

HOW FEASIBLE IS A US \$100 TRILLION TRANSITION TO A GREEN ECONOMY UNTIL 2030/2050?

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Abstract

The paper analyzes from various angles the feasibility of the transition to a green economy which has been evolving from a concept to an action plan with key targets and deadlines. The cost of the transition has been estimated and many implications have been assessed. But a planned global transition from classic fuels to renewable energy, involving 8 billion people, is a very large project that may encounter many challenges in its implementation. The analysis attempts to identify some of these challenges and to propose clarifications and solutions. The conclusions suggest a gradual approach and a permanent adaptation to the possibilities and limits encountered by the peoples and economies of the Earth. This adaptation is the more so recommended as the historical responsibilities to the current climate change situation are different, while the impact of climate change is often more oriented towards developing countries.

Keywords: green economy, net zero economy, renewable energy, feasibility of transition to green economy

JEL classification: Q40, Q50.

1. Overview of the international context of the transition to a green economy

Irrespective of the scale or significance of a project, be it personal or professional, small, or large, two conditions are to be met before anything else: 1) **the possibility of materialization of the project** from the point of view of the availability of specific technical, scientific, financial and knowledge inputs; 2) **the existence of a will/determination** in favor of supporting and implementing the project until its completion, despite the manifestation of shortcomings and unfavorable economic and social implications.

The second condition could be heavily influenced by politics and politicians, but the wide social acceptance is still very important, particularly because large scale projects or transitions require both **some efforts and sacrifices** from the part of the population at large or from the part of certain segments of population and **a relatively long time**. In case of large scale and comprehensive transitions it is an objective characteristic that not all parties involved will benefit, there will be some winners and some losers, and therefore all these aspects should be factored in before initiating such a process or before evaluating its feasibility.

In this context, the transition to a green or net zero economy can be defined as the transformation at global scale of society and economy from the extensive use of

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fossil fuels and the pollution and degradation of environment to the extensive use of renewable resources which are not polluting the environment and are not conducive to climate change.

The support of such a transition has been manifested, at least in a declarative way, since many decades, starting with the establishment of the Intergovernmental Panel on Climate Change (IPCC) by the United Nations Environment Programme and World Meteorological Organization (IPCC, 2022) in 1988.

Key moments in raising awareness on the objective need for such a transition have been the Kyoto Protocol (1997) and the Paris Agreement (2015). The 6th Assessment Report of the Intergovernmental Panel on Climate Change that consist of several thousand pages and was published as reports of three working groups during 2021-2022 period have put even more stress on the urgency of implementing such a transition and provided huge amount of data in support of the findings presented (IPCC, 2021, 2022). The most updated perspective (in relation to the date of preparing this paper) on the objective need for the transition to a green economy and on the responsibilities of the humankind for climate change has been presented at the COP27 conference on climate change that took place in Sharm El-Sheikh, Egypt, between 6-20 November, 2022 (UN, 2022a).

This research starts from the assumption that there is an (almost) unanimous decision in favor of the transition to a green economy that will allow for the control and even reversal of climate changes and, by this, will allow for a sustainable and survivable Earth for the coming generations. The fact that at COP27 were present representatives from about 200 countries and economies, more than 100 heads of state and over 35,000 participants represents a solid proof for the assumption above (UN, 2022b).

Given the fact that climate and habitable conditions know no borders it is obvious that nobody would accept the transformation of planet Earth into a place not favorable to the continuation of biological life. At the same time, given the fact that pollution of environment in different ways (which are more numerous than air pollution) is a phenomenon with global impact, the solution/solutions require multilateral participation in order to obtain measurable/significant results. Partial actions and partial results provide very little to no result for such a global problem.

Despite the (quasi) unanimity of this rational position, the implementation of the transition to a green economy at a global scale raises numerous practical challenges of different natures: ethical and historical, technological, financial, managerial, etc. In the following we will attempt to assess the feasibility of the transition to a green economy from these points of view and propose some pragmatic solutions that may constitute useful advice for the macroeconomic decision makers.

2. Challenges to the green transition

2.1. Ethical and historical challenges

As mentioned above, the Earth population is confronted in different degrees with the consequences of climate change and some immediate and practical solutions are urgently needed. Beyond technical and scientific details, there is a sensitive issue related to the historical responsibility for the current situation.

