# 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 raw materials demand till 2050

# Global Initiative to Save Our Climate

## 1. Background and Goal of the present work

Most of the currently available scenarios for the IPCC 1.5°C and 2°C pathways show a large decrease of energy consumption and an extensive use of intermittent sources with storage capabilities while a few others entail an increase or a stagnation of consumption associated with condensed adaptable energy sources.

These considerations are extremely important as they govern the type of strategy to put forward within the two IPCC pathways. Trying to sort out and analyse all the possible human made contributions to energy generation would be beyond the scope of our paper. Therefore, we will address the issues from a more global perspective, using input from the most recent of the numerous studies already done on the subject.

First, we have to stick to our goal which is to help politicians, decision makers and other people in charge avoid some of the potential traps associated with various strategies while ensuring that several related Sustainable Development Goals (SDGs) are achieved, at least up to the end of the century and possibly beyond.

Our strategy is to first determine envelopes, i.e. to establish limits beyond which 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”.

## 2. Methodology

### *2.1. General*

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

Assuming that a given energy source such as solar, wind, etc. would provide the world with 100% of its needs towards the middle of the century so that the excess of GHGs can be reduced over time by the end of the century seems rather reasonable according to the shape of GHG concentrations anticipated by most of the “successful” models, i.e. those which achieve the 1.5°C or 2°C goals.

Accordingly 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, as well as the estimated resources.

Additionally, pollution is to some extent taken into account in terms of its impact on the local population, i.e. on related SDG.

### *2.2. Selected energy sources and GHG reduction items*

- 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

To which, one should add:

- Batteries to cope for the intermittence of solar and wind energies
- Hydrogen production
- Direct Air Capture with Carbon Storage (DACCS)
- Bio Energy with Carbon Capture and Storage (BECCS)
- Electric vehicles
- Bio-diesel

## 3. Limitation factors, introduction of a new unit

### *3.1. Element Limitation Factor (ELF)*

In order to rank the different energy sources and related items, one has to establish their capacity to provide the required energy / service along with their own limitations. For example, a technology cannot be considered as capable of satisfying the needs if it requires more than the entire world resources of a given material (which we call Element Limitation).

We define the Element Limitation Factor (ELF) as a ratio between the consumption and the resources. If this ratio is greater than one, the technology cannot provide alone 100% of the energy needs, i.e. this factor gives an upper limit for each of the retained energy sources and GHG reduction items.

**Limitation factors per element shortage by 2050**

| Selected energy sources and GHG reduction items | Element limitation | Element Limitation Factor |
|---|---|---|
| Solar energy with or without thin layers and with or without recycling | Metals | > 4 |
| Wind power | Rare earths | 2 - 3 |
| Bio energy | Biodiversity | < 1 |
| Hydraulic power | Locations | 10 |
| Nuclear power without reprocessing and Gen-IV reactors (fast breeders) | Uranium | 2 |
| Nuclear power with reprocessing and Gen-IV reactors | None | < 1 |
| Batteries to cope for the intermittence of solar and wind energies | Lithium and Rare Earths | > 20 |
| Hydrogen production | Efficiency | 1 - 10 |
| Carbon capture as a mean to curb the evolution of the GHG concentration | Volume and Location | > 10 |
| Bio Energy Carbon Capture and Storage (BECCS) | Locations | 1 |
| Electric vehicles with permanent magnets | Rare earths | > 10 |
| Electric vehicles without permanent magnets | None | < 1 |
| Bio-diesel | Food share | > 2 |

*ELF for the retained energy sources and Green House Gas reduction items*

### *3.2.* Assessment

Thanks to the ELF, the shortcoming of many scenarios is immediately visible, in particular the scenarios that rely on intermittent energy sources in association with batteries.

The scenarios where the energy source values are close to one or less than one are the only realistic ones till 2050.

## 4. 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) is 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.

The development of nuclear energy, associated with bio-energy and carbon capture and storage (BECCS), and, to some extent, the use of other energy production in remote areas in conjunction with batteries has the potential to satisfy 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” by 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 $CO_2$ emissions.

These are addressed properly based on the adequate use of advanced nuclear cycles in combination with other relevant energy sources when applicable.