

Trend Analysis of Using of Green Energies in Georgia until 2040

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Abstract: The main sources of green energy (GE) as the cleanest form of energy or types of renewable energy sources (RES) are: wind, water, sun and earth. While the world, especially in the most developed countries of the world, has advanced far in the application of various forms of green energy (GE), in Georgia this field is in its infancy and it is not possible to predict when the first major positive developments in this field will be made. The paper presents the forecast and trend analysis of the use of green energy (GE) in Georgia until 2040. According to the data on the plans of the state authorities of Georgia for the development and use of various forms of green energy (GE), the highest forecast growth of the development of these types of energy is expected in the field of wind energy (WE) until 2025 with a value of CAGR of 154.82 [%].

Keywords: Energy, Green energy (GE), Sustainable energy (SE), Clean energy (CE), Renewable energy (RE), Renewable energy sources (RES), Wind energy (WE), Trend analysis, Continuous annual growth rate (CAGR).

1. Introduction

Energy represents the ability of a body or system to do some work. There are many forms of energy, such as: Kinetic energy, Potential energy, Thermal energy (heat), Internal energy, Electrical energy, Chemical energy, Elastic potential energy and others.

One of the most commonly used forms of energy is electricity, which is a basic part of nature. The global tendency is for electricity production to increasingly shift to renewable energy sources (RES) for environmental reasons.

The consumption of energy in the world, from year to year, is growing (which is in direct correlation with the daily increase of the human population), and therefore the need for its production is also increasing. The vast majority of that energy is from non-renewable sources (currently more than 80%), which is already causing undesirable consequences for the environment. One of the solutions, in accordance with the principles of sustainable development, lies in reducing the share of fossil fuels in the total production and consumption of energy. So, the share of renewable energy sources (RES) should be significantly increased in the future, because there are fewer and fewer non-renewable energy sources and their reserves are running out, and also their harmful influence has become more pronounced in the last few years.

Currently, of the annual energy consumption, at the world level, appr. 50 [%] spend on industry, appr. 25 [%] is used for transport, and the remaining 25 [%] is consumed by households and the commercial sector.

China and India have the highest growth in consumption of all types of energy, at the world level, and of the developed countries, the highest growth in energy consumption is recorded in the USA, while the EU records a decrease in energy consumption from appr. 2 [%].

All these facts show that the best solution from this situation is in the increasing use of renewable energy sources (RES) and green energy (GE) [1, 4-6, 12-13, 15-16, 20]. The state and perspectives of the development and application of different types of green energy (GE) in different countries of the world are presented in works [3, 17-18, 24-26, 28, 31].

Currently, in the world, especially in the most developed countries, the application of various forms of green energy (GE) has advanced far, in Georgia this field is in its infancy and it cannot be predicted when the first major positive developments in this field

will be made. So that the state authorities in Georgia have foreseen in the following period until 2040 a greater application of these forms of energy, which is the goal of this paper with the trend analysis.

2. Classification of Natural Energy Sources

Considering the time possibility of exhaustion, natural or primary sources (forms) of energy can be divided into (Fig. 1) [8, 11, 19, 21-22, 29-30]:

1. Non-renewable energy sources (NRES):
 - Fossil fuels (coal, oil, natural gas, oil shale);
 - Nuclear fuels;
2. renewable energy sources (RES):
 - Water power (energy of water currents, sea currents and waves, tides);
 - Biomass and biogas, including wood and waste;
 - Solar radiation energy;
 - Wind energy;
 - Earth's internal heat (geothermal energy);
 - Tidal energy;
 - Wave energy.

Renewable energy (RE) is that form of energy that is renewable (naturally replenished) and produced from sources that are constantly renewed, meaning that this form of energy is created from natural sources (sun, wind, rain, waves, geothermal heat and similarly).

There are different types and categories of renewable energy sources (RES) (Fig. 1). According to the time of creation, renewable energy sources (RES) are divided into two main categories:

- traditional renewable energy sources such as biomass and energy from large hydroelectric plants and
- "new renewable energy sources" such as solar energy, wind energy, geothermal energy and the like.

