

HIROSHIMA, Japan, August 2011

The ominous shadow of the Atomic Age: an experience to phase out forever

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Foreword. The considerations of the present contribution are extracted from much more extensive and systematic treatments in two books of mine, unfortunately in Italian, respectively on nuclear armaments and civil nuclear power: A. Baracca, *A Volte Ritornano, il Nucleare; La Proliferazione Nucleare Ieri, Oggi e Domani (Sometimes They Come Back, Nuclear; Nuclear Proliferation Yesterday, Today and Tomorrow)*, Milan, Jaca Book, 2005; and A. Baracca and G. Ferrari Ruffino, *SCRAM, ovvero La Fine del Nucleare (SCRAM, or rather The End of Nuclear Power)*, Milan, Jaca Book, 2011

Almost 70 years ago “civilized” mankind, in an impetus of pride (and under powerful material interests), undertook a project typical of a superman: reiterating the ancient myth of Prometheus, or of the sorcerer’s apprentice, it flattered himself of curbing the “atomic fire”. That insane choice subjected mankind, for the first time, to the danger of his own extinction caused by a nuclear holocaust, and created problems of a kind that admit no solution and will presumably rest on him until his disappearance from this Planet.

In fact, nuclear processes play a fundamental role in the structure of the universe, but at least millions of kilometres away. On the Earth nuclear processes exist, but they are in the substance “fossil” relics of the original processes of the formation of the universe, and play only a marginal role in the physical and chemical processes on our Planet. The latter, in fact, wholly depend on the external electrons in atoms, and involve energies, and temperatures, millions of times lower than those needed in order to trigger processes. This is the basic reason why the by products of the artificial processes which activate the nuclei of the atoms cannot be neutralized by the natural processes on Earth, and they must be left to their natural evolution, which in several cases takes hundred of thousand, or millions of years. Every attempt to find technological solutions for these problems is doomed to create even new problems. The technological illusion must be abandoned: it has already created epochal problems, which became a defiance for the future itself of human kind, an immoral inheritance left to future generations. It’s time – if not already too late – to retrieve ways of living, displacing, producing, consuming in less wasting ways, in equilibrium with Nature, its resources and processes. The enormous problems generated by our “civilization” until now must be dealt with in the best and less dangerous ways, first and foremost the by products of the man-made nuclear processes.

I am quite sure that at present a large majority of world population is in favour of a complete elimination of nuclear energy, in all its forms and uses. We must succeed in transforming this widespread opinion into explicit will and concrete action in order to impose such a choice. Unfortunately, the political regimes in the world, in spite of even deep formal differences and their call to formal “democracy”, with a few exceptions, if any, rule and impose political and economic choices under the pressure of mighty powers (among them nuclear and military industries), and against the majority of public opinion and interest. Our challenge is to overturn this situation, and impose the respect of the will and interests of the majority.

In Italy we have recently won some important national referendums which were directly connected to this problem. In general terms, the Italian population firmly asked that what we call *common goods* are unavailable to private profits: in the first place, water and public services. Energy is among them: it is in fact an essential resource for life, but it is at present subject to private interests and profits. Unfortunately, even in this case of such a striking expression of public

will, our political class, quite independently from its specific orientation, is trying to ignore and betray such will, using also violent repression when the latter erupts against unpopular projects contrasting with common interest. The main aim of Governments is to make citizens pay for the speculations of international finance and the debts of the banks, that led to the present economic crisis.

I think that it is advisable here to specify that national referendums in Italy have a repeal character, i.e. they can only propose the repeal of official laws. The *referendum* concerning energy was specifically devoted to an emergency, an horrible law which was imposed by the Berlusconi government instrumental for the reintroduction of nuclear power in Italy. The Italian people had already voted against nuclear power in a referendum in 1987, which led to the final closure of the four nuclear plants which had operated in Italy.

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Japan has been the country which suffered the first brutal, inhumane mass nuclear “test”. At present it is suffering the worst accident in nuclear power plants. Japanese people has paid too heavy a cost in this Atomic Age: it is a duty for all the peoples of the world to unite their efforts in order to definitely phase out nuclear energy, both civil and military! The sacrifice of Japanese population has already been instrumental for Italian population for gaining the vote in the referendum against nuclear power: now I feel as an absolute duty to do all the possible for helping Japan, and to join the forces for phasing out nuclear power also in Japan and all around the world, as already Germany and Switzerland have decided.

