EUROPE REGIONAL PROFILE

2014 – 2017

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Executive Summary

This document is an updated version of the Europe Regional Profile (ERP) that was used as a planning tool for the elaboration of the 2009-2013 regional technical cooperation programme for the Europe Region.. This updated version covers the period 2014–2017. It takes into account recent developments in the areas of peaceful use of nuclear energy and includes lessons learned from the Fukushima accident. The regional technical cooperation programme in the Europe Region aims to enhance collaboration among the Member States of the region, as well as with other partners such as the European Commission (EC). The document, prepared jointly by Member States and the IAEA Secretariat, builds on the experience gained during 2009–2013 and is complemented by additional information available from national and regional sources.

The four thematic areas identified in the 2009–2013 ERP remain the same. These are:

i. **Nuclear and Radiation Safety**, including nuclear installation safety, radiation safety, emergency preparedness for nuclear or radiation emergencies and nuclear security.
ii. **Nuclear Energy**, including nuclear power and fuel technology, waste technology, decommissioning and nuclear sciences.
iii. **Human Health**, including nuclear medicine, radiotherapy, medical imaging and medical physics.
iv. **Isotope and Radiation Technology Applications**, including environmental, agricultural and industrial applications.

Following is an analysis of the above thematic areas pertaining to the current situation in the Europe Region. It follows the theme-specific priorities as well as cross-cutting areas for regional or sub-regional cooperation:

Nuclear and Radiation Safety:

- Emergency Preparedness and Response for Nuclear and Radiation Emergencies
- Knowledge Management and Capacity Building, including Safety Assessment
- Long Term Operation and Engineering Aspects of Nuclear Facilities
- National Regulatory Infrastructure
- Nuclear Safety
- Occupational Radiation Protection
- Public and Environmental Radiation Protection
- Radiation Protection in Medicine

Nuclear Energy:

- Development of Adequate Scientific and Engineering Capabilities
- Human Resources for Nuclear Power
- Nuclear Fuel Cycle (NFC)
- Nuclear Installation Performance / Operational Experience Feedback

- Nuclear Power Planning and Introduction
- Waste Management/Decommissioning

Human Health:

- Improving Clinical Practice in Radiation Oncology
- Supporting the Establishment of Gamma Cameras and Positron Emission Tomography (PET) and PET/ CT

Isotope and Radiation Technology Applications:

- Isotope Production for Human Health
- Environment Monitoring and Preservation
- Advanced Materials

Cross-cutting Areas:

- Education and Training
- Institutional Capacity Building
- Nuclear Knowledge Management

The above list is an indication only and does not exclude consideration for new areas of cooperation that could arise. Thus, the Europe Regional Profile complements the ongoing consultative process between Member States and the Secretariat in identifying possible areas of cooperation.

1 INTRODUCTION

1. Regional projects constitute a key feature of the IAEA's technical cooperation programme in the Europe Region. These projects consist of activities that benefit group of countries that have common problems to solve. The inputs to these projects usually comprise of meetings, workshops and training events. In some cases, limited provisions can be made for equipment and expert services that would enhance the national infrastructure and harmonize capabilities among participating Member States.
2. For smaller groups of Member States in the Europe Region, regional cooperation among Member States also takes a sub-regional approach in order to address the common problems.
3. The Regional Profile for 2014–2017 was jointly prepared by the Member States and the IAEA Secretariat. It is an update of the Regional Profile for 2009–2013. It takes into consideration the current situation and emerging trends, as well as relevant additional and new data available from national and regional sources. The Regional Profile complements the ongoing consultative process between Member States and the Secretariat, aimed at identifying possible areas of cooperation.

2 SITUATION ANALYSIS

4. A situation analysis has identified the following main features and trends in the Europe Region. These could be important for both the Regional Profile and subsequent decision-making process during the planning of the Regional Programme:

- Member States in the region use a wide range of different applications of nuclear energy and radiation sources. They also have significant differences in their socio-economic development;
- joining the EU continues to be the major goal for a number of countries in the region;
- the impact of the recent economic crisis remains a challenge for Member States in the Europe Region;
- environmental problems have become more and more serious globally;
- the consequences of Chernobyl accident remain a major challenge for the region;
- the IAEA Action Plan on Nuclear Safety contains lessons learned from the Fukushima accident that has to be implemented in the region;
- demand for a safe, economical, secure and reliable energy supply is increasing, options for addressing this demand may include nuclear power, if such a solution is appropriate for the particular Member State that is considering it;
- radioactive waste and spent fuel treatment, storage and disposal facilities are important pre-conditions for the both the development of nuclear power and the use of isotope applications;
- service life extension and power up-rate of operating nuclear power plants (NPPs) have been decided upon and in some cases implemented;
- irradiated fuel repatriation and conversion of research reactor fuel from highly enriched uranium (HEU) to low enriched uranium (LEU) are carried out;
- the retirement of experienced personnel and decreasing resources for research represent a challenge for the future of nuclear power in the region;
- further increasing public awareness and public involvement in the decision making process stands high on Europe Region's priority list;
- effective international cooperation and dialogue remains a prerequisite for the successful and safe implementation of new nuclear power construction in the region.

