Regional Strategic Priorities for 2012-2017

Background

As decided at the 38th NRM, a Working Group comprising experts in RCA Thematic Areas and persons knowledgeable about RCA policy matters met in Vienna in February 2010 to make recommendations regarding the RCA Regional Priorities for 2012-2017. They were guided by the RCA Regional Profile, which contained the information provided by RCA Member States in response to the survey conducted, and an analysis of the past RCA Projects, inputs provided by the Technical Officers and their own knowledge and expertise.

The draft report of the Working Group containing descriptions of areas of priority in the four thematic areas of Agriculture, Environment, Human Health and Industry are herewith submitted for the approval of the 32nd NRM. This document is expected to be used as a tool in deciding on the RCA projects to be implemented in 2012-2017.

The Division for the Asia and the Pacific of the Department of Technical Cooperation is engaged in developing a Regional Cooperative Framework (RCF) for the whole Asia and Pacific Region and the RCA strategy is expected to be a part of this overall strategy. An expert group for drafting the RCF is expected to meet on 19-23 April. The NRM will be briefed on the outcomes of this Meeting. The RCF will be based on a Working Paper prepared during a preliminary meeting held in February.

Proposed Action

The National RCA Representatives may consult their National Thematic Sector Coordinators, National Project Coordinators, and other relevant persons and provide their inputs during the discussion under this Agenda Item in order to adopt the document containing the proposed priority areas for the RCA Programme, given in the Annex, with the required revisions.

Annex

REGIONAL COOPERATIVE AGREEMENT

INTERNATIONAL ATOMIC ENERGY AGENCY

RCA Strategic Priorities for 2012-2017

To be adopted at the 32nd Regional Meeting of the National RCA Representatives April 2010

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Executive Summary

The Regional Cooperative Agreement for Research, Development and Training Related to Nuclear Science and Technology (RCA) is an agreement among the Governments of 17 Member States of the IAEA in the East Asia and the Pacific Region, established under the auspices of the International Atomic Energy Agency to promote and coordinate cooperative research, development and training projects in nuclear science and technology. The programme is owned and managed by the RCA Member States through a well-established network of policy makers and scientists, with the IAEA playing a supporting role.

The RCA Member States have decided to carry out a comprehensive review of the outcomes of past RCA activities and develop its future programmes based on this analysis and on the information on current needs obtained from the Member Sates through a Survey. This information has been compiled to form the RCA Regional Profile.

The identification of the focus of the future RCA activities were carried out by a group of technical experts guided by RCA policy makers using the information in the RCA Regional Profile, criteria for RCA Projects adopted by the Member States, TC Strategy and Criteria for TC Projects, inputs from the technical officers of the IAEA and their own knowledge and experience.

The following are the main areas of focus recommended for RCA activities in 2012-2017.

Thematic Area – Agriculture

1. Plant Mutation Breeding
   The focus is on: the use of new irradiation technologies such as ion beam irradiation; and, strengthening of established networks for exchange of mutant germplasm and technology transfer.
2. Animal Production and Health
   The short term focus is on: improving the efficiency of utilization of feed by ruminants: better manure management: prevention of water pollution: standardisation of nuclear and related techniques for the diagnosis and control of animal diseases: and, export certification of food of animal origin.
   The medium term focus is on: the use of molecular methods for selection and breeding of superior stock: and, molecular diagnostic methods and irradiated vaccines for animal disease control.
3. Food Irradiation
   The focus is on: the use of alternative irradiation technologies, such as x-rays and electron beams on account of the negative public reaction to the use of gamma irradiation: development and harmonisation of standards: and, retraining of quarantine inspectors on the use of irradiation for phytosanitary purposes.
4. Soils and Land-use
   The focus is on: compound specific isotope analysis for the identification of critical land degradation areas in the landscape, in addition to natural and anthropogenic radionuclides and stable isotopes.
5. Insect and Pest Control – Sterile Insect Technique (SIT)
   The Working Group recommended that the National RCA Representatives consider the information provided in the main report on SIT and decide whether or not this technology area should be considered as a priority area for the RCA.

Thematic Area – Environment

1. Sustainable air particulate matter monitoring
   The focus is on: the continuation of the activities commenced under the previous RCA Projects on monitoring Air-Pollution; and, extending the use of Nuclear Analytical Techniques in investigations on cultural heritage.
2. Sustainable water resources development
   The focus is on quantification of groundwater resources, environmental forensics; and, effects of climate change on various aspects of the water cycle in terrestrial environments.
3. Sustainable marine coastal resources development
   The focus is on: the integration of the application of nuclear isotopic techniques to support marine and coastal zone studies on land-based sources of pollution; and, establishment of guidelines for authorities on remediation steps for better management of the marine environment.

Thematic Area – Human Health

1. Intensity modulated radiation therapy (IMRT)
   The focus is on: protocols for patient management, immobilisation procedures, electronic image acquisition, contouring of cancers and surrounding normal tissues and organs, treatment planning using adequate computers and software, treatment delivery with image guidance; and, quality assurance.
2. Hybrid nuclear medicine imaging (PET/CT and SPECT/CT) in cancer management.
   The focus is on: strengthening and improving the quality of the practice of hybrid nuclear medicine technologies, PET/CT and SPECT/CT, by providing training on cross-sectional imaging and reporting: and, on clinical applications in oncology.
3. Image Guided Brachytherapy for predominant cancers in the region.
   The focus is on: strengthening the ability of RCA Member States to use evidence-based methodology in the practice of high quality brachytherapy.
4. Management of common cancers in the RCA region by radiation therapy (RT)
   The focus is on: the development of clinical protocols and guidelines for the use of RCA Member States for management of common cancers in the region.
5. Nuclear Medicine in the Management of Cardiovascular Diseases
   The focus is on: strengthening and improving the application of nuclear medicine, mainly SPECT, in the management of cardiovascular diseases.

Thematic Area – Industry

1. Non-destructive testing
   The focus is on: computed tomography and digital radiography for improving industrial safety, productivity and product quality.
2. Radiation processing technology
   The focus is on: radiation grafting technology for specific applications and electron beam treatment of industrial waste including use of mobile EBM generators
3. Use of radiotracers for industrial troubleshooting and process optimisation
   The focus is on automation of testing methodologies; application to studies of advanced industrial systems such as trickle bed reactors; field testing of radioisotope generators for application in industrial studies; and, validation of computational fluid dynamic codes.

RCA STRATEGIC PRIORITIES FOR 2012-2017

1. INTRODUCTION

1.1 THE RCA PROGRAMME

The Regional Cooperative Agreement for Research, Development and Training Related to Nuclear Science and Technology (RCA) was established in 1972, as an agreement among the Governments of participating Member States to promote and coordinate cooperative research, development and training projects in nuclear science and technology through their appropriate national institutions, in cooperation with each other and the IAEA. The IAEA performs secretariat duties under the Agreement and subject to rules and procedures of the IAEA for providing technical assistance, supports cooperative projects implemented under the Agreement. Seventeen Member States of the IAEA, namely Australia, Bangladesh, Peoples' Republic of China, India, Indonesia, Japan, Republic of Korea, Malaysia, Mongolia, Myanmar, New Zealand, Pakistan, the Philippines, Singapore, Sri Lanka, Thailand and Vietnam are the current signatories of the RCA.

Over the past 38 years of its existence the RCA Programme has very significantly contributed to the development of the capabilities of its Member States to apply nuclear science and technology to address socio-economic issues of their countries. The programme is owned and managed by the RCA Member States through a well-established network of policy makers and scientists, with the IAEA playing a supporting role. While policy matters that govern the implementation of the RCA Programme are decided by National RCA Representatives appointed by the Governments of the parties to the Agreement, the scientific programmes are managed by a network of scientists in the Member States. The Member States decide on the projects to be implemented based on a set of criteria that they have developed which includes their national priorities and the potential for regional cooperation, and they play a major role in preparation of project concepts, development of the project designs, project implementation and evaluation of ongoing project performance.

