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Resource Requirements for Nuclear Power Infrastructure Development

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RESOURCE REQUIREMENTS FOR NUCLEAR POWER INFRASTRUCTURE DEVELOPMENT

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FOREWORD

The IAEA's statutory role is to "seek to accelerate and enlarge the contribution of atomic energy to peace, health and prosperity throughout the world". Among other functions, the IAEA is authorized to "foster the exchange of scientific and technical information on peaceful uses of atomic energy". One way this is achieved is through a range of technical publications including the IAEA Nuclear Energy Series.

The IAEA Nuclear Energy Series comprises publications designed to further the use of nuclear technologies in support of sustainable development, to advance nuclear science and technology, catalyse innovation and build capacity to support the existing and expanded use of nuclear power and nuclear science applications. The publications include information covering all policy, technological and management aspects of the definition and implementation of activities involving the peaceful use of nuclear technology.

The IAEA safety standards establish fundamental principles, requirements and recommendations to ensure nuclear safety and serve as a global reference for protecting people and the environment from harmful effects of ionizing radiation.

When IAEA Nuclear Energy Series publications address safety, it is ensured that the IAEA safety standards are referred to as the current boundary conditions for the application of nuclear technology.

The appropriate infrastructure is essential for the safe, secure, peaceful and sustainable use of nuclear power. Member States introducing nuclear power programmes face the challenge of building the necessary infrastructure for the first nuclear power plant. IAEA Nuclear Energy Series No. NG-G-3.1 (Rev. 1), Milestones in the Development of a National Infrastructure for Nuclear Power, first published in 2007 and updated in 2015, defines three milestones in the development of infrastructure and provides detailed guidance for 19 specific infrastructure issues. The guidance in the publication is referred to as the 'Milestones approach' and is a framework intended to help Member States that are considering or embarking on a new nuclear power programme or expanding an existing one. The approach aims to guide Member States through the steps necessary to successfully develop their programme, highlighting issues to address and providing benchmarks ('objectives') against which progress in addressing these issues can be measured.

Understanding the resources required to meet the objectives and — more broadly — to implement a nuclear power programme is of great interest to Member States. However, it is recognized that certain factors can influence the resources required, which may differ from one Member State to another.

This publication provides insight into the resources required to develop the infrastructure needed for a new nuclear power programme. It addresses each of the three phases of the Milestones approach and provides an estimate of the person-years required for the most resource intensive 'meta-activities' by key organizations: the government or nuclear energy programme implementing organization (NEPIO), the regulatory body and the owner/operator.

The IAEA wishes to acknowledge the valuable assistance of the contributors to this publication, in particular S. Mortin (United Kingdom). The IAEA officers responsible for this publication were B. Magné of the Division of Planning, Information and Knowledge Management and M. Kovachev, A.K. Stott and P. Warren of the Division of Nuclear Power.

EDITORIAL NOTE

This publication has been edited by the editorial staff of the IAEA to the extent considered necessary for the reader's assistance. It does not address questions of responsibility, legal or otherwise, for acts or omissions on the part of any person.

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CONTENTS

1. INTRODUCTION

1.1. BACKGROUND

Developing a nuclear power programme is a major undertaking requiring careful planning and preparation. Prior to the investment in the nuclear power plant (NPP) itself, the process requires adopting relevant policies, establishing appropriate legal and regulatory frameworks and developing the required institutions and human resources (HR). It also requires investment in new or upgraded physical infrastructure (roads, rails, ports, the electrical grid and associated equipment, environmental monitoring systems, etc.) and undertaking a wide range of technical studies and evaluations. These activities are included in and known as 'development of the infrastructure needed for a nuclear power programme'. The IAEA has developed a framework that is intended to help embarking and expanding Member States proceed through the steps necessary to develop their nuclear programmes successfully, highlighting the issues that they will need to address and providing benchmarks ('conditions') against which progress in addressing these issues can be measured. The approach is described in two key IAEA Nuclear Energy Series publications: Milestones in the Development of a National Infrastructure for Nuclear Power, NG-G-3.1 (Rev. 1) [1] (hereafter 'the Milestones approach') and Evaluation of the Status of Nuclear Infrastructure Development, NG-T-3.2 (Rev. 1) [2]. As explained in Section 2, these publications divide the development of infrastructure into three phases and identify three key organizations.

The investment required to develop this infrastructure is considerable. It needs to be funded by the Member State considering nuclear power long before the benefits of an operating nuclear power plant arise. For this reason, Member States have expressed interest in understanding the cost ('resource requirements') of developing this nuclear power infrastructure. These costs will include the allocation of staff to required activities, the training of staff, the hiring of consultants for specialist advice and studies, and the construction of supporting physical infrastructure, as well as other costs associated with developing the required infrastructure. Even though the actual cost of each of the elements will vary significantly from one Member State to another, this publication seeks to provide some guidance for Member States to support their evaluation of the resource requirements for their specific circumstance.

1.2. OBJECTIVE

The main objective of this publication is to provide resource estimates broken down by phase, organization and resource intensive meta-activities. A meta-activity is a collection of individual activities that together represent a significant activity grouping at the programme level. They are a key tool in the analysis of resources presented in this publication and are defined in Section 3.4.

1.3. SCOPE

This publication will provide guidance for Member States that wish to assess the resources required for development of the infrastructure needed for their nuclear power programme. Resource estimates are presented in person-years, to smooth out countries' economic differences, in particular in terms of labour costs, which may vary significantly.

The data are presented in sufficient detail that they can also be used by countries that have decided to expand their nuclear programme after a long period without building any new nuclear power plants. The infrastructure requirements are defined in detail in the IAEA's Milestones approach [1]. Specific requirements related to safety infrastructure are defined in the IAEA Safety Standards Series No. SSG-16 (Rev. 1), Establishing Safety Infrastructure for a Nuclear Power Programme [3].

The publication mainly considers the 'soft' infrastructure elements, such as developing national policies, developing a legal and regulatory framework, and establishing and staffing key organizations with competent resources. The publication also considers the resources required for key activities, such as siting and environmental impact assessment, as well as for stakeholder engagement and industrial involvement The required improvements to the country's physical infrastructure (roads, rails, ports, electrical grid improvement, environmental monitoring systems, equipment, etc.) are also important elements to consider when establishing the overall cost, but they will be project and country dependent, and are not included in the resource estimates in this publication. Some examples of costs are given in the appendices.

This publication does not attempt to provide information on the competences that will be required by the organizations involved in the nuclear power programme. Although the majority will be in engineering and scientific fields, competences will also be required in other areas, for example legal, contracting, finances, administration and management. References [4–10] provide further guidance on competence requirements, development and management.

1.4. STRUCTURE

This publication comprises six sections, including the Introduction. Section 2 summarizes relevant information concerning the Milestones approach [1]. Section 3 describes the methodology used in the project to develop this publication. Section 4 provides an overview of the resources required and provides a breakdown by meta-activity. Section 5 provides a breakdown of the results by each of the key organizations. Section 6 provides a summary and conclusions. Appendices I–III provide examples of resource information for a nuclear energy programme implementing organization (NEPIO), a regulatory body and an owner/operator using data from three Member States, respectively.

1.5. USERS

This publication is primarily intended for Member States who wish to estimate and plan for the resources required during each phase of development of the infrastructure required for their nuclear power programme. It can be used at the national level and the organizational level.

The publication may also be beneficial to vendor countries who intend to discuss the funding of the preparatory work needed by a recipient country to develop its national nuclear power infrastructure.

2. THE MILESTONES APPROACH

2.1. PHASES

The Milestones approach [1] considers the development of nuclear power infrastructure in three phases. It suggests that the time from the initial consideration of the nuclear power option by a country to the operation of its first nuclear power plant is about 10–15 years, noting that this may vary, depending on the resources devoted to the programme.

Phase 1 primarily involves a series of pre-feasibility studies to enable the country to understand the implications, requirements and benefits of a nuclear power programme. These studies also help the country to make a knowledgeable commitment to a nuclear power programme, should it decide to proceed. The majority of this work can be carried out by the Member State itself, supported in some cases by consultants. Reference [3] suggests a duration of one to three years for this phase.

Phase 2 primarily involves the development of national policies and a legal and regulatory framework, establishment or upgrading of key organizations, development of the required HR, completion of key studies (such as siting, environmental impact, grid and waste management studies) and the implementation of a stakeholder engagement plan. It also involves the development of financing options and a requirements document for engagement with potential suppliers. Reference [3] suggests a duration of three to seven years for this phase.

Phase 3 is where the financial and contractual commitments are made and construction of the NPP is carried out. While this latter activity is the responsibility of the contractors, the owner/operator and the regulator need the competence and processes to oversee the construction programme. In Phase 3 the operating organization implements its major recruitment and training programme in preparation for commissioning and operation and develops safety, security, safeguards and emergency response programmes. Waste management arrangements also need to be developed. Reference [3] suggests a duration of 7–10 years for this phase.

2.2. KEY ORGANIZATIONS

The Milestones approach [1] identifies three key organizations as the main players in the development of the nuclear power infrastructure: the government, the owner/operator of the nuclear power plant and the regulatory body. Each has a specific role to play, with responsibilities changing as the programme advances.

Several government departments, ministries or agencies will be involved in the development of nuclear power infrastructure and it is assumed that the government will create a mechanism (which may involve high level and working level committees) to coordinate the work of all organizations involved in infrastructure development (including the owner/operator and the regulatory body when they are established). In the Milestones approach [1] and other related publications, this mechanism is referred to as the nuclear energy programme implementing organization (NEPIO). Reference [7] describes the work of the NEPIO in detail for each phase. In most countries, one particular government agency (e.g. a part of the ministry of energy or an atomic energy authority) has the role of organizing the work of the NEPIO.

The second organization is the regulatory body or bodies. So far, all countries embarking on new nuclear power programmes, and who have enacted or drafted their national legal framework for nuclear power, have or plan to have a single independent organization regulating nuclear safety, nuclear security and safeguards. In most cases the same organization is also responsible for regulating the use of radiation sources as well as nuclear power. Other national regulators will also be involved in the nuclear power programme, such as the environmental regulator, and their resource is also included.

The third organization is the owner/operator[1] of the nuclear power plant. This may be a stand-alone organization (whose shareholders can be either the government, other national (public or private) organizations such as an electricity utility, or non-national organizations or consortia) or it may be a unit within an existing organization, such as a national power generator. Reference [8] describes the role of the owner/operator in detail for each phase.

