

Milestones guide newcomer countries on road to nuclear power

By Dick Kovan

About 30 countries are currently considering or planning to build their first nuclear power reactors or have already ordered a reactor or started plant construction. This new wave of interest, which started around 2004–2005, has meant that many “newcomer” countries have turned to the International Atomic Energy Agency for assistance in developing a nuclear power program.

The establishment of a nuclear power program is a major undertaking that requires careful planning, preparation, and investment in time and human resources. Countries that are considering introducing nuclear power into their energy mix face the challenge of building the necessary national nuclear infrastructure. According to the IAEA, infrastructure includes all facilities, activities, and arrangements needed to set up and operate a nuclear program. These range from the facilities and equipment used for building nuclear plants and handling and transporting nuclear and radioactive materials, to the legal and regulatory framework within which all necessary activities are carried out, as well as the human and financial resources to implement them.

The IAEA has responded to this growing demand by increasing the assistance it offers. Its basic services include expert missions that provide targeted assistance, such as identifying a country’s infrastructure development needs and gaps; workshops that offer platforms for helping to overcome challenges in introducing a nuclear program; and new and updated publications that provide guidance and practical examples for infrastructure development.

The Milestones approach

The IAEA has also developed an approach to introducing nuclear power in a country

The growth in interest in the nuclear option has led the IAEA to expand its nuclear power services for newcomer countries.

that is set out in the document *Milestones in the Development of a National Infrastructure for Nuclear Power*. Published in 2007, it has become the foundation document guiding countries in the development of a nuclear infrastructure and the basis of the agency’s assistance program in this area.

There were two things about the Milestones document that were new to the IAEA’s usual guidance approach, explained Anne Starz, acting head of the newly formed Nuclear Infrastructure Development Section: It was comprehensive, and it was phased. Being phased meant that the development of each element of the infrastructure is undertaken in phases, much like nuclear construction projects. The Milestones approach is also very comprehensive, taking into account 19 important infrastructure issues (see table below). The IAEA also took a broad view of what may be required by consulting widely across the agency and beyond.



Photo: D. Calmes/IAEA

Starz

Starz joined the IAEA in 2008, and in 2010 she was named head of the Integrated Nuclear Infrastructure Group (INIG) formed within the Nuclear Power Division of the agency’s Nuclear Energy Department.

When the INIG was established in 2010, Starz said, no one could be certain how the widening expectation for nuclear power was going to pan out. Nevertheless, a mechanism for organizing and coordinating the agency’s activities in this area was needed.

She called the INIG a “one-stop shop” for newcomer member states to get an answer to the question: “We want nuclear power; what should we do?” Their follow-up questions, Starz said, often include:

- How is a government decision on nuclear power achieved?
- How is an experienced workforce created for operating a nuclear project?
- Can the IAEA help develop a legal and regulatory system for a nuclear power program?

Besides developing and managing activities within the Nuclear Power Division, the INIG also reached out to other parts of the agency, such as the Department of Nuclear Safety and Security and the Office of Legal Affairs, to expand what it could offer to newcomer countries.

Over the past few years, the renewed interest in nuclear has turned into concrete programs. The United Arab Emirates has started a construction program, contracting a Korean consortium to build four reactors. That deal includes substantial assistance in building the needed infrastructure in the UAE. Belarus has started building the first of two nuclear units, while several other countries are ready to embark on nuclear projects. Newcomer countries will need support, and not just for a couple of years, but over a long period of time, Starz stressed.

In January, the INIG was upgraded to the Nuclear Infrastructure Development Section, whose mission, Starz said, is still basically the same: providing a one-stop shop for supporting countries that want to start or restart nuclear power programs.

The Milestones document

In developing the infrastructure for building a nuclear power program, there are a range of activities that must be completed. The IAEA’s Milestones document divides these into three progressive phases of development. The completion of the work of each phase is marked by a specific “milestone” at which the progress of the infrastructure development can be evaluated and a decision made as to whether or not to move on to the next phase.