5. Technical Cooperation is an important and efficient mechanism that ensures effective and open exchange of experience and practice among the Member States in all areas related to the peaceful use of nuclear energy. In particular, renewed interest has been expressed in the fields of nuclear power and the environment, including interest in the consequences of the Chernobyl and Fukushima accidents. The Member States have also stressed the importance of extending the lifetime of existing NPPs as well as the construction new units in the region.

The analysis highlighted that, to a large extent, the trends and priorities outlined in the previous European Regional Profile remain valid. The main aim of this revision, therefore, is to update the document based on the significant progress made in the region through the implementation of the regional TC programme during the 2009–2013.

2.1 Nuclear and Radiation Safety

National Regulatory Infrastructure

6. In some countries in the Europe Region, the regulatory infrastructure for the control of radiation practices and sources is not yet fully developed. There are countries where notification, authorization, inspection and enforcement processes are still not applied to all radiation practices. Furthermore, the scope of these activities does not address all radiation safety issues associated with a given practice. Without an established regulatory infrastructure, any further efforts to address other priorities will be not be effective. Authorisation in some countries is still carried out without a formalised procedure, or procedures are not fully consistent with the IAEA standards. It is necessary to develop comprehensive staffing plans and training programmes to maintain the sustainability of the achievements made by the regulatory bodies that have been established or strengthened in the Member States.

Nuclear Safety

7. Following the Fukushima accident, the stress tests (safety assessments) which were carried out in the region, alongside routine regulatory body activities, have resulted in a number of recommendations aimed at further improving nuclear safety. Some have already been implemented, while others are to be implemented in the near future.

Occupational Radiation Protection and Control of Exposures

8. The optimization of occupational exposure has not been a priority when planning or operating devices that had the potential of radiation exposure in some Member States. An inventory of radiation sources exists and is updated in most countries. However, not all inventories are consistent with international recommendations (e.g. in some countries information about sources do not always correspond to those at the actual workplace, or information on sources used or stored at authorized practices is lacking).
9. In some countries, adequate technical services like calibration facilities are still lacking, while those facilities that exist are not adequate to meet the needs operational radiation protection. Furthermore, in some countries, there is sometimes no comprehensive management programme in place for the different levels of the operational radiation protection programme (RPP).
10. Some countries have not paid sufficient attention to workplace monitoring.

Radiation Protection in Medical Exposure

11. Lack of qualified experts in several areas of radiation protection in medicine, particularly in diagnostic and interventional radiology, remains a problem in some Member States. Others need to upgrade their regulatory authorization and inspection processes, especially with regard to advanced diagnostic and therapeutic techniques.

Radioactive Waste Management, Decommissioning and Remediation

12. Few countries do not have established policies on pre-disposal management, radioactive waste storage, decommissioning, as well as the associated arrangements to fully implement those polices. There is still room for improvement in in the field of radioactive waste management, including human resource development. Some countries have not carried out any comprehensive assessments of chronic exposure. Countries with past legacy of radioactive contamination can provide radiation protection services to a limited extent.
13. In some countries, the concept of clearance of radioactive material, consistent with IAEA standards during the implementation of radioactive waste management activities is not applied.

Long Term Operation and Engineering Aspects of Nuclear Facilities

14. Most reactors operating in the region are for long term operation. Some reactor operators have already applied for an extended operation licence or are in the process of service life extension. iIt is important that the regulators and operators in the region have a clear and coordinated approach to plant specific (periodic) safety assessments, in particular for critical systems, structures and components. Power up-rates have been implemented in several countries, but still remain a challenge for the region.

Knowledge Management and Capacity Building

15. Due to the ageing and retirement of qualified personnel and the in-between long period when only a few nuclear facilities were built, interest in nuclear education decreased in the region, resulting in a lack of newly qualified personnel in all organizations operating in the nuclear power area. In addition, nuclear knowledge was partly lost during the long pause in nuclear power development. Identification and preservation of critical knowledge is essential for maintaining and/or expanding a nuclear programme. For example, advanced techniques in probabilistic and deterministic safety analyses exceed the capabilities of many organizations, and even countries. Therefore, it is necessary to accelerate nuclear education and training, emphasizing expanded regional cooperation.

