SERVING HUMAN NEEDS
NUCLEAR TECHNOLOGIES IN THE MARKETPLACE

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Many peaceful nuclear technologies today stand firmly established. They are being widely applied and accepted around the world in such fields as health care, food production, manufacturing, electricity generation, and environmental protection. Among the IAEA's 132 Member States, interest in constructively applying the tools of nuclear science and technology -- especially outside the energy sector -- remains high, although priorities, needs, and policies have changed over time.

Nuclear technologies, like others, have had to mature in a competitive and changing marketplace. Developments in other technical fields continue to have an impact, both positive and negative, on the atom's comparative advantages. So, too, have changing attitudes in the influential arena of public opinion that can help to drive, or stall, technological applications and innovation. Perceptions of nuclear issues range from strong rejection of energy applications by large groups to general acceptance in medical and environmental fields.

In recent years, the recognition has grown that science and technology are keys to reducing poverty around the world, with awareness mainly tied to rapid advances in fields such as biotechnology, communications, and medicine. On a global scale, the world's agenda for securing "sustainable development" rests in many ways upon the more effective transfer of scientific and technological tools and knowledge to developing countries, where most of the poor live and where populations are projected to grow the fastest over the coming decades. Nuclear science and technology is making important contributions to meeting basic human needs and raising standards of living in the developing world.

As the new century unfolds, however, some important branches of nuclear science and technology are in transition, facing new challenges and opportunities in adapting to changing marketplaces. In many parts of the world, the sustainability of national nuclear and research institutions is a matter of concern, especially in developing countries. New approaches and strategies will need to be developed and put into place to enable fuller use of nuclear applications that can bring real benefits for meeting basic human needs in developing countries.

This article looks at the major factors that have contributed to the changing nuclear picture; outlines a strategy for national nuclear institutions to achieve greater self-reliance and sustainability; and addresses the role that the IAEA can play in helping to implement the strategy. It also reviews how nuclear science and technology are contributing to national and global goals of sustainable development.

For the IAEA -- whose specific mandate is to "accelerate and enlarge the contribution of atomic energy to peace, health, and prosperity" -- the changing and challenging global picture has strengthened efforts to enhance the contribution of nuclear science and technologies in key fields of human development. A multi-faceted programme of technical cooperation serves as the main vehicle for the transfer of nuclear science and technology to developing countries. The programme's emphasis is on supporting projects that respond to the priority needs of each country, produce an economic or social impact, and reflect the distinct advantages of nuclear technology over other approaches.

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Emphasis is equally placed on capacity-building through education, training, and sponsoring research, as well as on development and demonstration of nuclear and related applications. Through coordinated research projects, for instance, institutes from developed and developing countries join forces to solve common problems and to adapt emerging nuclear techniques for use in developing countries. The Agency's own research and service laboratories in Vienna and Seibersdorf, Austria, and in Monaco support these activities by improving quality assurance through global laboratory networks and reference materials. Supported projects focus, for example, on the use of radiation and isotope techniques to increase food production, fight diseases, manage water resources, and protect the environment.

An important feature of the IAEA's work is cooperation with a range of partners, including United Organizations, scientific and technical institutes, and development agencies.

CONTRIBUTIONS OF NUCLEAR TECHNOLOGIES TO BASIC HUMAN NEEDS

Despite its high political visibility, electricity generation -- a field in which nuclear power today accounts for about 16% of the world's total electricity generation -- is clearly second in economic terms to the multitude of nuclear applications unrelated to electric power production.

In the food and agriculture area, nuclear and related

applications are varied and effective. For example, insect sterilization techniques (called SIT) to control and eradicate pests -- including the Mediterranean fruit fly and New World Screwworm in large areas — have produced significant gains in livestock and fruit production. It has been integrated into campaigns against the tsetse fly, which transmits human and cattle diseases that severely limit agricultural productivity, and now is set for expanded use in Africa.

