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Climate change through the eyes of a chemist, energy, technologist

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Abstract

In this article, the author made an attempt to present and analyze issues related to global environmental problems, and in particular, the role of carbon dioxide in global warming.

Well-known facts and unexpected findings are intended to awaken in the reader a critical attitude towards the prevailing beliefs in these matters.

From the point of view of a chemist, the reality of extracting CO_2 from air and converting it back into fuel is assessed. Simple energy calculations make it possible to assess the ability of "green" energy to replace carbon and influence the climate warming process. And finally, the key proposals are presented from the point of view of a technologist, since it is technologists who make real and implement the most daring discoveries and projects of scientists and inventors.

Key words: Climate change, carbon dioxide, CO_2 carbon, greenhouse gases, renewable energy.

Information revolution

In modern society, the development of science has led to global informatization. You can now get an answer to any question with a few taps of the keys on your computer or smartphone. Another question - how adequate will such an answer be? The fact is that the Internet (however, like the human brain), is looking for easy ways to save energy. And the easy way is that the user is presented with the most accessible, widespread information. The habit of “looking through” a huge amount of information wean people off from deep meditation on individual issues. Thus, even if the information is false, but it is liked by the majority of users and is actively disseminated, it soon occupies a dominant position in the minds of people [1].

According to the author, one should take a critical look at the dominant idea in the field of combating global warming. Let's talk about carbon dioxide.

Enemy or friend?

Carbon dioxide (CO_2, carbon dioxide) is only less than a thousandth of the composition of the air, but it is an integral part of life on earth. He participates in the processes of the life cycle of all animals and plants. Plants absorb it, and release oxygen, while animals absorb oxygen and release CO_2. In inanimate nature, the processes of release and absorption of CO_2 also occur. This gas is emitted by volcanoes, and also reliably binds in the shells of mollusks,

from which limestone mountains are then formed. Carried away from the atmosphere by rains, CO_2 turns into weak carbonic acid, which gradually destroys mountains. The good solubility of carbon dioxide in water is known to us from carbonated drinking water. There, the gas is dissolved under pressure, and after opening the bottle, its bubbles burst into the air. The solubility of gases strongly depends on temperature - in cold water, twice as much carbon dioxide can dissolve than in warm water. For this reason, the world's oceans constantly absorb or release CO_2, depending on the heating or cooling of the water in very large volumes [2, 3].

Our daily life and activities are full of carbon dioxide. With the help of carbon dioxide, fires are extinguished, potable water is preserved. Solid CO_2 (dry ice) helps preserve food and vaccines. CO_2 is used in metal welding. Lush buns are made from the carbon dioxide produced by the yeast. If there were no carbon dioxide in the atmosphere, modern civilization would have lost the main building material - concrete, since CO_2 is necessary for the hardening and strength of concrete [4].

However, the industrial revolution, rapid population growth, and higher living standards were accompanied by a sharp increase in human demand for energy. Energy is needed for the operation of industrial enterprises, transport, heating and lighting. And it is the use of carbon fossil fuels, the combustion of which produces carbon dioxide, that allowed us to achieve the modern level of comfort.

So CO_2 is our friend and fellow traveler on the path of progress? Not certainly in that way. The increase in the content of carbon dioxide in the atmosphere is now considered to be the main culprit for the intensification of the greenhouse effect [5].

The stability of the average temperature on the Earth is ensured by the balance of the heat received from the Sun by the rays of visible light and the heat returned back into space by the thermal (infrared) rays of the heated surface of the Earth. It is this balance that carbon dioxide disrupts by absorbing infrared rays, especially at night.

The seriousness of the situation is confirmed by the appeal of the UN Secretary General to all countries - to declare a climate emergency, up to the reduction of greenhouse gas emissions to zero [6].

So carbon dioxide is enemy number 1 for the Earth's climate?

Do we need to fight the enemy?

It seemed that humanity had every reason to start a struggle and conquer at least its own CO_2, as the saying goes: "We have littered ourselves, we will clean it up ourselves."

What are the ways for this?

1. Reduce and even eliminate CO_2 emissions from all sources;

2. Extract CO_2 from the atmosphere and store it in underground storage facilities or process it into other useful substances;

3. Plant billions of trees that will extract CO_2 from the atmosphere (another option for this path is to stimulate the growth of aquatic plants (phytoplankton)).

Consider the reality and consequences of implementing such decisions.

1. Reducing CO_2 emissions means abandoning thermal power plants, internal combustion engines in transport, waste incineration, and eliminating meat consumption (animal husbandry is one of the largest sources of greenhouse gases) [7].

How realistic is this in the foreseeable future? Although some eco-activists are verbally ready to give up all the benefits of civilization, no government will allow such a radical decrease in the level of well-being of the people. Of course, scientific progress does not stand still, but the goal set by the UN Secretary General is still very far from being achieved. Rather, even the realization of this goal still looks fantastic. The advanced countries that actively advocate reducing emissions are themselves exporters of coal, oil and gas. Climate agreements are still only on paper.

