EUROPE REGIONAL PROFILE 2018–2021

Executive Summary

This document is an updated version of the 2009-2017 Europe Regional Profile (ERP). The profile was used in the context of elaborating the 2009-2013 and 2014-2017 regional technical cooperation programmes. This updated version covers the period 2018–2021. The regional technical cooperation programme 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 2009–2017 and is complemented by additional information available from national and regional sources.

The four thematic areas for the Europe Regional Profile are as follows:

i. **Nuclear and Radiation Safety**, including nuclear installation safety, radiation protection, 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.

A brief analysis of the above thematic areas pertaining to the current situation in the Europe Region is presented:

Nuclear and Radiation Safety:

- Governmental and Regulatory Framework and National Regulatory Infrastructure
- Knowledge Management and Capacity Building
- Safety Culture and Occupational Radiation Protection
- Security of Radioactive and Nuclear Material
- Emergency Preparedness and Response to Nuclear and Radiation Emergencies
- Public and Environmental Radiation Protection
- Radioactive Waste Management, Decommissioning and Remediation

Nuclear Energy:

- Sustainable Energy Development and Energy Policy
- Knowledge Management and Capacity Building
- Nuclear Installation Performance and Engineering Aspects of Nuclear Facilities
- Research Reactors
- Nuclear Fuel Cycle

Human Health:

- Quality of Medical Services
- Knowledge Management and Capacity Building
- Introduction of Linear Accelerators, Gamma Cameras and Positron Emission Tomography (PET) and PET/CT

Isotope and Radiation Technology Applications:

- Use of Isotopes and Ionizing Radiation
- Environment Monitoring and Preservation
- Advanced Materials

The above list is an indication only and does not exclude consideration of new areas of cooperation that could arise. The Europe Regional Profile guides and 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 (TC) programme. These projects deliver cooperation support and address regional needs. Activities of regional projects usually comprise of meetings, workshops and training events such as regional training courses and group scientific visits/fellowships.
2. It is possible to address the challenges of smaller groups of Member States in the Europe Region through a sub-regional approach.
3. 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.
4. All Members States in the region are eligible for support. The following countries currently participate in IAEA's technical cooperation programme: Albania, Armenia, Azerbaijan, Belarus, Bosnia and Herzegovina, Bulgaria, Croatia, Cyprus, Czech Republic, Estonia, Georgia, Greece, Hungary, Kazakhstan, Kyrgyzstan, Latvia, Lithuania, Malta, Montenegro, Poland, Portugal, Republic of Moldova, Romania, Russian Federation, Serbia, Slovakia, Slovenia, Republic of Tajikistan, the former Yugoslav Republic of Macedonia, Turkey, Turkmenistan, Ukraine, Uzbekistan.
5. Even though most of the participating countries have their national programmes, there are a few countries, which participate only in the regional programme.
6. Some countries only receive minor support from the regional programme and national programme but support other countries by providing expertise and extra budgetary resources.
7. The Regional Profile for 2018–2021 was jointly prepared by the Member States and the IAEA Secretariat. It is an update of the previous Regional Profiles (for 2009–2013 and 2014-2017) and 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 guides and complements the ongoing consultative process between Member States and the Secretariat, aimed at identifying possible areas of cooperation.

2 SITUATION ANALYSIS

8. The situation analysis has identified the following main features and trends in the Europe Region. These should be taken into account for during the planning of the next regional programmes:

- there is a wide diversity of Member States in the region – significant differences in their socio-economic development level, and a wide range of different applications of nuclear energy and radiation sources;
- most Member States in the Europe Region already have a functional national legal and regulatory infrastructure. There are 9 countries operating nuclear power plants and 2 countries building their first nuclear power plants. There are more than 10 countries, which operate research reactors;
- 15 of the Europe Region Member States are members of European Union (EU) and additionally 4 Member States are accession countries to the EU;
- most Member States are parties to the Joint Convention on the Safety of Spent Fuel Management and on the Safety of Radioactive Waste Management and Convention on Nuclear Safety;

- the IAEA Action Plan on Nuclear Safety has been and continues to be implemented in the region;
- the demand for a safe, economical, secure and reliable energy supply is increasing, options for addressing this demand may include nuclear power;
- radioactive waste and spent fuel management, storage and disposal possibilities are important pre-conditions for the development of nuclear power;
- safe management possibilities for radioactive waste are pre-conditions for the use of isotope applications;
- environmental impacts, public awareness and stakeholder involvement are becoming more important in the decision-making processes;
- the consequences of the Chernobyl accident still represent a major challenge for some areas of the region;
- service life extension and power up-rate of operating nuclear power plants (NPPs) have been decided upon and in some cases implemented;
- there is a constant need for knowledge management of the personnel to secure radiation and nuclear safety;
- effective international cooperation and dialogue remains a prerequisite in securing radiation and nuclear safety in the region.

