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Editorial

Saving the planet and the human society: renewable energy, circular economy, sobriety

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Abstract. Planet Earth is a very special spaceship that cannot land or dock anywhere for being refueled or repaired. We can only rely on the limited resources available on the spaceship and the energy coming from the Sun. The huge amounts of carbon dioxide produced by using fossil fuels in affluent countries has caused global warming, which is responsible for climate change. Ecological degradation of the planet is accompanied by an increased social disparity. As Pope Francis warns, we are faced with a complex crisis which is both social and environmental. Strategies for a solution demand an integrated approach to combating poverty and protecting nature. If we want to continue living on planet Earth, we must achieve the goals of ecological and social sustainability by implementing three transitions: from fossil fuels to renewable energies, from a linear to a circular economy, and from consumerism to sobriety. Science, but also consciousness, responsibility, compassion and care must be the roots of a new knowledge-based society.

Keywords. Sustainability, energy, materials, environment, climate crisis, social crisis, economy, efficiency, sobriety.

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Scientist are called to see
what every one else has seen
and think what no one else
has thought before

1. LIVING ON SPACESHIP EARTH

The image taken by the Cassini Orbiter spacecraft on September 15, 2006, at a distance of 1.5 billion kilometers, shows the Earth as a pale blue dot in the cosmic dark (Figure 1). There is no evidence of being in a privileged position in the Universe, no sign of our imagined self-importance.

There is no hint that we can receive help from somewhere, no suggestion about places to which our species could migrate.

Like it or not, planet Earth, the only place we can live on, is a kind of spaceship that travels in the infinity of the Universe. It is a very special

spaceship, however, because it cannot land or dock anywhere for being refueled or repaired. Any damage has to be fixed and any problem has to be solved by us passengers, without disembarking. We travel alone in the Universe, and we can only rely on the energy coming from the Sun and on the resources available in our spaceship.[1] The first thing we passengers should be aware of is that the planet Earth has "finite" dimensions. Therefore, the resources we have are limited and the space for waste disposal is also limited. This is an undeniable reality, even though many economists and politicians seem to ignore it.

The views from space have allowed us to observe the entire Earth as a planet. In the Earth-at-day images from the space, national boundaries are invisible and this may strengthen the consciousness of the collective human responsibility for the future of our planet. On the contrary, the Earth-at-night images show boundaries: those between affluent and poor areas. The passengers of spaceship Earth travel, indeed, in very different "classes". Disparity is the most worrying feature of our society. The number of billionaires has almost doubled, with a new billionaire created every two days between 2017 and 2018. They have now more wealth than ever before while almost half of humanity have barely escaped extreme poverty, living on less than $5.50 a day.[2]

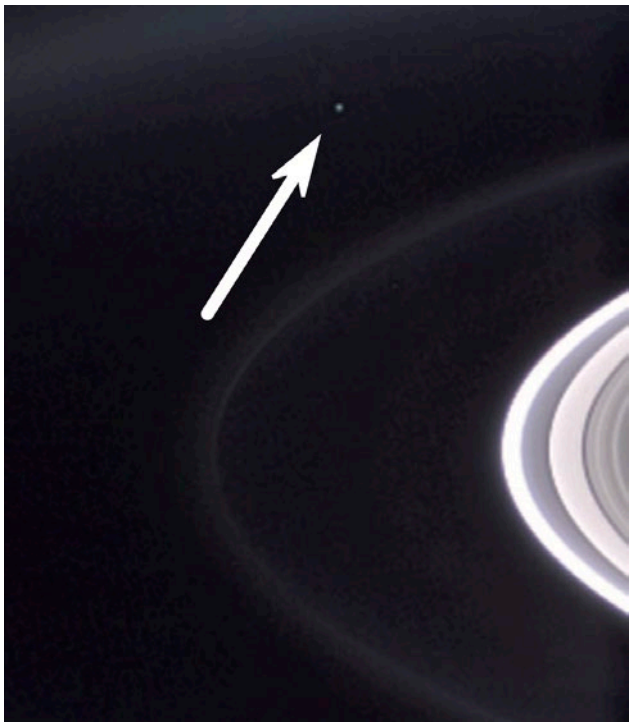

Figure 1. Photograph taken by the Cassini Orbiter spacecraft on September 15, 2006, at a distance of 1.5 billion kilometers from Earth. The dot to the upper left of Saturn's rings, indicated by the arrow, is the Earth. Saturn was used to block the direct light from the Sun otherwise the Earth could not have been imaged.