In Phase 1, the Milestones approach [1] assumes that a nuclear regulatory body and an owner/operator of a future nuclear power plant have not yet been established. The NEPIO instituted by the government is therefore the mechanism for ensuring that all required studies are conducted, and for coordinating the compilation of information necessary for the government to make a knowledgeable commitment, and to proceed (or not) with the development of a nuclear power programme. As the specific arrangements for the NEPIO vary from one country to another, it is difficult to define precise roles and hence resources for

[1] Generally, the owner/operator is a single organization, although the functions can be separated. In several countries the owner function generally starts in an existing government owned organization and the arrangements for the operating organization evolve as the programme develops.

the various organizations contributing to the NEPIO. In this publication, all the resources required for the work in Phase 1 are allocated to the NEPIO (see also Section 5.1).

For Phases 2 and 3, activities and resource requirements are allocated to the regulatory body, the owner/operator and the NEPIO, as appropriate. Some work is also allocated directly to the appropriate government ministries. The actual split between what is allocated to the NEPIO and what is allocated to other government entities will depend on the arrangements in each country and the resource intensity. The assumption in this publication is that management, coordination and policy making activities are allocated to the NEPIO, while resources that provide advice on specific matters such as national security and financing are allocated to Government.

The resources for any technical support organizations are not identified separately in this publication, as this will be very country dependent. In general, the resource is allocated to the sponsoring organization. Each country will decide how this is split between internal resources and various consultants and/or technical support organizations.

3. APPROACH USED TO ESTIMATE RESOURCES

3.1. NUCLEAR INFRASTRUCTURE COMPETENCY FRAMEWORK

Based on the Milestones approach [1] and a number of other publications addressing specific aspects of nuclear infrastructure, the IAEA has developed a Nuclear Infrastructure Competency Framework for nuclear power programmes [9] (hereafter ‘the Competency Framework’). This is a database, available on-line, that identifies the activities of each key organization in each phase of the Milestones approach [1]. This list of more than 200 activities to be completed for the development of the nuclear infrastructure needed for a nuclear power programme was the starting point for a group of experts to estimate the resources required to develop a nuclear power programme.

3.2. EXPERT GROUP ANALYSIS

The first step in the approach used by the IAEA to estimate the required resources was to obtain the opinion of a focus group comprising experts with varied backgrounds. Some of the experts had relevant experience with the development of different aspects of nuclear infrastructure in the past. Other experts were engaged at that time in developing nuclear power infrastructure in their respective countries. As a group they provided estimates of the resource required for each task (or in some cases a combination of tasks) listed in the Competency Framework [9]. The discussion was facilitated to ensure that suggestions were tested and a group consensus was reached.

The estimates developed by the group of experts were then benchmarked against publicly available data on resources. This was mainly for activities carried out by NEPIOs, based on information provided by newcomer countries, and by regulatory bodies, as a number of such organizations publish data on resources used for regulatory activities.

For the purposes of this publication, the resource estimates were based on the development of a nuclear power programme of two units, in a country that already has some experience of and capability for managing large infrastructure projects. For a country driving the development of its nuclear power infrastructure based on a clear government commitment, this publication estimates the resource to complete each task identified in the Competency Framework [9]. In practice, the resource required will be affected by the overall timeframe for developing the nuclear infrastructure. This of course will be different in each country, and in some countries the programme development remains ‘stuck’ in a phase,

awaiting key decisions or a change of circumstances in a key area. In some cases, this will require a re-evaluation of information or extended discussions involving additional resource.

The data presented here do not include such additional resources. The reference durations used for each phase were five years for Phase 1, five years for Phase 2 and seven years for Phase 3. In general, these durations are consistent with those suggested in Ref. [3], although the time assumed for Phase 1 was greater. However, the level of resource in the first two years is relatively small, with the resource expended over these first two years being only 20% of the total for Phase 1.

3.3. COUNTRY INFORMATION

Additional verification of the information elicited from the group of experts was obtained from countries involved in nuclear power infrastructure development. Verification was obtained in some cases for detailed tasks (e.g. developing a management system) and in other cases for the main activities undertaken during a particular phase for one or more of the key organizations. No country had systematically kept records of resources used against a work breakdown structure that matched that of the Competency Framework [9], but the data were used to validate or supplement the information provided by the focus group of experts. Examples of resources for a NEPIO, a regulatory body and an owner/operator are provided in Appendices I–III.

3.4. GROUPING OF ACTIVITIES

It is important to recognize that the Competency Framework [9] lists activities at a detailed level and that some of these activities are interrelated. The intention of this publication is not to define the resource for each individual activity, but to use the list to develop an estimate of the total resources needed, broken down by organization and by phase. In addition, as noted earlier, the individual activities are grouped into resource intensive meta-activities, with a meta-activity being a collection of individual activities. This publication uses this approach, rather than grouping the activities by infrastructure issue, in order to focus on items that require a significant level of resource and represent major elements of developing a nuclear power programme. It is important to recognize that the importance of an activity is not linked to the level of resource required. For example, failure to communicate regularly with stakeholders can result in a programme being cancelled or suffering significant delays, but the level of resource required to communicate effectively is small compared to that for many other activities. For this reason, not every infrastructure issue is discussed in detail in this publication. Detailed information about the different issues can be found in the Competency Framework [9] and the Nuclear Infrastructure Bibliography [11].

It is recognized that at the detailed level there may be significant variations from country to country in the resource estimates for a particular activity. Different approaches are followed by countries and organizations in managing their activities. The national pool of skilled HR may also differ and affect the resources available to conduct certain activities. However, at a higher level, where the detailed activities have been aggregated into meta-activities, the overall results and key messages will have less uncertainty and will be adequate for resource planning.

The approach used to define meta-activities was an iterative one. Each meta-activity is a collection of individual activities that together represent a significant activity at the programme level and is significant in terms of the resources required. This resulted in some activities involving more than one organization and spanning more than one phase (e.g. Develop and maintain organizations) but others involving only one organization in one phase (e.g. Prepare licence applications). The grouping used is defined in Table 1 and each of the meta-activities is discussed in more detail in Section 4.

The overall process described above is summarized in Fig. 1. The aggregated results (upper right hand side of Fig. 1) are discussed in Section 4.

TABLE 1. DEFINITION OF META-ACTIVITIES

Designation	Description
Develop pre-feasibility studies, policies and strategies	This includes all the necessary studies (often included in a pre-feasibility report) for developing the comprehensive report[a] to allow a knowledgeable decision, including stakeholder engagement activities. It also includes the subsequent development of policies such as those for safe, secure use of nuclear power for peaceful purposes, spent fuel and waste management, industrial involvement and HR development
Develop legal and regulatory framework	This includes review of and adherence to international legal instruments, the development and enactment of the comprehensive nuclear law, a review of all other legislation that may impact on the nuclear power programme and the development of regulations and guides to control the use of nuclear power and establish a licensing and oversight process
Conduct site related activities	This includes the site survey activities, the site selection and characterization activities and the preparation and submission of the environmental impact assessment. It includes the submission of the site licence/permit applications, depending on the regulatory requirements of the country. It also includes work to identify and implement physical infrastructure upgrades, such as grid, roads, ports, etc.
Develop and maintain organizations	This includes the activities of establishing organizations, defining structures and management systems and recruiting and training staff (except those trained specifically for operation and maintenance under the engineering–procurement–construction (EPC) contract — see the meta-activity, Train staff for NPP operation). It also includes the activities related to stakeholder engagement and to emergency preparedness and response, as the resources required for these activities are not sufficient to warrant being a separate meta-activity
Select vendor and negotiate contract	This includes defining the approach to financing, contracting and vendor/contractor selection, evaluating offers, developing technical specifications and negotiating the contract for plant construction
Prepare licence applications	This is the task of the owner/operator in reviewing information provided by the vendor and developing the additional information required to apply for two main licences: the construction and operating licences. It also includes the response to questions from the regulator. (Note that the site licence application and the preparation of documents required in the environmental impact assessment (EIA) process are covered by the meta-activity, Conduct site related activities.) Submissions for other licences/permits required by the operating organization and programmes requiring regulatory review (such as the radiation protection programme, training programme, maintenance programme, etc.) are also included
Review licence applications	This is the regulatory task of reviewing the siting, construction and operating licence applications or a combined licence application. It also includes the regulatory review of the environmental impact assessment, and any other permit applications by the relevant authority
Oversee manufacture and construction	This is the owner/operator activity of overseeing the work of the vendor during construction. It involves confirming that contract requirements are met, reviewing non-conformances, witnessing manufacture and construction
Train staff for NPP operation	This includes the cost of hiring staff to enable them to be trained and gain experience prior to commissioning

[a] IAEA Nuclear Energy Series NG-T-3.14, Building a National Position for a New Nuclear Power Programme [12], describes the pre-feasibility studies and the comprehensive report.

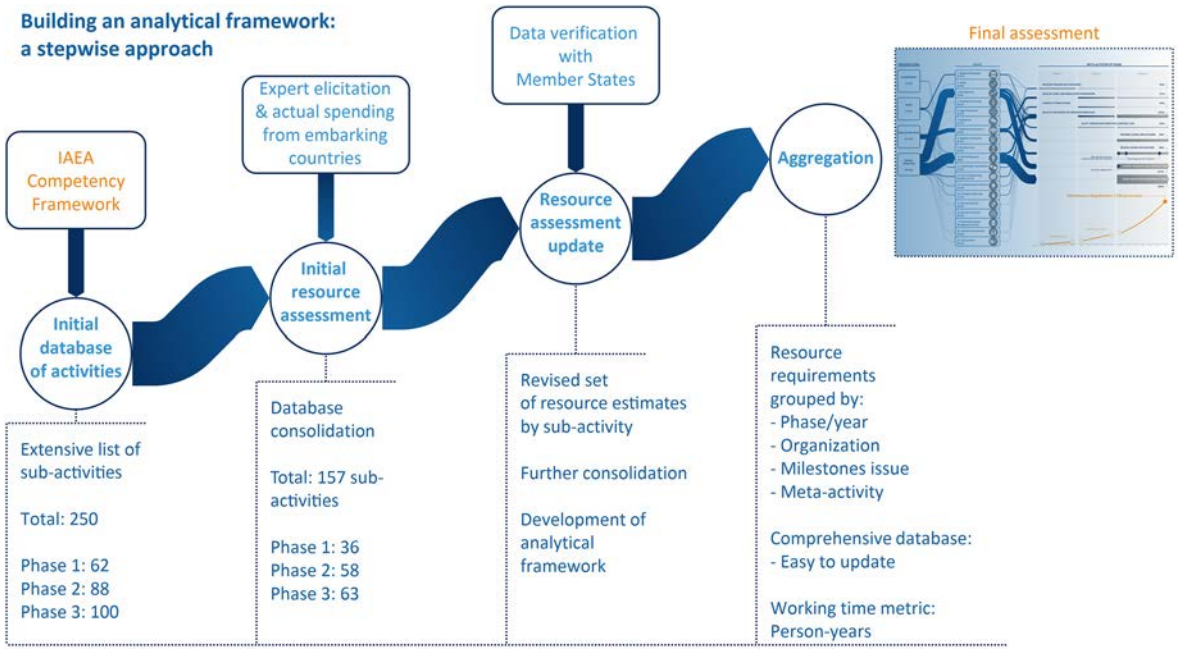

FIG. 1. Summary of the process to determine aggragated resource requirements. (The final assessment is presented in Fig. 2.)