Even assuming that emissions can be reduced and eliminated, there is no guarantee that global warming will stop or reverse. Many scientists believe that a direct link mechanism has already been launched, when warming causes melting of snow and ice cover, which reduces the reflection of solar heat, and unreflected heat causes melting of glaciers. Both of these processes mutually accelerate each other, and warming is proceeding at an accelerated pace [8].

Industrial extraction of carbon dioxide from the atmosphere and its processing.

In 2007, British entrepreneur Richard Branson pledged a $ 25 million prize to anyone who proposes a way to extract carbonic acid from the air. Many years have passed and the question of RBC magazine: - You announced a prize of $ 25 million for the technology of re-capture of carbon dioxide from the atmosphere. Are there any successes along the way? Branson replied:

- “Approximately 8 thousand people have applied, of which we have selected a dozen ideas, which we are following with great interest. I can't say that anyone is close to winning a prize in the near future. Because one must be able to capture as much carbon from the atmosphere as the whole of Europe produces in a year, otherwise climate change cannot be stopped ”[9].

In the opinion of the author of this article, this is a vivid example of an incorrect problem setting. It is more realistic and economically more profitable to extract CO_2 from the

flue gases of thermal power plants or boiler houses, where its content is from 7 to 10%, and in the air, it contains less than 0.1%.

It looks like an attempt to catch a fox not with a trap placed near the burrow, but with many traps placed throughout the territory of its residence.

In other words, capturing CO_2 from the air will require hundreds of times more energy, while more CO_2 will be released into the atmosphere than extracted.

It must be said that the extraction of CO_2 from flue gases has long been used to obtain carbon dioxide for industrial use. For this purpose, special installations are being built, the operation of which pays off by selling commercial carbon dioxide [10].

In reality, we have a huge variety of sources of emissions from land, air, water vehicles, forest fires, burning landfills, etc. This makes extracting CO_2 from the air, in order to restore the climate, a very expensive undertaking.

Attempts to regenerate carbon dioxide, replacing oxygen atoms with hydrogen, are faced with the fact that exactly the same energy is required to reduce carbon, which was released during its combustion. The thermochemical equation of the carbon combustion reaction has the form: $C + O_2 \rightarrow CO_2 \uparrow + 394$ kJ.

The two arrows in the equation indicate that the reaction can go either forward or backward. However, the process of combustion of carbon proceeds with the release of heat, and for the reverse process, heat will be required to heat CO_2, moreover, even more heat will be required, since the reverse reaction effectively occurs only at a very high temperature.

In other words, to obtain (theoretically) 12 g of carbon from CO_2, you will need energy equivalent to burning 10 g of gasoline (the author's calculations).

However, even if climate warming itself stops, science should not stop on the path of limiting the combustion of carbon fuels, since an increase in the content of CO_2 in the atmosphere and ocean is associated with the possible acidification of water in the ocean and the death of many species of flora and fauna.

1. Implementation of the plan to plant billions of trees that will extract CO_2 from the atmosphere seems quite realistic and promising. However, there are doubts here:

At first. For extensive forest plantations, land is required, provided with conditions for the growth of trees - the presence of fertile soil, a sufficiently warm climate, the presence of rain. But all such lands have long been occupied by forests, fields, agricultural crops. This means that it is necessary to use forest clearings and unusable desert lands, for the latter, artificial irrigation is desirable, which will also require huge costs.

Secondly. In a few decades, trees will age, and timber will become a potential source of greenhouse gases in the event of rotting or burning. Already, some parts of the Amazon forest have begun to emit more carbon dioxide than to absorb [11]. Drought and heat are believed to be the reason.

As you can see, the reality of this point is questioned by the fact that the existing forests are being cut down at an accelerated pace, and they only talk about planting new forests.

From the point of view of a technologist who realistically evaluates the feasibility and effectiveness of projects, the following conclusion can be drawn:

- Since the process of extracting carbon from the atmosphere is already effectively carried out by nature during photosynthesis (the absorption of CO_2 by green plants under the influence of sunlight with the release of oxygen), then one should not invent new, elegant, but useless technologies, but simply help nature. For example, the same flue gases from thermal power plants, containing not only carbon dioxide, but also nitrogen oxides, can be used as fertilizer for fast-growing algae or phytoplankton. And there are reservoirs for cooling water near every large power plant. The resulting biomass can be used for animal feed or stored.

Will renewable energy save us?

The issue of switching to renewable energy sources should be considered separately. Undoubtedly, wind and solar energy has a great future. However, there are also problems [12].

- instability of electricity generation, depending on the weather and time of day, which requires the creation of reserve capacities from traditional energy sources;

- possible environmental and humanitarian problems. People do not want to live next to huge wind turbines because of the constant noise and possibly dangerous infrasound radiation. In addition, accidents occur on turbines, blades break off from them, which weigh up to 30 tons. Birds often break on the blades of windmills and burn up in the rays of solar mirror-type power plants [13, 14].

- low energy density of the sun and wind. Solar power plants require huge areas and occupy, among other things, land suitable for agriculture.

But despite the problems, solar and wind energy shows constant growth.

