LIMITS TO GROWTH – CHANCES FOR DEVELOPMENT.

Global Challenges and the Long-term Outlook of Global Development (ODNAKO journal)

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We need a ruthless understanding of reality, no matter how terrible it is, or else we'll be simply excluded from history.

Alexander Zinoviev

The authors became interested in the topic "Global challenges and threats of the first half of the 21st century" in the middle of 2010. The study of long-term trends had been started in the "Rostock Group" company as a search of technologies and solutions of a question "how to make the future world a better place?" We were searching for medical and biotechnologies, which could help to avoid aging, cure fatal diseases, but while working with a variety of sources we have noticed issues and risks that could lead to global catastrophes.

We have studied most of published surveys from organizations (the UN, the World Bank, industrial and consulting companies) and independent researchers (V. Smil, D. Meadows, E. Lovins, L. Brown and many others), have met many of them personally or entered into correspondence. From the very beginning our motives and interests were guided by a practical approach and questions like 'What should we do to change the situation?' 'Which solutions are capable to deal with the problems?' This article represents our vision of global issues and challenges.

Exponential Growth

Surveys vary widely in their estimates of the future, starting from a complete prosperity of technological civilization and to doomsday warnings.

The most famous study addressing the prospects of development of our civilization is 'Limits to Growth'. In 1972 a research group from MIT consisting of spouses Dennis and Donella Meadows, Jorgen Randers and William W. Behrens III has issued a report 'Limits to Growth' on request of the Club of Rome. The main conclusion of it was that we live on the Earth in a physically limited world (resources are finite, as well as our ability to recycle wastes), that's why following a model of continuous growth is harmful, soon or late the humanity will face the scarcity of resources on the one hand and the negative impacts of the impaired environment on the other. That could lead to catastrophic consequences: depletion of resources, destruction of the environment and, as a result, a sharp decline of population (because of hunger, diseases, etc.)

The report has become very popular; it has been translated in 37 languages and sold in more than 12 million copies. 'Limits to Growth' has also been widely criticized due to unrealistic forecasts, but although some specific details became objects of heavy criticism, the basic logic of the report – that the humanity lives in a limited world and violation of these limits could bring it to a catastrophe – was beyond question.

Some indicators of consumption and emission in the U.S.A., Russia, China and India.

	the U.S.A.	Russia	China	India
Meat, kg per person per year		61	53,45	3,7
Energy, kW per person per year , 2008)	13654	6435	2455	566
Cars, per 1000 persons)07)	451	206	27	10
CO2 emission, t per person per year ank, 2009)	17,7	11,1	5,8	1,4
CO2 emission, Gt /year	5,5	1,71	7	1,74
Population, mln.	309,05	141,75	1338,3	1170,94

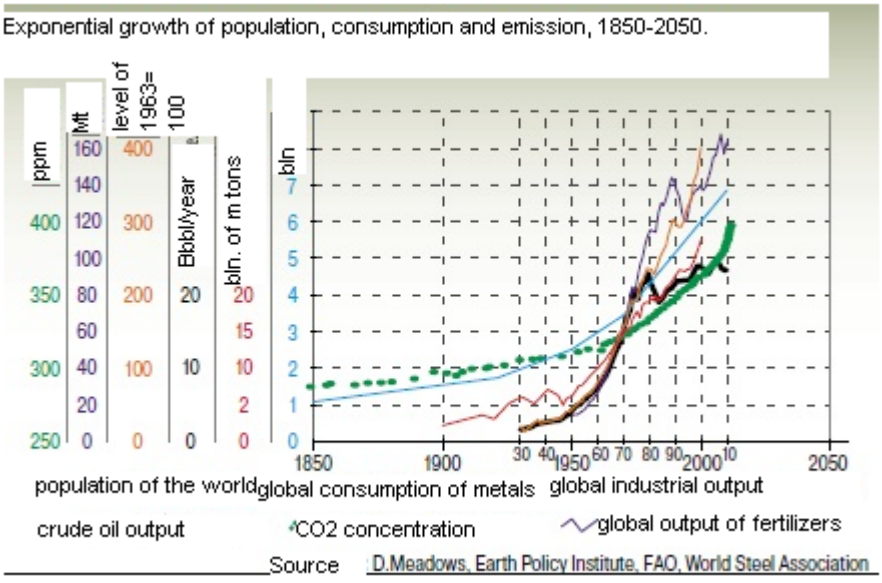
The greatest concern is an exponential increase of consumption rate of resources and emission rate starting from the late 19th – early 20th century and to the present days (see the chart). The main drivers of this growth – the increase in population ("How many people consume resources?"), the growth of consumption ("How much one person consumes at average?") and the mode of consumption ("Why consumption has precisely this mode in the long run?")