According to the Milestones document, the three phases of development are as follows:

Milestones 19 Infrastructure Issues

- | | |
|---------------------------------|--------------------------------------|
| 1. National position | 11. Stakeholder involvement |
| 2. Nuclear safety | 12. Site and supporting facilities |
| 3. Management | 13. Environmental protection |
| 4. Funding and financing | 14. Emergency planning |
| 5. Legislative framework | 15. Security and physical protection |
| 6. Safeguards | 16. Nuclear fuel cycle |
| 7. Regulatory framework | 17. Radioactive waste |
| 8. Radiation protection | 18. Industrial involvement |
| 9. Electrical grid | 19. Procurement |
| 10. Human resources development | |

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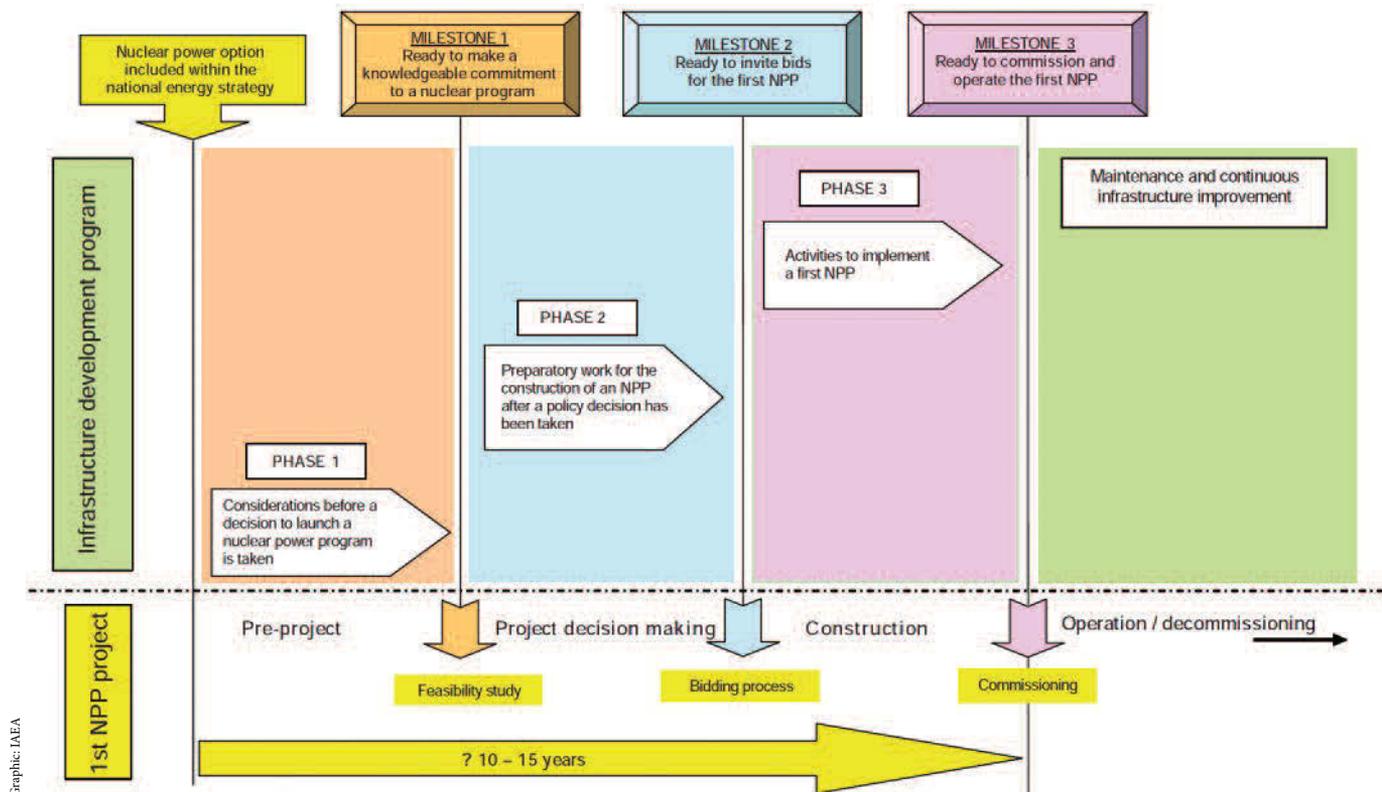