The RCA Member States have adopted a Medium Term Strategy for the period 2006-2011, which has been subsequently reviewed, revised and extended for the period 2012-2017. The Medium Term Strategy focuses on the RCA Vision and Mission, its Core Values, Governance, Success Factors, Strategic Directions and Performance Indicators.

In 2002 the RCA Member States established a Regional Office in the Republic of Korea for the purpose of promotion of the RCA and its activities as well as establishing partnerships with other regional organizations engaged in activities of mutual interest in order to achieve the RCA vision of being recognized as an effective partner in providing nuclear technologies that address socio-economic needs and contribute to sustainable development in the region. More information on the RCA Programme can be obtained from the web-site of the RCA Regional Office, www.rcaro.org .

1.2 RATIONALE FOR A REGIONAL STRATEGY

As mentioned above, the projects to be implemented under the RCA Programme are decided by the Member States based on agreed criteria which include their national priorities and potential for regional cooperation. In the past this decision has been made at a Regional Meeting of the National RCA Representatives. The National RCA Representatives, guided by the recommendations made by the Standing Advisory Group on Technical Assistance and

Cooperation (SAGTAC)[1] decided that a more strategic approach should be utilized in deciding on the future priorities for the RCA Programme in order to further refine and improve the current procedures. The 31st Regional Meeting of the National RCA Representatives saw the merits of having an in depth analysis carried out of the RCA Projects implemented in the past. This would identify the strengths and weaknesses, the gaps in the technology transfer achieved through these projects, the extent of end-user involvement and other information that would be relevant for planning the future RCA Programmes. It was also seen that a long-term strategy extending over several TC cycles, based on the analysis of the previous projects and based on the current needs of the RCA Member States would be helpful in overcoming the limitations that stem from planning for one TC cycle at a time.

1.3 DEVELOPMENT OF THE STRATEGY DOCUMENT, WORK METHODOLOGY

The task of developing the methodology for establishing the RCA Strategic Priorities for the period 2012-2017 was delegated by the 31st Regional Meeting of the National RCA Representatives (NRs) to the Working Group appointed to extend the RCA Medium Term Strategy. The Working Group comprising representatives of Australia, China, India, Indonesia, Japan, Malaysia, New Zealand and Pakistan, met in Vienna in July 2009 and recommended the following.

1. Conducting a survey to identify the needs of the Member States

2. Compilation of the information provided by the Member States and information on past RCA Projects by an external consultant to form the RCA Regional Profile.

3. Formation of a Working Group consisting of three members per thematic area, with two being specialists in the respective fields and one NR for each theme to provide guidance related to policy.

4. Development of RCA Strategic Priorities by the Working Group based on the information contained in the RCA Regional Profile, inputs provided by the IAEA Technical Officers, and their own knowledge and expertise.

5. Adoption of the recommended strategy by the Regional Meeting of the National RCA Representatives to be held in April 2010.

The composition of the Working Group formed for development of the Strategic Priorities is given in Annex 1. The Regional Profile comprising of the details and outcomes of all the RCA Projects implemented in the past and the details of the outcomes of the survey conducted to identify the priorities of the RCA Member States could be obtained from the RCA Secretariat. The Executive Summary of the Regional Profile is given in Annex 2.

2. RCA PRIORITY AREAS FOR 2012-2017

2.1 AGRICULTURAL SECTOR

Introduction
Agriculture worldwide is facing a number of key strategic issues that need to be addressed by activities in the agricultural sector:

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[1] Issues and Options Paper for Strengthening the IAEA's Technical Cooperation Regional Programming Approach - Third Meeting of the Fourth Standing Advisory Group on Technical Assistance and Cooperation

- The world population is predicted to increase to 8.2 billion by 2030, resulting in the need to increase agricultural productivity for meeting the increased demand for food to feed the population.
- The changing global climate requires better adaptation of crops and livestock to extreme and unpredictable climate conditions.
- These activities need to be performed in an environmentally sustainable manner, to prevent depletion of resources and to prevent leaving a detrimental legacy to future generations.
- There is increased emphasis on global trade, food safety and security, and increasing shelf life of food products. Currently, about one third of all food produced is wasted either somewhere in its path to the consumer or by the consumer.

Background

Since the establishment of the RCA, many problems in the agricultural sector have been effectively addressed using nuclear technologies. Technically, some of these technologies have reached considerable levels of maturity. In addition, a range of new and complementary technologies (e.g. ion beam irradiation, compound-specific isotope analyses, high-throughput analyses), as well as more efficient applications of the mature technologies, have the potential to make a significant contribution to addressing new challenges identified in the above key strategic issues.

Strategic Directions

Future projects in the agricultural thematic sector will continue to build on a platform of a combination of nuclear technology and traditional techniques. The application of new technologies, both nuclear and non-nuclear, will enhance the effectiveness of the technologies and provide outcomes that go beyond “business as usual”. In some areas, they will also assist in improving the public’s acceptance of the use of nuclear technologies in agriculture.

Even where nuclear technologies applied in the agricultural sector have reached a high level of technical maturity, there is a significant need for consolidation in terms of documentation, capacity building, and training to ensure their effectiveness and sustainability at the regional and national scale. TCDC is able to play a significant role in this context.

Many key strategic issues can only be addressed by multidisciplinary approaches, not just in the agricultural sector. Therefore, a significant challenge for the development and implementation of some future projects will relate to an integated technological approach across different technical areas and even thematic sectors.

Future projects in the agricultural sector will contribute to the following key outcomes:

- increased productivity and quality of food of plant and animal origin, through sustainable use of available resources;
- better adaptation to extreme climate conditions;
- provide benefits across the region; and,
- facilitate global trade in food through regionally harmonised regulatory systems and enhanced food safety.

<u>Priority Area 1: Plant Mutation Breeding</u>

Rationale, discussion of the need and beneficiaries

Mutation breeding techniques have played a very significant role in addressing world food and nutritional security problems by developing new mutant germplasm and mutant varieties.

By the end of 2009, induced mutations have made significant contributions in development and release of more than 3000 mutant varieties in more than 170 crop species by more than 60 countries in the world. 1877 mutant varieties, which accounts for more than 60 % of the total mutant varieties in the world, have been released or approved for cultivation in the Asian and Pacific region.

The previous RCA projects have focused on enhancing crop genetic diversity, improving stress tolerance, and establishing a mutant germplasm network. The results have provided a very good foundation for integrated improvement of crops. For the future, there is a need to continue efforts to induce and identify new sources of mutant genes and to develop new mutant varieties with higher yield potential and better quality. This is of increased relevance and importance in the context of the predicted need for adaptation to combat predicted climate change as well as resistance to emerging diseases. This much-needed boost to crop productivity will contribute to addressing the region's rising demand for food in a timely manner. It will also contribute to increasing the production of high-value crops for domestic and export markets, thus making a difference to hundreds of thousands of smallholder farmers through sustainable improvement of livelihood.

Technological priorities
Traditional nuclear technology has been widely used in plant breeding. However, some new nuclear techniques, such as ion beam irradiation although not widely used at present does have the potential to increase the efficiency of mutation breeding. New opportunities such as the use of high-throughput screening techniques are also emerging, which can increase the speed and efficiency of mutation induction and development of new mutant varieties.

Ion beam irradiation is an established technology in the industrial/medical fields. It has also been shown to be effective in mutation induction and crop improvement. It provides a wider range of mutations; however, it also poses challenges in its application in terms of the availability of suitable irradiation facilities and their operation.