Radiation induced mutations are used to produce crops with greater yield, higher quality, and improved resistance to salinity or pests.

Food irradiation is employed to preserve freshness and to eliminate bacteria and pathogens that can cause disease and even death. As ozone-depleting fumigation chemicals are banned and more stringent limits are set on salmonella germs in food, this radiation technology becomes increasingly indispensable for transboundary trade in agricultural produce, and for assuring food hygiene standards.

In the field of human health, new nuclear techniques are developed with each passing year. The field employs more than two million researchers and practitioners engaged in medical uses of radiation for the prevention, diagnosis, and treatment of disease.

In recent years, for example, the Agency has placed significant emphasis on the validation of new nuclear tools for diagnosing drug-resistant strains of malaria and tuberculosis. Other work is related to diagnostic procedures in support of medical applications ranging from paediatrics to cardiology and the use of isotopes in nutrition studies to track the intake of vitamins and other nutrients. Significant effort also is being devoted to helping developing countries meet the increased need for radiotherapy services. Cancer cases are rising

Photos: Nuclear technologies contribute to improving child nutrition and are being enlisted in the fight against malaria, which claims the lives of over a million children each year. In other fields, radiation techniques are used in plant breeding to produce better crops. *(Credits: Carnemark/World Bank; Kinley/IAEA)*

rapidly in the developing world as lifespans increase, and treatment systems often are lacking.

Water resources is an area of increasing worldwide concern. Today, over one billion people are without access to clean water, and about two-thirds of the global community will face shortages of clean water by 2025. In addition to desalination projects, the Agency has supported extensive use of isotope hydrology to plot groundwater aquifers for sustainable water resource management. Also supported is research and development on the use of advanced electron beam accelerators to disinfect drinking water and waste water.

An array of environmental analysis and cleanup techniques are the focus of other Agency projects. For example, the use of ionizing radiation to clean flue gases from coal-fired plants -- a technology catalysed by the Agency -- is being developed or used in Bulgaria, China, Japan and Poland. Another important initiative is the coordination of efforts to study nuclear techniques for the detection of abandoned landmines, which continue to maim civilians in regions of past conflict. The unique advantage of neutron-based humanitarian demining lies in the fact that the method identifies explosives directly through their obligatory nitrogen content, as compared to error-prone metal detection devices.

In each of these areas, the Agency seeks to promote the development and self-reliant application of techniques that serve the priorities of its Member States. The use of nuclear technologies in developing countries can be expected to keep growing, as local infrastructures improve in response to the changing marketplace.

As it evolves, the Agency's role as a facilitator and centre of nuclear technology can have even greater impact. Key aims are to strengthen national research and development capacities, and to provide core scientific and technical support to IAEA Member States. IAEA programmes are designed to provide opportunities for developing countries to fully participate in global and regional research and information exchange, thereby extending the benefits from the safe and effective use of nuclear techniques. Moreover, the IAEA can provide training and research support at its own laboratories for the benefit of scientists from the developing world.

Meeting the scientific and technical challenges ahead will serve the needs and interests of developing countries. Nuclear and isotope techniques, appropriately integrated with other technologies and adapted to individual sectors of development, help address many of the earmarked priorities in the UN Millennium Declaration, Agenda 21, the global action plan, and resolutions and decisions of the IAEA's policymaking bodies.

IAEA TECHNICAL COOPERATION

The IAEA's founding Statute underpins efforts to ensure the use of "atoms for peace" through global cooperation.

This basic consideration remains the foundation of the IAEA Technical Cooperation Programme, the chief mechanism for nuclear technology transfer. The Programme began in 1958 as a modest effort involving US $2 million annual delivery, at a time when few countries boasted nuclear technology infrastructure. Today, truly useful nuclear technology infrastructure exists in all regions of the world. The Programme now involves partners in 100 Member States, and covers goods and services worth $87 million a year.

