

Impact of climate change on electrical energy losses in electrical networks

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Abstract. One of the global problems in the world is greenhouse gas emission. There are several reasons for this problem, one of which is electricity. This article provides a brief summary of the current state of electricity waste and analyzes the impact of electricity waste on greenhouse gas emissions, as well as ways to reduce greenhouse gas emissions from the point of view of electricity generation. The situation of greenhouse gas emission in the territory of Uzbekistan and how much of it corresponds to the share of electricity losses is shown.

1 Introduction

The growth of electricity losses in electric networks is an objective process for countries with a crisis economy and reformed energy sectors, and is a sign of the existing gap between consumers' ability to pay and electricity tariffs. Inadequate investments in electric grid infrastructure and electricity accounting system, quality supply of electric energy, structure of electric currents according to voltage levels, lack of full-scale automated information systems for collecting and transmitting information about electric energy balances in electric networks.

2 The current state of the investigated problem

Analytical results of current research shows that the main part of electricity losses in power grids falls on low-voltage distribution power grids, as you can see from Figure 1. [1-3, 8, 16-20].

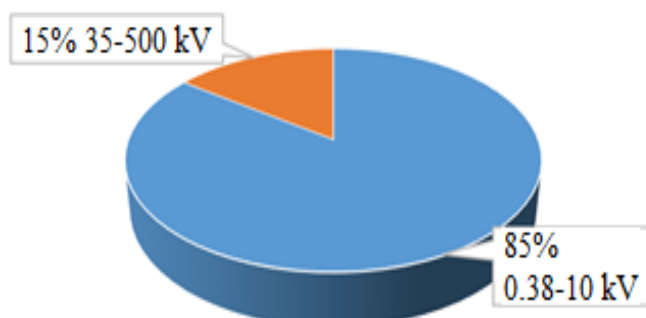


Fig. 1. Percentage of electrical energy losses

In addition, when strategies to reduce climate change events are considered, reducing electricity waste is rarely taken into account. However, ongoing scientific research shows that by reducing electrical energy consumption,

greenhouse gas emissions reduction is an important tool [2, 14-15].

Electricity in transmission and distribution systems requires additional electricity generation to compensate for losses, which necessarily increases the demand for additional fossil energy resources. Renewable energy resources are directly related to greenhouse gas emissions.

The calculations show that the amount of global emission offsets is about one billion metric tons of carbon dioxide equivalent per year, which is in the same range as the annual emissions of heavy trucks or the entire chemical industry (in 2021 from the global chemical industry greenhouse gas emissions were 925 MT CO₂).

Most of the electricity is generated in central power plants and sent over long distances through high voltage transmission lines and delivered to consumers through the distribution network. As power moves through the electrical grid, resistance in the metal wires creates heat in the power lines. This results in a part of the energy obtained from fuel energy resources used to generate electricity being lost in transit.

We can see the proof of this through Joule's lens law:

$$Q = I^2 \cdot R \cdot t [J]$$

Here, Q is the amount of heat released when an electric current flows through the conductor. I is the value of the electric current, R is the active resistance of the conductor.

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power grid are more than the emissions of some industrial enterprises Figure 2 [4, 11-13, 21-25, 9, 10].

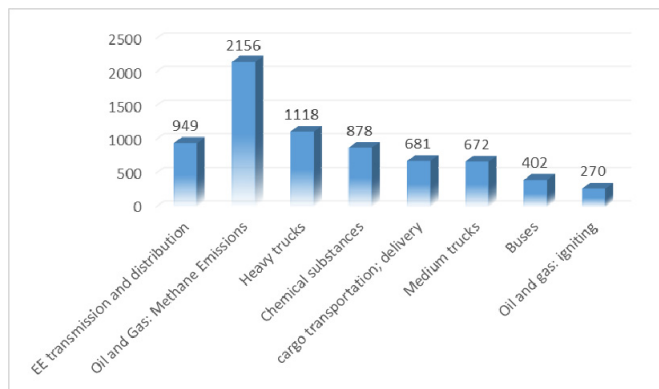


Fig. 2. Causes of greenhouse gas emissions and their amount. It is measured in million metric tons of carbon dioxide equivalent

Also, according to the data of 2020, the share of greenhouse gas emissions in the year section is shown in 3 Figure. electricity generation accounts for the second largest share of greenhouse gas emissions (25% of 2020 greenhouse gas emissions). However, about 60% of electricity comes from burning fossil fuels, mainly coal and natural gas.

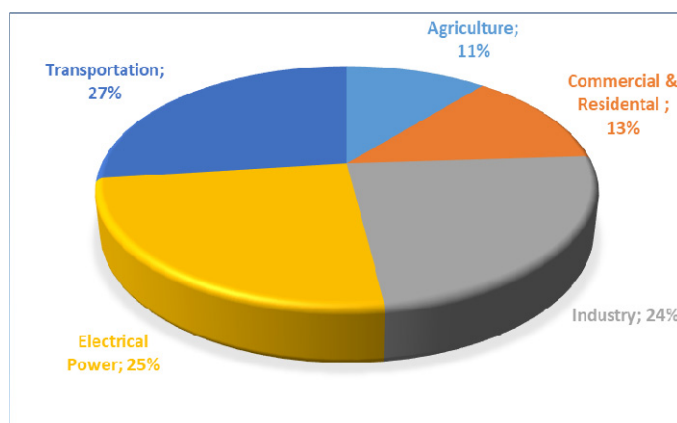


Fig. 3. Share of greenhouse gas emissions in 2020

The electricity sector includes the generation, transmission and distribution of electricity. Carbon dioxide (CO₂) accounts for the majority of greenhouse gas emissions from the sector, but smaller amounts of methane (CH₄) and nitrous oxide (N₂O) are also emitted. These gases are released during the burning of fossil fuels such as coal, oil and natural gas to generate electricity. Less than 1% of the sector's greenhouse gas emissions come from the insulating chemical sulfur hexafluoride (SF₆) used in electricity transmission and distribution equipment [26-31, 9, 12, 14].

