IAEA
International Atomic Energy Agency
Atoms for Peace and Development

Technical Meeting on the Status, Design Features, Technology Challenges and Deployment Models of Microreactors

Virtual Event

26–29 April 2021

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Information Sheet

Introduction

Advanced small modular reactors (SMRs) are being developed in many Member States. The current technology development trend includes microreactors. These reactors, which typically generate up to 10MW(e), are designed for high operational performance and reliability, enhanced transportability to site by modularity, adopt optimum safety margins, while also being economically competitive, e.g. affordable. For deployment to become a reality, these very small power plants must be resilient in niche energy portfolio, also have proper security and intrinsic proliferation resistant characteristics. These reactors are primarily targeted to supply power at remote sites with mining operations, island communities, to power oil platforms and to be applied in maritime shipping. These deployment opportunities exist in remote areas in North America, South-East Asian archipelagos, Africa and the Middle East.

Compared to SMRs, which aim to address energy demand by adding incremental capacity with moderate financial commitment for utilities, microreactors are targeted more at niche markets and will typically compete in a market currently served by diesel generators. Consequently, some experts see microreactors as the entry pathway for SMRs, especially since the business case for microreactors may initially be more favourable and because no other off-grid solutions currently exist. Several designs are also included in the 2020 edition of IAEA Booklet on *Advances in Small Modular Reactor Technology Developments*.

Microreactors have several unique characteristics. To a greater degree than other SMRs, microreactors can be more easily fabricated in a factory setting, can be more easily transported to sites and connected to the end user of electricity and heat, have smaller footprints and may be self-regulating based on inherent and passive safety systems, thus being able to achieve a high level of control and safety with minimal operator actions. They are also not limited to a specific type of moderator, coolant, or neutron energy range and exhibit widely different characteristics.

Objectives

The main objective of the event is to conduct a detailed technical discussion on the current status of microreactor design and technology developments in Member States. Several deployment models will be discussed, including the elaboration of technical requirements and associated technology solutions. Contributions in the form of papers, presentations and session discussion summaries will result in the preparation of an IAEA Technical Report Series (TRS). This TRS is intended to represent an objective summary of reference information for interested organizations, nuclear energy professionals and decision makers from countries involved in microreactor technology development or deployment.

Target Audience

The event is open to representatives from organizations in Member States, including government organizations (i.e. national nuclear energy agencies, policymakers on energy technology, nuclear power regulators and research and development (R&D) agencies), and industry (microreactor vendors, engineering companies, plant operators, technology developers and end users).

Working Language(s)

English.

Topics

This event will feature presentations on microreactor designs, the status of the technology, innovative deployment approaches, new materials, advanced manufacturing and construction techniques, challenges for near-term deployment, approaches to site preparation, operation, maintenance, nuclear safety, safeguards and security, and the non-electric applications, etc. Presentations on microreactor-specific deployment models will be welcomed, especially those covering aspects of technology, remote operations, innovative power conversion systems, and ownership and operator models.

Participation and Registration

All persons wishing to participate in the event have to be designated by an IAEA Member State or should be members of organizations that have been invited to attend.

In order to be designated by an IAEA Member State, participants are requested to send the **Participation Form (Form A)** to their competent national authority (e.g. Ministry of Foreign Affairs, Permanent Mission to the IAEA or National Atomic Energy Authority) for onward transmission to the IAEA by **5 March 2021**. Participants who are members of an organization invited to attend are requested to send the Participation Form (Form A) through their organization to the IAEA by the above deadline.

Selected participants will be informed in due course on the procedures to be followed with regard to administrative matters.

Please note that the IAEA is in a transition phase to manage the entire registration process for all regular programme events electronically through the new InTouch+ (https://intouchplus.iaea.org) facility, which is the improved and expanded successor to the InTouch platform that has been used in recent years for the IAEA's technical cooperation events. Through InTouch+, prospective participants will be able to apply for events and submit all required documents online. National authorities will be able to use InTouch+ to review and approve these applications. Interested parties that would like to use this new facility should write to: InTouchPlus.Contact-Point@iaea.org.

