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NUCLEAR POWER ENERGY AFTER THE FUKUSHIMA ACCIDENT

1. INTRODUCTION

Fukushima after Chernobyl, a major accident every 20 years – and not per millennium as the probability calculation would forecast, the anti-nukes resume their attacks fiercely hammering: "It is imperative to give it up."

Mrs Merkel, the Chancellor of Germany who was instrumental in passing a law in 2010 for a 12 years extension of reactors operating life, was forced to reconsider this decision and made plans for the final shutdown of all German reactors late 2022. In Switzerland, it is intended not to replace the reactors, the last of which will work until 2034.

Doubts settle in French minds: Don't we play the sorcerer's apprentice? What would happen to us if a major accident occurred?

In order to answer the anti-nukes' arguments, let's resume the statement of Greenpeace[1]: "*Greenpeace was founded in the early 70's to protest against U.S. nuclear bomb testing. Forty years later, our conviction is always the same: nuclear energy jeopardizes our planet. It is dangerous, unnecessary and costly. In France, the world's most nucleated country, the nuclear lobby (citing the State, Areva, EDF....)*[2] *prevents any national debate. EHV (extra high voltage) transmission lines endanger the health of residents. Spent fuel and nuclear waste casks are shipped through France in violation of the most basic safety rules. We denounce plutonium reprocessing and waste disposal projects. The French nuclear policy is irresponsible, unworthy of a democratic country.* "

The following text, worked out by the GASN, responds to the anti-nukes arguments, addressing: the dangers (including waste), energy requirements in France and in the world, the cost of nuclear energy, the control of civil nuclear technology by the society.

2. NUCLEAR ENERGY IS DANGEROUS

Speaking about danger, which risk do we refer to? Risk of sudden death due to radiation (the ghost of nuclear weapons is in the background)? Risk of slow death from diseases due to radioactive contamination? (See GASN sheet No. 41.) Risks associated with proliferation (nuclear threat) and terrorism (threat of radioactive pollution)?

We will compare all these risks with other industrial and societal risks, including of course those associated with waste management.

Energy source	Rate deaths/TWh	% world energy
Coal	161	26
Oil	36	36
Natural gas	4	21
Biofuel/Biomass	12	
Peat	12	
Solar (rooftop)	0,44	< 0,1%
Wind	0,15	< 1%
Hydro - world	1,4	6
Nuclear	0,04	5,9

http://nextbigfuture.com/2011/03/deaths-per-twh-by-energy-source.html

2.1. NUCLEAR EXPLOSION HAZARD

The Chernobyl accident was an explosion of the reactor core (see GASN sheet No. 46). The resulting injuries concern fire-fighters who were seriously irradiated: of 237 participants, 28 died within 3 weeks, 19 others died between 1987 and 2004, for various reasons not necessarily related to radiations.

These figures are comparable to those of the explosion of the AZF factory in Toulouse, France (2001): 30 killed, 2500 injured, but lower than in Bhopal, India (1984): 3828 identified deaths, nearly 12,000 invalid.

However, no movement arose to "give up imperiously" chemical plants. After the Seveso accident (1976), measures had been taken to classify hazardous sites in Europe and place them under State control.

For nuclear energy, radiation hazard concerns the personnel, in case of accident, but also during maintenance operations. GASN sheet No. 39 deals with the surveillance of the personnel of subcontracting companies providing maintenance to French nuclear power plants (NPPs).

2.2. THE DANGER OF RADIOACTIVE CONTAMINATION

Whether we analyse the disaster of Chernobyl or the disaster of Fukushima (see GASN sheet No. 47), the number one issue that directly affects people is the radioactive consequence.

[1] *http://www.greenpeace.org/france/fr/campagnes/nucleaire/*

2 Which is a non-sense: a lobby being a pressure group on State representatives, it cannot be composed of the State and public companies!

