

Coordinated Research Programme

1. Title of the Programme

Small Reactors without On-Site Refuelling

2. Background Situation Analysis

The need to address technology development for Small (less than 300 MW(e)) and Medium Sized (300-700 MW(e)) Reactors (SMRs) is supported by several arguments. On one hand, the principal drivers behind projected large increase in global energy needs are population growth and economic development in today's developing countries, which often have small electric grids and insufficient infrastructure. Reactors fitting into the SMR range appear to be an appropriate nuclear power option to meet this demand. Moreover, many developing countries have limited capacities for investment, especially as comes to hard currency, and small turnover of capital in the electricity market. In this context, an SMR may represent the only affordable option of nuclear power for such countries.

SMRs offer an option of electricity generation coupled with seawater desalination, which meets the urgent needs of many developing countries. SMRs could offer a variety of passive safety features that may be difficult to attain at nuclear power plants (NPPs) with reactors of large unit power, which makes them a good potential choice for countries with insufficient nuclear infrastructure and limited number of human resource. SMRs provide an attractive domain for fuel leasing and facilitate an option of factory fuelled and transportable power plant, e.g. barge-mounted, which may be a solution for countries with limited capabilities in mastering nuclear fuel cycle, or for those who prefer to be just end users of nuclear power. For some countries new employment opportunities are created through the multiplicity of plants, which increases upon the reduction of unit power. Higher employment opportunities lead to a higher standard of living and to other societal benefits.

In industrialized countries, electricity market deregulation is calling for power generation flexibility that smaller reactors may offer. Some countries may face lack of sites that are appropriate for further construction of large-capacity plants. Also, SMRs are of particular interest for advanced future non-electric applications, such as hydrogen production, coal liquefaction, and other process heat applications, etc.

On the other hand, there are more generic arguments to support SMRs, such as that new technologies cannot be deployed at once to a large scale. Learning from a small prototype plant, which also includes breeding of knowledge and training, may be a necessary step in reaching the final goal of wide-scale deployment of an innovative technology.

Summarizing the arguments mentioned, it may be stated that at a particular point in time, when a necessity to limit the emissions of carbon dioxide is acknowledged by the majority of countries, SMRs may have a good chance to be implemented in many developing and industrialized countries and may contribute a lot to the sustainable development through both, electricity production and process heat applications. As these reactors may include innovative technologies, and as it takes time to develop

them, relevant R&D are to be started well ahead. These statements are strongly supported by the evidence of many new and on-going activities for SMRs worldwide.

Upon the apparent diversity of conceptual and design approaches to SMRs as practiced in different countries, it may be helpful to define the so-called enabling technologies for as many SMR concepts as possible. The enabling technologies are the technologies that need to be developed and demonstrated to make a particular reactor concept viable. These may include key technologies for the primary circuit, such as particular coolant, fuel or structural materials technology, or core configurations to ensure optimum reactivity feedbacks, or technologies to realize natural circulation and passive heat removal, passive safety systems etc., but also the technologies that are essential to secondary or subsidiary circuits, e.g. power generation circuit, or to the specifics of plant design and configuration, e.g. certain options to cope with natural and human induced external events. While reactor concepts and design approaches may vary from country to country or even between different designers within a single country, certain enabling technologies may be essentially similar. Identification of the enabling technologies and relevant R&D needs may speed up the development and implementation of many SMRs by effectively streamlining the efforts of their designers through increased international co-operation.

Definition of the enabling technologies and relevant R&D needs for SMRs may also facilitate a link to national or international technology development for nuclear reactors beyond the SMR range. In turn, this will contribute to a dialogue between major nuclear vendors and potential national or regional users, which may help define how the developments of few industrialized countries could be later on adjusted to the specific needs of developing countries or regions.

Non-technical issues that could facilitate the deployment of SMRs are also of high importance. With a variety of SMR designs being developed worldwide it is likely that final selections for their deployment will be made on a market basis. Therefore, the analysis of market conditions for specific countries and regions complete with the analysis of specific demands and comparative assessment of various nuclear power options becomes not less important than addressing the issues of technology development itself. The outputs of such analyses would bring the efforts of SMR designers to a closer link with the existing and projected market realms, contribute to the adjustment and streamlining of many of them and will also facilitate broader international cooperation. All this would contribute to a more focused approach in RD&D and, therefore, would improve deployment opportunities for SMRs.