Growth of Population and Consumption

Projections of the population for the 21st century are constantly being changed, but the trend is obvious – the population continues to grow. During 1900-2000 the population grew by 3.7 times.

The UN estimate: 8 bln. to 2025 and 9 bln. to 2050. The leaders of growth are India (+ 415 mln. to 2050), Pakistan (+ 154 mln.), Nigeria (+ 134 mln.), Ethiopia (+ 91 mln.), China (+ 72 mln.). The most difficult task for countries with a growing population, which they need to resolve to maintain internal stability, is to provide at least the same level of consumption to new members of society.

The increase of consumption per person is much more important driver of exponential growth. During the first part of 21st century about 2 billion people will move from the low to the middle level of consumption. Comparing the current rate of consumption in rapidly developing China and India with more developed Russia and the prosperous U.S. (see the chart) shows that the consumption is of different orders of magnitude. The purpose of the developing countries in the long run is to provide living standards comparable to the level of developed countries. A decent purpose, but where can they find so much meat, so much energy and so many cars? What resources will be needed to provide such a change of consumption level? After all, even a slight increase of consumption per person in the developing world will give a huge increase of global consumption. That's why the growing population and growing consumption add to already enormous pressure on renewable and non-renewable resources.



Jared Diamond in his book "Collapse" points out that the consumption level per person in China is still 11 times smaller, than in the U.S. If China reaches the level of the States, and at the same time no other country increases consumption and population (including China) remains the same, the global level of consumption would double (oil consumption would have been increased by 106%, metals – by 94%). If India follows China, the global level of consumption

would triple, and if other developing countries wouldn't stay behind, the global consumption rate would have been increased by 11 times, as if the population of the Earth would have been grown to 77 billion people.

In a world of limited resources the population growth isn't the main reason of possible overrange, as both 9 billion and 1 billion people could completely deplete resources, but over a different period of time. The mode of consumption itself – striving to the continuous growth – is a much more serious threat.

It's hard to blame the ordinary people for that, we all live according to the particular social pattern, which is typical for the current level of understanding. If country's economic is growing, if GDP is growing, everyone wants to improve their living conditions, buy an apartment, car and other goods. It's an existing pattern of the modern world: that's how reach people live, and others want to live exactly the same way! But there are about 1 billion rich people today and about 6 billion of those who could have a better life! Do we have enough resources to continue following the already established mode of consumption?

Fuel and Mineral Resources

The most important resources for existing civilization are fossil fuels (coal, oil, gas) and minerals (ferrous, nonferrous and precious metals, apatite-nepheline ore, uranium and many others).

The most urgent task today is to provide resources for the existing energy system,b which is the basic industry of the civilization (electricity, energy for warming and transportation). Energy is limited both by finite resources – coal, gas, oil and uranium are finite and soon or late will be exhausted, and by the emission – continuous increase of the emission from energy conversions affects geochemical changes and causes significant change of the environment. It's worth to note that, most likely, the humanity won't be able to 'drain dry' all resources, as due to lack of resources they would become too expensive to produce. Some experts suggest that the main trend of 21st century would be not so much scarcity, but constantly rising cost of resources. It is therefore necessary to understand in advance how the society will live in conditions of significant growth of resources? How should be organized a transition to other sources? What resources would it be? And a crowd of such-like questions.

There is a variety of different models and estimates of when resources for existing power system are going to be exhausted – in 45 or in 200 years. But even skeptics don't deny that in the current century the humanity will go through a difficult stage of transition from hydrocarbons to a new source of energy.

