Nuclear Energy Series publications under preparation July 2019_V2

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54. Reference Plan for Self Sufficiency in the Supply of Selected Radioisotopes Produced in Research Reactors: Case Studies

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55. Specific Considerations in the Assessment of the Status of the National Nuclear Infrastructure for a New Research Reactor Programme – Reference document for the INIR-RR Missions
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64. International Nuclear Management Academy (INMA), Master's Nuclear Technology Management Programmes
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70. Research Reactor Spent Fuel Management: Options and Support to Decision Making

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Additional information for NES publications under preparation (as listed in Part I)

Title	Information
1. Disposal Options for Smaller Radioactive Waste Inventories	This report will present possible disposal strategies and options for smaller waste inventories. It aims at providing further insight on possible cost-effective long-term waste solutions to countries having such a waste inventory. The report will review the main strategic choices that countries with a relatively small waste inventory will need to make. Typical considerations that may be noted when Member States in such a situation try to come to a safe and economically feasible management solution for such inventories are: • waste repatriation (e.g. for some of the DSRS inventory, and possibly for RR-SF) • store safely until enough waste is accumulated for an economically feasible disposal project • reprocess spent fuel or not • dispose of waste in a national facility or follow a dual-track approach considering an international disposal facility In all cases, the endpoint will be disposal, and with the exception of agreed repatriation, the Member State will need to develop (national approach), or contribute to the development of(possible dual-track, international approach), an adequate disposal solution. Therefore, the report will present a portfolio of disposal options which could offer a safe and affordable disposal solution. The identified disposal options are: • underground caverns • silo-type facilities • shallow borehole (of the order of several ten metres) • deep borehole (of the order of several hundred metres) • deep shaft • converted mine • very deep borehole (of the order of several kilometres) Predisposal activities such as waste processing, and storage are outside the scope of this work. The issue of affordability mainly manifests itself for wastes that require underground disposal, and not so much for low-level wastes. The report therefore will address intermediate-level and high-level wastes and near surface disposal solutions are not included.

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2. Costs Assessment Methodologies for The Back End of the Fuel Cycle	The objective is to develop a guidance document on developing the back end of the fuel cycle (BEFC) cost elements. It is proposed to structure the document in a manner whereby it can be readily updated. The main body of the document will be generic high level guidance and the appendices will contain reference information which will evolve with time. Reference information to include tools for making decisions (matrix, map) including: risks and uncertainties valuation; approach/methodology for comparing options; and case studies and appropriate use of base data. Previous joint efforts between the NFCMS and PESS have resulted in a number of publications on costing spent fuel storage (TRS-361 and NF-T-3.5). These publications cover only storage costs, and focused more on costs themselves rather than on methodologies. In 2011 arising from a TM on costs in the BEFC a new study was initiated looking at costs in the BEFC. The study was not complete and a recent CS (September 2017) was held to review the status of this work and to make decision on the value in continuing such a study The main conclusions form the CS held in September 2017 was the value is continuing the 2011 study was questionable. The experts, however, identified a gap and proposed that a **guidance** document on how to develop cost elements in the back end of the fuel cycle (BEFC) for input to any assessment including but not limited to an environmental impact assessment was not readily available and would be of value to the member States.
3. Options for Managing Separated Plutonium	To identify and describe credible options for managing the stored products from civilian reprocessing activities (separated plutonium). Technical options for managing separated plutonium. Reference will be made to the existing Technical Report (IAEA-NF-T-4.4) for managing RepU. Technologies considered should be viable within the next 50 years. The report will be limited to options for separated plutonium from civilian reprocessing activities, but reference may be made to the options which have been used or considered for military grade plutonium.
4. Establishing and Managing a Radioactive Waste Management Organization with Responsibility for Repository Development	The objective of the document is to advise on practical aspects of a repository development project, in particular on how to prepare, plan, launch, perform and manage it. Technical activities shall be performed taking into account the possible mutual interactions between cross-linked tasks and relevant interfaces among project components. It is intended to describe managerial processes rather than to specify detailed technical solutions. In this frame, the document should cover both near-surface and geological disposal programmes, with their varying duration, technical focus and intensity of site characterization and assessment, but highlighting similar decision-making processes, methodologies, public interaction, information/data management and sequencing of main activities. The document will be introduced by the consideration of prerequisites before starting a repository development project, followed by the overview of component's specifications, their relationships, and indicative sequence of key

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	activities/stages. Based on experience from countries with advanced programmes, it will further include stepwise description of appropriate planning, managing, organizing, staffing and implementing repository development process that will be illustrated by country cases.
5. Managing Siting Activities for Nuclear Power Plants (NG-T-3.7 (Rev.1))	Milestones in the Development of a National Infrastructure for Nuclear Power, an IAEA Nuclear Energy Series publication (NG-G-3.1 (Rev.1)), provides detailed guidance on a holistic approach to national nuclear infrastructure development, over three phases. Nineteen issues are identified in this guide, ranging from development of a government's national position on nuclear power to planning for procurement related to the first nuclear power plant. An important element of the holistic approach is the selection of appropriate site(s) for the construction and operation of NPPs using a comprehensive management system to support the planning and implementation of the siting activities, and to ensure that the required quality of the activities is achieved. Done well, it will ensure the right choice of site(s) taking into account safety, environmental, technical, economic and social factors and will allow the project to be completed in each phase within its programme. If not properly planned and executed, it is likely to result in major delays to a programme or even failure to complete the intended project. As a growing number of Member States started to consider the nuclear power option, they asked for guidance from the IAEA on how to launch a nuclear power programme. The current publication was developed to provide information on the development of the siting and supporting facilities for NPPs including managing and coordinating the selection and evaluation activities of possible sites for a nuclear power plant among all stakeholders, including regulators. The current guide will be revised to provide additional and updated information on the development of the siting and supporting facilities for NPPs, taking into considerations lessons learned from the INIR missions. The text and basic structure of original version will be revised.
6. Decontamination Approaches during Outage in Nuclear Power Plants: Experiences and Lessons Learned	The purpose of this report is to provide best practices and recommendations for decontamination techniques used during outages in order to improve effectiveness of outage implementations, reduce the cost and the dissemination of the contamination in and outside the plant, to mitigate the radiation exposure of the workers and of the public and to minimize secondary waste. As such, the report will address latest good practices, lessons learned, operating experiences, methods, procedures and tools associated with fundamental of decontamination, in particular during outages. This new document containing decontamination techniques will complement the IAEA handbook on decontamination fundamentals in preparation called "Decontamination methodology and approaches". All technical detail regarding decontamination techniques were excluded from this handbook. The scope of this technical document focused on the outage is to:

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	• Collect the latest information on the knowledge focusing on decontamination of systems, structures and employees during outages in NPPs, • Compile the best practices in decontamination during outages • Provide the benefits expected This publication will not describe the decontamination steps required after the final shutdown of the plant for decommissioning which are quite different. It will also not provide guidance on more general aspects such as factors relevant to selection of a decontamination approach and the decision-making process, which will be treated in details in the IAEA handbook "Decontamination methodology and approaches" to come.