After the Chernobyl disaster, 400,000 people were displaced, and nearly 6 million people were exposed to the radioactive contamination that resulted, in places, in whole-body 50 - 150 mSv (millisievert[3]) doses accumulated in a few weeks. At Fukushima, 80,000 people were evacuated, as a precaution, from the 20 km area surrounding the NPP. We fully understand that the prospect of evacuating Rhine valley, Normandy, or Rhone Valley territories, arises fierce opposition from the owners of agricultural land and from many of townspeople!

Should we analyse equivalent civilian events involving population displacements, we would mention dams' erection: let's remember the protests in France, in the 50's, when flooding mountains valleys... In China, the Three Gorges Dam, the world's largest one (18 GW), required the displacement of 1.8 million Chinese living on the 1,000 km2 of the reservoir ; its break would put 75 millions people downstream at risk.

Analysing Chernobyl accident consequences, we notice that:

• Flora and fauna, which were severely affected in the vicinity of the plant, did adapt to the new conditions, the forbidden zone eventually become a sanctuary for wildlife thriving there. However, neither meat nor vegetables (mushrooms, berries) are edible according to our health standards, which excludes any agrarian activity in the exclusion zone.

• Resident animals have become more resistant to a high dose of radiation, they have developed natural defences (hormesis effect), a phenomenon that could be used to decrease the side effects of human radiotherapy.

• Plants malformations remain, varying according to species (e.g. birches mutate less than pine trees). Some pictures may have upset people showing children malformations, as displayed by the media after the accident. But let's be clear, if there may be deformity of the foetus exposed to radiation (depending on the level of radiation) during pregnancy, there is no genetic transmission of radiation effect: this was proven by the studies performed after Hiroshima and Nagasaki bombings.

Regarding the effect of radiations (see GASN sheet No. 12), it must be compared to other causes of cancer: toxins (tobacco, alcohol), chemical pollution (urban and agricultural). Due to lack of epidemiological studies, which are very complex to achieve (see GASN sheet No. 42), the effects of chemical and biological pollutions are indeed difficult to quantify. That is the reason why it is not possible to give serious figures about the health of populations affected by the aftermath of Chernobyl, due to the sociological confusion which occurred in the former Soviet Union (see sheet GASN No. 45). Let us simply recall that a human cell undergoes every day nearly 90,000 breaks of one of the two strands of DNA, and a dozen breaks on both strands at a time, simply because of its metabolic environment. These DNA breaks are repaired by a powerful cellular repairing biological system (the double-stranded breaks are less easily repaired). One sievert (which is a very high radiation dose) issued in a very short time (thus producing a maximum effect) causes about 1000 single strand breaks, and forty double-stranded.

In France, tobacco – the leading cause of cancer – would be responsible for 60,000 deaths per year (one death out of 10) and passive smoking for 3,000 to 5,000. For one smoker out of four, life expectancy is reduced by an average of 20 years and results in death before the age of 65. Yet, nearly 50% of 18-34 aged people do smoke!

To conclude this section, let's keep in mind that the 3rd generation EPR (see GASN sheet No. 13) was designed to confine radioactivity even in case of major accident (core fusion), and will not need in any situation any evacuation – even temporary – of surrounding population. In addition, after every ten years, the nuclear plant operator has to perform a global safety review which is evaluated by the ASN (the French Nuclear Safety Authority).This review allows continuous safety upgrading: as a feedback from TMI accident, hydrogen recombiners, and particle filters have been placed on the containment of French PWRs. In the case of Fukushima Dai-ichi NPP (equipped with BWRs), it could have avoided the explosions in the units # 1, 3 and 4, and would have limited the release of radiocaesium that compelled to the evacuation of nearby populations.

2.3. THE DANGER OF PROLIFERATION AND TERRORISM

Tensions with Iran and Pakistan are threats to the international stability. However, is nuclear energy so much involved?
It is much easier and faster for a country which wants to manufacture nuclear weapons, to enrich uranium with centrifuges.

