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**IEA: NZE2050**

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The analysis of the International Energy Agency IEA

The IEA is a subdivision of the OECD. It was founded in 1974 by 16 nations as a reaction to the oil crisis of 1973. The IEA has required the reputation of a competent and respected institution. They publish the famous *World Energy Outlook* and always have been concerned about a reliable data base, analysing production and demand as well as providing a realistic forecast. For example, in 2015 the IEA new policies scenario made a prediction of the global energy needs in 2040. Fully aware of the emission problem, they expected a reduction of the fraction of fossil fuels from 85% to 70% until 2040. To achieve this goal, the installation of renewable energies (RE) had to be strongly supported and increased. Nevertheless, the yearly production of fossil energies would keep on growing until 2040. With other words: In spite of the strong worldwide growth of RE production, the IEA predicted that RE would not even satisfy the steady increase of the global demand. This IEA outlook presented little hope for a significant reduction of the coal, oil or gas production until 2040. Of course, this view was in disaccord to the Paris emission goals and the IEA contracted the image of a protector of “yesterday´s fossil industries”.

In a convincing and careful approach, the IEA was able to bridge the gap between their well-founded scenarios and other, possibly overoptimistic climate goals. In May 2021, the IEA “took the bull by the horns” and responded directly to the goals of IPCC. The IEA published a comprehensive new analysis, which looks very different at first glance. Nevertheless, it turns out to be a realistic continuation of their previous work. It is called “NET ZERO by 2050” and presents the emission budgets of three realistic examples of global pathways into the future. This study does not provide any new climate model. Instead, it relies completely on IPCC data and climate studies. The IEA uses the calculated emission data from their own database and scenarios and combines these “energy related emission data” with the climate projections, which have been published in the IPCC reports. The study covers 220 pages, is clearly organized and well worth reading [7].

Pathway No.1: Continue along the presently stated policies (STEPS)

The STEPS scenario takes into account all policies, which are backed up by existing legislation and ruling. Future “possibilities”, hopes und wishes are not considered. Under these circumstances most probably the global emissions will not decrease. Instead, they will remain at about 36 Gt CO2 /year and keep this level until 2050. It is noted, that the strong recession of global travel due to COVID-19 pandemic resulted in a small dip of 2 Gt CO2/y or approx. 6% only. A recovery after the pandemic is expected. Under these conditions, a global temperature rise of 2.7°C until 2100 is estimated (50% probability). This scenario ends up far away from the Paris goals and comes close to previously published expectations.

Pathway No.2: All open promises become true (Announced Pledges Case, APC)

The APC pathway is much more optimistic. It is assumed, that all promises and already mentioned possibilities are fulfilled completely and in a timely matter. With other words: It is the lowest emission path, which we can hope for under the present political conditions. This path demands significant efforts from all nations and shows that the CO2-emissions would drop to 22 Gt/y until 2050. Certainly this would be a big success – but only half the way to NET ZERO in 2050. The largest contributions to the emission reductions are provided by very high investments into sustainable electrical power generation. The global demand in electrical power doubles. New power grids for underdeveloped countries and areas are installed. The investments in photovoltaics and wind turbines are growing especially fast and in 2050 their production of electrical energy is ten times higher than in 2020. Nuclear power and hydro are growing moderately. A fraction of the remaining coal power plants is fitted with carbon capture and storage (CCS) technology. The total end-energy needs for industry, buildings and mobility will stop growing and remains essentially stable. Also, the mineral oil demand and supply for mobility remains stable, not increasing and not yet decreasing. Although many new cars are running on electricity, the need of mineral oil for cars, trucks, airplanes and ships drops slightly. Hydrogen very slowly becomes a fuel for transportation. It is the authors (ChB) opinion, that this APC case will imply rigorous global changes and regulations, but indeed may describe a realistic option, which one might use for future planning.