9. 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, there is renewed interest in the fields of nuclear power and environmental protection. The Member States have also stressed the importance of extending the lifetime of existing NPPs as well as construction of new units in the region.
10. Support activities under the TC Regional Programme will be mainly focused on sustaining a sufficient number of well-trained personnel and building capacity of young specialists to enhance the capabilities of involved parties.
11. The analysis highlighted that the trends and priorities outlined in the previous European Regional Profiles remain mostly 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 programmes during the 2009–2017 period.

2.1 Nuclear and Radiation Safety

Governmental and Regulatory Framework and National Regulatory Infrastructure

12. In some countries in the Europe Region, the regulatory infrastructure for the control of radiation practices and sources is not yet fully developed and there are several countries, which are in the process of updating their legislation.
13. There is a need for formalized procedures to ensure consistent application of radiation safety procedures. There is also need for comprehensive staffing plans and training programmes to maintain the sustainability of the achievements made by the regulatory bodies established in the Member States.

Knowledge Management and Capacity Building

14. National regulators are key players in nuclear and radiation safety and they are facing more and more challenges. For example, the need to ensure communication with all stakeholders.
15. Due to the ageing workforce and retirement of qualified personnel and long periods when only a few nuclear facilities were built, interest in nuclear education has decreased in the region, resulting in a lack of newly qualified personnel in the nuclear power area. The need for decommissioning of the nuclear facilities should be considered as well.
16. Radiation protection requires qualified staff as well, however often these needs in a Member State are not enough to support sustainable national teaching programmes. This means that the regional approach should be continued.

Safety Culture and Occupational Radiation Protection

17. The optimization of reducing occupational exposure has not been a priority when planning or operating devices that have the potential of radiation exposure in some Member States.
18. Some countries have not paid sufficient attention to workplace monitoring, especially when considering the internal exposure of workers.
19. More attention is given to enhancement of safety culture among operators to increase their level of awareness regarding their responsibility.
20. Safety Assessments are an integral part of all the main decisions in radiation and nuclear safety and in these processes, it is crucial to involve the stakeholders. The countries in the region often have the necessary technical knowledge, however communication could be improved. It is important to use the regional framework where appropriate.

Security of radioactive and nuclear material

21. 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.
22. Attention is given to prevention of illicit trafficking of nuclear materials. There is a need to maintain cooperation between all involved stakeholders.
23. 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.

Emergency Preparedness and Response to Nuclear and Radiation Emergencies

24. Several Member States have recognized a need to improve existing arrangements in various areas after the Fukushima accident. 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.
25. 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.

Public and Environmental Radiation Protection

26. Because of growing public awareness, there is need to provide more information about protection of the public and environment. On the regional scale, it is important to harmonize the approaches.
27. The problems related to the migration of chemicals, heavy-metals, etc., have led to more active cooperation in this area. As a result of such cooperation more environmental studies have been performed at the regional and sub-regional levels, using nuclear, radiotracer and stable isotope methods.

Radioactive Waste Management, Decommissioning and Remediation

28. 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 are countries with disposal options for radioactive waste, however there are also a remarkable number of countries, which do not have any disposal options available.
29. In some Member States, radioactive waste is collected and stored at centralized facilities or on-site. However, there are often limited capabilities to treat this waste, especially to minimalize the amount of the waste for future treatments, including the disposal. There are several countries in the region, which have a legacy of radioactive contamination.
30. There is still room for improvement in the field of radioactive waste management, including human resource development. Some countries have not carried out any comprehensive assessments of chronic exposure. 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.

2.2 Nuclear Power

Sustainable Energy Development and Energy Policy

31. There are several countries, which must address the increasing gap between electricity supply and demand. Additionally, there is a strong will to increase the contribution of low pollution and low Greenhouse Gas emission sources of energy in the future.
32. In order to provide more energy security, it is important to diversify the sources of energy supply.
33. 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.
34. Member States which have decided on the introduction of nuclear power require guidance and support to establish the necessary infrastructure.

Knowledge Management and Capacity Building

35. 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 is to 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.

36. 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 still suffer significantly from both insufficient governmental financial support and an increasing in the number of retirements.