As its scope increased, the Programme's direction

changed, to emphasize the need for investments that produce tangible benefits to recipients. The capacity building of the past has become a springboard for helping to meet high priority goals for sustainable development. This new phase is characterized by the mobilization of existing capacity to solve problems at the national and regional levels. Technical cooperation projects are now much more closely linked to national development priorities.

But key challenges remain that influence progress. They are linked to the different types of nuclear applications and to the different capabilities and levels of national support that nuclear institutes have attained.

Photo: Scientists use nuclear and isotope techniques to obtain critical data for managing water resources. *(Credit: IAEA)*

DISTINCT & DIFFICULT CHALLENGES

There are two distinct types of nuclear technology applications: those related to nuclear power generation, and all others. Any analysis of efforts to employ nuclear technology to help countries meet their development goals must take this difference into account. The situation in countries with active or planned nuclear power plant programmes differs greatly from those without them.

From the standpoint of IAEA technical cooperation, the distinction between nuclear power and other "non-power" nuclear applications -- namely, those in fields such as health care, environmental protection, and food and agriculture, for instance -- is important. The IAEA's experience has shown that the promotion of non-power nuclear applications in developing countries having nuclear power is more straightforward because of well-established infrastructures. The nuclear authority (typically the Atomic Energy Commission, or AEC) commands more resources, capabilities, and political support. It is in a stronger position to take ownership and sustain non-power applications because of relatively stable funding.

The situation stands in stark contrast to the weaker conditions in countries without nuclear power programmes or plans. This is the case for most countries, especially in the developing world, where nuclear infrastructures are lacking or not well grounded. The situation is an outgrowth of nuclear power's stagnation over the past decades, and its lingering uncertain prospects.

In these countries, the government's support for setting up nuclear infrastructures has declined steadily alongside nuclear power's changing fortunes. Most of the AECs and nuclear institutes, especially in developing countries, today are struggling to survive. The government, especially the mainline development-oriented ministries, often have no knowledge of the potential benefits of nuclear applications. The private sector also remains largely unaware, or simply is preoccupied with other investments.

How to turn the situation around is a vital issue. More efforts are needed so that AECs and national institutes can gain the self-reliance and capability to build an infrastructure through which greater contributions to national development goals can be gained from nuclear applications.

The IAEA's experience suggests there is ample room for optimism, though improvements will take time. Some key considerations are especially encouraging and should improve the prospects of maintaining viable national nuclear institutions.

- The nuclear technology infrastructure built up over the past five decades is considerable, but it is presently under-utilized.
- Nuclear applications can provide innovative solutions

that are either indispensable or have clear competitive advantages over alternative approaches.

■ The potential socio-economic impact of nuclear applications is far from marginal: in developed countries, the contributions of non-power applications to the economy actually exceed those associated with nuclear electricity production. Studies in the USA in the 1990s, for example, showed that nuclear and radiation technologies outside of electricity production contributed nearly $300 billion a year to the economy.

For developing countries, the way forward will demand the identification and exploitation of new opportunities, and adaptation to a changing nuclear marketplace encompassing both the public and private sectors.

TAKING NUCLEAR TECHNOLOGIES TO THE MARKETPLACE

Two parts make up the marketplace for non-power nuclear technology applications. The first is in the public sector, among the mainline development ministries whose programmes invest the government's resources in diverse areas such as water, health, agriculture, nutrition and environment. The second is in the private sector -- the real commercial market, based on the investment of private capital.

The Public Sector. In many developing countries, the most easily accessible marketplace for nuclear technology applications will remain the public sector. This encompasses many governmental organizations that have the mandate and the resources to take effective action.

For nuclear institutes, a key lifeline is the establishment of mutually beneficial partnerships with mainstream development ministries -- such as those responsible for public service activities in agriculture, water resources, health and environmental protection. In many cases, arrangements already exist and can be strengthened. In other cases, they can be created through proactive approaches that encourage partnerships in areas where nuclear applications contribute to national goals.