In addition to renewable energy (RE), the following terms are often used in the literature: green energy (GE), sustainable energy (SE) and clean energy (CE). The question arises whether there is a difference between: GE, SE, CE and RE energy and what is the difference.

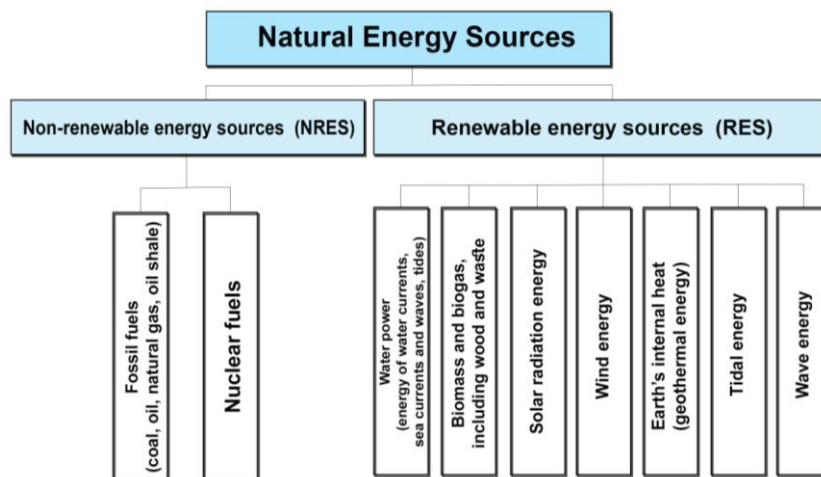


Fig. 1. Division of natural or of primary sources (forms) of energy, considering the time possibility of depletion

3. Trend Analysis of Using of Green Energies (GE) in Georgia until 2040

Georgia is country from 3.7 million people, nestled between Russia, Turkey, Armenia and Azerbaijan. About 70 [%] of the electricity in the country comes from hydropower. The 20 [%] is garnered from coal and natural gas, and the rest is covered by imports from Russia [14, 23]. Which means that the use of renewable energy sources (RES) and green energies (GE) in Georgia is insignificant, but the construction of new wind parks and photovoltaic devices is planned [14, 23].

For trend analysis of using of green energies (GE) in Georgia until 2040, data that exist in state bodies and the public were used to predict the use of different forms of green energies (GE) for Georgia for the following period: today, 2025, 2030 and 2040 (Table 1). In Table 1, for each form of green energy (GE), the CAGR (Compound Annual Growth Rate) is determined and the time period is determined, based on which the trend and forecast of the use of these forms of energy in Georgia until 2040 can be observed.

Based on the data from Table 1, the values of different forms of green energy (GE) for Georgia until 2040 (Figure 2) and the values of the CAGR index (Figure 3) are shown.

Based on Table 1 and Figures 2 and 3, it can be seen that the largest growth in the use of green energy (GE) in Georgia until

2040 will be wind energy (WE), with an increase from the current 77 [MW] to 2000 [MW] in 2040, with a CAGR index of 21.12 [%] for that period, followed by solar energy (SE), increasing from the current 70 [MW] to 1320 [MW] in 2040, with a CAGR index of 18.86 [%] for that period.

4. Examples of Effective Use of Wind Energy

Wind energy (WE) is a form of energy derived from the power of the wind. It represents a conventional renewable energy source (RES), which has been used for centuries to obtain mechanical, and more recently, electrical energy [2, 10, 26-27].

Wind energy (WE) belongs to the group of renewable energy sources (RES) and green energy (GE) and can help reduce dependence on fossil fuels. Wind is an indirect form of solar energy and is caused by the differential heating of the earth's surface by the sun. It is estimated that around 10 million [MW] of energy is continuously available from the wind [2, 10, 26-27].

Wind energy (WE) is converted into a useful form of energy, electricity, by means of wind farms. In classic windmills, wind energy (WE) is converted into mechanical energy and is directly used for grinding grain or pumping water. In the last few tens of years, wind farms have also been built for the production of electricity. Figure 4 shows a practical example of wind power plants and their use for obtaining wind energy (WE).