The intrinsic *dual-use* of nuclear technology: drawbacks and dangers

It is fundamental to recall the well known, but too often unperceived by the civil society, intrinsic and unavoidable *dual-use* of nuclear technology. Actually, “civil” nuclear technology has been a product of military developments. Not only because the early purpose of governments and militaries was military, and the investments in the whole system of nuclear armaments have largely outweighed those in the “civil” sector. It is well known that the designs of commercial nuclear reactors directly derived from the nuclear reactors developed for military naval propulsion: they were chosen not because they were safe, but because they worked on submarines. Few alternatives were seriously investigated after light water reactors were selected for Navy submarines: once light water reactors gained government backing and the many advantages that conferred, other designs could not break into the market. There were political and corporate imperatives to commercialize nuclear power with whatever designs were already to hand: it was geopolitically useful for the United States to show they could offer civilian nuclear facilities to its allies and the companies who built the plants (mainly GE and Westinghouse) did not want to lose the competitive advantage they had gained as the contractors of the Manhattan Project.

During the Cold War nuclear arsenals grew up to extremely foolish limits (*MAD* was the acronym for *Mutual Assured Destruction*), which could have destroyed human kind a large number of times. If this holocaust did not happen, it was not simply the consequence of such a threat and of the equilibrium strategies of the Cold War, since in fact it was barely avoided in several warnings by mistake. It is important to remark that the system of nuclear armaments does not reduce to the nuclear warheads, since the most complex and costly part consists in launchers, carriers, control and warning systems, and so on, which are continuously renewed, with big expenses.

Dual-use will accompany nuclear technology as long as it will exist: even after its final casting off, due to the almost indefinite persistence of enormous quantities of artificial fissile materials of military interest (plutonium, actinides).

The persisting danger of nuclear arsenals and of the increasing horrors of war

After the collapse of the Soviet Union a process of reduction of those “*mad*” nuclear arsenals began, but it slowed at the end of the 1990s (well before the “Twin Towers” attack of September

11, 2001), and almost stopped under the Bush Jr. Administration. Nuclear arsenals reduced from their maximum of almost 70.000 warheads around mid 1980s, to almost 26.000 intact warheads: which is a reduction, but not a disarmament.

President Barack Obama daydreamed about the final elimination of nuclear armaments, but the final treaty established in a tiring way with Russia in 2010, the New START (*Strategic Arms Reduction Treaty*), is in my opinion widely unsatisfying. In fact, even if it reversed the policy of the Bush Administration toward Moscow, the reductions it provides are quite limited, and scheduled in the far 2017 (although the limits of the numbers of deployed warheads are being reached now, which means that greater reductions are possible). From 26.000 intact warheads left by the Bush Administration, almost 23.000 are left at present (although only some 5.000 are counted as strategic operative deployed warheads, but some thousands of additional tactical warheads is not taken into account). The extremely dangerous state of “launch on warning” of a part of the deployed arsenals, a residual of the Cold War strategy, has not been eliminated. While the expenditures for new and more powerful nuclear arms systems do not decrease, meaning the reliance of the militaries on nuclear armaments.

The danger of nuclear proliferation persists, and can even grow with the growing diffusion of nuclear technology, of international tensions, and of wars, which moreover become more and more inhumane. The danger of the use of nuclear arms is still very concrete.

The more so, since we witness an extremely dangerous evolution of the military system: the development, deployment and continuous modernization of the (enormously expensive) systems of missile defence are leading to a terrible aggressive system, increasing instead of decreasing international insecurity and the dangers of war (also nuclear). In my opinion a further decrease of the number of nuclear warheads will be physiological, and I wonder that it was not reached now, since a much lower number of them will presumably be necessary in a military system integrated with missile defence systems. I fear therefore that nuclear disarmament is unfortunately still far away. We must therefore multiply even more our efforts for growing popular consciousness and will all around the world.

Moreover, the enormously powerful military-industrial complex will obstacle with every means disarmament!

