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Global Energy and Temperature Balance, Greenhouse Effect and Comparison of Scenarios of Influence on Temperature Increase

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ABSTRACT
The article considers the simplest and most indicative correlations between greenhouse gas emissions (primarily energy and transport) and global temperature rise. Their contributions to the global greenhouse effect are shown. It is shown that, when taking as a determining, not annual, but cumulative emission, the difference in the final effect - an increase in the temperature of the earth, for various ways of developing energy and transport (RES vs. conventional energy, electric transport vs. transport on hydrocarbon fuel, etc.) is extremely small and cannot be the base for choosing methods of reducing the rate of climate warming.

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Introduction
Weather anomalies outside the window, the 2021 Nobel Prize in Physics for research on climate and the effects of carbon dioxide on warming, the strategic plans of many countries, the avalanche of pages of the media, the Internet, scientific reports, plans of the largest companies, overloaded with the energy climate agenda - all this requires that sometimes simple estimates based on primary data and their understandable connections, (and not myths wandering from source to source, simulacra and expert opinions) updated and clarified the understanding of the situation in its most basic moments.

At present, the indisputable but dominant view is that climate change and, in particular, the increase in temperature in recent decades, firstly, are associated with human activities, and, secondly, this temperature imbalance can lead to critical consequences.

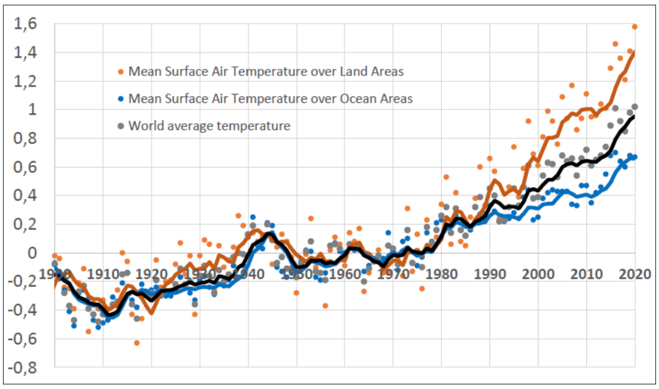

Figure 1: Global Land and Ocean Temperature Index

Hence the issues that, as recent events have shown, require a clear analysis and responsible solution.

Should we do something? What exactly should I do? The result? How much will it cost?

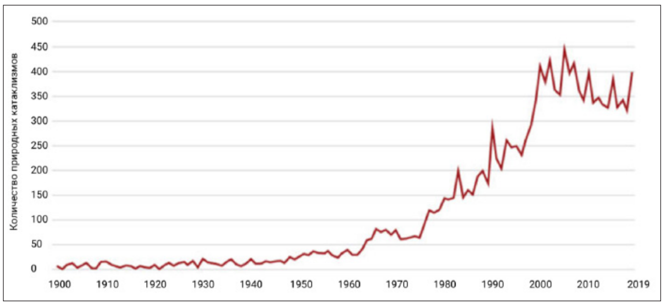

Figure 2: Increase in the number of natural disasters in the World 1900-2019. Includes: droughts, earthquakes, volcanic activity, storms, floods, forest fires and extreme temperatures [1]

If we do not answer these questions, we will become witnesses, participants and culprits of the growth of natural disasters in the World, the pronounced dynamics of which since 1975 is demonstrated by Figure 2.

Background
The amount of carbon contained in the atmosphere in the form of carbon dioxide, its amount in the oceans, and the fluxes produced by various natural and anthropogenic sources are shown in [2]. Each year, green plants absorb approximately 100 billion tons of carbon from the atmosphere during photosynthesis and growth. (This corresponds to an average productivity of 20 c/ha of green mass by 10% ofthe international surface). Approximately the same amount of carbon is released each year back into the atmosphere when green plants are consumed by secondary consumers, their chemical decomposition, forest fires and other natural causes. The total amount of carbon in biomass, including soils, is estimated

to be about 2200 billion tons, which corresponds to an average lifespan of about 20 years (close to the lifetime of a tree). The food chain of the human-pig-grain community adds only 1 billion tons per year to the balanced carbon cycle. Plankton and other ocean plants living at depths of up to a hundred meters, where sunlight penetrates and where photosynthesis reaction is possible, exchange with the atmosphere about the same amount of carbon, 90 billion tons per year, as terrestrial plants [3]. The ocean contains a huge amount of carbon - about 40,000 billion tons, in the form of carbon dioxide dissolved in water at great depths, but the exchange between the surface and the deep layers is very slow. Such an exchange has a characteristic time of 500-1000 years and at the current concentration of carbon dioxide in according to modern estimates, the atmosphere provides pumping about 2 billion tons of carbon per year.
Geological sources of carbon dioxide are not large. For example, the source of CO_2 from volcanic activity and erosion of geological structures supplies the atmosphere with only 0.1 billion tons of carbon per year, which is much less than biogenic fluxes.

Total anthropogenic emissions were 5.54 billion tonnes of carbon (or 20.3 billion tonnes of CO_2) in 1990 and 10.5 billion tonnes of carbon (or 38 billion tonnes of CO_2) in 2018.

Subject of analysis
Since it is assumed that the increase in averagetemperatures in the World is determined by the total anthropogenic emission of greenhouse gases1, and that, in turn, is the world energy balance, it makes sense to analyze the world balance, and not particular regional cases, to calculate the effects.

Within the energy balance itself, it is relevant to compare the scenarios:
- Fuel change scenario from coal (~3.8 tonnes of CO_2/toe2) to less carbon dioxide (~2.2 tonnes OF CO_2/toe)
- The scenario of changing carbon fuel (coal, gas) to renewable energy sources.

