines the variety of Georgia's physical geography: there are mountains, valleys, plains, lowlands, glaciers, wetlands, arid lands, lakes, rivers and 18 geysers. Mountains cover a significant part of the territory: 54 per cent of it is located at an altitude of 1,000 m above sea level. In addition to the Great Caucasus range, there are several other mountain ranges in Georgia. The most important is the Likhi Range, running from the North to the South and dividing the country into its Eastern and Western parts.

Almost every climatic zone is represented in Georgia except for savannas and tropical forests. To the North, the range of the Great Caucasus protects the country from the direct penetration of cold air. The circulation of these air masses has mainly determined the precipitation regime all over the territory of Georgia. The climatic picture totally differs in both parts of Georgia as divided by the Likhi Range.

[1] *The official website of National Statistics Office of Georgia (Geostat) available at https://www.geostat.ge/en/modules/categories/41/population*
[2] *https://www.clipartmaps.com/?s=Georgia+Map+For+PowerPoint%2C+Country%2C+Administrative+Districts%2C+Capitals*

The climate in **West Georgia** is highly diverse, altering in certain areas very sharply from humid subtropical to permafrost. The climate is determined by the Black Sea coast to the West, and by the amphitheatre of three big mountain ranges (the Great Caucasus, the Likhi and the Meskheti), in addition to the surrounding Kolkheti lowland (wetland) in the center. The Black Sea coastal zone has a humid subtropical climate. The average annual temperature there is 14-15^{0}C, with extremes ranging from +45^{0}C to -15^{0}C, and annual amounts of precipitation vary between 1,500 mm and 2,500 mm.

Picture 2: Climate Map of Georgia[3]

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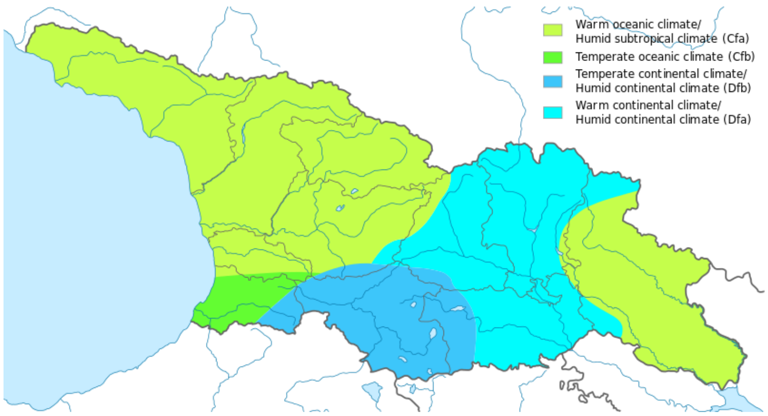

Source: World Maps of KÖPPEN-GEIGER Climate Classification

The climate of **East Georgia** is dry: in the lowlands, it is a dry subtropical climate, and in mountainous areas it is alpine. The average annual temperature is 11-13^{0}C in the plains, and 2-7^{0}C in the mountains. The absolute minima are -25^{0}C and -36^{0}C respectively. The absolute maximum reaches +42^{0}C, and the absolute minimum falls to -42^{0}C in the high mountains (the slopes of Mount Kazbegi). The annual amounts of precipitation vary in the range of 400-600 mm in the plains, and 800-1,200 mm in the mountains.[4]

Georgia's fertile soil and diverse climate are favorable for the production of various agricultural products in different regions, such as grapes, nuts, fruits, wheat, corn, and sunflowers, which itself determines the introduction and development of various types of biomass production. Consequently, the methodologies for the case studies have been chosen based on this priority. The hazelnut shell generated in horticulture and the vineyard pruning generated in viticulture both of which are primarily characteristics of the region of Eastern Georgia, such as the Kakheti region, and Western Georgia, such as the Samegrelo and Guria regions.

Energy Sector Overview of Georgia

Georgia is a net importer of fuels and energy products. The country relies on imports of natural gas (2.69 bcm in 2019), oil products (1.35 Mt in 2019)[5] and some hard coal and biofuels to meet most of its energy needs. Oil is imported mainly in the form of refined oil products (diesel, 40.7 per cent, and gasoline, 40.4 per cent).[6]

In terms of energy supply, Georgia's energy production covers less than one-fourth of its energy demand (21.4 per cent in 2019). Most of Georgia's domestic energy production (1.09 Mtoe in 2019) comes from hydropower and biofuels/waste (0.768 Mtoe biofuels and 0.245 Mtoe waste). Production of fossil fuels exists but is very limited (6.2 ktoe of lignite, 35.6 ktoe of crude oil and 8.3 ktoe of natural gas in 2019).[7]

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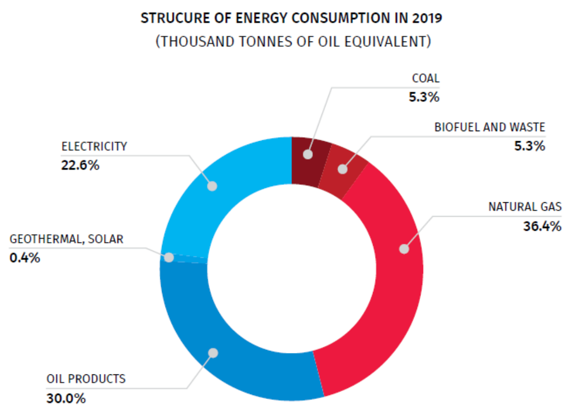
[3] *http://koeppen-geiger.vu-wien.ac.at/present.htm; World Maps of KÖPPEN-GEIGER Climate Classification;*
[4] *The 2nd National Communication to UNFCCC available at https://unfccc.int/resource/docs/natc/geonc2.pdf*
[5] *Energy Profile, International Energy Agency (IEA) available at https://iea.blob.core.windows.net/assets/3effac34-6632-47ce-a7c7-a16197a2c106/CountryPages_Georgia_FINAL.pdf*
[6] *Ibid;*
[7] *Energy Profile, International Energy Agency (IEA) available at https://iea.blob.core.windows.net/assets/3effac34-6632-47ce-a7c7-a16197a2c106/CountryPages_Georgia_FINAL.pdf*

In 2019, Georgia's energy demand was 5.1 Mtoe. Georgia's energy consumption per capita is two times lower than the world average, but it is growing very quickly. From 2000 to 2018, both energy demand and electricity consumption per capita multiplied by more than 1.6 times. The energy mix is relatively diverse compared with other countries in the region. In 2019, natural gas was the first fuel in the energy mix (45.4 per cent), followed by oil (27 per cent), renewables (20.4 per cent) and coal (4.7 per cent). Nearly 75 per cent of Georgia's electricity generation comes from hydro production (75.3 per cent in 2019), with the remaining production from natural gas and from a 20.7 MW wind power plant (84.7 GWh in 2019).[8]

Within the total energy consumption structure, the share of 36.4 per cent comes on natural gas. Oil products (30 per cent) and electricity (22.6 per cent) are also characterized with a relatively high share. During 2019, 5.3 per cent share of consumed energy comes on the biofuel and waste, while the remaining 5.7 per cent share has coal and geothermal energy.[9]