Table 1. Data on the use of different forms of green energy (GE) in Georgia until 2040

Energy Year	Wind		Solar		Hydro with water reservoir		Hydro running water		Installed capacity	
	Value [MW]	CAGR [%]	Value [MW]	CAGR [%]	Value [MW]	CAGR [%]	Value [MW]	CAGR [%]	Value [MW]	CAGR [%]
Today	77	-	70	-	150	-	-	-	4500	-
2025	500	154.82	250	88.98	430	69.31	230	-	6500	20.19
2030	1230	19.73	800	26.19	430	0.00	230	0.00	6500	0.00
2040	2000	10.21	1320	10.53	740	11.47	-	-	7900	3.98

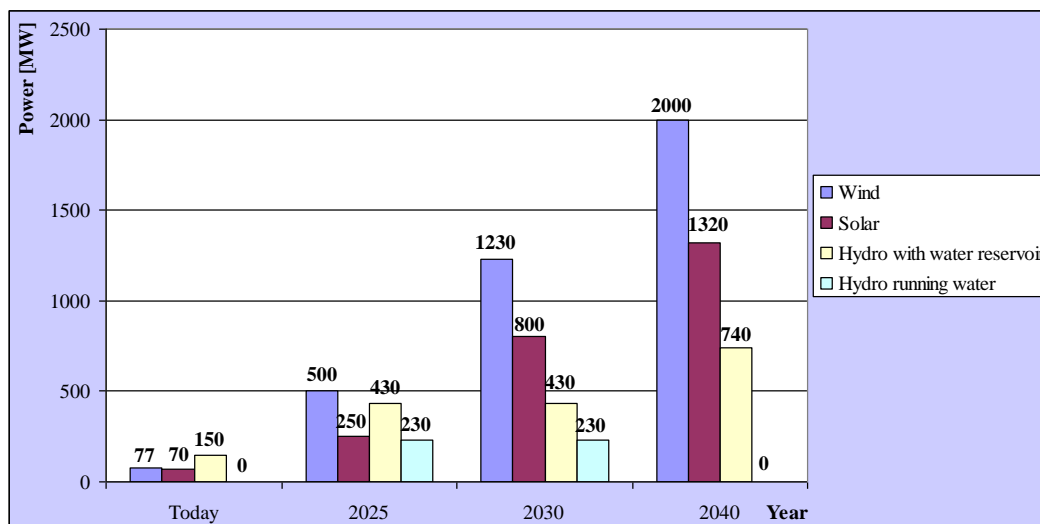


Fig. 2. Graphic representation of the value of use of different forms of green energy (GE) in [MW] in Georgia until 2040

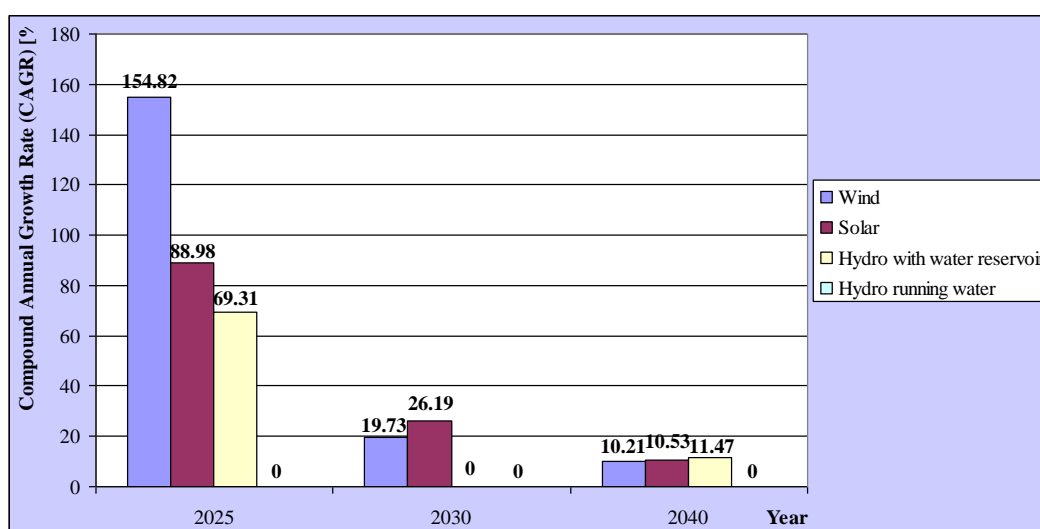


Fig. 3. Graphical representation of the value of the CAGR [%] on the use of different forms of green energy (GE) in Georgia until 2040



