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Prospects and Challenges of Alternative Renewable Energy Resources Development in Georgia

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ABSTRACT

Substitution of fossil energy resources by alternative, renewable energy-carriers is an acute problem on our planet today taking into account natural decrease of fossil resources and adverse consequences accelerating climate change. Presently there is widespread support for renewable energy, particularly of solar and wind energy, which provide electricity without rising of carbon dioxide emissions. Harnessing these for electricity depends on the cost and efficiency of the technology, which is constantly improving, and reducing costs per kilowatt. In this connection, the problems of substitution of fossil fuel by alternative, renewable energy sources are evaluated in Georgia too. The alternative renewable energy resources are evaluated and analyzed in the context of agreement between the EU and Georgia about priority use of renewable. The national development plan is made up to summarize existed and perspective resources and policy and goals to achieve. This plan is designating the share of renewable energy resources for 2020-2030 years in sectors of transport, electric power energetic, heating-cooling etc. taking into account energy efficiency.

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Introduction

Renewable resources include solar energy, wind, falling water, waves, geothermal energy etc. Renewable resources energy use for heating of water, for mechanical energy by converting to electricity or power, wave, ocean current, ocean thermal and other technologies are still in the research, as well as, non-electric renewable energy technologies such as solar water heaters and geothermal heat pumps that are based on renewable resources too [1,2] .

Renewable resources are different. For example, geothermal resources require extraction. So drilling for geothermal resources involves with drilling for petroleum. Wind and solar resources are generally free for taking. There is no technical requirement for treatment. Biomass is often encompassing wood and wood waste, agricultural waste and residue, energy crops and sometimes landfill gas resources. Hydroelectric resources are linked with surface water rights, including portable water, irrigation, recreational rights etc. So, there are individual treatment of hydroelectric resource issues [3,4].

Renewable resources are environmentally benign. Renewable energy facilities generally have very modest impacts on environment. Clean technologies can have significant indirect economic benefits. For example, unlike fossil fuel, renewables neither need scrubbing technologies for mitigation of air pollution, nor cleaning polluted rivers or earth around sites contaminated with fossil fuel by-products. Furthermore, they provide greenhouse gas reduction. Renewable energy facilities enhance the value of the overall resources base of a country by using the country's indigenous resources for electricity generation. Reduced dependence on fuel import, reduces exposure to currency fluctuations and fuel price volatility [5,6].

In this paper, we studied and analyzed the heat energetic complex of the country, its present condition and prospects of development taking into account the nontraditional, renewable energy resources. Georgia has strategic geopolitical position in the region and has potential to become energetic hub, at the same time developing transmission of energy resources among directly between its neighbors (Azerbaijan, Turkey, Russia, Armenia, Iran), as well as Europe and central Asia regions [7].

Georgia is striving to be integrated in European Union structures. The membership in the European Union opens the possibility for implementation of European energy system standards in planning, management and operation and will help to become a member of European electric energy market. The country is able to increase local renewable energy resources share and by this mean to reduce the share of thermal energy generation working on imported fuel. It gives us the opportunity to increase the level of energy independence and at the same time clear energy sources share in total energy balance of the country. At the same time it will help to increase transitive potential of the country, strategic directions of country's development and opportunity of energy submission security [8].

Results and Analyses

Local and International Context and Relations

In 2014 has been signed the agreement between Georgia and European Union about association that already has come into force. According this agreement Georgia in October 2016 joined the European Energetic Union [9]. It obliges Georgia: to make its legislation to conformity of European Directives; transposition of major standards and legislation; to make up and implement the national plan concerning renewable energy; to develop new energetic policy; to make up nearer, middle and long-term strategic plans for development of energy sector by 2030 [10].

According to the data given in table 2.1.1 the share of the renewable energy sources in the whole energy consumption of the country was 27.9 % [11].

Table 1: The share of the renewable energy sources in the total energy consumption (2014-2020)

N	Indices	Years	Used energy
1.	The Share of renewable energy sources in the total energy consumption	2014	27,9%
2.	The share of projected renewable energy sources in the total consumption	2020	30,0%
3.	The expected total energy use in 2020 (GWeh)	2020	52887
4.	The expected amount of renewable energy targets (GWeh)	2020	866

National renewable energy plan has 3 sectors: heat-cooling; electric energy (doesn't include transport energy use); and transport. In 2020 the share from the total renewable sources are as follows (Table 2.1.2).