In his encyclical letter Laudato si' Pope Francis warns:[3] "The pace of consumption, waste and environmental change has so stretched the planet's capacity that our contemporary lifestyle, unsustainable as it is, can only precipitate catastrophes (paragraph 161). He adds: "We are faced not with two separate crises, one environmental and the other social, but rather with one complex crisis which is both social and environmental. Strategies for a solution demand an integrated approach to combating poverty, restoring dignity to the excluded, and at the same time protecting nature" (paragraph 139).

If we want to continue living on Earth, we must achieve the goal of ecological and social sustainability by going through three transitions: from fossil fuels to renewable energies, from a linear to a circular economy, and from consumerism to sobriety.

2. FROM FOSSIL FUELS TO RENEWABLE ENERGIES

Energy is the most important resource for humanity[1]. In the present Anthropocene epoch[4], as primary energy we use mainly fossil fuels, a non-renewable resource that in the long run is going to be exhausted. In 2018, *every second* in the world we have burned 250 tons of coal, 1140 barrels of oil and 105,200 cubic meters of gas,[5] generating heat along with pollution and 1074 tons of carbon dioxide (CO_2).

That the use of fossil fuels generates substances that are harmful to health has always been known, but it was only in the mid-1980s that another, more serious, problem emerged: the enormous amounts of CO_2 released into the atmosphere cause global warming (greenhouse effect) which is responsible for climate change.[6]

Since 1992, several United Nations sponsored conferences tried to tackle the problem of climate change without success. In 2014 the 5th IPCC (*Intergovernmental Panel on Climate Change*) Assessment Report showed that the influence of human activities on climate change is unequivocal and increasingly worrying: the Earth warms up, glaciers melt, sea level rises, drought advances, extreme weather events are more and more frequent. In December 2015, after a long cycle of negotiations, the United Nations organized a conference in Paris, preceded by Pope Francis' encyclical *Laudato si'* in which climate change and related problems had been addressed with great authority and concern[3]. At the Paris Conference, 196 national delegations approved an agreement based on the following points: (i) it is absolutely neces-

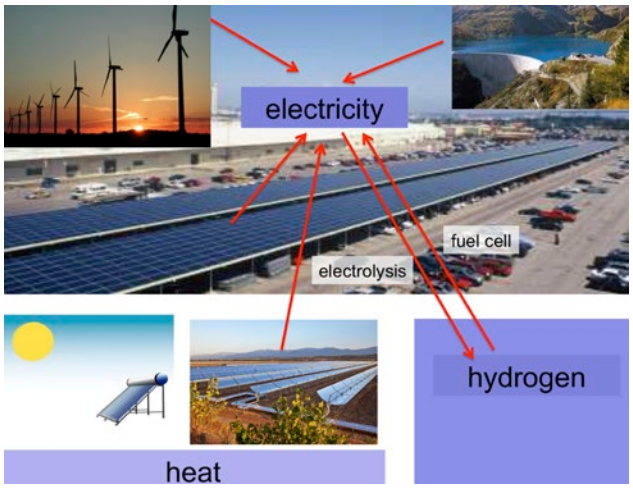

Figure 2. Renewable primary energies generate electricity.

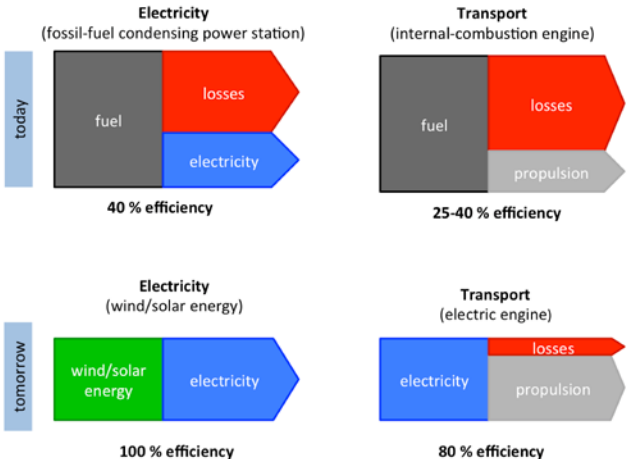

Figure 3. Conversion of primary energy (fossil fuels or wind/solar energy) into electricity and mechanical energy (adapted from[10]).

