Energy and the growing role of electricity

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In the public mind and in the media, we often confuse energy transition with transition in electricity production. Yet electricity accounts for less than 20% of the final energy consumed [1]. It is therefore necessary to have an overview of this consumption. Fossil fuels account for 80% of the world's primary energy (i.e. total energy) [2], a worrying situation that has changed little over the last thirty years despite the strong development of renewable energies. It is spent in three main areas: transport, heat production and electricity production. And fossil fuels dominate all three sectors worldwide. The necessary reduction in greenhouse gas emissions therefore implies a number of major changes.

As far as transport is concerned, the solution lies in the development of electric or hydrogen-powered vehicles, or even synthetic fuels. Progress on batteries for electric vehicles is described in the fourth part of this issue. Electricity sources will of course have to produce enough to meet this new need: typically 60 TWh for a fleet of twenty million cars, compared with the 480 TWh consumed annually in France today for transport. In the case of hydrogen-powered vehicles, the essential vector is once again the electricity used for the electrolysis of water. Electricity also plays a major role, particularly in combination with biomass, in the production of synthetic fuels.

Electricity still seems to be playing an increasing role in reducing greenhouse gas emissions in heat production: development of heat pumps in conjunction with improved building insulation, development of industrial processes using electricity rather than fossil fuels. Better thermal insulation of buildings and more widespread use of heat pumps will reduce the fossil fuel energy used for heating in France by more than 100 TWh, but supplying them will require additional electricity generation of several tens of TWh.

In every case, electricity is set to play a major role. This is another reason why its production should be carbon-free. But another consequence is that it is unrealistic to expect a fall in the corresponding production. The development of emerging countries will lead to a doubling of the world's primary energy consumption, with the trend in electricity consumption being even stronger because of the reduction in the major imbalances between rich and poor countries (fig. 1) and because of the necessary transfer to electricity of uses that rely on fossil fuels. This change in electricity consumption at global level is also necessary in France, albeit to a lesser extent in percentage terms, to support the transfer from gas to heat pumps for heating, the production of hydrogen or second-generation biofuels, the development of electric vehicles, industry and data centres, as well as the expected increase in the population. Energy efficiency improvements will not offset this trend.

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Renewable technologies (hydro, wind, solar and biomass) and nuclear power make it possible to produce electricity without the use of fossil fuels: it is therefore possible to decarbonise electricity production. Worldwide, 2/3 of electricity comes from fossil fuels [1], and the change we need to make is a major one. This is no longer the case in France, where 72% of electricity is generated by nuclear power, 12% from hydroelectricity, 4% from wind power, 2% from photovoltaic and 2% from bioenergy (2016 [3]). The effort required to move away from fossil fuels therefore only concerns 8% of the country's total electricity production. However, the law passed in France in 2015 implies a reduction in the proportion of nuclear power to 50%. If we keep to the objective of moving away from fossil fuels, the only solution is to increase the use of wind and solar power, since the sites available for hydroelectric power are almost all already in use and the production potential of bio energies is limited. Unfortunately, these sources of electricity are intermittent, both for wind and solar power, especially in our latitudes. This major problem of intermittence will be discussed in part four. Nuclear power, on the other hand, has no such limitations. This is why it will also be developed in countries that have mastered this technology and whose public opinion does not reject it en masse. This is particularly the case in China, India, Russia and countries in the Middle and Far East.

Electricity can be generated by thermal power stations (fossil, biomass or nuclear), by hydroelectric power stations, or by wind and solar power. All these technologies are now mature, but wind and solar power are more recent and are undergoing massive development worldwide. This second part is largely dedicated to them.

In the case of solar power, two technologies are available: photovoltaic and concentrated solar power. The former is easier to develop and less expensive, while the latter has the advantage of being less intermittent. Both solutions are considered in the articles by Daniel Suchet & Jean-François Guillemoles, followed by Gilles Flamant.

Wind energy will also be discussed in this section in the article by Joachim Peinke and André Fuchs, while for nuclear energy, which has already been the subject of a special issue of *Reflets de la physique* [4], elements about its possible future are discussed in part 3.

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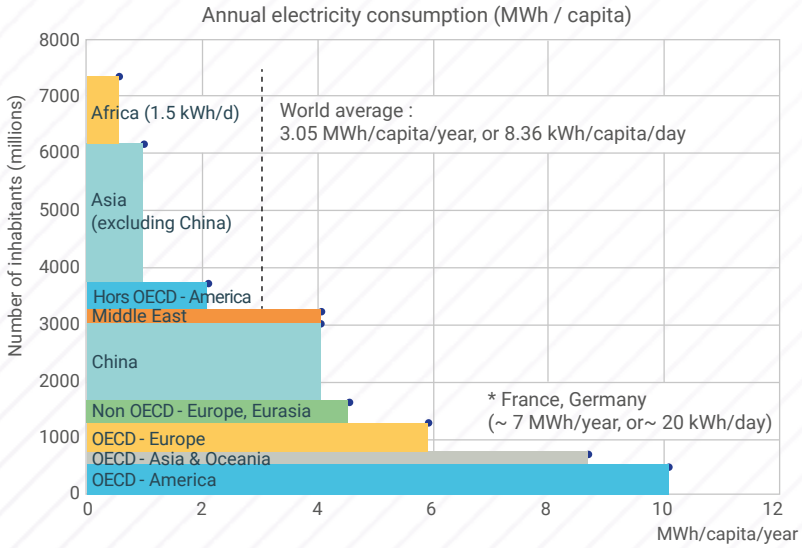
As for biomass and its energy uses, a discussion of its possibilities and its real impact on reducing greenhouse gases is worthwhile. Its real potential lies in its use in combination with electricity, either to produce heat or synthetic fuels. That's why Guillaume Boissonnet 's article at the start of this second part is devoted to it.

Finally, thermal power stations have the disadvantage of low thermodynamic efficiency. We could therefore consider giving them the dual role of producing electricity and heat. The latter, instead of being released into the environment, could be used for heating or industrial purposes. These cogeneration techniques, already developed in some countries, are discussed in the final contribution by Martin Leurent and Henri Safa. ▮



1. Distribution by region of the world of the annual quantity of electricity consumed per capita (MWh, x-axis). On the ordinate: number of inhabitants. The consumption gaps of 1 to 20 are set to narrow. (Source: IEA 2015)

1• https://cutt.ly/wikipedia-prod-electricite

2•https://cutt.ly/conso_energ_mondiales

3• www.ecologie.gouv.fr/production-delectricite

4• *Reflets de la physique*, **60** (décembre 2018).