Let's recall the famous Simon-Ehrlich wager, entered in 1980 between professor of ecology of Stanford University Paul Ehrlich and professor of economy of Maryland University Julian Simon.

Ehrlich bet that the prices of resources would constantly increase because growth of the population leads to the scarcity of resources. In particular, Ehrlich claimed that metal prices will rise by 5 times in 10 years.

Simon bet that price of resources increase while they are being exhausted, but long before the complete exhaustion science and engineering will find a way to replace them with more accessible and therefore cheap resources.

Simon proposed Ehrlich to select five resources and claimed that none of them will have a five time higher price in 10 years. Ehrlich accepted the bet and choose five rare and utterly necessary metals: copper, chromium, nickel, tin and tungsten. In a 10 years Ehrlich has lost the bet and had to pay Simon 10 thousand dollars officially. When they were entering the bet, prices of all these metals grew, that's why engineers were searching for the ways to replace the

expensive resources and eventually found them. Even the inflation rate, which was rather high during that decade, couldn't help: metals dropped much more than money.

Levels of oil, gas and coal consumption are orders of magnitude higher than for the metals mentioned above, and the existence of civilization is based on fossil fuels. Transition to non-hydrocarbon energy with zero CO2 emission by 2050 will require the replacement of 10TW of electro and thermal energy and 10 TW of energy used for transportation. We believe that such transition is possible before resources will be exhausted and become expensive, but it means we should start discussing and programming such transition right now, since the scale of the task is impressive. The need of timely decisions can be illustrated by words of D. Meadows: "We are going to a gas station before we have an empty tank, at least when we have enough to get to a gas station!"

The transition will be extremely complex and time-consuming, especially given the uncertainty about the new resource. Of course, you can rely on the 'invisible hand of market', hope that new technologies will be created that would allow mining deeper and poorer reserves. As a result, production costs will increase and the final price will rise. Rise of the base resource prices would increase investment in substitutes, and market mechanics could refocus the industry to the new configuration. But there are at least two reasons for doubt. The first one – an increase of resource price causes an increase of its extraction, which will speed up the depletion (a classic example is the depletion of fish stocks in the 20th century). The second – commercial financing of such capital-intensive industry as energy would be successful only given a wide range of alternative solutions, which have passed the process of research and development. But at the R&D stage business rarely take part in a project because the process of development in such field could take decades, and even when it's well-planned, no one can guarantee a success. Therefore developing of alternative technologies becomes a matter of governmental concern.

Researchers agree that the only reasonable alternatives to polluting hydrocarbon energy today are solar and wind energy. Engineers and scientists over the world work to increase their efficiency, reduce costs, develop better batteries and solve many other tasks. Looking at the recent projects, SunShot Initiative of the U.S Department of Energy seems to be very interesting. It aims to reduce the cost of kilowatt of solar energy to 1000 US dollars by 2020. Reshaping of government in Denmark is speeding up the 100 per cent transition to the renewable energy. Plans of China to dramatic increase of capacities of wind and solar stations are also clear.

Bill Gates holds an alternative view. He believes that solar and wind energy won't be able to provide the humanity with the necessary amount of energy and save it from climate change. Existing technologies won't be widely used by business because of their high cost and low level of efficiency. They are supported only by state subsidies, but only business can provide their extensive adaptation. Gates himself is investing in nuclear energy, technologies that help to generate energy from algae and a few other projects. In 2009 at the TED conference he stated that "if research would help to find a new source of energy by 2020, we'll be able to build up to 100 new stations and conduct a large-scale testing of technology by 2030. And only by 2050 we'll be able to spread the technology over the whole world. In other case, the world should be prepared for the hard time, and possibly a catastrophe, of the energy industry".

Agriculture

In addition to scarcity of energy and mineral resources, in 21st century the humanity could face a serious shortage of food. One of the greatest challenges here is to meet the growing needs of the population and at the same time to reduce the burden of food production on the ecosystem.