In France, in order to reduce the risk of proliferation, plutonium recycled from spent fuel reprocessing is mixed with uranium into MOX fuel (which is burnt in nuclear reactors), rather than being stored on shelves. Improved treatment processes are studied, such as coextraction, so that the plutonium is never pure in the treatment cycle (see GASN sheet No. 7).

Also, why would terrorists hijack a shipment of spent fuel, protected by security forces and placed in a reinforced container, while it is simpler to blow up a dam, or a gas plant, or even hijack a plane to crush it on a city (New York, 09/11/2001)? Cyber attacks against Estonia (April 2007), Lithuania (June 2008), Latvia (February 2010) and Iran (June 2010) show that one can attack a country without the need for a weapon. Bacterial contamination is discreet and efficient (thirty deaths in Germany in June 2011) and for more spectacular attacks, terrorists hit urban transport (Paris, July 1995 ; Madrid, November 2004 ; London, July 2005).

[3] *Mean exposure in France is 3 mSv/year (incl. medical radiation exposure)*

2.4. NUCLEAR WASTE

Let us say clearly that anti-nukes lie when they beat the slogan "there is no solution for nuclear waste". In fact, all human activities produce waste, and the most important quantities in France come from agriculture.

Indeed, due to its very specific dangers and to the conditions of scientific development (France has been a leading country, with the Nobel prizes attributed to Marie Curie and Frederic Joliot), nuclear industry was the first to early take care of the treatment of its own waste. In France, spent fuel treatment for recycling is carried out on an industrial scale, according to the principle of sustainable development, making our country a world leader in this field.

Recycling allows to economize some 17% of our needed uranium, to recycle plutonium instead of storing it as radwaste, and to isolate non-recyclable waste such as high activity fission products, which are turned into glass then packaged in stainless steel containers, designed to be placed in a geological storage (see GASN sheets No. 7 and No. 3). Such high activated wastes represent only 10 grams per year and per Frenchman.

Intermediate-level long-lived wastes are also placed in sealed stainless steel containers to be disposed of in deep wells. Short half-lived (30 years) radwaste is currently stored at special sites monitored vis-à-vis leaks; its amount is 450 times less than the hazardous industrial waste produced in France, some of which are highly toxic: Even if improvements have still to be looked for, nuclear waste management in France could be used as an example compared to some other industries which do not always show as much civic sense in waste treatment.

Besides, in the absence of nuclear energy, France would need to use coal which is the primary (50%) source of electricity in OECD countries. However, a 1000 MWe coal plant, operating 6600 hours per year and producing 6.6 TWh, rejects 1500 tons of dust, 40,000 tons SO2, 20,000 tons NOx, and 5 millions tons CO2!

In order to replace the 400 TWh produced by nuclear energy every year in France, you simply need to multiply these pollution figures by 60, add the ash slag pile loaded with heavy metals and low-level radioactive impurities, concentrated by a factor of 10 during combustion (about 10 kBq / kg), and take into account the detriment due to rail transportation of some 30 million tons of coal per year (15 000 trains tracting one hundred wagons each one loaded with 20 tons of coal). Recall that sulphur and nitrogen dioxides are toxic (highly irritating), causing acid rains and ocean acidification: their health effects are immediate, while the acidification effect of soils and sea, and the greenhouse effect of CO2, will play in the longer term, but in an almost irreversible way during the century. And concerning CO2 sequestration (see GASN sheet No. 35), it is difficult to imagine that environmentalists will agree to store under their feet tons of CO2 that could escape and destroy all life on vast territories, as was the case in Lake Nyos, Cameroon (1986), while they do not accept carefully packed nuclear waste in stable geological layers!

3. WE CAN GO WITHOUT NUCLEAR ENERGY

Sure, since it was the case until the middle of the XXth century, just as they could go without fridge, washing machine, internet and air conditioning...

But do not look at the world only through Western consumers' spectacles: developing countries require access to energy – which is liberating from human condition, and 2 billion people still lack access to electricity.