The severe and unavoidable drawbacks of nuclear power: problems with no return

The claimed advantages of nuclear power for the production of electric energy are hardly recognizable behind the lies and tricks of the nuclear industry: and public opinion is misinformed. The point is that the economic business connected with nuclear power are enormous, \$ tens of billions, and this makes the issue not very transparent in all its phases. The cost for a new nuclear plant has grown in recent years from \$ 3-4 billions to \$ 6-9 billions. And one must add that the implications of the nuclear disaster in Japan will raise the overall costs even further: this raise has happened after every severe accident, since it implies a deep revision of all safety regulations and systems, as it happened after the Harrisburg (1979) and Chernobyl (1986) accidents.

It is convenient to remark that nuclear power uses a kind of energy of extremely high quality, but unavoidably wastes it since it is exploited transforming it into heat, i.e. energy of the lowest quality: the intrinsic physical properties of nuclear fuel drastically limit the energetic efficiency of nuclear plants to not much more than 30%, against for instance the gas combined cycle, which has reached efficiencies over 55%. A nuclear plant is therefore, substantially, a boiler of water using an extremely sophisticated and dangerous energy source with a quite low efficiency.

Moreover, uranium is a non renewable resource, and the evaluation of present and reasonably foreseeable richer fields lead to the conclusion that, at present rates of consumption, uranium will exhaust in 50-70 years, before the exhaustion of oil. Poorer minerals could be used only under certain limits, due to the fast raise of costs and the energy balance for their extraction and processing.

The assertions on the advantages of nuclear power are in general based on the consideration of a single phase of the entire nuclear cycle, i.e. the construction and operation of the plant, disregarding the other complex and costly phases: i.e., the “head” front – uranium mining, extraction, processing and enrichment – and the “cue” ones – the management of the various kinds of radioactive residues and the decommissioning of dismissed plants.

So, nuclear power is claimed to be carbon-free. This is obvious when uranium undergoes the chain reaction inside the reactor, but all the other phases of the nuclear cycle produce carbon dioxide (and other greenhouse gases in certain phases). The balance is at present in favour of nuclear energy in comparison with fossil fuels, but if poorer minerals had to be extracted and processed (operations that produce huge quantities of carbon dioxide), the emissions of the whole nuclear cycle would raise, and could overcome those of fossil fuels. In any case, it has been evaluated that in order to get even a modest reduction of global emissions, the construction of thousand of new nuclear plants would be required (the majority of the around 440 plants in operation are aging and will have to be closed in the next 2 or 3 decades), implying astronomic costs which seem hardly compatible with the growing world economic difficulties and chaos. Even the probability of severe accidents would grow with the number of operating plants (see later on). One must conclude that nuclear energy seems not the best way at all for reducing carbon emissions.

Nuclear power succeeds in justifying and economically sustaining itself only through a swindle, cleverly concealed by the politician and the nuclear industry, and strangely unperceived by the main part of the public opinion: huge costs and responsibilities are “externalized”, i.e. discharged on taxpayers. Otherwise nuclear power would be definitively out of market. No other energy source relishes on a so high public support and direct or indirect financing. This usually happens for the management and final disposal of highly radioactive long-lived artificial nuclear remnants and wastes: it is scandalous that for half a century this problems has been delayed, and at present no country in the world has yet provided a long term final disposal for them. It is scandalous, but understandable, considering the enormous problems and dangers involved: this should have advised since long time to stop the further production and accumulation of these remnants, which would have amounted to phase out nuclear industry. The project of Yucca Mountain geological disposal in the U.S. has been finally abandoned after decades of design and work and \$ billions of expenditures, leaving unsolved the problem of the disposal of tens of thousands of tons of spent fuel, “temporarily” stored in spent fuel pools, whose enormous danger have dramatically emerged in the disasters in the Fukushima Dai-ichi nuclear plant. Now this new danger, disregarded until now, raises alarms all over the world, even for the newly designed reactors, since the spent fuel pools are always outside the primary containment.

Italian users are still paying in the electric bill the costs for the management of the modest nuclear residues, and the decommissioning of the four reactors closed since 25 years. Italy still lacks a national deposit for nuclear wastes, which are “temporarily” stored in several sites.

