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# Alternative scenario for the energy transition

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First of all, we must recognize both the magnitude of the issues at stake - carbon neutrality by 2050, the gradual abandonment of fossil fuels, energy sovereignty - and the great complexity of the variables involved, whether in terms of the diversity and constraints of energy sources and exploitation, or at the organizational, societal, environmental and political levels (ADEME 2013, ADEME 2021a, Affaire du siècle 2021, GIEC 2021, Ministère 2022, Wiki EC 2022).

The ADEME study on the French energy transition is a comprehensive, precise and instructive source on which we must rely in order to define the strategy to follow towards 2050 (ADEME 2021a, ADEME 2021b). Each of the 4 ADEME scenarios contains interesting proposals, but it is scenario 4 that seems to us the most realistic and acceptable for the population as it is not based like the others on a drastic reduction of energy needs.

The major difficulty is to find the energy sources that will replace fossil fuels without imposing unpopular laws for the reduction of the needs (Finon 2015). The energy mix we propose is slightly different from that of ADEME Scenario 4, which suffers from several drawbacks. We recommend priority investment in the photovoltaic / STEP (Station de Transfert d'Énergie par Pompage) coupling, especially in cities and isolated villages located on hills or mountains, taking care to preserve our forests and our landscapes as much as possible, with a target to be specified, which could be around 200 TWh per year (ADEME proposes 180 TWh). This idea, which has been neglected for complex political reasons (Ministère 2006), has been successfully implemented in several places, such as Corsica. As STEP and photovoltaic systems are relative low-tech, affordable and with good recycling rates (Cancel 2019, CRE 2019, De Wild-Scholten 2013, Prix-Elec 2022), they can easily be developed at large scales, and the subsidiarity principle can be implemented for the decision process and the control of the systems. Importantly, the water basins of the STEP can easily be located underground to avoid occupying agricultural or urban surfaces. The size of the systems can also be easily adapted to the needs, for example with relatively small basins and small solar panels surfaces in order to supply energy to small villages, which is more difficult with huge wind turbines. Solar energy is also more regular than wind energy: It never falls below 10% of the maximum capacity during the day, while it can drop to zero for the wind.

Concerning nuclear energy, we propose to increase its capacity as the ADEME foresees, but this will not be easy and, above all, it will take time, because many power plants are at the end of their life, and the potential sites for large-scale power plants are not numerous (ADEME 2021a, ADEME2021b).

As the energy agency clearly explains, a massive development of biomass is expected, in particular through the valorization of waste of all kinds as well as through the production of biogas and biofuels. However, as the production of energy from waste is not profitable, it can only be implemented by taking the French energy sector out of the globalization of trade. For the biomass production, we propose to go even further by developing, in a reasonable way, the bioethanol sector as a fuel for some categories of cars. Compared to ADEME scenario 4, an additional 60 TWh of

biomass could be produced. An important issue is to develop biofuels taking all agricultural surfaces into account, especially the ones dedicated to food production as well as forests, water management (Bisch 2018), natural reserves and local ecosystems. This problem is tightly linked to the ecological footprint of the French people upon the French territory (Wiki EE 2022), and poses the question of demographic limits. Overall, the objective is to minimize the loss of living standards, with a control of the energy needs. It can be noted that in the 3 other ADEME scenarios, an important decrease in energy consumption is expected, even though the trend is stationary and the population is slowly growing, mainly because of a positive migration balance. ADEME did not integrate in its model demographic parameters, but it is clearly a key variable of the problem. According to our calculation, if there is a stagnation of energy needs per person, energy needs would increase up to 7% from now to 2050 if there is no change in the migration balance.

Onshore wind, offshore wind, tidal turbines, and other energy sources should also be considered, without being prioritized with respect to their costs, high-tech requirements, maintenance complexity, low recycling rates, and by ensuring their acceptability by the population. Compared to ADEME scenario 4, this could lead to 10 or 20 TWh less, but this would be compensated by photovoltaics (+20 TWh, see previous paragraph).

Reducing the immigration rate is a sensible political question with economic and social impacts that are out of the scope of this paper. However, for the energy transition problem, its role should not be neglected. For instance, if some efforts are made to stabilize the French population such that the immigration rate is divided by a factor of 3 (+100 000 instead of +300 000), cumulative benefits would be expected:

- In comparison with ADEME estimates, there would be a reduction of energy needs on the order of 7%.
- As agricultural needs would be lower to feed the population, a larger part of agricultural surfaces could be dedicated to biofuel production, on the order of 60 TWh equivalent.
- In ADEME scenarios, an unsolved problem is the reduction of fossil fuel needs for planes and boats. A significant increase of the biofuel production could therefore help a lot in achieving a full energy transition by 2050.

These efforts have to be made in conjunction with a strong CCS (carbon capture and storage) strategy at large scales, as suggested in ADEME scenario 4 (2021a).

Finally, it is important to remember that we must be cautious and that this scenario should not be considered as a definitive and non-negotiable objective. On the contrary, it is necessary to consider an ongoing study involving the actors in each field, to study all the issues in order to adapt and possibly modify the choices in the most relevant way, in order to ultimately reach the objectives that have been set, in particular carbon neutrality as soon as possible for the French (Salotti 2022).

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