In tackling the climate change crisis, **one approach** is to start from the assumption that nowadays the Earth population has a problem (irrespective of its roots and nature) and that something should be done. According to this approach the problem (climate change) is for everybody on planet Earth and the solution is the responsibility of everybody.

Another approach, which includes the historical responsibility dimension, starts from the different responsibilities of countries / economies in generating the current situation: it is obvious that developed countries that started the industrial revolution by the end of 18th century have a much more substantial responsibility for the accumulated effects of pollution.

Choosing one approach or another may lead to different solutions and different degrees of approval from the part of countries and peoples of the planet Earth. While developed countries are much more comfortable with the first approach as it puts all the peoples and all economies in the same category, the developing countries are much more inclined to support the second one, because their contribution to accumulated pollution is much lower than that of developed countries.

The approach that starts the analysis from the present-day situation consider that peoples and countries are responsible for the pollution that happens at present on planet Earth in direct proportion to the quantity of emissions of today or of recent periods such as the last 5 to 10 years. Such an approach ignores the pollution that happened already in other historical periods, especially after the beginning of the 1st Industrial Revolution (we can place this period before 1850 as a relative historical date. The 1850 date is also taken into account when present day increase of global temperature is measured.). Therefore, this approach could have been correct only if peoples and countries of the Earth would have started the polluting emissions that influence and determine climate change in recent times, from the same conventionally considered date.

In case of such an approach we can analyze the contribution of different economies to the overall pollution of the environment based on the most recent data. The result of this approach is presented in Figure 1. If we judge the issue of present times CO₂ emissions that contribute to climate change, the conclusion is obvious: the largest polluters should do something to reduce and eliminate their pollution. In this scenario the largest polluters of today bear the largest responsibilities.

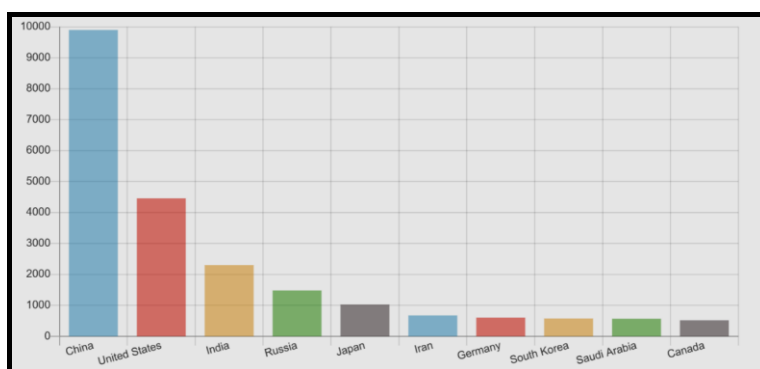
Even if one accepts this approach, the analysis is complicated by the characteristics of globalization that implies a huge role played by foreign direct investment which generated the delocalization of many activities from developed countries to developing ones. In order to have an objective analysis regarding responsibilities, a differentiation is necessary between the pollution generated in a country by local/domestic companies and the pollution generated in the same country by affiliates of transnational corporations.

From the same perspective of the most recent data regarding CO₂ emissions, if instead of the ranking the largest polluters based on total quantities of CO₂ emissions expressed in million tons CO₂, we look at the top most polluting countries per capita expressed in tons CO₂ we obtain a different picture – Figure 2.

From an economic point of view some comments are important. In case of measuring the level of development of a country, the Gross Domestic Product (GDP)

per habitant is more relevant because it allows for comparing countries with different numbers of population and also because the higher the GDP per habitant, the more developed the country is, meaning the value added per person is higher when the level of development of a country is higher.