Military nuclear remains a solid, but hidden background for the support of civil nuclear programs. An ideological stimulus for those governments which perceive the acquisition of nuclear technology at least as an open door if they even would evaluate to go nuclear. For nuclear powers several costs of the civil programs can be shared with, or hidden in the state-owned military sector: formation of technicians, equipment, laboratories, nuclear waste disposal, and so on. France is a striking case, since both the military and civil sectors are state-owned, and not sharply separated: French consumers pay cheaply electric energy in the bill, but as taxpayers pay out further money for military budget, in a considerable part of which finances the nuclear arsenal and armaments, in which several costs of the civil programs can easily be hidden.

A further scandalous “externalization” of costs is represented by the limited liability of nuclear industry in case of severe accidents. Japan is unfortunately the dramatic living example of this, since the main burdens and costs of the accident will be covered by the State (i.e. by taxpayers),

exempting Tepco by covering them. This fact should be sufficient for convincing the whole Japanese people to pretend the final phasing out of nuclear power generation.

On the other hand, releases, venting and discharges of radioactive isotopes during the normal operation of nuclear plants constitutes a burden for civil society, in terms of additional health consequences. Such releases, and their consequences, are denied by the nuclear industry and public authorities in cahoots with it, although some releases are regularly authorized, and are even logical: for instance, in France authorized releases of tritium have been officially raised for the new fuels with high burnup in the newly built nuclear plants up to 185,000 billions Bq/year. Contrary to the accepted radioprotection model and rules, it is increasingly evident the health damages of the prolonged exposure to low doses of radiation, even below natural background, and internal exposure due to inhalation and the entrance of radioisotopes into the food chain. The radioactive pollution of the Earth atmosphere is in my opinion a true crime against humanity performed by nuclear industry and the governments which have supported it and have developed and widely tested nuclear armaments (including depleted uranium ammunitions).

A technology too complex to control: the unattainable myth of safety in face of the enormity of risks and consequences

The nuclear disaster at Fukushima Dai-ichi happened unexpected to nuclear propaganda, but unfortunately largely expected for the “Cassandras” who since long criticize this source of energy, unheard or disdained by nuclear industry and political power. When I finished to write the recent book I have cited in the foreword, it was barely a couple of months before the Fukushima accident, in the wake of the Italian referendum, and we foresaw the menace of a severe accident in French nuclear plants: which in any case can happen at any moment!

It would be long and complex to discuss the criteria and methods on the base of which the probability of the occurrence of nuclear accidents is evaluated (they are extensively discussed and criticized in the above mentioned book). Let me say first of all, as a Physicist active in the field of statistical mechanics, that, contrary to the way the probability of accidents is presented to the public, when an event is attributed a *probability*, this means in the first place that that event *certainly will happen*, early or later, and for the intrinsic rigorous meaning of probability it is impossible to predict when! If it were not so, life would have never appeared on Earth. If the predicted probability is low, one can expect that the event will happen later on, if it is great that it will happen sooner: but it is absolutely impossible to predict when. For instance, uranium has a mean life around 4 millions of years, but if I observe a sample of uranium, disintegrations happen continuously: it's true that a macroscopic sample contains an enormous number of nuclei, but those which decay now do not wait millions of years, even if there will be others which will not decay even after a billion of years.

With this specification, one must remark the intrinsic limitations of the approach for the evaluation of the probability of the occurrence of a severe nuclear accident: only the probability of failures to specific components is evaluated, on the basis of models or simulations, and taking into account obviously only the *known* or foreseeable causes of failures. But it is unavoidable that other factors which have non been taken into account can cause or start a severe accident. Natural catastrophes, and their intensity, are intrinsically unforeseeable. As I have mentioned, severe accidents to the spent fuel pools were never considered in the past, however they occurred in the plant of Fukushima Dai-ichi!

Moreover, nuclear technology is one of the most complex ones humankind has realized, the more a system is complex, the less is controllable and predictable: the science of complex systems has established that even a small and marginal cause may have dramatic and unpredictable consequences on the behaviour of the whole system. In every system aging causes more failures (it is the Second Law of Thermodynamics); while human errors are unavoidable.