4. RESULTS

4.1. OVERVIEW

Before looking at any of the resource requirements estimates in detail, the bigger picture will be presented as an overview of the results. The total resources (excluding hardware costs such as grid enhancements and site preparation) required for the development of the infrastructure for a nuclear power programme have been estimated at just over 7700 person-years. Not all of this will be provided directly from the staff of the government, the owner/operator of the nuclear power plant and the regulatory body, as some of it will be provided by contractors — consultants and technical support organizations. As mentioned in Section 2.2, government required resources have mostly been allocated to the NEPIO established by the government, but resources that provide advice on specific matters such as national security and financing have been allocated to other government entities (labelled as 'Government' in the figures).

Figure 2 provides an overview of how these resources are broken down by organization, phase, meta-activity and infrastructure issue, in the form of a Sankey diagram. The thickness of the lines is proportional to the amount of resource required. For example, the owner/operator resources contribute to many of the infrastructure issues, but are mainly used in infrastructure Issues 3 (Management) and 10 (HR development). The resources for Issue 3 are mainly used for the meta-activities, Prepare licence applications and Oversee manufacture and construction.

The left hand side of Fig. 2 shows a breakdown by organization. Approximately three quarters of the total resource will be provided by the owner/operator (for information, 60% of this resource is in the last three years of Phase 3). While some of this resource cost can be factored into a feasibility cost model and recovered through the cost of electricity produced, it is important to recognize that all of this resource will need to be funded by the Member State before any electricity is produced.

The central column shows the resources broken down by infrastructure issue. The most resource intensive issues are Management, Regulatory Framework and HR Development. Together they account for 84% of the total resource. As noted earlier, it is important to state that resource intensity does not

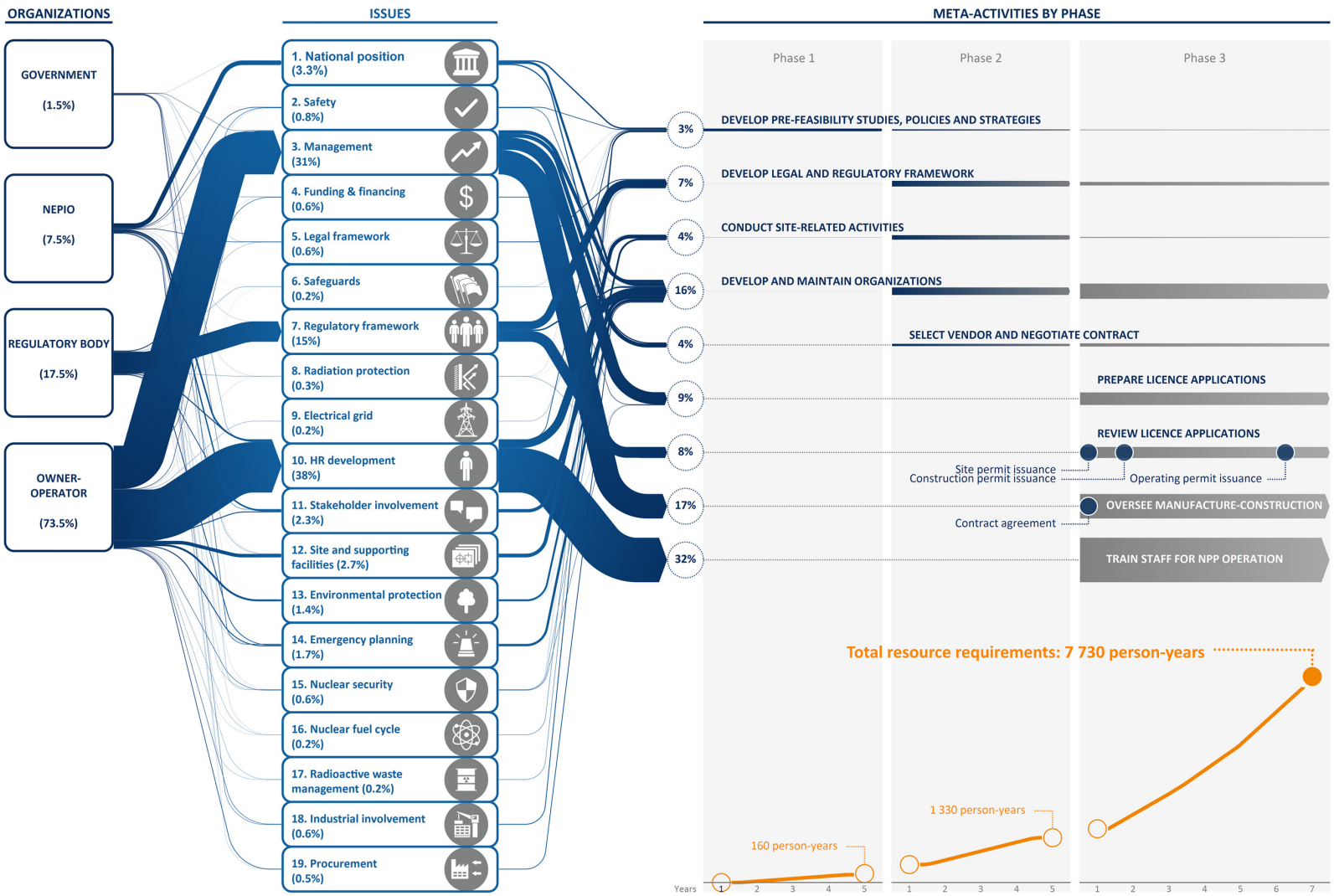

FIG. 2. Overview of resource requirements.

equate to significance for the programme. For example, poor stakeholder involvement could result in delay to or even cancellation of the programme. The 2% of resource expended in this area is essential. This example also provides an illustration of what is included in the resource estimates. It is likely that the programme will involve construction of one or more visitor centres. While the resources to staff these centres are included, the cost of building them is not.

Returning to Fig. 2, the right hand column shows the percentage of resource expended on each meta-activity, varying from 3% to 32%, and the distribution of that resource across the phases. Four of the nine meta-activities only take place in Phase 3.

Finally, Fig. 2 shows the buildup of resources used. By the end of Phase 1, a total of 160 person-years has been expended; by the end of Phase 2 this has increased by almost an order of magnitude to just over 1300 person-years and by the end of Phase 3 the total resource required is estimated to be just over 7700 person-years.

4.2. META-ACTIVITIES

Figures 3 and 4 show the estimated resources for each meta-activity. Figure 3 shows how the meta-activities and resources are split between the phases of infrastructure development and Fig. 4 shows the contribution of each organization to each meta-activity.

The main meta-activity in Phase 1 is 'Develop pre-feasibility studies, policies and strategies', but there are five separate meta-activities that need to be resourced in Phase 2, shown on the left hand side of Fig. 3. The three largest meta-activities overall are 'Develop and maintain organizations', 'Oversee manufacture and construction' and 'Train staff for NPP operation'. These three meta-activities account for over 65% of the total resources for Phase 3.

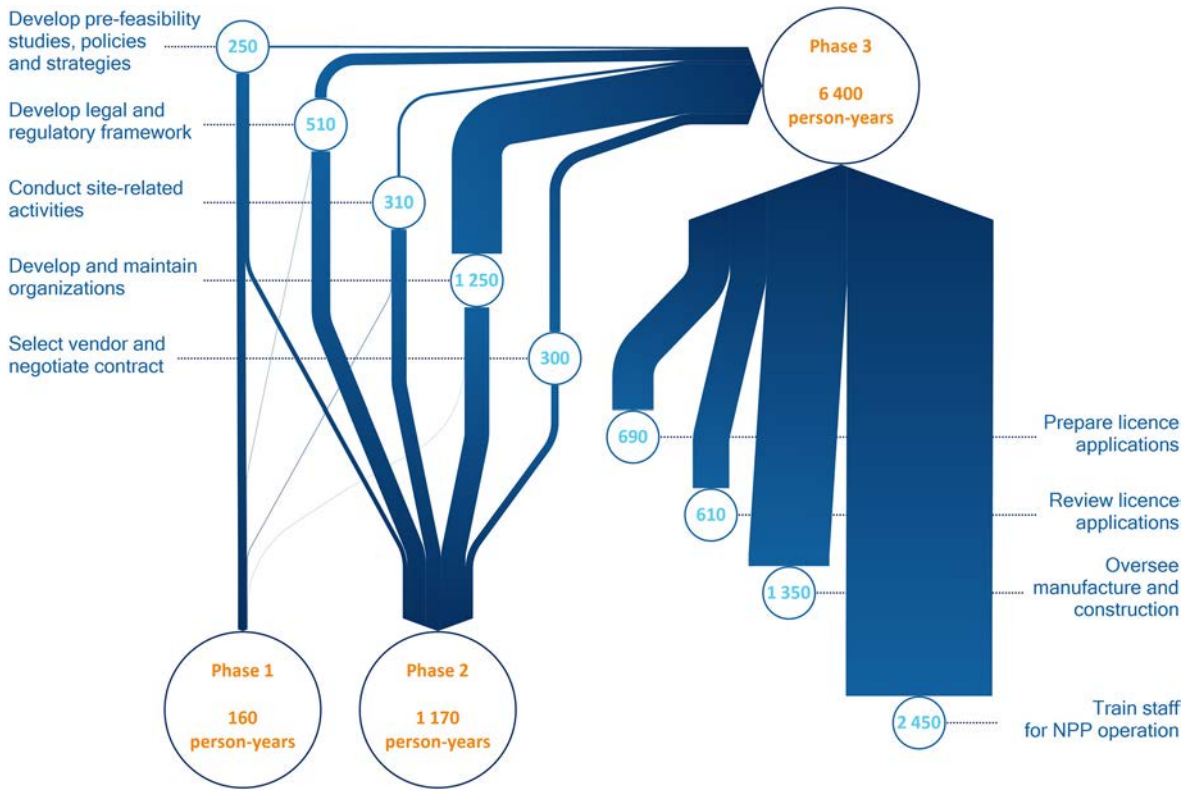

FIG. 3. Breakdown of resource requirements by meta-activities and Milestone phases.