Emergency Preparedness and Response to Nuclear and Radiation Emergencies

16. In the aftermath of Fukushima accident, countries re-assessed their emergency preparedness and response measures. A number of Member States have recognized a need to improve existing arrangements in various areas. The main challenges identified are enhancement of those measures (including those for multi-unit sites), approaches and methods of source term estimation, development of procedures and joint actions by various governmental agencies, and improvements in international cooperation and initiatives in the field of remediation. Member States in the Europe Region still have common needs and face common problems in developing and harmonizing national systems for preparedness and response to radiation emergencies.

Nuclear Security and Safeguards

17. Accidents in industry transport and fuel transportation pipes as well as illicit trafficking of nuclear materials and explosives require measures for prevention.
18. Under the Global Threat Reduction Initiative, the repatriation of highly enriched research reactor fuel has been carried out in several countries in the region. Additional actions are planned for the future. Enhanced physical protection of radioactive material and of facilities using radiation sources remains a challenge for the region. Nuclear security capacity building activities are delivered in the region with the support of the Nuclear Security Fund.

2.2 Nuclear Power

Development of Adequate Scientific and Engineering Capabilities

19. Developing and launching nuclear programmes, both for electricity generation and non-electrical energy applications, requires the development of adequate scientific and engineering capabilities. The region has an excellent history in nuclear science and engineering, and a well-developed network of research and engineering institutions. Unfortunately, following the economic transition period, nuclear research and development institutions (RDI) still suffer significantly from both insufficient governmental financial support and an increasing in the number of retirements. Although there are many research reactors in the region, they are not utilised efficiently. Moreover, the expansion of advanced nuclear energy applications in industry, medicine, agriculture and science has brought new challenges for nuclear science and engineering.

Human Resources for Nuclear Power

20. The Fukushima accident highlighted the need for well-trained NPP personnel. Training and refresher courses are essential, particularly when state-of-the-art science and technology must be implemented. Correspondingly, the necessary engineering and technical support in all related fields (e.g. engineers, chemists, metallurgists, physicists, geologists, radiologists) should be available throughout the lifetime of a nuclear installation (from conception to decommissioning). Thus, access to higher education and the availability of appropriate curricula at universities should be promoted for future operation of NPPs.

Nuclear Fuel Cycle

21. Given the evolution of fuel design and core design (cladding materials, manufacturing process, high burn-up, etc.), together with possibilities for more demanding or challenging operational conditions, it is important to determine if present fuel safety criteria are adequate. The economic situation is creating new opportunities for some countries in the region to restart uranium mining. Advanced approaches to spent fuel management are being considered by a number of countries.

Nuclear Installation Performance/Operation Experience Feedback

22. The operational safety of nuclear installations (NIs) in the Europe Region has reached a relatively high level. Sharing experience and knowledge within and among NIs and regulators is a valuable tool for improving safety and safety culture. It is important to disseminate lessons learned to

improve the design, operation and maintenance of NIs. Openness and transparency in operation and regulatory practices are also essential to enhance public confidence.

Nuclear Power Planning and Introduction

23. Nuclear power plays and will continue to play an important role in the socio-economic development of the region. Planning tools should help countries answer questions on how existing NPPs can compete in the electricity market and how new NPPs might fit into long-term development plans. The growing trends for energy/electricity trade among neighbouring countries require the evaluation of supply possibilities in other countries as well as the pooling of resources at the regional/sub-regional level. The Member States which have decided on the introduction of nuclear power require guidance and support to establish the necessary infrastructure.

Waste Management/Decommissioning

24. In some Member States, radioactive waste from the operation of NIs is collected and stored at centralized facilities or on-site. This is not consistent with international practices. In many cases, waste management should be improved in terms of waste minimization and waste volume reduction, as well as in regard to quality assurance requirements, optimisation of waste management practice and maintenance of an integrated waste management system. A number of countries face the difficulties in NI decommissioning; particularly of NPPs. Human resource development for this type of activity is considered a long term challenge for the region.

2.3 Human Health

Nuclear Medicine

25. Nuclear medicine offers essential procedures for a variety of medical specialisations. Positron Emission Tomography (PET) is available in several Member States. State-of-the-art procedures are being implemented in areas that include cardiology and oncology.
26. While many countries already have the appropriate infrastructure to use gamma camera, SPECT and other in-vivo nuclear medicine studies on a routine basis, certain medical facilities still lack adequate human resources. As hospitals acquire new technologies, and in order to maintain the high levels of best practices, training in the safe and effective use of nuclear medicine applications is required. Training will allow nuclear medicine practitioners to upgrade their capabilities, and will contribute to their professional development.

Radiotherapy

27. Radiotherapy is an indispensable component in the treatment of cancer patients, and is considered appropriate for more than 50% of cases. Within the Europe Region, there are vast discrepancies in the availability of facilities to provide radiotherapy in compliance with internationally accepted standards.
28. With the installation of new machines in the region, the replacement of obsolete with modern hardware and software, and appropriate training of medical staff, many patients have better access to radiotherapy and receive more effective treatment with higher cure rates. Nevertheless, qualified professionals (technologists, medical physicists and radiation oncologists) trained in modern

radiotherapy techniques are still needed in the Europe region to satisfy the staffing requirements of medical centres, to achieve and maintain the highest levels of best evidence-based practices.