Nuclear Installation Performance and Engineering Aspects of Nuclear Facilities

37. 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.
38. Following the Fukushima accident, the stress tests (safety assessments) which were carried out in the region alongside routine regulatory body activities have resulted in several recommendations aimed at further improving nuclear safety. Most of them were implemented.
39. Most reactors operating in the region are meant for long term operation. Some reactor operators have already applied for an extended operation license or are in the process of service life extension. It is important that the regulators and operators in the region have a clear and coordinated approach to plant specific (periodic) safety assessments, for critical systems, structures and components. Power up-rates have been implemented in several countries, but remain a challenge for the region.

Nuclear Fuel Cycle

40. 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. Advanced approaches to spent fuel management are being considered by several countries. The economic situation is creating new opportunities for some countries in the region to restart uranium mining.

2.3 Human Health

Improving quality of medical services

41. With the installation of new radiotherapy equipment in the region, the replacement of obsolete hardware and software, and appropriate training of medical staff, many patients have better access to diagnostic and treatment, 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, and to achieve and maintain the highest levels of service.

42. 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.
43. Nuclear medicine offers essential procedures for a variety of medical disciplines. Positron Emission Tomography (PET) is available in a number of Member States. State-of-the-art procedures are being implemented in areas that include cardiology and oncology.
44. In many Member States, 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.
45. Obesity, in particular amongst children is a growing concern in the European region. Stable isotope techniques can be used to monitor and evaluate nutrition and physical activity interventions thus contributing to accurate and effective analysis.
46. 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 regarding advanced diagnostic and therapeutic techniques.
47. As part of the medical procedures, patient protection and safety must be ensured. There is a growing trend in the number of countries where patient doses are being recorded.

Supporting Introduction of Linear Accelerators, Gamma Cameras and Positron Emission Tomography (PET) and PET/CT

48. Many countries in the region are establishing national cancer control programmes, and 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.
49. 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.

2.4 Isotope and Radiation Technology Applications

Use of isotopes and ionizing radiation

50. Use of radioisotopes significantly contributes to the improvement of health care in most

countries. However, supply of and access to reactor-produced radionuclides is lacking for brachytherapy, such as ^{213}Bi/^{225}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 ^{99}mTc/99Mo generators, ^{64}Cu, ^{76}Br and ^{211}At.

51. 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.
52. At present, various methods involving ionizing 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. Nonetheless, the development of harmonized protocols and standards remains a challenge.
53. 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.
54. Nuclear and radiation technology plays an important monitoring role in preventing accidents in industry, transport and fuel transportation pipes, as well as in preventing illicit trafficking of nuclear materials and explosives.
55. Nucleonic control systems, 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. Radiotracers are applied to investigate industrial installations and processes.
56. In some parts of the region, the Sterile Insect Technique (SIT) is used to improve food safety and production and to reduce pesticide usage. Currently EU permits using food irradiation techniques for spices and herbs. There are studies on plant mutation through the application of radiation, as well as on plant nutrition, using radiotracer techniques, carried out. A potential exists for greater use of the technology and some Member States have established irradiated food detection laboratories on their territories.
57. Nuclear and nuclear-derived technologies can be used to quickly diagnose animal and zoonotic diseases, which have the potential to spread from animals to animals and animals to people. Many veterinary laboratories lack the capacities and equipment to apply such technologies.
58. 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.
59. Research reactors: Although there are many research reactors in the region, often they are not utilized efficiently. There are several of them which are closed, pending closure or partially decommissioned.

Environment Monitoring and Preservation

60. 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 purification of industrial and municipal wastewater, 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 microbiological contaminants (application of electron beam).
61. 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 in this context 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.
62. The region also faces challenges in the agricultural sector and in particular land degradation and soil erosion problems. Isotopic applications are being used for diagnostic and monitoring activities.
63. 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 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

64. Micro- and nanotechnologies have been developed in many Member States. Their application in areas such as materials, medicine, agriculture and environment, calls for regional cooperation.
65. 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.

3 ENVISIONED PROGRAMME OUTLINE

3.1 Nuclear and Radiation Safety

Knowledge Management and Capacity Building

66. 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. Also, the training of regulators and operators needs to keep pace with advances in technology. In order to support their efforts towards transformation and institutional development, support is needed on a regional basis.
67. It is important to strengthen regional capabilities for preserving and transferring nuclear knowledge 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. Qualified staff are key for the development of an adequate national regulatory infrastructure.