Burning coal requires more carbon to produce electricity than burning natural gas or oil. Although coal use accounted for about 54% of CO₂ emissions from the sector, it accounted for only 20% of the electricity generated in the United States in 2020. In 2020, natural gas use accounted for 39% of electricity, and oil use increased by more than 1%. In 2020, the remaining generation came from non-fossil fuel sources, i.e.

nuclear (21%) and renewables (20%), including hydroelectricity, biomass, wind and solar. Most of these renewable energy sources, such as nuclear, hydroelectric, wind and solar power plants, emit almost no radiation [5, 18, 14, 16].

Studies have shown that electricity consumption varies greatly from country to country. In 2016, total transmission and distribution electricity losses reached 19% in India and 16% in Brazil. But they were more than 50% in Haiti, Iraq and the Republic of Congo. This means that only half of the electricity produced reaches consumers or is counted as usable power, and the other half is wasted on the road.

In developed countries, electricity waste was lower: the United States accounted for 6% of electricity waste in 2016, Germany 5% and Singapore 2%. These figures show that it is more efficient to transmit electricity over short distances to large population centers than to send electricity over long distances to consumers located in many rural areas.

The easiest way to solve the technical losses is to use the most advanced technologies and to modernize the existing infrastructure for long-distance transmission and local distribution of electricity. Transmission improvements can be made, for example, by replacing inefficient (low-efficiency) power transmission lines (EUL), reducing the resistance in the EUL and thus reducing electrical energy waste, as well as by controlling the high-voltage power flow [9, 18, 4, 5].

Similarly, improvements in distribution can be achieved through proper management of load and power distribution, as well as optimal layout of distribution lines. Innovations such as the adoption of digital technologies to direct power flows can also play a role.

Solutions for non-technical losses are more difficult and can only partially reduce the associated emissions. The causes of high electricity wastage are varied, such as hurricanes or wars in Haiti and Puerto Rico in recent years, or extreme events such as a combination of poor governance, corruption and poverty, as seen in India. For both types of losses, countries with a large share of fossil fuel generation and inefficient grid infrastructure can reap higher environmental benefits by reducing emissions and reducing electricity waste in transmission and distribution [16, 17, 19].

There are various options for reducing greenhouse gas emissions associated with electricity generation, transmission and distribution. The following table lists these possibilities and gives examples, Table 1 [6, 7-10].

Table 1

Types	Ways to reduce greenhouse gases	Examples
Increasing the efficiency of power plants operating with fossil energy resources	Improving the efficiency of existing fossil fuel power plants through the use of advanced technologies, and replacing high-emission power plants with low-emission ones.	Converting a coal-fired boiler to natural gas or co-firing with natural gas. Conversion of a single-cycle gas turbine to a combined cycle turbine.
Renewable energy	Using renewable energy sources rather than fossil fuels to generate electricity.	By connecting power plants powered by wind, solar, hydro, and geothermal sources, as well as some biofuel sources to the grid
End-use energy efficiency improvement	Reducing electricity consumption and peak demand by improving energy efficiency and savings in homes, businesses and industry.	By classifying the payment of the main electricity consumers for the consumed energy
Nuclear energy	Applying electricity from nuclear energy instead of energy from burning fossil fuels.	Extending the service life of existing nuclear power plants and creating new nuclear power plants.
Carbon sequestration	Popularization of electricity generation from CO2	

3 Situation of greenhouse gas emissions in uzbekistan

The share of greenhouse gas emissions is also increasing significantly in the territory of Uzbekistan, for example:

➤Greenhouse gas emissions (CO₂) in 2016 amounted to 10,523 (kt CO₂ equivalent), which is 6.11% more than in 2015.

➤In 2017, greenhouse gas emissions (CO₂) amounted to 10,953 (kt CO₂ equivalent), which is 4.09% more than in 2016.

➤In 2018, greenhouse gas emissions (CO₂) amounted to 11,247 (kt CO₂ equivalent), which is 2.68% more than in 2017.

➤In 2019, greenhouse gas emissions (CO₂) amounted to 116.71 (kt CO₂ equivalent), which is 3.77% more than in 2018.

Using the above information, we can find out how much electricity is used to generate greenhouse gases, Table 2 [7].

Table 2

years	Greenhouse gas emission value (kt CO ₂ equivalent)	Share of electricity %	The cost of electricity in the production of greenhouse gas emissions (kt CO ₂ equivalent)	The cost of electricity in the production of greenhouse gas emissions (MWh)
2016	170,89	25	42,7225	51,47289
2017	176,31		44,0775	53,10542
2018	183,81		45,9525	55,36446
2019	188,759		47,18975	56,85512

So, according to the section of 2019, about 56.8 MWh of electricity, that is, a certain part of the waste of electricity, was spent on the creation of greenhouse gas emissions.

4 Conclusion

Through research, we found out that one of the main causes of greenhouse gas emissions is the losses of electricity that occurs through the transmission and distribution of electricity. Also, the situation of greenhouse gas emissions in the territory of Uzbekistan and how much greenhouse gas emissions were released during the years 2016-2019 and what is the share of electricity losses calculated.

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