Specific requirements
A short-term requirement is to strengthen and drive the established network for exchange of mutant germplasm and information on mutation breeding through training courses, workshops, expert missions and to make improved use of existing facilities in the region for technical services.

The necessary technical infrastructure for the newer technologies is still limited to just a few MSs. Therefore, in the medium term, MSs will have to commit significant resources to infrastructural development, while establishing cooperative arrangements with established facilities and Regional Research Units (RRUs). This could become more cost-effective if combined with applications in other thematic sectors..

Priority Area 2: Animal Production and Health

Rationale, discussion of the need and beneficiaries
Most developing countries in the Asia-Pacific region are undergoing steady economic growth, which is driving an increase in the consumption of and demand for animal products. This requires more efficient and increased productivity of livestock, without depleting the available natural resources and also keeping environmental impacts at a minimum. It has also been established that a considerable amount of animal products are subject to losses along the production and marketing chain. Therefore, improving the keeping quality of food will contribute greatly to its more efficient distribution and utilization.

Efficient production of food of animal origin in many MSs is limited by the genetic capacity of animals, the availability and quality of year-round feed, management and reproductive efficiency, and the presence of diseases. Poor sanitary and keeping qualities of food, as well as factors that hinder international trade, reduce their availability to consumers as well as the profitability for the producers.

Previous RCA projects have addressed some of these issues and developed potential solutions. There is now a need to validate, apply and disseminate these technologies more widely. Furthermore, emerging molecular technologies could be harnessed to achieve greater gains in livestock productivity and food safety.

This will benefit national livestock development and extension systems, livestock producers, distributors, exporters, importers and regulators, as well as consumers of food.

Technological priorities

Animal production:

A short-term need exists for the application of methods for improving the efficiency of utilization of feed by ruminants resulting in reduced methane emission (by quantification of rumen microbes), better manure management (by tracking nutrient flows and polluting elements), and preventing water pollution (by using isotopes as tracers, either through labelling or by using their natural signatures).

In the medium term, new technologies for using molecular genetics for selection and breeding of superior stock (by analyses for microsatellites, SNPs and DNA sequencing) will become important for enhancing livestock productivity as well as disease resistance.

Animal health and food safety:

There is an immediate need to standardise, document and quality-assure nuclear and related techniques for the diagnosis and control of animals diseases (ELISA, PCR), and for testing and export certification of food of animal origin (microbiological, RIA, HPLC), to ensure the quality and safety of food and to facilitate international trade.

In the medium term, technologies such as new molecular diagnostic methods and irradiated vaccines, will become important for animal disease control.

Specific requirements

Animal production:

Short-term: translation of applications for improving the efficiency of digestion and reducing methane emission, better manure management, and preventing water pollution, from *in vitro* to *in vivo* and on-farm applications.

Medium-term: incorporation of molecular methods for selection and breeding of superior stock.

Animal health and food safety: harmonize the protocols for utilization of nuclear and related diagnostic techniques to control animal diseases, and institute QA procedures for regional and international trade.

For both areas, there is a need for human resources development through the compilation of materials for training, their use at the national and the regional level and wider dissemination of information to end-users and beneficiaries.

Priority Area 3: Food Irradiation

Rationale, discussion of the need and beneficiaries
Post harvest food losses due to damage by insects, rodents, bacteria and mould, or from sprouting or over-ripening of produce, are estimated to be between 25 and 40 % in many countries. Irradiation is an effective and safe method for preserving food, as it reduces spoilage, improves food hygiene, and extends shelf life. Irradiation is also an effective method for quarantine treatment, thus significantly facilitating regional and international trade.

Sanitary applications for food irradiation are mature and very promising but commercial uptake has so far been relatively slow. However, the phasing out of chemical treatment of food under the Montreal protocol will limit the available technologies that can be used which can be expected to increase the importance of food irradiation as a treatment method. There is also scope for work in special cases, e.g. food for hospital patients, who have compromised immune systems.

Technological priorities
The conventional method of food irradiation by ^{60}Co is affected by issues relating to the availability, handling, regulation and transport of the radioisotope. Additionally, its uptake is still restricted in may countries as the result of negative public perception. Therefore, other methods, such as x-ray and electron beam irradiation, are gaining more importance.

Specific requirements
There are immediate requirements for phytosanitary applications. Quarantine inspectors are currently mostly trained to evaluate food that has been chemically treated. In contrast, irradiation does not actually kill all pests but prevents their ability to reproduce or live beyond a certain life stage. This requires the development and harmonisation of standards and retraining of quarantine inspectors.

Sanitary applications are continuing, albeit at a lower scale. The requirements relate to special applications, e.g. food for hospital patients, and the benefits from irradiation in the context of increasing food prices.

With both sanitary and phytosanitary applications, the move towards alternative machine sources requires knowledge transfer regarding dosimetry and design of electron beam and X-ray techniques and the operation of these facilities. These aspects would significantly benefit from TCDC.

Priority Area 4: Soils and Landuse: Isotopes from molecular to global scales

Rationale, discussion of the need and beneficiaries
The steady increase of the contribution of animal - derived protein to the diet in many MSs has significant implication on land-use. In some MSs, maize used as animal feed, is increasingly grown in areas of steep slopes. This can cause erosion and have a degrading impact on soil and water quality. Sustainable agriculture depends on maintaining an appropriate balance between the use of soil nutrients and water resources for crop and livestock production systems and environmental protection.

An integrated approach is required to solving problems related to this declining soil and water quality caused by the rapid land use change, combining aspects of livestock management with cropping systems and plant breeding, and ultimately the environmental impacts of these processes, such as nutrient cycles and water management. Furthermore, in many MSs, the predicted climate variability and change could lead to more extreme weather events, such as droughts and flooding, both in terms of magnitude and frequency.

Isotopic techniques applied to soil and land use studies play a crucial role in providing tracers to study natural and anthropogenic processes. This will provide individual farmers with insights on more effective and efficient livestock, crop, soil and agricultural water management and give political decision makers the background for informed decisions on adaptation and mitigation options at the national and regional scale.

Technological priorities

Traditionally, soil erosion studies have significantly benefited from the study of natural and anthropogenic radionuclides, such as ^{137}Cs, ^{210}Pb, ^{7}Be. Depending on the half-lives of these radionuclides, assessments covering time frames of up to 100 years can be performed. These techniques will continue to play a vital role, in particular in the adaptation of integrated land and agricultural water management practices to the regional conditions and challenges.

In addition, stable isotope techniques (e.g. carbon and nitrogen) have been used as tracers to study soil processes, providing information about origin of soil and linked nutrients in the agricultural landscape, as well as stability of the soil material. In recent years the technique of compound specific isotope analysis has provided a quantum leap in this area, by enabling the identification of critical land degradation areas in the landscape and the fate of individual compound classes. As the technology will mature over the next three TC cycles, this can be extended , in the medium-term to studies of radionuclides, such as ^{14}C.

Of significant importance in this context is the availability of background data about the regional and global distribution of stable and radioactive isotopes in soils (Isoscapes).

Specific requirements

Instrumentation required for studies of “traditional” radionuclides, particularly gamma detectors, are available in most MSs. Their operation is reasonably straightforward and normally requires little or no chemical preparation.

In contrast, the technology of stable isotope-ratio mass spectrometry is less widely accessible in the region. As a short-term activity, capacity building through knowledge transfer is therefore required to enable MSs to make effective use of investments in this technology. Compound-specific isotope analysis (CSIA) is a continuously developing application, and is currently available in only a very few MSs, in terms of both infrastructure and technical expertise. Therefore, clear mechanisms for capacity building (establishment of RRUs, training courses) will need to be established in the short-term, while mechanisms for efficient end-user uptake will need to be developed in the medium-term.