Papers and Presentations

The IAEA encourages participants to prepare full papers and give presentations that will contribute directly to fulfilling the objectives of the event and that cover the following related topics on microreactors technology development and deployment scenario:

- Microreactor designs and status of the technology;
- Innovative deployment approaches;
- Innovative nuclear materials;
- Advanced manufacturing, modular assembling and construction techniques;
- Challenges for near-term deployment;
- Innovative approaches to site preparation, operation, maintenance, nuclear safety, safeguards and security;
- Specific deployment indicators (including specialized and benchmark indicators) and models (including ownership models, takeback policies, replacement units etc.);
- Non-electric applications and nuclear cogeneration, including hydrogen production;
- Other considerations, e.g. legal, financing emergency planning and rationales of deployment; and
- R&D needs to facilitate licensing of the designs.

Technical papers should be written following the instructions provided in Appendix A and must be submitted electronically in the form of a Microsoft Word document to the Scientific Secretaries of the event, together with **Form for Submission of a Paper (Form B)** by **5 March 2021.**

Authors will be notified of the acceptance of their proposed presentations by **22 March 2021.** Those authors whose papers are accepted will then be requested to prepare and submit their presentations in Microsoft PowerPoint or PDF format by email to the Scientific Secretaries of the event by **19 April 2021**.

IAEA Contacts

Scientific Secretary:	Co-Scientific Secretary:	Administrative Secretary:
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Subsequent correspondence on scientific matters should be sent to the Scientific Secretaries and correspondence on other matters related to the event to the Administrative Secretary.

Appendix A

IAEA Required Format

Paper length: min 8 pages, max 16 pages

Paper format to strictly follow the below instructions

TITLE 14 point bold Times New Roman
Name of Authors and Affiliations, 12 point Times New Roman

Default language: Should be set to English (UK). However, please note that IAEA style is to use "…zation" rather than "…sation" and "…ize" rather than "…ise" in the corresponding verbs.

Headings and Subheadings: Do not use more than four levels of heading. The number should always end with a full stop.
Headings and subheadings are numbered to facilitate reference, and should be typed as follows:

1. INTRODUCTION	**12 POINT TIMES NEW ROMAN CAPITAL**
1.1. INTRODUCTION	12 POINT TIMES NEW ROMAN
1.1.1 Brief history	**12 point Times New Roman bold**
1.1.1.1 The early days	*12 point Times New Roman Italics*

Fonts for the text: Times New Roman. The font size can either be 11 or 12. It should be consistent throughout the manuscript.

Page Layout:

— **Paper size:** Standard, 21 cm × 29.7 cm (A4).
— **Page set-up:** Margins: top: 2 cm; bottom: 2.7 cm; left/right: 2.5 cm.
— **Alignment of text:** Should be set at 'justified'. The first line of a paragraph should not be indented.
— **Line spacing:** Line spacing should be set at 'single'. Leave a line of blank space between paragraphs.
— **Numbering of pages:** Alignment outside (under Page Setup/Layout/Headers and Footers, select 'different odd and even'), with numbers in Times New Roman 11 point.
— **Leave only one space after a full stop.**

Figures and Tables:

- Tables and Figures should be incorporated in the text and not be listed in the end of the manuscript as Annexes. They should be placed close to their first in-text citation.
- Tables and Figures should be numbered consecutively throughout all sections and appendices.
- The size of the table headings and the tables itself should be the same as the size used for the text and this throughout the manuscript. If you have big tables you may use one size smaller, but again the same size should apply throughout the document.
- For **figure** captions, if possible, use one size smaller.
- Do not wrap text around tables and figures.

Figure numbering and captions: Arabic numerals and italics should be used.
The caption should begin at the left-hand margin unless it is shorter than the type width (for portrait figures) or type length (for landscape figures) of the page, in which case it is centred on the page. A full stop should be added at the end of the figure caption. The figure precedes the figure caption.

Example:

FIG. 24. Determination of optimum contact time for uranium extraction [5].

FIG. 25. Tonnage of uranium recoverable from EAR-I at costs of up to US $80/kg U for the period from 1977 to 1990.

