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CHANGES IN THE ENERGY PRODUCTION TO REDUCE THE ENVIRONMENTAL IMPACT

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ABSTRACT

One of the most debated topics of our time is climate change. For this reason, the European Union and the countries of the world are taking several steps to reduce and reverse the effect. When we talk about climate change or sustainable development, it is very important to also talk about the energy sector. The European Union aims to achieve climate neutrality by 2050, which will require significant changes in our lives, it will be a major challenge for mankind. In 2019, fossil fuels accounted for 80% of the world's energy production. The production of energy from fossil fuels has several negative effects aside from climate change. When fossil fuels are burned, gases and particles harmful to human health are released into the air and some of the fossil fuels are raw materials to produce plastics, for example. If we use it for energy production, we waste our raw materials. What are the options for reducing the environmental impact? How can coal-based energy production be replaced? What are other ways to reduce the environmental impact? These topics are discussed in the article.

Keywords: climate, energy, sustainability, emissions, waste

1. INTRODUCTION

Climate change means lasting and significant change locally or globally in average temperature, average rainfall, or wind [1]. We have been talking about climate change since the 19th century, the first calculation was made in 1896 by Samuel Pierpoint Langely and his partner Frank W. Very, who tried to determine the surface temperature. In the late 19th century, scientists first debate those large-scale emissions of greenhouse gases from human activities could change the climate. In the 1960s, there was more and more convincing evidence of warming caused by carbon emissions a fact that is already proven today [2]. Climate change is caused by the appearance of higher than natural concentrations of greenhouse gases, the percentage of which is shown in Fig. 1. Natural greenhouse gases play a role in the Earth's heat economy. Greenhouse gases: water vapor, carbon dioxide, methane, nitrogen oxides, and halogenated hydrocarbons (CFCs) [3-4].

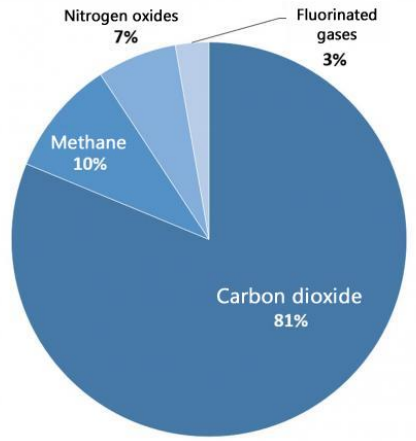

Figure 1. Greenhouse gas emission [5]

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The most significant greenhouse gas in the atmosphere is water vapor. The presence of carbon dioxide is a small part of the atmosphere, however, according to NASA's research, its presence contributes more to the warming trend. Furthermore, the situation is further aggravated by deforestation, which allows carbon dioxide to be present in higher concentrations.

Phenomena according to NASA's researchers that could cause global warming [3]:

- Variations in the Intensity of the Sun
- Industrial Activity
- Agricultural Activity
- Deforestation
- Earth on a Feedback Loop

2. CURRENT ENERGY PRODUCTION'S IMPACT ON THE ENVIRONMENT

As mentioned earlier, the largest source of greenhouse gas emissions from energy production is carbon dioxide.