Fig. 1. For countries considering the introduction of nuclear power, the IAEA’s Milestones approach provides guidance through a phased development program, as illustrated in the diagram above, to build the infrastructure needed to construct and operate their first nuclear plant.

■ Phase 1: Considerations before a decision to launch a nuclear power program is made.

■ Phase 2: Preparatory work for the construction of a nuclear power plant after a policy decision has been made.

■ Phase 3: Activities to implement a first nuclear power plant.

The following are the corresponding milestones:

■ Milestone 1: Ready to make a knowledgeable commitment to a nuclear program.

■ Milestone 2: Ready to invite bids for the first nuclear power plant.

■ Milestone 3: Ready to commission and operate the first nuclear power plant.

In describing the activities that take place during each of the three phases and associated milestones, the document focuses a lot of attention on the three major organizations involved in the development of a nuclear power program: the government, the owner/operator of the plant, and the regulatory body. Each has a specific role to play, with responsibilities that change as the program advances (see Figs. 1 and 2).

Milestone 1

The first phase of the infrastructure development program begins when the country’s government accepts nuclear power as a possible energy option. It culminates with Milestone 1, when the government is in a position to decide whether or not nuclear is appropriate for the country. To get to that

point, it is essential that the state acquire a comprehensive understanding of the various obligations involved in introducing nuclear power, and has a strategy to discharge them, before any decision is made.

Usually, the government will form an implementing organization to undertake studies to identify and describe the infrastructure requirements and initially promote the development of the program. During this phase, this organization would be responsible for developing a clear understanding of the country’s energy needs and the “potential role, appropriateness, and viability” of nuclear power in its long-term energy plan. Its report at the end of Phase 1 should clearly show an understanding of the infrastructure that needs to be developed and have viable plans for its introduction, identifying resource requirements and time frames. It should also prepare plans for the development of organizations to undertake the roles of regulator, owner/operator, and technical support.

Milestone 2

Following a government policy decision to proceed with a nuclear power program, substantial work to build the necessary level of technical and institutional competence will be undertaken and the legal framework put in place. The focus of the second phase is the preparation for the construction of the nuclear power plant. By the end of Phase 2, the necessary infrastructure should be in place to allow for the invitation of formal bids from vendors or to enter into a com-

mercial contract for a nuclear plant and to supervise its construction. Other important goals would be the development of an independent regulatory body to a level at which it can fulfill all of its oversight duties.

The owner/operator (or utility) will have to have developed the competence to manage a nuclear power plant project and to achieve the level of organizational and operational culture necessary to meet regulatory requirements. It should also be able to demonstrate that it is an informed and effective customer.

Milestone 3

During the third phase, all of the activities necessary to implement the first nuclear power project should be put in place. At the end of this phase, the owner/operator will have developed from an organization capable of ordering the country’s first nuclear plant to one capable of commissioning and operating a plant. This will require significant recruitment, development, and training for all levels of staff. The owner/operator must also be able to demonstrate that it can manage the project throughout its life cycle.

