Some unresolved questions and unaddressed points

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Perhaps you, the reader, have in mind an important point that merits inclusion in the debate on civil nuclear power (French or international), but which hasn't been addressed in the previous pages. It is frustrating, but inevitable; the size constraints of a publication like this one prevent us from being able to deal with the subject exhaustively. We outline here a summary of those issues that have not been dealt with. In addition, there are some issues that we believe are still unresolved and we try to identify the most critical aspects of them.

Decisions with a long-term commitment

Civil nuclear power, perhaps more than other industrial activity, involves future generations, in the sense that they will need to be able to commit energy, money, know-how, manpower and space to deal with the impact of our existing power plants, whether or not they end their operations without incident. It is a legacy of debt that they will not even have had the benefit of, unless they in turn find sufficient resources and energy to devote to it. But even if they do, will it be an endless cycle, destined to finally burst like a bubble?

How can society, in all its diversity, collectively identify and embrace such obligations, including the moral and practical issues, in the long term? Political decisions require a global weighing of the disadvantages of nuclear power (whether proven or as a risk) against the already proven damage to the climate caused by all energy sources. To inform such decisions it would be useful to reach a consensus on the profitability of nuclear power as a source of energy[(a)] as well as in terms of complete carbon balance, including all the steps involved in its decommissioning, and to compare this with other forms of electricity or power generation.

Public debate is notoriously difficult, for deep reasons (and not only because of the bias that each side tends to accuse the other of). On the one hand there is the problem of having to weigh up and compare different kinds of arguments, many of which are not readily accessible or do not have consensus. Also, decisions are often taken within a national framework, whereas the consequences, in terms of energy use or risk of accidents, are also measured at local or international level.

Nuclear power requires stability in international relations, which in turn has consequences for geopolitics. The agreements between the World Health Organization (WHO) and the International Atomic Energy Agency (IAEA) have been criticized by some organizations.

The following affect the French nuclear industry alone: its links with the embargo on South Africa at the time of apartheid; the dispute with Iran over Eurodif; links with the regimes of producing countries such as Kazakhstan or Niger; for the latter,

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the serious impact of mining on its inhabitants; the sending of French soldiers or private military companies to the Sahel; the French proposal to sell nuclear power plants to Libya, followed shortly afterwards by military intervention which led to the fall of the government.

Practical questions

Do we have to abandon nuclear power, and can we? According to the advocates of maintaining it, it is risky to reduce nuclear power production: who can predict whether the industrial balance of the sector and the reliability of the energy supply will be maintained? They put the climate issue, which is urgent, ahead of the waste issue, which is longer-term. Those in favor of phasing out nuclear power explain that it has significant environmental impacts given that it currently accounts for only 3% of world energy, that it is itself not very resistant to global warming[b] and that its phasing out could be compensated for in other ways, including by reducing energy consumption or by replacing electricity where it can be done so easily (e.g. for heating) with more efficient forms of energy. Global and local scenarios can help us to weigh up these considerations[c], although the final outcome is more a political than a technical decision.

The possible end of nuclear power could be largely determined by our response to finite uranium resources, the accumulation of waste and the increasing number of plants to be dismantled. In October 2018, a report by the Institute for Radiological Protection and Nuclear Safety (IRSN) [1] indicated that "the shutdown of reactors loaded with MOX fuel may lead to short-term saturation of spent fuel storage facilities. However, a scenario including the shutdown of those reactors using only uranium fuel could delay or even prevent the saturation of these storage facilities." This raises the question of the technical requirements and consequences that an eventual phasing-out of nuclear power would entail.

The technology used is subject to wide-ranging debate. What are the advantages and disadvantages of the third-generation reactors under construction, the EPRs[d]? Should fuels other than uranium be included in the debate: what prospects do plutonium breeders (generation IV) or thorium (whose reserves are greater than those of uranium) offer?

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What must be made of prototypes for research on fusion (ITER), on fast reactors (ASTRID) or on spallation sources (MYRRHA) with a view to the incineration of certain waste? Will they remain prototypes or will they lead to workable solutions?

French decision-making

The waste issue also triggers endless debate. The French government has focused on deep disposal of high-level long-lived waste (HLLLW). However, this type of storage is not purely passive due to the possibility of over-heating and the release of hydrogen which makes it necessary to ventilate the underground caverns. This requires a constant power supply (without interruption of more than a week) for hundreds of years; in turn, this requires political and energetic stability. Not to mention geological stability, which must be preserved over tens or hundreds of thousands of years. Opponents of this approach consider that deep storage would be largely irreversible, without having been tested beforehand at full scale, and without any dependable means of communicating with future generations. They also point out that the current storage plans only concern waste from the current stock: if we continue to produce it, will we have enough materials (borosilicate glass and steel), power and capacity to be able to store it?