Source data
The analysis is based on primary data on energy consumption from various energy resources, given by the World Energy Agency in the dynamics of 1990-2018, available from open sources [4]. The initial tables of the IEA since 1990 are as follows [5].

Table1: The structure of the world's energy balance in Ktoe (thousands of tons of oil equivalent). 1990 year.

	Coal	Crude oil	Oil products	Natural gas	Nuclear	Hydro	Wind, solar, etc.	Biofuels and waste
Production	2222701	3241549		1687399	525520	184064	36571	903428
Import	335327	1634762	585465	436948				1004
Export	-343047	-1573769	-648282	-435564				-365
Changes in inventories	5605	-11945	5432	-26596				95
Fuel and energy complex	2220587	3290597	-57385	1662187	525520	184064	36571	904162
Translations		-88219	96216					
Statistical differences	-25476	-734	-3654	14346			88	-218
Power plant	-954406	-28752	-233792	-218247	-516434	- 184064	-32307	-17234
CHP	-192467	-1517	-74015	-256953	-9086		-535	-35367
Thermal installations	-70482	-213	-41794	-106783			-430	-6351
Gas processing	-3684		-5064	2713				-32
Oil refining		-3171065	3114390					
Coal Transformation	-152102	232	-3190	-241				-104
Liquefaction plants	-14224	5457		-2255				
Other conversions		19613	-19910	-653				-46640
Own use of the energy industry	-40920	-7566	-175705	-126803				-6924
Loss	-15087	-6919	-867	-22902			-6	-333
Total final flow	751739	10913	2595230	944409			3382	790960
Industry	456462	2906	328705	362133			129	110658
Transport	9389	21	1482403	56612				5900
HOUSING	153007	106	196212	274851			2339	639538
Commercial and public services	51535	4	93908	116084			299	11427
Agriculture / Forestry	14320	2	104939	7515			58	5603
Fishing	39		5819	2			6	3
Other	40991	230	28528	38194			550	17832
Non-energy use	25995	7644	354716	89018				

Total CO_2 emissions can be determined, taking into account the coefficients both given in the literature and those obtained from the analysis of emission data also reported by IEA.

Table 2: Specific emissions of different types of carbon fuels

Carbon fuel		Tons of CO_2/toe
Coal	Coal	3,84
Crude oil	Crude oil	2,57
Oil products	Petroleum products	2,57
Natural gas	Natural gas	2,15
Biofuels and waste	Biofuels and waste	3,84

Base for predicting temperature changes

The prediction of temperature change is based on a rather simplified, but nevertheless quite correct assumption of the linear dependence of temperature on the concentration of CO_2, and the concentration of CO_2, in turn, on the total (cumulative) release of CO_2, including:

- Natural, fairly balanced release and absorption of CO_2 as a result of natural processes at the level in 2018 367 billion tons (100 billion tons of carbon) per year.
- And anthropogenic generation at 38.5 billion tonnes (10.5 billion tonnes of carbon) per year.
- Since the temperature deviations are 3-5°K from the average temperature at the level of ~ 290°K (1-2%) and the change in emissions (under the assumption of the balance of natural emissions and the increase in the concentration of CO_2 only due to the anthropogenic factor (5%), the assumption of a linear relationship reflects the correlations on these small deviations quite well.

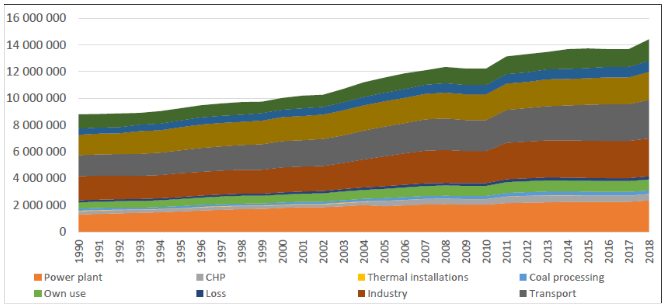

Figure 3: Structure of primary energy consumption, 1990-2018, ktoe

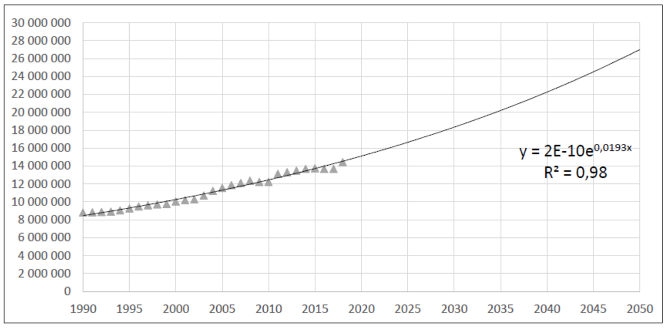

Figure 4: Total Primary Energy Consumption, Statistics and Forecast, ktoe

The overall forecast with a growth rate (historical and forecast) of ~1.9% per year corresponds quite well to the correlation between the dynamics of world GDP and total energy consumption with an average GDP rate of [6] 3.1% per year and an elasticity coefficient of 0.61. This also coincides with the detailed analysis and forecast given in the monograph "Macroeconomics and Electricity of the World. Status and Prognosis 1970-2017-2050"7.

Summary of the assessment model

The figures present historical data (NASA, etc.) on such parameters as: Cumulative CO_2 emissions, CO_2 concentration in the atmosphere, and temperature increases across the World. On this basis and clearly traceable interdependencies, it is possible to determine the basic correlations and their prediction - up to temperature dynamics.