7. Design Basis Reconstitution for Long Term Operation of Nuclear Power Plants	The purpose of this Nuclear Energy Series (NES) is to collect and discuss essential elements of a design basis reconstitution project to support Member States with operating NPPs as well as the embarking countries as a future reference.
	The final deliverable will be a new technical document that will describe current challenges, operating experience, good practices and lessons learned associated with design basis reconstitution for long term operation. The document is intended to be used by the Member States in assessing, updating, and implementing their own design basis reconstitution practices in an effective, efficient, adequate and timely manner.
	The scope of this technical document is to:
	• Collect the latest information on the knowledge focusing on following topics;
	  • Best practices and pitfalls for configuration management from existing nuclear power plants to keep documentation accurate and up to date
	• Introduce how to avoid degeneration between design requirements, physical configuration and facility configuration information;
	  • Introduce different design reconstitution programmes for nuclear power plants
	  • How to reconstitute design and facility configuration information
	• Propose for embarking countries key learnings in establish comprehensive and reliable management system to acquire and keep design information up to date; and
	• Lessons learned from operating countries;
	• Provide practical recommendations for effectiveness and efficiency of design basis reconstitution and how to organize and document the design information.

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8. Design Modification Process in Nuclear Power Plant Lifetime	The objective of this publication is proposed to be providing a guidance on effective and efficient design modification process for nuclear power project and plants in all life stages, and presenting fundamentals, common practices, challenges, issues/solutions and operational experience. Scope of this publication is a comprehensive evaluation and discussion of key topics raised by MSs where a guidance for owner/operator organizations on the design, design modification and design control processes not only for the operation stage but also for design and construction stages needed, with the consideration of: • The methods and tools for design changes during design and construction, as well as during operations of NPPs; • The understanding and streamlining of a standard and simplified design modification process among responsible designers (RDs) and design authorities (DAs). • The implementation and effectiveness of efforts (including specific reasons and methods) on design process, modification of design and provision of scientific and technical support. Specifically, the topics on the concept of a design and its control [Symbol] not only during the operation but also during design, construction and commissioning stages [Symbol] with adequate engineering competency and responsibility will be discussed, as they are essential in order to: • Identify any design and specification modification issues during the design stage rather than later during operation, since addressing these retrospectively would entail a cost and time burden; • Make design changes with full knowledge of the design basis, design intent, design philosophy and of all the details of implementation history of the design by validation; • Interface with the regulatory body of the design changes in a controlled and informed manner; • Transfer the detailed knowledge used in the design to/from the operating entities' technical support organizations and RDs; • Understand and update the track and records of design information to the conception of the design.
9. Fire Protection Guidelines in Nuclear Power Plants	This report is intended to reflect the recent status of the worldwide nuclear power industry and to provide further detail guidelines and assistance in enhancing the fire safety of operating nuclear power plants, as well as supplements existing IAEA publications on fire safety. The Utilities and the Regulatory bodies will benefit from the detail guidance and the good practices included in this report on the basis of the current practical experience. This NES report will be created using international experiences from the worldwide nuclear power industry, and inputs from experts concerned with fire hazard analysis (FHA), fire engineering, the systematic assessment of fire safety, regulatory aspects, and plant fire protection. The report will reflect the following focal points; • Fire protection program including organization, procedures and quality assurance programme, • Regulations, codes and standards related to fire protection (summary of IAEA and country standards / regulations),

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	• Technologies and design features used to protect NPPs from fires (review of available active and passive features with a lot of examples / photos), • Operating plant activities designed to minimize fire potential and impact (e.g. housekeeping, transient material control, periodic inspection and surveillance, chemical and gas bottle storage, review of plant modifications related to fire protection, control of temporary modifications, training and qualifications etc.), • Fire safe shutdown analysis & probabilistic risk assessments (intent, methodology plus some example output), • Emergency Programs as they relate to fire (e.g. manual fire fighting, pre-fire plans, drills, linkages to local fire fighting organizations), and • Major fire related operating experience related to nuclear industry
10. Evaluation of Human Resource Development for Nuclear Facilities	The objective of the document is to support a holistic approach to human resource development covering the full nuclear worker lifecycle. It will; • Identify current challenges and key issues that Member States face when implementing a human resource development programme across the full worker lifecycle. • Identify the key requirements necessary to ensure member states maximise the available human resource capital by ensuring a coherent workforce plan across the complete lifecycle. • Produce the outline for an IAEA technical document detailing the necessary actions, activities and standards necessary to ensure the worker lifecycle requirements are understood and actively managed from the selection and recruitment, initial training and development, ongoing career development including leadership and management development, through to retirement. • Develop the methodology required to support an agency review service for human resource development across these areas of activity. The document will cover the general requirements, methodologies and considerations for workforce across the full range of nuclear activities and facilities, from nuclear new build programmes, facilities in routine operation through to decommissioning and waste management: • pre-selection and recruitment and the links to feeder education and training organisations • initial training and development programmes • career development, motivation and staff retention • leadership and management role selection and development

