

## RENEWABLE ENERGY BY 2050: MULTIPLE CHALLENGES

Recently, group 3 of the Intergovernmental Panel on Climate Change (G3-IPCC) published the Special Report on Renewable Energy Sources (RE) and Climate Change Mitigation (<http://srren.ipcc-wg3.de>). This report includes an evaluation of the technical potential (TP), current production, costs and legal aspects of six sources: biomass, solar, wind, geothermal, hydrological and oceanic. Solar energy has the largest TP (1575-49837 EJ/year, where EJ:  $10^{18}$  joules), followed by geothermal (128-1421), wind (85-580), biomass (50-500), hydrological (50-52) and oceanic (7-331). For comparison, global energy consumption in 2008 was 492 EJ. Less than 2,5% of TP is being utilized. Clearly, RE sources have a very high TP; however, they only represent 13% of the total present supply, where eolic, solar and geothermal energies together provide ~0.5%, hydro-electrical 2.3% and biomass (mostly traditional) 10.3%. For ground transportation, ~2% is supplied by biofuels. The cost of RE is, in general, significantly higher than that of fossil fuels (FF). Employing current technologies the cost of the same amount of electrical energy is USD 0.04 for carbon, 0.08 for gas, 0.12 for wind and 0.20 for solar energy.

In the above mentioned report, 164 energy scenarios proposed for 2050 by diverse organizations/institutions are analyzed. There, the participation of RE in the energetic matrix varies largely; the most pessimistic view indicates a RE involvement of only 15%, half of them place it between 15 and 27%, while the most optimistic view reaches 77%. Questionably, this last scenario, *Energy (R)evolution*, by *Greenpeace*, was highlighted in the press release by G3-IPCC and multiplied by the worldwide press, headlining that by 2050 RE could provide ~80% of the energy. Surprisingly, when considering that the world population will grow by  $\sim 2 \times 10^9$  inhabitants, in that scenario the global energy consumption would be ~17% lower in 2050 than today, revealing an exaggerated optimism about the increase in energetic efficiency. Other options for de-carbonization, such as carbon capture and sequestering (CCS) and the nuclear one, will not partake.

The potential certainly exists, but the utilization of RE presents technological, economic and political challenges, including citizen's acceptance. It is estimated that

a significant contribution of REs in electrical generation would cost  $\sim 5 \times 10^{12}$  USD in the present decade and  $\sim 7 \times 10^{12}$  USD for 2021-2030. The first challenge for the field is cost reduction.

An interpretation of the available data is that the RE contribution would be that predicted by the majority of the scenarios (<40%), where non-renewable sources and/or technologies predominate. However, many studies included in the report could be non-representative or non-objective, since they were prepared by specific-interest groups, which explains the variability (13-77%) of RE participation. Too much optimism, as that in the press release of G3-IPCC, can be counterproductive, giving the impression that global warming would be solved since RE would replace FF by 2050, which is hard to achieve. Also, the scenarios that limit the emissions of greenhouse gases (GHG), so as to avoid warming  $>2^\circ\text{C}$ , carts before horses when adjusting the kind of energy to a pre-determined emission of GHG.

It is unavoidable to know the GHG emissions and consequent global warming by 2050. A challenge for the IPCC would be to produce with the support of scientists, professionals and technicians, a realistic/objective projection of the participation of the different energetic alternatives, renewable or not, including FFs, as a function of the needs and availability of energy, costs and financial capacity, political will and international cooperation. Great investments in the FF area are still under way, challenging the development of CCS. Could geo-engineering play a role in the removal of atmospheric  $\text{CO}_2$ ? Different aspects to the climate would have to be considered as well, such as biodiversity, degradation of ecosystems and food production menaced by biofuels.

In view of the expiration of the Kyoto Protocol it is mandatory to reach binding international agreements regarding the reduction of GHG, where RE plays a preponderant role. Unfortunately, the needed political will to achieve this goal doesn't seem to exist. Several industrialized countries have indicated that they will not sign for a new period of the Protocol. The more vulnerable countries should prepare their adjustment to eventual disastrous climate changes. The challenges exist. Will they be faced?

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