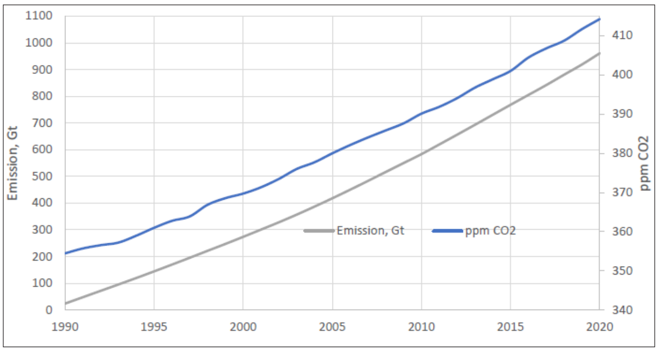

Figure 5: Cumulative Emissions and Concentrations of CO_2. Historical Data

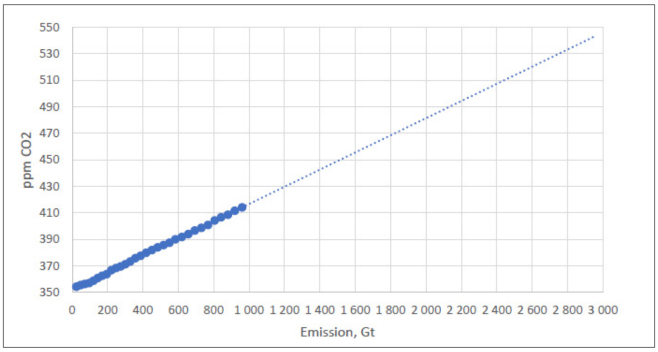

Figure 6: Cumulative Emissions and Concentrations of CO_2. Correlation and Prediction

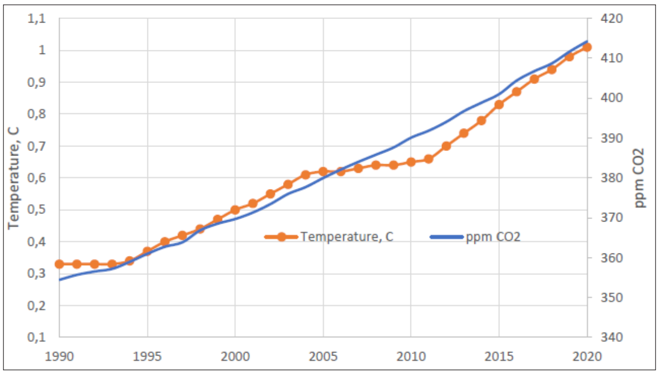

Figure 7: Average Earth Temperature and CO_2 Concentration. Historical Data

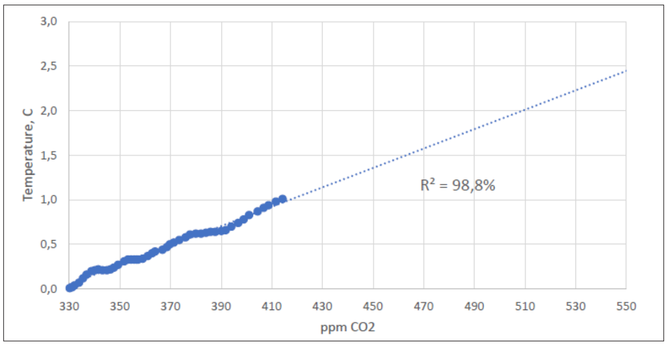

Figure 8: Increase in CO_2 concentration and increase in the average temperature of the Earth.
Correlation and Prediction

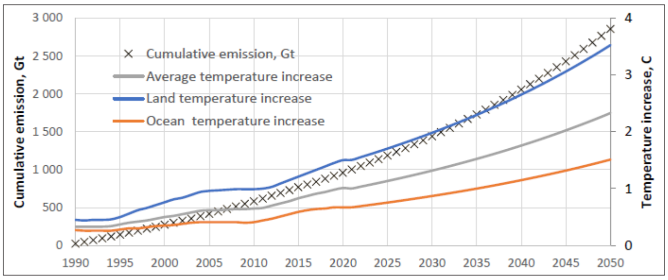

Figure 9: Cumulative emissions of CO_2 and temperature increases. fact and express forecast (coincide with most forecasts) CO_2 emissions and concentrations are not the only reason for the greenhouse effect and temperature increases. However, the concentration of CO_2 allows us to assess the dynamics and relationship between the anthropogenic factor and the increase in the temperature of the Earth.

Forecast of the structure of energy consumption in all areas (energy, industry, transport, etc.)

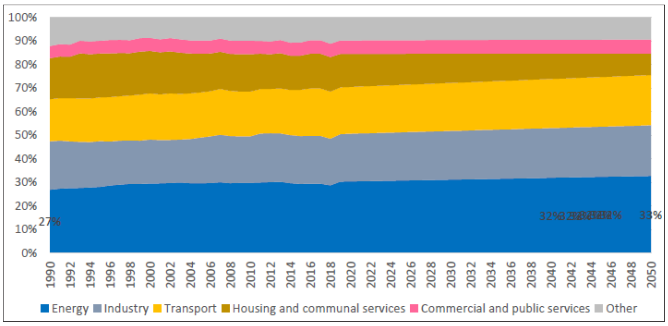

Figure 10: Structure of primary energy consumption by directions, statistics and forecast

As can be seen from the figure, the structure of consumption in this segment is quite conservative. Changes are units of percent. However, ihave noticeably increased the weight of energy and a decrease in the share of housing and communal services in the overall balance.