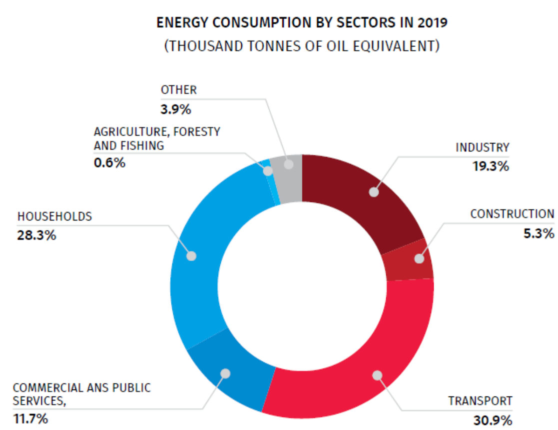
Figure 1: Energy Consumption in Georgia, 2019



Source: Geostat, 2019

The sectoral analysis of the energy consumption shows that the largest consumer of the energy is transport sector, with 30.9 per cent share of total consumption in 2019. 28.3 per cent comes on households, 19.3 per cent - on industry, 5.3 per cent - on construction, 0.6 per cent – on agriculture, forestry and fishing, while the remaining 15.6 per cent is distributed on commercial and public service and other consumers.[10]

Figure 2: Energy Consumption by Sectors in Georgia, 2019



Source: Geostat, 2019

As a net oil and gas importer, Georgia relies heavily on imports of natural gas, oil products and hard coal to meet most of its energy needs. In fact, net imports in total primary energy supply rose from 47 per cent in 2002 to

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[8] *Ibid;*

[9] *Energy Consumption in Georgia in 2019, Geostat available at* https://www.geostat.ge/media/35420/Results-of-Energy-Consumption-Survey-2019.pdf

[10] *Ibid;*

80.2 per cent in 2019 to meet the rising energy demand. After the energy crisis in 2006, the country began reducing its energy imports from the Russian Federation and increasing those from Azerbaijan. 93.4 per cent of natural gas and about 45 per cent of oil consumption is now imported from Azerbaijan. Gas imports are the highest during the winter months when there is a greater need for heating and less hydropower capacity is available for electricity generation. Interconnected with the Russian Federation, Azerbaijan, Armenia and Turkey, Georgia exports its seasonal excess of electricity from hydropower. Although Georgia has had a growing negative net balance of electricity since 2012 (with exception in 2016), it still exports the small amount of excess electricity in the summer months.[11]

In addition, it should be noted that fuelwood is still remaining the main source of space heating in rural areas. Most wood for fuel is harvested unsustainably and used inefficiently, causing the forest depletion and other related environmental problems. Despite the fact that Georgian government has conducted a gasification programme that allowed a significant number of rural households to switch to gas the fuelwood still remaining the main energy sources (22.4 per cent of energy produced from domestic sources), especially in Georgian rural areas.

Methodology for the Selection of Case Studies

Agricultural Sector Overview in Georgia

Georgia's climate and soil have made agriculture one of its most productive economic sectors. Accordingly, Georgia's fertile soil and favorable climate support production of a wide variety of agricultural products, including grapes and wine, berries, nuts (hazelnuts, almonds, walnuts, and etc.), citrus fruits, apples, peaches, and apricots. However, its mountainous territory limits total available arable acreage, especially for field crops. Despite this, the agriculture sector for Georgia remains an important sector in terms of GDP contribution accounting about 7-8 per cent of GDP for the last five years.[12]

It should be noted that currently the agricultural activities are based on a dual system of family holdings and commercial operators. More than 90 per cent of the production is concentrated within highly fragmented small-scale family holdings. On average, the size of a family holding is 1.22 ha, fragmented into two or three land parcels of 0.45 ha on average. Around 82 per cent of family holdings produce mainly for self-consumption, while the remaining 18 per cent produce cash crops. About 25 per cent of agricultural land is private and 30 per cent is leased. About 1.3 million people are employed in this sector, which is 55 per cent of the total employment of the country.[13] In general, Georgia is a country of high agricultural potential, but currently is not capable to use its potential fully.

Agricultural Waste Potential in Georgia

The large part of Georgian population traditionally practices gardening, growing field crops and uses wood for heating or cooking. Total area of the country's territory is 68.7 thousand sq. km., 40 per cent of which is covered by forests. Nearly 2.6 million hectares is agricultural land, including 468 thousand hectares of arable land, 115 thousand hectares of land with perennial crops and 1940 thousand hectares of permanent meadows and pastures. The picture below represents the main agricultural directions in Georgia's horticulture field, which produces a significant number of agricultural residues annually and has important energy potential.

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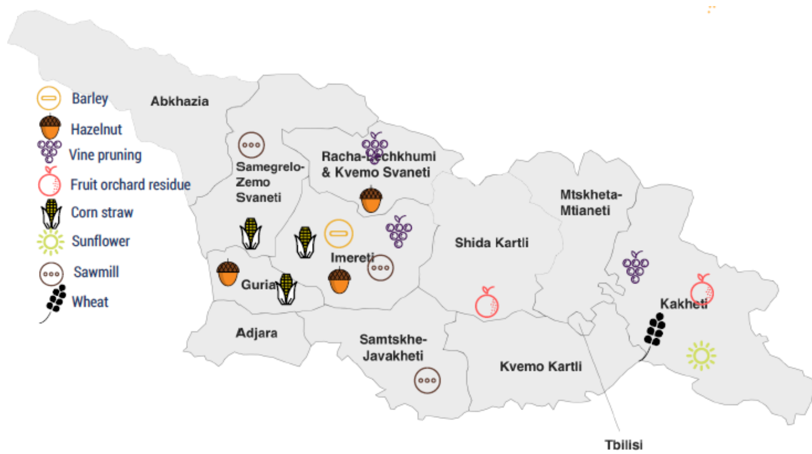
[11]Georgia Energy Profile, International Energy Agency (IEA) available at https://iea.blob.core.windows.net/assets/3effac34-6632-47ce-a7c7-a16197a2c106/CountryPages_Georgia_FINAL.pdf

[12] International Trade Administration available at https://www.trade.gov/country-commercial-guides/georgia-agricultural-sector

[13]Assessment of wood and agricultural residue biomass energy promotional in Georgia, World Experience Georgie (WEG) prepared for UNDP under Micro-Capital Grant Agreement for Non-Credit Related Activities of 26.06.14 available at http://weg.ge/sites/default/files/final_biomass.eng_.pdf

Picture 3: Agricultural Waste as Energy Potential in Georgia



Source: Biomass Country Profile: Georgia, UNDP

It's estimated that more than one million and a half tons of agricultural residues and more than one million of forest residues are produced every year in Georgia, with a potential to generate together 36.5 Picojoules (PJ). To be more precise, more than 50 per cent of the total biomass energy potential is from corn straw, with a production of over a million tons/year. Fruit orchard, wheat, vine pruning and hazelnut together account for 24 per cent of the total biomass energy potential.[14] Based on the estimated information, Kakheti, Samegrelo Zemo-Svaneti and Imereti are the most attractive regions for biomass residues production in Georgia.

In order to avoid energy poverty in rural regions and satisfy the population's heating needs, it is crucial that energy be used more efficiently, and that fuelwood is supplemented or replaced further by alternatives such as upgraded modern biofuels made from agricultural residues, and other fuels.

Based on research,[15] the total of 304 Kt of agricultural residues, with 5.6 PJ of energy resource is generated in Georgia from perennial crops production. The energy potential of perennial crops' residue is 1,565 TWh/year. Main resource for perennial crop residues is:

- Vineyard's pruning residue;
- Fruit orchards' pruning residue;
- Hazelnut shells and cuttings;
- Bay leaf cuttings.

