The Energy Transition

The challenges of defossilisation

This special report on energy marks the culmination of a long-term project by the SFP's Energy & Environment Committee. The initial impetus for the project was provided by Michel Spiro. In the editorial entitled "Physicists facing the challenge of global warming" in issue No. 55 of *Reflets de la physique* (October-November 2017), he already indicated the main themes in which physicists should get involved to face this global challenge of the energy transition. This transition must lead to a move away from fossil fuels, which currently account for more than 80% of primary energy resources supply worldwide and provide around 60% of our final energy consumption in France and Europe.
The scale of the challenge is immediately clear!

As Catherine Langlais pointed out in the editorial in issue 60 of *Reflets*, devoted to nuclear electricity, physicists cannot remain indifferent to the scientific challenges and social issues involved in abandoning fossil fuels. The SFP and the scientific community in general have a duty to shed light on these debates by providing factual information and objective analyses, which are all the more necessary for subjects on which opinions are so strongly influenced by political and even ideological choices.

In any case, the members of the Energy & Environment Committee worked hard to prepare this dossier, with the aim of avoiding any ideological presuppositions and with scientific rigour as their only bias. They first had to define its logical organisation and content, then find the authors of the contributions from among the best specialists (more than half of them from outside the committee. Then after a very long editorial process and exchanges with the *Reflets de la physique* editorial committee, the final result was this issue.

In choosing the topics to be covered and organising this issue logically, we naturally took as our starting point the fundamental questions raised by François Graner and Stefano Panebianco (and taken from a 1978 dossier!) in their conclusion to the issue on nuclear power: "How much energy do we need? Is there a relationship between energy consumption and standard of living? What energy do we need? What energy sources can we count on for tomorrow or even today?".

The dossier is divided into five parts:
1• Measuring the issues and challenges
2• The main sources of low-carbon electricity and heat
3• A few avenues for defossilisation currently being explored
4• Management of non dispatchable sources of electricity
5• Environmental impacts and risks of energy sources.

It is clear that, despite its size, this dossier could not be exhaustive, so that certain subjects, however crucial, such as those relating in particular to building heating and civil engineering (materials, heat pumps and geothermal energy, etc.) could not be developed. They could be the subject of another dossier or specific articles, as could the complex issue of energy sobriety. A second limitation is that, apart from a few exceptions, we have essentially confined ourselves to the national or European context. We hope, however, that its content will shed some useful light on a number of aspects and scientific and technical data relating to the energy transition.

As coordinator of this project, I would like to extend my warmest thanks to all those who have contributed to it, first and foremost the authors and colleagues of the Energy and Environment Committee, who were fully committed right up to its final completion thanks to the work of the *Reflets de la physique* editorial committee, its managers Charles de Novion and Stefano Panbianco, and the layout artist Laetitia Morin. But this project would not have been possible without the support and renewed confidence of the successive presidents of the SFP, Michel Spiro, Catherine Langlais, Guy Wormser and Daniel Rouan. Our warmest thanks to them all.

Article available on website https://www.refletsdelaphysique.fr or https://doi.org/10.1051/refdp/2024s004

It is our duty to show the younger generations that a path of hope is possible and that the ecological transition can succeed thanks to a fruitful dialogue between scientists, citizens and political decisionmakers.

Taking account of objective constraints and the laws of nature is not an option, or, as Francis Bacon (1561-1626) wrote, "Natura non nisi parendo vincitur", i.e. "Nature to be commanded must be obeyed".

Drawing by Maika at the time of the launch of this issue, in 2017.
I dedicate this dossier to all children, and in particular to my two granddaughters Maika and Shino. Future generations must not be abandoned to the throes of eco-anxiety, or left to pipe dreams or radical dystopias.

This report does not claim to cover the whole subject, either by covering all the issues relating to the energy transition or by being exhaustive on each of the subjects dealt with. Above all, we have endeavoured to provide an objective and factual knowledge base to help inform the public debate. But it is clear that when it comes to the very first question, "How much energy do we need? "all we have done is provide information and analyse the constraints imposed by the laws of physics.

But if it's true that no society can sustain itself without a sufficient supply of energy and withdrawals from its environment (food, fuel, mineral resources, etc.), is there a minimum, an optimum? Where do we stand in relation to these limits? Apart from the direct link with recent advances in thermodynamics, this question naturally leads on to that of sobriety, or even degrowth, which is a complex subject. We must not lose sight of the global dimension of the problem, and the enormous disparities in energy consumption patterns. In assessing possible gains, we also need to distinguish between the consumption or carbon footprint of households and that generated by the collective organisation of the functioning of human societies (public services, infrastructure, industry, etc.). Is it possible to reach *a priori* conclusions before carrying out a serious analysis of the studies and data available?

Another area of work concerns the impact of the energy transition on mineral resources, a crucial subject just touched on in this dossier. What can we expect from recycling? The development of energy sources that minimise the need for materials? These are all open and motivating questions on which we physicists can gather factual, objective information, in a cross-disciplinary spirit and without bias, so that we can inform our fellow citizens scientifically, indicate the possible options… and make people understand that there is no simple solution and that the success of the energy transition does not depend solely on political decisions or changes, but also on advances in R&D on highly motivating subjects.

Gérard Bonhomme
Chairman of the SFP Energy
and Environment Committee

List of members of the SFP's Energy and Environment Committee who played an active part in preparing this report:

Jean-Louis Bobin, Gérard Bonhomme, Bernard Bonin, Élisabeth Huffer, Christian Le Brun, Francis Penent, Gérard Pierre, Jean Poitou, Henri Safa, Bernard Tamain, Claude Stefan†, Jacques Treiner, François-Marie Bréon, Stanislas Pommeret, Michel Spiro, Daniel Suchet.