Today, a 1000 MW coal-fired plant is started every week in China with the pollution that entails. China and India have also invested in wind power, especially in deserts, because this technology does not require water unlike coal-fired or nuclear power plants. But wind is a random phenomenon, and with average availability ratios of 20% in France, wind power remains more expensive than nuclear power by a factor 2-3, depending on local economic and wind conditions (see GASN sheet No. 31).

Regarding wind power, it is striking that no one questioned the privatization of the seas, once spaces of liberty accessible to all. Bays were first polluted with fish farms, and now artificial islets are blooming off, creating a wreck risk for vessels, with wind turbines more massive (7 MW, almost 200 m at blade top) and numerous (parks including a hundred turbines). No "environmentalist" denounced such a creeping privatization...

On the other hand, environmentalists have long opposed the development of extra high-voltage lines (for example, linking Spain and France). Yet although still expressed on the website of Greenpeace, the claim disappears from the discourse of the Greens because it goes against the development of wind energy. RTE (the French Electricity Networking Company) envisages, in its 2011 report, "a significant strengthening of cross-border trading capabilities with the creation of new interconnection lines leading to a doubling of current capacity. For illustration, an analysis conducted in Germany by DENA (German Energy Agency) highlights the need for approximately 4000 km of extra high voltage power lines to support the integration of renewable energy. "

4. NUCLEAR POWER IS EXPENSIVE

In the absolute, such an assertion does not make sense: it must be precised: who pays? for what? when?

4.1. CONTROLLING ENERGY COSTS IN FRANCE

Nuclear power was developed in France after Great Britain and at the same time as Germany, Switzerland, Belgium, Spain and Sweden, for reasons of energy dependence: after two oil crises, it was urgent to control energy imports, when coal and gas reserves had run out. With nuclear, uranium counts for only a few percents of the MWh production total cost, whereas for fossil fuels, the fuel costs reach half of the production cost and exceeds it for natural gas. Nuclear power makes it possible to control costs of electricity generation, in a comparable manner as renewable energies (from wind, sun and biomass) do.

4.2. A LONG-TERM POLICY

A decade is necessary to launch a nuclear program. Investment costs are important in comparison to gas-fired plants. Per MWe, the investment costs are comparable to wind power (but with a much higher and predictable availability ratio, keep in mind that as electricity cannot be stored, the only relevant economic comparisons involve global parks able to answer at any time to the demand), and much cheaper than solar energy. Nuclear plant lifetime is now 60 years, therefore the price of money (discount rate) is of great importance when evaluating the future cost of nuclear energy production. As previously mentioned, another important parameter is the availability coefficient : it reaches 90% with nuclear plants, whereas average value for wind energy is 20% in France (and even less in Germany) and could reach 35% with offshore windmills, but with increased investment and maintenance costs.

4.3. NUCLEAR RESEARCH IS EXPENSIVE!

False, when considering that the entire French research program corresponds to profits realized by the sale of electricity during 2 fiscal years only. Per energy unit nuclear research costs half as less as crude oil prospection.

4.4. REPROCESSING IS EXPENSIVE!

False, the prospective study[4] to Prime Minister showed that the two routes, direct disposal of spent fuel and recycling, were financially equivalent. By cons, reprocessing allows to divide significantly the mass of high level long lived radioactive waste to be stored, to reduce its toxicity, and to recycle unused material (uranium and plutonium), in compliance with sustainable development principles.

4.5. DISMANTLING WILL BE VERY EXPENSIVE!

On the one hand, a provision for dismantling costs (see GASN sheet No. 30) is already included in the MWh price, on the other hand the report of the French Court of Auditors issued in January 2012[5] mentions that the doubling of the dismantling costs would impact the MWh price by only 5%.