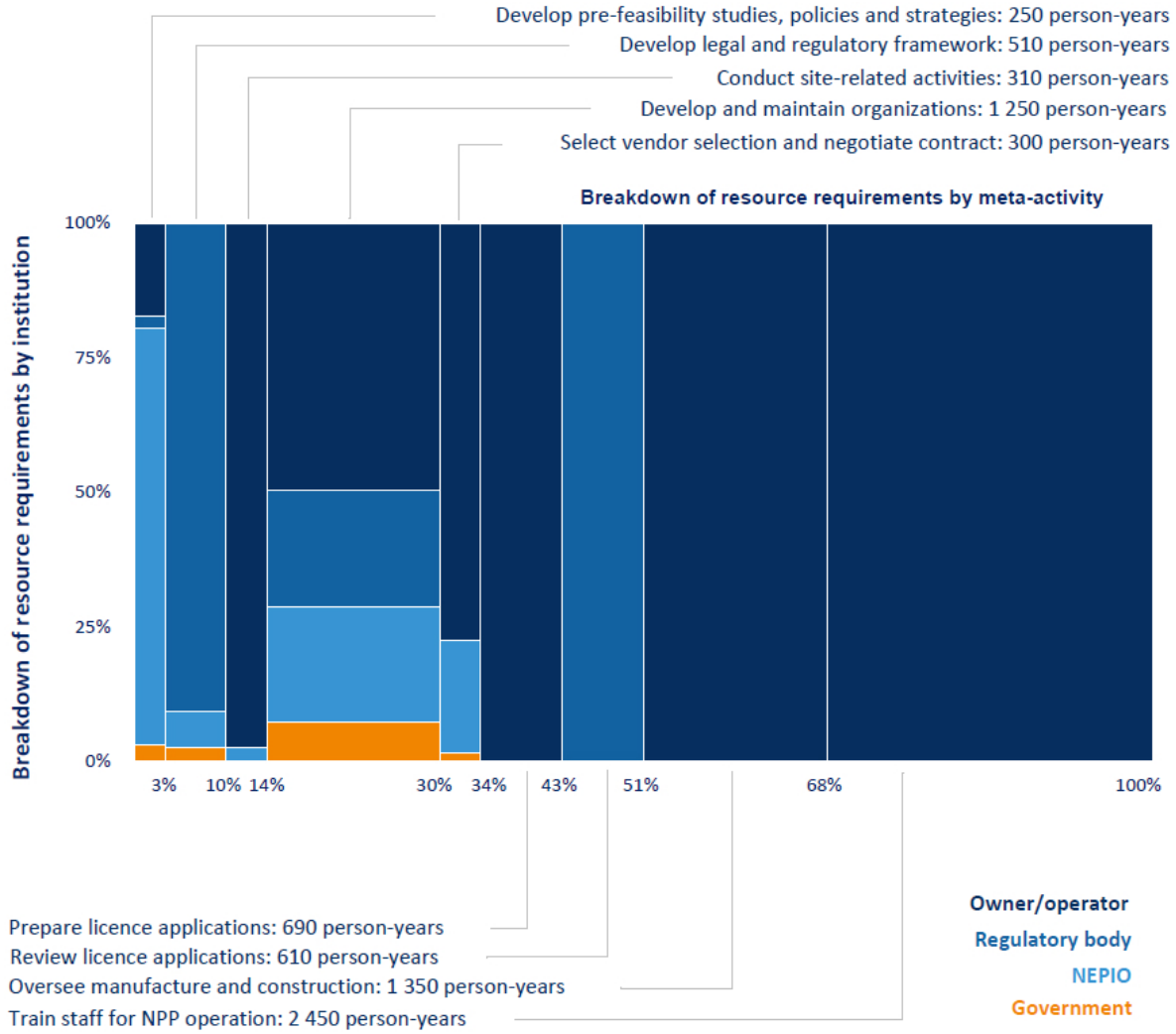

FIG. 4. Breakdown of resource requirements by meta-activities and institutions.

The rest of this section considers each meta-activity in turn and provides further information on their resources and management.

4.2.1. Develop pre-feasibility studies, policies and strategies

The bulk of the resource estimated for 'Develop pre-feasibility studies, policies and strategies' in Phase 1 (almost 60% of the total for this meta-activity) is to conduct the studies required for each infrastructure issue and develop a comprehensive report to enable the government to make a knowledgeable commitment. This task is the main job of the NEPIO in Phase 1, occupying almost 150 person-years, 90% of the total Phase 1 NEPIO resource. Some countries have carried out all these studies using their own resources and others have used varying degrees of consultancy support. Consultancy support can be a useful way of gathering international experience quickly, but equally carrying out these studies using national resources is a useful way of developing a deeper national understanding of the issues. Whichever approach is adopted, there is a clear need for a national evaluation of various options and decisions on the option, or options that are most appropriate for the country. Further discussion on NEPIO resources is contained in Section 5.1.

For Phase 2, the major policy areas requiring significant resources are safety, industrial involvement, and fuel cycle and radioactive waste management. For Phase 3, the relatively small resource on this

meta-activity is mainly focused on industrial involvement strategy and fuel cycle and radioactive waste management strategies.

4.2.2. Develop legal and regulatory framework

'Development of the legal and regulatory framework' is one of the main Phase 2 meta-activities (along with 'Conduct site related activities' and 'Develop and maintain organizations'). The bulk of the resource will come from the regulatory body and will be focused on developing and/or adopting the regulations and guides required for licensing. In Phase 2, the estimated resource is just over 300 person-years and in Phase 3 it is just under 200 person-years. Different countries have adopted different approaches to developing regulations, in part depending on their contracting strategy. Where a range of potential vendors are being considered, it is important to develop technology-neutral regulations. While relevant IAEA safety standards, or those of another country, can provide a good basis for developing regulations, considerable regulatory effort is still required to develop a good understanding of the basis of the regulations.

Some of the resources can be provided by technical support organizations (TSOs) or, through bilateral agreements, by regulators in other countries, but a significant proportion will need to come from the national regulatory body itself. It is also important to identify which regulations need to be developed in Phase 2 and which can be developed in Phase 3.

Development of the legal framework involves three main tasks: preparing for and ratifying international instruments, developing the comprehensive nuclear law and reviewing and amending other laws that might impact on the nuclear power programme. The resource for each of these has been estimated as approximately 10 person-years. This resource is heavily dependent on the response of government to the proposals. In several countries there have been a number of discussions and iterations of the law before an acceptable position is reached. This is likely to increase the resource required. It is also important to recognize that while the resource allocation is relatively small, the time taken to complete these activities may be considerable due to the length of the process to draft, adopt and implement national laws.

4.2.3. Conduct site related activities

In Phase 1, the requirement is to conduct a survey of the country and identify potential regions where a nuclear power plant could be constructed, identify potential sites within those regions and then identify candidate sites for further investigation. The more resource intensive work is carried out in Phase 2 to establish the actual site and then carry out the site characterization studies. The work required is described in Refs [13, 14]. The resource for the Phase 1 work has been estimated as approximately 10 person-years. Some countries have used consultants to carry out this work, but others have carried out the work themselves using software mapping tools.

The work for Phase 2 requires much more resource and generally involves a mix of national and consultancy resource. Universities often have many of the data and models required. The overall resource has been estimated as approximately 250 person-years. This includes some grid studies, site characterization and the environmental impact assessment. In addition to HR requirements there will be a need for hardware costs involved in investigating the site and monitoring site related parameters.

Most newcomer countries have adopted a licensing approach that requires a site permit/licence to be issued prior to any consideration of a construction licence. The resource to prepare a site licence application is included here.

The amount of work for these Phase 2 studies will depend on a number of factors, including the number of sites, the extent of public consultation expected and the availability of suitable sites.

Some confirmatory work, including environmental monitoring on and around the site, is also required in Phase 3, but the resource requirements are considerably lower (estimated as fewer than 50 person-years).

4.2.4. Develop and maintain organizations

Once the commitment has been made to develop a nuclear power programme, establishing a nuclear regulatory body and an owner/operator of the future nuclear power plant are essential steps for the further development of the programme.

This begins early in Phase 2 and the overall resource has been estimated at just over 400 person-years split between government, NEPIO, the regulatory body and the owner/operator. It includes activities related to defining structures and management systems and recruiting and training staff. As mentioned earlier, the resources for activities related to stakeholder engagement and to emergency preparation and response are also included in this meta-activity.

As well as workforce planning, defining structures, processes etc., and the overhead resources required for recruitment and training, the cost of employing staff during their training when they are 'non-productive' is included here. Once staff reach sufficient competence to carry out their work, the resource is allocated to other meta-activities, such as 'Develop legal and regulatory framework' or 'Select vendor and negotiate contract'. In reality, the divide between 'Develop and maintain organizations' and other meta-activities will not be so clear-cut and some of the resource allocated here will be used for other activities.

Of the total 400 person-years in Phase 2, approximately a quarter are allocated for stakeholder engagement and roughly 60% are allocated to recruiting and training staff. As well as these resources, there will be costs associated with information centres, offices etc.

The total resource estimated for Phase 3 is approximately 840 person-years, of which the two largest components are further competence development, including establishing the owner/operator training department (42%), and further development of the organizational structure and management system (30%). Again, there will be significant costs associated with items such as a training centre, offices and emergency monitoring equipment.

4.2.5. Select vendor and negotiate contract

This implementation of this meta-activity varies considerably between newcomer countries. Some have established an early intergovernmental agreement with a selected vendor country and others have issued a bid invitation specification, evaluated offers and concluded a contract with the chosen vendor. The resources will vary depending on the route chosen, but in all cases there is a need for the customer of the EPC contractor to develop technical requirements that form the basis of the contract.

The estimated resources are approximately 120 person-years in Phase 2 and 180 person-years in Phase 3. Early in Phase 2, the country will need to decide on its contracting strategy and therefore there will be a significant involvement of the government/NEPIO. Developing the bid invitation specification and/or technical specifications is the role of the owner/operator. The Phase 3 resource is required in the first two years and is all in the owner/operator except for a small government input. This latter resource is likely to have some involvement in the final vendor selection, as well as in the financial agreement, such as provision of a sovereign guarantee. The extent of resources required to negotiate the contract will vary significantly, depending on the number of vendors being negotiated with and the nature of financial and technical support being requested. More detailed guidance on this meta-activity is contained in Refs [15, 16].