Accordingly, taking into account the carbon coefficients (Table 2), the structure of annual CO_2 emissions is as follows:

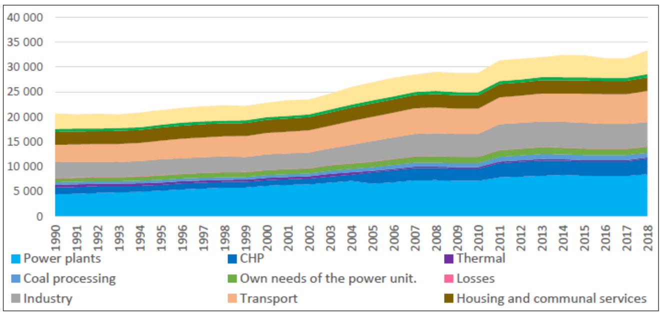

Figure 11: Dynamics of annual emissions of CO_2, million tons

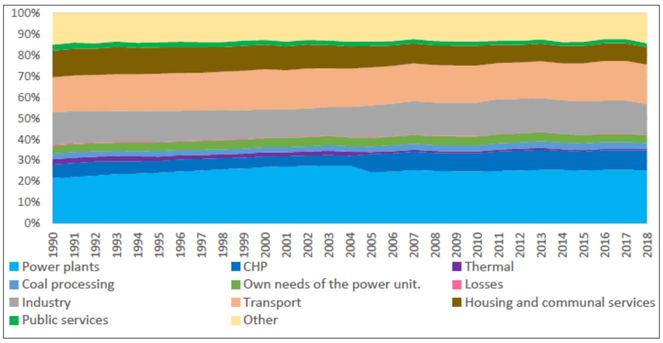

Figure 12: Dynamics of the structure of annual CO_2 emissions
Or, moving on to annual, cumulative anthropogenic emissions

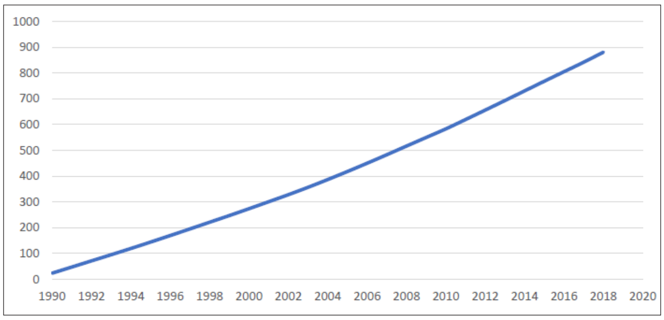

Figure 13: Total anthropogenic cumulative CO_2 emissions, Gigatonnes

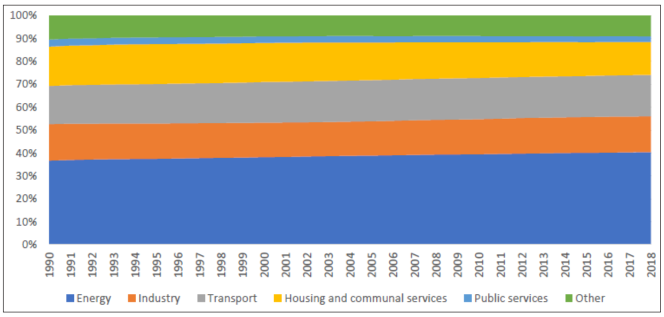

Figure 14: Dynamics of the proportions of energy and other cumulative emissions of CO_2

As can be seen from the final graph, the proportions of the emission structure are extremely conservative and, despite the overall increase in emissions as a whole, the contribution of aggregated energy emissions to total emissions remains at the level of 36-39%.

As a preliminary conclusion, even if we exclude the carbon footprint of the entire fuel and energy complex, then from the estimated total increase in temperature by 2-3 degrees, we will benefit only 0.7-1.2 degrees. At the same time, long-term linear trends make the analysis more transparent and stable.

Forecast of the energy structure in the conservative scenario
In the energy sector, carbon and carbon-free generation contribute to total energy consumption, but only energy using combustible fuels has the potential to reduce emissions. This intra-energy structure, based on the IEA data, looks like this:

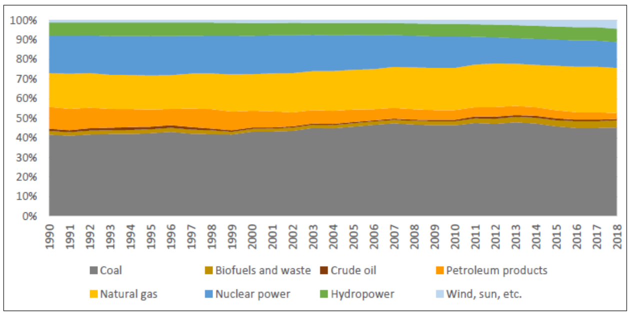

Figure 15: Dynamics of proportions of energy emissions CO_2

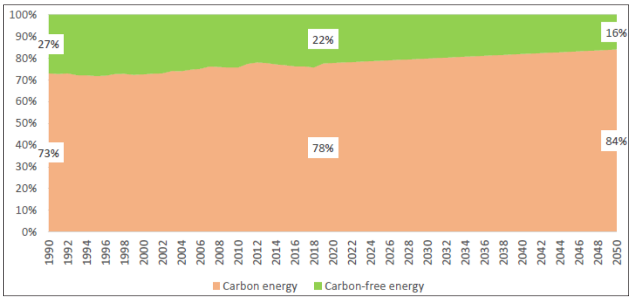

Figure 16: Dynamics of CO_2 emission proportions - carbon and carbon-free energy. Statistics and forecast in the inertial scenario

At the same time, the overall increase in the share of carbon energy in the balance sheet (by 11%) due to carbon-free, primarily nuclear energy, looks rather paradoxical - more than 6% Thus, the total resource for reducing the carbon footprint of energy in total emissions is approximately 37% * 84% = 31%. Of these, the scenario of changing fuel from coal (3,755 tons of CO_2/toe) to gas (2,167, tons of CO_2/toe) concerns only the relevant components of the fuel balance of the energy sector itself.