One notable trend of SMRs is represented by Small Reactors without On-Site Refuelling¹. Such reactors may be factory produced and fuelled and brought back to the factory for refuelling after their fuel lifetime expires. Traditionally, they are

¹Small Reactors without On-Site Refuelling are defined herein as reactors which have a capability to operate without refuelling and reshuffling of fuel for a reasonably long period consistent with the plant economics and energy security, with no fresh and spent fuel being stored at the site outside the reactor during its service life. They also should ensure difficult unauthorized access to fuel during the whole period of its presence at the site and during transportation, and design provisions to facilitate the implementation of safeguards. In this context, the term “refuelling” is defined as the “removal and/or replacement of either fresh or spent, single or multiple, bare or inadequately confined nuclear fuel cluster(s) or fuel element(s) contained in the core of a nuclear reactor”. This definition does not include replacement of well-contained fuel cassette(s) in a manner that prohibits clandestine diversion of nuclear fuel material.

associated with the need to provide competitive autonomous energy sources for remote or scattered areas in some countries, or with an option to deploy transportable NPPs, e.g. barge-mounted, or with an option of NPP leasing to countries with limited nuclear infrastructure. However, some recent proposals focus on an option to use small reactors without on-site refuelling within modular configuration of high-capacity plants, which may increase competitiveness of the latter through reduced construction and operation and maintenance costs. As there is an option to draw upon industrial experience of mass production², small reactors without on-site fuelling may have a high potential to benefit from design standardization and serial production.

Small reactors without on-site refuelling appear to present a range of specific problems, such as provision of long-life core operation without refuelling, an option of sound implementation of many passive safety features, special requirements to safety and proliferation resistance, problems associated with making the plants demountable and transportable, and, last but not least, issues of economic competitiveness, which altogether justify the need to single them out as a special class of SMRs. Multiple R&D for small reactors without on-site refuelling that are being performed worldwide, and the single fact that lead-bismuth cooled small reactor with long-life core was, among others, selected for further development by the Generation-IV International Forum are indicative of the importance of this trend.

Finding solutions to some non-technical issues, such as establishing legal and institutional provisions to facilitate internationally accepted design certification, leasing of fuel or nuclear islands, or even complete NPPs, as well as the establishment of Multilateral Fuel Cycles (perhaps on a regional basis) may be of benefit to the deployment of many advanced SMRs, independent of their particular type. Specifically, an option for fuel or NPP leasing coupled with an option of Multilateral Fuel Cycles may be of essential benefit for the deployment of Small Reactors without On-Site Refuelling in many developing countries that are embarking on a nuclear programme without having a sufficient nuclear infrastructure. Moreover, Small Reactors without On-Site Refuelling may offer a very attractive solution for cost-effective implementation of safeguards in scenario of large-scale global deployment of nuclear energy, as will be essential for providing long-term energy security to many developing and industrialized countries in an environmentally benign way.

To their disadvantage, many of the on-going efforts for development of small reactors without on-site refuelling appear to be rather isolated and scattered around the world, and more often than not miss a systematic approach to the analysis of their deployment potential and opportunities.

The Agency may increase the capabilities in IAEA Member States to develop and deploy Small Reactors without On-Site Refuelling by facilitating Co-ordinated Research to define and elaborate the prospective enabling technologies relevant for Small Reactors without On-site Refuelling and information exchange to define the guidelines of legal and institutional framework, which would govern the deployment of such reactors worldwide. Since several countries have on-going activities for such reactors, a coordinated research programme is proposed among interested research institutions in order to share the relevant information, optimise the resources, and integrate related R&D efforts.

² While the experience in production of small reactors for nuclear submarines is usually mentioned first in this connection, other experiences of mass production, such as those for commercial aircrafts, ships, or even cars may be not less relevant

3. Overall Objective and Scope

The **overall objective** is to increase the capabilities in IAEA Member States to achieve progress in the development and deployment of Small Reactors without On-Site Refuelling by formulating major requirements for Small Reactors without On-Site Refuelling and increasing international cooperation for the development of key enabling technologies for such reactors.

The **scope** of the project involves the definition and development of the prospective enabling technologies, such as technologies to ensure lifetime core operation without refuelling, and identification and comparative analysis of inherent safety features and passive safety design options.

