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ТОПЛИВНЫЕ ЭКОЛОГИЧЕСКИЕ СТАНДАРТЫ

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Аннотация

В данной статье проанализирована стратегия перехода мирового сообщества к нулевым выбросам углекислого газа в атмосферу от транспортных средств. В ходе работы определены современные топливные экологические стандарты.

Ключевые слова: топливо, экологические стандарты, углекислый газ, загрязнение атмосферы.

FUEL ENVIRONMENTAL STANDARDS

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ABSTRACT

The strategy of the global community's transition to zero carbon dioxide emissions from vehicles is analyzed in the article. In the course of the work, modern fuel environmental standards are determined.

Keywords: fuel, environmental standards, carbon dioxide, air pollution.

The population of planet Earth is growing rapidly. Over the past 60 years, the number of people in the world has more than tripled. On average, the annual natural increase in the world's population is in the range of 1.2-2%, which in quantitative terms amounted to 96 million people in 2020 [1].

At the same time, all living people need various products, goods, food, and for one reason or another it is necessary to move themselves, or to move loads. A huge number of industries and transport operating on hydrocarbons significantly degrade the human environment. In particular, they pollute the air. Air pollution has reached such proportions that 3 of the 5 most common causes of death in October 2021 are associated with the respiratory system. These diseases are: chronic obstructive pulmonary disease, lower respiratory tract infection, trachea, bronchus, lung cancers [2].

The fight against air pollution began in 1979, when the global community came together to develop common environmental principles to reduce air emissions. Most countries have signed a number of conventions to reduce the level of emissions into the atmosphere of various substances, heavy metals and persistent pollutants, as well as the United Nations Framework Convention on Climate Change (UNFCCC) on greenhouse gas emissions [3].

The main sectors of human activity that gave the greatest pollution were energy and transport. Therefore, first of all, the attention of the world community was drawn to them.

Within the framework of the UNFCCC, many countries have developed and implemented programs for the production and use of "green electricity". This type of electricity got its name due to the fact that renewable energy sources (RES) are used to obtain it, the use of which does not pollute the air space in the process of generating electricity, in contrast to the use of traditional energy sources of fuel oil, coal, etc. Renewable energy sources include: solar, geothermal, tidal energy, wave and wind energy, and a number of other types of energy. After the start of the implementation of green electricity programs, the construction of power plants operating on renewable energy sources began to prevail over the construction of thermal power plants (TPPs). From 1992 to 2018, the total nominal generated capacity of power plants in the world increased 2.5 times (Fig. 1). At the same time, the total share of TPPs during this period decreased relative to the total generated energy from 64.4% to 61.2%, and the share of alternative power plants producing "green electricity" increased 38 times, increasing in total from 0.4% to 15. 1% of the total installed capacity (Fig. 2).