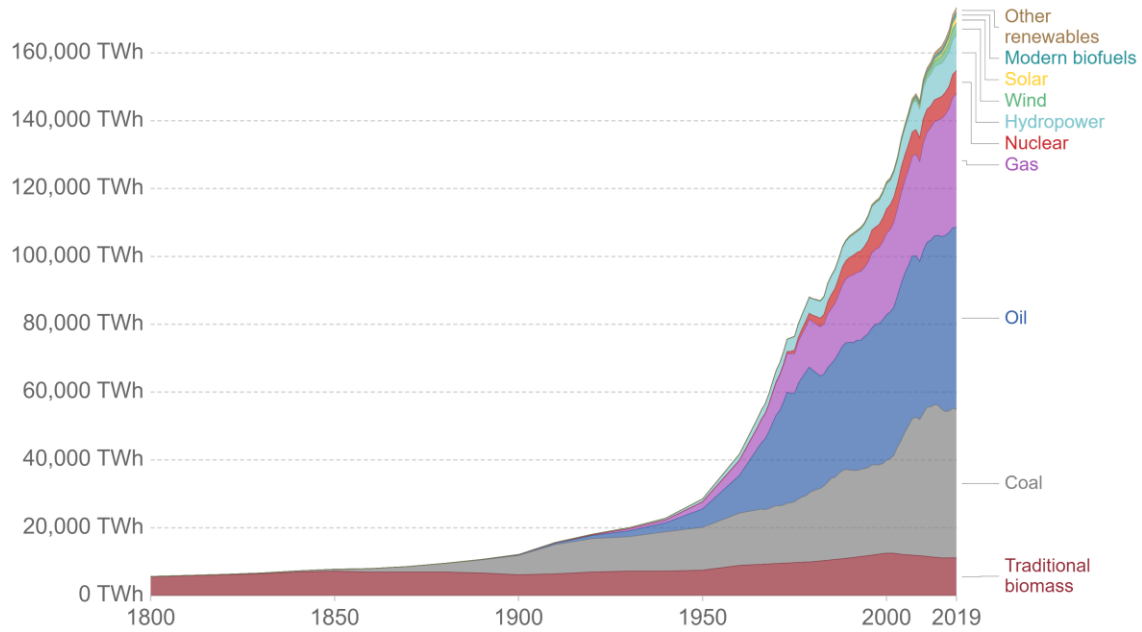

Figure 2. Change in the composition of energy production over the years [6]

It can be seen in Fig. 2 that currently energy production is primarily from fossil fuels (coal, oil, gas) accounting for almost 80% of the world's energy demand in 2019. In 2019, 10% of energy demand was covered by renewable energy and about 4% by nuclear energy. The proportion of nuclear energy has not changed significantly over the years while renewables (Solar, Wind, Hydro, Other renewables) have grown by 70% in the last ten years, most significantly the solar power which has over 3000% increase. In addition, a steady increase in energy demand can be observed, the growing demands must be produced from environmentally friendly sources [6].

The production of energy from fossil fuels has several negative effects such as global warming, air pollution, declining amounts of fossil fuels, which are also raw materials to produce plastics, for example. If we use it for energy production, we waste our raw materials. Global warming (or climate change) is one of the problems; the other is air pollution which caused health problems to the people. One of the goals of

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the European Union and the world is to achieve a circular economy and sustainable development for which the production of energy in a sustainable way is essential. According to a study by Martins [7], a significant proportion of European countries still produce 60% of their energy from fossil fuels, but in some countries, the proportion is even higher, at almost 80%.

2.1. Health effects of fossil fuels

During the combustion of coal, carbon oxides, sulphur oxides, nitrogen oxides, particulate matter and in some cases, heavy metals are released into the atmosphere.
In addition to greenhouse gases, there are also significant emissions of sulphur dioxide, amounting to about 88 Mt per year, from the combustion of sulphur-containing fuels, the smelting of ores and the industrial processing of elemental sulphur. The danger of sulphur dioxide lies not only in its toxic effects but also in its reaction with atmospheric water vapor since it is highly soluble in water and forms sulphuric acid [8].
Carbon oxides from the combustion of carbonaceous fuels may include carbon monoxide (CO), carbon dioxide (CO_2), carbon suboxide (C_3O_2) and metal anhydride ($C_{12}O_9$). Of the above oxide compounds, only carbon monoxide can be considered an air pollutant that is toxic to humans and animals. The harmful effects of carbon dioxide on naturally occurring processes are one of the main environmental problems today.
The pollutants in the ambient air are largely nitrogen oxides, which can come from households, industrial combustion plants and power plants, as well as from transport. Exposure to nitrogen oxides can cause respiratory illness. Nitrogen oxides also contribute significantly to the formation of acid rain [8].
In industrial and power plant applications, increased attention is paid to the number of compounds emitted in the air. The legislation currently in force in Hungary is (4/2011 (I. 14.) VM) which contains the emission limit values [9].

2.2. Another important factor

In addition to fossil fuel-fired power plants, it should also be emphasized that, in addition to power plants and transport, the household also plays a significant role in greenhouse gas emissions. According to EUROSTAT, 20% of total CO_2 emissions (which is 3.5 million tonnes CO_2 equivalent) come from households, 21% from industrial applications, 22% from power plants and 12% from transport [10-11].