Generally, there will be no limitations regarding particular types of small reactors without on-site refuelling or anticipated terms of their deployment. However, special focus will be made on the enabling technologies which will be defined as high priority ones.

4. Specific Research Objectives

The proposed Coordinated Research Programme is the first one to follow a systematic approach in addressing technology development issues that could facilitate the development and deployment of small reactors without on-site refuelling, i.e., will provide initial definition and elaboration for the set of technology development issues that was defined as a priority one at the IAEA Consultancy Meetings 622-I3-03CT12471 and 622-I3-04CT01981 convened with broad participation of the designers of such reactors from around the world on 1-3 December 2003 and on 15-17 March 2004 respectively, and the IAEA Technical Meeting 622-I3-TM-26459 “Innovative Small and Medium Sized Reactors: Design Features, Safety Approaches and R & D Trends” convened on 7-11 June 2004. Therefore, depending on and drawing upon the results of this particular CRP some of its specific objectives may later on become the overall objectives for new Coordinated Research Projects.

The Specific Research Objectives are as follows:

1. To identify the requirements and broader specifications for NPPs with Small Reactors without On-Site Refuelling for selected representative regions, and to outline pathways for commercialisation of plants with: (i) small transportable reactors for offshore platforms or barge-mounted installations for use in countries with shortage of terrestrial sites, including countries with a cluster of small islands for possible near-term deployment; (ii) small transportable reactors that could facilitate cost-effective implementation of safeguards in scenario of large-scale global deployment of nuclear energy;
2. To review the approaches to ensure long-life core operation without refuelling and to perform a comprehensive coordinated study of long-life cores for small reactors of various types with a focus on the issues posed by extended fuel burn-up;

3. To review and validate inherent safety and passive safety design features for Small Reactors without On-Site Refuelling, in particular, to review and perform comparative analysis of accident performance of such reactors, if necessary, including the analysis of corium confinement capability inside RPV, to support the absence of any need for emergency evacuation in the neighbourhood; to review, analyse and compare the predicted operation of passive reactivity regulating systems and of several passive decay heat removal systems, including those being efficient during the entire run of a design basis accident.

5. Cooperation with other Departments of the Agency

As concepts and projects of Small Reactors without On-Site Refuelling in many cases rely on design and safety approaches that are radically different from those implemented in currently operating reactors, cooperation with the Division of Nuclear Installations Safety is viewed as important for all activities specified in the Coordinated Research Programme. Such cooperation is to guide the designers of Small Reactors without On-Site Refuelling on a consistent strategy of passive safety design options, in particular, through bringing to the attention of designers the on-going IAEA activities for the development of Safety Requirements and Guides for nuclear power plants (NPPs) with advanced reactors, and to provide a feedback on design and safety approaches pursued for Small Reactors without On-Site Refuelling that may eventually facilitate the preparation of further revisions of IAEA Safety Fundamentals, Safety Recommendations, and Safety Guides for advanced NPPs.

6. Expected Research Outputs

The expected output from the Agency is a TECDOC [or TECDOCs as required] including the following:

- Results of the analysis of requirements and broader specifications for NPPs with Small Reactors without On-Site Refuelling for selected representative regions complete with an outline of the options for commercialisation of plants with such reactors;
- Summary of the state-of-the-art in the approaches to ensure lifetime core operation without refuelling, and the results of benchmark analysis for long-life cores of several small reactors performed with different codes and data sets, including identification of further R&D needs and options for validation and demonstration;
- Summary of the state-of-the-art in inherent safety and passive safety design options for Small Reactors without On-Site Refuelling, including the results of comparative analysis of selected accident scenarios and of the operation of several passive reactivity regulating systems and passive decay heat removal systems for small reactors of different types, complete with identification of further R&D needs and options for demonstration.
- Propositions and plans for further research in the areas defined by the Specific Research Objectives, when justified.

Additional outputs are anticipated to include papers in technical journals authored by personnel of the participating institutes.

7. Action Plan (Including Activities)

Potential participating institutes:

At the IAEA Consultancy Meetings 622-I3-03CT12471 (December 2003) and 622-I3-04CT01981 (March 2004) convened with broad participation of the designers of small reactors without on-site refuelling from around the world, the following expressions of interest regarding participation in the CRP were provided by representatives of organizations in Member States which are involved in R&D on Small Reactors without On-Site Refuelling.

