

Trend Analysis of the Use of Different Forms of Energy in Georgia for the Period 2000-2023

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Abstract: *The main sources of green energy (GE), considered as the cleanest forms of energy or types of renewable energy sources (RES), are wind, water, sun, and earth. While the world, particularly in the most developed countries, has made significant progress in adopting and applying the various forms of green energy (GE), in Georgia this field is in its initial stage and it is not possible to predict when the first major positive developments will be made. This paper presents an analysis of total energy supply (TES) and domestic energy production (DEP) in Georgia for the period 2000-2023. The value of the continuous annual growth rate (CAGR) in Georgia for this period for TES is increased by 3.10 [%] and for DEP is decreased by -0,21 [%] and cumulative growth index (CGI) for TES is increased by 201.63 [%] and for DEP is decreased by 95,34 [%].*

KEYWORDS: ENERGY, GREEN ENERGY (GE), SUSTAINABLE ENERGY (SE), RENEWABLE ENERGY (RE), RENEWABLE ENERGY SOURCES (RES), TOTAL ENERGY SUPPLY (TES), DOMESTIC ENERGY PRODUCTION (DEP).

1. Introduction

Energy is the capacity of a body or system to accomplish work. There are different forms of energy, namely: kinetic, potential, thermal (also known as heat), internal, electrical, chemical, elastic potential energy and many others.

Electricity, as a fundamental aspect of nature, is among the most widely utilized forms of energy. Globally, there is a growing trend towards generating electricity from renewable energy sources (RES) due to environmental considerations.

The consumption and production of energy worldwide are steadily increasing each year, closely linked to the continual growth of the global human population. Currently, the overwhelming majority of global energy production, (exceeding 80%) comes from non-renewable sources, leading to adverse environmental effects. To address this, sustainable development (SD) principles advocate reducing reliance on fossil fuels in energy production and consumption. Consequently, there is a persistent need to substantially increase the use of renewable energy sources (RES) in the future. This shift is imperative due to the diminishing reserves of non-renewable energy sources (NRES) and their escalating environmental impact observed in recent years.

The largest portion of global energy consumption currently goes to industry, accounting for approximately 50%. Transport follows with approximately 25%, while households and the commercial sector together consume the remaining 25%.

China and India are currently witnessing the most substantial growth in energy consumption on a global scale, encompassing all forms of energy. Among developed countries, the USA saw the largest rise in energy consumption, while the EU experienced a decrease of approximately 2 [%] in energy consumption.

All these facts indicate that the most effective solution to address this situation lies in increasing the utilization of renewable energy sources (RES) [4, 21, 23, 27, 39-41] and green energy (GE) [2, 6, 12-13, 18, 20, 24-25, 28, 30, 34,

37-38, 43, 53-55, 58, 60]. Research and studies detail the current status and future prospects of developing and implementing various types of renewable energy sources (RES) and green energy (GE) across different countries worldwide [4-5, 29-35, 44-46, 49, 56, 58].

The research, analysis and studies of the use of all types of energy in Georgia is presented in papers [7, 9-11, 16, 20, 26, 36, 40, 43, 48, 51-54].

Currently, many of the world's most developed countries have significantly advanced the adoption of various forms of green energy (GE). In Georgia, however, this field is still in its early stages, and it is uncertain when significant progress will be achieved. Nevertheless, Georgian state authorities have formulated a strategy aimed at increasing the utilization of renewable energy sources (RES) by 2040 [16, 26, 43, 52, 54]. Therefore, the aim of this paper is to describe the analysis of trends in the use of different forms of energy sources in Georgia for the period 2000-2023.

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) [51-54]:

1. Non-renewable energy sources (NRES) and
2. Renewable energy sources (RES).

Non-renewable energy sources (NRES) are sources that are consumed much faster than they can be naturally renewed. This means that they are depleted over time and cannot be regenerated in the short term. Their quantity is limited, so they are considered unsustainable in the long term. These are (Fig. 1) [1, 51-54]: Fossil fuels (coal, oil, natural gas, oil shale), Nuclear fuels.