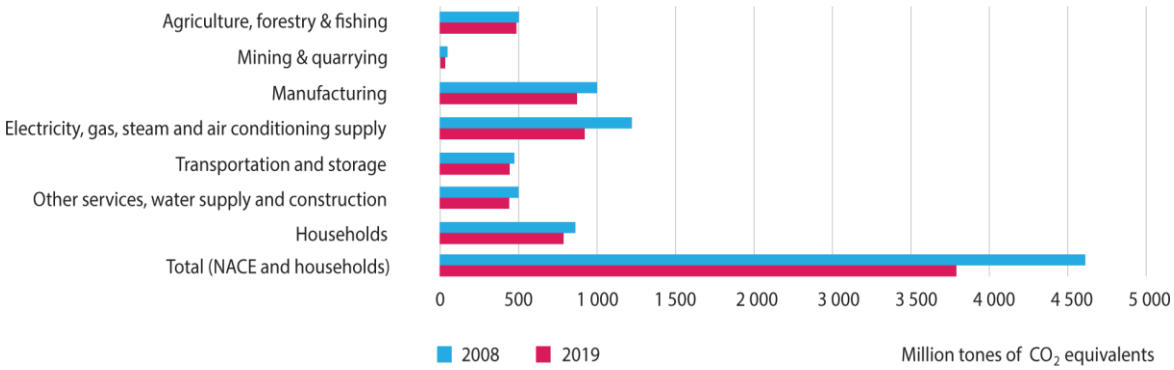

Figure 3. Greenhouse gas emissions by economic activity, EU-27 2008 and 2019 [10]

Fig. 3 shows that the number of emissions from households rivals the amounts emitted by power plants and industrial activities. It also shows that emissions from transport are only 60% of emissions from households, so households' emissions are not a negligible factor.

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3. CLIMATE PROTECTION MEASURES

Global warming is now an everyday topic for scientists, politicians, and the public. Several energy and climate plans have been developed over time, some of which are briefly reviewed in this section. The common goal is to keep the global average temperature rise below 1.5 Celsius. In International and domestic climate plans, the priority is to decarbonise energy production and everyday life. The largest energy and climate plan currently underway in Europe is the European Green Deal.

3.1. European Green Deal

The European Union has been fighting against climate change from the beginning. The current policy on climate change is the European Green Deal. According to Green Deal the European Union's expectation of member states is to have an overall climate-neutral economy by 2050. The short-term goal of the Green Deal is to reduce emissions by 55% until 2030 compared to the 1990 emissions. The long-term goal is climate neutrality or sometimes also called zero carbon. This also means that the use of natural gas must be completely replaced, and transport must be placed entirely on an electric basis [12-13].

Figure 4. European Green Deal [14]

The European Climate Law assists in the implementation of the Green Deal by setting up a monitoring system with continuous monitoring and necessary intervention to ensure climate neutrality [14].

Targets set for 2020 (which have been achieved) [15]:

- 20% reduction in greenhouse gas emissions (compared to 1990)
- 20% of EU energy production from renewable sources
- 20% improvement in energy efficiency

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3.2. EU's Emissions Trading System

The Emissions Trading System limits the number of greenhouse gases that can be emitted by energy-intensive industries, power plants and airlines. The quantity of allowances is subject to a cap set by the EU. Based on this, companies will receive units or buy more. Over time, the cap is reduced, so the number of emissions also gradually decreases. The ETS aims to stimulate innovation and the use of low-carbon technologies [16].

- It operates in all EU countries, including Iceland, Liechtenstein and Norway
- Emission limitation of about 10,000 installations in the energy sector, industry, and aviation
- Covers about 40% of the EU's greenhouse gas emissions

ETS gases:

- Carbon dioxide (CO_2) from electricity and heat production, energy-intensive industries, oil refineries, steel mills, iron smelters, aluminium production, paper production, chemical plants and commercial flights.
- Nitrogen oxides (NO_x)

4. POSSIBLE STRATEGIES FOR REDUCING EMISSIONS

Table 1. Possible strategies for reducing CO_2 emissions [19]

Strategy	Application	Advantages	Limits
Energy efficiency and energy conservation	Applied mainly in commercial and industrial buildings	Energy-saving from 10% to 20% is easily achievable	May need a larger investment
Use of clean fuels	Replacing coal-fired power plants with natural gas	Natural gas operates with 40-50% fewer emissions, higher combustion efficiency and cleaner flue gas	Higher costs, more expensive natural gas
Clean coal technologies	Integrated gasification combined cycle (IGCC)	Lower emissions can be achieved with coal	More investment is needed to the technology
Renewable energy	Construction of hydro, solar, wind and biopower plants	The use of local resources does not emit harmful substances or greenhouse gases	Highly dependent on local resources, may be more expensive than conventional energy production
Nuclear power plants	Nuclear power plants, fusion power plants (currently under research)	It does not emit harmful substances or greenhouse gases	Negative social repercussions especially since the Fukushima disaster
Afforestation and reforestation	Accepted in all countries	Natural and sustainable CO_2 sinks	Limits future land use
Carbon capture and storage	Applicable for point sources	Efficiencies of up to 80% can be achieved	The industrial application of the technology has not yet been proven