The effective use of information on the regional distribution of isotopic signatures in soils (Isoscapes) will require the establishment and enhancement of networks to collect these data and make them available to users within the region.

As there are considerable synergies with aspects of environmental sustainability, strong integration and communication with proposed areas in the Environment sector are necessary to avoid duplication and maximise impact.

Insect and Pest Control – Sterile Insect Technique (SIT)

Rationale, discussion of the need and beneficiaries

Insects account for a significant part of the world's pre-and post harvest food losses. An important strategic component to raise productivity and promote global food security is investment in pest management practices that sustain the natural balance and reduce reliance on pesticides. This area could become important with new challenges resulting from climate change, increasing prices of food in the international market. These are transboundary phenomena and may require to be addressed at the regional scale.

Proven technology to reduce insecticide use and crop destruction are the sterile insect technique (SIT) and related biological pest control methods. There has been no RCA project regarding insect and pest control in the past. However, there is one ongoing non-RCA regional project on fruit flies with participation from 23 Asian/Pacific countries and two national TC projects. At least three RCA MSs have mass rearing and irradiation facilities. Personnel training and knowledge transfer on SIT through a regional project will increase the applications of this environment friendly nuclear technique and the production of high-value crops, benefiting thousands of famers

It is recommended that NRs consider these factors and decide whether or not this technology area should be implemented through an RCA project.

Technological priorities

International standards to facilitate the export of fruit and vegetables should be implemented, including the creation of areas of low pest prevalence through systems approaches by the effective integration of these biological techniques.

Emphasis should not only be SIT, but also on integrating with the other the uses of nuclear techniques in support of the mass production and deployment of biological control organisms.

Specific requirements

A large supporting infrastructure and an area-wide approach with the involvement of all stakeholders, including the private sector.

Human resources development through the compilation of materials for training, their use at national and regional level and wider dissemination to end-users and beneficiaries.

It is recommended that NRs consider these factors and decide whether or not this technology area should be implemented as a priority through an RCA project.

2.2 ENVIRONMENTAL SECTOR

INTRODUCTION

Four billion out of the world population of seven billion in 2010 come from the developing world in the Far East and South Asia. In 2020, this part of the world will account for 4.5 billion out of 8 billion world population. This population surge paralleled with increasing standards of living in the developing world correlates with increasing demand for natural resources such as water, energy, food sources, living spaces, and puts increasing pressure on the environment to cope with human activities. Environmental pollution can be a consequence of these activities. If unabated, the environmental impacts may be catastrophic for the present as well as future generations.

The RCA has contributed to the global effort of environmental protection since 1987 through regional cooperation in research and development, technology transfer and training using nuclear science and technology. Projects in the areas of air pollution, fresh water resources and marine and coastal pollution were the focus of regional cooperation. As of 2009, there were about 11,211 person days of inputs and a total expenditure of US$5.5 M on the environment sector. The projects have generated regional databases of high quality, which provide science-based information for the formulation of environmental policies and regulations by relevant government agencies to protect the public as well as the environment. This may be considered as one of the significant impacts of the RCA environment-related projects. Actions taken by the end-users, be they government agencies, the industry, the academe, and the public redound to enhanced quality of life and contribute to socio-economic development of the participating countries. Another significant accomplishment is the build up of available trained manpower with the knowledge and skills in nuclear analytical techniques, and methodologies for evaluating environmental impacts which can be used to implement new programmes for the next five years.

KEY STRATEGIC ISSUES

The Member States have identified three priority areas namely, air, water, and the marine environment which are interlinked compartments. Contaminants from air enter into surface water system, which migrate to ground water and seawater. New programmes must build on the physical, human, and scientific infrastructures established over the past two decades. These new activities or initiatives are supported by a rich history and great success both in nuclear technology transfer and user uptake providing direct socio-economic benefits, and lessons learned to enhance the pathway to sustainability.

Knowledge preservation must be a strong component of the new programme considering the inevitable turnover of staff due to attrition by retirement and other causes as well as it underpins the sustainability of the technologies. This can be accomplished by training of new staff from the participating as well as potential new Member States, documentation of analytical results and technical reports, formulation of training materials for the conduct of national training courses and TCDC.

Sustainability of the projects must be addressed through exerting greater effort to involve end-users, if possible, at the start of the projects. Greater involvement of the academic sector may enhance greater uptake of the technology as this sector provides the feeder stock and the scientific exchange necessary for sustainability. Engagement of the relevant government agencies should be enhanced as these are directly involved in policy making and regulatory oversight, and these can make use of the data generated by the projects.

Since environmental issues being addressed by the RCA are not confined to the RCA region alone, but are also experienced by other parts of the world, collaboration with others offers a great opportunity for RCA to continue its track record of being a trailblazer in terms of ideas, methodologies and project management and at the same time learn lessons from the other agreements in planning and implementing environmental projects

EXPECTED OUTCOME

Regional databases, relevant nuclear analytical techniques and facilities, and nuclear analytical skills now existing in the region are expected to enhance the capability to generate more knowledge on the fate of environmental pollutants as these affect the livelihood and health of communities in the Asia-Pacific region. Knowledge management, being an integral part of the implementation of projects, ensures the sustainability of scientific know-how in the region.

KEY FOCAL AREAS

As the priorities given in the survey, the following focus areas under the environment sector are recommended:

1) Sustainable air particulate matter monitoring;
2) Sustainable water resources; and,
3) Sustainable marine and coastal resources.

Additionally the following two new projects were identified:

1) Assessment of mining contamination and mineral processing using portable XRF instruments and in-situ methodologies; and,
2) Assessment of environmental impact of radioactive pollutants to harmonise the system for comparability of data, benchmarking and nuclear safety.

Priority Area 1 - Sustainable air particulate matter monitoring

The new project on transboundary air pollution builds on the success stories of three former RCA projects (RAS/8/082 (99-02); RAS/7/013 (03-07), RAS/7/015 (08-11). These projects have created a new capability in the region that is much sought after by end-user organisations operating in the environment sector. The projects have critically delivered new nuclear analytical technology to the region and the interpretation of air particulate data to many end-users. Much care has been taken to integrate new members into the initiative, to up skill technical staff and to transfer the data into local government and other decision making institutions. Success of the projects includes: participation of up to 16 Member States; direct contribution from UNDP (RAS/8/082) and Republic of Korea (RAS/7/015); nuclear analytical technology transfer; new awareness of usefulness of NATs in environmental science; establishment of RRUs assisting Member States with nuclear analytical services; identification of local, regional and transboundary air particulate matter pollution; generally a growing high end-user activity providing input funding that exceeds the programme funding; consideration of data for policy programmes and air pollution management and finally establishment of the first regional database on fine and coarse air particulate matter spanning at least 5 successive years. High quality results pointing to excellent QA/QC were published in more than 10 international publications. These outputs point to a healthy sustainability of air particulate matter monitoring in the RCA, with clear socio-economic benefits stretching from human health to visibility degradation and first identification of some long-range transboundary pollution events causing trouble in affected countries and adding information to the climate change community.

The new project will pick up from the successful work and will include new aspects of movement of polluted air regionally and potentially even globally. Sampling of air in rural areas (national parks etc) would add value to the programme by providing samples less affected by human pollution sources and therefore enhancing the detection of transboundary pollution events. A new component of the project will be linking air pollution to cultural heritage. It is envisaged that the new project will enhance the sustainability by involving predicted new members to the IAEA from the RCA region (Cambodia, Laos and Papua New Guinea) and also establishing a new end-user group in cultural heritage.