The article 'Solutions for a cultivated planet' (Nature, October 20, 2011 г.) shows that to match the amount of produced food to the population growth, consumption growth, changes of diet and development of bioenergetics we should double the level of food production in coming

decades. But it's impossible to double the size of farmlands; yield is not growing as fast as before, GMOs are not a solution too, because their long-term impact on human and biosphere is unknown. Along with providing the necessary amounts, the issue of agricultural influence on the environment should be resolved. It's necessary to reduce emission of greenhouse gases, especially methane, which is a product of animal husbandry, because its greenhouse effect is much greater than of CO2, stop deforestation, loss of biodiversity and habitat, reduce fresh water pumping, especially in regions with a competing demand for water, stop water pollution with chemicals, reduce the impact on nitrogen and phosphorus cycles.

In the autumn of 2011 the authors participated in the milestone meeting of the Balaton Group (group of system researchers, created in 1981 by Dennis Meadows). When we were asked how serious the issues in agriculture are in the long term, we came to the consensus-answer: "The issues in agriculture are very serious, but local, and many of them could be resolved using technologies and new management systems. We believe that the most significant global issue is the increase of CO2 concentration, it's a 'fire at home' – until we find the solution to this problem, others are even not worth thinking!"

CO2 Emission and Climate Change

It's already clear now that causes of climate change are anthropogenic by nature. Starting from the second half of the 19th century, when rapid growth of fossil fuel combustion and a mass conversion of ecosystems to agricultural lands has lead to a significant increase in emission of greenhouse gases, begins a period when human being has a global impact on climate. By the 1990s, global warming has become the main cause of concern because of its unprecedented nature and possible consequences.

The main greenhouse gases are carbon dioxide, CO2 (77% of emission), methane, CH4 (15%), nitrogen oxide N2O (7%). Huge amounts of CO2 emission are the main reason why this greenhouse gas draws broad public attention. The atmospheric CO2 concentration today is 393 ppm (parts per million). For the past 650 thousand years CO2 level had never been below 180 ppm and above 300 ppm. Emission scenarios for 2100 forecast a wide range of possible concentrations – from 540 to 970 ppm.

CO2 is the long-living atmospheric gas, its average lifetime is more than 100 years. The response in inertial climate system is delayed, and the time lag between an increase of CO2 concentration and a rise of temperature due to the greenhouse effect is estimated at about 50 years. So the recent rise of temperature is the reaction to the development of 1940-1980s, primarily of the U.S., Europe, Japan and the USSR. So far there has been no response to the development of the last decades, for example, to the rapid growth of China.

The current IPCC estimate shows that an increase of the average surface temperature by 2100 could be 2-4.5 ºC and the most probable estimate is about 3 ºC. The scenario does not exclude the possible increase of temperature significantly higher than 4.5 3 ºC.

All economies are only subsystems of the biosphere, so any significant change of the ecosystem leads to the multiple consequences for the economy. Under various assumptions, the consequences could be either globally insignificant or locally devastating. In 2001 reinsurance company Munich Re estimated the final cost of the global warming caused by doubling of preindustrial greenhouse gas level to 550-600 ppm as not exceeding $300 billion a year. If this estimate turns out to be close to the real cost, the economic consequences of the global warming won't be radically different from many other issues that require significant capital investments and operating costs. It also implies that the reach countries will be easily able to cope with the new expenses, but for many developing countries even the moderate warming will heavily contribute to already unmanageable costs.

In his 2006 review N. Stern came to the conclusion that the cost of climate change could be limited to about 1% of GWP only if coordinated measures will be taken in the next 10-20 years. Otherwise, the global annual cost could reach 20% of GWP and higher. 2 OM range of possible costs of the global warming (0.2-20% of annual GWP) shows that the temperature change can either have minor economic impact or become an unprecedented economic burden.

The climate change will significantly affect agriculture. An average yield of major crops will drop significantly – by about 10% for each degree of warming. Flooding and salting of coastal farmlands due to the sea level rise, decreasing of the rainfall in tropics and subtropics, growing number of natural catastrophes along with erosion, decreased soil fertility and growth of the population of developing countries will have a significant long-term impact on agriculture. That's why L. Brown considers mass famine as the most catastrophic result of the climate change for the humanity.