Below are considered the most common agricultural residues in Georgia that have a promising potential in terms of conversion into biomass energy:

- **Vineyards** have the biggest potential in agricultural residue of Imereti, Kakheti, Racha Lechkhumi and Kvemo Svaneti and Kvemo Kartli regions. Vineyards have the biggest part in agricultural residue of Georgia, but they are not used as an alternative heating source, most of the residues are left in the field or burnt. According to the information provided by farmers, the transportation and storage costs are much higher than value of alternative heating resource. There is a clear tendency to increase the area under grape plant; accordingly, through establishment of modern intensive vineyards the amount of produced biomass will increase. Total residue 108 kT, with 2,0 PJ total energy resource is annually yielded in Georgia from established vineyards. According to the research, there are 37 419 hectares of vineyards in Georgia and energy value of residue per unit of area is 54.2 GJ/Ha.

[14] *Biomass Country Profile: Georgia at https://www.undp.org/sites/g/files/zskgke326/files/migration/ge/UNDP_GE_ENV_biomass_energy_Georgia_profile_eng.pdf*
[15]*Assessment of wood and agricultural residue biomass energy promotional in Georgia, World Experience Georgie (WEG) prepared for UNDP under Micro-Capital Grant Agreement for Non-Credit Related Activities of 26.06.14 available at http://weg.ge/sites/default/files/final_biomass.eng_.pdf*

- **Fruit orchards** are also an important source of biomass. Total residue 81 kT, with 1.5 PJ total energy resource is available from fruit orchards. At present, the total land area occupied by orchards has decreased by more than 60 per cent to about 40,000 hectares out of which up to 12,000 hectares are focusing on apple production and 10,000 hectares are focusing on citrus. As the result of data analysis, the apple orchard pruning leaves the highest residue (21,715 t) and bio-energy resource (406,074 GJ) are in Shida Kartli region; pear orchards' pruning has highest residue (1 140 t) and bio-energy resource (21,318 GJ) - again in Shida Kartli region; peach orchards' pruning highest residue (5,289.6 t) and bio-energy resource (99,444 GJ) - in Kakheti region.

- **Hazelnuts** are the third biggest provider of agricultural residue in Georgia. Currently, hazelnuts represent 24 per cent of Georgian agricultural exports. Estimated number of hectares in cultivation is up to 15 000 hectares under hazelnut plantations. Hazelnut orchards, as well as processing capacities, have grown intensely in Georgia reaching 40,000 tons of raw hazelnuts harvested annually or about 5 per cent of world supply. 67,629 t biomass/1264671 GJ energy are available every year from hazelnut production in Georgia. Main hazelnut producer regions[16] are Samegrelo-Zemo Svaneti (area – 10,114 ha, total residue – 28,319 kg, total energy production – 529,569 GJ), Guria (area – 3,339 ha, total residue – 9 349 t, total energy production -174 830GJ) and Imereti (area – 1305 hectares, total residue – 3 654 t, total energy production – 68,330 GJ). Hazelnut generates the residues in the form of fronds and shells. About 10 fronds are shed per tree per year, yielding about 1.4 kg. Dry woody biomass per frond or, assuming a density of 200 trees per hectare, about 2,800 kg. per hectare. Hazelnut shells are used in stoves as an alternative heating source mainly in small towns and villages of Samegrelo-Zemo Svaneti and Guria Regions. Average harvest of hazelnut is up to 40 000 ton/year. Yielding up to 24,800 ton/year of shell residues. About 1.55-ton dry shell residue becomes available per hectare per year. Average Heating Value for hazelnut is 1.6 PJ.

- **Bay leaf** is also an important source of residue. Due to favourable climatic and soil conditions this plant is mainly spread in the western regions - Adjara, Samegrelo Zemo-Svaneti, Guria and Imereti - of the country. 9,000 t residue of bay leaf is available annually in Georgia, which can be used as 0.2 PJ energy resources. Most of this residue – 7,500 t is available in Samegrelo-Zemo Svaneti region.[17]

In general, waste management in Georgia is regulated by the Waste Management Code, which regulates the implementation of measures facilitating waste prevention and its increased re-use as well as environmentally safe treatment of waste which includes recycling and separation of secondary raw materials, energy recovery from waste, and safe disposal of waste. It should be noted that the Code does not define the management of agricultural residues in a separate chapter/article. Their management is determined within the framework of municipal non-hazardous waste, where it is noted that "burning the municipal non-hazardous waste (leaves, garden/park waste, household waste) in an open manner or in a non-designated incinerator will be fined".[18]

As mentioned above, a significant number of agricultural residues is generated in the Georgian agriculture sector that is not used for any purposes, they are just thrown in the fields. Moreover, according to the existing laws and regulations, Georgian farmers and/or private companies that are involved in the horticulture activities are not allowed to burn residues in the fields which becomes an additional burden for them in terms of penalties.

As a result, the use of agricultural waste as an energy resource, which can promote the improvement of energy efficiency, has the greatest potential to bring about a number of benefits, including those for the agricultural

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[16] *Abkhazia region is currently a region that is not controlled by the Georgian government.*

[17] *Assessment of Wood and agricultural residue biomass energy promotional in Georgia, World Experience Georgie (WEG) prepared for UNDP under Micro-Capital Grant Agreement for Non-Credit Related Activities of 26.06.14 available at http://weg.ge/sites/default/files/final_biomass.eng_pdf*

[18] *Low of Georgia; Waste Management Code (Chapter X, Article 35) available at https://matsne.gov.ge/en/document/view/2676416?publication=12*

industry as a whole, by generating additional revenues and establishing the green jobs, as well as for the purpose of reducing energy dependence at both regional and national levels.

Unfortunately, there are currently very small number of cases in utilizing agricultural residues as a source of energy in Georgia. Furthermore, the projects that were put into practice happened as part of several programs and/or projects that were funded mainly by the donor organizations. The case studies that are being presented reflect the local experience and lessons learned that have been introduced into practice by the "Energy Efficiency Center Georgia" (EECG) in the rural areas of Georgia, more specifically in Samegrelo-Zemo Svaneti, Adjara, and Kakheti regions.

The following four case studies show how agricultural residues, such as hazelnut shells and vineyard pruning residues, have been used as an energy source in Georgia. These demonstration projects were supported by various donor organizations and implemented by EECG.

Selection of Small Business for Case Study

Georgia has a very high potential for biomass in general, however, the bioenergy industry is quite small and poorly coordinated. It could be said that there are only a few bioproduction companies in Georgia that are active in the biomass production business. Their main activities revolve around the production of briquettes from forest residues, which is at the same time not competitive with firewood or even natural gas due to its high market price.

As for the production of energy resources from agricultural residues, the matter is even more complicated, it can be said that the market in this direction is not developed at all. To be more specific, agricultural residues such as vineyards pruning, fruit cuttings and/or even bay leaf branches, their production as energy resource and subsequent sale are not made by the business sector at all.

The only exception may be the nut production business where companies that are trading and exporting Georgian hazelnuts are non-directly involved in this process. More specific, businesses that process nuts in enterprises generate residues in the form of shells, which are then either exported as raw materials for furniture production and/or some amount of it is sold locally for being used by local population as energy resource in the stoves. Therefore, at present in Georgia, the production of energy resource from hazelnut shell as energy-efficient product does not have a consecutive and systematic approach. It is presented more pragmatically depending on the demand of the local market.

