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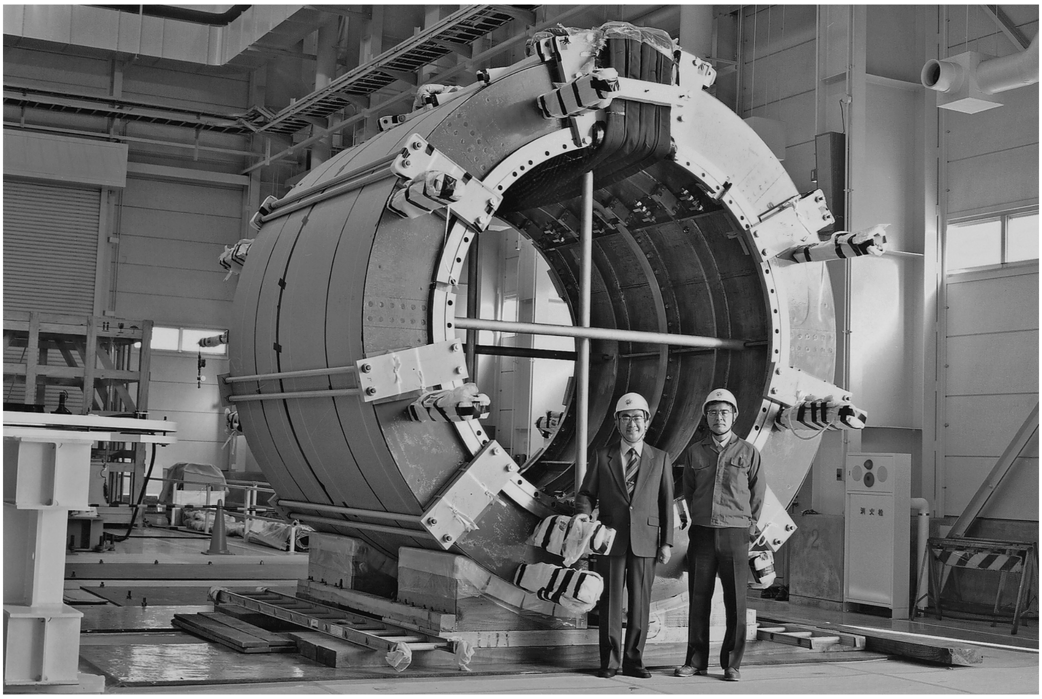
OUTER MODULE OF THE CS MODEL COIL DELIVERED TO NAKA

by Dr. K. Okuno and Dr. H. Tsuji for the Joint Central Team and the Japanese Home Team

After years of continuous and dedicated effort by the engineers and industries involved internationally since 1992, another major milestone has been achieved in the L1 (CS Model Coil) Project. The Outer Module of the CS Model Coil has been delivered to the Naka Fusion Research Establishment of JAERI on 11 November 1998 (see Figure 1). The Outer Module had been under fabrication at Toshiba (JAHT) since October 1996 when Toshiba had received the first conductor from Ansaldo (EUHT).

The Outer Module has eight layers wound in two-in-hand configuration, a total weight of about 50 tonnes, a height of 2.8 m, an inner diameter of 2.7 m and an outer diameter of 3.6 m, which corresponds to 2/3 of the outer diameter of the Final Design Report ITER CS and is of similar size to options under consideration for the Reduced Technical Objectives/Reduced Cost ITER design. The Outer Module uses heavy-walled, square jacketed conductors of 3,000 m in total produced by the EUHT, JAHT, RFHT and USHT through international collaborative procedures.

The Outer Module will be assembled together with the Inner Module in the test facility at Naka to constitute a 640 MJ coil, which will be the largest Nb_3Sn coil operating at 13 T ever built. The Inner Module is in the final stage of the fabrication at Lockheed Martin (USHT), and is planned to be delivered to Naka in early 1999.



H. Tsuji (Head of JAERI Superconducting Magnet Laboratory) and Co-worker T. Ando in front of the CS Model Coil Outer Module which was delivered to the test site at Naka, JAERI on 11 November 1998.