4.2.6. Prepare licence applications

This and the meta-activities that follow are Phase 3 activities. The resource estimate is approximately 170 person-years for the construction licence and 520 person-years for the operating licence.

For the construction licence, the vendor will provide the bulk of the information as part of the supply contract and that work is not included here. However, the owner/operator is required to review the information provided by the vendor and develop the additional information required to apply for the

construction licence. The owner/operator will also need to manage the process of responding to questions from the regulator during the licensing process. There will be further requirements for information during construction, but in terms of resource, this has been allocated to preparing for the operating licence.

The assumption is that 80–100 people per year will be engaged for the duration of Phase 3. Of course this does not mean 80–100 people working full time. There will be a relatively small number of staff working full time in this area and a large number of staff working part time, providing expertise in a range of technical, scientific and management disciplines.

For the operating licence, much more of the information required will need to come from the owner/operator itself, for example information on training arrangements, radiation protection, emergency preparedness and response arrangements.

4.2.7. Review licence applications

This meta-activity covers the review by regulatory bodies of the licence submissions from the operating organization and the inspections during manufacture and construction. The estimated resource is just over 600 person-years, split approximately 75%/25% between review and inspection. The review of the construction licence will be the first major activity for the licensee and the volume of documentation will be huge. For a design that has an approved reference plant, the regulator is likely to rely significantly on the original licensing review in the country of origin, but will want to build its own understanding and look in detail at site related aspects. The regulator is also likely to make significant use of consultant resources for this task but then use the interactions with the consultants to develop its own capability. It is assumed that by the time of the operating licence, the regulator is expending about 70 person-years per year on this meta-activity. Again, there will probably still be some use of consultants.

For inspection activities during manufacture and construction a significant fraction of the resource is likely to come from specialist inspection companies, but it will also be a major activity for regulatory body staff. Towards the end of Phase 3 they will also need to develop plans and capabilities for inspection during operation.

4.2.8. Oversee manufacture and construction

This meta-activity covers the owner/operator's role in overseeing the work of the EPC and other contractors. The previous section addressed the regulator's role of inspection during Phase 3. The total resource allocated to this task is almost 1400 person-years and it is important for newcomer countries to note that even with a turnkey contract this is a major task to ensure that the contract requirements are met in full, that the licensee responsibilities are fulfilled and that the owner/operator takes every opportunity to learn during the construction period. The resource estimate here is based on between 200 and 375 person-years per year.

The experience of those who have been involved in this activity is that this is a unique opportunity in the life of the NPP to acquire engineering knowledge that will be essential for operating the plant safely and effectively. Of course the monitoring of the EPC contractor requires experienced staff and the owner/operator is likely to supplement its own resources with consultant resources, often known as the owner's engineer. The assumptions in the resource levels here reflect this and recognize that some of this will be new staff shadowing consultant or EPC experts.

4.2.9. Train staff for nuclear power plant operation

This is the largest of all the meta-activities, with an estimated resource of just over 2400 person-years. It covers the training that is required to develop the competences necessary for NPP operation. Although it is common for the EPC contract to include training of operations and maintenance staff, the training of other staff will need to be provided by the owner/operator. The training under the EPC contract takes between two and five years, depending on the role. In addition, some of the more senior roles require

experience and additional training. While the EPC contract pays for the training, the owner/operator needs to recruit and pay the salaries of the staff under training. The assumptions behind the numbers proposed are that 100 staff are recruited at the start of Phase 3 (to act as senior operators and trainers), rising to 550 in the two years before startup of the NPP.

5. RESOURCES AND MAIN ACTIVITIES FOR EACH KEY ORGANIZATION

5.1. NUCLEAR ENERGY PROGRAMME IMPLEMENTING ORGANIZATION

Reference [7] describes the responsibilities and functions of a NEPIO as well as its organization. It notes that there are many ways to structure a successful NEPIO.

In some countries the NEPIO is an organization that is appointed by the government, with its own staff and budget. In other cases, the NEPIO is a committee whose staff and budget have been borrowed from other organizations in the State. In all cases, the NEPIO will ideally include a high level interagency decision making mechanism to ensure that its recommendations to the government have strong and broad support. These differences in organizational structure do not have a significant impact on the resources required to carry out the activities. However, they do blur the lines between what this publication might consider as NEPIO resources and government resources. The approach taken here is that in Phase 1 all the government involvement is included under NEPIO resources. For Phases 2 and 3, an attempt has been made to distinguish between government and NEPIO resources. Those tasks associated with establishing key organizations, planning, monitoring and coordinating the development of nuclear infrastructure are assigned to the NEPIO. Those tasks that clearly belong in a government entity, such as national security, national emergency response, or ministry of finance, are assigned to the government.

In Phase 1, the NEPIO's principal responsibility is to coordinate the preparation of the studies and compile the information necessary for the government to make a knowledgeable commitment to proceed with the development of a nuclear power programme. If the government decides to proceed, the NEPIO's principal responsibility in Phase 2 is to coordinate and monitor the development of the necessary infrastructure among the various responsible parties — for example, government ministries, regulators and the designated owner/operator — to bring the country to a point of readiness to issue a bid or negotiate a contract for the first NPP project. In Phase 3, the NEPIO, with representation from the owner/operator, the regulatory body and the specific agency identified as responsible for the government's role in the nuclear power programme, ensures the overall development of the infrastructure to sustainably implement the national strategy.

Figure 5 shows the resources estimated for the NEPIO. The two meta-activities requiring most NEPIO resource are 'Develop pre-feasibility studies, policies and strategies' (~200 person-years) and 'Develop and maintain organizations' (~270 person-years). The former is the main Phase 1 focus for the NEPIO. In Phase 2 both of these meta-activities involve significant NEPIO resource. In addition, the NEPIO will need to allocate some resource to the process of selecting a vendor and developing the legal and regulatory framework. The right hand column of Fig. 5 shows a further breakdown of the key individual activities for the NEPIO and the phase in which they occur. For example, the most resource intensive activity is 'Monitor progress and organization developments against programme objectives', and this is a Phase 3 activity. The next most intensive resource activity is stakeholder engagement during Phase 2. (In Phase 3 much of the stakeholder engagement is done by the government, the regulatory body and the owner/operator).

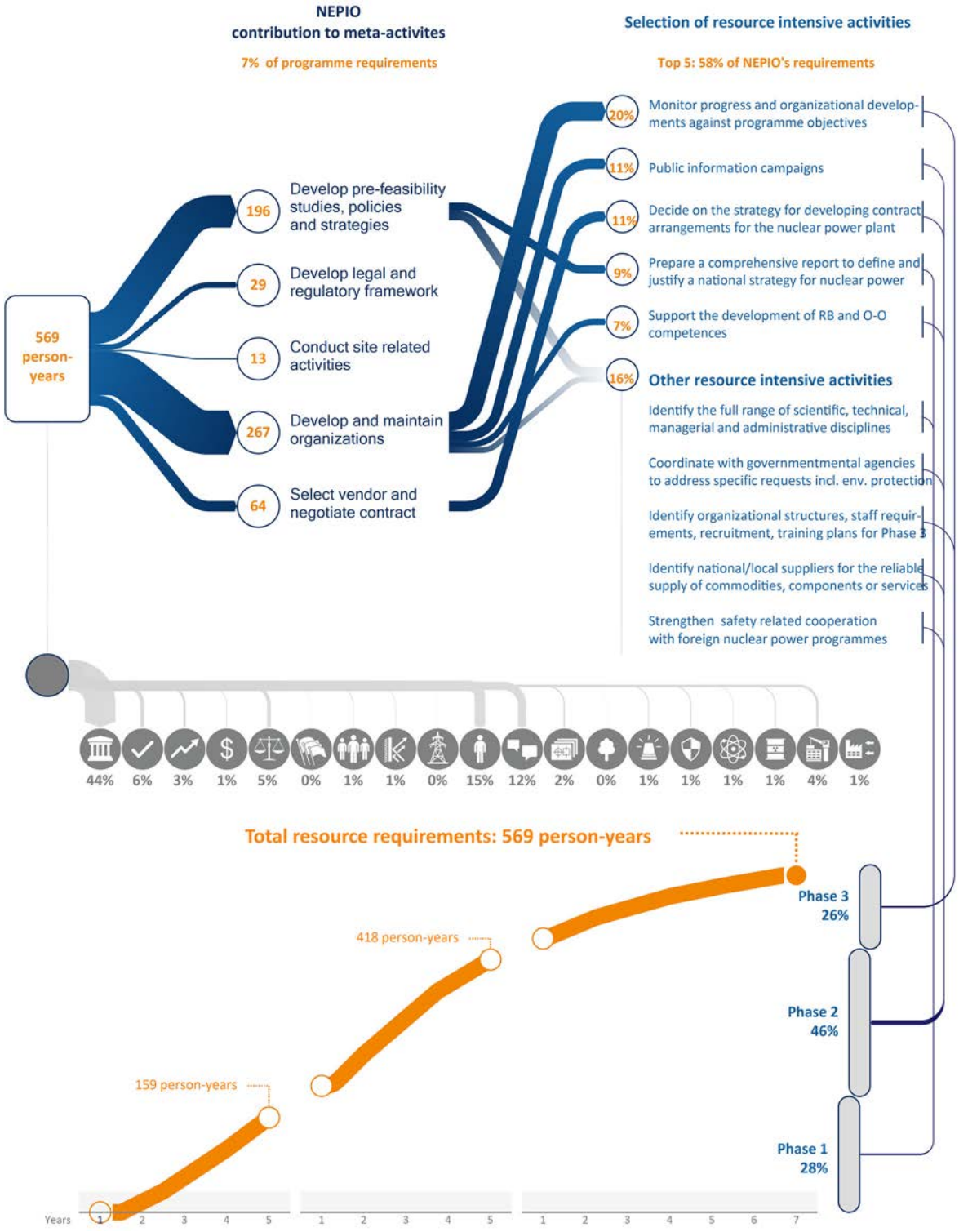

FIG. 5. Overview of NEPIO resource requirements.

The centre of Fig. 5 shows the split of resource by infrastructure issue. As would be expected, considerations related to national position use almost half the NEPIO resource. The next two most significant infrastructure issues for the NEPIO resources are HR development and stakeholder involvement.

The graph at the bottom of Fig. 5 shows two additional important points. Firstly, that the NEPIO resources in Phase 2 are significantly greater than in Phase 1, reflecting the importance of ensuring that

the conclusions and recommendations of the comprehensive report are implemented successfully in Phase 2 through the owner/operator and regulator. Secondly, that significant resources are still required in Phase 3 to monitor and coordinate the programme and provide the necessary government input.