Experience gained through IAEA technical cooperation teaches that effective partnerships begin when nuclear institutions identify, and reach out to, the managers of government programmes. It is usually through these channels that one finds the quickest and surest route to end-users, those who can deliver tangible benefits to people and the economy.

Sometimes these partnerships are based on directly harnessing nuclear technology to provide a more efficient solution. Examples would be the use of the sterile insect technique in pest control, rather than chemical insecticides, or radiotherapy to improve the care of cancer patients. In other cases, nuclear techniques help to solve problems outside the nuclear sector by providing decision-makers and planners with key data and information. An outstanding illustration is the use of isotope hydrology analytical techniques for water resources management.

When working with development partners, the AEC may find itself in a subsidiary role, with project implementation mainly in the hands of other research institutions or organizations. This is an important role, one that offers AECs the opportunity to be leading supportive forces for achieving national development goals. Proactive involvement through frequent liaison and coordination can raise nuclear technology's profile -- and awareness of what its benefits are -- with local planners and policymakers, while expanding the AEC's constituency among end-users and donors. By promoting the national interests, rather than simply its own self interests, AECs can gain both credibility and trust as reliable scientific and technical partners for development.

Given the challenges and needs, especially in the poorest countries, a prime area for creating productive partnerships lies in the mitigation of poverty. Nuclear sciences and applications have shown they provide technical solutions to some of the world's most burning issues. By addressing basic human needs, AECs can open avenues for effective cooperation with a range of national, regional, and global partners.

Partners include international organizations dedicated to specific fields, such as food security and agriculture, education, or health. The partnerships bring added value through

synergistic interaction within the UN system. Examples include the Joint Division of the IAEA and Food and Agriculture Organization (FAO); cooperative activities and programmes with international organizations including WHO, UNDP, UNICEF, UNEP, and WMO; and collaboration through the International Centre for Theoretical Physics, supported by UNESCO, the IAEA, and Italy.

The Private Sector. Approaching the private sector presents big challenges and risks, and also great opportunities. To succeed in this marketplace, nuclear institutions must be ready to think and act just like business enterprises, even if they do not plan to actually set up for-profit subsidiaries.

Behaving like a business concern, rather than a research institute, implies the willingness and capacity to succeed in at least the following areas:

- understanding the marketplace and its development potential so as to identify prospective clients, and reaching them with effective marketing strategies, including demonstrations and sound feasibility studies;
- setting prices that are both attractive to clients and profitable;
- knowing the competition's strengths and weaknesses.

Moreover, the usual rules of commercial competition need to be followed to win and keep clients.

These include providing:

- products and services that are tailored to clients' needs, and meet the user requirements for quality assurance;
- sales, engineering, training and technical services;
- opportunities for technology transfer, or for joint ventures based on proprietary technologies.

Meeting all these criteria for penetrating commercial markets can involve a difficult, even painful, transition. But some nuclear institutions, otherwise facing the prospect of demise, have emerged from that transition healthier and more self-reliant. They have found that they can play major roles particularly in the industrial sector. *(See box, page 11.)*

Several elements characterize a working environment that nurture a successful transition. If these elements are not in place, and properly adjusted to local circumstances, experience suggests that they should be established. They are a precondition to any serious efforts to enter commercial markets.

The following actions, most of which can proceed in parallel, will help to set the stage for success:

- Seek full support from the government for new ways of doing business and ensure that national policies are conducive to success; changes may be required.
- Assemble a small lead team consisting of capable managers with sound track records in business, using existing, technically competent staff with proven managerial capacity.
- Adjust internal operational policies and working practices to provide flexibility and incentives so that the lead team can function effectively.
- Identify and capitalize on areas of core competence by using existing mandates for traction, in areas such as radiation protection; technical backstopping for industry; and regulatory services.
- Define market opportunities for which the institution has unique strengths and established infrastructure.
- Prepare attractive feasibility studies, and conduct concrete demonstrations.
- Provide leverage to existing government subventions by seeking synergy with private-sector clients through mixed funding arrangements and joint ventures.