68. 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 and webinars may also be applicable.
69. Educational courses in the field of radiation protection are offered through the Postgraduate Education Course (PGEC) in regional training centres. The educational course is dedicated to young professionals. 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.
70. Networking in a broad sense has been recognized as an important tool to sustain development in nuclear and radiation safety, for both regulatory and industry staff. 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.
71. The most effective regional cooperation tool is the utilization of regional experience and the exchange of information on good practices. In addition, it is important to encourage networking and sharing of experience between research institutions, technical support facilities and other organizations. Knowledge management is becoming an integral part of public management and business operations, and remains relevant to the Europe Region.
72. Additionally, in many countries a need has arisen to formalize inspection and enforcement procedures in order to establish official authorization procedures as part of their management systems. 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.

Safety Culture and Occupational Radiation Protection

73. At many facilities workers doses can be assessed or/and controlled through workplace monitoring. However, it can be sometimes challenging to assess the internal doses. Therefore, comprehensive routine workplace monitoring of radiation exposure should be carried out at regular intervals and these procedures should be based on internationally accepted methods.
74. 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.

Emergency Preparedness and Response to Nuclear and Radiation Emergencies

75. In emergency preparedness, there are several topics of concern for Member States. These topics

include managing the medical response, keeping the public informed, taking counter-measures against ingestion and longer-term protective actions (including agricultural counter-measures), mitigating the non-radiological consequences of emergencies, training in response to radiation emergencies and regional and interregional assistance.

76. The topics that need to be addressed through a regional approach include: 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
77. The lessons learned post-Fukushima have highlighted the importance of off-site emergency centres as well as the careful design of emergency action centres.

Public and Environmental Radiation Protection

78. Because of common possible impacts on the environment and human health, anthropogenic and natural radioactivity require similar approaches in monitoring.
79. 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. In addition, particular attention within the context of environmental monitoring activities should still be given to the Chernobyl situation.
80. 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.

Radioactive Waste Management, Decommissioning and Remediation

81. The priority areas in the Europe region are: waste minimization, management of radioactive waste, international aspects of waste management and decommissioning. In order to find common solutions and approaches to similar problems, waste management discussions should be held at the international level.
82. Safe management of radioactive waste and decommissioning activities require the establishment of an adequate legal, governmental and regulatory infrastructure, including licensing for decommissioning. The national strategy for management of radioactive waste is a framework for moving toward a sustainable program to deploy an integrated system capable of transporting, storing, and disposing of spent fuel and radioactive waste. The preparation and updating of the strategy is crucial.
83. These strategies include different topics, where regional approaches are essential. For example, education and training in the area of radiation and waste safety. Harmonization of definitions and requirements for qualification is essential for successful cooperation within the region.
84. The technological aspects of safe waste management and decommissioning, as well as a set of problems connected to the social and financial aspects of it, are important topics for discussion at the regional level.
85. There are several countries in the region, which are facing legacy waste problems. 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.

86. 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. As several of these activities have similarities and some of them can cause impact 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 countries.

3.2 Nuclear Power

Sustainable Energy Development and Energy Policy

87. 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.
88. Launching and extending nuclear programmes requires the development and maintenance, of engineering capabilities in site selection, design, evaluation and modernisation of Nuclear Installations. Recent extreme natural events (tsunamis, storm surges, hurricanes and earthquakes) have called for a detailed review of their siting and design.

Knowledge Management and Capacity Building

89. It is now widely accepted that leadership and management of safety have a profound influence on the safe performance of Nuclear Installations (NI) and they are essential in development of the strong nuclear safety culture. 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 the Fukushima accident and is underlined by the IAEA Action Plan on Nuclear Safety and Convention on Nuclear Safety.
90. Assistance to Member States in effective licensing and oversight processes for Nuclear Power Plant new designs, re-designs and technologies, construction, ageing management, plant life extensions, etc., should be continued.

Nuclear Installation Performance and Engineering Aspects of Nuclear Facilities

91. The following topics are priorities in regional cooperation: 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 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.
92. 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.

Nuclear Fuel Cycle

93. Priority areas 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, considering, among others, such aspects as resources of low enriched uranium and capabilities for actual fuel assembly fabrication.

3.3 Human Health

Improving quality of medical services

94. The use of practice-specific codes of practice, for the fulfilment of regulatory requirements in diagnostic radiology, nuclear medicine and radiotherapy, needs to be improved and implemented in some countries.
95. 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.
96. 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.
97. 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.
98. 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.

99. 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 or Stereotactic Radiotherapy are likely areas for training cooperation in this field.

Knowledge Management and Capacity Building

100. Most Member States in the Europe Region need to train more radiation oncologists, nuclear medicine doctors, 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.
101. 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.
102. 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.