The same French political decision-makers considered, during the moratorium of the Bataille law, that storage is not the only option. They advocated developing new ways to incinerate, recycle or transmute these same high-level, long-lived wastes. However, unlike storage, these processes struggle to cope with mixed wastes: they must first be separated, which we know how to do technically, but not yet on an industrial scale (not to mention the cost effectiveness, which is not among the objectives). How would research on incinerator systems tie in with deep disposal?

Technical decisions relating to the entire sector have been made by the French government, and have been debated within, among others, the Parliamentary Office for the Assessment of Scientific and Technological Choices (Office Parlementaire d'Evaluation des Choix Scientifiques et Technologiques, OPECST). However, the political proposals on fundamental and long-term issues have not yet been debated, amended and voted on by Parliament as such, except for one very visible issue, that of waste. The importance of the political issues under consideration requires collaborative, democratic processes for debate and decision-making, in full transparency and trust, which does not seem to be widely-accepted practice within the French community at present. Is it conceivable to improve the functioning of democracy, and to better integrate experience in order to make corrections a posteriori? And how do we manage, politically and financially, risks that are very unlikely yet would have far-reaching consequences?

The structure of the French sector

Transparency and trust must also extend to operators and their regulators, and here too consensus seems far from being reached. The error and incident rate in the French nuclear industry, clearly better than in many other industries and human activities, may still seem too high in relation to community expectations. This question in particular is raised by the issues of cracks and brittleness of reactor vessel steel, including that of the EPR.

The current independence of the Nuclear Safety Authority (ASN) and the Institute for Radiation Protection and Nuclear Safety (IRSN) is underlined in the checks carried out on a day-to-day basis, but critics question the ability of the ASN to impose a rigorous review of the entire industry if it deemed it necessary. Are the inspection records accurate, and how much actual influence does the High Committee for Transparency have [2]? Why is the military secret, which is in itself a democratic issue because it safeguards the policy-makers from accountability to their fellow citizens, applied as much towards civilian nuclear energy [3] as to military use? Are the links (especially concerning the engineers of the Corps des Mines) between State structures, regulatory bodies and operators now a thing of the past[(f)]?

Even if it has no direct consequence on decisions taken in the future, it may be useful to recall the history of the French nuclear industry, which is only partially dealt with in this issue: the creation of the CEA and the Marcoule center, the choice of pressurized water reactors, the Messmer Plan for civil nuclear power decided in 1974 following the first oil crisis, the construction of and problems with fast neutrons breeder reactors and the EPR. All this in the context of the simultaneous development of an entire industrial sector and a movement that challenges it. It would be interesting to look more closely at this history of the French sector, including its international context.

The need to think in the long term raises the question of the political and financial stability of decision-makers and operators, whether public or private. One of the first political arguments against nuclear power (recently revived [4]) was that it led to the establishment of a centralized and authoritarian State. Does nuclear management require a certain type of State or institutions? As for the French nuclear operators, now governed by private law, they are in the midst of a reorganization, and are involved in important and delicate international negotiations[(g)]. Should they be protected from competition?

Health and Environment

A few pages on the impact of nuclear power on health and the environment cannot be enough to cover the entire subject. The effects (not necessarily specific to nuclear power) of mining operations on producing countries and their workforces have aroused opposition, for example in Ganbaatar in Mongolia, in Falea in Mali, or with regard to the rights of Australian Aborigines [5].

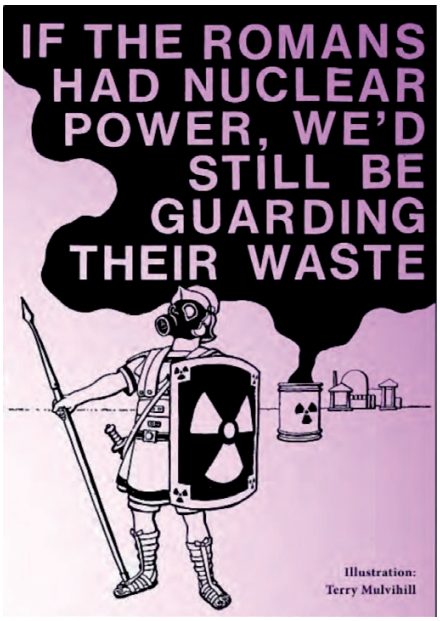
The impact of an industrial accident, which is rarely mentioned in this issue, can seem different depending on whether it is considered from a weekly, annual or generational perspective. Lessons have been learned from the accidents at Windscale/Sellafield, Three Mile Island, Chernobyl and Fukushima, based on the information available. Radioactivity in the sea affects marine biodiversity and fisheries, while airborne radioactivity can directly affect individuals and contaminate soils, with effects on food. While the consequences for Windscale were mainly in terms of the environment, Chernobyl

and Fukushima also revealed (beyond profound differences in the capabilities of States and companies in responding to and managing the situation) the impact on social relationships, family ties, people's psychology, business practices, trust in the authorities and the media, animals, all of which cannot be reduced to a purely financial balance sheet[h]. In the case of Chernobyl, the number of people affected, the extent of the damage to their health and the number of deaths remain controversial. In the case of Fukushima, the density of housing in the affected areas has highlighted, both for the authorities and the people concerned, the difficulties of decisions to evacuate or return, as well as those to do with daily life i.e. living, eating, playing, breathing, working, travelling.