INIR missions

Virtually every country that has made the decision to start a nuclear program is using the Milestones document as a guide. While each country will have to adapt it to its specific circumstances, a government will likely request that the IAEA stage Integrated Nuclear Infrastructure Review (INIR) mis-

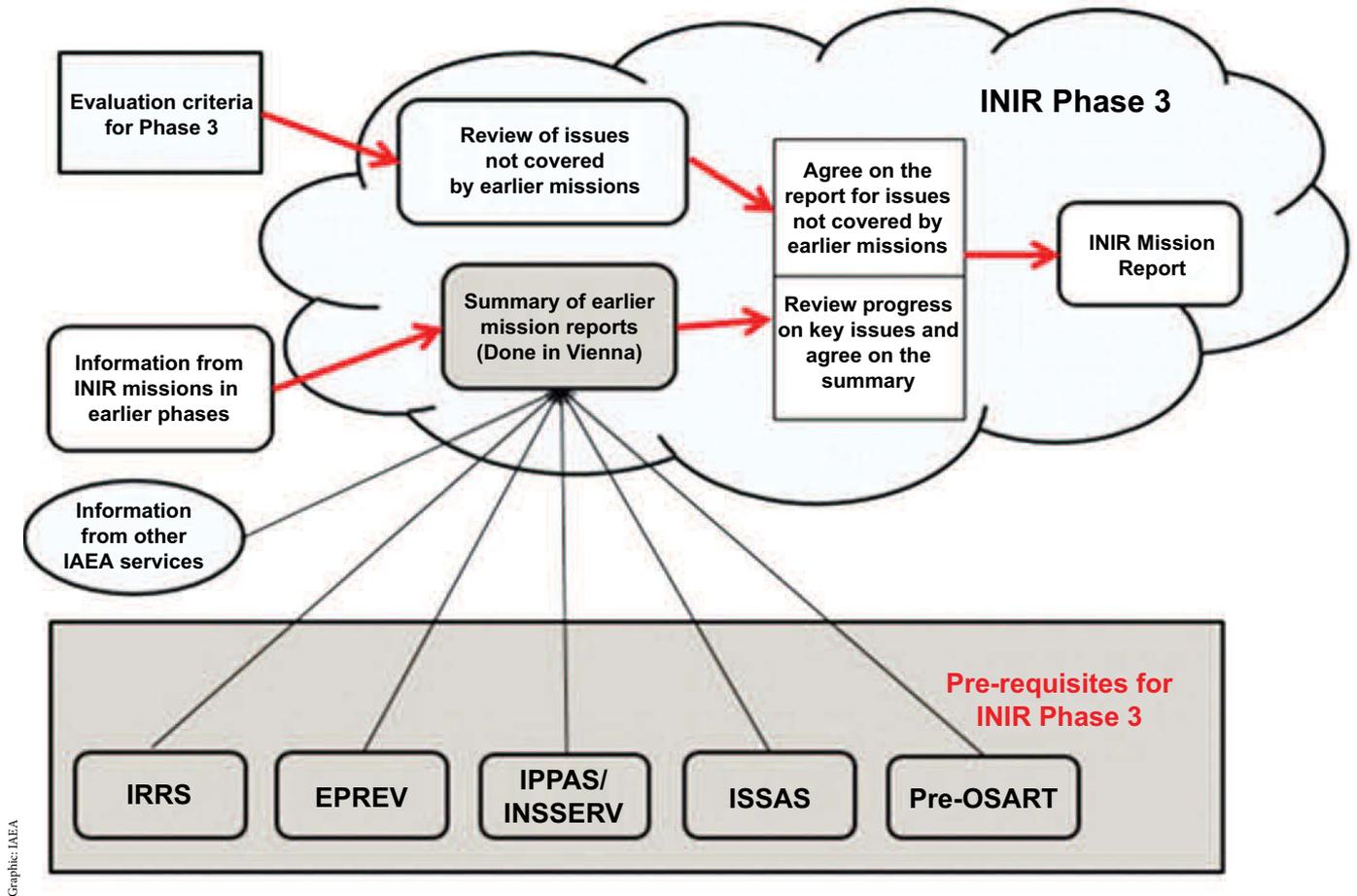


Fig. 2. An INIR Phase 3 mission pulls together available assessments of the state of the project, starting with a review of the results of previous INIR infrastructure missions and other agency missions carried out by safety-related services, including the Integrated Regulatory Review Service (IRRS), the Emergency Preparedness Review Service (EPREV), the International Physical Protection Advisory Service/International Nuclear Security Advisory Service (IPPAS/INSSERV), the IAEA Safeguards Advisory Service (ISSAS), and the Pre-commissioning Operational Safety Review Team Service (Pre-OSART).

sions to review its progress and identify gaps where additional efforts may be needed.

