

Foundations for Knowledge Management Practices for the Fusion Sector

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Abstract

This paper intends to overview the status of fusion activities and to present emerging issues related to the management of resources and knowledge in fusion projects; they can be better addressed by looking at appropriate methodologies and tools in the thematic areas of knowledge management. After a short introduction outlining the present transition phase of the worldwide fusion activity, I will present a preliminary analysis of emerging requirements and challenges, which create the foundations for knowledge management practices for the Fusion Sector. Differences between the fusion and the fission sector will also be discussed, and appropriate practices for some selected challenges will be proposed and analyzed.

Introduction on fusion activities

Fusion Energy promises manifold advantages as an energy source because it is based on abundant primary resources, environmentally friendly without any carbon emissions, and it produces very little radioactive waste. It is expected to play an important role in the world's energy supplies in the second half of the 21st century.

An exceptional global R&D programme on fusion, based on several national and international projects, is planned to take place in the next forty years. The multibillion-euro ITER facility is currently under construction in the south of France. It is a joint experiment of seven parties: China, India, Japan, Korea, Russia, the United States, and Europe (which acts as a single party and is represented by the European Commission) which represent more than half the world's population and 85% of the planet's industrial product. ITER aims to demonstrate the scientific feasibility of fusion as an energy source, and to test key technologies for a fusion power plant. The specific objective is to obtain energy gain $Q = 10$, and generate ~500 MW of fusion power with 50 MW of input power during periods of 400 seconds. Several different fusion projects (usually named as DEMO, for DEMOnstration power plant) are in their conceptual design phase. DEMO is somewhat larger than ITER. DEMO is a prototype of a fusion power plant with grid connection aimed at demonstrating the commercialization of fusion energy. The specific objectives of DEMO include tritium self-sufficiency, full plant energy efficiency, use of low-activation neutron-resistant materials, and continuous operation. Moreover, a series of fusion facilities around the world are operating or are planned to be built, in order to sustain mainstream fusion energy development and to explore innovative fusion concepts. An increasing number of countries are joining the fusion community.

The fusion community is now in an important transition phase due to the expansion of fusion activities from a science-driven approach to a technology- and industry-driven approach. Global fusion activities are moving from the R to R&D phase to the realization of the most advanced fusion

device (ITER) managed by an unprecedented international collaboration, from the deuterium-deuterium to the deuterium-tritium plasma operations which need nuclear installations and nuclear licensing to operate, and to the substantial involvement of the industrial sector. During this transition phase, the world fusion community is still facing scientific and technological challenges, and the IAEA is already strongly involved in supporting its Member States in the exchange and building of knowledge related to these issues. Nevertheless, new types of challenges at different levels have recently become apparent. The emerging gaps are mainly related to the management of resources and knowledge in the fusion sector. Many issues must still be addressed in order to assure a sustainable development of national and international long-term fusion programs.

Preliminary analysis of emerging challenges

A preliminary analysis has identified emerging issues in areas of critical importance:

- Building of knowledge base for safety standards and licensing regulations for fusion installations. Fusion reactors are based on deuterium-tritium plasma; due to tritium and the high neutron fluxes, any experimental devices operating with deuterium-tritium plasma require nuclear installation and indeed nuclear licensing to operate. ITER has been the first nuclear fusion facility for which a full safety case has been prepared and subjected to the review of a nuclear regulator. Nevertheless, at present, there are no official fusion-specific safety standards and licensing regulations for fusion power plant construction and operations which can support DEMO and other future nuclear fusion facilities. It is essential to employ an integrated approach, built on the basis of the unique ITER experience as well as on the long-term experience in the nuclear fission sector, in order to develop safety regulations and implement them in a safe design. [1,2]
- Long-term management and preservation of scientific data. All fusion devices generate large amounts of data, data about design and construction, operations, physical measurements, scientific results etc. All types of data must remain accessible throughout and beyond the lifetime of the device. This is essential for reducing labor and costs. Based on the Joint European Torus (JET) experience, it has become evident that preservation of fusion-related data needs to be addressed with an appropriate strategy, including software and hardware, as well as appropriate knowledge transfer in order to maintain usability in the period of post-operation of a fusion device and mitigate the risk of knowledge loss. [3]
- Intellectual Property Management. Fusion research institutions have produced and continue to develop valuable scientific expertise and knowledge in fusion science and technologies. While fusion is moving toward the larger involvement of industry, these important know-hows must be transferred to high-tech industrial companies. Disseminating intellectual property rights within a complex structure of collaborators and handling know-how and confidential information are a priority. To meet this challenge, it is important to establish policies and to build utility models and tools appropriate for fusion, paying attention to both facilitating industry involvement in the fusion sector, and accelerating technological innovation.
- International coordination and knowledge sharing. Fusion is multi-disciplinary and involves several physical and technological areas. It is well known that no single laboratory can have all competencies for the success of the R&D fusion program, and no single experiment can

solve all the problems facing a fusion power plant. Out of the science-driven approach, in a phase where the economic profit of fusion is in sight, the challenge of maintaining highly efficient international coordination and knowledge sharing is more complicated. They are still essential for optimizing strategies and decision making in order to avoid waste and duplication, and for improving efficiency and reducing project costs of national fusion programs. An example is the set of DEMO machines now being considered world-wide (DEMOs); although they have the same missions and similar adopted solutions, they are competing project running in parallel in different countries. [4]

It is well known that these issues must be addressed with attention because they pose the serious risk of increasing costs or being behind schedule; they could inhibit the success of national and international fusion projects. The experience of knowledge management practices in the fission sector represents an asset for the development of knowledge management practices for the fusion sector. Nevertheless, it is essential to pay attention to the strong differences between the fusion and the fission sector, such as scope, economy, human resources development, and safety procedures. Some appropriate practices, products and services for addressing the abovementioned issues will be proposed and discussed.

References

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