4.6. CIVIL NUCLEAR RISK INSURANCE IS UNDERVALUED: THE STATE WILL HAVE TO PAY IN CASE OF DISASTER!

That's right, insurance liabilities are limited in Western countries, otherwise this risk would no longer be insurable. "*Nuclear energy is an area where state responsibility is mainly based on the notion of exceptional risk faced by the population due to the pursuit of public interest, or based on national solidarity. The State may even be held responsible for its approval or its failure in licensing procedures*".[4]

The insurance cost paid by nuclear operators in France used to be less than for other OECD countries due to the public character of French companies (EDF, Areva), but the situation will be reviewed to comply with the international rules[5].

In Japan, the Government had to commit for compensation of the consequences of the evacuation, unless TEPCO would have risked to go bankrupt. However, the Fukushima accident revealed the lack of control of NISA (Nuclear and Industrial Safety Agency) vis-à-vis the nuclear operator TEPCO. It is not possible to talk about risk insurance in a country, regardless of the control that the State has with respect to plant safety.

4.7. URANIUM ORE IS A NON-RENEWABLE RESOURCE

Indeed, proven and assumed reserves are estimated to represent one hundred years at the current level of nuclear operation. But on the one hand the low price of uranium during the last decades did not encourage new prospection, on the other hand uranium ore is relatively dispersed and can be extracted at lower levels (hence at higher prices) but lower political risks than oil or gas. Recall that the price of uranium accounts for only a very small part in the MWh cost, its doubling would not affect more than 5% of the total.

Furthermore, by the end of the century, new Generation IV reactors (see GASN sheet No. 22) will be able to take the relay of current ones and will consume uranium-238 and thorium-232, extending uranium resources capacities to millennia.

In conclusion, in the French economic conditions, nuclear MWh cost is similar to the one produced by coal or gas-fired plants, but it does neither produce CO2 nor pollute with oxides of sulphur, nitrogen and carbon.

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[44] *Etude économique prospective de la filière électrique française ; JM Charpin, B. Dessus, R. Pellat - juillet 2000* http://lesrapports.ladocumentationfrancaise.fr/BRP/004001472/0000.pdf

[5] *Les coûts de la filière électronucléaire, Cour des Comptes, Rapport public thématique (Janvier 2012)*

5. NUCLEAR IS NOT DEMOCRATIC

For many years, anti-nukes asked for a referendum on nuclear energy in France, like the one which led to stop nuclear production in Italy, and was recently confirmed in a new vote. In other European countries, government's energy policies were approved by the parliaments. In Germany, agreements between parties were discussed before submission to MPs' vote. In Finland, a broad debate was held before the decision was taken to invest in a 3rd generation unit.

In France, a national debate on energy was held in 2003. The National Commission for Public Debate discussed this issue in 2005. A public debate on the EPR concerning Flamanville NPP took place the same year.

The Law "Transparency and Nuclear Safety", passed in 2006, established a Nuclear Safety Authority (ASN) in charge of regulation, independent from the Ministries, and at a local level, Information Commissions (CLI). These Commissions discussed the incidents that occurred in nuclear plants and which must compulsorily be declared according to the regulatory process. Despite the significant developments of transparency completed in France for the last twenty years, anti-nukes did not renew their slogans.

6. CONCLUSION

In France, nuclear industry was developed for independence considerations. It does not pollute the environment, risks vis-à-vis the populations are under State control, costs are competitive. With energy savings and sorting - valuation of waste, nuclear industry is a major actor of sustainable development.

The state control of this risky activity corresponds to the French philosophy of society organization: a respected State power, management of the strategic activities by public companies (EDF, Areva).

At the societal level, nuclear energy is relevant of ethics principles which some consider as backward-looking: vision of national issues in the long term, management of large public investments by the state, as opposed to the short-term political development set up since the 80', based on deregulation favoring financial speculation. As a result, the French nuclear system is not exportable following a purely mercantile approach.

We need to progress in order to dispel the "fears" exacerbated by anti-nukes lobbies, all the more sly as they are invisible: public education in physics (power, energy, etc.) and radioactivity units should be developed, physicists should use simple comparisons and physicians should better inform about disease mechanisms and risks.

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