U.S.A.: Argonne National Laboratory (ANL) has participated in the planning of the CRP, and plans to participate in the CRP. In particular, the representative of ANL noted that some concepts are being considered both in IAEA activities for Small and Medium Sized Reactors and in the Technology Roadmap of Generation-IV, therefore, opportunities may arise in the future for collaborative activities between IAEA and Generation-IV International Forum (GIF), and both GIF and the Agency could benefit from better coordination of activities for small reactors suitable for deployment in developing countries. Los Alamos National Laboratory (LANL) and Pacific Northwest National Laboratory (PNNL) are interested in participating in the CRP.

Japan: Research Laboratory for Nuclear Reactors of the Tokyo Institute of Technology (RLNR TITech) and Central Research Institute of Electric Power Industry (CRIEPI) have participated in the planning of the CRP, and plan to participate in the CRP.

Russian Federation: Experimental Design Bureau for Machine Building (OKBM), Institute of Physics and Power Engineering (IPPE), Russian Research Centre “Kurchatov Institute” (RRC KI) have participated in the planning of the CRP, and plan to participate in the CRP. All-Russian Research Institute of Atomic Machine Building (VNIIAM), Experimental Design Bureau “Gidropress”, Research and Development Institute of Power Engineering (RDIPE), Institute of Theoretical and Experimental Physics (ITEP), All-Russian Research Institute for Inorganic Materials (Bochvar Institute) and Central Research Institute of Management, Economics and Information (TSNIIATOMINFORM) are interested in participating in the CRP.

India: Bhabha Atomic Research Centre has participated in the planning of the CRP, and plans to participate in the CRP. Indira Gandhi Centre for Atomic Research is interested in participating in the CRP.

Indonesia: the Bandung Institute of Technology (ITB) has participated in the planning of the CRP and plans to participate in the CRP; P2SRM Kompleks Puspitek of the National Atomic Energy Agency of Indonesia (BATAN Serpong), Pusat Penelitian

Teknik Nuklir (PPTN Bandung), Gajah Mada University, and Badan Penelitian dan Pengkajian Teknologi (BPPT) are interested in participating in the CRP.

Brazil: the Federal University of Rio Grande Do Sul has participated in the planning of the CRP, and plans to participate in the CRP. Instituto de Pesquisas Energeticas e Nucleares (IPEN) of the National Commission on Nuclear Energy and Cidade Universitarias of Rio de Janeiro and Pampulha are interested in participating in the CRP.

U.K.: the Imperial College of University of London is interested in participating in the CRP.

Italy: the University of Pisa is interested in participating in the CRP.

Vietnam: Institute for Nuclear Science and Technology is interested in participating in the CRP

Justification for potentially exceeding 15 participating institutes, with, in some cases, more than one participating institute per Member State

Considering the above expression of interest, it can be seen that potentially approximately 28 institutes and organizations from 9 Member States may join a CRP. This is a reflection of the fact that small reactors without on-site refuelling of different types (water cooled, sodium cooled, lead-bismuth cooled) are of potential interest to many Member States, and that multiple though scattered activities for them are on-going worldwide.

In turn, the multiplicity of activities is defined by a variety of reactor types and design approaches pursued by various institutes and organizations worldwide, which will remain quite reasonable for a quite long period, since final selections for the deployment of such reactors are to be made on a market basis, which assumes and definitely needs competition.

Another reason for the multiplicity of activities is a rather early stage of development of such reactors, under which a decentralized approach is prevailing with many relatively independent research teams undertaking their own efforts and pursuing their own approaches to the design of small reactors without on-site refuelling even of one and the same type. As one of the goals of this CRP, which is the first one for small reactors without on-site refuelling, is to co-ordinate and focus the scattered efforts of their designers in Member States, it would be unwise to pass by any noticeable relevant activities or even expressions of interest in Member States.

In the U.S.A, both Argonne National Laboratory and Los Alamos National Laboratory have some activities for lead-bismuth small reactors, while Pacific Northwest National Laboratory carries out some R&D for small water-cooled reactors

with pebble-bedded fuel.

In Japan, the CRIEPI develops conceptual designs of several small reactors with different types of coolant, while Research Laboratory for Nuclear Reactors of TITech focuses on the innovative nuclear energy systems with such reactors, and also develops concepts of small lead-bismuth cooled reactors for such systems.

