

## Discussion\*

Rafael Mariano Grossi, Jeremy McNeil, Giorgio Parisi,  
and Wolfango Plastino

*Wolfango Plastino: Should nuclear energy be a part of the energy mix that moves us onto a more environmentally sustainable path? If so, what are the kind of activities that would move nuclear power higher on the climate change agenda?*

*Jeremy McNeil:* I am an ecologist who works on the effect of climate change on agricultural and natural ecosystems, and obviously any form of energy that will reduce the production of greenhouse gases, such as nuclear energy, is in my mind something that we should seriously investigate. Like everything else, though, it comes at a cost, and there are benefits and there are disadvantages, and we have to look at those. And while nuclear plants do not produce greenhouse gases, there is the whole question of radioactive waste that we have to deal with. In Canada, of course, this has been a very active area of debate, and there are two possible approaches: one is the deep geological disposal, whereby the waste is put very deep into the ground in areas that are extremely solid, and thus the probability of leakage is reduced, particularly as they have developed multi-barrier approaches. There is always the question, as this waste lasts for thousands and thousands of years, of what might happen: could they leak? And as a result, there is another group that is taking an above-ground approach, and it has basically been called “rolling stewardship”, whereby the responsibility passes from one generation to the other; the argument for that is that science and technology might develop a means by which we can actually reduce the dangers of radioactive waste with future development.

In my mind, to be honest, it’s extremely important that we look at alternatives. Of great importance for us as scientists is the

\* The text below is the full transcript of the Round Table that followed the *Lectio Magistralis* by H.E. Rafael Mariano Grossi, Director General of the International Atomic Energy Agency.

question of education. We have the data, we mustn't just believe that because we believe something, everybody else will, as well. We must have an open dialogue between scientists and politicians; we must work with agencies such as Professor Grossi's. We really need to make sure that the public understands. And I think that this is an important role that academics and academies can play. We have serious problems with climate change, and nuclear energy is obviously one of the potential solutions that we must investigate at great length, but with transparency, and by presenting both the benefits and the disadvantages.

*Giorgio Parisi:* The use of nuclear energy in the future is a highly controversial point. I have discussed it with many friends and with many fellows of the Academy, and the viewpoints are quite different. The difficulties in finding a common viewpoint also arise because there are many different issues which are interwoven here. There are not only environmental issues, but there are economic issues and societal issues; we also have problems with the import/export of developing countries that should be taken care of. And then, as President McNeil was also saying, we have the problem of the relation between science and society in education, which should be taken into account.

Let me present some personal considerations, since it's clear that I certainly can't speak here in the name of all academics, because there are many different opinions. I am very convinced that, as we know, from what we have seen from Chernobyl and also from the Japanese accident, most of the damage that is done by nuclear plant reactor incidents happens in the vicinity of the reactors. They say up to one hundred kilometres – certainly, more than one hundred kilometres, the damage is very minimal. But the regions that might be at twenty, thirty kilometres are also the most likely to be evacuated, at least in a very serious accident. Therefore, this type of damage, which is very serious, is proportionate to the population around the centre.

We have been very lucky in the past; the populations around Chernobyl and also around the Fukushima reactor were not as high-density as the Val Padana. Therefore, as far as the possible damage in proportion to the population, we can say more or less that the benefits do not strongly depend on the region where they are constructed – especially if you think of it from the ecological point of view; for carbon reduction, it is region-independent. Of course, if you want to transport energy, it is clear that you would like to have reactors near to populated regions, but of course this includes very high costs. I think that in countries like Italy, Belgium,

the Netherlands and some regions also of China and India, the construction of reactors should be avoided, because these are the worst places to construct reactors if you look at the ratio between benefit and risk.

As Professor McNeil was saying, there is a serious problem in the whole world regarding long-term management of radioactive waste. There are so many unsolved problems. For example, there is no final decision for the long-term, permanent deposit of waste in the United States. The Yucca Mountain Project failed, a similar project in salt mines in Germany failed, and so of course we can have nuclear waste for hundreds of years, for thousands of years. We know how to control it. But it is unclear where we can put it, in a place where we can forget it – not for the rest of the universe, but at least for ten or a hundred or a thousand years, or something like that.