29. Medical facilities in several countries and centres of the region operate in compliance with internationally acceptable standards. There is a common interest in applying new diagnostic and treatment techniques, e.g. Intensity-Modulated Radiation Therapy (IMRT) and Image-Guided Radiation Therapy (IGRT) in radiotherapy in combination with image fusion (CT/ Magnetic Resonance Imaging (MRI), SPECT/CT, PET/CT), for better diagnosis and therapy. However, before transferring to IMRT, the overall level of radiotherapy in the centre should be adequate. Since the implementation of IMRT requires substantial resources, it should be introduced step-by-step, in order not to compromise the quality of standard care provided to the all patients.

Radiology

30. In many Member States in the region, appropriate infrastructure to carry out mammography, CT, angiography and general radiography quality assurance testing for the image quality necessary for effective diagnosis and dose control is already available. However, many medical facilities still lack adequate human resources. As hospitals acquire new technologies, training on best practices in image quality is required.
31. Many countries in the region are establishing national cancer control programmes, are trying to improve their infrastructure, install new technology and make more effective use of limited human resources. Therefore, areas for regional cooperation in the medium term should be mainly focused on introduction, implementation and improvement of cancer care capacity in Member States through integrating nuclear medicine, diagnostic radiology and radiotherapy into comprehensive national cancer control programmes that will maximize diagnostic and therapeutic effectiveness.

2.4 Isotope and Radiation Technology Applications

Radioisotope Applications (reactor and cyclotron type)

32. Use of radioisotopes significantly contributes to the improvement of health care in the majority of countries. However, supply of and access to reactor-produced radionuclides is lacking for brachytherapy, such as ^{213}Bi/^{255}Ac generators, ^{177}Lu and ^{90}Y/^{90}Sr generators and accelerator-produced radionuclides for SPECT, PET and brachytherapy like ^{123}I, ^{18}F, ^{11}C, ^{124}I, ^{86}Y, ^{68}Ga/^{68}Ge and ^{99m}Tc/^{99}Mo generators, ^{64}Cu, ^{76}Br and ^{211}At.

Radiation Sterilization in Medicine (gamma sources and electron accelerators)

33. Radiation sterilization by the application of accelerators, gamma sources and electron beam or X-ray systems is widely used to sterilize disposable health care products in several countries. Some countries in the region possess large accelerators or gamma based facilities, others have built or plan to build pilot or commercial facilities. Further development of the technology depends on the availability of suitable radiation sources and on the implementation of management systems.

Food Safety and Agriculture

34. In some parts of the region, the Sterile Insect Technique (SIT) is used to improve food safety and to reduce pesticide usage. Studies on plant mutation through the application of radiation, as well as on

plant nutrition, using radiotracer techniques, are also carried out. Food irradiation was approved by the World Health Organization (WHO), Food and Agriculture Organization of the United Nations (FAO), IAEA and Food & Drug Administration (FDA). However, the EU permits its use only for spices and herbs. A potential exists for greater use of the technology and some MSs have established irradiated food detection laboratories on their territories.

Environment Monitoring and Preservation

35. Fossil fuels are the primary energy sources in many countries in the region. It is a source of environmental pollution and thereby, a trans-boundary issue. Regional cooperation here has real added value. Among the various technologies available today, electron beam flue gas treatment technology, based on the application of accelerators, has been used in the region. For air pollution monitoring, systems based on beta-ray attenuation are adopted. Stable isotopes ratio analyses allow the monitoring of greenhouse gases, sources and sinks, and acidic pollutants.
36. Contamination of surface and groundwater by industrial waste and anthropogenic activities is also a serious problem in many countries. Because of the increasing level and complexity of polluted effluents from urban areas and industry, the development and implementation of new technologies for cleaning up of industrial wastewater, municipal water, groundwater and drinking water is critical for the environmental health of many countries. Among possible water treatment options, radiation processing can be used to degrade toxic organic compounds and biological contaminants (application of electron beam).
37. There are other problems that are connected with the migration of pollutants. This led to more active cooperation in this area. As result of such cooperation more studies have been performed at the regional and sub-regional levels, using nuclear, radiotracer and stable isotope methods.
38. The region also faces soil degradation problems. Industrial and mining activities, including energy production by fossil fuels and nuclear power plants, result in the release of different pollutants, including radionuclides, to the environment. This affects both humans and biota. The impact of contamination requires assessment in order to provide both diagnostic information to prevent recurrence of the pollution and to assist in finding remediation measures for different terrestrial and aquatic ecosystems.