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4.1. Carbon Capture and Storage (CCS)

Carbon capture and storage (CCS) is a way to reduce CO_2 emissions from fossil fuel power plants. During the CCS process, the carbon dioxide is separated from the flue gas generated in the power plants and then transferred to geological storage. With this method, power plants can reduce carbon dioxide emissions by 80%-90%. The disadvantage is that the process is energy-intensive, and the carbon capture equipment reduces the efficiency of the power plant nor is long-term underground or ocean storage currently resolved. Modernization of power plants is a challenge in several states, such as Poland, where implementation is long overdue. In Germany and the Netherlands, public opposition to underground storage of carbon dioxide [17].

In the United States, half of greenhouse gas emissions come from energy production and industrial activities [5]. According to the International Energy Agency estimates that carbon dioxide emissions from energy production and industrial activities could be reduced by 20% using carbon capture and storage technology [18]. The three strands of CCS technology are currently being developed: post-combustion separation, pre-combustion separation by coal gasification and oxyfuel combustion. The closest technology to implementation and application is post-combustion separation. Several methods have been developed for the separation of carbon dioxide from the flue gas, for example, chemical method, physical membrane, or cryogenic method. Which technology is used is largely determined by the composition of the flue gas to be treated, which depends fundamentally on the quality of the fuel and the design of the combustion. The advantage of capturing carbon dioxide after combustion is that it can be retrofitted to existing power plants; according to current knowledge, carbon capture reduces the efficiency of a power plant by 6-10%. The gross efficiency of coal-fired power plants varies between 27-45% [19-20].

Oxyfuel combustion is one of the most developed technologies for carbon capture and storage. Oxyfuel combustion refers to fuel being burned in a mixture of oxygen and recycled flue gas [21]. Idea is that after combustion the fuel apart from pollutants consists only of carbon dioxide and water vapor. Therefore, it is not necessary to remove the carbon dioxide, only to remove the water vapor from the mixture and the remaining product is (almost) pure carbon dioxide [22]. According to research by the Argonne National Laboratory, the formation of nitrogen oxides can be reduced by 50% using oxyfuel technology [23]. The deployment of CCS technologies in the case of existing power plants, in the absence of support, can increase the price of electricity by 50-90% [24]. Nor can it be overlooked that according to the U.S. Environmental Protection Agency (EPA) not all countries have sufficient carbon storage capacity. Furthermore, according to surveys, no one wants to set up carbon storage facilities near them.

4.2. European renewable energy directive (RED)

Renewable energy sources (wind, solar, hydropower, biomass and biofuels) are alternatives to fossil fuels that help reduce greenhouse gas emissions and diversify the energy mix and also reduce the dependence of fossil fuels on an unreliable volatile market. In the Renewable Energy Directive, the EU regulatory framework has undergone significant development in recent years. EU leaders set a target in 2009 for 20% of EU energy consumption to come from renewable energy by 2020, which has been achieved and in 2018 a target has been set to increase this by a further 12% by end of 2030 [25-26].

4.3. Hungarian National Energy and Climate plan (NEKT)

The most important goal in international and domestic climate plans is the decarbonisation of energy production and everyday life, which is only possible with the combined use of nuclear and renewable energy, writes in NEKT. In addition to the decarbonisation of energy production, the main objective of the NEKT is to strengthen energy sovereignty and energy security while maintaining low prices [27].

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- Carbon-neutral nuclear energy accounts for almost half of Hungary's electricity production.

As mentioned earlier, the European Union expects member states to have an overall climate-neutral economy by 2050, which means that natural gas consumption must be fully replaced, and transport must be put on an electric basis. Hungary attaches great importance to the implementation of the "polluter pays" principle, according to which the costs of decarbonisation should be borne by the countries and companies that are most responsible for the current situation [27].