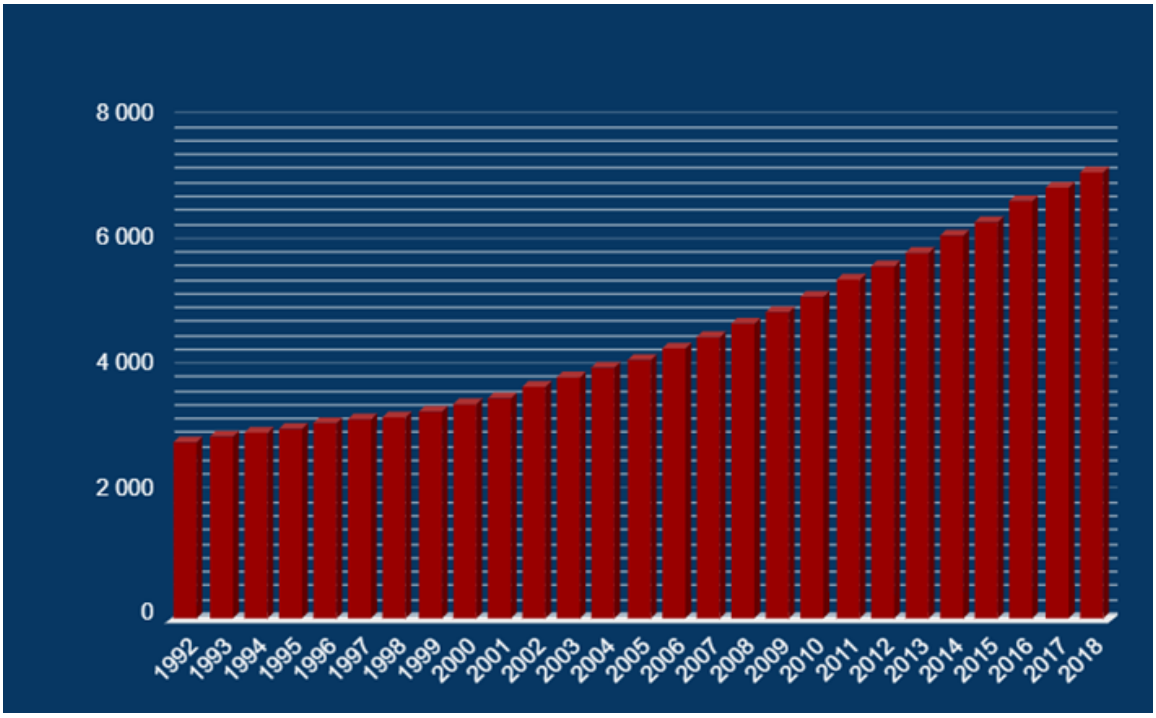

Figure 1. World energy. Dynamics of installed nominal capacity – net power plants, 1992-2018, GW.

[Electronic resource]. https://www.eeseaec.org/mirovoe-energeticeskoe-hozajstvo

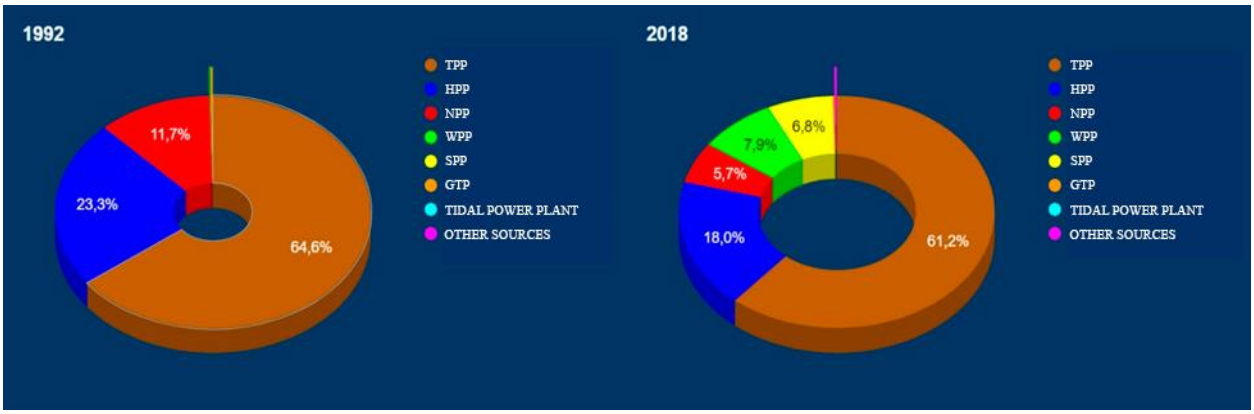

Figure 2. World energy. Structure of installed capacity of power plants by type for 1992, 2018, GW (%).

[Electronic resource]. https://www.eeseaec.org/mirovoe-energeticeskoe-hozajstvo

Of course, at the same time, it is immediately impossible to abandon power plants using traditional types of fuel such as fossil fuel, nuclear fuel (uranium, thorium) and others in favor of power plants using renewable energy sources. And therefore, the results of the transition to renewable energy sources will not be noticeable immediately, but the transition has already begun and at a fairly good pace.

