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Do you think the international situation and perspectives for nuclear energy are nowadays healthier and more positive than a few years ago or are we still at the bottom line?

There are some people who have begun to talk about the second birth of nuclear power, but we must recognize that the health of our industry is very sensitive to a lot of social and political parameters and events. The history of nuclear power has been always dominated by big political decisions, each one corresponding to a definite period of the recent history. After the Second World War, nuclear power was dominated by secrecy and classification, and there was not a true industry, only research. A second period started for us in 1953 when president Eisenhower launched his program "Atoms for peace", and the Spanish nuclear field benefitted quite a lot from international collaboration. During the sixties, the construction of the first Spanish NPP began within a very optimistic climate dominated by the idea of continuous, everlasting economic progress which required new sources of energy. However the social horizon changed abruptly because of two crisis: the ecological revolution which was very powerful in seeding social fears and concerns about nuclear energy, and the oil crisis which triggered an economic crisis that lasted about a decade and reduced dramatically the growth of the energy demand. On the other, there have been two accidents that have feed the antinuclear power opinion. Curiously, each of the accidents happened in one of the superpowerful countries, what also had some political effects. Harrisburg was the frustration of the confidence on our capability to operate complex systems. We have to recover it by obtaining a perfect NPP performance one year after other. Chernobyl was a disaster. Radioactivity was spread out largely because the accident was a reactivity trip which yielded a large amount of energy. In its origin, the accident was absolutely stupid, as for as it began with an electro-mechanical experiment badly designed and

erroneously performed. This technical mistake can not be understood by laymen. People only understand that a big radioactivity release was possible, although its consequence for human health and environment has been limited to numbers that are limited in comparison with other types of industrial and transport accidents, for not to say anything about natural catastrophes. The recent earthquake suffered in Armenia killed more than 50.000 persons. However, Armenia's Nuclear Power Station withstood the earthquake. That was a good example of the nuclear power safety excellence, but in any case it will be difficult to forget Chernobyl. Hence, it seems very difficult to predict the success of a second birth of nuclear power at short term. Nevertheless, at long term that success will be a necessity for any industrial or post-industrial country. Our commitment as nuclear professionals is to work for guaranteeing such a success.

Does it mean that you foresee and actual rebirth of nuclear power if the NPP performance remains positive? So to speak, does the nuclear power future depend on the nuclear professional's success?

Yes, indeed. It is true that antinuclear movements and public concerns are very strong. It is true that a country like Sweden has approved a nuclear phase-out, but we must point out that this decision was taken in 1980 to be started slowly in 1995 to be completed in 2010. There is a general, unfounded feeling that a magic solution to the energy crisis can be found in the meanwhile. But there are not magic solutions at all in science and technology. We know today perfectly the energy sources provided by nature. Therefore, if NPP performance remains economic and safe, the nuclear fission option will be taken into account again, even in Sweden. But we must not forget that light water reactors are a rather inefficient way to exploit uranium ores. They obtain less than 1% of the potential energy contained in natural uranium.

Hence, you consider highly necessary to boost nuclear research to improve the fuel efficiency in future reactors.

Some people think that it was not an intelligent policy to slow down nuclear research once the commercial deployment of LWR was established, but as a matter of fact it was very difficult to maintain the budget to search solutions for the XXI century. Breeders are not clear candidates for two sound reasons: reactivity accidents and plutonium industry. An accident like Chernobyl is extremely unlikely in a LWR, but it can not be said the same about FBR. On the other hand, the risk of proliferation (more than environmental concerns) stopped breeder research in the USA. So, it is difficult to decide where to put the money for fission research. In this very moment there are two lines of development with two different objectives: the first one is aimed at safer reactors. The wording "inherently safe reactors" is fashionable nowadays. The main item there is to design passive safety systems and reactor cores that can not suffer reactivity accidents. This is very important. A Nuclear Power Plant is something really complex but there are two roots of problems, nuclearly speaking: reactivity and radioactivity. If both phenomena are controlled under any circumstance, the reactor will be inherently safe. Nuclear knowledge nowadays is rather complete, what means that a full safety analysis can be carried out to ensure a suitable reactor response under any conceivable circumstance. But inherently safe reactors are not going to be better uranium or thorium burners.

Therefore you think it is also important to investigate on advanced reactors, don't you?

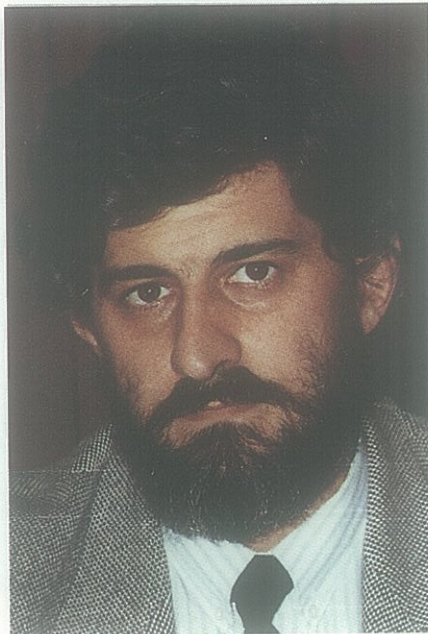
Yes, this is the second line of development, but it is not as clear as the first one. You can establish very precisely the objectives of nuclear safety and you can work in that direction. The final result will be a safer reactor. Probably it will not be cheaper, but this is another point. We can say with the current standards that we can afford more expensive, but safer, nuclear electricity. However, it is not easy to identify where to go for obtaining much higher fuel efficiency. The critical parameter here is the conversion ratio. If a reactor family has a ratio lower than one, it will be unsuitable to exploit efficiently the fissionable natural resources. We must look for conversion ratios larger than one, that is, breeders. In this regard we have to go down to very scientific concepts as the neutron spectrum, spectral indexes, cross sections and so