4.4. Decarbonisation of domestic energy production

According to NEKT, one of the most important domestic decarbonisation tasks in the transformation of the lignite-fired Mátra power plant is based on low-carbon technologies, thus removing coal and lignite from domestic electricity production by 2030. At the same time, the Mátra power plant's strategically important base power plant is also the largest carbon dioxide emitter in Hungary, accounting for almost 50% of the carbon dioxide emissions of the entire energy sector, thus accounting for 14% of the total domestic greenhouse gas emissions. The transformation of the Mátra power plant is the construction of a gas turbine power plant and construction of a new photovoltaic power plant and an industrial energy storage unit, as well as the energy utilization of non-recyclable waste. Furthermore, by 2030, two new 120 MW nuclear power plant units will be built in Paks in Hungary [27].

4.5. Domestic renewable energy

The share of renewable energy in the heating and cooling sector – by additional measures – can reach 30% in 2030. Efficient utilization of biomass in heating systems, both in district heating and in the use of ambient heat through heat pumps. The implementation of the Green District Heating Program (Zöld Távhő Program) and the placement of as many of the individually heated buildings as possible on a renewable basis will play a key role in replacing natural gas and increasing their use of renewable energy sources in the heat market. In addition to domestic natural gas, the use of alternative gas sources (biogas, biomethane, hydrogen in the future). According to their estimates, biogas can realistically replace about 1% of the natural gas demand. In the area of convergence, Hungary sets a renewable energy share of at least 14% by 2030. To achieve this goal, the share of first-generation biofuels produced from food and feed crops will increase to almost 7% and the share of second-generation (or advanced) biofuels and biogas produced from waste will increase to 3.5% in Hungary's transport final energy consumption [27].

5. WITHOUT COAL-BASED ENERGY PRODUCTION

Table 2. Distribution of world electricity generation [28]

Source	World (2020)	Europe (2019)	Hungary (2020)
Coal	**33.79%**	17.49%	10.63%
Natural gas	22.79%	19.23%	26.17%
Hydro	16.85%	15.84%	0.8%
Nuclear	10.12%	**23.25%**	**47.52%**
Wind	6.15%	11.56%	1.94%
Oil	4.37%	1.3%	1.03%
Solar	3.27%	3.87%	4.79%
Other renewables	2.72%	5.52%	7.12%

Tab. 2 shows the distribution of world electricity generation. Currently, a significant portion of electricity comes from coal-fired power plants. However, Europe differs significantly from the world average. Much

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of Europe's electricity production comes from nuclear power plants, followed closely by gas, coal and water, followed by wind and then by other renewables, solar and oil-based energy in the smallest proportion. In total, renewable energies account for 36.79% of Europe's total electricity, so if we add them up, renewables account for the largest share of electricity generation within Europe, which is 3-4% ahead of the world average. Almost half of the electricity generation in Hungary comes from the Paks Nuclear power plant, renewables (in total) account for 14.65% of electricity generation. Coal-fired electricity generation is 10.63% in Hungary and almost 70% in Poland. In Hungary, coal-fired electricity means a 10.63% outage, which must be made up by 2050 [29-30].

5.1. What are the possibilities?

- CCS-technologies
- Renewable energy sources
- Nuclear energy
- Import

CSS technologies have already been discussed above, can be costly to implement and have a negative social impact, as the share of coal-fired energy production is less significant in Hungary, so other solutions may be more cost-effective, but in Poland where almost 70% of energy production is based on coal, the development of CCS technologies may be more cost-effective.
To replace it with renewable energy, let's look at domestic numbers.

Table 3. Domestic energy production [28]

Source	Quantity [TWh]
Nuclear	16.06
Natural gas	8.85
Coal	3.59
Other renewables	2.41
Solar	1.62
Wind	0.66
Oil	0.35
Water	0.27
Altogether	33.81

The current amount of renewable energy production is 4.96 TWh, an additional3.59 TWh is needed to replace coal-based production, of course without considering the growing electricity demand as switching from transmission to electricity is likely to significantly increase electricity demand. Since in Hungary the 277/2016. (IX. 15.) on the construction of wind turbines [31], therefore, the most obvious solution from the renewable energy sources is the establishment of solar parks, which would mean increasing the current solar energy production by 2.5 times, which would involve a significant financial investment and the involvement of large areas of land that had been prepared.