Advanced Materials

39. Micro- and nanotechnologies has been developed in many Member States. Their application in areas such as materials, medicine, agriculture and environment, calls for regional cooperation. New developments in the field of nanomaterial, related to the mechanical and physical properties of materials, may have far reaching impact, e.g. on nuclear reactor engineering.

Nuclear Forensics

40. At present, various methods involving ionising radiation are being applied in criminal investigations, such as mass-spectrometry studies of scene-collected evidence. Many Member States in the region have been applying such techniques for several years. None-the-less, the development of harmonised protocols and standards remains a challenge.

Nuclear Security and Radiation Technology Applications

41. Neutron and accelerated particle activation methods have proven to be a powerful tool in identifying fissile materials, including shielded materials. Member States have demonstrated substantial progress in the development and application of such techniques. Dedicated regional fora for the exchange of know-how and experiences among specialists could further enhance regional cooperation.

Analytical and Diagnostic Methods

42. Nuclear and radiation technology plays an important active or monitoring role in preventing accidents in industry, transport and fuel transportation pipes, as well as in preventing illicit trafficking of nuclear materials and explosives.
43. Nucleonic control systems (NCS), recognized as the most requested of the radioisotope techniques for measurement and analysis, are widely used in industry to improve product quality, optimize processes and save energy and materials.

Investigations and Preservation of Cultural Heritage Objects

44. The preservation of cultural heritage is important for the Europe Region. Nuclear analytical methods (neutron activation analysis, X-ray fluorescence, etc.) play an important role in object identification (painting, sculpture etc.) and in the selection of preservation methods. In addition, radiation technology can be directly used for the preservation of some types of cultural heritage artefacts.

3 PRIORITIES FOR MEMBER STATES

3.1 Nuclear and Radiation Safety

Emergency Preparedness and Response to Nuclear and Radiation Emergencies

45. The following elements have been identified as having the highest priority in the majority of the Member States concerning the improvement, development, harmonization and maintenance of national infrastructure: managing the medical response, keeping the public informed, taking agricultural counter-measures, counter-measures against ingestion and longer-term protective actions, mitigating the non-radiological consequences of emergencies, training in response to radiation emergencies and regional and interregional assistance. Moreover, there are also other high priority working elements for some countries, namely: threat assessment, development or change of national subsidiary regulations for emergency preparedness and response, assignment of basic responsibilities and improvement of national emergency plans and procedures. The lessons learned post-Fukushima have highlighted the importance of off-site emergency centres as well as the careful design of emergency action centres.

Knowledge Management and Capacity Building including Safety Assessment

46. The training of operators and regulators needs to keep pace with advances in technology. International cooperation and networking are effective tools for supporting the development of expertise in nuclear power, for both regulatory and industry staff. In addition, it is important to encourage networking and sharing of experience between research institutions, technical support facilities and other organizations. The training packages and networks established by the IAEA will continue to be important elements of national nuclear power programmes. The main mechanism, identified by General Conference resolutions for the provision of radiation protection, is the Postgraduate Grade Education Course (PGEC) offered at Regional Training Centres. Further to this basic professional training course, specialisation in a particular thematic safety area is obtained by attending specialised training events.

Long Term Operation and Engineering Aspects of Nuclear Installations

47. Launching and extending nuclear programmes requires the development and maintenance, of engineering capabilities in site selection, design, evaluation and modernisation of NIs. Recent extreme natural events (tsunamis, storm surges, hurricanes and earthquakes) have called for a detailed review of NIs siting and design. Long term operation and power up-rating of existing reactors poses extensive engineering challenges to maintain or enhance the safe operation of NIs. An on-going and permanent exchange of experience on methodology and the results of extension of safe NPP operation at the regional level is necessary. The development and utilization of advanced techniques in both Probabilistic and Deterministic Safety Analyses far exceeds the capabilities of many organizations and even countries. This has to be taken into account among the Member States' needs. The need for executing periodic safety assessments is widely acknowledged. This would require interregional cooperation.

National Regulatory Infrastructure

48. The most effective regional cooperation tool is the utilisation of regional experience and the exchange of information on good practices. The input of accurate and timely data into existing databases, such as the IAEA's Radiation Safety Information Management System (RASIMS) and to keep up-to-date information on the current status of the regulatory infrastructure in the region should be considered as the first step in providing for international (bilateral and regional) cooperation.
49. Additionally, in many countries a need has arisen to formalize inspection and enforcement procedures in order to establish official authorization procedures. In some countries only general procedures are in place. It is, therefore, necessary to elaborate appropriate procedures for sources and practices related to different risks. In order to avoid gaps and duplication of regulatory activities some countries need to establish a formal mechanism of cooperation and sharing of responsibilities among all relevant national bodies involved in the implementation of the regulatory programme.
50. Qualified staff are key for the development of an adequate national regulatory infrastructure.
51. Majority of countries should improve their management systems in order for them to perform their regulatory programmes effectively and efficiently. The Member States' interest in the development of management systems increases as their level of implementation of regulatory activity procedures increases.