Table numbering and headings: Arabic numerals and capitals should be used (no full stop at the end of the table heading). The Table caption precedes the table.

Example:

TABLE 1. CALCULATED MINIMUM DETECTION LIMITS (MDL) 11°

Element	MDL (ppm)
Cu	5
Zn	6
Pb	12

References:

The title 'REFERENCES' is written in 12 point capitalized, Times New Roman bold without any numbering in front. There is no line space between references. References should start on an odd numbered page. References are cited in the text as numbers in square brackets, e.g. [10] corresponding to the order in which they are first mentioned. The order of the items in a reference is indicated below by the numbers in parentheses and illustrated by examples. Inclusion of the titles of articles from journals or conference proceedings is necessary.

A. Books and reports

(1) Name(s) of author(s) or editor(s): surname first, fully capitalized, followed by a comma; then the initial(s), followed by a comma (if the first (or given) name is required in full, only the first letter is capitalized); 'Jr.' or 'III' last, followed by a comma. Editors' names given instead of authors are followed by (Ed.) or (Eds). For a report, if no author is named then the corporate author (if any), i.e. the originating institution, should be given, spelled out in full, in capitals.

(2) Title of book or report, with initial capitals, followed by a comma, then followed by the edition number if necessary (e.g. '2nd edn'). If the work cited is the proceedings of a meeting, 'Proc. Conf.', 'Proc. Symp.', etc., followed by the name of the town, a comma and the year of the meeting, should be added in parentheses (see Ref. [2]).

(3) Volume number in Arabic numerals (even when the volume number in the work cited is in Roman numerals), written as, for example, 'Vol. 1', and not as for journals (see Section C below).

(4) Report number, if any and IAEA Series type, if relevant.

(5) (a) Name of publisher, without Ltd, Inc., & Co., etc. (but note Pergamon Press, Academic Press); or (b) Name of originating institution in full (see Ref. [3]) .

(6) (a) The place of publication must be included (maximum two places); or (b) For reports, the place of origin must be included if not already part of the name of the originating institution (compare Refs [4] and [3]).

(7) The year of publication, in parentheses.

(8) The number of pages may be given (see Ref. [1]).

(9) All references end with a full stop.

Examples:

[1] STEPHENSON, R., Introduction to Nuclear Engineering, 2nd edn, McGraw-Hill, New York (1958) 491 pp.

[2] Plasma Physics and Controlled Nuclear Fusion Research 1994 (Proc. 15th Int. Conf. Seville, 1994), 4 vols, IAEA, Vienna (1995).

[3] TEVEPAUGH, C.W., Impact of the Resource Conservation and Recovery Act on Energy Facility Siting, Rep. ORNL/TM-7768, Oak Ridge Natl Lab., TN (1982).

[4] DOUGLAS, R.L., HANDS, J.M., Jr., Gamma Radiation Surveys at Inactive Uranium Mill Sites, Technical Note ORP/LV-75-5, Office of Radiation Programs, Environmental Protection Agency, Las Vegas, NV (1975).

[5] INTERNATIONAL ATOMIC ENERGY AGENCY, Quality Assurance in Biomedical Neutron Activation Analysis, IAEA-TECDOC-323, IAEA, Vienna (1984).

B. Articles and chapters in books and reports

(1) Name(s) of author(s), as in A(1) above.

(2) Title of article or chapter in double quotation marks, with an initial capital only for the first word (see Ref. [5]) and, of course, for proper nouns (see Ref. [6]).

(3) Title of book or report, as in A(2) above. If the article or chapter title is not given, the book or report title should be preceded by 'in' (see Ref. [7]).

(4) Volume number, as in A(3) above (see Ref. [9]).

(5) Name(s) of editor(s) in capitals, followed by a comma and the abbreviation Ed. or Eds, all in parentheses, if the publication is a collection of papers by various authors (see Ref. [5]).

(6) As for A(4-7) above.

(7) First page number of article or chapter (and the last if known), or the section or chapter number, followed by a full stop.

Examples:

[5] HOWLAND, G.P., HART, R.W., "Radiation biology of cultured plant cells", Applied and Fundamental Aspects of Plant Cell, Tissue, and Organ Culture, 2nd edn (REINERT, J., BAJAJ, Y.R.S., Eds), Springer-Verlag, Berlin (in press).