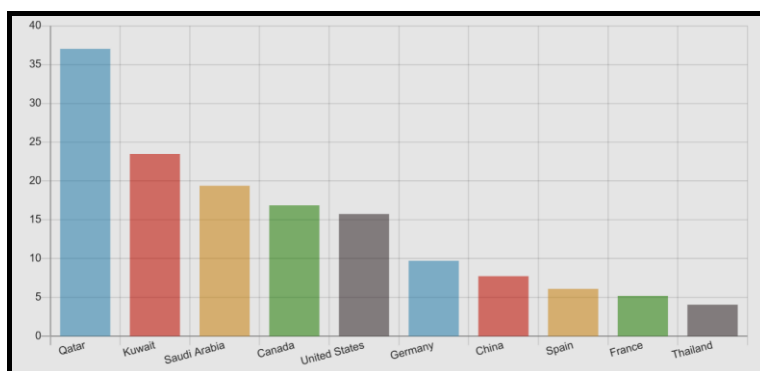
Figure 1. Top 10 countries as CO₂ emissions in 2020 (million tons CO₂)



Source: Climate Consulting - Most polluted countries in the world: 2022 ranking, based on data from BP Statistical Review of World Energy 2021, at page <https://climate.selectra.com/en/carbon-footprint/most-polluting-countries>

The same line of thinking is not valid in case of determining the responsibility for pollution because the largest impact on the environment is determined by the largest quantity of CO₂ emissions. The reason for presenting the data in Figures 1 and 2 was to demonstrate that even if we refer to the same historical period, the line of arguing can be different, and the responsible parties (countries and economies) could be different depending on the representation of data.

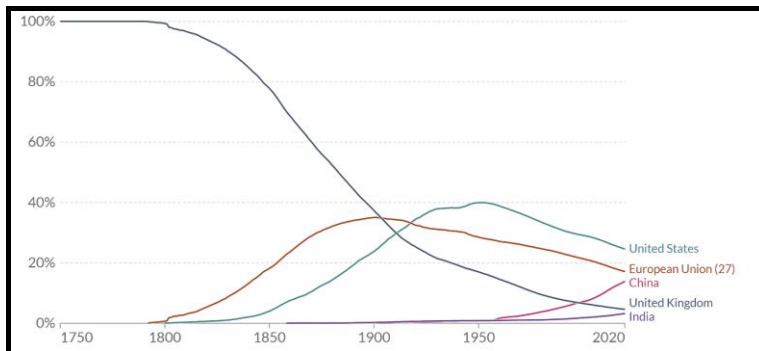
Figure 2. Top 10 most polluting countries per capita (tons of CO₂) in 2017



Source: Climate Consulting - Most polluted countries in the world: 2022 ranking, based on data from BP Statistical Review of World Energy 2021, at page <https://climate.selectra.com/en/carbon-footprint/most-polluting-countries>

The second approach put things in perspective and measure **the cumulative emissions** of CO₂ since the beginning of the 1st Industrial Revolution. In this case, if we try to identify the peoples and countries that generated the largest quantities of CO₂ emissions between 1750 and 2020 the ranking is different – Figure 3.

Figure 3. Contribution of most polluting countries measured by cumulative CO₂ emissions between 1750 – 2020 – in percentage of total quantities of CO₂ as of 2020



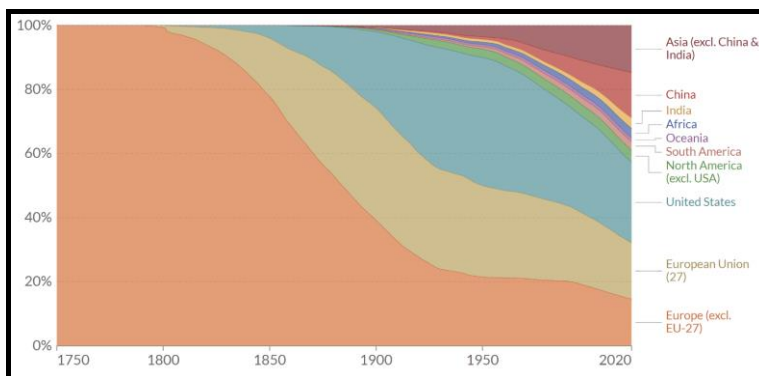
Source: Our World in Data based on the Global Carbon Project, at page <https://ourworldindata.org/contributed-most-global-co2> **Note:** The European Union (27) group refers to the CO₂ emissions of the current member countries for the periods before the existence of European Union.

In our view, **the ethical approach** (that include the historical perspective) is that which takes into account the whole contribution to pollution in general and CO₂ emissions in particular because the consequences that manifest in our time are the result of the whole pollution since the beginning of the 1st Industrial Revolution and not only the pollution from the past 10, 20 or 40 years.