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	• staff movements into retirement and the necessary skills and knowledge management requirements and opportunites • lessons learned from experience (previous assessments, operating experience, proven practices, etc.).
11. Workforce Planning for New Nuclear Power Programmes (Rev.1)	Original document published in 2011. Fast moving area of development that requires updating to include lessons learnt from recent NNB programmes. The original supporting document 'Staffing of a New Nuclear Power Programme' has been converted into 'working material' document and will be used as an 'eBook' type document on the HRD Portal to collect best practices etc. from current organisations in member states.
12. Commissioning of Nuclear Power Plants: Training and Human Resource Considerations (Rev. 1)	Original document issued 2008. Current version does not include the IAEA Milestones approach and needs upgrading to factor in the commissioning 'phase 3' approach. The commissioning of the plant is primarily a pre-cursor to operating the plant and a key activity is developing and assuring the competence of the operational workforce.
13. Managing Human Resources in the Field of Nuclear Energy (Rev. 1)	The objective of this publication is to provide guidance for addressing human resources in the nuclear energy field to ensure its safe, efficient, and reliable use. This guidance should be used to establish the appropriate human resource management, education, training, and a framework for human performance improvement that: • provides competent human resources in a reliable and effective manner; • provides the knowledge, skills, and abilities to achieve the mission; • instils appropriate attitudes; and, • improves human performance; in order to provide sustainable development, and to ensure safe and efficient functioning of the nuclear industry in all phases of its lifecycle. This publication is intended to be applicable to:

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	• Nuclear facilities; • Activities using sources of ionizing radiation; • Radioactive waste management; • The transport of radioactive material; • Radiation protection activities; • Any other practices or circumstances in which people may be exposed to radiation; • The regulation of such facilities and activities; and, • Other activities affecting nuclear facilities, and entities involved in the nuclear industry sector (such as research and development organizations, suppliers or contractors providing products and rendering services for the nuclear facilities, and technical support organizations).
14. Staffing of a First Nuclear Power Programme and Nuclear Power Plant: Guidelines and Practices	The purpose of the publication is to provide practical guidance and examples on staffing and developing training system for a first Nuclear Power Programme and first NPP being deployed in a country. The scope of this report includes: • A review of the key HR issues as part of the wider nuclear power programme • Staffing needs for the Nuclear Power Plant Owner and Operating Organization of the first Nuclear Power Plant, with a focus on the overall Human Resource Development, Education and Training requirements • Staffing of other organizations such as the nuclear energy programme implementing organization (NEPIO) and the Nuclear Regulatory Body or Technical Support organizations
15. Grid Reliability and Stability for Nuclear Power Plant Operations	The objective of this NES is to review the needs, challenges and solutions in Member States on key areas of interfacing and operating electric grid systems and NPPs and will address the grid-NPP reliability and stability elements for the Member States. The guidance will deal, in particular, with establishing, maintaining and sustaining a reliable grid in support of safe and efficient operation of NPPs. The topics to be covered in this document will consist of specific information on the experience, benefits, risks, difficulties and challenges involved in grid reliability for safe and efficient operation of NPPs, including (please also see Attachment 1: Proposed Content based on the exploratory content by experts): • Technical aspects of equipment and design for grid to improve reliability; • Integrated work among stakeholders building and maintaining NPP-Grid interface; • Interface around the step-up transformer and on-site distribution for reliability of sending/receiving off-site power; • Methods for estimating off-site power reliability for input to the safety evaluations;

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	• Reliability improvement against hazards (natural and man-made); • Operation of a reliable grid with nuclear generation being an important share; • Grid structure evaluation and reliability requirements for connecting the first NPP; • Newcomer, expanding and established Member State operational experience for grid reliability including upgrade, maintenance and planning of grid to support nuclear generation in the energy mix.
16. Invitation and Evaluation of Bids for Nuclear Power Plants, 2017 Edition (NP-T-3.9 Rev. 1)	To update NP-T-3.9 to align with the currently supported list of IAEA products and publications, including the nuclear contracting toolkit, and procurement guidance document NP-T-3.21 (currently in publication). The scope of this document will not change. That is, the document will focus on bid invitation, bid evaluation and contracting taking into account recent information on the bidding process experienced by Member States, and available tools to assist that are available from the IAEA.
17. Management of Design Review and Acceptance by Nuclear Power Plants	The objective of this document is to provide a generic guidance, based on the operating experience and current knowledge, for developing, establishing, implementing, assessing, and continually improving a structured design review process. As such, it will provide a set of guidelines that integrates safety, performance, and economic aspects to achieve safe, reliable, and efficient operation of a NPP with an emphasis on strengthening the design decision making capabilities. In order to provide guidance for a structured and rigorous design review process, the document will develop an understanding of responsibilities, fundamental and specific elements and techniques, interfaces, and control and assessment methods of the review process for design decision making capabilities at various stages of NPP's lifetime.
18. Foreign Material Exclusion Management in Nuclear Power Plants	The guideline is intended to address all relevant aspects related to FMI prevention and to introduce a collective guidance and best practices in the FME management area. The scope of this report covers all FMI prevention activities such as administrative, technical, in-field techniques and controls. The report will not cover the details of mitigation and recovery techniques of foreign materials such as FOSAR (Foreign Object Search and Retrieval) programmes, however, the fundamental steps of ensuring safety and performance of SSCs in case of an FMI event will be provided in the report. The report will reflect the following focal points: • Management strategy of FME; • Administrative, technical, and human behaviour aspects of prevention of FMI, e.g.:

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	- Zoning and Engineered Barriers - Equipment Inspection, Logging, and Accounting - Cleanliness and Housekeeping - Work Planning and Implementation - Liquid and gas intrusions/Chemistry FMIs - In-field Verifications and Controls • Compilation of the operational experience application for programme improvement. • Thus, a FME programme guideline should: • Provide means to prevent FMI events during construction, operation, and maintenance of NPPs; • Provide means of establishing policy, procedure, and organizational culture for FME management and awareness; • Provide means for learning from FMI operating experience, and applying to existing programmes and procedures; • Provide a quantitative means to determine the efficiency of the programme. The final deliverable is a NE Series technical report that will describe methods and steps of establishing and improving a successful FME Management. These guidelines are intended to be used in preparation and/or improvement of FME programmes, policies, and procedures by the Member State organizations that are listed as end-users
19. Flow Accelerated Corrosion Management in Nuclear Power Plants	All reactor types have experienced some type of FAC related events in their piping systems. Many utilities have started the analysis of pipe wall thinning phenomenon using the available large amount of measurement data from operating plants. Plants have had FAC campaigns implemented for many years, and even with a mature and established FAC approach, events continue to occur. The following items are will be considered in the new CRP: • Overview of world literature on material degradation issues of NPPs, focusing onpipe wall thinning and rupture; • Behaviour and mechanism of pipe wall thinning and rupture; • Inspection and monitoring of pipe wall thinning and rupture; • Stress corrosion cracking and Mechanical, thermal and corrosion fatigue; • Determination of corrosion-assisted stress crack growth rate Basically a new NES will provide experiences, good practices and examples on how to improve and ensure that the majority of the aspects of a solid FAC approach have been covered, such as: • A list of FAC examination locations; • FAC system susceptibility analysis to update predictive models;