An INIR mission is carried out by a team of international experts with direct experience in nuclear infrastructure, along with specialized agency staff who follow a review methodology that is set out in the main INIR guidance document. Before the mission, the appropriate national authorities must conduct a self-evaluation, an important element in the INIR mission procedure. In addition to reviewing the self-evaluation, the team will hold interviews with the staff of the key organizations, undertake site visits, and review other relevant documents to determine the status of the country's infrastructure. The mission team then evaluates the information collected, identifying what is being done well, where progress is being made, and which areas need additional work. Suggestions and recommendations are provided in a report to the government.

There have been 12 INIR missions to date. The first was conducted in 2009 in Jordan, and a follow-up mission took place in 2012. Other newcomer countries that have used the service include Bangladesh, Belarus, Indonesia, Poland, Thailand, Turkey,

the UAE, and Vietnam. Three countries—Belarus, Poland, and the UAE—have made the results of their INIR mission available on the IAEA website.

An INIR mission was also carried out in South Africa, which after 30 years of operating the two-unit Koeberg plant is considering a new-build program. The mission, carried out in January 2013, reviewed the status of the existing nuclear infrastructure to assess whether it can support a new-build program. Some other countries with small programs have also indicated to the IAEA their interest in building new nuclear plants.

Among the most useful aspects of an INIR mission identified by newcomer countries, Starz noted, are the following:

- Provides a deeper understanding of the strengths of the country's program and where additional effort is needed; also gives newcomers a sense of confidence about the steps they are taking.
- Demonstrates to the international community that the country is open and transparent about its plans for nuclear power.
- Provides the opportunity for international experts to make important recommendations regarding what to do next.

Starz expects many more countries to be requesting INIR missions in the future. Jordan is to have another mission in August, Nigeria is scheduled for one later in 2014, and a number of other countries are lined up for 2015.

INIR Phase 3 mission

Starz explained that INIR missions have been focused on the first two program phases, which cover decision making and institution building and planning. She said that an INIR mission for Phase 3, which covers plant construction, was not considered at first because the INIG thought that by the time plant commissioning approaches, "all the bases" would have been covered by earlier INIR and other missions (see Fig. 2), giving confidence that the infrastructure would be in place and functioning properly.

However, around the time that the UAE was undertaking pre-construction work at the site of its first nuclear plant—the first newcomer to do so in decades—the Fukushima Daiichi accident happened. This led to greater concerns about safety, which was the topic of a post-Fukushima IAEA minis-

IAEA services for newcomers

Since the beginning of 2014, the International Atomic Energy Agency has announced a number of new and updated services and meetings focusing on the needs of nuclear newcomer countries. The following are among those offerings.

Catalog of Services

The new *IAEA Catalogue of Services for Nuclear Infrastructure Development*, based on the IAEA's Milestones approach, is now available to countries embarking on a new nuclear power program. The new catalog allows member states to request assistance for their national organizations. Users can identify and select available IAEA services either by program development phase or by the organization of interest—for example, the government's implementing organization, the regulatory body, or the owner/operator of a plant. The catalog lists both existing IAEA services and those being developed. Each existing service is linked to a relevant IAEA web page. The forms of assistance available include training courses and workshops, advisory services, expert missions, and other training tools and networks.