Table 2: Distribution of renewable energy sources shares in different sectors (GWeh)

N	Indices	Year			
		2017	2018	2019	2020
1	Heat-Cooling	503	506	508	511
2	Electrical energy	801	831	878	919
3	Transport	21	22	24	40
4	Total in (%)	30,8	30,4	30,1	30,0

On the frame, convention of the United Nations Climate Change in 2015 held in Paris, Georgia presented the document about decreasing Green House Gasses (GHG) on 15%. It is lower than was demanded by scenario of business traditional development until 2030. Decrease of GHG emissions by this scenario can be increased up to 25% instead of 15% but it depends on some circumstances. At the same conference, Georgia presented in annex the forestry sector's role for resilience of climate change [12]. They are implementation of sustainable management of forests of Georgia; afforestation; natural regeneration assistance; and enlargement of reserved areas of the country.

Presently US AID is developing the project (EU4 Energy) for energy market that aims: to develop possibilities of trans-border relationship; optimization of energy investments; integration of renewable energy sources in total energy network; improvement of statistical data level of energetic; assistance in the formation of sustainable development of energetic policy.

Prognoses, targets and policy for stimulation of renewable energy sources

Heating and Cooling

Options of heating and cooling by using renewable energy sources can be arranged this way:

Heating

- Energy efficiency and conservation options in buildings and industry;
- Design of buildings heating by solar energy;
- Heating by geothermal energy;
- Heating by solar, thermal or geothermal energy sources where there are insufficient other energy sources;
- Using geothermal heat pumps where it is possible using electricity getting from renewable energy sources;
- Biomass energy that will be used in integrated bioenergy system for cogeneration of electric and heat energy;
- Generation of heat energy by burning biomass getting by anaerobic process.

Cooling

- Options of energy efficiency and conservation in buildings and industry;
- Passive cooling options (for example: design of passive cooling of buildings; ventilating of buildings without additional energy use in summer etc.);
- Cooling systems working on solar or ground's upper layers geothermal energy;
- Heat-cool supplying systems getting from heat pumps;
- For stimulation of using renewable sources of energy it is necessary to know:
- Prognostic demands;
- The level of using renewable energy sources in existed heat-cool systems and prognostic demand on heat-cooling taking into account energy efficiency.(Table 2.2.1.1) [13]

Table 3: Prognosis of energy use in heat-cool systems (ths. GWeh)

Indices	Years								
	2014	2016	2018	2020	2022	2024	2026	2028	2030
Total energy consumption	22.0	22.5	23.0	25.0	27.0	29.0	32.0	33.5	36.5
Total energy consumption with energy efficiency	22.0	22.5	22.0	23.5	25.0	27.4	28.5	30.0	32.0

In 2014 by heat-cool systems was used 25.6% of renewable energy, though by 2030 it is expected to decrease to 21.5% due to increase use of natural gas. In 2020 on installment of solar water heaters was totally invested 3.5 million Euro (from this amount 1.4 million Euro was subsided). 9200 solar water heater panels have been installed by which was generated 26.0 GW/h heat energy.

Some positive results are in using geothermal heat (thermal waters). In 2014 was used 93.0 GW/h geothermal energy. In the same 2014 was used 5.4 ths.GW/h heat energy from biomass for heat-cooling processes. In 2015 was used 4.6 ths.GW/h heat energy from biomass and in 2016 4.5 ths.GW/h. According to the forestry agency of Georgia, annual accessible resource of firewood is 600ths. kub.meter, when annual average consumption is about 2.1-2.5 m. cub. Meter [14].

Transport

For stimulation of renewable energy sources in transport it is necessary to be studied: present level of using renewable energy sources in transport; prognostic demand and questions concerning using electric energy from renewable energy sources; using biomass energy as renewable energy resource in transport. According to EU demand in total energy source for transport, 10% must be renewable. It will be possible by: increasing energy efficiency; using electric cars and bioenergy (Table 2.3.1) [9,15].

Table 4: Prognosis of energy use in transport (ths. GWe)

Indices	Years								
	2014	2016	2018	2020	2022	2024	2026	2028	2030
Total consumption	15.5	17.5	18.5	21.0	23.0	26.0	27.5	29.0	32.0
Total energy consumption with energy efficiency	15.5	17.5	17.0	18.0	20.0	22.0	23.0	25.0	27.0

In 2014 transport (underground. railways) used 266.8 GWh electric power, 80% from this amount was from energy source. Presently from total automobile transport 650 thousand are light vehicles, 72 thousand taxi cabs. 2.1 thousand buses 8 thousand vans, 14 thousand light and 40 thousand heavy trucks which use the following energy sources: diesel, petrol, CNG, LPG. [15,16]

For stimulation of using renewable energy sources the excises for electric cars are cancelled. Besides, some electric charging stations are already installed.

Presently the most usable biofuel in Europe is biodiesel made from rape, which can be deleted in diesel getting from oil. Biodiesel imported to Georgia annually axed 120 million liter. Bioethanol is now a new source of bioenergy, which can be deleted with petrol. For production of bioethanol is used wheat. Production of one liter of bioethanol costs 0.85Euro. In 2017-2030 for production of this bioethanol will be necessary 50-60 million Euro. Besides, for production of this amount of bioethanol we'll need 100 thousand hectare wheat crops [16].