When discussing carbon-free energy issues, it seems that sun and wind are the main alternatives to using fossil fuels. However, a much larger contribution is made by hydroelectric power plants, the installed capacity of which is several times greater than that of solar and wind power plants. In addition, one should not forget about nuclear power plants,

which occupy a dominant position in the electric power industry of many countries and also do not emit CO_2 into the atmosphere.

Having carried out simple calculations, it is easy to make sure that with an annual increase in the commissioning of new renewable energy capacities by 20%, it will be possible in 10 years to generate all modern electricity on a carbon-free basis.

But in addition to power plants, there is transport, which also emits carbon dioxide, and its conversion to electricity will require the construction of a huge number of new power plants. The transfer of air transport to electric energy, in general, does not seem realistic yet.

In addition, when compensating for the installed capacity of a power plant, we do not take into account the fact that each power plant also provides heat, which heats tens of thousands of homes. So it is necessary to transfer them to electric heating. This will require huge funds.

It will be necessary to solve the problem of accumulating electricity. So far, even the most advanced TESLA batteries [15] are twenty times inferior in energy capacity to gasoline.

It looks like the prospect of zero energy is being pushed back into the 2050s.

The question is, do we have a time until 2050. Carbon dioxide is inert and can exist in the atmosphere for decades. And already its current concentration is accompanied by sharp climate changes. If ice melts on the poles, permafrost melts in the Siberian tundra and methane freezes there, the heated ocean will release dissolved CO_2, then no look at the efforts to limit industrial emissions. carbon dioxide, in 2050 we may have a greenhouse effect that will have unpredictable consequences for life on Earth [16].

How to save the planet from overheating?

So far, there are no sufficient grounds to believe that the victory over anthropogenic carbon dioxide will be effective in the case of a simultaneous increase in its emission from warming up the water in the ocean. And the increase in the temperature of the water in the ocean is recorded constantly [17]. Therefore, if you stop or stop heating the surface of the land and ocean, you can get a temporary head start on the fight against carbon dioxide.

Let's look at the problem through the eyes of a technologist.

How does carbon dioxide interfere with the removal of excess heat from the surface of the Earth, and where does this heat come from on our planet?

Let's imagine that the Earth is a greenhouse, and the atmosphere is transparent glass. Glass, like CO_2 in the atmosphere, does not allow thermal (infrared) rays to pass outside the greenhouse heated by the sun. If an excessive temperature rise occurs in such a greenhouse, then you can open part of the glass and release excess heat outside the greenhouse. With the

Earth, this will not work. Another method is to close part of the glass from the sun's rays, thereby reducing the flow of heat from the outside. But this method will reduce the lighting and the plants will receive less light, respectively - the yield will decrease.

The main source of heat on Earth is the Sun. Reducing the supply of solar energy to our planet could remove the problems with climate warming. There are two ways to do this:

1. Shield part of the Earth's surface from the sun's rays (for example, by increasing cloud cover, dusting the atmosphere, or creating a "space umbrella") [18].

2. Reflect part of the solar energy by mirrors installed on the surface of the earth or water.

The first path is expensive and fraught with unpredictable consequences. The second path is partially carried out by nature with the help of snow and ice cover in the polar regions, reflecting up to 90% of the sun's rays. But the planet is losing the area of glaciers, and that part of the solar heat, which was previously reflected by them, remains, causing an increase in air and ocean temperatures.

The second way is closer to natural, real and economically viable in comparison with the fight against CO_2. The fact is that mirrors reflect solar energy hundreds of times more efficiently than it is removed by the thermal radiation of the earth. And for visible light reflected by mirrors into outer space, there are no barriers from greenhouse gases.

Our project called "REFLECTION OF THE PLANET" is to controllably reflect some of the sunlight into space, for which we set the fields of mirrors in desert areas, near the equator, where the solar energy density is maximum. Orient the mirrors in the direction of the sun's rays to reflect the light into the sky. Fields of mirrors in desert areas or on platforms in the ocean do not bode well for nature. On the contrary, they suggest many positive effects for nature and people. By using retroreflection instead of light reflection, you don't have to worry about the orientation of the panels.

The location of reflectors in the tropics will become several times more efficient than glaciers in the polar regions, due to the reflection of direct, rather than oblique rays of sunlight.

Thus, it is possible to regulate the flow of heat to the Earth by installing or removing reflectors. It is clear that efforts to create reflectors will be proportional to the reduction of heat flow, in contrast to the fight against carbon dioxide, the effectiveness of which is indirect and not confirmed by human experience.

This proposal, in contrast to the requirements for the reduction of carbon-based energy, does not lead to the shutdown of the business, but, on the contrary, will create new jobs for

the construction and installation of reflectors. In addition, when the need for mirrors disappears, the panels can be used to install solar modules to generate electricity.

Perhaps those activists are right who urge not to spend billions on a flight to Mars, but to deal with warming on Earth.

Yes, this will require a lot of effort and resources, but if we really want to fight, and not imitate the fight against global warming, I consider it necessary to discuss and implement this proposal.

Read more in the author's publication "Stop Global Warming"[19].

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