One other problem that makes difficult large-scale construction of nuclear plants – and I am not discussing a single or a few cases, but large-scale construction, since if you don't have large-scale construction, it will impact very little, in a marginal way on CO<sub>2</sub> – is that nuclear energy is an extremely complex technology to import from abroad. Many developing countries may not be able to construct safe reactors themselves – I don't mean reactors in general, which is easy, but latest-generation safe and stable reactors – the reason being that the technology must be imported from abroad. And this is something that would have some weight in the technological independence of the country; for it's clear that if a country becomes dependent on outside intervention, this goes in the wrong direction, because it is very important that developing countries become, as far as possible, economically independent from others.

Even developed countries should become independent, in some cases. I remember there was a shortage of masks in Italy and in many other countries, because we were dependent in the same way on other countries for the construction of masks and similar individual protection. So it's clear that economic independence is very important.

And I think that one kind of action that should have the highest priority is energy-saving actions. Energy-saving actions are very important. One of the places where you can save an incredible amount of energy is in ecologically friendly building. We have a huge amount of energy that goes into heating – this depends on the country, of course; not so much in Africa; but even in Africa, if you want to have the same level of life as in the developed countries, you will have a certain amount of air conditioning in

the future. Now if you start to put air conditioning in a place with bad insulation, it will bring a lot of waste, so I think that improving insulation of buildings will be extremely important. And insulation technology made by local development will strongly contribute to the local economy.

*Rafael Mariano Grossi:* This is a fascinating debate. What we hear from President Parisi, and especially from certain comments by Dr. McNeil, is that what's really important here is to have a debate with full transparency, where the discussion is based on scientific fact and information, and not on ideological aspects. One feels sometimes that around the issue of nuclear energy – in particular in some parts of the world, in Europe for example – there is a lot of emotion, and a lot of positions that are based on beliefs, but sometimes not so much on scientific information.

As I said, I do not consider myself a nuclear lobbyist, but the reality of the world is that nuclear energy in the world is growing. It's not diminishing. So I think we should talk about things as they are. And why is this happening? Are people jumping irresponsibly into activities that they should not be doing? I don't think so. What we see is that for many, many countries – for a number of reasons, including some relating to energy independence, for example in Eastern Europe; for diversification of energy matrices, like in the Arab world; the necessity of facing the ambitious goals of decarbonization, in countries which are consumers of coal, like China or India – for a variety of reasons, what we see is an increasing trend. And I would quote, not the representative of a nuclear utility, but the Intergovernmental Panel on Climate Change, which, as many of you must know, is a group of distinguished scientists from all over the world. Having studied the current trends and evolution in terms of decarbonization and energy in all of their projections and the different models that they have established to get to a decarbonized global economy, nuclear is part of it. The issue is how much nuclear you have, or if you have any. There are some countries that are not going for it; as I was saying, forty-two countries at the moment have embraced it. And by the end of the decade, there might be around fifty. So what we are saying is that this is a growing trend.

What's important here – and I think that Professor Parisi was mentioning some of these issues – is that we have adequate answers to the safety operation of nuclear power plants, including waste, where, from our perspective, the problem is more of social acceptance than of technical lack of answers. Because the answers are

there. A few months ago I was on the island of Onkalo in Finland, where half a mile underground you have an incredible feat of engineering, and a deep geological nuclear repository is ready for licensing. So the issues of waste are also there, and the cases that we know are of course debated. And rightly so. In democracies, these things should be debated, and all the information should be set before the public to reach an informed decision.

So, from the perspective of the IAEA, what are we trying to do, how are we trying to contribute? In two ways. First of all, by ensuring through the safety standards that we administer all over the world that there is a lowest common denominator. There are some countries that have highly developed and sophisticated safety structures. Some others, less so. What we want is to make sure through the IAEA that everybody has at least the minimum required levels.

This is one thing. And the other thing is, when working with countries – especially those newly acceding to nuclear energy – to make sure that they do everything as they should, and work within and with the international community through the commissions and committees on safety standards that we have, in order to ensure that whatever they do, it is done in a way that is beneficial, and beneficial to all.

*Wolfgang Plastino: There are regional concerns regarding the water disposal from the Fukushima Daiichi nuclear power plant as it may affect the water environment in that part of the Pacific Ocean. Are those concerns well founded?*

*Rafael Mariano Grossi:* It's an excellent question, because this is one of the topical issues of the day. As many of you know, around the stricken nuclear power plant, the water that has been used to cool off the stricken reactors has been accumulating, and the Japanese government has arrived at a decision to dispose of it through controlled discharges of treated, processed water. And there are concerns, mainly expressed by some regional, coastal countries: China, the Republic of Korea, some other South-East Asian countries, and even by Japanese people. I was myself in Fukushima; I was talking to the fishing associations and groupings and journalists, and of course there are concerns. You ask in your question, Wolfgang, whether these concerns are justified. I would say these concerns are legitimate. Every concern has to be taken seriously and with due respect. Because these people need to be

reassured that if anything is done, it will be done in a way which will not be harmful to the environment.

