Proposal for a Coordinated Research Project (CRP)

1. Title of CRP: Elements of Power Plant Design for Inertial Fusion Energy

The proposed duration is approximately five years, starting in late 2000 and running through 2005.

2. Background Situation Analysis (Rationale/Problem Definition)

Fusion research is proceeding effectively to develop a new energy source that is abundant, safe, environmentally acceptable, and economical. There are two major approaches, Magnetic Fusion Energy (MFE) and Inertial Fusion Energy (IFE). The basic physics of IFE (compression and ignition of small fuel pellets containing deuterium and tritium) is becoming increasingly well understood. New megajoule-class laser facilities under construction in the USA and in France are expected to demonstrate ignition and energy gain in this decade. Fusion reactor design studies indicate that IFE power plant are feasible and have attractive cost, safety and environmental features.

Based on recent advances by individual countries, IFE is now at the stage where large benefits can be obtained from a coordinated approach in the form of a CRP. This CRP will help Member States to promote the development of plasma/fusion technology transfer and to emphasize safety and environmental advantages of fusion energy. The CRP will document the state of art and conduct research to help resolve key issues. While there are many issues to be resolved and significant technology development needed, this CRP will focus on interface issues including those related to 1) the driver/target interface (e.g., focusing and beam uniformity required by the target), 2) the driver/chamber interface (e.g., final optics and magnets protection and shielding), 3) the target/chamber interface (e.g., target survival during injection, target positioning and tracking in chamber). This CRP will also include an assessment of the state of the art of the technologies required for an IFE power plant (drivers, chambers, targets) and systems integration and assessments of environmental, safety and economic (ESE) aspects.

Both theoretical and experimental work will be conducted. This research will involve scientists from both developed and developing Member States, and the latter will benefit from close interaction with advanced organizations (laboratories, universities, and private companies) in developed Member States.

3. Overall Objectives

The overall objective of this CRP is to stimulate and promote the Inertial Fusion Energy development by improving international cooperation. The improvements are 1) to coordinate complementary experts related to IFE power plant design, 2) to avoid duplication of effort, (3) to speed progress by sharing knowledge, manpower and costs, and 4) to attract the attention of and invite experts of other fields who are interested in IFE power plant development.

The four major components of IFE power plant (driver, target or fuel pellet, chamber, and the remainder of plant, i.e., power conversion) encompass many fields of engineering. It should be noted that there is not a single way to combine these components. For example, a particular chamber design could work with more than one target or drive type. The integration of the components must, however, account for the unique requirements and constraints of the various subsystems. Therefore, while much technology development can be conducted in parallel, close coordination is needed for effective systems integration and when addressing the interface issues.

IFE power plant design has very specific objectives, and it is not a common advanced engineering field. There are, however, many experts who are interested in finding new applications of their expertise. The related engineering fields of IFE power plants include optic and laser engineering, materials processing, ablation hydrodynamics, vacuum technology, neutronics, material development, liquid metal technology, and other generic advanced technologies. It is very important to attract the attention of outside experts and allow them to contribute to the development of IFE. A CRP on IFE power plants will help accomplish this by giving broader exposure to the design challenges.

4. Specific Research Objectives

The specific research objectives of this CRP fall into three categories: Technology Assessment, Interface Issues, and System Integration and Assessments.

i) Technology Assessment – Review and summarize the current status of key technologies of IFE power plants including drivers, chambers, target fabrication and injection systems, and the remainder of plant (power conversion systems, etc.). For each system, recommend development steps

ii) Interface Issues – Identify key issues and possible solutions for driver/target, driver/chamber, and target/chamber interface issues. Reflect the feedback effects to each component from the investigation of interface issues. Coordinate research in addressing and resolving interface issues.

iii) System Integration and Assessments – Integrate the subsystems of the power plant and evaluate the environmental, safety and economics aspects of candidate IFE power plant designs. Recommend pathways, technologies and developments needed to produce an integrated system that meets the goals of developing environmentally acceptable, safe and economically competitive power plants.