Nuclear Safety

52. It is now widely accepted that leadership and management of safety have a profound influence on the safe performance of NIs. They are essential to the development of the strong nuclear safety culture that is indispensable to Nis safety. Continuous improvement in the areas of regulatory functions and activities, as well as in the management systems in Member States, is a priority. The promotion of safety culture and high levels of harmonised nuclear safety practices is an important direction for regional cooperation. This is more emphasized in the aftermath of Fukushima accident and is underlined by the IAEA Action Plan on Nuclear Safety. Assistance to developing countries in effective licensing and oversight processes for new designs and technologies, construction, ageing management, plant life extensions, etc., should be continued.

Occupational Radiation Protection and Control of Exposure

53. Although a network of Secondary Standards Dosimetry Laboratories (SSDL) has been set up by the WHO/IAEA, those laboratories in some countries primarily deal with therapy level standards. They do not cover radiation protection needs to (i) ensure that instruments work properly and are suitable for their intended use, (ii) accurately provide the instrument readings showing the true value of the measurements and (iii) adjust instrument calibration.
54. At many facilities personnel dose can be assessed or/and controlled through workplace monitoring. Therefore, comprehensive routine workplace monitoring of radiation exposure should be carried out at regular intervals.
55. In some Member States, the hazards of naturally occurring radioactive material (NORM) can be related to previous or present mining and milling of radioactive ores or other activities. Some of these activities result in Technically Enhanced NORM (TENORM). Some of these can cross national boundaries. This shows the need for further development of national and international activities in this field for optimisation and harmonisation of approaches used in different MSs.

Public and Environmental Radiation Protection

56. In some countries the regulatory control of authorized activities need improvement. Some countries neither have regulations nor have the capabilities to provide for the control of radioactivity in materials for recycling like scrap metal. Absence of control can lead to radiation incidents and can have trans-boundary effects, e.g. denial of shipments.
57. Sufficient criteria for radioactive discharges are not in place in all the countries of the region. Existing monitoring programmes are neither always sufficient nor respond to adequate regulatory requirements.
58. Concerning NORM, reducing public exposure to indoor radon, the primary source of radiation exposure for the majority of people, remains a priority for the Region.

Radiation Protection in Medical Exposure

59. The use of practice-specific codes of practice, for the fulfilment of regulatory requirements in diagnostic radiology, nuclear medicine and radiotherapy, still needs to be improved and implemented in some countries. The application of the recommendations from IAEA Safety Report Series will assist in this respect.
60. Some Member States need to strengthen the requirements for appropriate management programmes for diagnostic radiology, interventional procedures using X-rays, nuclear medicine and radiotherapy.

Such programmes should include routine calibrations for radiation measuring instrumentation, assessment of the implementation of dosimetry protocol, and a well-established quality control and quality assurance programme.

61. A number of Member States need to implement requirements for reporting to the regulatory authority cases of any mal-administration of radiation doses to radiotherapy patients. Often, sufficient attention is not paid to errors already made in dose administration. Or information on such errors is disseminated only within a narrow group of interested persons. Experience shows that analysis of the circumstances, plays an important role in the prevention of future such errors, and in the improvement of regulatory oversight and guidance.

Environmental Monitoring and Decommissioning/Waste Management Issues

62. Several Member States have to deal with considerable amounts of waste emanating from their nuclear power programme (e.g. Chernobyl accident). These fall into various classes of activity such as operational and back-end-due (i.e., spent fuel) and waste from active or decommissioned operations for milling and mining of radioactive ore mills. On the other hand, natural radioactivity from radon and other gases are specific to the region. Because of common possible impacts on the environment and human health, anthropogenic waste and natural radioactivity require similar approaches to environmental monitoring.

3.2 Nuclear Power

Nuclear Installation Performance / Operation Experience Feedback

63. Seven priority areas have been identified in this field: assurance and quality of services for NIs; in-service inspection and maintenance, including risk informed on-site inspection and maintenance; operational feedback and exchange of experience; human factors in operation; self-assessment; modernization of instrumentation and control (I&C) systems to establish digital systems; ageing/plant life management and operational data collection, processing and exchange. It is necessary to guarantee the quality of services provided through outsourcing, and to enhance the technical competence of scientists/engineers in the field of reactor core and fuel reliability.

Development of Adequate Scientific and Engineering Capabilities

64. Most research facilities in the Europe Region were designed many years ago, and some are of little use today. IAEA TC should work to assist both institutions running the facilities and the regulatory authorities to assure safety during the remainder of their operational life and their decommissioning. Cooperation among countries possessing such facilities becomes increasingly important, taking into account the need to facilitate continued basic research on both materials behaviour under irradiation and other ageing mechanisms under realistic conditions.