forth, and this is a very large field. Moreover, this is a self-consistent problem, as far as a change in the material composition in the reactor changes the neutron spectrum, not only the macroscopic cross sections. So, a definite objective is much more difficult to identify. For many years it was considered that Liquid Metal Fast Breeder Reactors could be a suitable way to exploit natural uranium to the utmost, but ten years ago the appeal of these reactors began to decline. There are of course many other concepts that have been analyzed only at a theoretical level or slightly more. For instance, spectral shift reactors, gas-cooled fast breeders, geometry variable reactors and so on. Those ideas would have to be reassessed from the viewpoints of the new safety objectives. In a few words, we must both lines of development. We need not only a safer reactor, but a more efficient one, as far as fission is concerned. For the longer term, humanity will need fusion.

What do you mean for longer term? Can you give some figures about that?

We can add some figures, of course, but everything must be considered as mere estimates. The evolution of energy demand depends on several parameters as the evolution of the world population and the rate of industrialization of the third world countries. But, at the current consumption standards we have oil for 30 years, gas for 40, uranium for 50 and coal for 200, if you take into account proven resources only. And some peculiarities must be added, like the coal market stiffness. Only 10 % of the world production goes to the international trade of import/export and it is not easy to increase this percentage. These figures are wellknown and have been proclaimed by the World Energy Conference, but people in general and politicians particularly seem not to be concerned about that. At least, they would have to be aware of that grey perspective. If fusion is not harnessed or solar energy is not deployed to a massive level, the energy crisis in the next century will be something like a civilization crack. It is really curious: people are concerned about the potential, highly improbable risk of nuclear wastes at long term, but they are not concerned at all with the energy shortages that will be extremely probable in 50 years from now. It seems that as far as oil is relatively cheap today, there will be oil available forever. But it is not true. It is just the opposite.

You have talked about nuclear wastes. Is this the most critical subject that must be faced now by the nuclear industry?



I do not think so. Wastes are an important subject but the most critical one is public and political opinion. Let us take the Swedish example, for instance. They had a very strong nuclear program in the seventies, but the 1980 referendum changed absolutely the perspective, and a phase out of nuclear power was approved. There is a paradox in the fact that Sweden is one of the countries with a practically solved waste program, both for medium and low level (with the Forsmark repository) and for spent fuel (the CLAB interim storage). Nuclear wastes in Sweden are not a real threat for the human environment, mainly it is compared with other types of risks and pollutions. The main problem for the Swedish nuclear industry, as well as for the western world, is the public and political opinion.

Is it possible to make something for modifying this opinion?

The main point will be surely an excellent performance of NPP. "No news, good news", we could say, because the media interest in nuclear power is just focused on accidents. They do not report positive news, in general. So, we have to obtain a perfect performance in our plants. The second point would be a positive press program launched by pro-nuclear people, but it is necessary to create a good media attitude towards nuclear power. If not, any program of this type will be worthless.

You have quoted before that we have uranium resources for 50 years only. I presume you are talking about LWR.

You are right, this figure is taking into account the current commercial reactors. We can multiply it 100 times if a system to burn U-238 is developed, but we have already talked about the problems related to breeders, for not to say anything about reprocessing. Commercial reprocessing facilities will have to face public debates probably much tougher than those encountered in NPP siting. But our commitment as nuclear engineers is to investigate and develop safe and economic ways to exploit nuclear energy so that the society could decide which energy sources have to be used. And we have also to remind the politicians and people in general that energy will be very scarce in 50 years if the energy options remain to be the same ones that we have today.

It seems that you want to underline the need of investigating on nuclear fusion.

That's true. Nuclear fusion research is being driven by scientific curiosity more than by commercial perspectives. Governments support this research, but under the policy that it is not a real need. It must be recognized that after the 1974 oil crisis a bigger boost was given to fusion research. However, there is not yet a single facility to test fusion materials properly. This is why I say that nobody but the fusion scientists are taking seriously this concept. However, many politicians say that fission and coal are just transition energy sources to bridge the gap until the deployment of commercial fusion. But these are words; no budget, no facts. Fusion will not be harnessed by good will but by scientific and technological research and development. Really, it is not urgent to dominate fusion. But if we want fusion energy to be available in thirty years we must launch and maintain a sound research program at an international scale.

In our conversation you have identified the public opinion issue as the critical point for nuclear power nowadays. What can a learned Association like SNE do to treat this problem?

What we have already done, with better means if possible. There is a direct approach: to take advantage of every opportunity to explain to people, politicians and newspapermen the reality of nuclear power, from basic principles and risks up to NPP performance. And there is an indirect approach: our Societies are good tools to organize conferences and seminars, to publish technical journals and to enable nuclear professionals to interchange knowledge and experience, what is very important to obtain good results from Nuclear Power Plants. I think our Societies must remain active in both lines.