Overall review of the energy contributions for the 1.5 and 2 degrees scenarios

What about the Sustainable Development Goals?

Sustainability of the energy sources versus energy and raw materials demand till 2100

Global Initiative to Save Our Climate – GISOC

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Introduction

Currently available scenarios for the IPCC 1.5°C and 2°C (1) pathways show a large decrease of energy consumption and an extensive use of intermittent sources with storage capabilities except for a few which entail up to an increase of the consumption associated with condensed tunable energy sources.

These considerations govern the type of strategy to implement within the two IPCC pathways. We will address the issues from a global perspective, using the input from the most recent studies.

Our goal is to help the politicians, decision makers and people in charge to avoid some traps associated with various strategies while ensuring that related Sustainable Development Goals (SDGs) are achieved.

Our strategy is first to set envelopes where the likelihood of not achieving the required SDGs is high.

The related SDGs retained in this paper are 1 “No poverty”, 2 “Zero hunger”, 6 “Clean water and sanitation”, 7 “affordable and clean energy”, 8 “decent work and economic growth”, 9 “industrial innovation and infrastructures”, 12 “responsible consumption and production”, and 13 “Climate action”.

Methodology

It is important at this stage to note that all the scenarios rely on the development of non-Green House Gas (GHG) energy sources mainly in the form of electricity.

The requirements in terms of consumption (mainly metals and rare elements for energy production and energy for carbon capture) can be derived and considered against the current production and known reserves and resources. Additionally, for some SDGs, pollution is taken care of.

The following energy sources and GHG reduction are selected:

Solar energy with or without thin layers and with or without recycling, Wind power, Bio energy, Hydraulic power, Nuclear power without reprocessing and Gen-IV reactors (fast breeders), Nuclear power with reprocessing and Gen-IV reactors, Batteries to cope for the intermittence of solar and wind energies, Hydrogen production, Carbon , Bio Energy Carbon Capture and Storage (BECCS), Electric vehicles, Bio-diesel.

Review of the different energy sources and additional items

Solar energy

As described in details (2), whatever strategy applies to solar energy, the goal of 100% is not achievable by far as the consumption of cobalt and lithium is way beyond the expected production and in some cases way beyond the resources, even with the improved technologies which are not yet in place. Solar cannot achieve a production in line with the consumption by a factor 4 or more and therefore the retained SDGs, e.g. SDG 7 “affordable and clean energy”.

Wind power

For wind power, the limitation comes mainly from the rare earths (and some metals) which are used in the permanent magnets (mainly). Progression of the rare earth use for wind power has increased even beyond the 2015 estimates (3) Currently the production of electricity from wind power is quite limited. A reasonable estimate to produce 100% of the energy would be an increase of fifteen to twenty folds.

Simply for rare earth and according to the current values (about 600 kg rare earth / MW), even with a release of rare earth from other, currently closed, mines and from recycling, the resources would not be sufficient, by a factor 2 to 3 to allow for wind power to produce 100% of the energy needs.

Bio energy

Bio energy relies on materials which are common on earth and therefore does not present a technological limit other than the local release of wood pollutants and the fast aging of the components which have to be replaced regularly at the plants. Bio energy can be combined in BECCS which enables to store most of the carbon dioxide generated.

Hydraulic power

As for bio energy, the needs are mainly for largely available materials and the sole limitation is related to the sites. As a consequence, hydraulic power, which has the lowest consumption per MWh, cannot achieve a large contribution to the global energy demand.

Nuclear power without reprocessing and Gen-IV reactors

Nuclear energy accounts for 15% of the total electricity generated in the world. It requires around 65 000 t of uranium annually. To cope with the electricity demand in a scenario including transport and heating, a factor 15 to 20 should be taken into account. Based upon the reserves, which amount to 6 142 200 tU in 2017 according to the red book (4), the generation of electricity would stop within 4 years, assuming that no new reserve would be found. The generated waste (spend fuels) are left for the next generation to take care of.

Nuclear power with reprocessing and Gen-IV reactors

The generation of electricity would at first originate from light water and heavy water reactors which would produce the necessary plutonium, retrieved by reprocessing and used in fast breeders. On this basis (5), (6), the available amount of uranium is enough to cope for several hundred years at a high rate. The OECD-NEA global approach (7) shows that none of the material used for a nuclear power plant would generate a shortage. This strategy divides by 80 the volume of and specifically designed transmutation reactors can reduce the time over which the wastes would have to be stored.

Batteries to cope for the intermittence of solar and wind energy

The lithium based batteries are the most likely to be used. This being said, their consumption of rather rare materials is high. It is estimated (2) that only a few percent of the needs could be covered by 2050, first because of the limitations from the resources and second because of the competition with vehicles batteries.

Hydrogen production

Hydrogen production as a mean to store the energy looks fine from a consumption of primary resources, particularly if generated in ad-hoc high temperature nuclear reactors (no total energy limitation) but also from solar or wind power with the limitations set above. On the other hand, its behavior makes it a somehow difficult product to handle

Carbon capture as a mean to curb the evolution of the GHG concentration

This technology also called DACCS (Direct Air Capture with Carbon dioxide long-term Storage) is requiring a high amount of energy, not to mention the need for appropriate sites for the storage. The current pilots show that one would have to master a 1000 fold production mechanism based on to be developed technologies while facing the inevitable leakages (0.05-0.5% per year depending on the ground). This technology also leaves for the future generations the burden of the CO2 storages maintenance.

Bio Energy Carbon Capture and Storage (BECCS) and direct wood capture

This technology is far less energy intensive as the CO2 is already concentrated. It still requires special sites and is facing the same problem of leakage as for atmospheric carbon capture or the migration of some toxic wood components away from the storage.

These technologies also leave for the future generations the burden of the CO2 storages maintenance.

Electric vehicles

Electrical vehicles require the use of permanent magnets to reduce the volume of the motor. Their expansion is currently limited and a factor over 60 should apply to have a large amount of electrical vehicles. As a result, the reserves of rare earth would be soon depleted; leaving only the way to improve the non-permanent magnet based motors, and to further develop with materials that are more common. Under the last condition, one can foresee a large share of electrical vehicles in the coming decades.

Bio-diesel

Bio-diesel requires by design vast crop production which in turn are found in opposition with SDG number 2 as was proved in recent years when, for example, riots occurred in Mexico following the rise of crop prices impact to basic food for the poor part of the population.

Conclusion

Based upon the analysis provided by the extended work of the references, one can see that the development of intermittent energy production (wind and solar) limited whatever improvements are made in the coming 40 years.

As a consequence, and taking into account other parameters, such as SDG 2, only bio-energy based on wood, hydraulic power and nuclear with reprocessing and Gen-IV reactors can cope with the most demanding scenarios (8).

The development of nuclear energy, associated with bio-energy and carbon capture from it (BECCS), and, to some extent, the use of other energy production in remote areas with cumulative equipment have a chance to enable the various SDGs retained in this paper.

The related SDGs retained in this paper were 1 “No poverty” providing that energy is well distributed, 2 “Zero hunger” allowing for the crops to be used entirely for food purposes, 6 “Clean water and sanitation” using the desalination and other electrically based treatment, 7 “affordable and clean energy” where nuclear with Gen-IV and hydraulic power are cheap, 8 “decent work and economic growth” accepting economic growth, 9 “industrial innovation and infrastructures” enabling improvements to existing solutions, 12 “responsible consumption and production” reducing the need to use scarce material, And 13 “Climate action” by enabling carbon capture and reducing the CO2 emissions. These are addressed properly based on the adequate use of advanced nuclear cycles in combination with other relevant sources of energy when applicable.

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