Simultaneously with the programs for the transition to the production of "green electricity" on an industrial scale, programs were developed to transfer vehicles from internal combustion engines (ICEs) using hydrocarbons as fuel to an alternative one, which does not release pollutants into the atmosphere, in particular carbon monoxide (CO) and nitrogen oxide (NOx). The emissions from vehicles are enormous. In 2016, according to the European Parliament, the share of carbon monoxide emissions from road transport was 43.7% of the total. This is significantly more than in sea (13.6% of the total) or air transport (13.4%). [4]. That is why the transfer of transport to alternative fuels in importance is on a par with the production of "green electricity". Hydrogen has been identified as an ideal replacement for hydrocarbons. Unfortunately, the rapid transition of vehicles to fuel that does not pollute the atmosphere was not possible. The first step was to develop safety standards for the use of hydrogen as a fuel. Then it was required to establish the production of hydrogen on the required scale. And it also was necessary to create a new transport operating on hydrogen fuel, with the infrastructure for it. And all this had to be done in parallel. Taking into account that all developments related to hydrogen fuel were at the level of several laboratories with enthusiasts, and there was no infrastructure, the process of switching to hydrogen fuel was assumed to last for tens of years. At this time, it was decided to pay all attention to reducing exhaust gas emissions from existing vehicles. This led to the adoption of a full-fledged and well-developed environmental standard – Euro-0 in Europe in 1988. This document clearly limited the amount of emissions that a car traveling on European roads can afford. The main indicators are produced carbon oxides (CO) and nitrogen oxides (NOx), as well as hydrocarbons (CH or HC). Carmakers had to adjust their factories to the required parameters. At the same time, road transport was divided into diesel and gasoline. The standards for each of them were slightly different and were introduced in different periods [5].

Similar to the environmentally friendly Euro standard, similar standards have been introduced in different regions of the world with minor differences. In America, Tier became such a standard, in Japan – Post New Long-Term (PNLT), etc. Many countries did not develop their own environmental standard, but joined one of the developed ones.

Together with the development of the standards, a strategy for the transition to each of them was developed. According to which in a certain year there was a change to the next environmental standard, more stringent in requirements than the previous one. Euro-1, adopted in 1993, regulated permissible emissions much stricter. And Euro-2 and Euro-3, approved in the late 90s - early 00s, provided for the reduction of some pollutants by 5-6 times [5]. In 2009, the European Union introduced the Euro 5 standard, which significantly reduced the amount of particulate matter in the exhaust of diesel engines and introduced VOC standards for gasoline engines. Compared to the early nineties of the last century, the emissions of particulate matter from diesel engines have decreased by 99%, and the amount of nitrogen oxide has decreased by 98%.

Achieving these emissions reductions in vehicles was not easy. To begin with, the engineers had to implement the Exhaust Gas Recirculation (EGR) system (Fig. 3). The main task of the EGR system is to effectively reduce the level of nitrogen oxides in the exhaust. The formation of nitrogen oxides during engine operation is caused by high temperatures. An increase in temperature in the combustion chamber of an internal combustion engine leads to an active increase in the content of nitrogen oxides in the fuel-air mixture. The high temperature in the combustion chamber of the internal combustion engine leads to the fact that oxygen and nitrogen, which are contained in the supplied air, begin to interact with each other [6].

Air enters the heated combustion chamber of the engine, where further nitrogen oxides are actively formed. This means that oxygen, which is necessary for the full combustion of gasoline in units of this type, begins to be replaced by the indicated nitrogen oxides. The working mixture, under the condition of a lack of oxygen, does not completely burn out, as a result of which engine power is lost, fuel consumption is noticeably increased, and the toxicity of the exhaust gases of the internal combustion engine also increases. If you return some of the exhaust gases to the intake manifold, this allows you to slightly lower the combustion temperature of the fuel-air mixture. Lowering the temperature automatically reduces the rate of formation of nitrogen oxides [7].