SPECIAL LECTURE

by Prof. H. Yoshikawa, President of the Science Council of Japan *

Prof. H. Yoshikawa giving the Special Lecture

We have come to crossroads in the fusion program. One road leads to the foundation of cooperation between nations striving to overcome the difficulties the world is confronted with, and the other leads to despair. It is my privilege to make some remarks in the memorial session of this prestigious international conference.

In recent years, many controversial issues have taken on global proportions which require strong international cooperation. One example is the problem of greenhouse gas emissions. In the current situation where the world population will increase, it is indispensable for all governmental foundations and local communities to cooperate with each other towards the ultimate goal of preserving the global environment while retaining their own cultures, social structures and regional customs.

The global environmental issue, which has emerged abruptly in recent years, is a typical problem that requires the world-wide cooperation necessary to solve our common problems. We have realized through the discussions we had first at the Earth Summit in Rio de Janeiro in 1992 and at the United Nations Framework Convention on Climate Change in Kyoto last year that international cooperation would have to be coordinated in a way that is totally different from previous bilateral government collaborations, civilian exchanges or industrial cooperation.

First, the issue we deal with is a problem of global extent, and our local actions trying to cope with the problem can also affect the whole world. Therefore, decisions taken or politics followed purely at the national level or for the benefit of a specific industry in the free market are not sufficient to address these emerging global issues.

Second, not only has the symptom a global scale, but also the problem usually progresses in an irreversible way. Therefore, neither allopathic treatment nor emergency remedies, for which usually an immediate effect is expected, produce satisfactory results.

Third, the emerging problems are not what humanity has experienced so far, and they cannot be solved in a straightforward manner with our present scientific knowledge. Consequently, the development of necessary countermeasures often involves fundamental scientific research.

The last point is that the many of such global issues arose as an integrated result of past actions of humanity which continuously strove to raise the standard of living.

Accordingly, an effective solution may not be obtained by the development of an innovative technology, but by a fundamental shift in the direction of our whole technological development.

We have understood that the solution of global issues would be obtained neither in the industrial free market competition nor with an increase of federal expenditures to support the individual fundamental scientific researches. We have realized that that advanced form of an international framework is most important where cooperative development of effective countermeasures and their implementation are taken care of, based on a common recognition of global problems. It is evident that we have made progress on the global environmental issues, collaborating in the arrangement of relevant international conferences. Here, it has to be emphasized that practical actions enhance common understanding, which in turn leads to further effective actions.

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* Prof. Hiroyuki Yoshikawa graduated in 1956 from the University of Tokyo, whose President he was from 1993-1997. The Science Council of Japan is a subsidiary organization of the Government. Its major function is to advise the Government on the results of its deliberations of important issues in the field of science and to recommend policies in the science area. Prof. Yoshikawa, in addition to being the President of the Science Council, is also the Chair of the Special Committee on the ITER Project under the Atomic Energy Commission of Japan.

This Article contains the text of the Special Lecture as given by Prof. H. Yoshikawa (with minor editorial changes) at the Artsimovich-Kadomtsev Memorial Session of the 17th IAEA Fusion Energy Conference in Yokohama, October 1998.

I have mentioned at the beginning of my talk that many of the controversial issues have to be considered as a global matter. There is no doubt that the global environmental issue is a typical case. However, it is worth noting that in many cases not only the national politics but also the industrial activities and even the individual modes of behaviour must be considered in relation to global issues. For some of these issues, namely the provision of food, management of natural resources or the supply and consumption of energy, we would have to make an advanced step forward, with equal weight placed on the global environmental issues under the international cooperation program.

In particular, the issue of energy shortage should, in principle, be managed collaboratively under governmental leadership, as it is sensitive to world economy and politics. However, in practice it is committed to the free market. The issue of future energy shortage requires an advanced framework of world cooperation. Therefore, we should as soon as possible develop practical methods of coordinating cooperative programs, even if the crisis is not foreseen to happen in the near future.

The inventory of our energy resources has been examined many times in the past few years. It is evident that the fossil and the light water reactor fuels, as our present energy resources, cannot be relied upon forever as they will eventually disappear. Therefore, it is indispensable to seek alternatives. However, the problem of forecasting future energy resources may be the following: the project may be technically feasible but suffer from scarcity of supply or, conversely, resources may be abundant, but prevailing technical difficulties prevent its implementation. In the present situation, it is in principle impossible to specify a single energy resource on which humanity could rely in the future. Fusion energy is one of the options. It is certainly one of the potential candidates, for which deliberate investigations in humanity's interest should be conducted.