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	• Compile both internal and external relevant industry operational experience; • Review and benchmark of calculation methods on piping wall thinning • Minimum piping wall thickness calculation approaches and acceptance criteria; • Evaluation of the changes resulting from plant modifications (power up rates and changes in system operating configurations, such as rerouting of piping and changes in piping or component materials); • The necessary up-to-date plant water chemistry data; • Life time management strategies to minimize or mitigate the consequences of FAC.
20. Summary Review on the Application of Computational Fluid Dynamics in NPP Design – Final Report of a Coordinated Research Project	The objective of this CRP on "Application of Computational Fluid Dynamics (CFD) Codes for Nuclear Power Plant (NPP) Design" is to assess the CFD codes in use, while the objective of this NES document is to provide a comprehensive overview of the CFD codes' current capabilities, their main application in NPP design, and how these state-of-the-art CFD codes contribute to technology advances. This document will include a background of the issue, describe selected activities in which CFD codes are currently used to aid in advanced reactor design, and the status of their verification and validation. Best practices and user qualification issues will be included. Contributors to the report include research organizations, reactor vendors, operators and CFD code developers.
21. Methodology for Nuclear Energy Cost Analysis	The main objective of the publication is to address nuclear newcomer countries needs in terms of approaches for cost estimation and management of cost estimates. Nuclear newcomers are interested primarily in infrastructure development and on the construction – and operation – of their first nuclear power plant. The report is intended to be periodically updated (e.g., every 2-4 years) to update information and accommodate additional topics of interest to IAEA Member States. The first release of this publication will focus on activities such as infrastructure development (both "soft" and physical infrastructure), reactor construction and operation (the focus will be on the present generation of nuclear reactors (Generation III and III+) and on the Small Modular Reactor (SMR) likely to be deployed within the next 10-20 years), reactor decommissioning, and management of spent nuclear fuel and radioactive waste. Estimating the costs attached to each activity, identifying their drivers, and exploring ways to reduce them, will be the main topics to be developed. The cost estimating techniques used in the conventional power industry derive from existing practices in large infrastructure projects and the process (chemical and petrochemical) industry. These approaches, described, for example, in AACEI's publications (AACEI stands for *Association for the Advancement of Cost Engineering International*), can be adjusted to the nuclear industry. Other potential references, and starting points, to frame cost estimating for nuclear

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	plants, could be the US GOA *Cost Estimating and Assessment Guide*, the UK HM Treasury *Green Book (Appraisal and Evaluation in Central Government)*, the US NASA *Cost Estimating Handbook*, and the US DOE *Advanced Fuel Cycle Cost Basis* report. The *table of contents*, in Annex, suggests an outline for the publication. The outline of the report is designed so that future report revisions can provide updated content and include additional cost areas (e.g., innovative nuclear power and fuel cycle technologies). N.B. The report is not intended to be a source of current nuclear costs or infer the validity of any specific cost for the use by Member States.
22. Financing Nuclear Power Plants in the Liberalised Market (A Reference Report)	• Provides case-by-case information on the financial models and contract approaches used or proposed by vendors/ host countries for building NPPs. The objective is to provide examples, therefore it's a financial cases database/ reference book • Ensures practical application of financial approaches (cases and examples), and help Member States with practical understanding of financing theories (what was used, how it was used, what's the outcomes, what's the challenges). Covers all the world's cases (all cases of building and planning NPPs) – the uniqueness of the report is pulling all the cases together. • Provides information about financing of the most cases of NPP construction (if the information is available from public sources). Includes the update on market reforms for the countries which have, build (in process), or propose (plan) to build NPPs, and the impact of the market reform on the model. • Also includes information about government incentives and subsidies for supporting nuclear (current and under construction) in the liberalized market.
23. Storage of Radioactive Waste	The primary objective of this document is to provide state-of-the-art guidance to Member States on the storage of radioactive waste and conditioned waste packages. It aims to align technical information with safety assessment and operational needs, to provide operating experience and lessons learned and to have an adequate basis for development of training material required for technology transfer to less-developed Member States. The information contained in the existing published Agency documents in this area will be consolidated, updated and organized in line with the proposed new Handbook structure. Consideration is given to waste storage in both initial unconditioned form (including liquid/sludge form) as well as disposal-ready conditioned waste packages awaiting final disposal.

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24. Decontamination Methodologies and Approaches	The objectives of this report are to: provide information and guidance on relevant factors (technological, safety, environmental, organizational etc.) in the selection of decontamination strategies and methods; set out general approaches to the holistic assessment of above-mentioned factors leading to the selection of preferred method(s); and inform the reader about experience and lessons learned from the application of decontamination techniques on success (or failure), through case studies. This report focusses on the decision-making factors to be considered when planning decontamination activities. It includes consideration of several relevant factors and how these factors are seen as a whole, in preparing an integrated programme. It is not the intent of this document to duplicate available information on proven decontamination technologies but rather prepare the user to make an informed decision regarding and selection and deployment of a particular decontamination approach and methodology.
25. Determination of Environmental Remediation End States	The objective of this report is to outline an approach to make an informed and transparent decision on what is the mutually agreed end state for a site to be remediated or being remediated. It is intended to provide the basis for achieving consensus on the “end state” so that all stakeholders involved in the decision-making process work off the same base and the potential for misunderstanding is reduced as far as possible. This publication focuses on the environmental remediation of sites affected by past practices in the nuclear fuel cycle - from uranium production to nuclear power generation facilities - , practices involving naturally occurring radioactive materials (NORM), nuclear research facilities, and includes legacy sites as well as areas affected by radiological or nuclear accidents and incidents. Remediation of former nuclear test sites is deliberately excluded from the scope of this document.
26. Decommissioning of Industrial and Research Gamma Irradiators and Management of Associated Radioactive Sources	This report is intended to collect information on experience and lessons learned from implementation of decommissioning projects for disused gamma irradiators and the management of their associated high activity sealed sources. Based on this information, the report will provide practical guidance for organizations that have a role in this process and will highlight typical issues and concerns in decommissioning irradiators. This document will cover all technical and organizational aspects related with the decommissioning of industrial and research gamma irradiators and the management of the associated radioactive sources including decontamination operations associated with leaking sources. Radiotherapy equipment (Teletherapy, brachytherapy), industrial radiography equipment, nuclear logging equipment and industrial gauges are out of the scope of this document, because their dismantling requirements are comparatively simpler. Information will be provided on the various types of gamma irradiators in use at industrial facilities, or research centers, and how their design and construction features affect decommissioning. Practical guidance will be given on decommissioning strategies and technologies for the