Renewable energy sources (RES) are natural resources (sources) of energy that are constantly replenished and cannot be depleted through use within a reasonable period of time. Their key advantage is that they come from processes in nature that occur continuously, and therefore represent a sustainable and environmentally friendly way of obtaining energy. Unlike non-renewables (oil, coal,

gas), they are environmentally friendly and contribute to reducing pollution and CO₂ emissions. These are (Fig. 1) [1, 3-4, 8, 15, 17, 19, 21-23, 26-27, 39-42, 46-47, 51, 56, 59]: Water power (Hydropower); Biomass and biogas

(including wood and waste); Solar radiation energy; Wind energy; Earth's internal heat (geothermal energy); Tidal energy; Wave energy and etc.

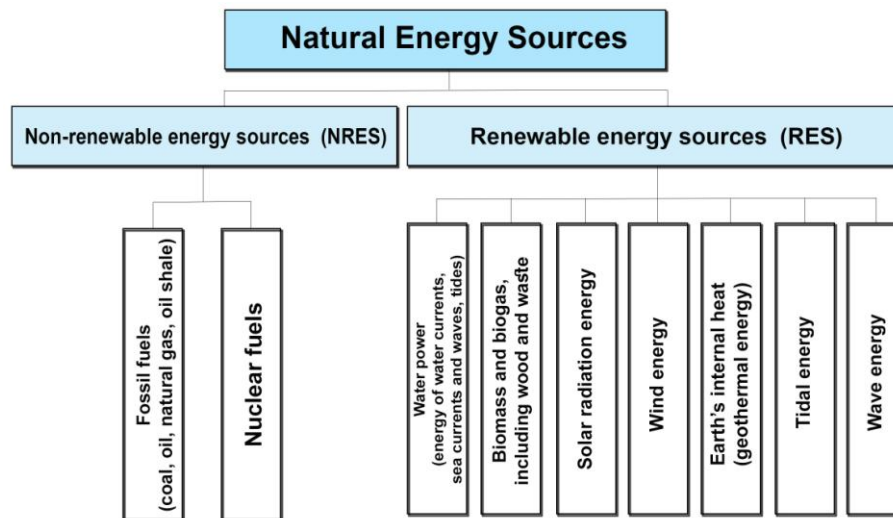


Fig. 1. Division of natural or of primary sources (forms) of energy, considering the time possibility of depletion [51-54]

Renewable energy sources (RES) in the last thirty years represent a new trend in the use and production of various forms of energy in all areas.

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 as to whether there is a difference between: GE, SE, CE and RE energy and what is the difference.

3. Materials and Methods

The energy sector in Georgia is mainly based on hydropower and firewood, in addition to fossil fuel imports. It is also an important transit country for the region, with major oil and gas pipelines passing through its territory.

Reports for the annual use of all types of energy in the world and by regions and countries are given in the annual publication World Energy Outlook (WEO) [57], report for 2023], published by International Energy Agency (IEA), from Paris (France).

For the graphical representation of the evolution of total energy supply (TES) and domestic energy production (DEP) in Georgia for the period 2000-2023 and for 2000 and 2023 years by different forms of energy we used software system MS-Excel.

For the trend analysis, we used the parameters CAGR (Compound Annual Growth Rate) and CGI (Cumulative Growth Index), used and described in the papers [14, 50].

4. Analysis of the Use of Energy in Georgia for the Period 2000-2023

In this chapter is to describe the trends analysis in total energy supply (TES) and domestic energy production (DEP) in Georgia for the period 2000-2023.

Total energy supply (TES) includes all energy produced domestically or imported, less energy exported or stored. It represents the total amount of energy needed to supply end users. Some of these energy sources are used directly, while most are converted into fuel or electricity for final consumption.

On Fig. 2 is given of graphical representation of the evolution of total energy supply (TES) in Georgia for the period 2000-2023 [16].

Table 1 shows the total energy supply (TES) in Georgia for the years 2000 and 2023 by different forms of energy with the calculated value for the CAGR (continuous annual growth rate) and CGI (cumulative growth index) in [%] for this period.

The value of total energy supply (TES) in Georgia for the 2000 is 119.258 [TJ] and for the 2023 has been increased to 240.457 [TJ] (Table 1 and Fig. 1).

The value of the continuous annual growth rate (CAGR) for total energy supply (TES) in Georgia for the period 2000-2023 is increased by 3.10 [%] and cumulative growth index (CGI) is increased by 201.63 [%] (Table 1).