As part of the Technology Assessment and the System Integration and Assessments (items i and iii), technical requirements will be defined for drivers, chambers, and targets (at the component, subsystem and/or system level). Also, near- and long-term measurable goals (metrics) will be established to help gauge progress toward an attractive power plant. These requirements and metrics can help guide R&D decisions. Funding should be devoted to concepts that meet the technical requirements and that excel in the performance metrics. These metrics can also be used to define the degree of success necessary to proceed to the next stage of development.

5. Expected Research Output

The CRP is expected to provide important information on the status of technologies needed for IFE power plants and recommendations on the R&D steps needed to advance these technologies to the next level. The output of this activity will be written reports, e.g., IAEA Technical Documents and institutional reports. Work under this CRP will also identify key interface issues and help coordinate research to resolve these issues. Results from analyses and experiments addressing these issues will be published (e.g., journal articles) and made available. Similarly, reports will be written describing analyses on ESE aspects of IFE power plants and any experiments conducted to support these analyses (e.g., measurements of mobilization fractions of key radioactive isotopes under accident conditions). Technical requirements and metrics will also be documented to help identify technically feasible and attractive approaches to IFE. The outputs of this CRP will lay the foundation for the coordination and planning of future integrated tests for IFE (e.g., an engineering test facility).

In summary, the Coordinated Research Program for five years will be useful and beneficial to give the clear direction for next step in IFE power plant development with the output of (a) review of the state of the art of the key technologies, (b) contribution of world wide experts in related fields, (c) coordinated integration of the results to evaluate IFE power plants and plan the next steps toward future development.

6. Action Plan

	Year 1	Year 2	Year 3	Year 4	Year 5
Technology Assessments					
Initial Review					
Requirements and Metrics					
R&D Plan					
Update Status Report					
Interface Issues					
Identify Issues					
R&D Plan					
Investigations					
Update Status Report					
System Integration and Assessments					
System Integration					
ESE Assessments					

A proposed time scale for the primary activities is shown here. The review of the state of the art of driver, chamber and target technologies will be completed as one of the first activities and an integrated R&D plan proposed. Technical requirements and metrics will be defined to quantify the technology assessments. At the end of the CRP, the technology status will be updated to reflect advances during this period. Work on interface issues will begin by identifying the key issues that require the most attention and proposing a coordinated plan to begin their resolution. Work on these issues will proceed for the remainder of the five-year CRP. System integration, environmental, safety and economics assessments and the implications for IFE power plant development will be an ongoing activity to help guide the research. Part of the integration and ESE efforts will include defining technical requirements and metrics by which to judge progress towards the goal of an attractive IFE power plant.

7. Inputs

7.1 Financial Resources Required (US$)

Items	**Year 1**	**Year 2**	**Year 3**	**Year 4**	**Year 5**
Research Contracts	16,000	20,000	30,000	30,000	
Research Coordination		25,000		35,000	35,000
Yearly Totals	16,000	45,000	30,000	65,000	35,000
Grand Total					**$191,000**

7.2 Other Resources Required

Support is required for attendance of a project officer of IAEA at the Research Coordination Meetings (if not held at the IAEA Headquarters). The project officer also would need to act as the scientific secretary performing the evaluations of proposals and progress reports.

7.3 Countries with IFE Activities

Australia	Hungary	Poland
Canada	India	Portugal
China	Israel	Russia
Czech Republic	Italy	Spain
France	Japan	United Kingdom
Germany	Korea	USA

8. Assumptions

The commitment of chief scientific investigators will be essential for the achievements of the objectives. All the organizations involved will have to ensure that the elements of power plant design for IFE are investigated to obtain meaningful conclusions. Five years will be sufficient for all the activities necessary for the successful completion of the project.

9. Logical Framework

Title: Coordinated Research Program on "Elements of Power Pant Design for Inertial Fusion Energy."

Overall Objective: to promote the Inertial Fusion Energy development by improving international cooperation and by coordinating wide technical fields and experts which are related to the IFE power plant design.