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	removal/recovery and management of the high activity sources. Reports on various gamma irradiators decommissioning projects that have been completed will be summarized. Lessons learned from both good and bad practices will be discussed. This report will address, among others, the following major issues: • Research and industrial gamma irradiators, types, number, construction and operational features • Estimated life and reasons for shutdown of gamma irradiators • Types and features of gamma irradiators and their influence on decommissioning • Radiological characterization of irradiators • Decontamination/dismantling strategies and their occupational / environmental impact; • Removal and Management (handling, conditioning, packaging, transport, storage and disposal) of the high activity sources during and after decommissioning. Experiences • Organizational and managerial aspects of decommissioning (including costs) • Project description, experience and issues (Annex) • Case histories (Annex)
27. An Overview of the Global Inventory of Radioactive Sources and Their Management	The objective of the document is to provide a good description of various applications, type of sources used, the nature of these sources, their number and distribution in various regions as well as the trend expected for the coming years. The Technical Document (TECDOC) to be titled ***"An Overview of the Global Inventory of Radioactive Sources and Their Management"*** will provide a range of information on the subject but is not intended to cover possible solutions and management strategies. This latter task is the subject for many other IAEA activities and guidance documents. The document is intended to provide insights and to enhance awareness on the source applications, the level of magnitude of their use and hence the level of magnitude of disused radioactive sources to be managed at the end of their useful life. The document will provide background information necessary to design appropriate policy and strategies for SRS and DSRS management (linking to NW-T-1.3). The document can be useful as a reference to competent national authorities and other national or international organizations concerned with the safe and secure management of sealed radioactive sources throughout their life cycle. The report gives a general background on the characteristics and applications of sealed radioactive sources, and on the emergence of alternative nuclear technologies. The normal life-cycle of a sealed radioactive source starts at its manufacture, continues through its supply and use (this may also include transfer through intermediate states and organizations), before becoming disused

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	The document will use established methodology to determine the quantity of sources in use and disused worldwide, such that appropriate management methods can be applied. Even though this document will address SRS that are in use, it will concentrate on disused SRS (i.e. SRS not in active use), and is intended to provide a basis for the estimation of the number of sources and not a review of the actual utilization practises. The document will not cover SRSs that are exempted from regulatory control (e.g. smoke detectors unless re-collected in large number).. While this document is relevant to all categories of SRS, the main focus is given to high-category SRS (i.e., Category 1, 2 and 3). This document reflects changes and developments that have occurred since the publication of TECDOC 620. The inventory issues are dealt with in details. This is seen important for policy makers and those involved in regional and interregional solutions. Integrated management solutions are not necessarily described in detail but only to the extent needed for policy makers and managers to plan for short to medium term plans.
28. The Borehole Disposal of Disused Sealed Radioactive Sources: An Overview	The concept of DSRS borehole disposal was first proposed in 1995 as an effective disposal solution for countries that do not have the possibility to co-dispose those sources with other radioactive waste. Since then borehole disposal of DSRS has evolved from a conceptual idea to a well-defined concept offering an internationally accepted solution for a wide spectrum of DSRSs that can be implemented in different geological and climatic conditions. In 2017 the Malaysian Nuclear Agency submitted a license application for the borehole disposal of their disused sources. The application is currently under review by the Malaysian regulatory authorities. The Ghana Atomic Energy Commission is preparing a license application for the borehole disposal of their DSRS inventory. With that important milestone, the IAEA decided to consolidate knowledge of the concept in a report. The report aims at collating existing information and capture the lessons learnt from the borehole disposal project in Malaysia and Ghana. This overview report provides a high-level overview of the borehole disposal system (BDS) for disused sealed radioactive source explaining what it is, how it looks like, why it can provide long-term safety and how it can be implemented. Its goal is to enable Member States to evaluate the suitability of the concept for their DSRS inventory. Predisposal activities such as source conditioning will not be within the scope of the report.

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29. Roadmap for Developing A Geological Disposal Programme	The document is expected to provide MSs with a good understanding of how geological disposal solutions are developed by identifying the key phases and activities that contribute to the development of a geological disposal facility as the disposal programme evolves from an early research and development phase to later phases such as construction, operation, and closure. The role of URLs in the development of the disposal programme will be described. The report will try to be as complete as possible by providing an envelope of activities that can be included in a geological disposal program. This does not mean that all activities need to be included, and some Member States will see that certain items are not relevant to their national programme. It however seems useful to develop a roadmap that is as complete and widely applicable as possible. The report will cover a wide range of aspects of the disposal programme such as the strategy and policy, the regulatory framework and licenses, science and engineering, financing, stakeholder engagement, safeguards and security, etc. This information will be arranged in the form of a matrix comprising rows and columns, where the rows are key activities and the columns are the phases or milestones in the disposal development timeline. Disposal development requires a solid and robust technical and scientific basis. This basis is built by RD&D providing the data and information for: 1. characterising the natural environment, understanding of its features, events and processes likely to provide for and impact on safety 2. engineering the disposal system, understanding of its features, events and processes likely to provide for and impact on safety 3. the safety assessment (and possibly environmental impact assessment) of the disposal system As part of this overall, generic guidance on how to develop a geological disposal programme, some specific activities may be analysed in more detail, in particular the requirements involved as well as the specific role and contribution of these activities to different phases of implementation of the disposal programme. One such example is the research, development and demonstration work conducted in underground research laboratories. Another is the iterative development of disposal system performance assessment. As yet another example we may cite the development and maintenance of a disposal system requirements management tool. The report will take under advisement the developments in the report “Costing methods and financing schemes for radioactive waste disposal programmes” that is currently being developed. As a disposal programme contains a whole range of activities and can become very extensive, assessing its cost can only be done once all the activities or items that need to be done in a disposal programme are identified. That is where a Work Breakdown Structure (WBS) of a disposal programme can be useful as it lists the activities and items of a disposal programme and structures them in a logical way. This WBS evidently needs to be consistent with the roadmap.