In terms of what we do, the IAEA has been working with Japan ever since the accident took place. And in particular, in this case, I discussed these matters in Japan with the then Prime Minister, Shinzo Abe, a year and a half ago, and I proposed to him that whatever was to be done, could be done with the IAEA. And I took the liberty, as head of an international organization, to suggest to him that they should avail themselves of our assistance – not because Japan needs any assistance in undertaking this, but simply because the international community needs a neutral, third-party with the technological ability to monitor whatever is going to be done there, through a process – a process that will take place before, during, and after the discharge of this water.

Of course, the water can be made acceptable to the environment, and, as those who are knowledgeable say – and I suppose Dr. McNeil, you are an environmentalist, you must know this – there are methodologies to get rid of the radionuclides, in particular the caesium and strontium, and also a number of other radionuclides that are present in this water before it is released, so that whatever is released is not contaminated, radioactive water. It's water that may contain some tritium. People have also been asking, why can't we do this only after tritium has been taken out of these volumes of water? And we also have been looking into this, to give people an idea – because again we have to inform, we have a responsibility to inform. In this 1.2 million tonnes of water, there are sixteen grammes of tritium; and this tritium will be disposed of after treatment, and in volumes that are reduced, because this water is not going to be released all of a sudden, as if one opened the floodgates; it's going to be done over the course of decades. You heard me well: decades. Maybe thirty years, or maybe even more. So it's going to be done in such a way that you have a function of volume of water, an amount of tritium, and the comparison with activities that are being carried out.

You know, effluents are a reality of industry, let alone nuclear industry. In any activity, there are effluents. So what we do is try to ensure that whatever we put back into our environment is not harmful, is not doing any damage to the fish, to the marine sediment, or to the water itself. This is what we are going to do. It's going to be a complex operation – one of the most complex operations that the IAEA is going to be undertaking – but we have started already. And also let me say – because this is also about acceptability, this is also about taking the right political decisions – I have set up a task

force at the IAEA where our experts will be joined by a select group of top scientists, like the Accademia Nazionale dei Lincei, coming especially from the countries that are expressing concerns, so that we will show, as far as possible, that we have an operation that is scientifically sound, politically honest and transparent.

*Jeremy McNeil:* I think the most important point, as Director General Grossi indicated, is transparency. People have concerns, and their concerns should be addressed, and in a very transparent way.

Obviously, he addressed the question of removing contaminants. As an ecologist, there's one other thing that we need to think about: what is the temperature of the water that is being released, and what is the relative volume and the area that might be affected? Now, that might sound silly, but as water doesn't change temperature as rapidly as air does, if you're releasing water at a much higher temperature – and that could be two or three degrees – than the ambient temperature, this can have an effect on the food chains, and as a result it could have a local or a broader effect. It may affect the growth of algae blooms; a slightly higher temperature may cause the proliferation of diseases that are present, like viruses that might be present in seafood. Now, the relative importance of that is going to be, as I said, decided by the temperature difference, and the amount of water being released relative to the volume that it's being released in.

Much of this can actually be mitigated by previous experience, because, as was mentioned earlier, this whole idea of effluents being put out into water systems is not new. I remember, a number of years ago, there was a very large factory that was producing aluminium, and they were taking water out of the lake, using it in the factory, and then putting it back in at a much higher temperature, which then caused problems with the ecosystem. Well, they said, "We have to control this", so what they ended up doing was actually building a series of greenhouses, and the hot water was pushed through, the heat was taken out, allowing them to grow vegetables during the winter, in an area where this normally couldn't happen, so they were available locally. And only then the water, at a temperature which was very close to the normal temperature, was returned. In that way they mitigated the problem.

So again, the science is available to address the questions that are being raised. We as scientists must work with politicians, we must work with the general public, and make sure that everything is presented in such a way that they understand that their concerns have been listened to and that there is science that can be applied to help mitigate problems.