To complement the data discussed above, an analysis has been carried out using country information provided by Poland. This information is discussed in Appendix I.

5.2. REGULATORY BODY

The Milestones approach [1] assumes that the regulatory body will be established early in Phase 2 either from an established radiation protection regulatory body or as a new organization. As noted in Ref. [10], the main activities required relate to establishing the organization with clear roles, responsibilities and processes; recruiting and developing competent staff; establishing a legal framework; developing regulations and guides for safety, security and safeguards; defining and implementing a licensing process; and defining and implementing an inspection programme.

As shown in Fig. 6, the two most resource intensive meta-activities are 'Develop legal and regulatory framework' and 'Review licence applications'. The first of these begins in Phase 2, defining the siting requirements, licensing process, design requirements and other requirements necessary for the bidding process (e.g. management systems, training requirements, quality assurance programme). A complete set of regulatory documents needs to be defined in Phase 3. These are also the second and third activities identified on the right of Fig. 5. (see also Section 4.2.2). The largest meta-activity for the regulatory body is 'Review licence applications' (note that this includes inspection activities during construction). This meta-activity is discussed in detail in Section 4.2.7. The third largest meta-activity for the regulatory body, with an estimated resource of approximately 250 person-years, includes resources required for stakeholder involvement and emergency planning (approximately 90 person-years).

Figure 6 also shows the total resource estimated for Phases 2 and 3. Although it shows almost twice the resource for Phase 3, this is not because the regulatory body is a much larger organization in Phase 3. It is partly because Phase 3 is longer than Phase 2, but also because the staffing of the regulatory body builds steadily through Phase 2, whereas in Phase 3 the regulatory body is fully functional throughout the phase.

To complement the data discussed above, an analysis has been carried out on annual reports published by the nuclear regulatory body in the United Arab Emirates. This information is discussed in Appendix II.

5.3. OWNER/OPERATOR

Reference [8] describes the roles and responsibilities of the owner/operator in each phase of the Milestones approach [1].

During Phase 2, the owner/operator will be established as a relatively small organization and will develop the capability to select and justify the site and establish technical specifications for the nuclear power plant to be included in the bid invitation or to guide negotiations with a preferred vendor.

Early in Phase 3, the owner/operator will need to assess offers and place contracts and begin a steady expansion of its capability in order to prepare a construction licence application and oversee construction activities. Towards the end of Phase 3, it will need the competence to prepare an operating licence application and be ready for commissioning and plant operation. The owner/operator will need to be an organization that is able to operate and maintain the nuclear power plant, with competent staff and a management system that is suitable for an operating nuclear power plant.

This growth in size and competence can be seen clearly in the graph at the bottom of Fig. 7 and also in the resources identified for each meta-activity. The resources needed for the initial meta-activities (developing strategies, conducting siting studies, negotiating a contract) are all significantly smaller than

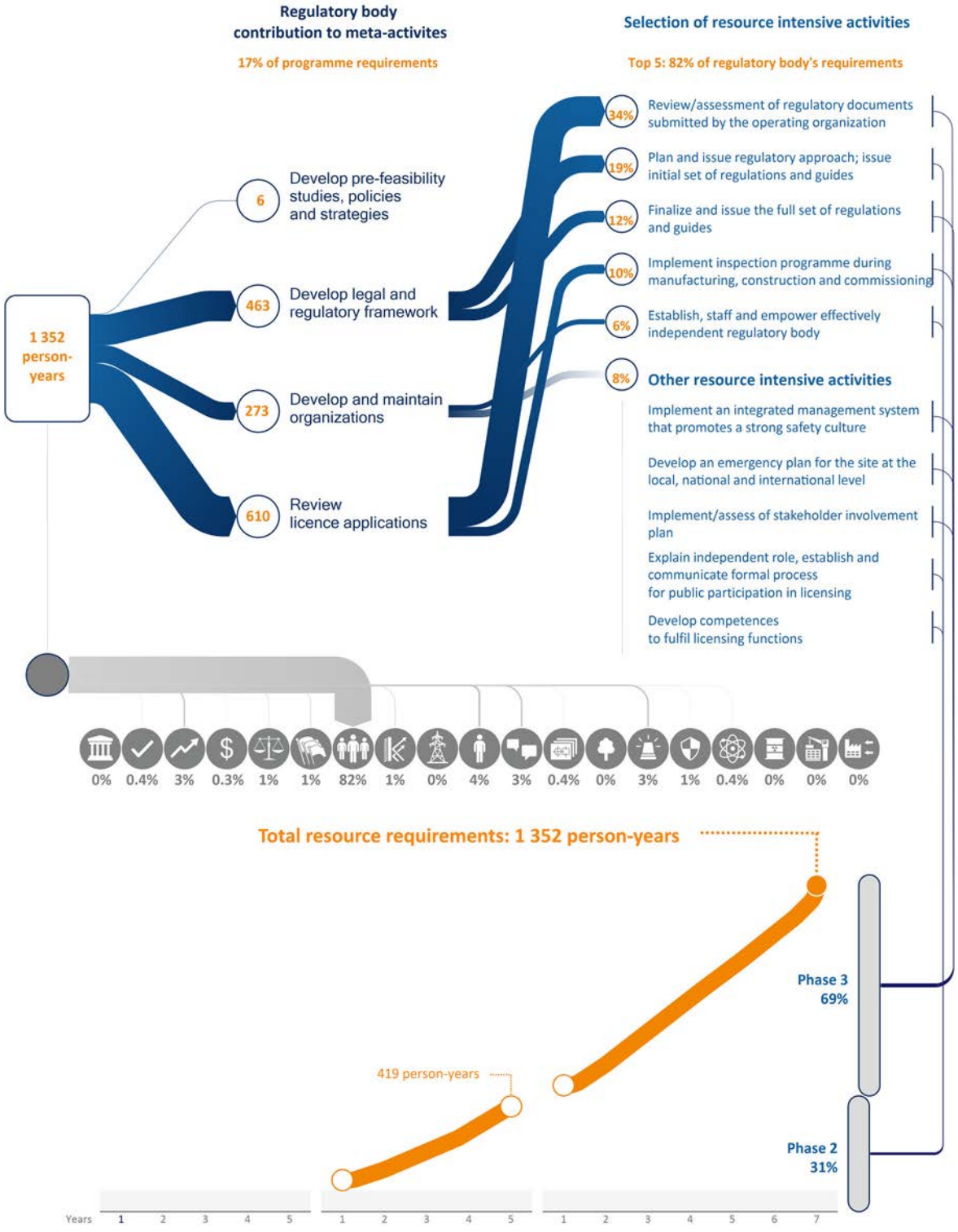

FIG. 6. Overview of regulatory body resource requirements.

those needed for any of the later activities of preparing licence applications, overseeing construction and staff training.

During Phase 2 and construction of the NPP, the owner/operator is likely to supplement its own resources with those of an owner's engineer (see Section 4.2.8). However, by the end of Phase 3 it needs

adequate resource in its own organization to operate the plant safely. The resource needed will depend on the staffing model for operation. There is considerable variation between Member States operating nuclear power plants, depending on a number of factors, including their experience, the number of units and the opportunities for outsourcing activities. Reference [8] includes one example of 820 staff for a two unit plant. The data here are based on a total resource at the end of Phase 3 of close to 1200 staff.

The activities identified on the right of Fig. 7 show the same picture as described above. The most resource intensive activities are associated with developing competent staff (activities 1 and 4), managing the construction contract (activity 2) and applying for licences (activities 3 and 5). These activities are also discussed above in Sections 4.2.7–4.2.9.

To complement the data discussed above, an analysis has been carried out on information provided by Belarus, as an example only. This information is discussed in Appendix III.

6. SUMMARY AND CONCLUSIONS

The resources (in terms of person-years) to develop the nuclear power infrastructure have been estimated based on the information in the Competency Framework [9]. The overall estimate is slightly over 7700 person-years. These resources will be a mix of national resources and, if necessary, foreign consultants/experts. The actual cost of these will depend on competence requirements, salary costs in the country and the split between national staff and foreign consultants. While the cost will be small compared to the capital cost of the nuclear power plant, it is still significant (estimated as 5–10%). Furthermore, the cost will generally not be part of the financing arrangements for the NPP and will need to be provided by the State, from its own funds or, for some activities, through bilateral support agreements.

These resources will mainly be needed in the regulatory body (just under 20%) and the owner/operator (~75%), although resources are also required in government departments, universities and other national organizations.

The publication has not sought to clarify the different competences required, though the majority will be engineers, scientists and technicians. The resources estimated include the overhead resources for administration and management. Competences will also be required in the areas of law, contracting and finance, although they will be a very small percentage of the total. References [4–10] provide further guidance on competence requirements, development and management.

The purpose of this publication is not to define the required size of organizations, but to aid countries in their forward planning of future resources required. Each organization will need to conduct their own detailed workforce planning studies to identify the numbers of staff needed and their competences and experience.