Assistance package for future owner/operators

As a key organization in developing the nuclear infrastructure of newcomer countries, the IAEA has developed an assistance package for future owner/operators focusing on their development during Phases 2 and 3 of a project, as set out in the IAEA's Milestones document. An owner/operator organization, which will become the legal entity licensed to operate a nuclear power plant, must clearly understand what must be done and how it has to act. The package consists of three parts: workshops on owner/operator responsibilities; expert missions on specific aspects of owner/operator activities, such as undertaking a feasibility study, bid invitation specification, and integrated management system development; and IAEA review services and missions.

Readiness review for nuclear construction

The IAEA has introduced a Construction Readiness Review (CORR) service aimed at assessing a nuclear project's readiness to proceed to its next phase of construction. A CORR mission will typically be deployed prior to the start of a major construction project or at a major project milestone. The assessment includes a review of planning processes, preparedness for subsequent project phases, major risks and issues, and engineering and construction readiness. Areas covered also include project management, engineering readiness, supply chain readiness, quality management and records, and human resources and training.

E-learning series for nuclear newcomers

To take advantage of the new Internet platforms, the IAEA has created an interactive e-learning series to explain how to use the IAEA's Milestones approach. The modules, which continue to increase in number, target a variety of stakeholders in member states interested in or embarking on a nuclear power program. These include decision-makers, advisors and senior managers in governmental organizations, regulatory bodies, utilities, and industries, as well as donors, suppliers, and other related bodies. Students, academics, and researchers may also use it to better understand the big picture of developing nuclear power programs.

The program is also being used to increase awareness of the IAEA's work, as well as to train people being recruited into the various organizations. Following are the current nine interactive e-learning modules for nuclear power development (more are planned):

- Module 1, *Implementing a Nuclear Power Program*, is an introduction and overview of nuclear power infrastructure development.
- Module 2, *Developing a Human Resource Strategy*, focuses on human resources management, a crucial element of a nuclear power program.
- Module 3, *Stakeholder Involvement*, emphasizes the importance of engaging stakeholders in a nuclear power program.
- Module 4, *Management of a Nuclear Power Program*, explains why strong management and leadership are needed for a successful program.
- Module 5, *Construction Management*, addresses the key challenges in constructing a nuclear power plant as part of the nuclear power program.
- Module 6, *Systematic Approach to Training*, is internationally recognized as a key tool for ensuring the competency of all nuclear power program personnel.
- Module 7, *Feasibility Study*, represents an important step in the justification of a nuclear power plant new-build project.
- Module 8, *Management Systems*, explains why a management system is needed and the steps to develop, implement, and continually improve it.
- Module 9, *Safety Infrastructure*, defines safety infrastructure and its importance in a nuclear power program.

Meetings

The IAEA's annual *Technical Meeting on Topical Issues in the Development of Nuclear Power Infrastructure*, held February 4–7 at IAEA headquarters in Vienna, is the main forum for senior managers and experts involved in developing new national nuclear power programs to meet and discuss challenges and common issues. Participants came from government ministries, organizations responsible for nuclear power program planning in newcomer countries, current and future owner/operator organizations, vendors, technical support organizations, universities, and regulatory agencies. The most important concerns related to attaining strong government support are a firm road map, stakeholder support, and financing. The focus of newcomer countries also included setting up an appropriate legislative and regulatory infrastructure, as well as building the institutions needed, with a clear allocation of roles and responsibilities. Human resource development remains a priority for embarking and experienced countries alike.

An IAEA *Workshop on Energy Assessments and Pre-feasibility/Feasibility Studies for Nuclear Power Programs*, held March 17–21 in South Korea, covered some of the first important steps to be taken by countries considering nuclear power in their national energy mix. A number of newcomer countries have requested guidance and training in this area. A pre-feasibility study helps answer questions that may be raised by different stakeholders, such as: Why nuclear power? Would nuclear power be competitive? Is nuclear power safe? How could a nuclear power program be financed? What would be the environmental impacts? Can nuclear power help combat climate change? What about nuclear waste?