Of strategic importance are also issues that need to be tackled from lessons learned: deficiencies are incomplete documentation of nuclear analytical technology, including air sampling, data interpretation and most importantly documentation on best reporting practises. The later has been identified as the most important issue for some countries significantly limiting the uptake of the technical programme outcomes by end-users.

Hands on training courses and documentation are of strategic importance to provide enhanced awareness of NAT in air pollution and uptake of technology by end-users. Core activities from the current programme need to be continued initially at the current level to enhance the regional database and relevance of data for local and national end-users, industry and other interested organisations dealing with global issues such as climate change. In some cases, visitors may need to be incorporated in the programme with limited participation. It is suggested that a prerequisite for participation in the new project is a clear link to a national programme. In past projects it has been observed that where participating MSs have no national programmes in place, this resulted in them being the weakest link.

It is recommended that the new programme will also include supplementary tasks in:

(1) Striving for closer connection between the RCA and other groups. In fact, considering that air travels globally, an interregional approach would be most desirable, for example by considering data from ARCAL and AFRA, if available.
(2) Impact of air pollution on cultural heritage focussing on ancient buildings, artefacts, paintings etc to determine the quality of the environment around cultural heritage, pollution of cultural heritage and defining environmental condition for preserving the cultural heritage. RCARO may assist in seeking funding opportunities and negotiate extrabudgetary funds, for example from UNESCO, regional offices of UNESCO etc. Locally and nationally, productive areas for funding sources (end-users) are various foundations, galleries and museums. This new objective will add value to the human health orientated core objective by identifying movement of pollutants and make better use of information for new end-users.

It is envisaged that this incremental strategic shift in project objectives would enhance the sustainability of the programme by carefully considering the needs of the Member States for human capability development in nuclear analytical techniques and the human health orientated end-users and phasing in of new end-users from a different community.

Priority Area 2 - Sustainable Water Resources Development

Water is one of the core elements of human existence. Over the last several decades, surface and groundwater resources are increasingly under pressure for a number of reasons such as increasing demand for food, increasing urbanization and industrialization. Groundwater resources are often the only reliable source of clean water in many parts of the world. Very often, the sustainable use of groundwater is limited by both water quality and quantity. The quality is mainly affected by untreated industrial and urban waste disposal, agrochemicals and mobilization of geogenic contaminants. Good quality aquifers are depleting due to over exploitation. Due to decline in water table, pumping cost rises and hydraulic gradients would also favour the saline water from nearby zones to take place of good quality water. The effects of climate change are being felt, with impacts across many economic sectors but water sector will be one of the most adversely affected areas. Rising global temperatures may lead to an intensification of the hydrological cycle, resulting in dryer dry seasons and wetter rainy seasons, and subsequently heightened risks of more extreme and frequent floods and droughts. Changing climate may also have significant impacts on the quality and quantity of water that is available and accessible. Therefore, it is imperative to adapt proper strategies to minimize climate effects for sustainable management of water resources. Adaptation measures have to be taken, including institutional, educational and project design changes.

For effective addressing of issues related to contamination, aquifer potential for sustainable exploitation and climate change impacts, one needs tools to study surface water and groundwater interactions; determine source(s) and rate of recharge; trace the sources, movement and fate of contaminants; and investigate groundwater dynamics. Environmental isotope tracers have the ability to do that because of their unique ‘fingerprinting’ of sources that are often preserved within the subsurface, and the radioactive natural isotopes that provide a time scale of subsurface flow. Integration of isotope techniques with conventional techniques gives excellent results. Facilities for commonly used isotopes have been established in most of the RCA MSs, while others are making efforts to do so. Water authorities refer their problem to the nuclear institutes only in some of the MSs. For improved water resources management with sustainable application of nuclear/isotope techniques, water-related RCA projects are to be continued in future cycles with special emphasis on dissemination of awareness of these techniques and development of human resources in end-user governmental organizations and institutes by involving them in the projects. Such projects will be beneficial to water boards and environmental protection agencies for formulation of regulations and sustainable management of water resources.

Seven projects concerned with the general area of Fresh Water Resources were implemented as part of the RCA Programme. RAS/8/059 supported isotope hydrology workshop and seminar held in China. Real field problems encountered in water resources management were addressed with active involvement of end users in five projects. Under RAS/8/084 "Isotope use in Managing and Protecting Drinking Water", capabilities were developed to undertake a quantitative assessment of the water resources and generate predictive models to enable decision makers to formulate management schemes for the judicious utilization and protection of the region's limited drinking water resource. RAS/8/093 project demonstrated the usefulness of integrating isotopic tools with the management programme for dam safety and sustainability. In RAS/8/097, Isotope Techniques were applied for groundwater contamination studies in urbanized and industrial areas with special reference to arsenic, fluoride and other metals under a sub-project "Geogenic Contamination of Groundwater". RAS/8/104 "Assessing Trends in Freshwater Quality Using Environmental Isotopes and Chemical Techniques for Improved Resource Management" filled the gap in information availability regarding ground water resource management, expanded the efforts into the development of a full-fledged regional database on water quality. The same project is continuing with a new number RAS/8/108 to establish long term database. In these projects 12 to 16 MSs participated with active involvement of end users therefore adoption of the technology by the water agency managers and policy makers has been successful at significant level. The project RAS/8/092 contributed to the formulation of appropriate strategies for the sustainable management of seven geothermal fields with a total installed electric power generation capacity of 1320 MWe. Isotope investigations were also carried out on 33 prospective geothermal reservoirs.

Keeping in view the requirements of RCA MSs, vital issues related to quality and quantity of water systems are to be investigated for improvement of water resource management. Isotopic tools will play vital role in these investigations. In general, the common regional issues can be covered in the future projects under following areas:

1. Quantification of groundwater resources (groundwater – surface water interactions, recharge rates)
2. Environmental forensics (identification of sources of pollutants - understanding anthropogenic and geogenic mechanisms)
3. Effects of climate change on various aspects of the water cycle in terrestrial environments (changes in runoff/river water discharges and interaction with groundwater; rise in sea level causing flooding of wetlands and lowlands, and seawater intrusion in to fresh water; changes in rainfall patterns (higher precipitation in some regions and reduction in others) etc.

Specific requirements for sustainability of the programme are to enhance awareness of end-users, training of relevant professionals in new techniques and data interpretation, uptake of the technical outputs by end-users, provide isotope analytical services to the MSs having insufficient facilities. In addition to regional training courses, national workshops/training courses involving possible end-users should be essential components in the future projects. Results should be disseminated to policy makers/responsible government agencies/end-users through executive management seminars, brochures and print media, etc.

Priority Area 3 - Sustainable marine coastal resources development

The Asia-Pacific region has more coastline than any other region in the world known for its rich biodiversity. The region supports 50% of the world's population with rapid growth rate and increasing industrial development. Growth in trade in fisheries resources and expansion of aquaculture activities are being felt in the region. Parallel to these developments is the threat of environmental degradation. Most of the Asia-Pacific countries are situated along the coast line and bear the brunt of coastal/marine pollution. Major types of pollution in these countries are toxic chemicals, sewage, agricultural nutrients, non-biodegradable litter, sediments and pollution from maritime transport and oil production. This problem is affecting the economy and public health on one side and destroying local and regional marine life on the other.

It is imperative therefore to understand the system within the region for a healthy environment and management of this natural resource. For the better management of the coastal zones, good understanding of the system, sources and movement of pollutants are imperative. Nuclear and chemical techniques are vital tools when use in conjunction for monitoring, movement and settlement of different pollutants in these environments.