Russian Federation broadly uses its experience in the design and operation of submarine reactors for the development of small reactors designated for civil nuclear power. In particular the OKBM is developing several projects for water cooled and sodium cooled small reactors without on-site refuelling, including the ones for use within floating, i.e., barge-mounted NPPs, while the IPPE and “Gidropress” develops the design of a small lead-bismuth cooled reactor. RRC “Kurchatov Institute” cooperates with VNIAM to perform R&D for small water-cooled reactors with pebble-bedded fuel. On its own, RRC “Kurchatov Institute” develops a concept of small molten salt reactor with pebble bedded fuel. TSNIATOMINFORM maintains an expertise and broad data base on the status and market demands for nuclear power in Russian Federation and worldwide. Bochvar Institute develops several innovative fuel technologies that are of potential interest to many designs of small reactors without on on-site refuelling. Finally, ITEP has competent research teams with the experience on R&D for several innovative reactor technologies applicable to Small Reactors without On-Site Refuelling.

In India, IGCAR is involved in the development of small reactors with fast neutron spectrum, while BARC is involved in the development of small reactors with thermal neutron spectrum

In Indonesia, the activities for small reactors without on-site refuelling are carried out on the academic level, with the research teams being scattered between different universities and research centres.

In Brazil, the activity of the Federal University of Rio Grande Do Sul for Fixed Bed Nuclear Reactor is shared with the INPEN of the National Commission on Nuclear Energy, and with Cidade Universitarias of Rio de Janeiro and Pampulha.

Participation of the research teams from the U.K. and Italy may contribute to the comparative analysis of accidents, while the Institute for Nuclear Science and Technology in Vietnam may contribute through identification of regional requirements and specifications for small reactors.

In the event that more than one Proposal for a Contract or Agreement are received from Institutes in Member States they will be examined to assure that they do not duplicate work and will contribute useful information in different areas.

Schedule:

The CRP is anticipated to have a 4-year duration, with a possible extension.

RCMs are foreseen as follows:

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| 1 st RCM: | 12/2004 |
| 2 nd RCM: | 12/2005 ³ |
| 3 rd RCM: | 6/2007 |
| 4 th RCM: (if necessary) | early-mid 2008 |

Activities

The activities planned are:

Activity 1 – Identification and prioritisation of the enabling technologies, concepts and designs of Small Reactors without On-Site Refuelling to be addressed in the CRP

Activity 2 – Definition of the scope of requirements and broader specifications to be identified for Small Reactors without On-Site Refuelling

Activity 3 – Identification of requirements and broader specifications for NPPs with Small Reactors without On-Site Refuelling for selected representative regions

Activity 4 – Review of the approaches to ensure lifetime core operation without refuelling and definition of the scope of benchmark analysis for long-life cores of Small Reactors without On-Site Refuelling

Activity 5 – Performance of benchmark analysis for long-life cores of several concepts of Small Reactors without On-Site Refuelling; identification of further R&D needs and options for demonstration

Activity 6 – Review of the inherent safety and passive safety design options for Small Reactors without On-Site Refuelling and identification of accident scenarios, passive reactivity regulating systems, and passive decay heat removal systems for comparative analysis

Activity 7 – Performance of the comparative analysis of selected accident scenarios, passive reactivity regulating systems, and several passive decay heat removal systems for Small Reactors without On-Site Refuelling

Activity 8 - Elaboration of propositions and plans for further research in the areas defined by the Specific Research Objectives of the present CRP

Activity 9 - Publishing of a TECDOC [or TECDOCs] on the results of the CRP

³ - the need to convene the 2nd RCM in less than 18 months after the 1st RCM is justified by complex character of the tasks and expected intense interactions of the participants of the CRP