But above all, the possible consequences of a severe nuclear accident are so gigantic that in my opinion only a probability rigorously equal to zero is acceptable, what corresponds to not having

any plant at all! It is with a deep feeling of sadness in my heart that I must say here that I am convinced that the consequences of the Fukushima nuclear accident are far from finished, are much more severe for this country and its population than authorities and nuclear industry have declared, and they are going on covering the real data, after the shameful lies of the first hour. I know of the tracing of radioactive caesium in cattle meat, which is very alarming, since it shows that radioactive pollution has reached an advanced stage in the food chain, and I have already commented on the severe consequences of continuative internal exposition to even low doses, especially in children.

I am well aware that there are projects and proposals for new designs of nuclear reactors, which should be safer, would “burn” the most dangerous and long-lived wastes, and would be breeders, i.e. would produce more nuclear fuel than they burn. The discussion of these projects would be long (they are discussed in detail in my mentioned book): suffice to say here that all those projects are at present only designs, on which technicians are working since many years, but not even a prototype has been realized yet. I frankly judge unscrupulous to guarantee fantastic properties before having realized them in the field of a technology which is so complex, that the results, or possible difficulties on the road, are impossible to foresee. The experience of France emblematic: it spent thirty years, and a lot of money, in the program of plutonium fast breeder reactors, *Superphénix* would have been the prototype of a new family, but it has been recently closed, together with the whole program (France equally had its advantage, since it managed plutonium technology and production for its *Force de Frappe*). As for Japan, it is not my job to recall you the history of *Monju*.

Nuclear power vs electric production

The basic data on electric needs and the contribution from nuclear power to them are usually withheld, or misrepresented to public opinion, which generally holds distorted ideas about them. In the first place, the consumes of electric energy are only around 17% of the world total energy consumption (with limited variations in the various countries), and nuclear power provides around 14% of it: it follows that nuclear power barely provides 2% of the total final world energy *consumption* (it is often misleadingly reported that nuclear power contribution is 6% of total energy *production*: the fact is that barely 2/3 of the energy produced in nuclear reactors as heat are transformed into electric energy). It is hardly believable that 2% of world energy consumptions cannot be substituted, or saved, without big problems!

Obviously the situation is different in various countries. France produces almost 80% of electric energy from the nuclear source, but has a seriously unbalanced electric system since nuclear plants cannot be easily regulated for the follow-up of the daily variations of energy demand: and popular opposition to nuclear power is growing at present. Germany has decided the phasing out of nuclear power in the next decade: several oppositions will certainly rise due to the big business of nuclear industry, but popular movement in favour of this choice is very strong, and Germany is the country which is investing more in renewable energies, which undoubtedly will be the basis for a sustainable world.

The case of Italy is emblematic. Italian users are told that our electric system is not sufficient to cover the electric demand, and we are obliged to buy electric energy from France. But the truth is very different. Installed electric power in Italy exceeds of almost 50% the maximum electric demand (the maximum overpower among European countries), and is continuously growing, since our electric system is inefficient and the construction of new, very efficient electric plants is a very profitable business. On the other side, the overdimensioned and quite rigid French nuclear system produces during the daily minimums of demand an overpower, which is sold at rock-bottom prices, extremely convenient, although not needed, for Italy.

I don't know exactly the situation of the Japan electric system and demand, but I am firmly convinced that a balanced phasing out of nuclear power, however gradual, is not only possible, but also very beneficial for the future of the country. I know the terrorism diffused by the nuclear

industry about the threats of blackout which would be caused by the shutdown of the nuclear plants. I must say on the one hand that I am firmly convinced that these threats are widely specious: they are based on the consideration of the present electric system as the only one possible, while there is a wide spectrum of alternatives, both for energy production and consumption, whose choice conflicts with the huge interests of the nuclear industry; energy choices are fundamentally a political choice, and alternative ones must be imposed by popular will to power, against its business. O am thunderstruck of the fact that the contribution of renewable energies in Japan remained stationary in the past 30 years, nor is scheduled any growth in the future, which is even more absurd given the high technological level of Japan: it indicates an explicit plan! On the other hand I must firmly say that no energy need can justify absolutely unacceptable accidents and consequences: when the contrary is asserted, what is wrong is the model of energy production and consumption, and it must be changed. This Planet is made to sustainably satisfy only the *possible*, and not *all imaginable* needs!

It is the moment to combine our forces for this purpose, and all over the world, in order to finally close the ominous Atomic Age, and commit ourselves to the solution of the problems it has left.

Thank you for your kind attention.