*Giorgio Parisi:* What has been said is very important. It's very important that all these kinds of concerns are addressed. There are concerns related to radioactivity, there are problems related to the temperature of the water. But I believe that the fact that the IAEA is going to monitor all these activities is extremely important, because transparency is unusually important in this situation, since people often do not trust governments. I don't say that they have any reason to mistrust governments, but it's a fact that many people do not trust even their own governments, or the governments nearby; so, to have an international agency that is going to monitor this situation, to check that all the radioactive heavy nuclei have been filtered out, that only a small amount of tritium will remain, is extremely important. Because if only tritium remains in a small amount, it's clear that there is no environmental danger, except as far as water temperature is concerned and so on. And this can be addressed. If there were heavy nuclei insertion, that would be a completely different story, and it is crucial that an independent observer – not only an observer, but an independent team of scientists, led by the IAEA – is overseeing the situation. If IAEA is overseeing this activity, I am completely confident that everything will go well.

*Wolfgang Plastino:* *Can you please highlight the initiatives to promote peaceful uses of nuclear science and technology to extend their reach across the globe, especially to developing countries?*

*Giorgio Parisi:* This is an extremely important issue, and as has already been said by Ambassador Grossi, one big issue is the treatment of cancer. Cancer has to be treated. There are many things that can be done with cancer, and one thing that is extremely important with cancer is some kind of radiation therapy. Radiation therapy is something that may completely change the outcomes of some kinds of cancer from negative to positive, or it might allow patients to gain many years, and it's clear that it's missing in many countries. So this is something that must be seen to. And also another important programme – of course, it is only for a small minority of people – is proton therapy. This therapy is an extremely sophisticated way to cure cancer, and it should be used only for a small number of cancers that are resistant to radiotherapy, or in some regions near the brain, or other regions where you can't use radiotherapy. And it's clear that even people in developing countries must have access to this type of therapy. Proton therapies are very expensive, but they include the construction of a small



accelerator, and this will be very important also at an educational level, since you have to train people on site that are able to do these kinds of things.

The other problem that I think is also as important as the treating of cancer is cancer diagnostics. Something like positron emission tomography. This can be done only if you produce, on the spot, a few kilometres away from the place where you implement this type of diagnostic tool, various types of reactive elements. Also scintigraphy, since all these types of diagnostic tools, which are crucial to see whether or not you have metastases, where they are and so on, have to be done with a very short half-life. You can have a combat bomb or some long-life radioactive elements for standard radiotherapy, but if you want to use positron emission tomography, you must produce the elements on the spot, and this is also very important. This is a very sophisticated technology that must be imported, and people in the country must learn to use it.

*Rafael Mariano Grossi:* I'll try to be brief, because I think you brilliantly explained things that we're actively working on: nuclear medicine, radiotherapy, diagnostics, theranostics, and the new trends. The agency is not only trying to give the hardware, but we are also working on capacity building. We are training the people. This is what needs to happen. The same applies as well to some of the areas I mentioned before, like plastic pollution, like food security with crops, with plant breeding and genetics.

We have a technical cooperation programme which is at the moment helping more than one hundred and forty countries. One hundred and forty countries are benefitting in one way or another from the work we are doing, which we are carrying out in the IAEA.

There is one thing I want to say. We more or less know the scientific areas, as we have mentioned. The problem is of course the vastness of the needs, and the expectations that are there, which require redoubled effort. And it is obvious that the meagre budgets of international organizations – for example, I have the budget of a small police force in a medium-sized city in Europe or even in Latin America, and we are doing non-proliferation work, we are doing a variety of things – is a fact of life. So this is why we are trying to reach out also to the private sector. We are reaching out to regional development banks, because these needs are there. And funding is not going to be reaching those who need it just because of the force of the market. We will have to be active and proactive in doing these things.

*Jeremy McNeil:* Obviously, one has heard all of the related issues for medicine. Because of my own field in entomology and working with insects within the context of food security, I would bring a little more detail into the whole idea of insect control.

We were very reliant on pesticides for many, many years; the idea was basically, if we have a problem, spray. And more and more we became aware of the ecological impact, which was very negative in many cases. So we've been working for more than half a century in the area of developing a much more integrated approach, called "integrated pest management", where one uses natural enemies, one uses resistant plants, and one of the other areas is what's called the "sterile male technique" that Director General Grossi actually mentioned in his plenary lecture.

In this case, there's a mass-rearing facility where you rear millions and millions of a given pest, and the males are sterilized using radiation, and then are released into the natural population, at a density that is way higher than the natural population – let's imagine, a hundred to one. So the probability of the female mating with a sterile male is much higher than with a regular male. And in doing this over several generations, you will end up decreasing the population.