Logical Framework for the IAEA Coordinated Research Project on “Definition and Elaboration of Enabling Technologies and Non-Technical Issues to facilitate the Deployment of Small Reactors without On-Site Refuelling”

| Narrative Summary | Objective Verifiable Indicators | Means of Verification | Important Assumptions |
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| <p>Overall Objective: to increase the capabilities in IAEA Member States to achieve progress in the development and deployment of Small Reactors without On-Site Refuelling by formulating major requirements for Small Reactors without On-Site Refuelling and increasing international cooperation for the development of key enabling technologies for such reactors</p> | <p>N/A</p> | <p>N/A</p> | <p>N/A</p> |
| <p>Specific Research Objectives:</p> <p>1. To identify the requirements and broader specifications for NPPs with Small Reactors without On-Site Refuelling for selected representative regions, and to outline pathways for commercialisation of plants with: (i) small transportable reactors for offshore platforms or barge-mounted installations for use in countries with shortage of terrestrial sites, including countries with a cluster of small</p> | <p>TECDOC[s] resulting from CRP is acknowledged by experts as presenting state of the art in the definition and elaboration of the enabling technologies and non-technical issues to facilitate the deployment of Small Reactors without On-Site Refuelling</p> | <p>Technical papers and reports of the nuclear power reactor industry, research institutes and universities referencing the TECDOC[s] and using the information therein</p> | <p>National support is provided to participating institutes, at least at the level characteristic of the moment of CRP initiation (2004)</p> <p>Intense coordination occurs among contract / agreement holders and with IAEA</p> |

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| <p>islands for possible near-term deployment; (ii) small transportable reactors that could facilitate cost-effective implementation of safeguards in scenario of large-scale global deployment of nuclear energy;</p> <p>2. To review the approaches to ensure long-life core operation without refuelling and to perform a comprehensive coordinated study of long-life cores for small reactors of various types with a focus on the issues posed by extended fuel burn-up;</p> <p>3. To review and validate inherent safety and passive safety design features for Small Reactors without On-Site Refuelling, in particular, to review and perform comparative analysis of accident performance of such reactors, if necessary, including the analysis of corium confinement capability inside RPV, to support the absence of any need for emergency evacuation in the neighbourhood; to review, analyse and compare the predicted operation of passive</p> | <p>Percentage of positive replies from questionnaires on project publications (TECDOC[s]).</p> <p>Number of hits (downloads/visits) to Web-located project publications (TECDOC[s]).</p> | <p>Data collected and processed by NPTDS</p> <p>Data from: <http://pub-dev.iaea.org/MTCD/publications/PubStatistics.asp></p> | <p>Appropriate technical support is provided to CRP by Project Officer</p> |
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| <p>reactivity regulating systems and of several passive decay heat removal systems, including those being efficient during the entire run of a design basis accident.</p> | | | |
| <p>Expected Research Outputs:</p> <p>The expected output from the Agency is a TECDOC [or TECDOCs as required] including the following topics:</p> <ul style="list-style-type: none"> • Results of the analysis of requirements and broader specifications for NPPs with Small Reactors without On-Site Refuelling for selected representative regions complete with an outline of the options for commercialisation of plants with such reactors; • Summary of the state-of-the-art in the approaches to ensure lifetime core operation without refuelling, and the results of benchmark analysis for long-life cores of several small reactors performed with | <p>TECDOC[s] presenting the expected output in each of the 10 topics</p> | <p>TECDOC[s] approved by the Publications Committee</p> | <p>Sufficient technical skills applied by participating institutes and sufficient involvement of the Project Officer in working with the chief scientific investigators to assimilate results of activities for clear presentation in TECDOC[s]</p> |

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| <p>different codes and data sets, including identification of further R&D needs and options for validation and demonstration;</p> <ul style="list-style-type: none">• Summary of the state-of-the-art in inherent safety and passive safety design options for Small Reactors without On-Site Refuelling, including the results of comparative analysis of selected accident scenarios and of the operation of several passive reactivity regulating systems and passive decay heat removal systems for small reactors of different types, complete with identification of further R&D needs and options for demonstration.• Propositions and plans for further research in the areas defined by the Specific Research Objectives, when justified. | | | |
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| <p>Additional outputs are anticipated to include papers in international conferences and technical journals authored by personnel of the participating institutes</p> | | | <p>Sufficient resources applied at participating institutes to prepare and present papers at international conferences and in technical journals</p> |
| <p>Activities:</p> <p>Activity 1 – Identification and prioritisation of the enabling technologies, concepts and designs of Small Reactors without On-Site Refuelling to be addressed in the CRP</p> <p>Activity 2 – Definition of the scope of requirements and broader specifications to be identified for Small Reactors without On-Site Refuelling</p> <p>Activity 4 – Review of the approaches to ensure lifetime core operation without refuelling and definition of the scope of benchmark analysis for long-life cores of Small Reactors without On-Site Refuelling</p> <p>Convene 1st RCM to review progress on Activities 1, 2, 4 and to plan collaboration in Activities 3, 5, 6</p> | <p>Will be verified when Research Agreements and Research Contracts are awarded</p> <p>Will be verified when RCM is convened</p> | <p>Approval of Agreements and Contracts by the Nuclear Energy and Safety Research Contract Subcommittee of the PCC</p> <p>Progress Reports from CRP participants</p> <p>Participants presentations at the RCM</p> <p>RCM Working Material Meeting Report</p> | <p>Suitable proposals submitted including provision of detailed work plans and appropriate information on the previous research of relevance</p> |