Specific Objectives: to 1) review technology state of the art, 2) investigate interface issues, and 3) perform system integration and assessments. The chief scientific investigators of involved organizations are responsible for coordinating their colleagues to get meaningful results.

Activities: include 1) review of state of art on IFE power plant design (including an evaluation of the new technologies) and propose R&D necessary to advance IFE development; 2) identify, and conduct research (analytical and experimental) on solutions to interface issues between the driver/target, driver/chamber and target/chamber; and 3) perform system integration and assessments of environmental, safety and economic aspects of IFE power plants. Formation of a technical network under this CRP will be useful for the efficient promotion of research work in a well coordinated way.

Chief scientific investigators will gather together in years 2, 4 and 5 to coordinate the program and to complete the final documentation. Some financial support will be provided to the organizations in developing countries with research contracts.

Narrative Summary	Objective Verifiable Indicators	Means of Verification	Important Assumptions
Overall objectives · Coordination of experts · Avoidance of duplication · Acceleration of progress	NA	NA	NA
Specific objectives · Technology assessment · Interface issues · System integration	1. Agreement on state of the art, interface issues, and system integration issues.	1. CRP Reports 2. Papers in Fusion Energy Conference and technical journals.	1. Governments fund the research. 2. IAEA continues CRP support. 3. Good communications exist among researchers & with IAEA. 4. Research achieves worthwhile results.
Outputs			
1. Task list for each participant.	1. Agreement on tasks	1. Task lists	1. Participants agree to tasks.
2. Report including technology assessment.	2. Agreement on technology assessment	2. Report on technology assessment	2. Participants agree on technology assessment. Participants write report.
3. Report on interface issues and system integration issues.	3. Agreement on interface and system integration issues.	3. Report on interface issues and system integration issues.	3. Participants agree on interpretations and write report.
4. Final report summarizing results of CRP and conclusions.	4. Agreement on results and conclusions	4. Final report	4. Participants agree on conclusions and write report.
5. Journal article or TECDOC.	5. Journal article or TECDOC.	5. Journal article or TECDOC.	5. Report quality is worthy of publication.
Activities			
Action 1. Task definitions.	1. 4 contracts and 12 agreements	1. Contracts and agreements awarded.	1. Suitable proposals submitted
Action 2. First RCM. State of research and technology assessment.	2. First RCM held 2001.	2. RCM report	2. Participants attend RCM.
Action 3. Second RCM. Progress on interface issues and system integration issues.	3. Second RCM held 2003	3. RCM report	3. Research results obtained and participants attend RCM.
Action 4. Final RCM. Conclusions	4. Final RCM held 2004	4. RCM report	4. Participants attend RCM and write report.
Action 5. Editing, revision, and publication.	5. Completion of editing & revisions.	5. Journal article or TECDOC.	5. Results sufficient for publication as journal article or TECDOC.

10. Brief Summary for IAEA Bulletin

There are two major approaches in fusion energy research, Magnetic Fusion Energy (MFE) and Inertial Fusion Energy (IFE). The basic physics of IFE (compression and ignition of small fuel pellets containing deuterium and tritium) is becoming increasingly well understood. Based on recent advances by individual countries, IFE is now at the stage where large benefits can be obtained from a coordinated approach in the form of a Coordinated Research Project (CRP). This CRP will help Member States to promote the development of plasma/fusion technology transfer and to emphasize safety and environmental advantages of fusion energy. The CRP will document the state of art and conduct research to help resolve key issues on IFE research. The CRP will focus on interface issues including those related to 1) the driver/target interface (e.g., focusing and beam uniformity required by the target), 2) the driver/chamber interface (e.g., final optics and magnets protection and shielding), 3) and the target/chamber interface (e.g., target survival during injection, target positioning and tracking in chamber). This CRP will also include an assessment of the state of the art of the technologies required for an IFE power plant (drivers, chambers, targets) and systems integration and assessments of environmental, safety and economic (ESE) aspects. Both theoretical and experimental work will be conducted. This research will involve scientists from both developed and developing Member States, and the latter will benefit from close interaction with advanced organizations (laboratories, universities, and private companies) in developed Member States.