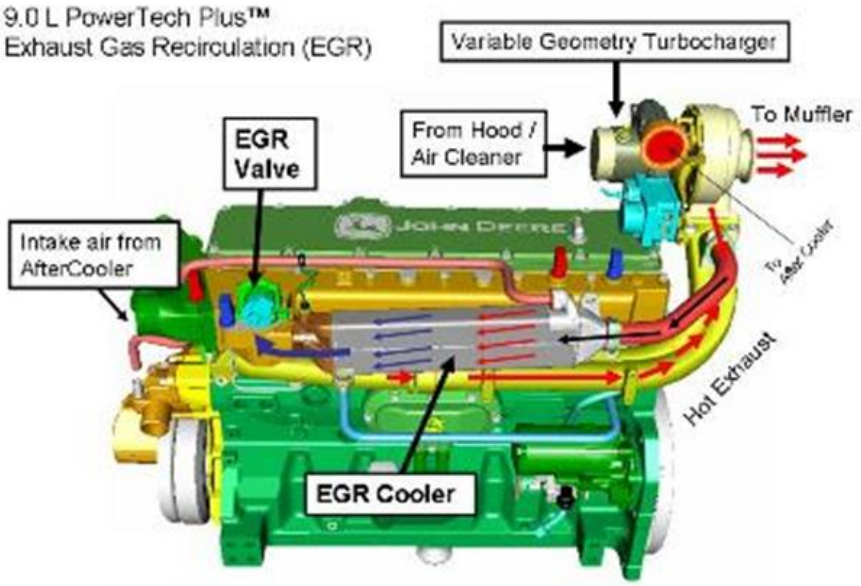

Figure 3. Working principle of Exhaust Gas Recirculation (EGR).
[Electronic resource].
http://salesmanual.deere.com/sales/salesmanual/en_NA/tractors/2011/feature/engine/9030/9030_egr.html

By lowering the temperature, EGR helps to increase the amount of soot, so the system must be equipped with a particulate filter, which retains soot and then, at a certain heating temperature, the exhaust system burns (regenerates) it. The EGR system also has a small drawback – the requirements for the quality of the fuel and the quality of the engine oil. Even one refueling with high sulfur diesel fuel can clog the catalytic converter [8].

To meet the Euro 3 environmental standards, the EGR system was quite enough. But with the introduction of the Euro-4 standard, a new system was needed, which was called Selective Catalytic Reduction (SCR).

The Selective Catalytic Reduction System gets its name from selectively targeting one type of pollutant, namely nitrogen oxides. At its core, the SCR method is quite simple: it boils down to the decomposition of nitrogen oxides into gaseous nitrogen and water vapor in reaction with urea (carbamide) on a ceramic catalyst (strictly speaking, nitrogen and water are reduced from nitrogen oxides, which is reflected in the name of the method). To achieve this, AdBlue containing urea is sprayed into the exhaust gas stream, the resulting mixture enters the catalytic converter, where, under the action of catalysts and high temperatures, the following chemical reactions take place:

Thermal decomposition of urea into methane and isocyanic acid – $(NH2)\ 2CO \rightarrow NH3 + HNCO$;

Decomposition of isocyanic acid into ammonia and carbon dioxide – $HNCO + H2O \rightarrow NH3 + CO2$;

Reduction of nitrogen from nitrogen oxides (at temperatures above 250 ° C) – $4NO + 4NH3 + O2 \rightarrow 4N2 + 6H2O$;

Reduction of nitrogen from nitrogen oxides (at a temperature of 170-300 ° C) – $NO + NO2 + 2NH3 \rightarrow 2N2 + 3H2O$.

This reduces the concentration in the exhaust gases of the most dangerous nitrogen oxides – monoxide and dioxide. This produces safe substances – molecular nitrogen and water vapor, as well as a certain amount of carbon dioxide. The SCR method is effective, but it requires the introduction of a special system and a new consumable into the vehicle – a liquid urea solution AdBlue [9].

From the point of view of neutralizing nitrogen oxides, SCR is not to be found fault with. But there are a number of operational drawbacks, in addition to the constant need to fill the tank with urea.

- Urea freezes in the tank already at -11 degrees Centigrade, so the nozzle cannot inject urea and the SCR system does not work. This fact significantly reduces the territorial application of this system or makes it completely impossible to use it in some regions of the planet.

- The system is demanding on fuel quality, as well as EGR.