Basically, the interest and involvement in the biomass production in Georgia are primarily driven by local non-governmental organizations and donor organizations. Through the implementation of various projects (research and demonstration), these organizations are trying to promote the awareness and interest among various stakeholders, including representatives of local authorities, business community, local population, etc.

There are not many initiatives being implemented, especially in the demonstration projects' part. And even when they are implemented, their long-term sustainability is becoming critical due to the poorly developed or even non-existent bioproduction market, particularly in the case of agricultural waste.

For this particular case, the demonstration projects covering practical applications of agricultural residues as energy source, and introduction of RE and EE measures with the participation of various stakeholders, were sought. As a result, the use of various agricultural residues (hazelnut shells and vineyards pruning) as biomass is discussed in the following four case studies, with the participation of various stakeholders such as local authority (municipality), business sector, farmers, and local population. This will provide the opportunity to not only see the gained benefits, but also recognize challenges from various aspects of the sector.

Case Study 1: Implementation of Energy Efficiency Measures in Zugdidi Kindergarten #15

One of the first demonstration projects «Energy Efficiency Measures in Zugdidi kindergarten #15» was implemented in 2015 in Zugdidi Municipality of Samegrelo-Zemo Svaneti Region located in the West Georgia. The project was financially supported by BP EXPLORATION (Caspian Sea) LTD Georgia and implemented by EECG in cooperation with Zugdidi Municipality City Hall envisaging the replacement of old wooden single glazed windows with double glazed PVC ones and construction of boiler house with shell reservoir along with installation of autonomous heating system (boiler, piping, radiators) working on the solid fuel – agricultural residues - hazelnut shells that is common for Samegrelo-Zemo Svaneti region.

Box 1: Short Information on Zugdidi Kindergarten #15

Zugdidi Kindergarten #15 is located in 2-storey typical old Soviet-style building, built in 1964 with total space – 1,050 sq.m.

There are roughly 35 staff members working at the kinder garten, which has more than 115 kids separated into 4 groups.

Before introduction of autonomous heating system, the kindergarten used wood fuel for heating of several rooms. Only 35-40 m3 of wood was used per season in the primitive four wood stoves, which did not provide adequate heating for this type of institution throughout the day. The total cost for heating per season was 5,000 GEL.

The demonstration project included two upfront capital investments: one with an impact on social and health, and the other with an impact on environmental protection. The overall cost of installation of the central heating system, which included the boiler with its full equipment along with the construction of the boiler house was about 32,000 GEL. This increased the kindergarten building's level of comfort while lowering the risk of indoor air pollution caused by soot generated from wood fuel (with 40% humidity) burned in primitive/non-energy efficient stoves. The second upfront capital expenditure, with a cost of 26,000 GEL, was related to installing a bunker with the delivery system needed for placing and supplying the biomass - hazelnut shells as agricultural residue - to the heating system; so, this one had an environmental impact.

As for the comparison of the CO_2 footprint of biomass vs. wood fuel; in Georgia, wood fuel is considered an unsustainable energy resource, as a result of its intensive cutting and desertification of forests for several decades. Moreover, the forest management reforms implemented in recent years have further limited the use of wood fuel; so, comparing the CO_2 footprint of biomass vs. wood fuel is complicated, as to determine what part of the wood fuel was consumed in a sustainable and/or non-sustainable way. Accordingly, the benefits obtained from the implementation of the project were compared with the hypothetical consumption of natural gas and therefore, a comparison was made with the hypothetical consumption of natural gas.

Picture 4: Zugdidi Kindergarten #15

The total amount of hazelnut shells needed for each heating season after introduction of 150-kW autonomous heating system is around 12,000 kg, costing a total of 2,640 GEL. If natural gas was used to heat the facility, the kindergarten would spend 9,700 GEL more on energy resource and produce 24,600 kg more CO_2.

Picture 5: Solid Fuel Boiler, Boiler House with hazelnut shell reservoir – Zugdidi Kindergarten #15

Case Study 2: Implementation of Renewable Energy and Energy Efficiency Measures in Erisimedi Kindergarten

Another demonstration project with a similar content was implemented in the Sighnaghi municipality located in the eastern Georgia. In particular, along with other RE and EE measures, the autonomous heating system (boiler, piping, radiators) and the boiler house working on the solid fuel – agricultural residues - hazelnut shell were installed in the kindergarten of Erisimedi village.

It should be noted that the Kakheti region is not a hazelnut culture region, unlike Samegrelo-Zemo Svaneti and Guria ones. It ranks only the 5th among regions of Georgia after Samegrelo Semo-Svaneti, Guria, Imereti and Adjara regions in terms of hazelnut area (ha) production and plantations[19].

Although there are only 388 ha[20] of hazelnut plantations in the Kakheti region, nut farming has grown in popularity among farmers in recent years. As a result, it has a high potential for use as the environmentally friendly and efficient-product fuel for replacing wood and/or gas.

Box 2: Short Information on Erisimedi Kindergarten

The Erisimedi kindergarten is a one-storey building built in 1989. During the winter season, the kindergarten used 17m3 of fuel wood, which was burned in 3 primitive wood stoves that did not meet relevant standards for creating indoor temperature in the entire building.

With introduction of the heating system the kindergarten annually needs around 3,000 kg hazelnut shells. The costs of purchase and transportation of hazelnut shells (3,000kg x 0,2 GEL= 600 GEL) was covered by the municipality. The consumed 17m3 of wood fuel was enough only for heating of 2 rooms for groups of kids and a room for personnel. The cost of used fuel wood was 1,050 GEL.

The project was implemented in 2018 with the financial support of BP EXPLORATION (Caspian Sea) Ltd. Georgia and envisaged the following measures:

- Introduction of modern autonomous heating and hot water supply system working on local agricultural residues - hazelnut shells to replace fuel wood.
- Introduction of a 30-tube solar water heater with water tank capacity of 300 litres integrated with heating and hot water supply system to provide the kindergarten with free hot water from May through October;

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[19] *Georgian Hazelnut Market Assessment, Perspectives issued by Tbilisi State University (TSU) available at https://dspace.tsu.ge/bitstream/handle/123456789/334/Georgian%20Hazelnut%20Market%20Assessment%2C%20Perspectives.pdf?sequence=1&isAllowed=y*

[20] *"Assessment of Wood and agricultural residue biomass energy promotional in Georgia" developed by World Experience Georgie (WEG) prepared for UNDP under Micro-Capital Grant Agreement for Non-Credit Related Activities of 26.06.14 available at http://weg.ge/sites/default/files/final_biomass.eng_.pdf*

- Introduction of grid connected micro solar PV plant (1 kW capacity) to provide the kindergarten with free electricity to cover its electricity needs and in summer period supply excess electricity to the grid;
- Introduction of energy efficiency measures for building envelope: insulation of building wall separating used and unused part of the building (30 m2) with 5 cm XPS boards and attic floor (110 m2) with 10 cm mineral wool.

This demonstration project followed the same approach as it was in previous case, which led to the achievement of social and healthcare benefits. The installation of the heating system, including all of its parts (radiators, pipes, etc.), as well as the building of the boiler house, cost around 12,000 GEL and had a positive social impact. Also, the environmental benefits were also achieved, for the purpose of which the bunker with a supply mechanism was installed, with a total cost of 5,100 GEL.

Picture 6: Solid Fuel Stove, Boiler House with Hazelnut Shell Reservoir – Erismedi Kindergarten

The savings mentioned in relation to firewood consumption may not be significant; however, the biggest success in this case is the social effect realized in terms of the improved indoor comfort for both kids and staff, achieved using the locally available resources rather than imported energy resources.