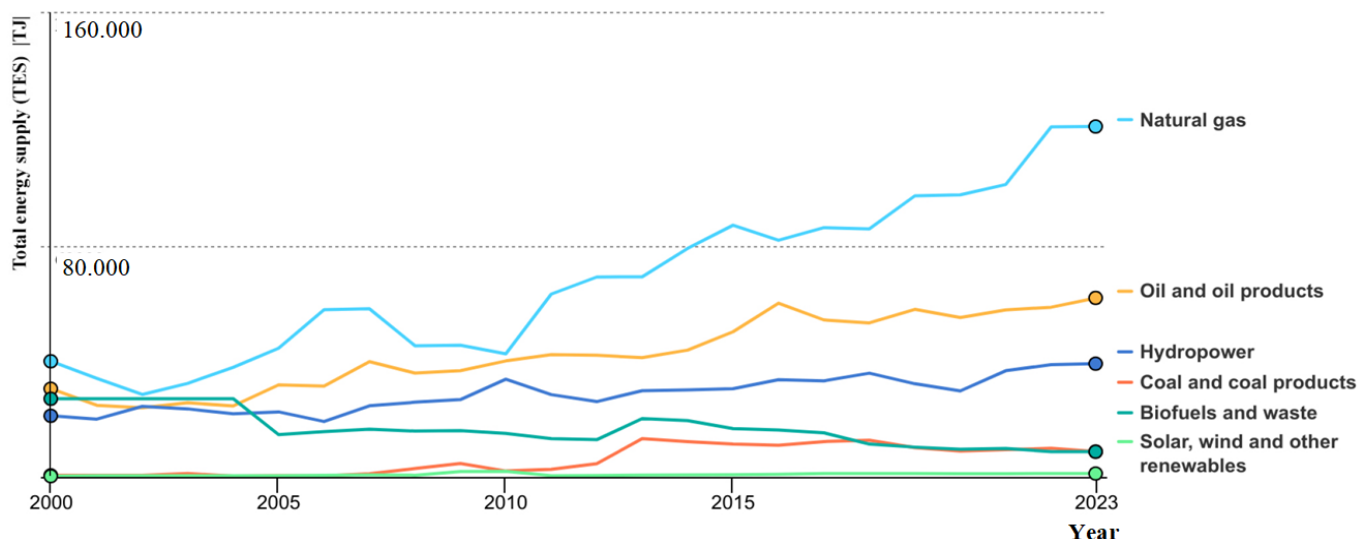


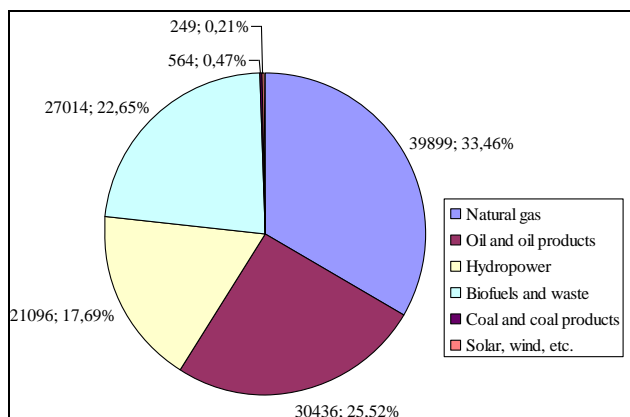
Fig. 2. Graphical representation of the evolution of different forms of total energy supply (TES) in Georgia for the period 2000-2023 [16]

Table 1. Table representation of comparative analysis of different forms of total energy supply (TES) in Georgia for the year 2000 and the year 2023