sary to reduce strongly, or better eliminate greenhouse gas emissions by 2050, to limit the increase in global average temperature to less than 2 ° C (possibly, less than 1.5 ° C) compared to the pre-industrial level; (ii) in tackling the problem of climate change, all countries must consider, respect and promote human rights; (iii) it is urgent that developed nations make financial and technological resources available to enable developing countries to reduce their greenhouse gas emissions.

Beyond the lack of concreteness of the commitments made, the Paris Agreement induced a strong cultural change. In spite of the withdrawal of the USA from the agreement, decided by President Trump in August 2017, there is a broad scientific and political consensus that the transition from fossil fuels to renewable energies will stop climate change, avoid the premature death of many people, increase the number of jobs, bring economic benefits and even advantages from the social point of view because the poorest nations, those most affected by climate change, are the richest in renewable energies[1]. However, at the Katowice conference in December 2018 it was verified that the energy transition proceeds too slowly and that the objectives of the Paris Agreement will not be achieved without a strong acceleration[6]. One of the most controversial problems about the transition concerns its costs/benefits, as thoroughly discussed with different opinions in two chapters of this issue.[7,8]

Renewable primary energies of the Sun, wind and water, that we should use to replace fossil fuels,[1] not only do not produce CO_2 and pollution, but they have the advantage of generating electricity instead of heat (Figure 2).

Electricity is the most valuable form of energy because it can be stored as chemical energy (batteries or hydrogen), used as such, or converted with high efficiency into mechanical energy (Figure 3).[9] Thus, the economy based on renewable energy sources is not only cleaner but also much more efficient than the fossil fuel based economy.

The energy transition from fossil fuels to renewable energy is proceeding. For example, at the end of 2018 the installed power was 505 GW and 591 GW for photovoltaic (PV) and wind energy, respectively.[11] At present PV is less developed than wind energy, but PV increases at a much faster rate (25% a year) and in 2050 it will become the most important source of energy for mankind. PV is indeed an ideal source of energy: it converts sunlight into electricity with 20% efficiency (100 times more than natural photosynthesis!), it can be used everywhere, it is scalable, long lasting, cheap and reliable. For some top research in the field of conversion of solar energy into electric energy, see.[12, 13]

The unavoidable transition from fossil fuels to renewable energies, however, is hindered not only by commercial competition, but even more by obscure interests of various kinds: military, because fossil fuels, with their high energy intensity, are not only the object of wars, but also the most important resource for fighting; national, because many countries have abundant reserves of fossil fuels and do not intend leaving them underground; financial, because speculation does not care about the health of the planet; economic, because in many countries oil companies have become so powerful as to condition government policy (this is what happens in Italy with ENI).

Therefore, all the people who care about our "common house"[3] should show a strong social and political commitment to accelerate the energy transition.

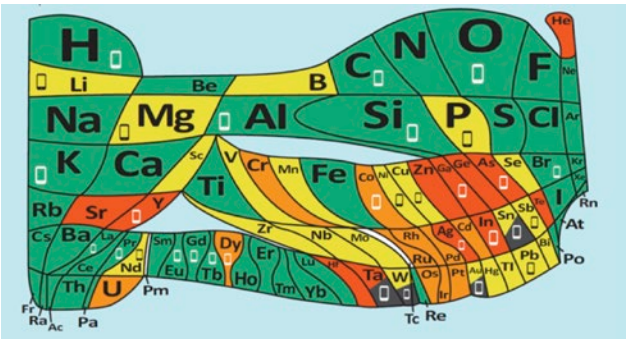

Figure 4. A "quantitative" Periodic Table [14].

3. THE MATERIALS PROBLEM

Since solar energy is abundant and can be converted with high efficiency, e.g. into electricity by PV modules, one could think that we are going towards an age of plentiful energy for every body.