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30. Evaluation, Management and Remediation of Trenches containing Historic Radioactive Wastes: Legacy Trench Sites	The research and application of nuclear technologies started in the 1950's, with the development of many research reactors, the subsequent opening of first-generation nuclear power plants and the development of medical applications. The approach to managing radioactive waste in these early days was often simple and, in many cases, used trenches. The objective of the report is to record good practices and lessons learned in the approaches used to characterise, assess and where necessary remediate sites with trenches containing historic wastes and to describe the key principles and processes necessary in managing 'legacy trench sites'. The report will also document the types of legacy trench sites found across Member States and record the specific experiences at some sites through case studies. The report is expected to cover the following topics • Overview of Legacy Trench Sites – details the characteristics of legacy trenches found in Member States and outlines the process for managing legacy trench sites. • Waste Inventory and Disposition – describes the waste types and emplacement methods and the associated uncertainties. • Site Evaluation – describes how to establish an inventory for the site through records and site characterization, and how to assess the potential risk posed to people and the environment. • Management and Remediation Approaches – describes the management and/or remediation approaches that could be used at a legacy trench site. • Defining the End State – describes the key considerations, including stakeholder management, and the process for defining the end state for a legacy trench site. • Information and Knowledge Management – describes the principles to ensure information and knowledge and is managed appropriately for a trench site.

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31. Mentoring and Coaching for Nuclear Knowledge Management	The objective of the document is to identify different approaches followed by nuclear organizations for coaching and mentoring and how it facilitates key organizational knowledge transfer. The scope of the document is to provide guidance on current approaches to the mentoring and coaching practices in nuclear industry organizations and to bring out the benefits associated with such practices including: • Describe different coaching and mentoring options followed in nuclear industry and how this tool is successfully deployed for knowledge transfer • Explain the benefits of coaching and mentoring and how it supports sustainable knowledge transfer • To provide used case examples of coaching and mentoring from successful nuclear organizations that can act as useful guidance.
32. Data Analysis and Collection for Costing of Research Reactor Decommissioning: Report of Phase 2 of the DACCORD Collaborative Project	To improve the general capability to prepare cost estimates for research reactor decommissioning, to determine the implications of different characterization strategies on cost and on designation of waste classes to assist the development of optimal approaches, and to understand the level of uncertainty of the cost estimates and the source of this uncertainty. A further objective is to continue and deepen the collaboration on research reactor costing that was developed during Phase 1. An improved methodology for costing of research reactor decommissioning will be developed based on the IAEA's CERREX software code for decommissioning cost estimation, providing: • The possibility to incorporate detailed radiological inventory information; and Analytical capabilities to better understand uncertainties in the estimate and sensitivity to variations in input parameter values. The report will extend the existing database of costing cases (from Phase 1), to provide additional benchmarking data and, specifically, to improve cost estimates for cases analysed in Phase 1 and will discuss new costing cases introduced in Phase 2. will also provide additional unit factors (e.g. for management of waste resulting from decommissioning) from the additional collected data sets and from other sources.

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33. Decommissioning of Nuclear Facilities: Training and Human Resource Development Considerations	Complete revision of NE Series Report NG-T-2.3 'Decommissioning of Nuclear Facilities: Training and Human Resource Considerations', taking account of main current needs in terms of training and other human resource development needs for decommissioning. The new report will address training and human resource development for decommissioning in an integrated way with other aspects of nuclear knowledge management, i.e. information and plant configuration management. Consideration will be given to inclusion of the following emerging topics, including: • Workforce planning and modelling requirements for organisations moving into the decommissioning phase • New ways of learning being applied across the nuclear education and training landscape to optimise costs and improve cognitive learning, • Inter-relationships between the operating and supply chain organisations and the required workforce modelling to meet the changing HR demands • Economic challenges for a cost-effective HR strategy.
34. Vendor and User Responsibilities in Nuclear Cogeneration Projects	The objective of this document is to: 1) Analyse responsibilities and requirements of users and vendors involved in nuclear cogeneration plants compared to the ones for standalone NPPs; 2) develop a generic algorithm to define the roles of various stakeholders in nuclear cogeneration project in general, and users and vendors in particular; in consideration of the technology, business models, regulations, public sensitivity, media involvement, scientific groups, etc; and 3) develop guidelines for vendors and users of retrofit and new build projects covering production of electricity and process steam for nuclear cogeneration applications such as desalination, district heating, hydrogen production. The scope of this document includes both new build as well as potentially retrofitted projects in terms of technical and managerial requirements within the context of the national, vendor's, and user's requirements that may be established for nuclear cogeneration projects. It will analyse responsibilities and requirements of stakeholders involved in nuclear cogeneration projects taking into consideration the different aspects of implementation, including: economic, technical, safety, environmental, communication, regulatory, and contractual issues. It will also provide an insight to issues and lessons learned from previous experiences on the planning and deployment of such projects. The document will highlight

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	and discuss concerns and challenges for nuclear desalination projects, being considered as example of nuclear cogeneration. Common understandings from stakeholders, including cases of multiple vendors for nuclear and the non-electric application plant (i.e. desalination plant) will be addressed. As a result, the document will provide an implementation roadmap and recommended practices for the project planning, commissioning, operation, and decommissioning of nuclear cogeneration projects.
35. Cost-Benefit Analysis (CBA) of New Nuclear Power Projects	The main objective of the publication is to provide practical guidance on how to conduct a Cost-Benefit Analysis (CBA) in the context of the feasibility study of new nuclear power projects. The scope of the publication is the "economic feasibility" chapter of the IAEA's publication on "Preparation of a Feasibility Study for New Nuclear Power Projects" (Nuclear Energy Series No. NG-T-3.3). The publication will develop the content of this chapter, providing a conceptual framework of a standard cost-benefit analysis, covering areas such as – demand and supply analysis; option analysis; financial analysis; economic analysis; and risk assessment –, and guiding the reader through the steps required to apply it to power generation projects.