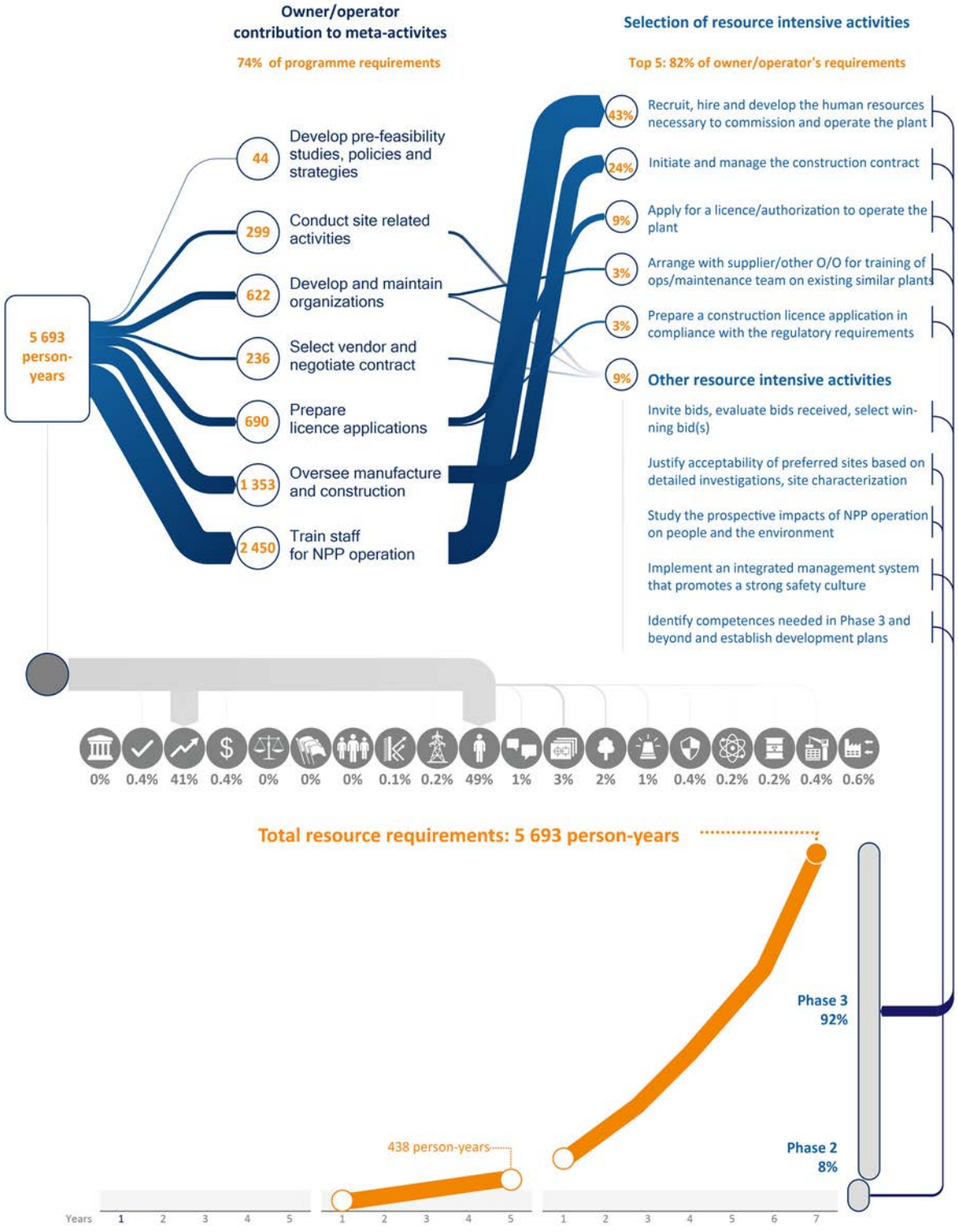

FIG. 7. Overview of owner/operator resource requirements.

Appendix I

RESOURCES MOBILIZED FOR NUCLEAR PROGRAMME DEVELOPMENT: THE CASE OF POLAND — NEPIO

I.1. NEPIO STRUCTURE AND STAFFING

The following outlines the structure and staffing of the nuclear energy programme implementing organization in Poland. The tasks and resources of the organizations that are represented on the NEPIO are presented in Tables 2–4.

(a) Department of Nuclear Energy (NED) in the Ministry of Energy.
(b) Organizational structure:
    (i) One Director;
    (ii) One Deputy Director/Head of Strategy and Regulation Unit, six staff;
    (iii) One Head of Public Communication and HR Development Unit, eight staff;
    (iv) One Head of Technical Infrastructure, Fuel Cycle and R&D Unit, seven staff.
(c) Total staff: 24 persons, including 18 experts (2 nuclear physicists, 5 engineers, 3 economists, 3 lawyers, plus others, such as public relations specialists).

TABLE 2. NEPIO TASKS AND RESOURCES — STRATEGY AND REGULATION UNIT

Institution	Areas of work	Tasks	No. of experts	Task duration (if completed) in person-months
		Preparation of draft amendments to the following laws, when necessary: (1) Atomic Law Act and (2) Act on Developing and Implementing Nuclear Energy Projects and Related Facilities	2 lawyers	18 months
Nuclear Energy Department	Legislation	Delivering opinions on draft laws and regulations related (directly or indirectly) to nuclear power development in the framework of the legislative process	1 lawyer	Continuous work

TABLE 2. NEPIO TASKS AND RESOURCES — STRATEGY AND REGULATION UNIT (cont.)

Institution	Areas of work	Tasks	No. of experts	Task duration (if completed) in person-months
Nuclear Energy Department, General Directorate for Environmental Protection, Nuclear Regulator (NAEA), Radioactive Waste Management Plant (ZUOP), Technical Support Organization (NCBJ), Project Company (PGE EJ1)	PNPP document	First draft	10 (engineers, economists, lawyers, others)	6 months
		Legislative proceedings	2 lawyers 1 other	12 months
		Cross-border consultations	~30 (engineers, lawyers, others)	36 months
		4 year progress report; PNPP document revision	10 (engineers , economists, lawyers, other)	3 months
Nuclear Energy Department	International cooperation	Cooperation with IAEA, NEA/OECD, INPRO	1 other	Continuous work
		European Union (EU) issues, bilateral cooperation	1 lawyer ¼ other	Continuous work
	Economic analyses	Financing system for the first NPP	1 economist	In progress since May 2016

TABLE 3. NEPIO TASKS AND RESOURCES — PUBLIC COMMUNICATION AND HUMAN RESOURCE DEVELOPMENT UNIT

Institution	Areas of work	Tasks	No. of experts	Task duration (if completed) in person-months
Nuclear Energy Department	HR development	Preparing a draft of the HR development plan	2 other	24 months
		Organizing of training and training materials for teachers		Continuous work
		Organizing of educational events (science picnics, demonstration lessons)		Continuous work
		Preparing analyses and reports on education, studies and training in nuclear sector	1 other	Continuous work
Ministry of National Education		Revision of National Profession Registry	1 other	0 months

TABLE 3. NEPIO TASKS AND RESOURCES — PUBLIC COMMUNICATION AND HUMAN RESOURCE DEVELOPMENT UNIT (cont.)

Institution	Areas of work	Tasks	No. of experts	Task duration (if completed) in person-months
	Public communication on nuclear power	Cooperation with journalists, preparing press information, social media (Facebook, Twitter), media monitoring, responding to inquiries, etc.	1 nuclear engineer	Continuous work
Nuclear Energy Department	Popularization of knowledge on nuclear power	Events, conferences, seminars, public opinion polls, information materials (leaflets, books, films, games), study tours, etc.	5 communication specialists	Continuous work
	Public communication regarding new waste repository	Media monitoring, public consultations, contact with local governors and society, information materials		Continuous work

TABLE 4. NEPIO TASKS AND RESOURCES — TECHNICAL INFRASTRUCTURE, FUEL CYCLE AND R&D UNIT

Institution	Areas of work	Tasks	No. of experts	Task duration (if completed) in person-months
Nuclear Energy Department	Radioactive waste management	National Plan for Radioactive Waste and Spent Fuel Management	1 lawyer 1 engineer 1 other	12 months
		New repository site survey	1 engineer 1 other	36 months
Nuclear Energy Department (NED), industry companies, TSO	National industry involvement (localization)	Training activities (workshops for industry participants)	1 industry manager/ economist (NED) 1 engineer (NED) (part time)	Continuous work
Nuclear Energy Department (NED), Transmission System Operator (PSE)	Transmission system	Grid studies	1 engineer (NED) (part time)	Continuous work
Nuclear Energy Department, Nuclear Regulator (NAEA)	TSO development	Adjusting of R&D institutes to the role of TSO	2 engineers (NED, NAEA) 2 others (NED, NAEA)	Continuous work

TABLE 4. NEPIO TASKS AND RESOURCES — TECHNICAL INFRASTRUCTURE, FUEL CYCLE AND R&D UNIT (cont.)

Institution	Areas of work	Tasks	No. of experts	Task duration (if completed) in person-months
Nuclear Energy Department	NPP technical infrastructure (roads, railways, bridges, etc.)	Development of NPP technical infrastructure	1 other	Continuous work

Note: Resources associated with external contractors are not reported.

I.2. CONTRACTORS

Contractors are used only in the two following cases:

— When a task requires specific knowledge and/or a large number of people;
— When mandatory due to national or EU regulations (e.g. external independent assessments).

Contractors can come from various backgrounds such as:

— R&D institutes;
— Government controlled institutions (e.g. Polish Geological Institute) or companies (e.g. Transmission System Operator);
— Private companies (e.g. public relations firms, engineering/design firms, think tanks).

I.3. REPORTED COST DRIVERS

The reported cost drivers are:

(a) Political factors — fundamental influence on decision making process.
(b) National and EU legislation and regulations (bureaucracy, paperwork) — these determine the length and costs of procedures, especially those dedicated to public procurement, environmental impact assessment and even the salaries of experts hired by the government institutions. Strict EU environmental regulations raise the cost of NPP preparatory works (site investigation, environmental impact assessment (EIA) report etc.), and they are not balanced, that is, the incremental cost of environmental protection procedures outweigh the actual value added (benefits) for the environment. The cost is finally paid by all consumers. This also concerns the radiation dose limits (linear-non-threshold hypothesis), which influence the size of the exclusion area around the NPP and force NPP owner to buy out a significant number of properties (houses, land). Be aware that mean population density around the currently investigated NPP sites is ~125 persons/km^2, not including seasonal changes (summer tourism). The financing system for the NPP may require consultation with European Commission, incurring additional costs and time (and time transforms into other costs).
(c) Adequate staffing — an insufficient number of people engaged in the project (NEPIO, utility, regulator) creates bottlenecks, slowing execution of the project and forcing the NEPIO to outsource activities that normally can and ought to be performed by its own staff (and for much lower cost).

Appendix II

RESOURCES MOBILIZED FOR NUCLEAR PROGRAMME DEVELOPMENT: THE CASE OF UNITED ARAB EMIRATES' FEDERAL AUTHORITY FOR NUCLEAR REGULATION

II.1. RESOURCES MOBILIZED

Figure 8 shows the staffing and breakdown of expenditure of the Federal Authority for Nuclear Regulation in the United Arab Emirates over a ten year period.