In Figure 3 one can note the significant contribution to CO₂ emissions of Great Britain during the period 1750-1900 in its capacity as the country where the 1st Industrial Revolution originated. Nowadays Great Britain is a country very advanced in using environment friendly technologies and emitting very little CO₂. But the present situation cannot eliminate the responsibility for past emissions.

A representation of cumulative CO₂ emissions for the period 1750 -2020 that include all continents and large countries is presented in Figure 4.

Figure 4. Cumulative CO₂ emissions for the period 1750-2020 that include all continents and large countries – in percentage of total quantities of CO₂ s of 2020



Source: Our World in Data based on the Global Carbon Project, at page <https://ourworldindata.org/contributed-most-global-co2> **Note:** The European Union (27) group refers to the CO₂ emissions of current member countries for the periods before the existence of European Union.

The analysis of Figures 3 and 4 leads to the conclusion that the responsibility for the current situation regarding climate change should be proportional to the cumulative contribution to CO₂ emissions. Such an approach is also in line with the internationally accepted principle: “The polluter pays” that has been adopted by the OECD since 1972 (OECD, 1992).

The ethical issues related to the responsibility for CO₂ emissions refer not only to the historical heritage but also to **the present days global supply chains**. Many developed countries have delocalized their production and multinational corporations established affiliates in developing countries. In some cases the contribution of these affiliates to the economic output of the host economies is significant and present numerous benefits for the development of the host countries. But, at the same time, these affiliates contribute to a large proportion of the CO₂ emissions of the respective countries where they operate.

2.2. Technological challenges

The technological challenges related to the transition to a green economy are related to several aspects, among which the following two are predominant:

- **the availability and maturity of technologies that may allow for a significant or complete transition** to new, environmentally friendly, sources of energy and of technologies related to production, distribution and use of goods and services. We stress at this point that the transition to a green economy is not only about energy but also about the production, distribution and use of goods and services.

- **the duration of implementation necessary for materializing the transition.** This duration is of objective nature, determined by engineering aspects and cannot be reduced beyond a certain limit. That means there is an objective necessary duration of implementation even if there are all necessary financial resources, all the equipment and human expertise and agreement for implementation among all participants.

The analysis of these two aspects can be based on previous experiences starting with the 1st Industrial Revolution. As one author pointed out, socioeconomic and political factors may determine long implementation time, way beyond what different strategies and policies consider (Söderholm, P., 2020). In this context, while history is not repeating itself, it is worth mentioning that the use of electricity in economic activities was discovered in the last quarter of the 19th century, but it took almost 50 years until it was fully used in the United States economy. This fact is relevant because United States has had since the very beginning a very pragmatic, efficient and fast modernizing economy. If it took so much time for United States, chances are that other economies might take even longer.

As regards the availability of technologies related to the transition to green economy we need to differentiate between two aspects:

- **The general idea of availability**, meaning the humankind has access and possibility to use a certain technology, or, in other words, somewhere on planet Earth, in some laboratories or in some countries there are certain technologies;

- **The availability of a technology for one country or another.** Previous and current situations point out to the fact that the availability on planet Earth and the accessibility in a given country of a certain technology are two different things. As feasible and significant results in the transition to a green economy cannot be

obtained if the necessary technologies are not available and accessible to most of the humankind, then the question of making available of green technologies to developing countries becomes a sensitive and fundamental issue.

The technological challenges can be better understood if one takes into account the magnitude of the envisaged transition to a green economy. According to a report issued by the International Energy Agency in 2021, in 2050 renewable sources of energy will represent 90% of production, out of which around 70% will be represented by photovoltaic and wind energy (IEA, 2021).