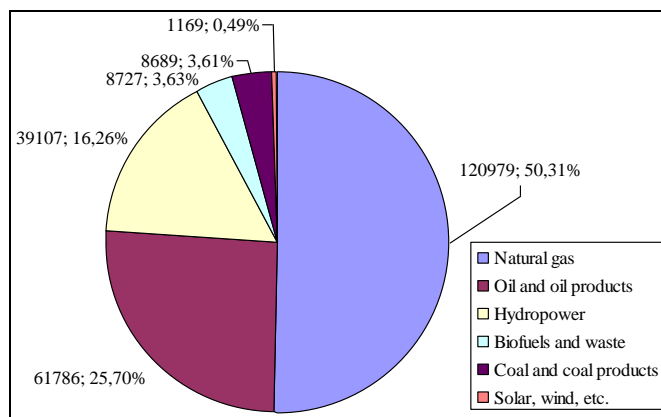
Different Forms of Energy	2000		2023		CAGR [%]	CGI [%]
	Value [TJ]	[%]	Value [TJ]	[%]		
Natural gas	39.899	33,46	120.979	50,31	4,94	303,21
Oil and oil products	30.436	25,52	61.786	25,70	3,13	203,00
Hydropower	21.096	17,69	39.107	16,26	2,72	185,38
Biofuels and waste	27.014	22,65	8.727	3,63	-4,79	32,31
Coal and coal products	564	0,47	8.689	3,61	12,63	1540,60
Solar, wind, etc.	249	0,21	1.169	0,49	6,95	469,48
Total	119.258	100,00	240.457	100,00	3,10	201,63

While Fig. 3 shown a comparative analysis of the evolution of total energy supply (TES) in Georgia for the year 2000 and year 2023 by different forms of energy.

The percentage of the largest value of the TES in Georgia for the 2000 is Natural gas with 33.46% (Fig. 3a), while in 2023 it is more than 50%, i.e. 50.31% (Fig. 3b).



a)



b)

Fig. 3. Graphical representation of comparative analysis of the total energy supply (TES) in Georgia for the year 2000 (a) and the year 2021 (b)

From Table 1 and Figs. 2 and 3, it can be seen that total energy supply (TES) in Georgia for 2023 have the following forms of energy: Natural gas has 120.979 [TJ] or 50,31 %, Oil and oil products has 61.786 [TJ] or 25,70 %, Hydropower has 39.107 [TJ] or 16,76 %, Biofuels and waste has 8.727 [TJ] or 3,63 %, Coal and coal products

has 8.689 [TJ] or 3,61 % and Solar, wind, etc. has 1.169 [TJ] or 0,49 %, retrospectively.

On Fig. 4 shown values of CAGR (continuous annual growth rate) in [%] of total energy supply (TES) in Georgia for the year 2023 compared to the year 2000 by different forms of energy.

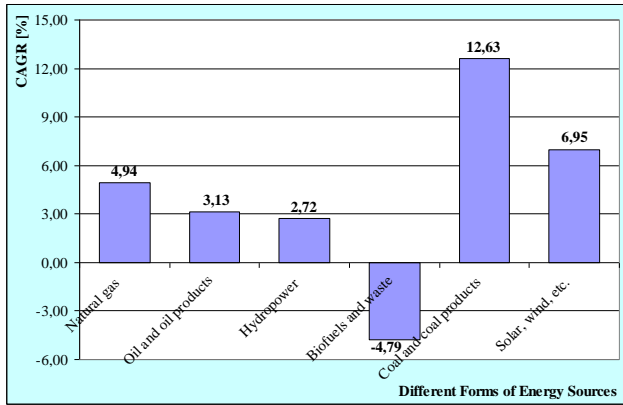


Fig. 4. Graphical representation of values of CAGR (continuous annual growth rate) in [%] of total energy supply (TES) in Georgia for the year 2023 compared to the year 2000 by different forms of energy

Domestic energy production (DEP) includes all forms of energy that are produced within the borders of a country. These include fossil fuels that are extracted by digging or drilling and that can then be used directly as fuel or to generate electricity. DEP also includes energy obtained by nuclear fission, as well as energy from renewable sources such as hydroelectric power plants,

wind power plants and solar photovoltaic systems. In addition, bioenergy – which includes modern and traditional forms, including the burning of municipal waste – represents a significant part of domestic energy production in many countries.

On Fig. 5 is given of graphical representation of the evolution of domestic energy production (DEP) in Georgia for the period 2000-2023 [16].

Table 2 shows the domestic energy production (DEP) in Georgia for the years 2000 and 2023 by different forms of energy with the calculated value for the CAGR (continuous annual growth rate) and CGI (cumulative growth index) in [%] for this period.

The value of domestic energy production (DEP) in Georgia for the 2000 is 55.200 [TJ] and for the 2023 has been decreased to 52.625 [TJ] (Table 2 and Fig. 5).