RCA studies on marine and coastal environments started in 1989, and six projects (RAS/8/065, RAS/8/083, RAS/7/011, RAS/8/095, RAS/7/016, and RAS/7/019) have been implemented. The projects made possible the training of manpower in marine sediment sampling and processing for pollutant determination and dating/sedimentation studies, nuclear analytical techniques, modelling and sediment transport methodologies, receptor-based marine toxin analyses for monitoring harmful algal blooms (HABs), and on understanding the behaviour of contaminants in aquatic systems.

The previous projects have generated databases, known as ASPAMARD or Asia-Pacific Marine Radioactivity Database, on radionuclide concentrations from various environmental samples, which have been included in the Global Marine Radioactivity Database (GLOMARD). The participating MSs have gained enhanced knowledge on the behaviour of contaminants in the aquatic and marine environments and using this knowledge to undertaking probabilistic ecological risk assessment modelling for radionuclides and non-radioactive pollutants.

The new project should strategically focus on the integration of the application of nuclear isotopic techniques to support marine and coastal zone studies on land-based sources of pollution and establishment of guidelines for authorities to take remediation steps for better management. Expected outputs are:

1. Data information on pollutant distribution patterns at selected sites in seawater, sediments, fauna and flora.
2. Provision of a comprehensive baseline data for various pollution sources that would be useful for pollution monitoring of the study area.
3. Assessment of the impact of disposal of industrial and municipal wastes on marine life.
4. Data of bioaccumulation to determine possible health risks by consumption of seafood.

Future activities must build on these capabilities in tackling current and emerging environmental concerns such as food safety caused by marine toxins and bioaccumulated metals and organic pollutants, coastal erosion and sedimentation, ocean acidification from climate change, carbon cycle.

Knowledge management should be an integral component of future activities involving mentoring, preparation of training materials, and the conduct of national training courses with immediate multiplier effect among project staff, end-users and beneficiaries.

RECOMMENDATIONS

- Detailed project design and formulation of supplementary activities should be carried out by experts in the field;

- The TCDC mechanism should be made full use of by both old and newly joined Member States;
- Documentation of results and technologies through publications, manual of procedures and protocols should be required at the end of the project; and,
- Engagement of end-users at the start of the project should be encouraged.

2.3 HUMAN HEATH SECTOR

INTRODUCTION

The Working Group in the Human Health Sector, with the cooperation and the information provided by the Technical Officers of the IAEA, has discussed the RCA project areas for Human Health Sector during the 2012-2017 cycles. The fields of Radiation Oncology, Nuclear Medicine, Medical Physics, Nutrition, and other specialties were taken into the consideration for the discussion of the possible project areas, and the Working Group has identified the following project areas.

The numbering of the priorities provided in this report reflects the order of the priorities which the Working Group considered to be significant (Priority #1 being the highest priority, and Priority #5 being the lowest priority).

Priority Area 1 - Development of intensity modulated radiation therapy (IMRT) capability in the RCA region

Rationale:

Cancer is a major health burden in the RCA region and is projected to increase significantly over the coming decades, as life expectancy improves, communicable diseases are controlled and health transition occurs.

Radiation therapy (RT, also called radiotherapy) remains one of the three pillars of cancer treatment, along with surgery and systemic therapy (chemotherapy). RT provides an exceptional use of nuclear technology for human benefit. RT may be used in the curative treatment of cancers, with the aim to eradicate the cancer permanently, or for palliation, to relieve distressing symptoms of cancer when cure is not possible.

For the curative treatment of cancer with RT, higher radiation doses lead to an improved chance of cure. However, higher radiation doses also cause a greater chance of side effects and complications, which can limit the dose that can be delivered to the cancer. As a result, there has been a constant improvement in technology to increase the dose to the cancer, while reducing the radiation dose to the surrounding normal tissues and organs that causes complications.

The standard of radiation therapy (RT) for the curative treatment of selected cases of several cancers in the developed countries is IMRT. This level of technological sophistication permits a higher chance of cancer control, with reduced risk of complications. IMRT has the possibility of being utilised for the curative treatment of common cancers in the RCA region, such as lung cancer, head and neck cancer, oesophageal cancer, and prostate cancer.

Currently, there are a limited number of centres in the RCA region that have the capability to deliver IMRT. One significant reason for this is the lack of suitably trained staff such as radiation oncologists, medical physicists, and radiation therapy technologists needed to support this technology. As a result, cancer patients may be treated using inferior techniques that have a reduced chance of cure and a greater chance of complications of treatment. These unfavourable outcomes are of major importance to cancer patients and their families, and also increase the cost to the health system, which must manage cancer recurrences and complications of treatment.

This project area builds on previous (RAS/6/048) and current (RAS/6/053) RCA projects in this thematic area. This proposed IMRT project area is a natural extension and progression of improvements in RT from simple treatments ("2D"), through "3D" conformal RT and finally to IMRT. The modern treatment delivery units – linear accelerators – that will be available globally in this project time frame (2012-17) are capable of supporting IMRT. (Many palliative treatments will continue to be delivered using the existing simple techniques.) TECDOC1588 developed by IAEA-NAHU provides a pathway to IMRT development for this project area. This project will logically commence towards the conclusion of RAS/6/053.

Therefore, there is great potential benefit to cancer patients who can access these advanced treatments. The beneficiaries of development of IMRT will be cancer patients, their families the cancer centres in the RCA region which will be able to acquire improved quality of radiotherapy, and the health systems. Patients will enjoy longer survivals with fewer complications.

Analysis of support requirements:
The development of IMRT is complex and requires a co-ordinated and phased approach that involves:

- all relevant professional groups, being radiation oncologists (ROs), medical physicists (MPs), and radiation therapy technologists (RTTs);
- all aspects of the radiation treatment process, including:
  - protocols for patient management
  - immobilisation procedures
  - electronic image acquisition
  - contouring of cancers and surrounding normal tissues and organs
  - treatment planning using adequate computers and software
  - treatment delivery with image guidance
  - excellent quality assurance programmes for all steps.

To accomplish these tasks, the activities should include:

- *Regional training courses* and *training tools* for all professional groups in all the listed topics; a range of training courses will be required, to cater for different skill and knowledge levels in the region.
- Utilisation of training packages which are in the process of development by IAEA-NAHU
- QA assessments at participating sites.

Technological priorities:

All participating centres must have linear accelerator technology capable of IMRT.

Specific requirements:

All participating centres must have a commitment to the project. This includes:

- Staff motivated to undertake the project to its logical and successful completion
- Availability of time and resources to undertake the project.
- The project area would aim at the following types of centres:
  - Those practicing IMRT at a basic level
  - Those with the capability for IMRT but requiring upgrading of skills prior to commencement of IMRT
  - Those with the intent to acquire IMRT capability in the near future.

Priority Area 2 - Improving the decision-making process in cancer management with hybrid nuclear medicine imaging (PET/CT and SPECT/CT)

Rationale:
The global incidence of cancer is increasing in both developed and developing countries and is expected to become a heavy health burden in the coming decade. This increase in cancers will raise challenges for health systems, clinicians, patients and their families. Technologies that improve the decision making process and optimize treatment have the potential to benefit society as a whole.

The use of PET scanning is well established in many developed countries and already accepted as standard quality of practice to manage many types of cancers, including lung, breast, colo-rectal, head and neck, cervical cancer, melanoma and non-Hodgkin lymphoma, many of which are frequently prevalent cancers in the RCA region. Its integration into oncological practice is based on the recognition that PET scanning may alter the clinical decision-making process in more than one third of the cases, mainly by avoiding surgery when it appears futile and diverting treatment towards more systemic treatments like radiation therapy, chemotherapy or any combination of.