The figure below shows both the historical trend and the forecast of fuel proportions under a completely inertial scenario - without transforming the structure of carbon energy. The stability of the trends of 1990-2018 in this case gives reason to extend them for the next 30 years. The most noticeable dynamics is in a rather inactive increase in the share of gas (from 24% to 31%) due to a decrease in the share of petroleum products (from 15% to 4%) with a slight increase in the share of coal.

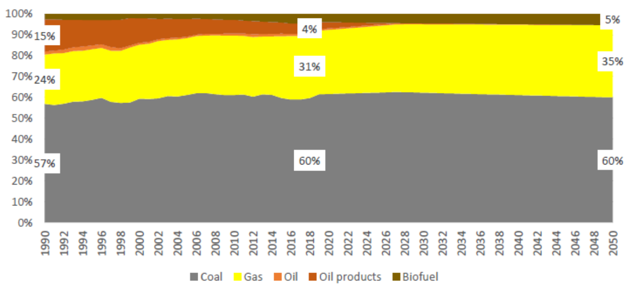

Figure 17: Dynamics of proportions of CO_2 emissions of carbon energy by type of resources. Statistics and forecast in the inertial scenario

Preliminary assessment of temperature effects in the energy sector
Thus, of the total energy resource for reducing emissions of 31% (in the event that it becomes carbon-free at the expense of renewable energy sources, or nuclear energy), the total resource for reducing emissions by replacing coal with gas can be up to 20% of the total emissions. This is the main resource for reducing the carbon footprint of the energy industry - primarily in terms of electricity generation.

Accordingly, if it is necessary to reduce the entire anthropogenic emission, leading to 3a temperature effect of 2-3 degrees, a complex and technologically costly "decarburization" of the entire energy sector will give **0.6-0.8** degrees, and a fairly simple classical fuel change to **0.4-0.6 degrees**.

This is not critical, but a fairly large part of the overall effect. At the same time, the difference between the scenarios of renewable energy and classical energy (NPP, TPP, HPP) is insignificant. For example, as can be seen from the figure above, **the total transport resource will also give about 20%** of the temperature reduction with **a full** conversion to carbon-free fuels (the works of the IEE show the potential share of the transfer of transport to electric and hydrogen cars ~ 30-40%, by 2050 or, in accordance with the above logic - 0.1 degrees). The resource of the entire industry is only 15% or ~0.3-0.4 degrees.

Scenarios for reducing the carbon footprint: inertial, "replacement of coal for gas", "replacement of coal and gas with renewable energy sources". Balance of natural gas

The structure of primary energy carriers is not regulated specifically and its dynamics corresponds to natural trends (for example, a slight increase in the share of the fuel and energy complex in the emission balance, etc. At the same time, the total gas consumption by 2050 in a conservative forecast , it may be 95.6 trillion cubic meters or 48% of the proven explored volumes of ~ 220 trillion cubic meters, of which the owners of which are in the top five countries - Russia (~50 trillion cubic meters), Iran (34 trillion cubic meters), Qatar (25 trillion cubic meters), the United States (15.5 trillion cubic meters) and Saudi Arabia (9.2 trillion cubic meters). This is 2/3 of all reserves.

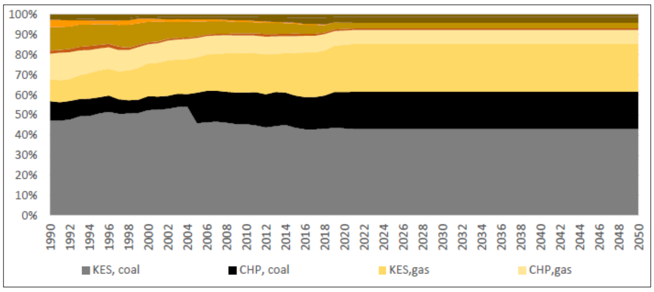

Figure 18: The structure of energy carriers in the inertial (conservative) scenario. Statistics and Forecast

The transition of electricity generation from coal and gas to renewable energy sources, In this scenario, a model of a sharp transition in 5 years of all coal and gas power generation to carbon-free (renewable, nuclear) sources of electricity is assumed. At the same time, coal-fired CHP plants are converted to gas to reduce the carbon footprint, since renewable energy sources are not quite well suited for heating.

Almost such a transition is impossible. But, as an extreme option, it demonstrates the framework of effects well.

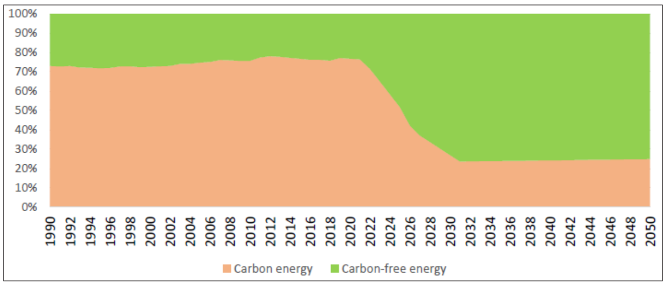

Figure 19: The structure of energy in the transfer of electricity generation from coal and gas to Renewable energy sources

The transition from coal to gas. This is a spent and relatively low-capital-intensive method. The model allows for a wide range of changes and accounting for parameters. In this scenario, as the most preferable, the following are calculated: the transition in 4 years of 50% of the KES to CCGT, 50% of the KES - the replacement of furnaces from coal to gas and 100 replacement of furnaces of coal-fired CHP plants with gas ones. At the same time, the efficiency of the steam power cycle is 35%, combined- cycle gas - 57%.