Case Study 3: Assessment of Firewood Consumption Reduction in Villages Surrounding the Machakhela National Park in Adjara Region

The project was implemented in 2016 in the Khelvachauri municipality of Adjara region with the financial support from UNDP. The project envisaged the assessment of feasibility of a variety of energy efficiency or energy alternatives that could allow households in the Machakhela valley located in the part of Khelvachauri municipality to reduce consumption of fuelwood while at the same time maintaining (or improving) their quality of life in an economically viable manner.

It should be noted that about 86.2 per cent (10,993 ha) of total area of the Machakhela National Park and its supported zone is considered as the lands of the forest fund. From them about 10,868 ha is covered with forest and about 30 ha is considered as a not-forest land category.

At the end of the 20th century, uncontrolled deforestation resulted in a lack of firewood resources in areas where roads were built. At the same time, cutting of trees has been banned on the slopes with inclination 35^0 and more due to the developing of natural catastrophic events.

> **Box 3: Short Information on Machakhela National Park**
>
> *Machakhela National Park is located in Khelvachauri Municipality and is 30 km away from Batumi City. The Park was established in 2012 with an area of 8733 ha. Territory of the park is represented with forests covering the slopes around the river Machakhela. Unique species of relict forests are represented in the area: Colchic bot box, chestnut, nut, hazelnut, bot, etc. There are three pedestrian trails integrated with the car route in the park area.*

A 10-year ban on forest cutting and/or at least little logging has been required for the recovery of forest resources and their restoration to operating mode. However, the initiative had previously been intended to identify some alternate strategies for supplying thermal energy to the local population.

The main energy sources of the local population in the community have been electricity for lighting and electrical appliances; firewood for hot water, heating and cooking which has been used almost all the year, and liquid petroleum gas mainly used for cooking in the spring-summer period. Community villages are not connected to the natural gas pipeline and are not going to make this connection. The reason of it is a geographical complexity of the valley which requires an immense number of investments.

Based on these circumstances, the project developed a proposal to the local population of community to replace the firewood (especially during the winter – heating season) with locally available agricultural residues - hazelnut shells. It should be noted that Adjara region is not so known for hazelnut culture as Samegrelo-Zemo Svaneti and/or Guria regions. Although, the Adjara region is located very close to the Guria region (with 65 km distance), where hazelnuts are produced, and therefore a certain number of shells are generated. With this reason, the agricultural residues were presented as one of the substitute energy resources for the community.

Box 4: Use of Hazelnut Shells as Energy Source - The Facts

- *11 families from different communities participated in the test.*
- *During the winter, each family purchased 2,900 kg of shells with 50 per cent co-financing.*
- *January-February was the highest consumption: on average 25-20 kg per day.*
- *Average consumption per family in winter - 2,575 kg.*
- *Total consumption of 11 families is 30,300 kg.*
- *1 ton of shell replaced 3.6 m3 of firewood;*
- *The cost of the shell, per family, is 580 GEL;*
- *Cost of 10 m3 firewood is 600-800 GEL;*
- *In total, at least 94 m3 of firewood were saved.*

Moreover, along with offering of alternative fuels, it became necessary to replace the existing used stoves with the suitable ones to the local population. However, for many of them it was impossible to replace it with a new suitable stove due to the community's limited social-financial conditions. Therefore, the project expert suggested them a simpler approach. In particular, converting the existing stoves, which entails attaching a separate inlet pipe to the stove for the purpose of delivering the hazelnut shells, that made it simpler to supply biomass fuel continuously. It should be highlighted that the effectiveness and reliability of both the remodelled stoves and the alternative biofuel were pretested with direct engagement and participation of the preselected families before local community would fully replace with suggested fuel.

Picture 7: Remodelled Stove for Hazelnut Shell and Testing Process in Surroundings of Machakhela National Park

Following a successful test, the community's self-mobilization led to the creation of an initiative group, which in coordination with the project expert contacted nut industry representatives, purchased, and transported agricultural residues for the winter season. As for the remodeling of the stoves, this problem was easily resolved with the assistance of local craftsmen.

The successful implementation of the project also determined the sustainability of the process through obtained benefits expressed in social and economic effects. The fuel replacement with locally available agricultural waste - now an alternative fuel - has gained the environmental benefits, such as the promotion of forest conservation.

Box 5: Nut Shells Consumption - The Facts

- *An Initiative Group was formed;*
- *For the winter of 2017/2018, 105 families expressed their desire to purchase 298 tons of shells;*
- *In September 2016, 142 tons of shells were purchased;*
- *The number of families for using the alternative energy source has been increased 5 times;*
- *The cost of 1 ton of shell was 160 GEL;*
- *3 tons of shell = 10 m3 of firewood;*
- *3 tons of shell 480 GEL;*
- *10 m3 of firewood = 600-800 GEL;*
- *In the winter of 2017/18, 500 m3 of firewood were saved - up to 200 trees were not cut;*
- *If 40-50 families switch to shell consumption every year and the consumption exceeds 600 tons by 2022, about 2200 more m3 of firewood are to be saved.*

Case Study 4: Biomass Supply Chain in Telavi Municipality

In 2018-2022, Energy Efficiency Center Georgia (EECG) implemented one of the most interesting and innovative demonstration projects in Telavi municipality with title «*Biomass Energy and Energy Efficiency Measures as a Sustainable Energy Solutions for Georgian CoM Signs*».[21]

The project was co-financed by the EU Commission (80 per cent) and Telavi Municipality City Hall (20 per cent) and implemented by EECG with aim to strengthen the managerial and technical capacities and skills of Telavi municipality staff in implementing the sustainable energy investment projects; promoting renewable energy production through utilization of locally available biomass with establishment of biomass energy supply chain.

The innovation of this project in the context of Georgian reality included itself not only the full thermal refurbishment of two kindergartens (IKALTO and TELAVI #1 kindergartens) through introduction of various RE and EE measures but also the use of locally available biomass – vineyards pruning residues - as energy source for heating of municipal buildings in winter season. It should be noted that vineyards pruning residues have never been used as energy source for heating buildings in Georgia, and this was the first innovative attempt and approach of using it as a biomass.

Box 6: Implemented RE and EE Measures in Kindergartens

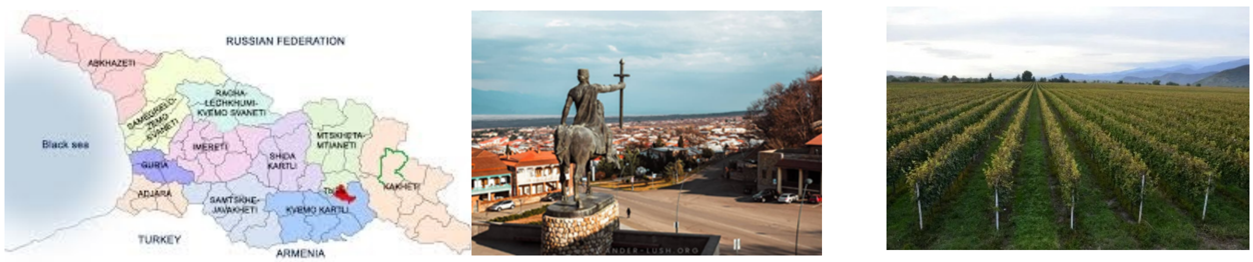
1. *Roofs' renovation and thermal insulation of attic floors with 20 cm thick mineral wool and waterproofing membrane covering;*
2. *Exterior walls' thermal insulation, including foundation walls (socle), with 10 cm rockwools and 8 cm XPS panels;*
3. *Installation of low emission double glazed PVS windows and doors;*
4. *Installation of decentralized (IKALTO KG) and central (TELAVI #1KG) ventilation systems;*
5. *Full replacement of electrical wirings and installation of EE lighting systems (LED Lamps);*
6. *Installation of autonomous heating systems (AHS) working on locally available biomass - vineyards pruning residues;*
7. *Installation of solar water heater systems (SWHs) connected to AHS;*
8. *Installation of 5.45kW (IKALTO) and 6,82kW (TELAVI #1) grid-connected PV systems.*