The value of the continuous annual growth rate (CAGR) for domestic energy production (DEP) in Georgia for the period 2000-2023 is decreased by -0.21 [%] and cumulative growth index (CGI) is decreased by 95.34 [%] (Table 2).

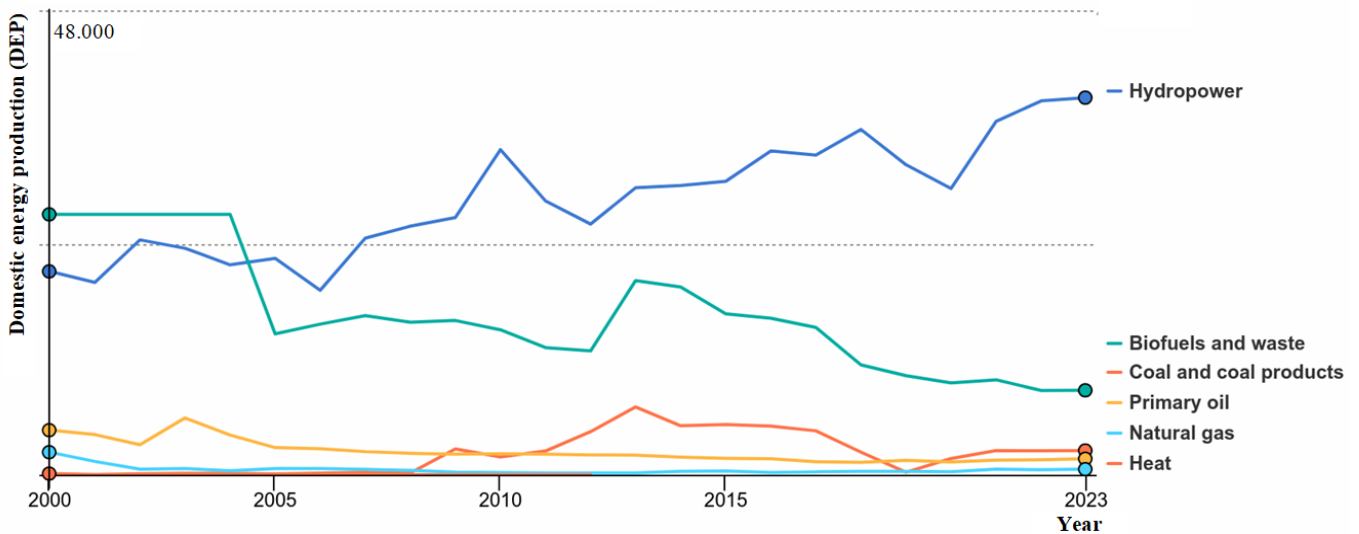


Fig. 5. Graphical representation of the evolution of different forms of domestic energy production (DEP) in Georgia for the period 2000-2023 [16]

Table 2. Table representation of comparative analysis of different forms of domestic energy production (DEP) in Georgia for the year 2000 and the year 2023

Different Forms of Energy	2000		2023		CAGR [%]	CGI [%]
	Value [TJ]	[%]	Value [TJ]	[%]		
Hydropower	21.096	38,22	39.107	74,31	2,72	185,38
Biofuels and waste	27.014	48,94	8.762	16,65	-4,78	32,44
Coal and coal products	123	0,22	2.516	4,78	14,02	2045,53
Primary oil	4.628	8,38	1.652	3,14	-4,38	35,70
Natural gas	2.339	4,24	588	1,12	-5,83	25,14
Heat	0	0,00	0	0,00	0,00	0,00
Total	55.200	100,00	52.625	100,00	-0,21	95,34

While Fig. 6 shown a comparative analysis of the evolution of domestic energy production (DEP) in Georgia

for the year 2000 and year 2023 by different forms of energy.

The percentage of the largest value of the domestic energy production (DEP) in Georgia for the 2000 is Biofuels and waste with 48,94% (Fig. 6a), while in 2023 it is Hydropower more than 50%, i.e. 74,31% (Fig. 6b).