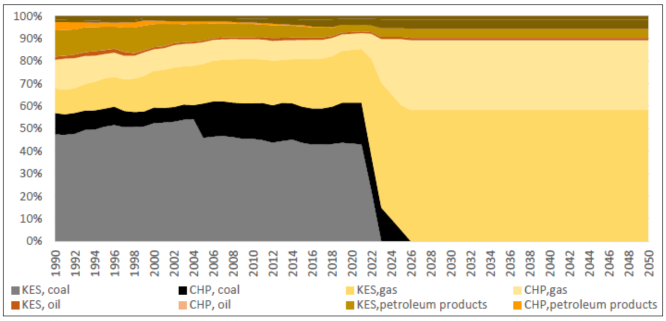

Figure 20: Structure of energy carriers in the transition from coal to gas

At the same time, the limitations of the model are not exceeding the proven gas reserves by 2050. In this case, its **total consumption is 79% of the proven reserves (220** trillion m3). In general, gas reserves are much larger. Table 3 shows this.

Table 3: Comparison of world hydrocarbon reserves [8].

Type of raw material	Proven reserves	Projected Resources
Conventional hydrocarbons		
Gas [9]	220 trillion m3	460 trillion m3
Petroleum	180 billion tonnes	370 billion tonnes
Coal	700 billion tons	18 trillion tons
Total, billion t.o.t.	about 1200	up to 20 000
Unconventional hydrocarbons		
Shale gas	200 trillion m3	330 trillion m3
Shale oil	47-55 billion tons	
Tar sands oil [10]	400 billion tons (only in Canada and Venezuela, excluding other deposits)	
Coal Seam Methane [11]	260 trillion m3	
Oil shale [12]	450 trillion tons of oil shale (equivalent to about 26 trillion tons of shale resin)	
Total (without gas hydrates)	25 000-30 000 billion t.c.c.	
Gas hydrates	up to 15,000 trillionm^3 (up to 17,000 billion tonnes of fuel equivalent)	

According to other data, the projected reserves of shale gas are 760 trillion cubic meters, proven, according to the American agency EIA, - 187.5 trillion cubic meters. The largest shale gas deposits are owned by KRN - 19.3% of world reserves, the USA - 13%, Argentina - 11.7%, Mexico - 10.3%, South Africa - 7.3%, Australia - 6%, Canada - 5.9%.

At the same time, in the inertial scenario, **~46%** of proven gas reserves can be consumed (from 220 trillion m3, in the scenario of switching to renewable energy sources **~38%**,, in the scenario of changing coal to gas ~79%. Taking into account other resources, for example, shale gas, this share decreases several times. Thus, despite the fact that in all scenarios the consumption is quite significant, the increased gas consumption will definitely not lead to a critical exhaustion of its resources in the horizon of 2050.

Results of carbon dioxide emission calculation

It should be emphasized that this analysis is focused only on the replacement of primary energy resources in the energy sector (coal for gas, KES for CCGT and RES, CHP from coal to gas), as the

most priority (in public discussions) malicious polluter of the environment, and do not affect contributions to the emission of transport, industry, housing and communal services, etc., occupying, nevertheless, up to 70% of total emissions. . At the same time, alternatives to the classical change of fuel (coal, which occupies, for example, most of the balance of Europe) to less carbon (gas) and the fashionable total replacement of conventional generation with renewable energy sources are compared.

The total volumetric indicators of consumption and production, as well as the final temperature effect, will determine the price of the issue and what exactly it will have to pay for.

In accordance with the consumption of carbon-containing energy carriers in each component of the balance (coal, gas, etc.) and Table 2 .Specific emissions of different types of carbon fuels from 1990 to 2050 are calculated in these scenarios.

As shown above, the desired effect of temperature increase correlates with the concentration of carbon dioxide, which, in turn, subject to the stability of natural factors of its generation and absorption, directly correlates with the value of the total cumulative anthropogenic emission.

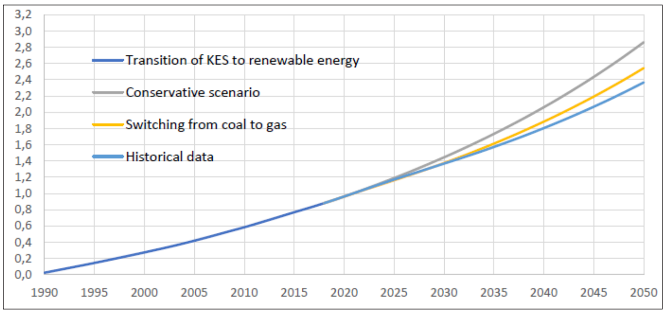

Figure 21: Total cumulative CO_2 emissions under different scenarios, trillion tonnes

Prediction of temperature effects

The correlation between total CO_2 and temperature is clearly visible in the graph below, which is based on calculations of total cumulative anthropogenic emissions. and according to the IEA data (see above) and NASA data on the change in land temperature [13].