Now, that requires an infrastructure, large facilities where you can do the radiation under proper controlled conditions. It has to be a species which is easily reared, which is not always the case with major pests. And so for use particularly in developing countries it will be absolutely necessary that we provide the needed infrastructure to help, and also the capacity building, even on the basis of science. There are a number of stellar examples of where this actually worked, but there are failures, as always, and it will only work under certain conditions. If you have an enormous, enormous population you won't be able to physically rear that many insects, to produce the overabundance of sterile individuals. In species that move over very large distances, you can have a problem, so you need to know that. Another is, do the females mate more than once? And in that case, this is very different from species that only mate once, because if they mate with a sterile male, physiologically females may be able to recognize this, and then re-mate multiple times.

So there is the potential there, we can use it; but again, it is the surveillance and transparency as it relates to the actual utilization, and the education so that people can move forward on this. But it has potential, and given the whole question of food security under the conditions of climate change, this is something that we really do have to work on.

Wolfango Plastino: *How can the main international actors, including international organizations, contribute to addressing the challenges related to nuclear proliferation posed by North Korea, and how can they manage the situation in the context of safeguard activities in Iran?*

*Jeremy McNeil:* The Director General has very much covered this, and this is really a major question of diplomacy. Along with IAEA, there are many other organizations that are working in the direction of inhibiting, and preferably stopping, nuclear proliferation. I think at the level of organizations like national academies, we need to work together with umbrella organizations, for example both the Accademia Nazionale dei Lincei and the Royal Society of Canada are members of IAP (Interacademy Partnership), we are both members of the Science 7 Group and the Science 20 Group, and it is through collaborations like this that we should be working, developing dialogues, and providing evidence-based information. We need to be building bridges rather than walls. And in this case – through transparency, providing information, talking with the other organizations that have the same goals as us – we will be able to educate and work with those other organizations that can help locally educate the general public. Because the whole question, as all of us have repeated before, comes down to transparency, and providing evidence-based and at-arms-length information, as we move forward to try to limit or eliminate these possibilities.

*Giorgio Parisi:* I fully agree with Professor McNeil, and I believe that education is a very important issue in this game. Collaboration between academies is very important, and I think that what is crucial, both in the case of North Korea and also with Iran, is to develop scientific ties with these two countries.

One major success story, for example, is the SESAME electron accelerator which is being constructed in Jordan, if I am correct, to which many regional countries are contributing. Among them are certainly Israel and Iran, and I remember that Italy also made some kind of contributions. Of course, this may be more difficult to do with North Korea, but I think that one should perhaps start with scientific collaborations, scientific exchange with people from North Korea, with the rest of the world – maybe on biology if they don't want to collaborate on nuclear facilities – and I think that would also be something that we should do, that we should not suppose that a student coming from North Korea or Iran to Italy to study is a dangerous terrorist.

I think that we should open up to scientific exchange, and academics may play a very important role in facilitating a scientific exchange with these countries, because scientists tend to trust one another. This is the meaning of the title of this series, Science Diplomacy, which Wolfango Plastino suggested. And I think that this starts also with scientific exchange among countries. This is something that should be strongly developed.

With Iran, this is somewhat possible; North Korea, not. But one may start to do something of this kind, maybe start to have exchanges regarding ecology with North Korea, or something else if they don't want to share certain things that may be too sensitive.

*Rafael Mariano Grossi:* I think there's (of course not surprisingly) a lot of wisdom in what Professor McNeil and President Parisi have just said.

I would retain two ideas from this. First of all, when it comes to non-proliferation, we have to recognize first that this is a reality, that it can happen; secondly, that you can best tackle this kind of thing through a family of efforts, rather than unilaterally applying certain restrictive measures. Limitations are necessary, and there are treaties and conventions, and the safeguards which we carry out work. This has to be, and is, constantly improved, because technology evolves, because the proliferator may be looking for alternative ways to do what they want to do.

There is also the very important point of intangible proliferation, in the sense of the passage of knowledge. And of course, we need, as an international community, cooperation in science, and academies of course are at the heart of this work. So, as I was saying, what we need to do is something that, at the end of the day, and when we are talking from a place of humanity like this, is quite simple to understand, and it's something at which human beings can and should excel: dialogue. Listen to each other. Cooperate. Do it with eyes wide open, but with a good disposition.

And I think that with this kind of approach, the chances that we catch whatever should be caught, but at the same time we allow the flow of knowledge and good will without problems, is possible. It's not impossible, certainly.