Fusion Energy

The importance of European fusion energy research

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1. Aim of this Position Paper
Energy is one of the key commodities especially in modern societies. One of the most pressing goals of research and development is the replacement of fossil fuels which are exhaustible and contribute to global warming by those which are safe, clean, sustainable and available everywhere. Nuclear fusion is one of the most promising in this respect. It is the purpose of this position paper to point out the important role of European fusion research, to summarise the status of this field and to encourage and urge governments to favourably decide on the next step.

2. The need for energy
The current drastic increase in oil prices underline the paramount importance of energy for a modern industrialised economy - a repetition of the oil crisis of the seventies. Modern industry depends on transportation and the secure supply of electricity. Our culture and civilisation depends on the availability of inexpensive energy. In addition, it is a moral obligation of the first world to provide access to a humane and civilised life also for the third world. The supply with qualified energy is one of the most important pre-requisites. In a peaceful world the living standards will be similar to those of the industrialised world everywhere. The future will therefore be characterised by an increase in energy demand, which cannot be compensated by the increase in efficiency of energy conversion and use. The main driving forces for increased energy demand are population growth, economic performance, specifically in the 3rd world, and technological progress.

The world's current energy supply is based mainly on fossil fuels - oil, coal and natural gas. Conventional oil and natural gas resources are expected to run out relatively soon - in case of oil probably in the first half of the 21st century, in case of gas at the end of this century. There are still easily available and ample reserves of coal. The end of cheap oil will have severe consequences on world economy as the global transport system is based on it. Breakdown in electricity supply would lead immediately to an almost complete stop of public and private life in the western countries. The burning of fossil fuels leads to an increase in concentration of the so-called greenhouse gases in the atmosphere. There are numerous indications that this increase has severely disturbed the subtle balance in the equilibrium between the radiation to and from the earth. It is therefore of paramount importance to keep open all reasonable options for future energy supply forms including fission and to develop new energy sources of a high ecological standard. In this position paper we will discuss only the possible role of heavy hydrogen fusion, in particular the respective European development, the structure of European fusion research, the current status and the next step.

3. What is fusion energy?
Fusion - the energy source of the sun and the stars - is one non-fossil option, which offers the prospect of meeting the requirements of operational safety, environmental compatibility and sustainability. It has the potential to play a key role in long-term, base-load electricity production and may open the door to a hydrogen based transportation system. Fusion fuels - deuterium and lithium - are evenly distributed on the earth. There are no significant constraints on resource availability even for an extensive use of fusion energy over centuries. The safety and environmental aspects of fusion power have been assessed in extensive, in-depth studies, all of which have confirmed the attractive characteristics of fusion power. Radioactive tritium develops as an intermediate step within the core of a fusion power plant. Detailed safety studies have shown, that tritium can be safely confined within the power plant. Furthermore, there is no possibility of uncontrolled power runaway since inherent physical processes limit power excursions of the plasma. Moreover, the inner core of a fusion power station will contain fuel for only a relatively short burning time of the order of minutes. Thus even in the case of a total loss of active cooling, melting of the reactor structures is excluded due to the low density of decay heat of the materials present. The radiotoxicity of the activated materials generated by fusion reactors during their lifetime will only last for relatively short periods of the order of a hundred years, and will then be comparable or even below the radiotoxicity of the ash of coal power stations. Thus, fusion waste would not constitute a permanent burden for future generations.

4. The European development of fusion energy
Work on controlled fusion started word-wide in the 50ies. The creation of the European Atomic Energy Community (EURATOM) in 1957, was the starting point for the European Fusion Programme, integrating the major national research activities in the field including those of Switzerland. It was reactor-oriented from the beginning. The long-term aim of the Programme has been laid down by Council decisions to be the "joint creation of safe, environmentally sound prototype reactors" for producing energy in an economically viable way. The reactor orientation of the Programme provides the focus and the coherence, which makes Europe a leading player in the field.

5. The structure of European fusion research
The research and development strategy of the European Fusion Programme is successfully based on work with a single, large, central facility, complemented by a number of specialised small and medium-sized devices run by the associations of the individual member states. The central facility, the Joint European torus (JET), a tokamak experiment in England, was approved in the 70ies, began operation in 1983 and is currently planned to operate at least until the end of 2002. The focusing of significant fusion research funding on JET has made it the pre-eminent fusion facility in the world and allowed Europe to take the lead in world-wide fusion research.

6. The status of fusion energy research
JET has produced significant fusion power in deuterium/tritium plasmas. For short periods the conditions of scientific break-even have almost been reached. At break-even, the fusion output power equals the external input power, which is necessary to maintain the fusion energy producing plasma state. Moreover, JET has demonstrated that fusion devices can be operated safely with tritium fuel and that radioactive structures can be maintained and modified using remote handling techniques. Japan, USA and Russia have fusion programmes of similar scope. At smaller scale, fusion research is carried out also in South Korea and India.

7. The next step
Due to the remarkable success of JET and of other European and non-European experiments, the world fusion community is now ready to take the "Next Step" of constructing a large device, which will produce burning plasmas under reactor conditions of high power gain in order to provide a reliable basis of proceeding to a demonstration electricity-producing reactor. The design of a Next Step is carried out within the framework of the ITER activities (ITER = International Thermonuclear Experimental Reactor), a collaboration between the EU (joined by Canada), Japan, Russia and originally USA. The updated ITER version developed and supported jointly by the ITER partners is ITER-FEAT. The design of this device has been completed and it can be built. The costs are approximately 3.5 billion Euro. ITER-FEAT will be the first device with a burning plasma core; it will develop the tools to handle this plasma state, it incorporates all fusion-specific technologies of a later power plant and it will demonstrate the integration of fusion physics and fusion technology.

DEMO will be the final step after ITER. It will demonstrate that an efficient production of electricity from fusion is both practicable and compatible with a low environmental impact at economic costs for electricity. In parallel to ITER-FEAT, the appropriate technology for a power plant has to be developed e.g. materials, which can tolerate high neutron fluxes and yield low activation.

8. ITER site and construction decisions

With these long-term prospects in mind, it is clear that public funding is still needed for further fusion energy development. The long-term reactor-orientation of the EU Fusion Programme must be maintained. This implies that the necessary decision on the Next Step, ITER-FEAT, has to be undertaken in the near future. Its construction should be decided during the sixth framework programme of EURATOM.

The EPS Executive Committee