This however, is not true because to exploit solar energy we need to construct equipment, machines and devices (e.g., PV cells), and to make them we must use materials available on the Earth. In the end, what we have on Earth are the chemical elements of the Periodic Table. Some elements are abundant, but others, including most of those needed for energy conversion, are scarce (Figure 4).

Therefore bottlenecks for the production of energy for final use are not the number of photons arriving from the sun or the availability of wind, but the materials we need for converting such primary renewable energies into the final energies that we use every day. Storage of the intermittent electricity generated by renewable energies is an important part of the problem.

Materials shortage affects several sectors of EU economy, in particular advanced technology.[15] The European Commission has compiled a list that contains 27 critical materials or classes of materials such as Platinum Group Metals or Rare Earth Elements.

Concern about criticity of some materials used for energy conversion and storage are based non only on shortage, but also on geographic, economic and political factors. For example, 95% of Rare Earth production comes from China and most of lithium, the basic component of the Lithium ion batteries used in ICT devices as well as electric vehicles, comes for Australia and Chile, and cobalt comes from a politically unstable country such as the Democratic Republic of Congo.[15]

4. FROM LINEAR TO CIRCULAR ECONOMY

As already underlined, Earth's resources are limited and the space available for waste disposal is also limited. Our current economic model however, the so called *Linear Economy* (Figure 5), is based on the assumptions that resources are infinite and that infinite is also the space for waste disposal: thus, we extract resources, use them to make products that then we throw away creating enormous amounts of waste that we think we can eliminate. All this by using energy from fossil fuels, which

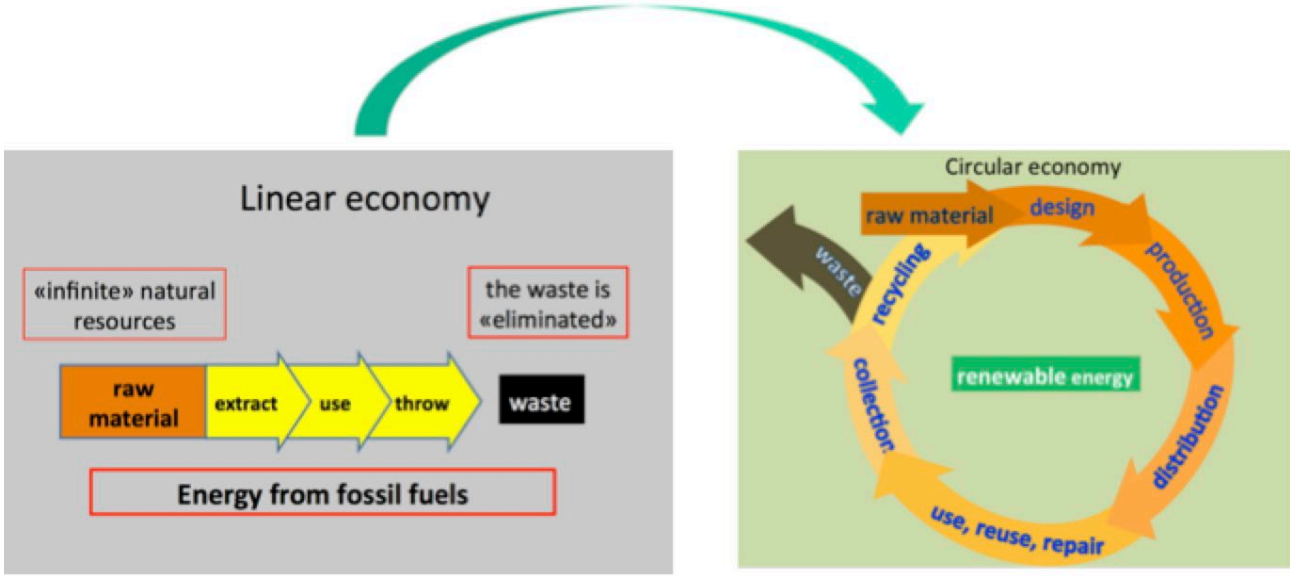

Figure 5. Schematic representation of the transition from a linear to a circular economy (adapted from[16]).