The regional project RAS/6/049, "Strengthening Clinical Applications of PET in RCA Member States (RCA)" under the RCA programme, was formulated to improve the clinical use of PET in general in the RCA region. Since the inception of RAS/6/049, however, the technology has evolved very rapidly and hybrid systems like PET/CT are now replacing stand-alone PET scanners worldwide. Also, the role of PET scanning in oncology is being increasingly recognized: indeed, there is growing evidence that PET/CT, which already proved very efficient in the staging of neoplastic processes, defining prognoses, planning the treatment (medical versus surgical), identifying of the target volume when radiation therapy is called for, and assessing tumor response to therapy. Furthermore, by visualising tumor regression/progression, it also makes it possible to assess treatment effectiveness. The use of PET/CT for radiation treatment planning is also an area of growing interest, not adequately covered under RAS/6/049 since the project was in its infancy when it was initially planned.

There is also a need to better exploit inherent capabilities of PET, such as quantitative data analysis for risk stratification through standardization of PET image acquisition. Quantitative ^{18}F-FDG PET is increasingly being recognized as an important tool for diagnosis, determination of prognosis, and response monitoring in oncology.

On a professional level, it results in an increasing demand for education, in a need for timely updates of clinical and procedural guidelines, and in the necessity for continuous adaptation and preservation of professional competence on every level. Also in the RCA region, the rapid growth of PET technology has seen the installation of many PET/CT scanners in the region. However, with this growth, the need arises for adequate training of nuclear medicine specialists reporting this new technology, leading them to gain extensive expertise in all areas of PET, and well placed to become the leaders for the education and training of nuclear medicine professionals in the RCA region. Based on these considerations, there is a need to make reliable information widely available to support and assist Member States to appreciate the usefulness and practice of PET scanning. Beneficiaries of the project are patients affected by cancer; referring clinicians; oncologists; radiation oncologists and oncology surgeons. The project will benefit both women and men since chronic diseases like cancers are almost equally represented in both sexes.

Technological priorities:
The technological priorities would be to strengthen and improve the quality of the practice of hybrid nuclear medicine technologies, PET/CT and possibly SPECT/CT, by providing training on cross-sectional imaging and reporting, and on the more recent clinical applications in oncology described above.

Specific requirements:
The requirements would be the Member States with technological capability of hybrid technology either with PET/CT or SPECT/CT with adequate protocols and the provision of dedicated professional nuclear medicine specialists who are involved in the oncological diagnosis.

Priority Area 3 - Practice of Image Guided Brachytherapy for predominant cancer in the RCA region

Rationale:
Incidence of cancer is rapidly increasing worldwide, and in the future years it can be expected to pose a threat not only to the health and well being of the global population but also to the national economies, especially of countries with limited resources. Recent developments in the field of radiotherapy have significantly improved its effectiveness as a curative and palliative treatment for cancer. Cancers of head and neck, uterine cervix, and prostate are major diseases for which brachytherapy plays a major role in curative treatment. They are among the predominant cancers in our region to control. For several decades, intracavitary brachytherapy treatments have been performed by reference doses at specified reference points rather than specified dose volume of cancer lesion. This is no longer considered suitable due to the large variation in dose to the cancer and the reduced chance of cure. Instead, dose prescription or treatment planning of brachytherapy should be based of CT images and patient position optimized by image guided with CT. This modern technology will improve local tumour control by brachytherapy and decrease side effects and complications caused by inadequate treatment conditions. Thus, developments in image guided brachytherapy for cancers has lead to the improved survival rate of cancer patients without increasing complications in developed countries and has become the standard treatment modality for radiotherapy for these cancers.

Hence, the project aims to improve regional and national capacities for brachytherapy services to provide access to a minimum standard of brachytherapy such as the ability to deliver image guided brachytherapy for most of the population by 2020 and use evidence-based guidelines to match the increasing call for high quality brachytherapy in the coming decades.

Current status of the RCA region:
In evaluation and assessment of present status by previous RCA project activities, technological transfer of practising proper brachytherapy for predominant cancers has been achieved in 2D-bases in the RCA region. Additionally, structure and organization for sustainable technological transfer of brachytherapy have been established among most of the MSs. At least, one of the central institutions of the most MSs is equipped with advanced treatment system which is capable of practising image guided brachytherapy. However, significant inhomogeneity of infrastructure and technology level still exists at the national level. At present, most of the institutions practice brachytherapy for predominant cancers in 2D-bases in the RCA region. Additionally, the gap between the growing number of cancer cases and the development of brachytherapy practice is substantial in the RCA countries with limited resources.

To improve the situation, there is a need to provide training for the brachytherapy staff, especially in our region to adopt and apply new technologies and treatment practices in their daily work. Additionally, it is necessary for the clinicians and medical physics support staff engaged in radiotherapy to adapt evidence-based guidelines to properly practice the new technologies. Furthermore, there needs to be awareness-building for hospitals with poor infrastructure and equipment to improve the situation. Hence, there is a need for collaboration with technologically advanced centres to enhance networking between advanced and developing centres to further facilitate the acquisition of the knowledge on new and advanced technologies. It is important to support and enhance national network for developing Image guided brachytherapy by education of staffs to transfer treatment technology. For this purpose, partnership with other organizations such as European Society for Therapeutic Radiology and Oncology (ESTRO) and Japanese Society for Therapeutic Radiology and Oncology (JASTRO) is expected to contribute significantly to achieve the goal.

When this is achieved, brachytherapy centres in countries with limited resources can improve and maintain the quality of brachytherapy to match the current standards and keep abreast with the global developments in the field.

Purpose:

Hence, this project is aimed at strengthening the ability of RCA Member States to use the modern technology and evidence-based guidelines to match the increasing call for high quality brachytherapy in the coming decades. Hence, the project try to improve regional and national capacities for brachytherapy services to provide access to a minimum standard of brachytherapy such as the ability to deliver image guided brachytherapy for most of the patients by 2020.

Sustainability:

Based on the established sustainable mechanism for national training programmes in RCA Member States through previous RCA projects, this project is expected to provide adequate self sufficiency and technical know-how in the clinical practice of image based brachytherapy for predominant cancers in the RCA region through regional training programmes. Moreover, the participating Member States are expected to enhance networks of information and training through better regional collaboration in education and research and thereby create sustainable mechanisms of information exchange, training brachytherapy personnel under their own responsibilities at the national level, e.g. new establishment of national organisation or strengthening of established national centres of radiation oncology or a society for training of brachytherapy for predominant cancers. Evidenced-based brachytherapy can be adapted to regional and national needs and radiotherapy personnel, especially radiation oncologists, in the RCA Member States will adapt the new development in brachytherapy applications and will improve their daily practice.

Technological priorities:

The current project area covers as nuclear technology, high-dose-rate intracavitary brachytherapy with Ir-192, interstitial brachytherapy with Ir-192 and with I-125, and interstitial grain with Au-189, etc.

These nuclear related technologies are important and fundamental modalities of radiation therapy for cancers.

Specific requirements:

The specific requirements are as following:

- Human resources such as Radiation Oncologists, Medical Physicists, and Radiation Therapy Technologists, capable of HDR brachytherapy or interstitial radiation therapy
- Capable of utilizing CT/MIR based treatment planning system

- Capable to access to CT and/or MRI

Priority Area 4 - Development of agreed clinical protocols and guidelines for the management of common cancers in the RCA region by radiation therapy (RT)

Rationale:
Cancer is a major health burden in the RCA region and is projected to increase significantly over the coming decades, as life expectancy improves, communicable diseases are controlled and health transition occurs.

There is evidence that patients who are managed according to evidence based guidelines have improved outcomes compared with those treated according to individual clinician preference. In the context of this project area, the development of clinical protocols and guidelines will be restricted to the curative treatment of common cancers in the RCA region.