[21]Covenant of Mayors Signatories committed within the EU initiative to reduce the GHG emissions on its municipal territories by 30 per cent by 2030. In Georgia, 26 municipalities are involved in the process, including Zugdidi Municipality (Case Study #1); Singhnaghi Municipality (Case Study #2) and Telavi Municipality (Case Study #4).

Georgia is the oldest wine producing region in the world. The fertile valleys and protective slopes of the South Caucasus were home to grapevine cultivation and wine production for at least 8,000 years.

As for Georgian regions, the Kakheti that is located in the east part of the country is most well-known for its vineyards and winemaking traditions. There are eight municipalities in the Kakheti region where the Telavi municipality is also recognized as one of the main viticulture centers.

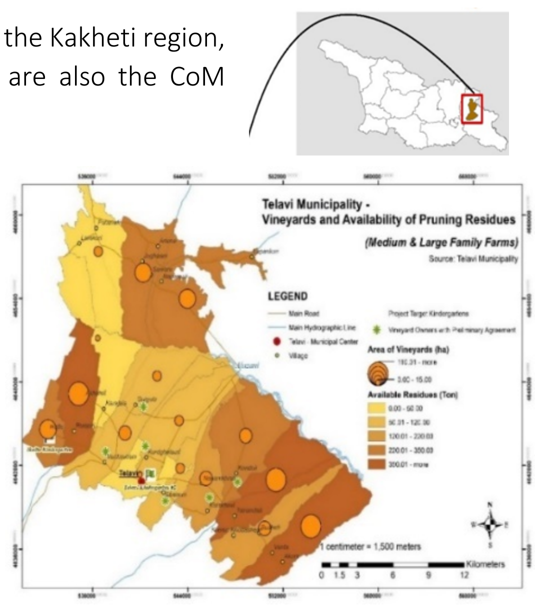
Picture 8 : Georgia, Kakheti Region, Telavi Municipality, Vineyeards



The Telavi municipality was one of the first municipalities in the Kakheti region which signed the EU initiative of the Covenant of Mayors (CoM) in 2014 and took the commitments to reduce CO_2 emissions on its municipal territory with 20 per cent by 2020 as well as developed its first Sustainable Energy Action Plan with preparation of the baseline emission inventory and development of sustainable energy action plan for the municipality. Moreover, in 2020 the municipality updated its commitments with meaning to reduce CO_2 emissions with 30 per cent by 2030.

It must be noted that Sighinaghi Municipality, that is located in the Kakheti region, and Zugdidi Municipality in Samegrelo-Zemo Svaneti region are also the CoM signatories.

According to statistics of 2018 in Telavi Municipality, there are around 6 000 hectares (ha) of vineyards, and this number is growing annually with meaning that in the municipality is generated a large number of agricultural residues that is not used for any purpose. Moreover, they are dumped in the fields and, in accordance with the Georgian regulations, farmers and/or companies engaged in the viticulture are not allowed to burn vineyards pruning residues in the field. Therefore, the enormous number of agricultural residues became an additional burden for them.



Picture 9: Vineyards and Availability of Pruning Residues[23]

In the framework of the project, based on the developed feasibility study[22] and gained lessons, the following facts were revealed:

- There are about 6,000 hectares of vineyards in Telavi Municipality with growing perspectives;
- Each hectare generates 1.5 to 2 tons of pruning;
- The total volume of biomass (vineyard pruning) is anticipated to be between 9,000-12,000 tons;

[22] *Feasibility study on Establishment of Biomass Chain for Telavi Municipality developed within EU funded project "Biomass Energy and Energy Efficiency Measures as a Sustainable Energy Solutions for Georgian CoM Signs"*
[23] *Ibid*

- Up to 40-50 tons of vineyard pruning residues are required each season to heat an average-sized building (800 to 1200 square meters);
- With this volume of biomass, about 150 to 200 buildings can be heated.

In Telavi municipality, a biomass supply chain was established for the purpose of heating two municipal buildings. This chain included the following activities:

- Full equipment of biomass supply chain with agricultural machineries and applications/tools;
- Collection, shredding, and storing of agricultural waste as a biomass for heating season.

Two 2-unit tractors with trailers were purchased for this purpose: one for collection pruning in the vineyards and the other with trailer for transportation and storage. As a result, the warehouse was also constructed. Additionally, a shredder for shredding bales and a round-baller application for gathering and producing vineyard bales have been purchased. Up to 55 tons of biomass (vineyard pruning residues) were gathered and shredded in just two seasons (2020–2021). During the project's implementation phase, the total operation cost was 15 780 GEL for a two-year period. The process was completed in accordance with the below presented scheme.

Picture 10: Biomass Supply Chain Scheme in Telavi Municipality

Pictures 11: Reflecting the Process of Collection, Transportation, Storing and Shredding the Biomass

As for the testing process for building, it was going on for four days. As the test was conducted during the heating season, it took several days to obtain the appropriate temperature not only in the whole building (1,050 sq.m) but also for separate structural part of building envelope (window glasses, walls as well as radiators). As a result, the average temperature in the building has reached to 18-21^{0}C and in the boiler temperature - up to 57-65^{0}C.

Analysis of Possible Areas for Improving Energy Efficiency

As was mentioned above, the market for biomass production in Georgia, particularly from agricultural residues, is underdeveloped or, more accurately, in the non-existent phase. In order to generalize the situation further, it should be noted that the biomass production as energy source from hazelnut shells is different from vineyard pruning residues.

Hazelnut production along with wine production is included in the top ten export products of Georgia. Accordingly, as it was mentioned in above based on statistics of 2013, there is about 15,000 hectares in total, characterizing with growing hazelnut plantations, and with potential to produce about 67,630 t agricultural (consisting with 43,531 t pruning and 24,097 t shells) residues annually as a biomass.

Only the Samegrelo-Zemo-Svaneti region, which is the main hazelnut producer region, generates 43,995 t of agricultural residues (consisting of 28,319 t pruning and 15,676 t shells).[24] It should be noted that in small towns and villages of the Samegrelo-Zemo Svaneti Region, where the majority of the nuts is cultivated and collected, hazelnut shells are more or less utilized as an alternative heating source in stoves.

As a result, the businesses that export hazelnuts are also engaged in the selling process of agricultural residues supplying the hazelnut shells to both domestic and foreign markets. As for hazelnut pruning, they are not utilized for any heating purposes, therefore they can play a significant role in this regard too.