There are other alarming changes of the global ecosystem. The rate of soil erosion is increasing. The global water cycle will always be governed by vast evaporation from the ocean, but human activity has already changed it to the extent when water supplies in some populous regions are close to the minimum required level or even below it. The global carbon biogeochemical cycle also became a matter of concern due to the significant role of CO2 in global warming, but the impact of human activity on the biospheric nitrogen cycle is much stronger. Anthropogenic change of the nitrogen cycle is inherently more challenging issue than the reduction of carbon emission from the conversion of energy. Although the transition won't be easy, an implementation of no-emission technologies of energy conversion is inevitable. But it's impossible to create species that don't consume nitrogen, and growth of the population and prosperity in 21st century will require improving the food quality, which, considering the distribution of population growth, will be largely based on increased use of fertilizers.

Why it is so important now?

The 'Vision 2050' report prepared by World Business Council for Sustainable Development calls the next 10 years as 'turbulent teens', the time of recognizing the global issues, technological breakthrough, the time of decision making. Why precisely the next 10 years? Because the scale of problems and necessary solutions is global, and the delay between recognizing of an issue and coordinated global actions would seriously impacts the future. Attempts to respond to global challenges are well known: Montreal Protocol, Kyoto Protocol, CLRTAP. In each case at least 20 years have been passed between a scientific recognition of an issue and a signing of an international agreement. The earlier we start taking necessary decisions, the more chances the humanity has to respond to the global challenges. It matters, as we are facing systemic issues that could lead to a systemic crysis. In his 'Hot, Flat and Crowded' Thomas Friedman points out that "in the next 100 years the depletion of nonrenewable resources, the violation of geochemical cycles, significant soil erosion, population and consumption growth could lead the mankind to a point of a 'perfect storm', when most of the troubles take place in one time. If the world falls into such a systemic crisis, it will be the end of "civilization as we know it".

Technologies as a solution

In recent years the debate over the coming technological pattern of civilization became more and more popular. Will it be based on nanomaterials or on biotechnology? It's possible, and we hope for it, that raising questions on scarcity and growing prices of resources together with a demand for radical change of our impact on the environment will give rise to the next technological stage based on an essentially more effective utilization of the resources, closing of operation cycles, recycling, shifting to the renewable sources of energy and so on. Of course,

technologies are not a silver bullet. The new technological stage should lead to structural changes in many social systems, consumer culture, education and even in a global governance. Such technological and social transformation can be achieved by two different ways. The first option is an emergence of actual scarcity or actual destruction of the environment. In such case the further development of the mankind would become a spontaneous adaptation to resulting conditions. The second one — political willingness and a soft moderation of deficit by imposing limits, minimal lower values, taxes and other measures that will assure a managed adaptation. It's clear that the second option is much more credible and humane. If humanity chooses the managed adaptation, it would become a real 'green' revolution. But for now, like Thomas Friedman says, "we're really having more of a green party than a green revolution".

The place of Russia

Given the substantial stocks of resources in our country, vast areas of fertile lands, positive assessments of crop yields growth due to climate changes, we can conclude that in the long run we can hardly find a country with more advantageous position than Russia. But these advantages should be taken very seriously. For now Russia stays aside from many initiatives, nevertheless we have a potential to become a world leader in resolving of various global problems.

It's clear that a new climate agreement will pay a considerable attention to the role of forests as a system of the CO2 disposal. Today the world is ready to spend on protection of resources which have a global significance. That's why, having the largest forest resources, we are to take the initiative to develop and promote a program of global recovery and increasing of forest area.

With a rational management of agricultural resources we can become a 'granary' of the world. Under the long-term contracts for food supply we can feed millions of people in the whole world, at the same time developing our technology, science and personnel. But today we offer Asian companies access to the Russian market and allow them to produce independently food for home consumption.

Obviously, wind and solar energy has very limited prospects in Russia due to climate conditions and the location of industrial facilities. Therefore it's important for Russia to initiate research of the entirely new fields of energy.

Thomas Friedman points out that developed countries should set targets of the new economy, restructure themselves and widely introduce new prudent technologies to the developing world. Russia has a unique place in all trends of global challenges, which may become a new foundation for the development and a new position of the country in the world.