- The relatively complex structure (Fig.4) results in high installation costs for the system and high operating costs due to breakdowns.

- If the SCR fails, the engine may not be started at all [10].

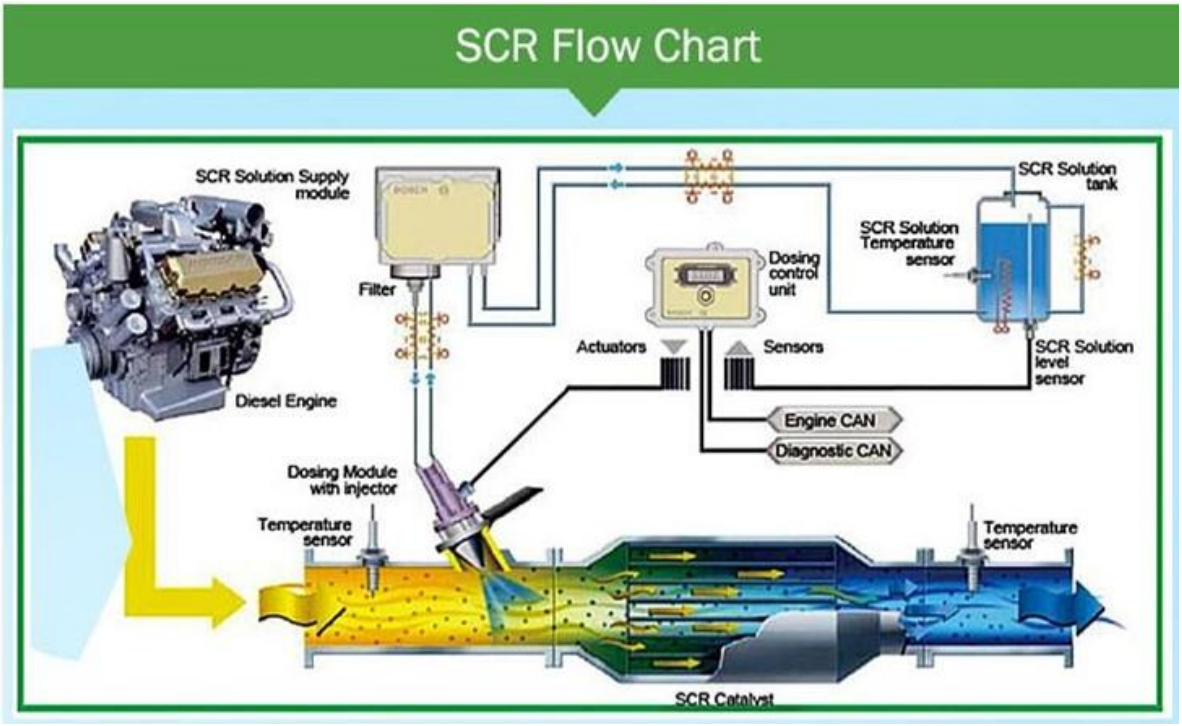

Figure 4. Selective Catalytic Reduction (SCR) operation diagram. [Electronic resource]. https://www.everbluesolution.com/adblue-def-for-scr-system-1000l_p112.html

Steps to reduce road transport emissions are paying off. Every year, each individual vehicle with an internal combustion engine produces less and less air pollution. But the number of cars growing every year neutralizes the positive effect. In addition, systems that allow you to remove harmful substances from the exhaust are not ideal, and in many regions, do not work for technical or economic reasons. Therefore, a motley map of environmental standards for passenger cars has developed in the world for 2021 (Fig. 5).