The likelihood of a future accident involving a French reactor is difficult to predict; the nuclear fleet has had five accidents that could have become serious and which have all been brought under control[i]. In addition to human error, which cannot be excluded, and extreme natural events, how can we take into account possible deliberate interventions such as attacks on a power station or spent fuel pool (storage pond) by a suicide bomber or terrorist pilot, in an era when the means of attack are rapidly changing? The debate on safety and security[j] also relates to the ageing of the power plants. In November 2017, the French press reported on the seismic risks and obsolescence affecting Armenia's only nuclear power plant, in Metsamor, and on the ruthenium-106 pollution that recalled the Mayak nuclear complex in Kyshtym (Russia), which in 1957 was the site of a serious accident that had been kept secret for a long time. Any extrapolation to the French nuclear fleet is tenuous.

In conclusion

To conclude these unresolved questions, we will recall those asked 40 years ago in the preface to a special issue on nuclear energy [6]: "How much energy do we need? Is there a relationship between energy consumption and standard of living, consuming more and living better? Who doesn't have enough energy, who wastes it, and why? What kind of energy do we need? Which one, for a given use, is the best choice from the point of view of the community and individuals? Is there a relationship between forms of energy and forms of society? Which sources of energy can we count on for the future or even for now? To what extent is nuclear energy indispensable to us? Is the French nuclear power program realistic? Is it realistic to want to stop it?" ▮



a. The "energy return on investment" (EROI) of a sector is the ratio of the energy it provides to the amount of energy used for production.

b. Power plants need to be cooled; in times of heat waves, they sometimes have to be shut down and this can happen even in Sweden.

c. See the article by S. Bouneau (p. 46) and that by N. Maïzi and F. Briens (p. 49).

d. The first generation of nuclear reactors is the now-obsolete natural uranium and graphite-gas (NUGG) reactor. The pressurized water reactors currently in operation in France are part of what is called the second generation. Pressurized water reactors under construction are called "third-generation" reactors, whose safety has been improved, such as the European Pressurized Reactor (EPR).

e. On the issue of waste, see several articles, in particular those by J.-Y. Le Déaut (p. 13) and B. Romagnan (p. 14), and the discussion with C. Stéphan and P. Barbey (p. 19).

f. Greenpeace is denouncing such links at the Conseil d'État (Le Canard Enchaîné, 3 October 2018).

g. The Uramin affair (financial scandal involving Areva), the difficulties of the EPR construction sites may have significant impacts on these operators and their prospects.

h. For an estimate of the cost of an accident, see the article by A.-S. Dessillons (p. 29).

i. St-Laurent-des-Eaux on 17 October 1969 and 13 March 1980, Le Bugey on 14 April 1984, Civaux on 12 May 1998, Le Blayais on 27 December 1999.

j. The report of the Commission of Inquiry on the Safety and Security of Nuclear Installations, known as the "Pompili Report" (28 June 2018), went well beyond the framework of safety to address various aspects of the industry. EDF responded to it on several dozen points: www.edf.fr/sites/default/files/contrib/groupe-edf/producteur-industriel/hydraulique/Notes%20d'info/note_info_pompili.pdf.
Barbara Pompili responded in turn: https://barbarapompili.fr/reponse-a-edf-concernant-rapport-de-commission-denquete/

References

1. IRSN report on the nuclear fuel cycle in France, October 24, 2018, www.irsn.fr/FR/Actualites_presse/Actualites/Pages/20181024_Publication-rapport-IRSN-sur-cycle-du-combustible-nucleaire-en-France.aspx
2. www.hctisn.fr
3. M. Prieur, « Nucléaire, information et secret défense, Débat public-Caen, 14 novembre 2005 », Revue juridique de l'Environnement 3 (2006) 289-301, www.persee.fr/doc/rjenv 0397-0299_2006_num_31_3_4550
4. https://zad.nadir.org/spip.php?article6177
5. See for example:http://falea.eu; http://mcca-ain.org/index.php/cris-de-victimes; « Australie, colonie de l'uranium », Revue Z, 6 (2012) 72.
6. M. Bosquet (or A. Gorz, pseudonyms of G.Horst), « Au soleil de l'an 2000, peut-on stopper le nucléaire? », Que choisir ? N° spécial Énergie (February 1978).