To evaluate the feasibility of fusion energy as one of the options, I would like to introduce two important viewpoints. One is safety and the other is cost whereas, in general, technical feasibility and cost are the fundamental issues in evaluating new technologies.

As to the safety considerations, the inherent safety of the fusion reactor as well as the safety of specific reactors are addressed by scientific experts. In regard to the cost estimate, on the other hand, we first have to clarify the significance of making large investments on fusion as one of the options, which does not, however, guarantee its feasibility. We will not be able to verify quantitatively that the amount of investment is appropriate. It is hardly possible to be accurate in estimating the cost necessary for the development of innovative technologies related to the construction of experimental, demonstration and commercial reactors. Furthermore, it is far beyond our predicting capability to be able to estimate how much society will profit from the fusion reactor, once it runs on a commercial basis. Fusion energy may not be competitive with the conventional energy production schemes such as fossil fuel or fission reactors, if its cost of electricity is higher. However, also the inverse situation may well occur in the future where society would have the benefit of relatively inexpensive electricity produced in the fusion reactor. The effort of intensive investigation assessing whether fusion energy is competitive or not in the future would be in vain with our present predicting capabilities as the outcome of the investment for which our commitment is presently urged would appear too far out on the economic time-scale.

In terms of energy source scaling, however, fusion is situated right after fossil fuel energy and light water fission power. In a situation where fossil fuel is exhausted and fission power is for some reason no longer available or, else, the global environmental issue is raised by society, we would have to rely on other possible options, regardless of the cost of electricity. Therefore, detailed discussions on the economic influence related to fusion energy do not seem to make any sense at present. I would say that the investment on research and development of fusion energy, which is advantageous in terms of reduced environmental threat and the stability of supply of an enormous amount of electricity, is a sort of insurance premium granting additional freedom of choice for the future of humanity.

A word of warning, however, is that investment on fusion energy does not mean producing a vast energy consuming society in the future. Should we be successful in reducing energy consumption while maintaining a satisfactory standard of living, we would come to the conclusion that alternative energy resources are not necessary. In this case, fusion energy will not be put into practical use, even if its technical feasibility is adequate. We would not think that our investment was after all futile, as we have paid for the insurance. Nobody would regret having paid for a life insurance if he enjoys a long life. It is certainly an appropriate investment. In other words, although fusion energy development and reduced energy consumption are options that are far apart from each other, I believe that they should be sought simultaneously in a sincere attitude.

The investment on scientific research for the insurance of the future is characteristic of the recent social situation, where the global environmental issue has become so important. It has never happened before in industrial technology development. The significance of investment thus made will largely be recognized, and we will have to maximize the efficiency of our investment.

Accordingly, I will discuss here considerations that would have to be made by a government, hosting an experimental fusion reactor such as ITER. If it were Japan, the primary issue the Japanese government would have to think about are the technical aspects related to energy shortage, significance of fusion energy and the feasibility of reactor construction. The other issue is the social aspect, such as the role of Japan in the international society, its national identity and the public consciousness of global issues. Even if Japan were successful in convincing its own parliament members and cooperating countries to host the experimental fusion reactor, it is necessary to assess the consequences when the program is successful or when it is terminated without any conspicuous results.

Let us categorize the possible outcomes of the program: The first case is that the experiment is successful, with accomplished technical developments. Fusion energy is recognized as a competitive alternative, and a bright future for the commercial reactor comes into our sight. In this case, Japan is admired as a leader of fusion research, and the success of the program would produce an enormous amount of economic profit.

The second case is that technical feasibility is established, but economic competence is poor. In this case, people might think that the investment was not fully recovered. However, it is certainly a great success in the sense that we have established a secure alternative source of energy for the future of humanity.

The third case is that energy consumption itself decreases, and the development of alternative energy resources is not urged any longer. Then, the ultimate goal seems to be lost, even if the technical development was accomplished. However, if such a change in the direction of the rail track in society is produced along with the effort of establishing an alternative energy source, I would say that the investment on fusion research retains its significance because it affects the direction which the development of society will take.