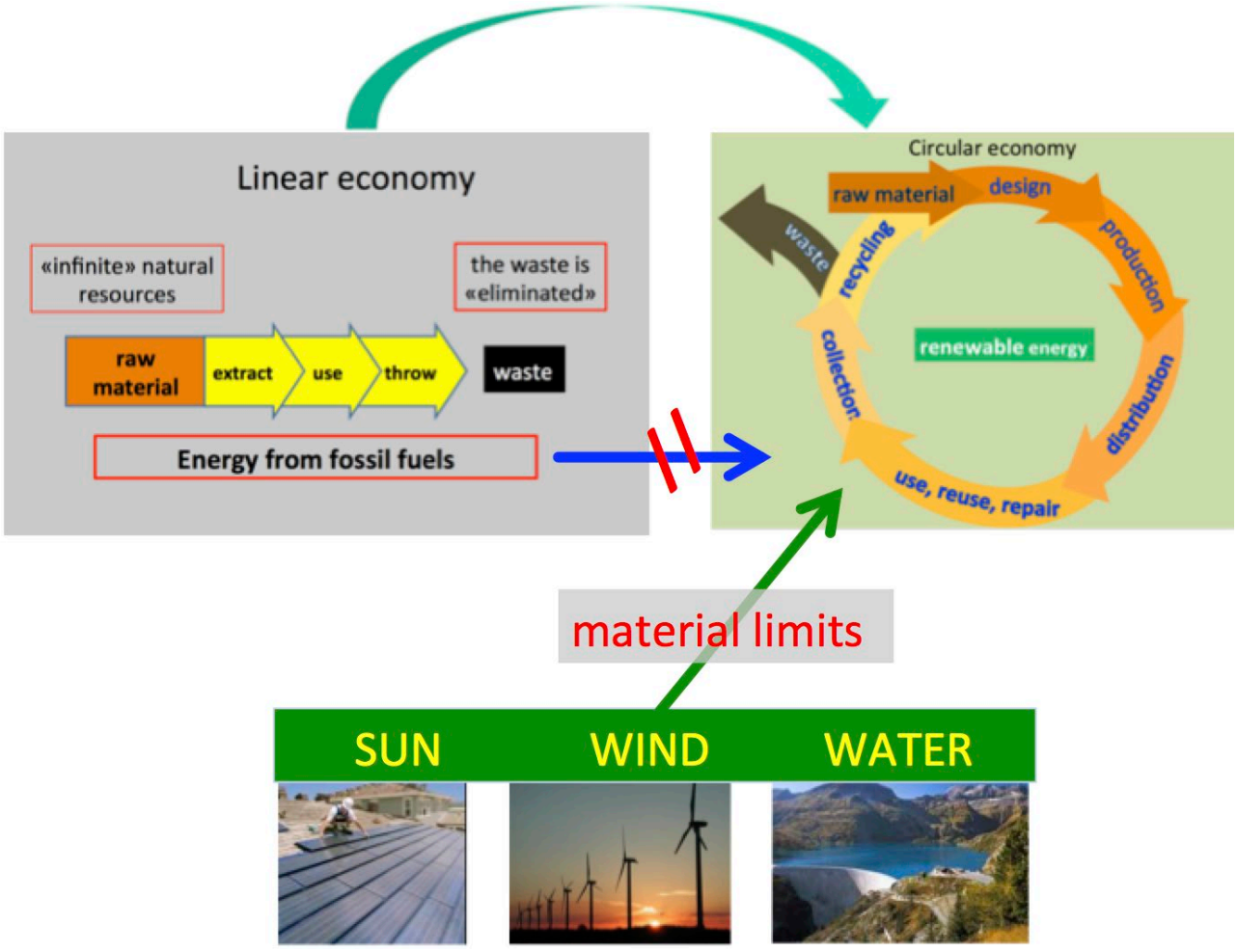

Figure 6. A circular economy system powered by renewable energies. The bottleneck is the avalability of materials for energy conversion (adapted from[16])

cause well known problems, including climate change. Such an economic model is clearly unsustainable.

We have to move to another economic model, the *Circular Economy* (Figure 5, right), which is based on the correct consideration that natural resources are limited. For this reason, raw materials must be used as little as possible (savings) and with high efficiency to fabricate things not only for use, but also for being repaired, reused, collected and recycled to provide new useful materials.

The only energy on which we can trust are renewable energies directly or indirectly related to sunlight (Figure 6). Therefore, more research should be devoted to improve energy conversion efficiencies and to develop means that can counter the two intrinsic defects of sunlight, low density and intermittency.