Biodiesel is a form of diesel fuel from plants or animals and consisting of long-chain fatty acid esters (FAEs). It is made by chemically reacting lipids such as animal fat, soybean oil, or some other vegetable oil with an alcohol, producing a methyl, ethyl. Biodiesel use has been increasing in the US lately. In the UK the renewable transport fuel obligation obliges suppliers to include 5%renewable fuel in transport fuel sold in the UK. Biodiesel is also is used in aviation. Biodiesel is used by Czech, Boeing, KLM and other aircrafts. The main issues in production of biodiesel is land and water resources. The land usually must either be removed from agriculture for food or fiber, or it means encroaching upon forests of natural ecosystems. Available fresh water for growing biofuel crops such as maize and sugarcane and for processing them may be another constraint.

Today bioenergy production is possible from different technologies and from different biomass. For example from agricultural and forest residues, energetic crops, etc. Using such type of biomass is obligatory for EU members. But commercial production of biofuel today is insufficient.

Hydrogen is now considered as a possible fuel for transport, if certain problems can be overcome economically. It may be used in conventional internal combustion engines, or in fuel cells, which convert chemical energy directly to electricity without normal burning. Hydrogen making requires either reforming natural gas with steam, or electrolysis of water. The former process has carbon dioxide as a by-product, which exacerbates greenhouse gas emissions relative to present technology. With electrolysis, the greenhouse burden depends on the source of the power. Electrolysers are indifferent at low capacity factors such as even dedicated wind or solar input world supply. Quite different rationale applies to using nuclear energy for hydrogen. Here the plant would be run continuously at full capacity. It would mean the maximum efficiency for the nuclear plants and that hydrogen was made opportunistically when it suited the grid manager with electrolyser capacity factors above 65% achieved. About 55 KWh is required to produce a kilogram of hydrogen by electrolysis at ambient temperature, so the cost of the electricity clearly is crucial [17,18].

Electric power

Electric power generated by all types of electro stations totally is 75% of all types of power stations. Though electric power generated by HES is 80% from the total electric power in the country. Presently the electric power generation exceed demand in the country. As it is projected all electric energy generated by thermo-electric power stations will be used for local needs. Besides, by 2030 80-83% of power demand will be satisfied by renewable energy sources [14.19] (Table 2.4.1).

Table 5: Prognosis of use of electric power (Ths.GWh)

Indices	Years								
	2014	2016	2018	2020	2022	2024	2026	2028	2030
Total consumption	9.5	10.1	10.9	11.7	12.5	13.4	14.2	15.2	16.5
Total energy consumption with energy efficiency	9.5	10.1	10.8	11.3	11.9	12.4	13.1	13.9	15.0

Prognosis of electric power generation by thermo-electric power stations is given in table 2.4.2.Thermoelectric power is generated from heat source, such as burning fossil fuel-coal, oil, indirectly through devices like steam turbines. Thermal power station is a power station in which energy is converted to electricity. Fuel is used to boil water in a large pressure vessel to produce high-pressure steam, which drives a steam turbine connected to an electric generator. Natural gas can also be burnt directly in a gas turbine similarly connected to a generator. The design of thermal power stations depend on the intended energy source: fossil fuel, nuclear, geothermal power, solar energy, biofuels and waste incineration [19].

Table 6: Prognosis of electric power generation by thermo-electric power stations

Indices	Years					
	2020	2022	2024	2026	2028	2030
Installed capacity of thermo-electric power stations, MGWe	1050	1050	1050	1450	1450	1450
Electric energy generated by thermo-electric stations, GWe	2375	2570	2750	2900	3125	3300

In the national executive project (NEEAP), energy efficiency is envisaged different measures for use of electric energy:

- Energy efficiency developments in housing-social sector (candescent lamps, electric devices and gadgets, other home electric technical devices, etc.);
- By implementation of energy efficiency in industry;
- By implementation of energy efficiency in outdoor lighting.

In spite of providing above sited measures in energy-efficiency according to the prognosis, consu-mption of electric energy in future will increase on 3.4%.