There are 37,419 hectares of vineyards totally in Georgia, grown primarily in three regions (Kakheti, Imereti, Kartli) and consisting of (primarily) ten different varieties of grapes. The number of agricultural residues of vineyards pruning can be determined multiplying cultivation surface with a coefficient, which describes residues productivity (t/ha). In case of demonstration project implemented in the Telavi from ha is available to produce about 1.5-2 t vineyards pruning residues depend on the variety of vine, cultivation methods and other factors.

It should be mentioned that in general vineyards pruning is traditionally used for roasting barbecue though, in general just a small number of residues are used for this purpose by farmers. Furthermore, several companies are operating in the region collecting vineyards pruning, packing and selling them in supermarkets, though the scale of it is too small compared with the total amount of residues generated not only in Telavi municipality but also in the entire Kakheti region in general. For more clarity, only Telavi municipality has 6,000 hectares of vineyards and therefore produces approximately 9,000 -12,000 tons of vineyards pruning every year. With this volume of vineyards pruning, it is possible to barbecue about 4,800-7,200 tons of meat (from 2.5 kg of vineyards pruning can be fired 1-1.5 kg of meat) annually which is about 48,000-72,000 pigs (from 1 pig is available 80-100 kg meat) that is an unrealistic number for only Telavi municipality with consideration that whole number of pigs in Georgia is about 168,000 as of data 2020[25].

In general, the vineyards pruning residues are generally cut up and then land-filled, or burned near the field, with additional costs for farmers and serious problems about parasites development or uncontrolled fires. Based on practice, the small farmers- peasants (owing up to 1-1.5 ha) use cuttings from vineyards for household purposes (for barbeques), that ultimately represents a very small amount whereas big farmers (owing more than 2 ha) and companies prefer to burn vine residue near the field.

But, based on the environmental regulations, as it was mentioned above, the farmers and/or private companies are not allowed to burn residues in the fields that become additional burden for them in terms of penalties. Alternatively, the big vineyard owners break a vine pruning residue into the small pieces and leave it in vineyards. This biomass is used as bio-fertilizer in vineyards for next year though their annual use is not recommended.

Considering that there is a great potential of agricultural residues, along with successful examples of its use as energy resource and energy-efficient product in the demonstration projects, it is crucial to be further interested and get the small businesses more involved in this direction. Due to the lack of experience and poorly developed

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[24]*Assessment of wood and agriculture residue biomass energy podetial in Georgia, WEG and prepared for UNDP under micro-capital grant agreement for non-credit related activities of 26.06.14 available at http://weg.ge/sites/default/files/final_biomass.eng_.pdf*

[25]*National Statistics Office of Georgia (Geostat); Agriculture of Georgia 2020 - I quarter (Preliminary Results on Animal Husbandry) available at https://cutt.ly/74pElub*

bioenergy production market, it is critical to support more demonstration projects where small businesses would be given more support and assistance. This would encourage the replication of similar projects in different municipalities and regions of the country. There were just a few examples when the business gets interested to produce the briquettes for hazelnuts shell. For example, in 2016 the Georgian-Ukrainian company "Eco-line Energy" located in Zugdidi municipality started the production of hazelnut shell briquettes processed with special technology. The briquettes were intended for both individual entrepreneurs and enterprises, and mainly were oriented to export the energy efficient product to the EU market. Unfortunately, the company temporarily stopped the production for some reasons, although it is known that it plans to resume production and return to the market next year.

It should be noted that development of bioenergy production contributes to the additional income for businesses, producing the innovative green products, creating new jobs and promoting the development of circular economy. For the Georgian regions and municipalities, it will promote the reducing of dependence on imported energy resources, as well as the development of local economy. As for local population, it will improve their quality of life in ecologically friendly environment and will employ in the green economy sector.

Implemented Energy Efficiency Measures

In the above-mentioned case studies, along with using of agricultural residues as energy resource in the solid fuel heating systems, various RE and EE measures were implemented. They included replacement of non-efficient lamps with efficient ones, replacement of old wood windows and doors with EE windows and doors, as well as insulation of attic roof. It should be noted that in some case studies, namely 1 and 2, separate measures were implemented. In case of Telavi municipality demonstration project, full thermal refreshment measures were conducted in both buildings (kindergartens), such as:

- Roofs' renovation and thermal insulation of attic floors with mineral wool;
- Thermal insulation of exterior walls, including foundation walls (socle), rockwools and XPS panels;
- Installation of low emission double glazed PVS windows and doors;
- Installation of decentralized and central ventilation systems;
- Full replacement of electrical wirings and installation of EE lighting systems (LED Lamps);
- Installation of autonomous heating systems (AHS) working on locally available biomass - vineyards pruning residues;
- Installation of solar water heater systems (SWH) connected to AHS;
- Installation of up to 5-6 kW capacity grid connected PV systems.

Potential Energy Efficiency Measures Recommended for Implementation

To fully understand the potential of energy measures it is crucial to introduce RE and EE measures along with using of biomass energy. It is well known that innovative sustainable energy projects cannot be implemented without complex approaches to achieve the desired social-economic as well as environmental, and other effects and benefits.

However, RE and EE initiatives can be categorized as short-, medium-, and long-term projects, as well as free or inexpensive initiatives or initiatives requiring capital investment. Therefore, it is important to outline all prospective energy efficiency measures in detail and in the order that they will be implemented.

Some energy efficiency measures can be started and implemented with short-term and low-cost measures that can be effective because they make an immediate impact and help getting people more interested and involved in the process.

Conclusions

The above case studies faced some barriers and challenges during the implementation process, necessitating consideration and the drawing of appropriate conclusions, both of which could be helpful to the projects to be successfully replicated in the future in other municipalities and/or regions of Georgia.

Given that all four case studies were related to the promotion and popularization of the introduction of agricultural residues as energy source, it may be concluded that revealed barriers and challenges are common. Thus, the following barriers and challenges were identified:

- **The administrative-institutional barriers and challenges** related to the establishment of biomass supply chain. It should be noted that this issue may be slightly different depending on the biomass (vineyards pruning residues) used. In the case of vineyards pruning, there has never been a precedent for using it as energy resource in Georgia, and therefore it has been related to an innovative approach. Therefore, establishing of supply chain involves a different set of challenges rather than hazelnut shells. More specifically, unlike hazelnut shell, which is a direct output of hazelnut production and hence does not require additional processes to get biomass, vineyards pruning residues require collecting, storage, and shredding before using it as energy resource. It is important to note that the same schemes should be considered in case of pruning of nuts, fruits and bay leaves. Within the Telavi project two scenarios were considered:
    - Process owned by the local authorities, i.e., when all process of the biomass supply management chain is implemented by the municipality;
    - Process owned by the third party such as farmer and/or private company while the whole process is supervised by the local municipality.

In case of the first scenario, when the municipality fully manages the process, it might be difficult for municipality to manage it in long-term perspectives due to its limited human, institutional, and/or financial resources. In case of another one, if the entire process is managed by the private sector under supervision of the municipality, then leasing of agricultural machineries and applications to (small) businesses from the municipality's side is insufficient for the biomass supply chain's profitability and sustainability in the long-term perspective.

- **The technical-engineering challenges** requiring the innovative solutions for heating systems working on the vineyards/fruit/nut, bay leaf pruning residues. For instance, the utilization of vineyards pruning due to its specific structure (shredded mass) has required introducing some of innovation solutions during the installation and action process of the heating system, which are, of course, manageable and surmountable.

- **The mental and behavioural challenges** connected to the service and maintenance of biomass heating systems. In Georgia, using natural gas is considered as a more convenient way as far as it does not require daily repairs and maintenance. Therefore, it is critical to educate local community about the benefits of such projects in terms of environmental protection, social-economic, and energy independence perspectives not only for the municipality and/or region, but also for the entire country.