Pathway No.3: The NET ZERO EMISSIONS by 2050 Szenario (NZE)

What would you do, if you were directly confronted with a possibly over-optimistic scenario, which describes the complete abandonment of fossil energies with the claim: “Yes, we can do it!” The best answer may be to take the optimists by their words and check all the needed requirements and conditions. The IEA has chosen this honest approach and carefully executed the calculations on the basis of the available data and information.
It may be wise to spend a couple of hours or days to study Ref. 6. and its coloured graphics in detail. In the following, a few facts are summarized. They provide an excellent guideline for scientific and political discussions and planning, although the actual conditions and goals will be difficult to meet.

The entire scenario is based on very strong international cooperation and needs worldwide implementation. The IEA is very optimistic about the general economy and assumes further economic growth with a doubling of the global BIP and a world population of 10 billion until 2050. In view of the total restructuring of the energy world, the spending on energy investments has to double at minimum – but no investments whatsoever are acceptable for new coal, oil or gas projects. The investments in photovoltaics (PV) and wind turbines have to be increased by a factor of 10(!). In parallel, nuclear power plays a significant role and the global number of nuclear power plants must be doubled. All the remaining coal power plants must be retrofitted with carbon capture and storage (CCS) – or they will be shut down.

The known oil and gas fields are sufficient to provide the entire remaining demand and the oil companies have to change into different projects of geological exploration, as CO2 storage as well as the further exploration and search for metals like Lithium and other minerals. All nations with large fossil resources have to expect strongly falling sales and revenues. Their cooperation and the reconstruction of their economies will be essential, but remain a challenge. In contrast to the APC scenario, oil will become much less important even for mobility and will be reserved for the chemical industries. The oil price probably will drop by 50% due to the shrinking demand. Of course, this opens frightening prospects for many nations living on oil revenues.

For coal, there is little room left either. Clean coal technologies together with CCS provide the only chance for survival of coal mines and coal power plants. To some degree, even bio-energy as wood shall be burned in power plants, if these are equipped with CCS. This permits an additional direct removal of carbon from the biosphere. The further lowering of the total emitted CO2 becomes an important element of the overall net zero emission concept.

The NZE scenario demands several immediate decisions and many checkpoints for 2030 are provided as benchmarks for success towards 2050. The final scenario comprises more than 400 milestones until 2050.
The NZE scenario requires the immediate start and implementation of all possible energy *efficiency* programs. In addition, the IEA guidelines demand to forcefully expand all technologies, which are already sufficiently developed and available. For example, the yearly investments and installations of market-ready technologies as PV and wind turbines must quadruple and the sales of electric cars have to grow by more than an order of magnitude. The IEA considers battery-electric cars as the most important change in mobility and ranks fuel cells and other less developed technologies as synthetic fuels as less relevant. Nevertheless in parallel, the research for future concepts as carbon capture and storage (CCS), better batteries, electrolysers and the entire range of hydrogen technologies need to speed up. The further development of immature technologies needs strong support to permit their implementation as soon as possible.

In the IEA scenarios, hydrogen becomes very important. Soon after 2030, huge quantities of hydrogen, produced in electrolysers by renewable electricity, will be needed for the chemical industry, for fuel cell vehicles and for the fabrication of synthetic fuels for aviation and ships. A world market for sustainable fuels (methanol, hydrogen, synfuels, ammonia, e.g.) has to be established. New chances are opening up for nations within the sunbelt for large area PV installations. In many coastal and windy regions, a forest of wind turbines must be erected. The generated renewable electrical energy must be transported by high voltage dc lines or converted onsite to synfuels by large plants. A world market for sustainable fuels is expected. Again, international cooperation becomes essential in order to bring these investments and technologies into the less developed areas. This supports the demand of the IEA that the developed nations have to strongly support the rest of the world in order to achieve the global climate goals.

Electrical power from environmental friendly sources will become of prime importance everywhere and for every use. In contrast to the German decision, the number and output of nuclear plants is expected to double. Hydropower is greatly favoured, but not available everywhere. Where ever coal plants remain indispensable for supply security of electrical power, they must be coupled with CCS. Will clean coal technology be market ready in time?