The *International Conference on Human Resource Development for Nuclear Power Programs: Building and Sustaining Capacity*, held May 12–16 at IAEA headquarters, focused on the challenges of developing competencies in personnel at all levels of nuclear power programs. Topics discussed included the critical role of human resource development, advances in knowledge management, networking and related initiatives, education and training programs, and attracting the next generation of nuclear professionals.—D.K.

terial conference in June 2011, where agreement was reached on establishing an IAEA Action Plan on Nuclear Safety, with the goal of strengthening nuclear safety worldwide. At the time, one concern voiced by some member states, Starz said, was whether or not states commissioning their first plant could assure the international community that they are ready to do so safely and securely.

The question that must be answered, she said, is “How does a country demonstrate that it is ready to start operation of its first nuclear plant?” After a considerable amount of discussion and consultation with member states, the idea developed of having an INIR Phase 3 review mission that pulls together all of the critical elements of a project, such as safety, regulatory and inspection procedures, emergency preparedness, safeguards systems, security, and physical protection, to assess whether the country is “in good shape and ready to go.” This is about infrastructure, Starz stressed, not the project or plant itself.

When studying how best to do this, it was discovered that some infrastructure issues had not been adequately covered by all the various missions and reviews undertaken for the project. A set of questions was then developed to identify and assess the gaps in the reviews. This led to an INIR Phase 3 mission that was very different from the



Photo: INEC/UAE

The construction of Unit 1 at the Barakah site in the United Arab Emirates began in July 2012.

other missions, which typically are interview based. The new INIR Phase 3 mission will start with a review of the results of the previous INIR missions, as well as other agency review services, and the set of questions. The mission team will then meet with country representatives to review the results of its initial analyses. This should help countries determine whether they are ready to commission their plant and operate it safely and securely. The first INIR Phase 3 mission is expected to be held for the UAE’s new nuclear program in 2016.

Milestones document update

The approach set out in the Milestones document is backward-looking, Starz explained, as it is based on experience from national programs that were developed many years before. With several years of doing INIR missions, and considerable feedback from Fukushima and other developments, the IAEA carried out a review process to create an updated version of the document. The new version will probably be ready by the end of this year.

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While there are no major changes to the document, Starz said, it will incorporate some new aspects. For example, a number of nuclear newcomers use a strategic partnership approach or go through a negotiation process for an intergovernmental agreement with a nuclear plant supplier country to establish the terms of a project, rather than undertake a competitive bidding process to select a technology and vendor. After looking carefully at how that might change the infrastructure demands, the group found that it doesn't significantly al-

ter the requirements. In some cases, it puts the responsibility for meeting some requirements on a different organization. In Turkey's build-own-operate arrangement for its first nuclear project, the responsibility for the workforce planning is shifted to the Russian consortium that is going to build and operate the reactors.

Starz also noted that this document is widely used, which is another reason not to change the structure or the basic guidance too much. "We want people to recognize and continue using it and not feel con-

cerned about a change in the middle of carrying out their program." It does, however, take into account important events and developments since 2007, including the Fukushima accident. "We think it is a much richer document," Starz said.

The IAEA's role and its limits

It is important to emphasize, Starz said, that countries make their own decisions. The IAEA's role is traditionally to gather international experience and distribute it through such means as guidance documents, expert missions, peer reviews, and technical meetings. "We are not consultants, and we are not taking decisions for countries," she said. "I like to think of the agency's work in this area of supporting nuclear power as small but strategic."

Also, Starz said, "The help provided is very specific to the country's request to what it needs, and it is usually a small but strategic intervention." It might involve reviewing one of its strategic documents, such as the basic feasibility study or site selection process, but the country has to make the decisions itself and actually carry out the work, she said. The complete document, *Milestones in the Development of a National Infrastructure for Nuclear Power*, is available on the IAEA's website at <www-pub.iaea.org/MTCD/publications/PDF/Pub1305_web.pdf>. **IN**

Photo: Directorate for Nuclear Power Plant Construction, Belarus



The first nuclear power plant in Belarus, at Ostrovets, is prepared for the first pour of concrete in October 2013.