From a practical point of view, in order to reach the net zero emissions in 2050 in the energy sector there will be a need of annual supplementary photovoltaic and wind generation equipment representing 630 GW for photovoltaic and 390 GW for wind. These figures represent 4 times the level of photovoltaic and wind generation equipment that was put into operation in 2020. In case of photovoltaic equipment, the annual supplementary 630 GW to be installed in order to reach the net zero carbon emissions target represent the equivalent of installing one of the largest photovoltaic parks in the world every day, meaning the addition of 1.7 GW every day. To put things in perspective, according to a ranking from September 2021 of the top 12 largest photovoltaic parks in the world, 8 of these had a capacity between 0.97-1.65 GW (that is comparable with the example above) and only 4 had a capacity between 2.05 GW to 2,8 GW (Sasibhooshan. G., 2021)

Another technological challenge is represented by the fact that renewable sources of energy require large power storage capacity because they have a variable output depending on the weather conditions. According to International Energy Agency estimates, this will mean a 40 times increase in battery installation from 2021 to 2030 and a 80 times increase if we consider the whole period of time between 2021 to 2050 (Carlin, D., 2021).

The projections for reaching net zero in 2050 also include among the hypothesis the annual increase by 4% of energy efficiency, a figure which is 3 times higher than the average of the last 20 years (IEA, 2021).

Without implying any answer, the question is if such achievements are really possible from a practical point of view. In our opinion, one necessary step before starting the implementation of various strategies and programs for transition to a green economy would be to check these figures that result from arithmetical operations with engineers and managers with expertise in large scale projects in order to determine the feasibility of implementation.

2.3. Financial challenges

Many discussions regarding climate change are centered around the importance of the transition to a green economy or around the responsibility of politicians and people in general for the wellbeing of the Earth and of the future generations. **This fact may lead to the perception that the problem consists in the lack of sufficient determination to make the decision in favor of transition.** The implication of such an assumption is that if the politicians and the people have the determination, the rest is just a matter of time and effort.

But the transition to a green economy is also a matter of money. The title of this article comes from a report issued in 2021 by the International Energy Agency that

took the first serious attempt in determining how much would cost to achieve the net zero carbon emissions in 2050 (IEA, 2021).

According to the estimates from this report, the annual investments in green energy between 2021 and 2030 will need to triple the current amount to over 4 trillion \$, while from 2021 to 2050 **the amount could be more than 100 trillion \$**. Anyway, this figure is not the only estimate available.

Another report from McKinsey & Company, issued in 2022, point to a much higher figure for attaining the zero emission goals in 2050, namely 275 trillion \$ between 2021 and 2050 (McKinsey & Company, 2022). The impact on economies, companies and individuals are expected to be substantial: only the annual increase of spending for physical assets is estimated at 3.5 trillion \$ for the next 30 years and would represent 50% of the global corporate profits, 25% of global tax revenues and 7% of household spending.

What is even more challenging is the fact that these expenses will not be distributed evenly over the next 30 years period. Like in case of any investment project, the majority of money is necessary in the initial stages that are envisaged between 2026 and 2030.

At the level of individuals the financial challenges will be reflected in an increase of the electricity bills by 25% between 2020 and 2040, and by 20% in 2050. The consumers will also need to replace most of their household appliances with new ones, more frugal as consumption of electricity but also more expensive.

In industry the cost of producing steel will be 30% higher than today and that of producing cement 45% higher. By 2050 it is expected that coal production will be completely ended, while production of oil and gas will be reduced to 50% of today's level.

The good news is represented by the fact that the above-mentioned reports and similar ones offer a pathway towards the net zero emissions goal. The not so good news is that it is not clear how such amounts will be available over a 30 year period of time, how the investments will be carried out in a global coordinated manner, how the population will face the increase of the cost of living and the loss of a global amount of 185 million jobs.

It is true that according to the same estimates the implementation of the transition to a green economy might create 200 million jobs but there are many probabilities: the 200 million jobs will be created if the 100 trillion \$ to 275 trillion \$ are available and invested in green technologies; the jobs created will not replace exactly the jobs lost, meaning there is no guaranteed correlation that the individuals that lost their jobs will be the ones to get the new jobs created; some jobs will disappear in certain countries and regions and other jobs will be created in another countries and regions.

2.4. Managerial challenges

In management it is generally accepted that one of the most difficult albeit unavoidable situations is represented by **the management of change**. Advice and best practices are available for management of change in organizations, small or large, but it is unavailable for global scale projects such as the transition to a net zero carbon emissions economy and society. The fact that such experience for planetary wide transitions is not available can be explained by the lack of any previous transitions of the same magnitude.