The last case is that fusion is found to be hardly feasible, owing to technical difficulties. Although the fundamental difficulties are not pointed out at the moment, we cannot be 100% perfect in assessing the feasibility. In this case, the development of fusion energy is a failure. However, it can at the same time be considered an investment as a premium for the preservation of global environment. Conversely speaking, we learn from the failure and may start thinking about limits of development. Therefore, it is not a total failure, even in this case.

In practice, the possible cases to be analyzed would have to be broken up into more detailed categories. However, we are currently not capable of predicting the environmental, economic and international situations at the time when conventional energy resources are exhausted. Therefore, it is not really important to discuss which cases we would fall into, but we should be prepared to claim that our investment as a premium was not too expensive in all the cases. If we can make such a statement, then we should make a decision in favour of an experimental reactor, for which the prediction of the profit is, in principle, impossible.

It is, however, true that we naturally prefer paying less for the premium. Therefore, it is necessary to extract the potential advantages of fusion energy development programs whatever the result would be. This result can be the proliferation of the knowledge acquired in the process of fundamental fusion plasma research towards more general scientific studies or industrial applications. The skill gained in international cooperation, related to highly specialized scientific and engineering development, may also be valuable for other fields. In particular, cooperative work between different generations would promote intimate friendships among the people who constitute society.

On the other hand, it is also important to reduce the cost of the whole program. In the case where the ultimate mission and the fundamental procedures are clearly defined, as is the case for ITER, the method of management would be different from those in other research institutes which are mainly concerned with general science. Therefore, a large effort would have to be devoted to reducing the cost of the program. The participation of experts in administration would also be effective, in order to balance the technical goals, development risks and costs.

It is thus hardly possible, in principle, to provide accurate figures related to the risk estimate when we commit ourselves to a national or a coordinated program in which intensive appropriation is involved. However, the question is whether we will do our best to maximize the efficiency of the program in producing collateral profit, whatever the result would be. Accordingly, only that program for which all possible significance and profit are maximized for a given amount of investment, regardless of its degree of scientific achievement at the final stage, deserves our commitment.

To maximize the efficiency of the program, many issues have to be clarified at present. These issues are important in considering the start of the experimental fusion reactor. First of all, we need to investigate the long term energy supply and consumption needs. Here, it is important to be impartial in assessing the energy demand, not being specific to a particular industry or to a community where the life style is uncommon.

Secondly, a feasibility assessment should be made for alternative energy resources, and a proposal should be made on development and utilization, incorporating the investment in scientific research and industry support.

The third issue are the possibilities of the commercial use of fusion energy as a safe and secure alternative. This would have to be studied from the viewpoint of the potential technical as well as administrative capabilities and the characteristics of industry structure. Here, it is above all important to acquire the participation from major industries.

The fourth point is that if Japan were to host ITER, we would have the responsibility of continuously supporting fusion energy development programs. A comprehensive long term plan must be made for a system in support of ITER and future fusion reactor development. This plan should specify the roles of universities and industries in related basic research such as material research, as well as the education and training of specialists. This plan should also provide a scheme for collaboration among different institutions.

The following issues may not be directly relevant to fusion only. However, they address the fundamental guidelines in distributing the appropriations and coordinating the international program.

In many fundamental scientific studies, some appropriation is required, and the way of distribution is in practice determined by the national strategy. As to the guidelines for the distribution, it is necessary to distinguish the purely academic research from the research required for the survival of humanity. They are not by all means antipodal. However, it is important to balance the weights of these two categories, reflecting social and economical situations. It is evident that the latter should be emphasized at present.

As I have mentioned at the beginning, there are many important issues and controversies, which have to be treated as global problems requiring global solutions, i.e. the provision of food and energy as well as the preservation of the global environment. In future, effective countermeasures have to be applied on the basis of global collaboration, well before the symptom progresses.

I have also emphasized that we would have to use different ways of decision making in order to cope with these global issues. In other words, it is essential for all friends in various nations to share their understanding and strive forward to improve the situation, defying the difference in cultures and the national borders. I would like to emphasize that in the particular case where scientific issues are involved, cooperation is indispensable, and the driving force of our collaborative effort shall not be the short term profit close at hand, but courageous decisions made by the integrated wisdom of humanity.