THE IAEA'S ROLE & SUPPORT

The IAEA Technical Cooperation Programme principally works through and with governments and their respective national nuclear authorities and institutes. A prime goal is to help them strengthen their capabilities for safe and productive uses of nuclear and radiation technologies in areas where the well-being and health of billions can be improved.

While the IAEA may encourage market approaches, including outreach to the private sector, the primary focus remains on direct cooperation with governments.

To improve the self-reliance and technical capabilities of national nuclear institutes, the IAEA's support to governments can take several forms.

By strengthening AECs through investments in

ACHIEVING SELF-RELIANT AND SUSTAINABLE NUCLEAR INSTITUTIONS: THE MALAYSIAN EXPERIENCE

Several developing countries have vigorous and even expanding programmes of nuclear applications outside the nuclear power field, including South Africa, Republic of Korea, Brazil, China, Pakistan, Argentina, India, and Malaysia. Their research and development (R&D) capabilities are justly deserving of recognition. However, with the exception of Malaysia, these countries all have nuclear power programmes.

The creation of the Malaysian Institute for Nuclear Technology (MINT) in 1972 marked the country's first step along the path to self-reliance and sustainability in nuclear technology. Today, with annual revenues at US $2.1 million and increasing, MINT has accomplished many of its original aims.

Products & Services. Commercialization has occurred in areas such as bio-materials; plant products; vulcanized natural rubber latex; medical diagnostic kits; radioisotopes for medical, industrial and agricultural applications. The Institute is also a major provider of services. These include medical products sterilization; instrument calibration; quality assurance for industrial and medical dosimetry; environmental pollution assessment; radiation monitoring and control; health and safety; facility design/engineering and process control; management of water resources; nuclear advisories, policies, and planning; training and certification in and radiation protection and non-destructive testing.

MINT's history falls into three phases. The period 1972-82 saw the creation of basic infrastructure, consolidation of R&D; establishment of priorities for commercialization and technology transfer. The period 1983-93 focused on development of centres of excellence in non-destructive testing, secondary dosimetry standards, and neutron activation analysis; construction of pilot plant facilities for gamma irradiation and electron-beam processing, etc. Since 1994, emphasis has been placed on marketing goods and services; contract research; and infrastructure adaptation.

Key features of the business model include:

- a pilot-scale Business Division and Technology Park within MINT;
- proven safety, reliability, and quality of goods and services;
- management policies that emphasise proper planning, implementation, monitoring and evaluation, using verifiable performance indicators to maintain proper control;
- a coordination network involving all key players
- flexible mechanisms, such as memorandums of understanding, partnerships, joint ventures and licensing arrangements.

infrastructure, especially in less advanced Member States, the IAEA will continue to help build capacity in nuclear science and technology. A particular emphasis is placed on projects involving applications and services that have proven their usefulness to mainstream ministries, or that present attractive opportunities for private investment.

By supporting AECs to form partnerships with mainstream development ministries, and other organizations, the IAEA can help them to move more swiftly in the direction of self-reliance. This strategy seeks to enhance the AEC's role in national policy- and decision-making, and to open opportunities for generating revenues.

A range of activites can be initiated and supported to stimulate and promote dialogue and outreach. They include projects, training events, and case studies that show how best to blend technical competence with sound management and business practices; and exchanges of information and experience, especially in the context of bilateral, regional and inter-regional visits and events, even those of mostly a technical nature.

In response to the challenges of the changing nuclear marketplace, the IAEA can support national nuclear institutions in new and useful ways, ones aimed at helping to create the skills required for enhancing capabilities and self reliance.

In doing so, the IAEA's historical role of supporting technical development will be reinforced so that more countries are able take action to strengthen both the management and application of nuclear science and technology for sustainable development.❐