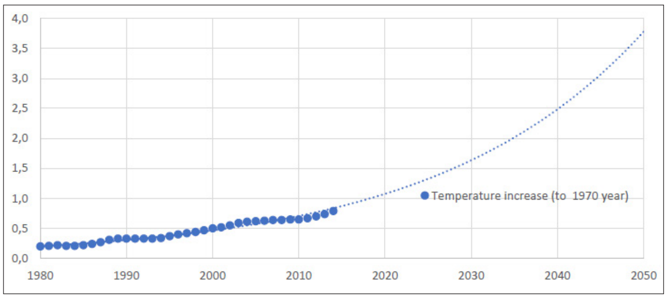

Figure 22: Statistics and prediction of temperature effects in a conservative scenario

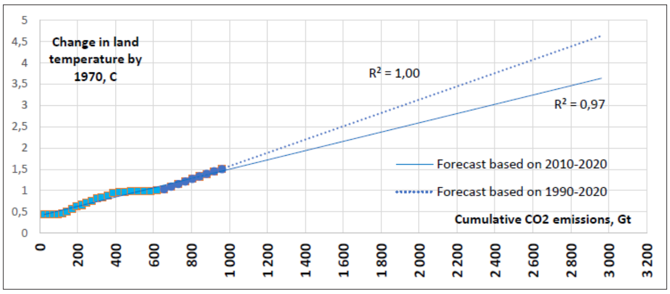

Figure 23: Final options for the correlation between cumulative CO_2 emission and temperature change

The correlation based on the dynamics of the last decade gives a higher growth rate than the base of 1990-2020, with an almost perfect linear relationship, but is based on a smaller base. Nevertheless, the level of interdependence of energy emissions and temperature change of 97% also allows for fairly correct estimates.

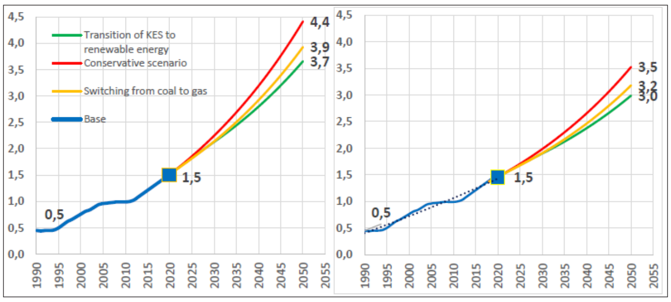

Figure 24: Predicting temperature changes in different scenarios

Realistic scenarios for energy development

When accepting the initial prerequisites for CO2 emissions and the structure of the electric power industry in 2020: electric power industry - 40% of emissions of total CO2 emissions, Fuel energy - Coal

- 60%, Gas - 30% and so on (oil products, etc.) - 10%.;
- Analysis and evaluation of more detailed and realistic scenarios were carried out:
- Conservative - the existing trends in the dynamics of the structure of the fuel electric power industry remain unchanged until 2050.
- Innovative - reducing the share of electricity production at coal-fired power plants by 2 times and replacing it with gas-fired TPPs. The share of coal-fired power plants is 30%, and gas-fired power plants is 60% by 2050 (for fossil fuel power);
- Ultra-innovative - the transition from coal to gas to CHP (heat is needed), and the complete replacement of coal and gas KEPs with renewable energy sources (~ 80% of generation). They showed, in particular, that when:
- Smooth by 2050 the share of electricity production at coal-fired TPPs to 30% and its replacement by gas-fired TPPs is 60%.

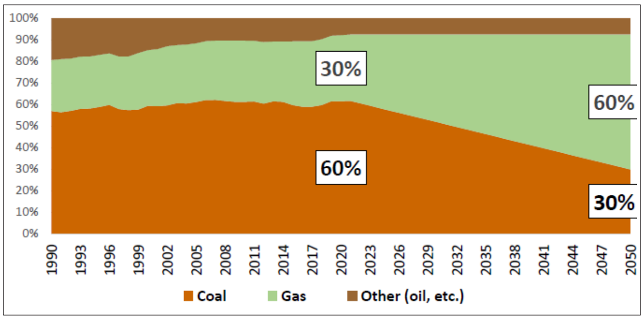

Figure 25: Fuel energy balance of 2020: coal-60%, gas-30%, other (petroleum products, etc.) - 10%

CO_2 emission balance of 2020: coal ~70%, gas ~21%, other (oil, etc.) ~9% and a linear reduction in fuel consumption due to coal by 2 times by 2050 (by ~30%).

The gradual transfer of this part of fuel generation to gas will lead to a reduction in the Cumulative emissions of coal-fired generation by 7% (*70% / 2 / 2 * 40%*) of total emissions compared to the inertial (conservative) scenario. The share of emissions of gas generation will increase by ~ 3%, since gas has 2.3-2.5 times lower specific emissions. A total of 7% - 3% = 4% - is a reduction in CumulativeCO_2 emissions from the transfer of half of coal generation to gas.

With a general temperature increase of 2-2.5 °C, the effect of the entire event will be no more than 0.1°C. With a term of up to 2050, the annual effect would be ~0.003 °C per year. This is an imperceptibly small amount.

Transport development

A simplified assessment of the contribution of a possible transport restructuring to reduce emissions was also carried out.