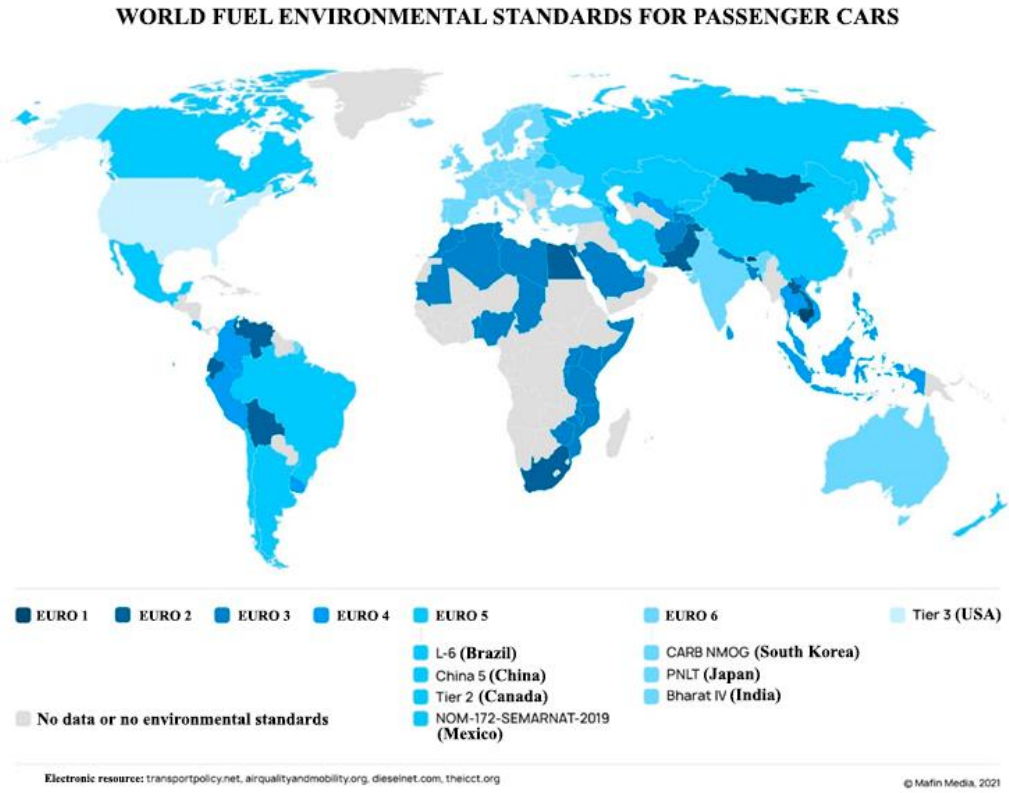

Figure 5. Map of environmental standards for passenger cars in the world, 2021. [Electronic resource]. https://mafin.ru/media/razbory/ekologicheskie-klassy-avto-chto-eto

In 30 years of combating emissions into the atmosphere, hydrogen fuel still has not received mass distribution. Hydrogen cars appeared, but they were single copies. And cars that have been put into mass production are available to a limited number of people due to their high cost. The first real sign that a hydrogen future is just around the corner was the Toyota Mirai (Fig. 6).

Figure 6. Toyota Mirai with fuel cell engine.
[Electronic resource]. https://ru.toyota.ee/new-cars/mirai/index.json

For October 2021, the basic equipment of the Toyota Mira is sold for 66,900 euros. This car has several essential characteristics:

- The power reserve of the car on a full tank is more than 650 km.
- Filling takes less than 5 minutes.
- CO2 emissions are equal to zero [11].

Despite the fact that this car reflects all the ideas of the world community about environmentally friendly transport, there are several constraining factors that prevent it from

becoming widespread. These factors are commonplace and solvable. The price is still quite high and the infrastructure is underdeveloped, in particular, there are few filling stations.

Governments around the world need to focus their work on infrastructure development. The increase in demand for hydrogen cars will give a demand for hydrogen, which will give a new impetus to the development of "green energy" and will inevitably lead to a decrease in the cost of hydrogen transport and so on in a spiral.

The Japanese government has already announced that from 2030 it plans to completely ban the sale of cars with internal combustion engines [12]. This means that in Japan by 2030 the infrastructure for hydrogen cars should be fully ready, and with it the production of hydrogen on the required scale.

Taking into account the development trends over the past 30 years, the current state of the energy and transport complexes and the immediate plans of countries concerned about the planet's ecology, it can be safely assumed that by 2070, all vehicles in the world will switch to fuel with zero emissions of harmful substances.

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