Finally, the discussed case studies, which are based on the practical experience gained from the implemented demonstration projects, have confirmed that the development of suitable mechanisms - started from policies and ended with action plans - supported by relevant legislative, economic, and financial initiatives will further contribute the growth of financial sustainability and profitability of the sector. It should be noted that relevant governmental authorities are currently working on the development of “the Energy and Climate Action Plan”, “the Renewable Energy Action Plan”, and “the Climate Change Action Plan”, where the measures/actions for the use of agricultural residues as an energy resource are considered; this will help the sector to create a sustainable demand for biomass and agricultural residues as an alternative energy source.

Recommendations to Stakeholders for Encouraging Energy Efficiency Measures and Delivery of Energy Efficiency Products in Georgia

Recommendations to the Government:

- Create mechanism for alleviation of the tax burden on agricultural residues as current system envisages impose of taxes for users of such resources;
- Adapt legislative initiatives and/or relevant regulatory measures for the generation of thermal energy from agricultural residues;
- Develop the innovative financial mechanisms (e.g., combination of loan and grants, guarantees or low-cost credit opportunities) for small businesses and farmers;
- Encourage the use of subsidies for biomass (solid fuel) technologies;
- Promote tax exemptions for renewable and energy-efficient energy technologies
- Ensure the awareness raising campaigns for various stakeholders: business sector, farmers, local authorities, local population.

Recommendation to Local Authorities:

- Explore the full potential of locally available agricultural residues in rural areas for development of relevant strategies and/or action plans and identify local users of produced energy efficient products (as energy source) by mapping.

Recommendations to Small Businesses Sector/Farmers:

- Encourage the establishment of agricultural cooperatives with participation of small businesses and/or farmers for the production and lobbying of energy-efficient products (as energy source);
- Create *Agricultural Residues' Collection Points* for their further processing and/or supply to consumers as an energy-efficient products (as energy source);
- Participate in the state and local programmes, as well as in the programmes announced by international donor organizations for creation of energy efficient products (as energy source).

The aforementioned recommendations will promote:

- Development of the circular economy and creation of green jobs at the local and national levels;
- Reduction of energy dependence on imported fossil fuels at local and national levels;
- Accessibility of clean energy and reduction of energy poverty in rural areas;
- Fulfilment of the international and national commitments made under the Paris Agreement and the Covenant of Mayors.

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Annex: Technical Information on the Applied Measures from Case Studies

***Case Study 1:** Implementation of Energy Efficiency Measures in Zugdidi Kindergarten #15*

Project Title: Implementation of Energy Efficiency Measures in Zugdidi kindergarten #15;

Project Duration: November 2013 - November 2015;

Donor: BP EXPLORATION (Caspian Sea) Ltd. Georgia;

Project Implementer: Energy Efficiency Centre Georgia (EECG);

Project Geographical Area: Zugdidi Town, Zugdidi Municipality, Samegrelo-Zemo Svaneti Region, Georgia;

Project Goal: introduction of such energy efficient measures such as installation of heating system working on the solid fuel – agricultural residues which are common for this region – hazelnut shell, and replacement of incandescent light bulbs with CFLs in the rooms;

Project Results:

- Installation of double-glazed PVC windows and doors and construction of boiler house with shell reservoir along with installation of autonomous heating system (boiler, piping, radiators) working on the solid fuel – agricultural residues - hazelnut shells.
- The total amount of hazelnut shells needed for each season after introduction of autonomous heating system is around 12, 000 kg costing a total of 2,640 GEL. If natural gas were used to heat the facility, the kindergarten would spend 9,700 GEL more on energy resource.
- CO_2 emissions reduction 24,600 kg per year.

Case Study 2: Implementation of Renewable Energy and Energy Efficiency Measures in Erisimedi Kindergarten

Project Title: Eco-Energy for Erismedi Kids;

Project Duration: July 2018 - April 2019;

Donor: BP EXPLORATION (Caspian Sea) Ltd. Georgia;

Project Implementer: Energy Efficiency Centre Georgia (EECG);

Project Geographical Area: Village Erisimedi, Sighnaghi Municipality, Kakheti Region, Georgia;

Project Goal: reduction of energy dependence and promotion of sustainable forest usage;

Project Results:

- Energy-efficient heating system, as well as solar photovoltaic (PV) and water heating systems installed in the kindergarten;
- Kindergarten's energy dependence comparing with baseline consumption decreased by 15 per cent;
- CO_2 emissions reduction 11,000 kg per year;
- Energy bills reduction by 890 GEL per year;
- By implementing an innovative method of using agricultural residues (nut shell), the pressure on the forest was reduced.

***Case Study 3:** Assessment of Firewood Consumption Reduction in Villages Surrounding the Machakhela National Park in Adjara Region*

Project Title: Expansion and Improved Management Effectiveness of Adjara Regions Protected Areas;

Project Duration: June 2016 - October 2017;

Donor: United Nations Development Programme in Georgia (UNDP);

Project Implementer: Energy Efficiency Centre Georgia (EECG);

Project Geographical Area: Villages Surrounding the Machakhela National Park, Khelvachauri Municipality Adjara Region, Georgia;

Project Goal: demonstration to all interested stakeholders with particular emphasis to households of Machakhela NP support zone villages that introduction of energy efficient solutions and renewable energy technologies can have economic, social, and environmental effects;

Project Results:

- Switching from fuel wood to such alternative fuels as sawdust briquettes and hazelnut shells;
- Introduction of energy efficiency stoves for burning the hazelnut shells and briquettes;
- Introduction of solar thermal collectors in households for hot water to replace fuel wood usage for this purpose;
- Capacity building and public awareness: micro demo home weatherization activities, publication and dissemination of thematic leaflets covering tested technologies;
- Monitoring of the tested measures.

Case Study 4: *Biomass Supply Chain in Telavi Municipality*

Project Title: Biomass Energy and EE Technologies as a Sustainable Energy Solutions for Georgian CoM signatories;

Project Duration: February 2018 - April 2022;

Donor: EU4Energy and Telavi Municipality

Project Implementer: Union “Energy Efficiency Center Georgia”;

Project Co-Applicant: Telavi Municipality City Hall;

Project Geographical Area: Telavi Town and Ikalto Village, Telavi municipality, Kakheti Region, Georgia;

Project Goal: enhance Georgian CoM signatory cities/municipalities capacities in climate change mitigation and fulfilment of sustainable local energy policy through implementation of investment projects in line with their Sustainable Energy (Climate) Action Plans.

Project Results:

Implemented RE and EE measures in IKALTO and TELAVI #1 kindergartens:

- Roofs’ renovation and thermal insulation of attic floors with mineral wool (20 cm);
- Thermal insulation of exterior walls, including foundation walls (socle), rockwools (10 cm) and XPS panels (8 cm);
- Installation of low emission double glazed PVS windows and doors;
- Installation of decentralized and central ventilation systems;
- Full replacement of electrical wirings and installation of EE lighting systems (LED Lamps);
- Installation of autonomous heating systems (AHS) working on locally available biomass - vineyards pruning residues;
- Installation of solar water heater systems (SWH) connected to AHS;
- Installation of up to 5-6 kW capacity grid connected PV systems;
- Total CO2 emissions were reduced by 171.6 t per year;
- Total energy savings 54,653 GEL per year.