Nuclear energy is playing a prominent role in the NEKT [27], it is no coincidence, the nuclear energy accounts for almost half of Hungary's electricity generation. In France, nuclear power plants account for 67% of electricity generation and the remaining 33% is 23% renewables and 10% fossil fuels (6.5% gas, 2% oil and less than 1% coal). 90% of French electricity production comes from climate-neutral energy sources. It can be observed that in countries where natural factors are not favourable for the use of renewable energies, nuclear energy or import is the most appropriate way to placing electricity production on a climate-neutral basis.

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Table 4. Distribution of world electricity production [28]

Source	France (2020)	Germany (2020)	Belgium (2020)
Coal	0.81%	23.66%	0.11%
Natural gas	6.48%	16.15%	30.32%
Water	11.74%	3.3%	0.32%
Nuclear	67.21%	11.33%	39.33%
Wind	7.42%	23.71%	14.42%
Oil	2.18%	3.97%	4.13%
Solar	2.5%	8.99%	5.37%
Other renewables	1.66%	8.9%	6.02%

As already mentioned, the European Union expects its member states to have an overall climate-neutral economy by 2050. For Hungary to have climate-neutral electricity production, the full replacement of natural gas consumption, the full relocation of transport to electricity, will cost about 50,000 billion Hungarian Forint [27].

6. SUMMARY, DIRECTION OF DEVELOPMENT

There are currently several debates about which direction would be appropriate. Some scientists and some members of the public support systems based on completely renewable energy sources with batteries, hydro storages, or other forms of energy storage. Another direction suggests the combined use of nuclear and renewable energy sources, as both directions have challenges (of course, not only these two directions exist), which can be assured that reducing fossil-based energy production is common in these directions.

6.1. The direction of development I propose

The development direction I propose would focus on energy production from nuclear and renewable energy sources, similar to France's energy production and proposed by NEKT. Energy production based solely on renewable energy sources carries several problems, so for the time being, this trend must be avoided in my opinion. It is important to note that the essence of carbon neutrality is the total value of emissions zero, which means that it is not necessary to completely exclude emitting technologies, but only to reduce them to an extent that can be neutralized by "sinks" (e.g., forests) in the country. I consider it important to develop an energy mix based on a full life cycle analysis, for example, the production of solar panels and the processing of waste has a significant environmental impact. Another important aspect is that currently a significant proportion (about 50%) of household waste is landfilled. Much of the waste that ends up in landfills has a high calorific value. Waste co-incineration with fossil fuels or incineration itself is not a negligible factor as waste is not included in greenhouse gas emissions. The European Union's goal is to reduce the landfill rate to less than 10% by 2035. Energy recovery of waste is a much better solution than landfilling if recycling in its material is not possible. The waste incinerator in Budapest incinerates 400,000 tons of waste annually, of which more than 1 million GJ of energy is sold, which covers the annual electricity needs of 140,000 residents and provides district heating to 25,000 homes [32]. These solutions have negative social repercussions. In my opinion because of the lack of knowledge and information. To change this, it is necessary to educate and enlighten people properly. It is important to highlight that the waste cannot be incinerated in households' fireplaces and boilers, when we incinerate waste at home it releases highly toxic gases because of the lack of burning temperature and flue gas treatment.

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6.2. European Green Deal important aspects

According to Green Deal, it is necessary to achieve carbon neutrality by 2050, which is a very ambitious goal. Here several aspects are essential to consider, as we can easily cause a bigger problem. Above all, it is important to ensure a reliable energy supply and to continuously meet the ever-increasing energy demand for development.

6.3. Other ways to reduce environmental impacts

When we talk about climate protection and energy, we must talk about the importance of waste as well. Minimizing waste, avoiding the production of unnecessary things, buying from local producers, selective waste collection, all help to save energy and protect the climate. The shorter the transport distance, the lower the CO_2 emissions. If there is more recycled waste in its material, there is less needed to coat new raw material, which saves energy. For example, recycling metals saves 70% of energy compared to mining, by recycling 1 ton of paper, we protect 17 trees also if we are recycling plastic, there is less chance that plastics will end up in the ocean. We can save a lot of energy with prevention and with proper waste management, so this is an important aspect. During the Proof-of-Concept innovation tender announced by the University of Miskolc in 2020, the development of an application that helps people to follow more environmentally friendly behaviour in everyday life has started by GW Tech [33]. The application will help everyone in selective waste collection and provide us with important and interesting facts, as above.

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