Nuclear Power Planning and Introduction

65. All aspects related to the planning, development and introduction of nuclear power programme, as well as the elaboration of research projects related to nuclear power and technology, are important in the region. It is necessary to distribute, among interested countries, tools for planning and establishing the required infrastructure for the introduction of nuclear power programme in the

new economic environment as well as share experiences gained from feasibility studies made in the region. The regional aspects of nuclear power planning are also important, taking into account the tendency towards integration of the national electrical power networks of the region.

Nuclear Fuel Cycle

66. Four priority areas have been identified. They are: fuel safety criteria and fuel licensing; spent fuel management (financial and safety aspects); NFC "back-end" for open and closed cycle; and NFC "front-end". They cover a wider nuclear fuel cycle range than just the technical aspects of the NFC front and back ends. From the security perspective, comprising both non-proliferation and assurance of fuel supply, possible expansion of nuclear power may require an assessment of fuel supply assurances within the region, taking into account, among others, such aspects as resources of low enriched uranium and capabilities for actual fuel assembly fabrication.

Waste Management/ Decommissioning/ Remediation

67. Five priority areas have been identified: decommissioning, waste minimization, low and intermediate level waste management, high level waste management and international aspects of waste management. In order to find common solutions and approaches to similar problems, waste management discussions should be held at the international level. The technological aspects of safe decommissioning, as well as a set of problems connected to the social and financial aspects of decommissioning, are important topics for discussion at the regional level. Decommissioning activities require the establishment of an adequate legal, governmental and regulatory infrastructure. Moreover, different options for decommissioning activities and the subsequent management of generated waste should be evaluated. Ongoing efforts are being deployed to support environmental remediation to reduce radiation exposure from contaminated land areas or other contaminated media, such as surface or groundwater, created in the region following nuclear and radiological accidents.

3.3 Human Health

Improving Clinical Practice in Radiation Oncology

68. Radiotherapy remains a major cost-effective modality for cancer treatment. Fostering and maintaining a quality assurance programme, leading to accurate dosimetry, dose delivery and patient protection is of paramount importance for the successful application of the technique. Within the Member States, training courses are planned to be organized targeting sub-regions in order to optimize the outcome.
69. It is necessary to support strategic planning for radiotherapy departments and/or radiotherapy services in individual Member States, backed by national cancer control programmes, with Agency initiatives such as Quality Assurance Team for Radiation Oncology (QUATRO) missions and the support of IAEA programmes such as the Programme of Action for Cancer Therapy (PACT). International recommendations on staffing requirements for radiotherapy centres are particularly valuable resources for Member States and could be adopted at the national level.
70. Some European Member States seek IAEA assistance to support their efforts in providing treatments such as IMRT (Intensity Modulated Radiotherapy). Considering the complexity of the IMRT treatment and its possible detrimental consequences if improperly applied, well trained staff is vital for its safe practice. Adequate staff training is essential prior to the initiation of an IMRT

programme. Therefore, national radiotherapy centres that are ready to make a transition from conformal radiotherapy to IMRT in the treatment of some tumours will additionally require, properly trained staff (medical physicists, radiation oncologists and radiotherapy technicians), dedicated to its implementation.

71. Member States require assistance in the development of radiotherapy centres with programmes that deliver treatments with a good 3D-conformal, optimized treatment plan, using all the necessary accessories for the accurate delivery of dose. New techniques such as IMRT, Image Guided Radiotherapy (IGRT) or Stereotactic Radiotherapy (SRS) are likely areas for training cooperation in this field.

Supporting the Establishment of Gamma Cameras and PET or PET/CT

72. The establishment of PET or PET/CT and gamma camera units with better resolution and anatomic localization capabilities would be helpful for the early detection and follow-up of cancer patients in the region. Training of all staff involved (physicians, medical physicists, radio-pharmacists and technologists) for both imaging and therapy applications are necessary under all circumstances. Harmonization, distribution and adoption of available guidelines, protocols and regulations published by professional societies and various international organizations would assist clinics in the Member States to elevate the quality of imaging and therapy techniques using radionuclides to internationally accepted standards.

3.4 Isotope and Radiation Technology Applications

Isotope Production for Human Health

73. In order to increase the overall quality of healthcare, a priority for the region, many countries are planning or have started the construction of PET centres. Due to the high investment needed to establish such centres, some countries will seek technical assistance via the TC programme, in particular through consolidation of domestic and international funds. IAEA TC could assist in enhancing the sustainability of regional capacities and promoting regional self-reliance, providing a framework for sharing best practices, facilitating the introduction of new technologies and applications (supported by appropriate human resource development), harmonizing regional norms and standards, enhancing partnerships and networks and supporting the achievement of common regional development goals.