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| <p>Activity 3 – Identification of requirements and broader specifications for NPPs with Small Reactors without On-Site Refuelling for selected representative regions</p> <p>Activity 5 – Performance of benchmark analysis for long-life cores of several concepts of Small Reactors without On-Site Refuelling; identification of further R&D needs and options for demonstration</p> <p>Activity 6 – Review of the inherent safety and passive safety design options for Small Reactors without On-Site Refuelling and identification of accident scenarios, passive reactivity regulating systems, and passive decay heat removal systems for comparative analysis</p> <p>Convene 2nd RCM to review progress on Activities 3, 5, 6, to plan collaboration or further collaboration in Activities 5, 7, and to plan preparation of TECDOC</p> | <p>Will be verified when RCM is convened</p> | <p>Participants presentations at the RCM</p> <p>RCM Working Material Meeting Report</p> | <p>Support of participating institutes by national or bilateral programmes is consistent with plans described by representatives of Member States at the Consultancy Meetings 622-I3-03CT12471 and 622-I3-</p> |
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| <p>Activity 5 – Performance of benchmark analysis for long-life cores of several concepts of Small Reactors without On-Site Refuelling; identification of further R&D needs and options for demonstration</p> <p>Activity 7 – Performance of the comparative analysis of selected accident scenarios, passive reactivity regulating systems, and several passive decay heat removal systems for Small Reactors without On-Site Refuelling</p> <p>Convene 3rd RCM to review progress on Activities 5, 7, to review draft TECDOC and plan completion of TECDOC, and to conduct Activity 8</p> <p>Activity 5 – Performance of benchmark analysis for long-life cores of several concepts of Small Reactors without On-Site Refuelling; identification of further R&D needs and options for demonstration</p> <p>Activity 7 – Performance of the comparative analysis of selected accident scenarios, passive reactivity regulating systems and several</p> | <p>Will be verified when RCM is convened</p> | <p>Participants presentations at the RCM RCM Working Material Meeting Report Draft TECDOC</p> | <p>04CT01981 in December 2003 and in March 2004</p> |
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| <p>regulating systems, and several passive decay heat removal systems for Small Reactors without On-Site Refuelling</p> <p>Activity 8 - Elaboration of propositions and plans for further research in the areas defined by the Specific Research Objectives of the present CRP</p> <p>Activity 9: Publish a TECDOC [or TECDOCs] on the results of the CRP</p> | <p>Will be verified when TECDOC is [TECDOCs are] approved for publication by the Publications Committee</p> | <p>Approval of TECDOC[s] manuscript by the Publications Committee</p> | |
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Brief Summary for the IAEA Bulletin:

This CRP has the goal of increasing the capabilities in IAEA Member States to achieve progress in the development and deployment of Small Reactors without On-Site Refuelling by formulating major requirements for Small Reactors without On-Site Refuelling and increasing international cooperation for the development of key enabling technologies for such reactors, including long-life cores and passive safety features and systems. Small Reactors without On-Site Refuelling are the reactors which have a capability to operate without refuelling and reshuffling of fuel for a reasonably long period consistent with the plant economics and energy security, with no fresh and spent fuel being stored at the site outside the reactor during its service life. Such may offer a very attractive solution for cost-effective implementation of safeguards in scenario of large-scale global deployment of nuclear energy, as will be essential for providing long-term energy security to many developing and industrialized countries in an environmentally benign way. This CRP is the first one to address technology development issues relevant for small reactors without on-site refuelling, and is being conducted within the frame of activities of the IAEA's Department of Nuclear Energy's for Small and Medium Sized Reactors in cooperation with the IAEA's Division of Nuclear Installations Safety.

References:

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