Supporting Introduction of Linear Accelerators, Gamma Cameras and Positron Emission Tomography (PET) or PET/CT

103. 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.
104. 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, through consolidation of domestic and international funds. IAEA 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.

3.4 Isotope and Radiation Technology Applications

Use of isotopes and ionizing radiation

105. 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.
106. Member States use ionizing radiation in a wide range of activities: forensic, industry, agricultural development, etc. Harmonized protocols and standards are important in securing radiation safety.
107. Using nuclear and nuclear-derived technologies to quickly diagnose animal and zoonotic diseases together with building capacities of veterinary laboratories is considered to be of high relevance in Europe.

Environment Monitoring and Preservation

108. Environmental Monitoring and investigation of different chemicals, heavy-metals, etc. using nuclear and complementary analytical methods, and the development of models is another priority in many parts of the Europe region

Advanced Materials

109. 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, including public-private partnerships, when appropriate.

Research Reactors

110. Most research facilities in the Europe Region were designed many years ago, and some are of little use today. Several of them are waiting for the decision about their future. IAEA 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.

4 RELEVANT INTERNATIONAL CO-OPERATION

111. As securing nuclear and radiation safety is obviously a worldwide challenge, there is need for international cooperation with other organizations, partnerships, networks and initiatives. This cooperation is as much as possible promoted through multilateral initiatives from international organizations such as United Nations.
112. Often different partnerships are mutually beneficial, synergizing all available resources to reach to as many interested parties as possible in the region, and provide access to the most needed high quality training opportunities.
113. The IAEA plays an active part in helping the international community with the achievement of the 17 Sustainable Development Goals (SDGs), which were adopted by the Member States of the United Nations. The Agency has identified nine Goals that are supported directly through programming.
114. The World Health Organization has provided technical support to formulate national strategic plans for the health system. There are also radiation related activities in the region, which were supported through NATO Science for Peace and Security Programme.
115. In the Europe region cooperation with the European Commission is mutually important.
116. IAEA offers also several review services and missions: the IAEA Integrated Regulatory Review Service (IRRS), the International Physical Protection Advisory Service (IPPAS), Integrated Safety Assessment of Research Reactors (INSARR), Safety Aspects of Long Term Operation (SALTO) Mission, Operational Safety Review Team (OSRAT) Mission, Quality Assurance Review Assistance Team (QARAT) Mission, Integrated Review Service for Radioactive Waste and Spent Fuel Management, Decommissioning and Remediation (ARTEMIS), etc. These services and missions can be incorporated into technical cooperation projects where appropriate.
117. It is necessary to support strategic planning in radiotherapy and nuclear medicine services in individual Member States with Agency initiatives such as Quality Assurance Team for Radiation Oncology (QUATRO) missions, Quality Management Audits in Nuclear Medicine Practices (QUANUM) 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.
118. The IAEA has been collaborating since 1997 with the European Society for Radiotherapy and Oncology (ESTRO), and since 2005 with the European Association of Nuclear Medicine (EANM), to provide specialized training opportunities to medical practitioners working in the areas of radiotherapy and nuclear medicine. The partnerships with ESTRO and EANM have played significant roles in the improvement of radiotherapy practice and the growth of nuclear medicine practice, leading to the overall improvement in radiation medicine services in Europe region.
119. The IAEA should encourage and assist research on and development and practical application of atomic energy and its applications for peaceful purposes throughout the world and foster the exchange of scientific and technical information and exchange of scientists for peaceful uses of atomic energy. The IAEA's Coordinated Research Activities stimulate and coordinate the undertakings of research by institutes in IAEA Member States in selected nuclear fields. Most of

the Coordinated Research Activities are carried out under its Coordinated Research Projects, which bring together an average of 15 scientific institutes from developing and developed countries to concentrate on problems of common interest.

120. 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.

5 CONCLUSIONS

121. The regional technical cooperation programme in the Europe Region aims to enhance collaboration among the Member States, as well as with other partners by facilitating cooperation between them.
122. Regional projects constitute a key feature of the IAEA's technical cooperation (TC) programme in the Europe Region. These projects deliver cooperation support and address the needs of the region.
123. The Europe Regional Profile guides and complements the ongoing consultative process between Member States and the Secretariat in identifying possible areas of cooperation.
124. The Europe Regional Profile strongly encourages creation of linkages between TC activities and the Sustainable Development Goals.
125. This Europe Regional Profile will be reviewed and revised as deemed necessary by Member States and the IAEA.