Transitions have happened before, for instance from steam engines and industrial equipment to internal combustion engines and electrical engines, from wired based telephony to cellular phones, from radio communications to television, etc. But the essential difference is that the transitions mentioned in the previous paragraph took place in a natural way, based on market mechanisms. Some technological inventions emerged, new products and services were created and they penetrated the market and disseminated gradually, depending on economies of scale, price signals, changes in the consumer behavior, etc. Such transitions were not imposed by administrative or political decisions and therefore **their implementation involved management of change but at the organizational level.**

In case of the transition to a green economy **the main challenge seems to be the “Earth organization”**: the planet Earth or the global economy consist of around 200 countries and entities, which are very different among themselves and very different even within themselves. In many of these entities there are in place market economy mechanisms and democratic decision-making systems which do not allow for imposing certain decisions without public consultations.

Under these circumstances, it is easy to agree on some general and humanistic goals (such as “Save the planet” or “Save the wellbeing of future generations”) but it is much more difficult to accept sacrifices when existing standard of living is low, and expectations are high in many if not all countries. And particularly when the costs of transition are not evenly distribution among countries and populations.

The success of a global project such as the transition to a green economy requires coordination and consistence in action over a 30 to 80 years period (2050 to 2100). The historical responsibilities of the largest polluters have to be accepted and adequate measures have to be implemented. The developing countries have to be assisted in achieving transition but also, they have to be compensated for losses already incurred due to climate change (the so-called “loss and damage” clause). Without these concrete steps the whole project lacks credibility and ethical support.

The recent Conference of Parties on climate change (COP27) that took place between 6-18 November, 2022 in Sharm-el-Sheikh, Egypt, offered a first hand experience on the level of cooperation that can be achieved (Harvey, F., 2022). In synthesis the results can be expressed as: general support for the goal (net zero carbon emissions), partial agreement on concrete steps towards the goal (agreement on phasing out coal, no full agreement on phasing out all fossil fuels), no clear mechanism for “loss and damage” compensation for developing countries affected by climate change. Many important decisions have been delegated to the COP28 conference of 2023. In synthesis, COP27 conference on climate change was not a failure, but at the same time was not a success: it was a step forward.

Conclusions

The transition to a green economy is a necessary, planet wide process but its implementation raises numerous challenges and necessary clarifications. The contentious points refer to the responsibilities for the current situation of the climate change, the sharing of costs of transition, the existence of necessary technologies and the supportability of the costs by different countries and populations.

It is easy to agree on a logical goal (the preservation of climate status on planet Earth) which is to be attained in 30 to 80 years' time (that is in 2050 or 2100). It is much more difficult to convince the population of developed countries that they should reduce their standard of living or the population of developing countries that they should give up their expectation for improvement of their existing low or medium level condition.

Getting back to the title of this paper, the perspective on the transition to a green economy is very important. If we start from the assumption that the funds necessary for the transition is available, then everything is an opportunity to spend them. If, on the other hand, we only know how much the transition to a green economy would cost, but we do not know yet where the money is coming from and how the funds will be converted into real equipment and sources of energy, it is another matter.

Beyond these historical and ethical aspects, as well as beyond the economic and social implications, there are also technological and engineering aspects that should be taken into account. There are limits related to the speed of implementation of the transition to a green energy, even if all the other conditions are met (technological, financial, political will and social acceptance). Photovoltaic and wind energy can be implemented only with a certain speed and current targets may be beyond that level. Nuclear reactors can be built and put into operation in a number of years and this cannot be accelerated. These arguments are not for giving up the transition to a green economy, but for securing all engineering data in order to succeed. In our opinion, the "less is more" approach is valid also in this case.

One particular aspect to be taken into account is related to the management of change to a green economy. More emphasis is needed in our view on explaining the situation to the population of each country, in coordinating actions among the regions of the same country and among countries, in being consistent over long periods of time and, especially, in sharing the costs among the countries of the planet Earth in an ethical manner.

A last thought is that the "best effort" approach should be advocated at all levels and in all countries as regards the transition to a green economy. Every entity (organization and corporation) as well as any country should strive for their best in the transition to a green economy and in their fight against climate change. Sometimes the best efforts are less than ideal results. But they are still very important because humankind will move forward and improvements in stabilizing climate could be obtained.

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