Can our civilization develop by adopting a circular economy powered by the electrical, mechanical and thermal energies obtained by the conversion of the primary, renewable energies of sun, wind and water? Perhaps not, if population continues to increase and everybody wishes to use more energy (and, in general, more resources), because of the bottleneck due to material limits (Figure 6). Therefore it could be wise to reduce our energy consumption, which poses a question: is it possible to live well using less energy and, more generally, less resources?

5. FROM CONSUMERISM TO SOBRIETY

The availability of energy is important for reaching a decent standard of life.[17,18] The average energy consumption of a United States citizen corresponds to about 7.0 toeq/year (toeq means tons of oil equivalent) or 9200 W, much more than the average energy consumption

of a European citizen, about 3.2 toeq/year, or 4200 W. Data concerning the analysis of a series of parameters describing the quality of life (e.g., human development index, infant mortality) suggest that, at the current levels of efficiency in energy conversion, a primary consumption of around 2.6 toeq/year per person (about 3000-3500 W) can guarantee a good quality of life.[17,18] Therefore, all we citizens of affluent countries could decrease our energy consumption without losing our wellbeing. The same reasoning can be extended to any other resource we consume.

Interestingly, Swiss scientists have estimated that 2000 W (about 1,5 toeq/year per person) represents a sufficient amount of energy to live comfortably and the Swiss government has thus proposed a law to decrease to 2000 W the energy consumption per person (presently around 4700 W) by 2050-2100.[19] Such a law, in the form of a referendum, has been approved on May 21 2017 by Swiss citizens. Thus, for people living in rich nations reducing energy consumption is indeed possible without compromising the quality of life, which is good news.

A second question, however needs an answer: how can an affluent person reduce his/her energy consumption? Scientist involved in the study of this problem say that there are two routes. One is acting on "things", which means to increase the efficiency of all the devices and machines we use every day. For example, using more efficient cars, replacing fluorescent lamps with LEDs, increasing the thermal insulation of the house, etc. Experience shows, however, that increasing the efficiency of "things" often does not lead to a reduction in energy consumption for several reasons,[20] including the so called "rebound effect").[21] It may happen, indeed, that an increase in energy efficiency encourages a greater use of energy services. For example, when a person replaces an old car with a more efficient one (say a Euro 4 with a Euro 6) sometimes he is so proud to have bought a greener car that ends up using it more than the old one.

The other way to reduce energy consumption is acting on "people" rather than on things. We must start from the concepts of sufficiency and sobriety and "kindly" solicit[22] and, in extreme cases, oblige people, with laws and sanctions, to reduce unnecessary use of energyec services. To consume less, we have to "do less": fewer trips, less speed, less light, less heating, etc. If, after having adopted the strategy of sobriety, what we use is more efficient, we will have a even greater saving: it is doing less (sobriety) with less (efficiency).

What we have discussed above for energy also applies to any other type of resources. We need to change our lifestyle based on consumerism, that means *produce-sell-buy-use-throw* away regardless of the resource consumed, the real utility of the object made or service supplied, and the kind of waste generated. We need to enter a logic of sufficiency to attain ecological stability. We need to learn to say "enough".

6. CONCLUSION

Up until now we have taken from Nature any kind of resources to increase our well-being. Only a relatively small part of mankind, however, has made use of them, and it appears that there are insufficient natural resources to bring all people at the level of consumption of affluent countries. The claim for new goods and services is deeply entrenched in Western culture, which sees growth and development as absolutes. Indeed, in the Western world, the pressure made by ceaseless advertisements quickly converts goods and services, originally considered luxuries, into necessities for everyone. We are persuaded to consume at a faster and faster rate, without any understanding of the consequences of that consumption. The most pessimistic among scientists think that at the end we will be forced by the degradation of the planet to chose sobriety.

Indeed, only a new set of ethics and policies, accompanied by decisive changes in attitudes and practices can prevent a destructive collapse of the planet. We should take the energy and climate crisis as an opportunity to move away from fossil fuels, to reduce disparities, increase international cooperation, and lead humanity to an innovative concept of prosperity. Science, but also consciousness, responsibility, compassion and care must be the roots of a new knowledge-based society.

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