ITER ON DISPLAY AT YOKOHAMA, JAPAN

by Dr. B. Green, ITER Joint Central Team

During the 17th IAEA Fusion Energy Conference (held in Yokohama, Japan from October 19 to 24), the ITER Project exhibited a display, primarily of the research and development which has taken place to support the design of ITER.

The ITER exhibit was displayed in a large room on the 3rd floor of the Yokohama Pacifico (the distinctively shaped conference centre building), alongside exhibits by three other fusion research organisations — the Joint European Torus (JET) Project, which used the display to commemorate 25 years since the original design team was established in 1973, the JT-60 U Project (Japan Atomic Energy Research Institute, Naka, Japan), and the National Institute of Fusion Studies (NIFS), Toki, Japan, which based its display on the recently constructed and commissioned Large Helical Device. Such displays were a somewhat new development for the IAEA Conference, but one that seemed much appreciated by the conference participants.

The ITER display featured 5 display boards describing the Project's aims, the goals and achievements of the Engineering Design Activities, and, in more detail, the physics studies and technology R&D especially 7 large R&D projects involving the superconducting model coil, the blanket module and divertor cassette and their associated remote handling, and the vacuum vessel sector. Other R&D work such as for heating and current drive systems were also presented.

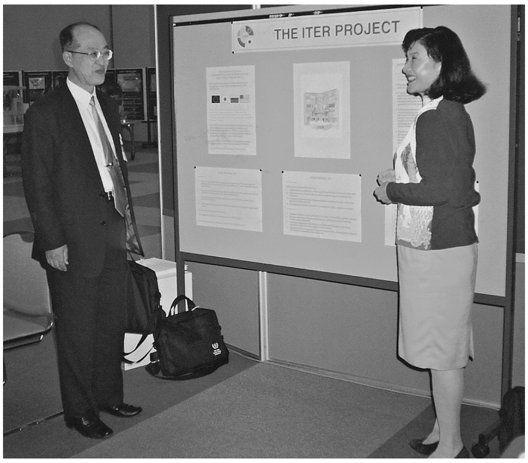
The display directed the interested visitor to more specific ITER papers and posters being presented at the conference.

Also featured in the exhibit were a 1/30 scale model of ITER (kindly provided by JAERI), the ITER brochure (in English, Japanese and Russian) with handout information material on each of the 7 large R&D projects, safety and the project in general, small samples of hardware from the superconducting model coil projects (jacketed conductor, a TF radial plate section and similar items); and videos of the Project (e.g. the electronic drawing office, assembly of the machine, maintenance of systems and the 7 large R&D projects (many provided by Home Teams)).

The display started on Tuesday, October 20, and ran through to the last day of the Conference. It was continually staffed throughout the day by Barry Green and Annick Lyraud from the Joint Central Team and Tomoko Ito from the Naka host support team, assisted by a roster of Joint Central Team participants to the conference. The display was strongly supported by the Director.

The messages of the display seemed to be well understood by all visitors, namely:

1. that over $700M has been expended on R&D in the EDA, resulting in validation of the design choices and the construction and testing of prototypes;
2. that this work has advanced considerably the technology in various fields, confirming the view that project-led R&D of this kind is a more effective way of doing this than generic fusion technology R&D;
3. that this R&D, although performed to support the ITER design, as described in the ITER Final Design Report, was not limited in its application, but can be directly applied to support the design of the reduced technical objective/reduced cost ITER, and significantly strengthens the overall technology data base for development of fusion energy.



At the Display: Ms. Tomoko Ito (ITER Naka JWS) greets a distinguished visitor – Ohta-san, Director of Naka Research Establishment; Change of roster: Alan Costley relieves Barry Green (both JCT)

The many visitors to the display (about 250 left their names in a guest book provided for the purpose) all expressed strong interest in the work presented. The participants came from most of the countries represented at the conference, not only those involved directly in the ITER Project. The IAEA, under whose auspices the ITER project is being conducted, was also most helpful and supportive, and expressed the wish to see such a display repeated.

Items to be considered for inclusion in the ITER Newsletter should be submitted to B. Kuvshinnikov, ITER Office, IAEA, Wagramer Strasse 5, P.O. Box 100, A-1400 Vienna, Austria, or Facsimile: +43 1 2633832, or e-mail: c.basaldella@iaea.org (phone +43 1 260026392).
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