Fig. 4 Primer vetroelektrana i njihovog korišćenja za dobijanje energije vetra (WE)

At the end of 2010, the installed capacity of wind farms in the world was appr. 100 [GW], which in percentage is only 1 [%] of the world's electricity needs. In Denmark, this value is 19%, in Spain and Portugal 9%, in Germany and Ireland 6% etc. (data for 2010).

Figure 5 shows the graph of wind energy (WE) (includes both onshore and offshore wind sources) generation in [TWh] by region for the period 1965-2022 [31].

Wind is a good, renewable, easily available and clean source of energy. The lack of wind rarely causes insurmountable problems when it participates in a small share in the supply of electricity, but with greater reliance on wind it leads to greater losses.

5. Conclusion

Fossil fuels such as: coal, oil or gas are a group of non-renewable energy sources that are decreasing in number (slowly disappearing) and also cause undesirable consequences for the environment, and their harmful influence has become more and more pronounced in the last few years. Whereas, renewable energy sources (RES) and green energy (GE) will not disappear because they are naturally renewable and at the same time do not have a harmful impact on the environment. Renewable energy sources (RES) and green energy (GE) are predicted to become economically competitive with conventional energy sources in due course.

The largest growth in the use of green energy (GE) in Georgia by 2040 will be from wind energy (WE), increasing from the current 77 to 2000 [MW] in 2040, with a CAGR=21.12 [%] for that period (or app. 26 times more than today's value), followed by solar energy (SE), increasing from the current 70 to 1320 [MW] in 2040, with a CAGR=18.86 [%] for that period (or app 18.85 times more than today's value).

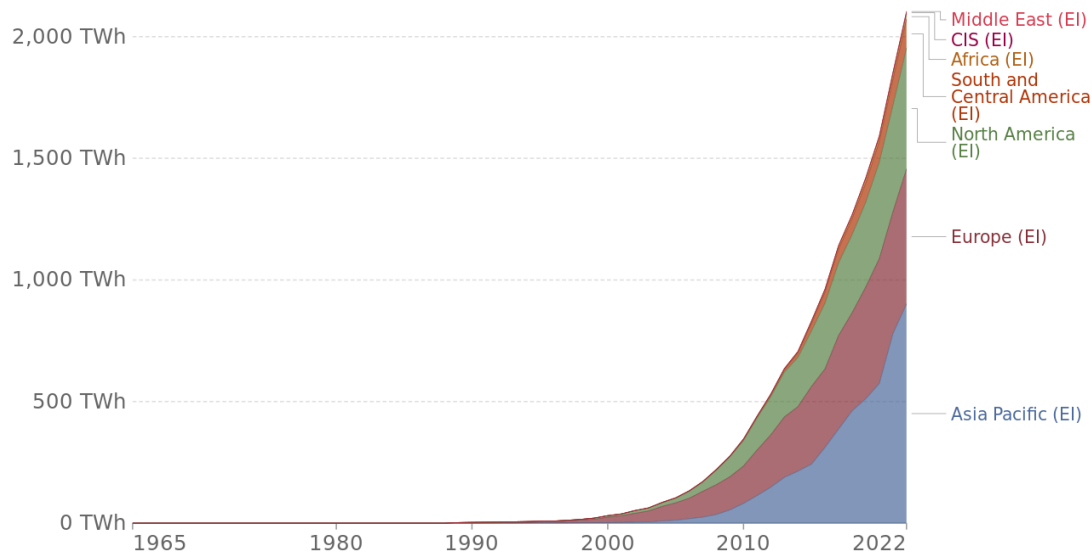


Fig. 5. Wind energy (WE) generation by region for the period 1965-2022 [31]

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