Hydroelectric power put into exploitation and data showing electric power generation increase is given in table 2.4.3

Table 7: Hydroelectric power stations

Project status	Number of projects	Inslalled capasity	Generated electro energy GW e/year	Investment, m. Euro	Probebility of exploitation %
1	2	3	4	5	6
NEEAP-project E-2; Policy and investments for HES's rehabilitation	-	131.0	218.1	97.0	-
HES-es with expressed interests and technical and economic finished research	19	734.4	2912.6	1583.0	100
1	2	3	4	5	6
HES-es with already expressed interest and technical and economic research is finished	13	1035.0	2823.1	1140.0	50
HES-es on the preliminary stage of technical and economic research	98	2489.9	11149.8	3604.0	25
Total	130	4390.3	17103.6	6424.0	-
Wheied avarage amount	-	2005.1	7329.7	3150.82	-

Utilization of wind energy generation has increased considerably in recent years in the world with annual increases in installed capacity around 10% in 2019, by installment of tens of thousands of turbines. Presently in Georgia the use of wind energy in on low level. In 2017 a wind electric station was put into exploitation in town Gori with capacity of 20.7 MW.

International Renewable Energy Agency (ERENA) statistics show that 699 GWe onshore and 34 GWe offshore turbines has been installed in 2020, up from 564 GWe in 2018 when 1263 TWh has been produced. Nearly 90% of the world offshore total is in Europe [20].

Wind turbines of up to 6 MWe are now functioning in many countries. Depending on site, most turbines operate at about 25% load factor over the course of a year(European average), but some reach 40% offshore. There is a distinct distinctive difference between onshore and offshore sites, though the latter are more expensive to set up and run. The most new wind farms are mostly offshore in shallow seas [21].

Here it must be also underlined the protests of ornithologists concerning adverse environmental impacts of wind farms development due to bird kills, especially of raptor species. In the USA half of a million birds are killed each year, including 83000 raptors (hawks, eagles, falcons etc.) [22]'

Electric energy production by wind electric power stations is given in table 2.4.4

Table 8: Electric power production by wind electric power stations

Project status	Number of projects	Installed capacity, MW	Generated energy, GW h/year	Investment, million Euro	Investment, million Euro
Progected	18	1157	4503	1727	10÷30
Wheied avarage amount	-	217	850	287	-

Using solar energy in Georgia is now on the initial stage. The major problem is finances. The pilot project of using solar photo-electric (transformers) installed capacity of 5 MGW is planned in village Udabno. The potential solar electric station putting into exploitation and electric power generation is given in table 2.4.5

In the world the solar energy generation is very popular. The best method utilizes light ideally sunlight, acting on photovoltaic (PV) cells to produce electricity. Flat plate versions of these photovoltaic cells can be mounted on buildings without any intrusion or requiring special support structures.

In 2020 China commissioned a 2.2 GWe solar PV farm covering 27 km2 territory near Xining in Qinghai province. Storage capacity of 203 MWh. India's MWe Gujeral Solar Park was commissioned in 2012 and aims for eventual 1000MWe capacity. The 100 MWe Perovo Solar Park in Ukraine was commissioned in 2011 also with 15% capacity factor. In the USA the 550 MWe Desert sunlight solar farm in the Mojave Desert opened in 2015 using cadmium telluride thin film technology. MidAmerican Solar owns the 550 MWe Topaz Solar Farms in San Luis Obispo County, California [23].

Solar energy use is developing in some other countries too: South Korea, Nigeria, Australia, Mongolia and others.

Table 9: Solar electric stations

Project status	Number of projects	Porojected capacity, MWE	Generated energy, GWE	Investment m. Euro	Probebility of taking into exploitation.%
Projected	11	505	675	422	20
Wheied average amount	-	105	142	88.5	-

By 2025 in village Gardabani is planned to put into exploitation biogass station by 3MGW capacity, with 24.0 GW/hour energy generation . Probebility of taking into exploitation is 50%.

So, the national renewable executive plan and expected results from 2020 and further period is given in table 2.4.6

Table 10: NEREP policy executive presumable expenses and results (for 2020 and further period)

№	Discription	Expected renewable energy use, thousand ton	Prisumable expences, thousand Euro
1.	Stimulation of water heating with solar energy	5.2	1 384.0
2.	Stimulation of electro cars	14.7	3 440.0
3.	Support of hydroelectric energy production	516.9	984 782.0
4.	Support of wind energy generation	25.2	70 500.0
5.	Support of solar energy production	0.7	4 903.0
6.	Support of geothermal energy production	61.6	Is not calculated yet

Conclusions

The national interest of Georgia's economy development needs the further perfection of energetic balance to be done mostly by enlargement of local resources base. The major accent must be done on energy efficiency. It is also necessary to increase the share of renewable energy resources in total balance of total energy production. The necessary measures of energy efficiency have been determined which reduces the total financial resources accordingly.

Development of energy efficiency will help to save finances of the country. According to the experts calculation the potential getting from energy efficiency is about fourth part of the country's total energy supply.

According to the association agreement among European Union and Georgia implementation of energy efficiency measures in industry, social sector and outdoor lighting is envisaged. But experts agree that in spite of all preventive energy efficiency measures the total energy use in the country will increase on 3.5% in average.

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