36. Operational Excellence at Nuclear Power Plants	The purpose of this document is to provide senior management of nuclear generating organizations with the overall picture of their current challenges, and to help them identify key factors to overcome them and make the most effective focus to sustain operational excellence under worldwide change in business climate.
	This document describes, but is not be limited to, the following aspects that could influence and impact sustainable operational excellence:
	• Core fundamentals and competencies to be preserved under changing business environment
	• Key goals to be achieved, barriers, actions and expected outcomes in following areas:
	  ○ Competitiveness
	  ○ Role in decarbonization
	  ○ New horizon in safety
	  ○ Human resource development
	  ○ Public confidence on nuclear energy
	  ○ Cost effectiveness and sustainability
	• Excellent Management model

37. Nuclear-Renewable Hybrid Energy System Opportunities	This publication presents opportunities for N-R HESs that could be pursued in various member states as a part of their future energy mix. It describes motivation for and potential benefits of N-R HESs relative to independent nuclear and renewable generation that produce electricity alone. Considerations for implementation are outlined, including gaps that

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	require additional technology and regulatory development. This document intends to equip decision makers and stakeholders with sufficient information to consider N-R HESs as an option within regional and national energy systems. The scope of this document includes fission systems traditionally designed for electricity generation, integration options for variable renewable technologies, summary of available case studies, high-level system configurations, stakeholder/public acceptance/regulatory/policy considerations, owner/vendor perspectives. Other considerations not included in this publication are technical design details, detailed analyses, systems integrated solely via the grid, etc.
38. Methodology for Assessing Pipe Failure Rates in Advanced Water Cooled Reactors – Final Report of a Coordinated Research Project	The objective of this NES is to report on the major outcome of the CRP on "METHODOLOGY FOR ASESSING PIPE FAILURE RATES IN ADVANCED WATER COOLED REACTORS", i.e. to share expertise and develop a methodology for predicting pipe failure rates in advanced WCRs built on the current state-of-knowledge on piping degradation and failures and statistical models of piping reliability on the basis of operating experience data in the current WCRs fleet. This document will include a background of the issue, a description of current methods used to predict plant piping failure rates in support of design certification PSA studies, description of a procedure on how to modify an existing set of piping reliability parameters derived for operating WCRs to a new set of piping reliability parameters for advanced WCRs, and description of the newly proposed methodology applicable to advanced WCRs. Expected content of the document is provided in Section 9.
39. Compendium of Results of Research, Development and Demonstration Activities Carried out at Underground Research Facilities for Geological Disposal	The objective of this publication is to provide an overview of the existing URFs around world, and a comprehensive overview of the main information on RD&D results obtained until today from URFs, presented with an understanding on how this contributes to the scientific and technical basis for feasibility and safety of geological disposal, in a range of host rocks. As such, this publication is intended to support Member States that would like to initiate their geological disposal programmes, by providing a reference allowing finding the more in-depth information and reports on URF RD&D results that may be of interest to inform their specific programme developments. This allows such Member States (i) to progress their national programmes based on solid, available scientific and technical basis – up until the moment where site-specific information is deemed necessary, and (ii) to plan their own national URF work – either in a dedicated facility or as a first part of the future geological disposal facility, based on prior experiences and recommendations obtained from existing URF programmes and RD&D activities. The publication is expected to present fundamental information such as original and current purposes, phased approach in planning tests and experiments, summary of historical and current tests and experiments, and future plan for existing

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	URFs. To the extent still possible, it will also attempt to provide relevant information obtained in URFs that have since been closed. However, describing all tests, experiments and demonstration that have been carried out in the URFs is not aim of this publication. The RD&D results are discussed and analysed to derive achievements and lessons learned so far, to provide relevant, in-depth insights to Member States intending to start a geological disposal programme. The rationale of how to present such information, and indeed the appropriate level of detail, will be subject of a first consultancy meeting – a well balanced approach between available, detailed national records and this international Almanac needs to be defined. Technical development for underground characterization and excavation is so fast in some area. Hence, appropriate experiences and technologies gained and developed from other underground facilities such as mines and research facilities are also incorporated into the publication. Given the significance of the proposed document to deep geological disposal programmes around the world, it is also proposed that the potential for shared interest and collaboration with the OECD/Nuclear Energy Agency (NEA) and the European Commission (EC) will be explored.
40. The Management of Site Investigations for Radioactive Waste Disposal Facilities	The objective of the document is to provide an overview of techniques and technologies that have been proved to obtain site investigation data for decision-making associated with the siting and construction of repositories for solid radioactive waste. The environmental domains covered by site investigations include the biosphere (broadly speaking, the surface and very near-surface environment in which organisms reside) and the geosphere. The proposed publication is concerned with investigations of both these domains and therefore the information to be provided will be applicable to investigations for LL W, IL W and SF/HL W disposal using both near-surface and geological repository concepts. The report is intended to support the sharing of knowledge between Member States and provide a platform for applied site specific site investigations in the large number of Member States with a need for near-surface and geological disposal of radioactive waste. In summary, the document will present techniques for both data acquisition and interpretation and will also provide examples where such techniques have been successfully used. Such up-to date information is not currently available in a single resource in the context of radioactive waste management. The principle scientific disciplines covered by site investigations include geology, hydrogeology, geochemistry, geophysics, rock mechanics, climatology and environmental studies. Understanding from all of these disciplines need to be integrated to provide a holistic three-dimensional understanding of a site and its evolution. This understanding is the basis for site specific radionuclide transport modelling that will ultimately determine the dose and risk associated with a specific disposal

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	concept. Eventually, these data will be principal inputs in developing a safety case. Technologies and techniques covering all of these discipline areas and how they inter-relate will be included in the publication. There are many methods available to determine various rock and hydraulic properties at the surface or underground, both from remote sensing, from mapping and in situ measurements on various scales and from measurements on samples in the laboratory. Such measurements provide data that have variable accuracy and precision and are generally representative of limited areas (e.g. immediately around boreholes). A comprehensive and up-to-date listing and explanation of all the currently employed site investigation technologies for data acquisition will be compiled in the report. Safety assessments for radioactive waste repositories require extensive site data for the development of robust conceptual models and also for the parameterisation, calibration and validation of numerical models, including the radionuclide transport models that are used to determine dose and risk arising from radionuclide migration. Site data needs to be processed and interpreted to provide the detailed understanding and knowledge necessary for these safety assessment studies. In particular we need to confidently determine the rock and hydraulic properties of interest for a site volume, between borehole control points and away from the surface, in order to appropriately populate radionuclide transport models and also to provide improved rock quality predictions for repository engineering studies. The uncertainty associated with data and conceptual models can be greatly reduced as a result of careful data collection, analysis and interpretation. This document will detail the scientific principles involved in data interpretation, including up-scaling and uncertainty analysis, and provide actual examples of applications. Document contents will include: (i) discussion of siting approaches; (ii) alternative site investigation strategies; (iii) summary of the various data acquisition and analysis technologies/methods, including the specific objectives, assumptions, uncertainties, limitations, logistical requirements and additional benefits associated with each method; and (iv) examples of applications. An appendix will be provided with an exhaustive listing of technologies and techniques in the form of a spread sheet, together with the key attributes for each technology and interpretation technique. Preferably, proven (robust and reliable) techniques will be included, but any newly identified techniques and methods will also be listed.
41. Management of Radioactive Wastes after Nuclear Accident	The objective of the document is: (i) to summarize updated information on waste management needs in the aftermath of a nuclear accident from pre-disposal through disposal, from an advance planning stage to the actual implementation in systematic way

