Nuclear fusion. Batistoni (ENEA): "A promising sign for ITER, which involves almost the whole world"

It may be an exaggeration to label nuclear fusion the Holy Grail of science. But it certainly has rekindled hopes of obtaining clean, waste-free energy. European scientists at the Joint European Torus (JET) laboratory in Culham, a village near Oxford, announced a major breakthrough: the reactor produced 59 megajoules of energy over five seconds (11 megawatts of power). Not only is this experiment of great significance in terms of the amount of energy generated, it also provides the data needed for ITER (http://www.iter.org), another larger fusion reactor. Italy plays a leading role in these projects. ENEA coordinates the Italian group engaged in conducting research and experiments in England and in building the components for the new plant in France. **Paola Batistoni**, head of ENEA's Fusion Development and Promotion Section, explains the scope of the JET experiment and outlines the next steps. "We have already developed several technologies needed for ITER fusion device," she says, "but we must continue to develop other technologies in order to have a demonstration reactor capable of outputting energy to the grid. Our target is to accomplish this by 2050." **Dr Gramolini, why is the JET experiment so important?** JET fusion-generated electricity of 11 megawatts is a huge power output. In addition, we managed to run the process for a long time, even if only for 5 seconds. If they are not sustained, fusion reactions will die out sooner. JET is an old system and it was not possible to extend the process for more time. **JET generated a fusion reaction already 25 years ago. Was the energy output twice as great this time**? No, it was almost three times that amount. But indeed, a record has been set. The JET achievement is encouraging. It bodes well for ITER, an experiment project involving almost the whole world. The other reactor under construction in France uses new technology and there will be no time limit on the process of up to one hour. Here the device is designed to produce up to 500 megawatts of fusion power. JET has been a major joint effort by the European Union, but ITER will be a great experiment for humankind with two thirds of the world working together to make it happen. I can recall no other undertaking of such magnitude. **Why do we say we will get clean energy from nuclear fusion? Is it related to the difference between fusion and fission?** Those are two opposite nuclear processes. Fission releases energy when heavy nuclei such as uranium, used in reactors to generate electricity, are split under specific conditions. By contrast, in nuclear fusion lighter elements, such as hydrogen nuclei, fuse to create heavier elements. Even in this case, a large amount of energy is released. This is exactly the same process that powers the sun and the stars. We are trying to replicate it to obtain a source of energy, such as electricity, for civilian use. In the sun, hydrogen atoms fuse together to release huge amounts of energy. In our laboratories we use two variants of hydrogen, deuterium and tritium. However, since we cannot recreate the same exact conditions, we heat the hydrogen in the form of gas at a temperature roughly ten times higher than the centre of the stars, as the densities are smaller. We attempt to capture the gas at one hundred and fifty million degrees by means of a specially configured magnetic cage, consisting of large magnets holding the gas away from the chamber walls so as not to melt them. **And fusion does not create any radioactive nuclear waste.** In the case of fission, wastes are highly radioactive fragments. In fusion, there is no radioactive waste, although the problem is not altogether eliminated. In a fusion process neutrons are produced that hit the reaction chamber and cause the internal materials to become radioactive. In our research programme we are developing low-activation materials that will allow radioactivity to decay over a period of about 150 years at the end of the reactor's life, thereby eliminating the need to identify permanent sites for storing waste materials. **Which steps will be taken next?** There is a European roadmap to fusion energy. ENEA is also a member of the EUROfusion consortium representing all European countries, which brings together over 4,000 scientists. The task of the Consortium is to implement the programme, which includes constructing ITER and then carrying out experiments to show that we can produce more fusion power than we are

using to support the process. In fact, we will be using 50 megawatts and we expect it to generate 500, or ten times the energy put into it. We have already developed a number of technologies to create ITER, but in parallel we must continue to develop other technologies in order to have a demonstration reactor capable of outputting energy to the grid. Our target is to accomplish this by 2050. **Is it a feasible goal?** I don't see any insurmountable obstacles. There is still a lot to be done. But I am confident that we will succeed. **Given the global concern to abandon fossil fuels, can we expect an acceleration?** There is great interest in nuclear fusion and several companies are also interested, which is good. I hope there will be an acceleration. The challenges are not overwhelming, I am confident. **What has been Italy's contribution?** Italy has been working on fusion for several decades, and over the years it has developed a wealth of expertise. ENEA is involved in the EUROfusion Consortium, coordinating some twenty institutes, including CNR, INFN, several universities and some industries. We are the consortium's second largest contributors after Germany. ITER uses superconducting cables developed in our laboratories, partly manufactured by Italian industries. About half of the magnets are made by our companies. We have also developed many critical components, including the component inside the reaction chamber where some of the fusion power is channelled. The heat flux sustained by this component, called a divertor, is comparable to the heat flux it would receive on the sun's surface. Our research is an example of a virtuous cycle whereby laboratories producing innovative technology and industry collaborate to generate a financial return for the country. Moreover, the European programme also aims to develop alternatives to the divertor, which may not be sufficient. In Italy we are thus starting a new fusion experiment, called DTT, which is being developed in Frascati in collaboration with ENEA, ENI and various research institutes and universities. This reflects the extent of Italy's commitment to the European effort.

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