74. Management systems development and laboratory accreditation are important for further implementation and for upgrading radiation sterilization facilities. High priority should be given to these areas.

Environment Monitoring and Preservation

75. The development of air and water pollution control is an important priority. International cooperation in the region will help both in technology and machine enhancement. Monitoring and investigation of different pollutants using nuclear and complementary analytical methods, and the development of models is another priority in many parts of the Europe region. In addition, particular attention within the context of environmental monitoring activities should still be given to the Chernobyl situation.

Advanced Materials

76. Nanotechnology is a promising and rapidly expanding field of R&D which may be applied in the development of advanced materials. Good quality accelerators for radiation processing are available in the region. However, costs must be reduced to achieve their broader utilization in industry. Recent developments in the field of nanotechnology may result in new applications related, for example, to nuclear reactor and fuel engineering. R&D in the field of nanotechnology is supported both by national funds and the EU Framework Programmes, proving the importance of this field for Member States. TC activities will facilitate and strengthen cooperation in the region regarding utilization of radiation technologies.

4 CROSS-CUTTING AREAS

4.1 Education and Training

77. Several Member States in the Europe Region have educational and training programmes in the fields of nuclear and radiation safety, nuclear energy, human health and isotope and radiation technology applications. However, these are not homogenous across the region. Nonetheless, strengthening and expanding existing methods for providing training to Member State professionals remains a priority for the region. Sub-regional and national multidisciplinary, thematic, or site-specific training courses with experienced trainers are needed. E-learning in some basic/theoretical fields may also be applicable.
78. The development of a national strategy for education and training in the area of radiation and waste safety is a basic requirement for a common understanding of problems within the region. Harmonization of definitions and requirements for qualification is essential for successful cooperation within the region.
79. Educational courses in the field of radiation protection are offered through the Postgraduate Education Course (PGEC) in regional training centres. Following this basic professional training course, specialisation in a particular thematic safety area can be obtained by attending specialised training courses developed by the IAEA. The educational course is dedicated to young professionals.
80. Most Member States in the Europe Region need to train more radiation oncologists, technologists and medical physicists to satisfy the staffing requirements of medical centres. Advanced centres in the Europe Region and other regions could be approached and encouraged to provide trainers who would collaborate in organizing one-year training programmes for radiation therapists/radiotherapy radiographers (RTTs), interventional radiology, nuclear medicine and diagnostic radiology technologists. Educational arrangements are available in the region for medical physicists. Since groups of scientists (medical, biomedical, etc.) in the Member States of the region have similar professional capabilities, operational environments and objectives, they could meet periodically to discuss methods to achieve their goals.
81. The essential role of medical physics in modern medicine, especially in the diagnosis of medical conditions and treatment of cancer, is well established. Although the staffing criteria and international recommendations regarding the number of medical physicists are well known in the Europe Region, much remains to be done in the harmonization and establishment of national educational and training programmes in medical physics, with an emphasis on clinical training.
82. RTT training with hands-on experience and collaboration with other advanced radiotherapy centres is needed, in particular through long term scholarships for students, practical courses with

hands-on experience in established and advanced radiotherapy centres, and by sending trainees for practical training or sending trainers to a radiotherapy centre to train its entire staff.

4.2 Institutional Capacity Development

83. Socio-economic changes in the Europe Region during the last few decades, namely deregulation and market-orientation, have brought challenges to national nuclear institutions. They have been requested to achieve a high degree of self-reliance and sustainability in the competition for survival, revival and growth. In order to support their efforts towards transformation and institutional development, support is needed on a regional basis. This includes introducing modern management practices, and providing key knowledge and skills in business planning, resource mobilization, marketing and intellectual property management. As the structural changes in parts of the region continue, nuclear institutions should become more competitive, market-oriented and self-sustainable. Therefore, continued attention is needed to develop partnerships and networks in the field of institutional capacity development. The benefits of promoting linkages with different partners and institutions should be available to all countries in the region, and further innovative and creative types of support in this area need to be explored.

4.3 Nuclear Knowledge Management

84. It is important to strengthen regional capabilities for preserving and transferring nuclear knowledge, not only in the field of nuclear energy/power, but also in a wide range of nuclear applications. Strengthening mechanisms to collect, maintain and disseminate knowledge is necessary in order to develop – through e-learning and other innovative educational technologies – the new skills and competencies necessary to ensure nuclear safety culture in all fields. Knowledge management is becoming an integral part of public management and business operations, and remains relevant to the Europe Region.
85. Networking in a broad sense has been recognized as an important tool to sustain development in different areas. A number of initiatives exist to establish networks focused on specific areas of interest and to create platforms for discussing common problems, sharing experiences, and supporting a harmonized approach to similar issues. These initiatives need to be expanded and strengthened.