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	(ii) to provide valuable lessons learned and recommendations to MSs on how to be prepared to initiate sound RW management activities from pre-disposal through disposal and their implementation processes in a future post-accident situation (iii) to provide valuable information to Member States primarily on technical, economic and socio-political aspects of waste management that effectively address the large waste volumes and implementation challenges likely to result from a nuclear accident and to encourage the development of national strategies to improve preparedness for such a situation. The IAEA Nuclear Energy Series publication will provide guidance for technological planning and implementation of the management of wastes from nuclear accidents from generation through disposal based on relevant experience from previous events. It should address following issues: (a) sources of waste that may result from an accident at a nuclear facility, and their possible characteristics; (b) waste management strategy and planning in accident situations; (c) waste management steps and options; (d) the implementation process; (e) techniques that can be applied to the characterization of accident related wastes; (f) collection/handling, transport, processing and storage of accident related wastes; (g) disposal strategies and considerations.
42. Management of Ageing and Obsolescence of Nuclear I&C Systems and Components through Modernization	The objective is to produce a new NE Series (NES) report to assist Member States in understanding the ageing effects, degradations mechanisms and obsolescence of nuclear I&C systems and components, and to address modernization strategies that can be used to cope with the mentioned issues. The goal of the document is to provide an overview on the current knowledge, up to date best practices, experiences, benefits and challenges related to the subject approaches (listed under “Scope”) in the life cycle of NPP I&C systems and components. The document is intended to be used by Member States to support the planning of ageing management and obsolescence monitoring, modification, replacement and modernization of I&C systems and components and to discuss how these activities can support the safe, reliable and long-term operation of nuclear power plants. The scope of the publication will cover the full range of types of I&C systems including protection, safety, control and information systems. It will be applicable for a plant throughout its life. The tentative list of areas for the scope of this publication include: • I&C systems and components of interest

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	• Understanding the ageing effects and degradation mechanisms
	• Monitoring of the ageing of I&C equipment
	• Maintaining the I&C of existing NPPs for longer lifetime with a high level of safety, demonstration of legacy I&C safety systems' fitness for purpose
	• Ageing simulation procedures and criteria; estimation of remaining lifetime of I&C equipment
	• Relationship between ageing, life cycle management and maintenance
	• Evaluation of costs, risks and benefits of different I&C maintenance options: repair, periodic replacement, modernization, etc.
	• Ageing management of I&C and electrical equipment and components
	• Obsolescence processes and managing the obsolescence
	• Cost effective I&C modernization strategies and techniques
	  ○ One-to-one (form, fit and function) modernizations
	  ○ Reverse engineering techniques
	  ○ Full system replacement, digitalization
	• Establishing criteria for the modernization
	• Management of interfaces between new and old systems in modernization projects where the old and renewed parts exist simultaneously
	• Change and configuration control and management issues related to I&C modernization
	• Regulatory/licensing aspects
	
	Lessons learned from experience (previously completed projects, operating experience, proven practices, etc.).

43. Enhancing National Safeguards Infrastructure to Support the Introduction of Nuclear Power	This publication provides guidance on safeguards-related activities that need to be carried out during each of the three phases of nuclear power infrastructure development. A country can use it to help ensure that: (1) It is aware of the safeguards obligations associated with the introduction of nuclear power; (2) The state authority responsible for safeguards implementation and the nuclear power plant (NPP) owner/operator plan and systematically develop the necessary technical and administrative competencies on timescales consistent with the development of the nuclear power programme, including, for example, for licensing requirements related

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	to safeguards; for locating, collecting, managing and reporting relevant information; for conducting domestic inspections; and for cooperating with the IAEA and relevant stakeholders. This may require additional staffing, training and technical capabilities. (3) It has, in a timely manner, adequately strengthened the state system of accounting for and control of nuclear material (SSAC) to (a) regulate and control the nuclear material and related activities associated with the nuclear power programme, (b) provide correct and complete information, on time, to the IAEA, and (c) facilitate IAEA verification activities through institutional arrangements and by providing access to IAEA inspectors. This publication covers the necessary safeguards infrastructure and associated activities required for the implementation of a nuclear power programme, within the context of a country's international safeguards obligations. The infrastructure needs are discussed in detail from consideration and decision-making, through programme implementation, construction, fuel delivery and preparation for NPP commissioning. Subsequent steps including operation, spent fuel and radioactive waste management and decommissioning are addressed to the degree necessary for informed decision-making and future planning.
44. Adoption of Systems Engineering Principles for Nuclear Power Plant Instrumentation and Control	The objective is to produce a new NE Series (NES) report to assist Member States in understanding the philosophy and methodologies on SE in general (as introduced e.g. by INCOSE) and to promote the adoption of SE and its different applications for the overall engineering lifecycle of safety significant instrumentation and control (as described in IAEA SSG-39). The goal of the document is to provide an overview on the current knowledge, up to date best practices, experiences, benefits and challenges related to the subject approaches (listed under "Scope") on SE. The document is intended to be used by Member States to support the introduction of the SE methodology for all stakeholders involved in the engineering lifecycle of safety significant I&C for NPPs and to discuss how these activities can support the safe, reliable and long-term operation of nuclear power plants. The scope of the publication will cover the essential activities to be performed through the whole engineering lifecycle of safety I&C with the involvement of various disciplines. The tentative list of areas for the scope of this publication include: • Systems engineering overview • Use and value of systems engineering • The various components of systems engineering (e.g. managerial, logistical, technical)

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	• Overall engineering lifecycle • Systems engineering for I&C design • Quality in the I&C life cycle • Regulatory/licensing aspects • Lessons learned from experience (previously completed projects, proven practices, etc.).

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