What about the human aspect? Will this long list of demands, regulations and drastic changes be acceptable by the general public? Will people change their lifestyle? The IEA suggests intense public involvement, increased awareness and better education on all aspects of this agenda, but remains very cautious about deep cuts in behavioural patterns. In summary, they do not expect more than 4% of the total reductions from direct changes in behaviour. For instance, air travel is not banned, but should not grow further. Rail transport, especially high speed trains for passengers and freight, should gain importance.

Aside from technology and behaviour, there is a third sector with significant impact. Farming, forestry and land use contribute 25 - 30% to the greenhouse gas (GHG) emissions. For example, the IEA estimates that a moderate reduction of the meat consumption in countries with the highest levels of meat consumption down to the global average level would reduce the GHG emissions by 1 Gt-equiv. per year.

Conclusion

In the past, the extraction and use of fossil fuels has offered fantastic benefits for mankind. We all became dependent on the available energy. Today, we are used to the best possible fuels for combustion engines, because Diesel and gasoline are perfect for a planet with Oxygen available everywhere in the atmosphere. These fuels have a high energy densitiy and they are available at low prices, as oil still is plentiful. Everybody knows that this wonderful party will not go on and continue forever – but the expected end of the fossil reserves is far in the future, possibly many decades or in the case of coal even two centuries away. The perspectives and promises of science were reassuring: In the future, nuclear energy plus the radiation from the sun will be sufficient to provide us with all the energy needed. Of course, it will take time to develop and deploy all the many new technologies and installations needed.

This scientific promise remains true and is not exaggerated. Unfortunately, there are severe problems arising: Do we have sufficient time for a peaceful and gentle change or is time already running out? Climate science demands a most rapid and drastic change away from fossil energies, because the impact and dangers of the emissions have been underestimated. All of a sudden, it is not the technology per se, but the speed of change and the size of the task which represent the true challenges. The goal itself, the complete change of our energy system to zero emissions, including renewable energies and nuclear technologies, is realistic and even remains unavoidable in the long run. Unfortunately, the desired speed of the transformation forms an immense challenge with many unsolved problems.

People all over the world have to face great changes and have to make significant efforts in order to abdicate the cheap fossil energies and to adapt to this new situation. The Narrative of the blessings of energy is replaced by the Narrative of the dangers of climate change. This change of the paradigm turns out to be painful. Who is able to finance all the needed new installations? Huge shifts of power and wealth are expected for individuals, companies and nations. This will lead to confusion, controversies and fierce conflicts. Hopefully these do not lead to military actions.

The IEA has suggested a peaceful and very tough, but possibly feasible pathway into a Net ZERO Emission Future by 2050. It even expects continuous economic growth - but not automatically for everyone. Instead, it predicts significant hardship for nations, companies and individuals, who work with fossil fuels and depend on them. The most difficult situation is expected for nations with large fossil resources, because they have to stop extracting and selling them. Is it possible to convince these nations peacefully to give up their valuable assets? Or will they continue to sell their resources in order to maintain their income, even at much lower prices? [8]
Without intense international cooperation and without mutual technical and financial support the NET ZERO proposal finally might turn out to be unrealistic. How many nations will follow the suggested path? Only the decades to come will show, because presently many details remain uncertain.

Together with many other scientists, the author is deeply concerned about the present situation. So far, the measured CO2 concentration in the atmosphere and the yearly increase do not show any influence of the global emission reduction programs. If the climate models correctly predict the future, unfortunately time will run out. Therefore also adaptation strategies are of immediate importance. They need careful studies, closer consideration and proactive implementation. Considering the fact, that humans unwillingly have changed the climate for millennia by deforestation and farming, even studies of climate engineering should not be excluded and ignored anymore.

[1]. www.iea.org/reports/net-zero-by-2050