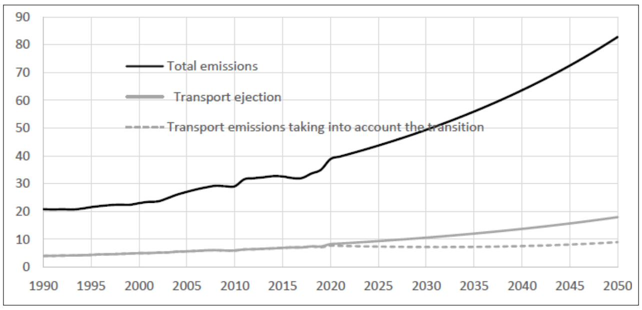

Figure 26: Annual CO_2 Emissions, Gigatonne

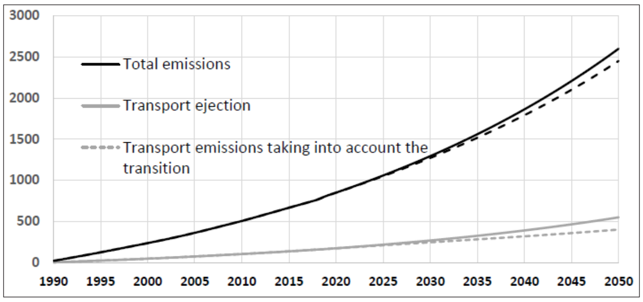

Figure 27: Cumulative CO_2 emissions, Gigatonne

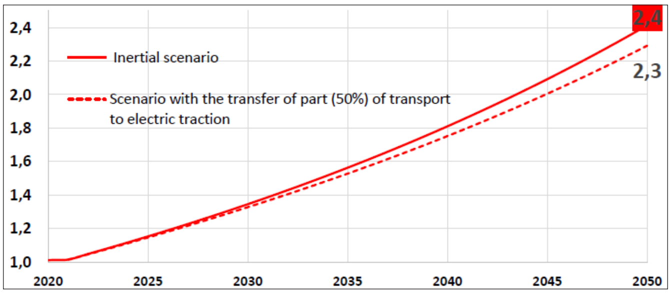

Figure 28: Temperature increase during the transfer of vehicles to electric vehicles and without it

With the share of transport emissions in 2020: ~ 16% in total emissions, a linear reduction in transport fuel energy consumption by 2 times (by ~8%) by 2050 and a gradual transfer of this part to electric traction will lead to a reduction in Cumulative transport emissions by 4% of total emissions compared to the inertial (conservative) scenario. With a general temperature increase of 2-2.5 ° C, the effect of the entire event will be no more than 0.1°C. With a term of up to 2050, the annual effect would be ~0.003 °C per year. This is also an imperceptibly small amount.

Results and conclusions

As the calculations show, by 2050 in the inertial (conservative) scenario, it is possible to predict an increase in temperature by 3.5-4.4 degrees by 1970 or by 2-2.9 degrees to the current state. This value is an indicator of the target effect.

At the same time, the transfer of electricity generation from coal and gas types of generation to renewable energy sources can give, respectively, **0.5-0.7** degrees as part of reducing this effect (~ 25%), and the transition from coal to gas (by replacing the steam-power cycle with a more efficient combined- cycle and changing coal fuel to gas, which has almost 2 times less specific CO_2 emission) - **0.30.5**- degrees (~ 16%).

These estimates coincide well with the preliminary estimates above. The difference of 0.1 degrees is due to a more detailed accounting of the structure of the KES / CCGT / CHPP and the consumption of the 3rd type of energy resources-petroleum products, which occupy a small but significant share in generation.

At the same time, the difference in estimates of the integral target effect in the range from 1.5 to 3.5 degrees practically does not affect the share of energy in it and its temperature effects.

Thus, **the difference in the effects** of the scenarios of a complete change in the type of resources in the electric power industry to the energy sector "coal is exchanged for gas" and "coal / gas is exchanged for renewable energy sources" **is less than 10% of the total target effect**, if as such we consider the non-increase in the current temperature relative to the current state.

Which country is the main reserve for reducing emissions?

The table below presents the specific emissions of electricity generation of the countries of the World in 2020.

Country	India	China	Japan	Germany	USA	Russia	EU-28	World
Specific emission of the entire generation, kg OF CO_2 per 1 kWh	0,653	0,646	0,493	0,438	0,414	0,338	0,283	0,480
Specific emission of fuel generation, kg CO_2 per 1 kWh	0,946	0,966	0,677	0,808	0,679	0,536	0,692	0,760
Share in global power generation	7%	27%	4%	2%	16%	4%	12%	100%
Share of emissions in global electricity generation	10%	36%	4%	2%	14%	3%	7%	100%
1% of global electricity generation accounts for % of emissions in global electricity generation	1,43	1,33 %	1,0 %	1,0%	0,88%	0,75%	0,6%	

At the same time, it is clearly seen that India and China have the greatest potential (in total, 46% of emissions). The U.S. accounts for 14% of emissions. Other major energy countries (Russia, Japan, Germany, Europe as a whole) have much lower emission levels.

With India's per capita electricity consumption rising to the global average (from 1208 to 3081 kWh/person per year), India and China (while maintaining their energy mix) could account for up to 56% of global emissions. This is more than 2 times higher than the entire potential of the United States, Europe and Russia. Therefore, their contribution to climate stabilization will be almost imperceptible even with the complete "greening" of their entire energy sector.

Conclusion

The use in many of the submitted materials of the annual (or its changes) emission indicators instead of the Cumulative (cumulative) emission gives a completely distorted assessment of the influences of various factors on the change in the Earth's temperature due to the greenhouse effect.

This is logical, since physically there is the most direct relationship between the concentration of CO_2, as the main factor determining the thermal transparency of the atmosphere, (and, consequently, the flow of heat transfer) and the change in temperature, directly dependent on this flow. That is, the greenhouse effect.

There are more complex models that take into account many other factors, as well as their interaction. However, as shown above, linear dependencies in the intervals of decades are quite adequate and conservative.

At the same time, a more physical integral approach, it turns out that the contribution of energy and transport to annual emissions (the most hyped and emphasized today) is in itself, of course, noticeable. However, under various scenarios for the development of these particular emission sources (conservative scenario, electrification of transport, accelerated transition to renewable energy, change of coal to gas, etc.), the difference in the final target indicator of the success of these scenarios - temperature effects - is extremely small.

Of course, in this regard, it makes sense to reassess the actual ways to minimize the level of climate warming. And, in any case, it is necessary to adjust their geography in accordance with the individual contributions of countries to the overall effect, the same for the whole planet.

Green technologies in electricity generation and transportation are the technologies of the future. However, their potentialand role in the regulation of greenhouses is extremely smalland - tenths of a degree for the entire period up to 2050. Accordingly, the total annual effect (thousandths of a degree on a global scale and ten-thousandths - for most countries) is negligible. And control is absolutely impossible.

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