Key milestones

2008 Federal Authority for Nuclear Regulation established

2010 Issuance of licence for site selection and characterization

2012 Issuance of construction licence for units 1 and 2

2013 Start review of licence application for units 3 and 4

2015 Issuance of construction licence for units 3 and 4. Twenty-three Barakah related safety inspections completed

2016 Start review of operating licence for units 1 and 2. Nineteen Barakah related safety inspections completed

2017 Start review of operating licence for units 3 and 4. Review of operating licence for units 1 and 2 is 85% complete. Forty Barakah related safety inspections completed

2018 Review of operating licence for units 1 and 2 is 95% complete. Twenty Barakah related safety inspections completed.

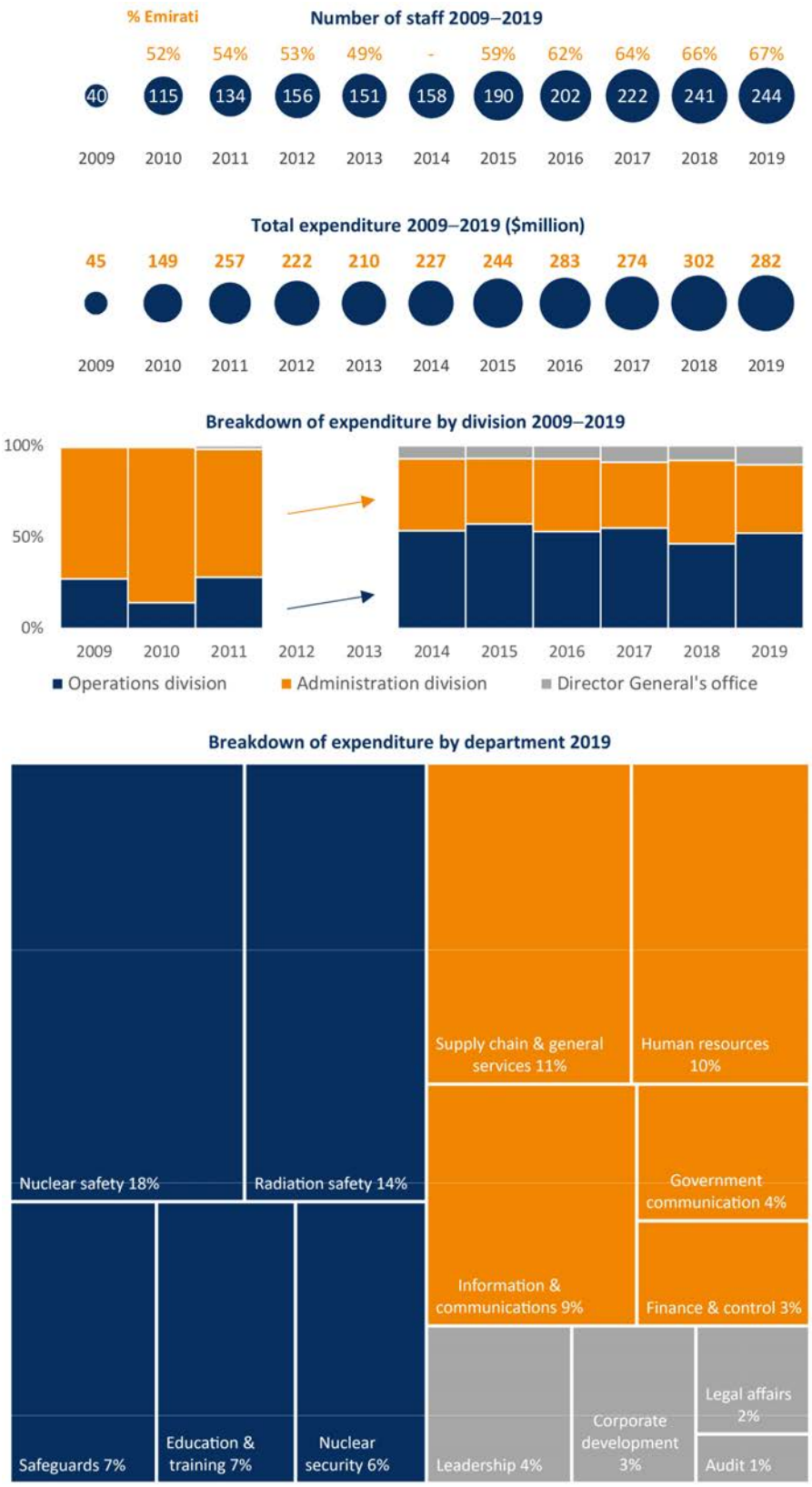

FIG. 8. United Arab Emirates' Federal Authority for Nuclear Regulation staffing and breakdown expenditure 2009–2019 (based on Annual Reports 2011–2019, courtesy of the Federal Authority for Nuclear Regulation).

Appendix III

RESOURCES MOBILIZED FOR NUCLEAR POWER PROGRAMME DEVELOPMENT: THE CASE OF BELARUS

III.1. RESOURCES USED

Tables 5 and 6 show the HR and budget breakdown for the nuclear power programme (two units (2400 MW total capacity)) in Belarus.

TABLE 5. HUMAN RESOURCE DEVELOPMENT 2008–2021 (NUMBER OF STAFF)

	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018	2020	2021 (planned)
Key organizations													
NEPIO/ managing company	11	11	11	11	11	11	11	11	11	11	11	11/20	11/20
Regulatory body	37	37	37	37	37	82	82	82	82	82	82	82	82
SSO/TSO	20	20	20	20	20	50	50	50	50	50	70/25	70/25	70/25
Belarusian NPP staff													
Total	28	36	40	52	65	139	283	498	863	1121	1680	1919	2533
Foreign experts (%)	11%	8%	10%	8%	6%	4%	8%	11%	11%	11%	9%	9%	7%

Note: Scientific Institution Sosny and the Center for Nuclear and Radiation Safety act respectively as the scientific support organization (SSO) and the technical support organization (TSO).

TABLE 6. SELECTED BUDGETS (IN US $ MILLION)

	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019
State budget for NPP current performance	0.4	0.9	1.1	1.1	1.2	1.9	3.4	6.1	7.0	11.0	16.5	24.7	21.3
National development fund for infrastructure construction	1.7	20.9	43.1	34.5	24.1	27.8	22.0	34.6	37.2	23.7	10.9	10.7	7.6
State programme for personnel training (64 specialists)									0.04	0.19	0.08	0.11	0.07
State programme for scientific support			2.1 (2009–2010)		1.3 (2011–2012)		0.39	0.34	0.27	0.30	0.25	0.22	0.17

Note: State budget for current performance of NPP, including salaries and taxation, consulting activities, expert services, membership dues, IAEA missions, etc.: ~US $100 million. National Development Fund for the construction of the infrastructure, including houses, roads, industrial base, visitor centre, etc.: ~US $300 million. State Programme of Personnel Training for Nuclear Power Programme involving preparation of specialists in the nuclear area: ~US $75 million. State Programme of Scientific Support for Nuclear Power Programme Development including the development of technical standards, conducting a survey, expert services, etc.: ~US $2.5 billion. State budget for Current Performance of Key Organizations — RB, NEPIO — including salaries and taxation, expert services, etc.: ~US $30 million.

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ABBREVIATIONS

EIA	environmental impact assessment
EPC	engineering–procurement–construction
EU	European Union
HR	human resources
NEPIO	nuclear energy programme implementing organization
NPP	nuclear power plant
R&D	research and development
SSO	scientific support organization
TSO	technical support organization

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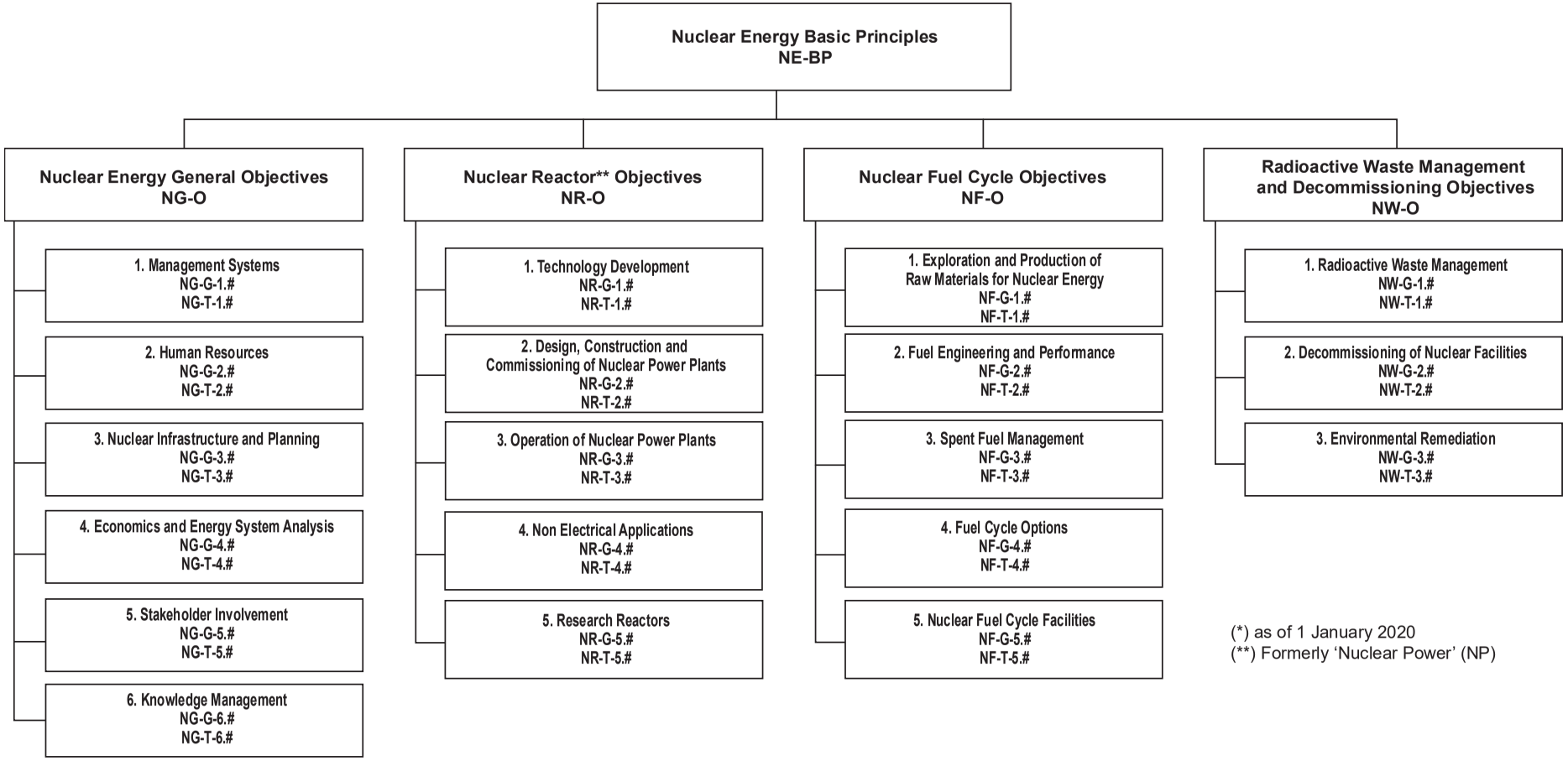

(*) as of 1 January 2020
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T: Technical Reports
Nos 1–6: Topic designations
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