From Table 2 and Figs. 5 and 6, it can be seen that domestic energy production (DEP) in Georgia for 2023

have the following forms of energy: Hydropower has 39.107 [TJ] or 74,31 %, Biofuels and waste has 8.762 [TJ] or 16,65 %, Coal and coal products has 2.516 [TJ] or 4,78 %, Primary oil has 1.652 [TJ] or 3,14 % and Natural gas has 588 [TJ] or 1,12 %, retrospectively.

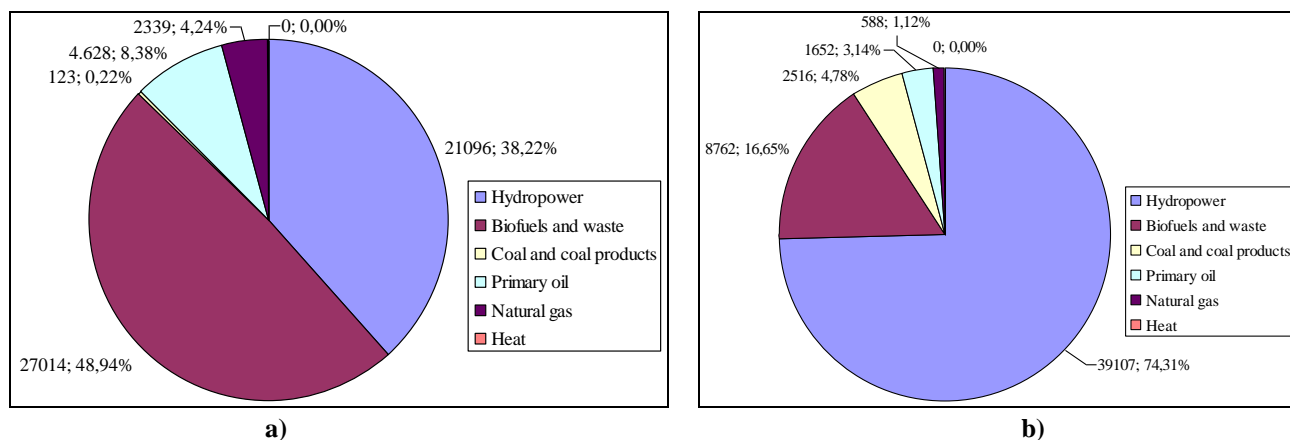


Fig. 6. Graphical representation of comparative analysis of the domestic energy production (DEP) in Georgia for the year 2000 (a) and the year 2021 (b)

On Fig. 7 shown values of CAGR (continuous annual growth rate) in [%] of domestic energy production (DEP) in Georgia for the year 2023 compared to the year 2000 by different forms of energy.

The greatest increase in total energy supply (TES), with the largest continuous annual growth rate (CAGR), in Georgia for the period 2000-2023 is attributed to Coal and coal products (CAGR=12.63%). Conversely, the decrease in total energy supply (TES) in Georgia for the same period is seen in Biofuels and waste (CAGR=-4.79%).

The greatest increase in domestic energy production (DEP), with the largest continuous annual growth rate (CAGR), in Georgia for the period 2000-2023 is attributed to Coal and coal products (CAGR=14.02%). Conversely, the decrease in domestic energy production (DEP) in Georgia for the same period is seen in Natural gas (CAGR=-5.83%).

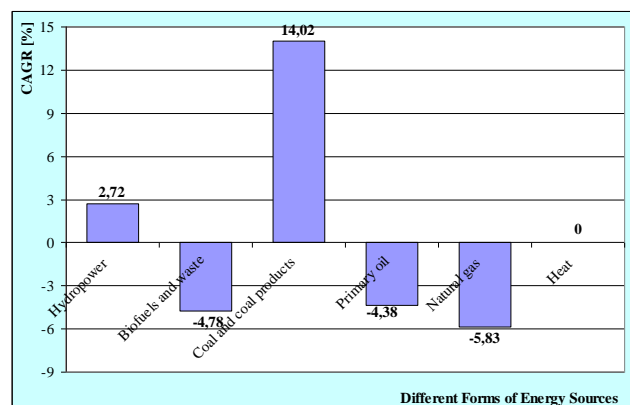


Fig. 7. Graphical representation of values of CAGR (continuous annual growth rate) in [%] of domestic energy production (DEP) in Georgia for the year 2023 compared to the year 2000 by different forms of energy

4. 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.

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