[6] BURKE, S.D., HOWELL, J.P., "Impact of prolonged wet storage of DOE reactor irradiated nuclear materials at the Savannah River Site", Proc. Topical Mtg on DOE Spent Nuclear Fuel — Challenges and Initiatives, Salt Lake City, 1994, USDOE, Washington, DC (1994) 118–124.

[7] GLASSER, A.H., CHANCE, M.S., DEWAR, R.L., in Controlled Fusion and Plasma Physics (Proc. 9th Eur. Conf. Oxford, 1979), Vol. 1, Culham Lab., Abingdon (1979) Sect. A3.1.

[8] KAUFMAN, L., DEW HUGHES, D., in Proc. Conf. on Calculation of Phase Diagrams and Thermochemistry of Alloy Phases, Pittsburgh, PA, 1979.

[9] GRAMBOW, B., LUTZE, W., "Chemical stability of a phosphate glass under hydrothermal conditions", Scientific Basis for Nuclear Waste Management (Proc. Workshop, Boston, 1979), Vol. 2 (NORTHRUP, C.J.M., Jr., Ed.), Plenum Press, New York (1980) 109-116.

Notes: [i] No commas are needed between the place of publication, the year of publication in parentheses and the page number.

[ii] The year of the meeting and the year of publication should both be given, even when they are the same.

[iii] When the published title of the proceedings is unknown, as much information as possible should be given. If the year of publication is unknown, the year of the meeting should be given, but not in parentheses.

C. Articles in journals

(1) Name(s) of author(s), as in A(1) above.
(2) Title of article if known, not in quotation marks and with initial capitals only for the first word and for proper nouns.
(3) Title of journal, correctly abbreviated.
(4) Volume number in Arabic numerals, in bold type, not preceded by 'Vol.'
(5) Issue number (only required when each issue has page numbers starting from 1 see Refs [10, 11]).
(6) Year of publication in parentheses and bold.
(7) First page number of article (and the last if known).

Examples:

[10] PEACOCK, K.L., Design of discrete bandpass filters for petroleum exploration, Oil Gas J. **83** 42 (1985) 121.
[11] ROYLE, A.F., Why geostatistics? Eng. Min. J. **180** 5 (1979) 92.
[12] COCHRANE, M.P., DUFFS, C.M., Endosperm cell number in barley, Nature **289** (1981) 399.

D. Other types of reference

A patent (as much information as possible should be supplied):

[13] MACEDO, P.B., LITOVITZ, T.A., SIMMONS, J.H., Fixation of Radioactive Materials in a Glass Matrix, Australian Patent 78/34388/B/, Int. Cl. CO3C 3/30, G21F 9/34, Sep. 1982, filed Mar. 1978; copies available from Commissioner of Patents, Canberra.

A paper without proceedings:

[14] AHLF, J., BELLMANN, D., DITTMER, H., MARTENS, H., "An irradiation capsule for reactor pressure vessel steel with a large specimen volume", IAEA-SR-77/54, paper presented at IAEA Sem. on Research Reactor Operation and Use, Jülich, 1981.

An abstract:

[15] KECKWICK, R.A., Jr., "Labelled antibody technique in communicable disease", Proc. 2nd World Congr. on Nuclear Medicine, Washington, DC, 1978 (abstract).

An IAEA Information Booklet:

[16] INTERNATIONAL ATOMIC ENERGY AGENCY, Nuclear Power, the Environment and Man, Information Booklet, IAEA, Vienna (1984).

Part of the US Code of Federal Regulations:

[17] NUCLEAR REGULATORY COMMISSION, Licensing Requirements for Land Disposal of Radioactive Waste, 10 CFR 61, US Govt Printing Office, Washington, DC (1983).

An electronic publication:

[18] UNITED STATES DEPARTMENT OF ENERGY, Aerosol Fog System for Fixing Radioactive Contamination, Technology Deployment Fact Sheet (1999), http://www.hanford.gov/techmgmt/factsheets/deploys/fogger.htm