In the field of RT, the scope of such guidelines includes:

- Criteria for selection of patients & cancers suitable for curative treatment
- Appropriate staging investigations
- Determination and contouring of target volumes and critical normal tissue volumes
- Dose/volume histogram assessments and criteria for acceptability
- Dose prescriptions
- Appropriate treatment planning techniques (eg 3D, IMRT etc)
- Immobilisation requirements
- QA procedures
- Patient treatment
- Clinical review and follow-up
- Data required for analysis

For some topics, a reference to IAEA or other agreed procedures may be the requirement. It should not be necessary to re-define many procedures. Note that this project area is an attempt to pull together all the procedures in the patient's treatment journey into a consolidated and comprehensive entity.

The cancers for guideline/protocol development should include:

- Head/neck
- Lung
- Oesophagus
- Prostate
- Cervix

Analysis of support requirements
Meetings with experts from the RCA region, familiar with the regional issues and problems, will be required for provide an evidence-based consensus for each cancer type.

Technological priorities
Nil.

Specific requirements
There should be agreement as to:

- the cancer types to be considered; and,
- the format and specific scope of the guidelines (eg inclusion of chemotherapy etc).

Note that this project will incorporate elements of the IMRT and IGBT projects. Thus, this protocol/guideline project area could be considered as a supplementary project to the main IMRT project.

Priority Area 5 - Strengthening the Application of Nuclear Medicine in the Management of Cardiovascular Diseases

Rationale:
According to the World Health Report 2002, cardiovascular diseases, along with cancers, are leading causes of mortality worldwide and are becoming a serious concern in developing countries because of increasing urbanization and changing lifestyles.

In Asia, Coronary Artery Disease (CAD) is starting to be one of the most acute health problems, due in part to the increased prevalence of diabetes, hypertension and smoking habits. Cardiovascular disease, particularly CAD, has a higher mortality in developing countries than in developed ones, and affects younger people and women disproportionately. It is well established that early diagnosis of CAD leads to better treatment and fewer complications. Nuclear cardiology with Single Photon Emission Computed Tomography (SPECT) is the most powerful tool to depict coronary artery disease in both asymptomatic and symptomatic patients. Since many investments have been made by the governments and the Agency in establishing functional nuclear medicine departments, one of the additional impacts of such regional cooperation could be the real incorporation of nuclear medicine techniques in the strategy of investigation and management of CAD. In terms of the numbers of procedures and equipment, nuclear cardiology is well developed in only a limited number of countries in Asia. This situation needs to change in the future in view of the dramatic increase in the demand for nuclear cardiology.

After a long period of steady adherence to myocardial perfusion imaging (MPI) (at an albeit very high professional level), the field of cardiovascular nuclear imaging has recently seen numerous new trends and changes. Those include: (1) the development of dedicated cardiac SPECT technology for faster acquisition, superior image quality, and reduced injected dose/radiation exposure; (2) the convergence of MPI and morphologic coronary artery imaging, stimulated by the success of CT angiography, by the increasing availability of SPECT/CT and PET/CT hybrid systems, and by the increasing body of evidence supporting complementarity of morphology and function; (3) a shift from SPECT toward PET as the more accurate technique (novel 18F-based perfusion agents under clinical development will give this trend a further boost); and an increasing and not only experimental but also clinical and commercial implementation of non-perfusion, molecular-targeted imaging techniques. For the most part, this rejuvenation and new drive in cardiovascular imaging is a result of growing competition from alternative techniques, of increasing awareness of radiation exposure and potential test overutilization, and — most important — of an increasing need for diagnostic tests with high accuracy and biologic specificity, which stems from the ever-increasing diversity of therapeutic options in cardiovascular medicine.

Beneficiaries of the project are patients affected by cardiac diseases; referring clinicians; cardiologists; interventional cardiologists; cardiovascular surgeons. The project will benefit both women and men since chronic diseases like cardiovascular diseases are almost equally represented in both sexes. However, currently women are typically under-diagnosed because of the lack of recognition of the burden of this disease on them. They could benefit from better management.

Technological priorities:

The technological priorities would be to strengthen and improve the application of nuclear medicine, mostly of SPECT, in the management of cardiovascular diseases.

Specific requirements:
The requirements would be the Member States with the capability of SPECT using the adequate protocols in the above-mentioned clinical application.

2.4 INDUSTRIAL SECTOR

Introduction

The applications of nuclear technology in industry range from the design of components and systems, to quality control and assurance, plant lifetime extension, process evaluation and optimization, troubleshooting, industrial processing, manufacturing, production of new materials, and process control. These applications can largely be grouped into four, namely non-destructive evaluation and testing, radiotracer applications for industrial process troubleshooting and optimization, radiation processing, and nucleonic control systems.

Industrial development is the cornerstone for growth and progress. The RCA has invested heavily in industrial projects as elaborated in the report. These investments, especially in human capital, technology transfer, and overall upgrading of capacity and capability in nuclear technology serve as good platform for the applications of these technologies to move ahead. The capacity that has been developed contributed to the overall growth in the region, which is experiencing rapid development.

Technology and the system to which it is applied keep on changing. It becomes imperative that capacity building, capacity utilization, and preparation for new emerging technology exist all at the same time at various level of emphasis. There should be a blend among existing projects that are drawing to conclusion, new projects being proposed, and activities to better anticipate developments beyond the last cycle. Based on that premise, the strategy for the industrial sector in the subsequent cycles is to (i) review current projects with the objective of achieving successful conclusions that jive well with those planned in 2012-2017, (ii) identify gaps that can be closed using supplementary activities in order to maximize the use of the results of those projects, (iii) develop and implement new projects, and (iv) seed new capabilities based on existing projects requirements so as to better handle future requirements.

Key Strategic Issues

The effectiveness of project implementation depends on the resources available. The MTS recommends that the number of projects be kept reasonably small so that they can be better implemented to achieve significant impact.

The review of current projects should phase out selected on-going projects where sufficient level of expertise exist in a majority of member states. This enables the initiation of new projects that have become more relevant in current scenario. Activities to maximize the results of the phased out projects could be implemented as supplementary activities, particularly to assist selected and newly joining Member States. New projects that form the core of the programme could be devised in a manner that better address current and anticipated needs of the region. Supplementary activities should also be included to prepare for new emerging technologies.

The dwindling supply of fossil resources, negative environmental impact of some conventional means for energy production, and the limited capability of renewable energy resources to supply bulk electricity for industrial needs have focused the attention of many countries in the region on the introduction of nuclear energy in their national energy mix.

Capacity that has been built on areas such as non-destructive evaluation can be implemented for enhancing the capability of the countries to use nuclear energy.

Notwithstanding the new interest on nuclear energy, it should not exhaust the capability to continue the non-power applications of the technology in other areas on industrial development. In countries without nuclear energy programme the non-power applications have been the main focus area. Capabilities and expertise in several sectors including industry have been developed. These capabilities should continue to be developed. Projects that would enhance added value of local resources should be continued. The results of CRPs should also be a source of inputs to new projects formulations.

The region is expanding with new countries joining as members. The need to build up the capacity and capability of the new members can be addressed through TCDC arrangement. The existence of several RRUs in the region can also serve as the resources to quickly build up the capacity. These activities should be supplemented with training materials, documentation on protocols and standard procedures. The element of knowledge preservation through systematic documentations should be an element in the forthcoming projects.

Expected Outcome

The consolidation of results of existing projects through documentation is expected to enhance the capability of the region to have its own repository of knowledge in main areas of the applications of nuclear technology in industry. The documentation could serve as references also for new personnel and shorten the learning curve to hasten their productive involvement in project implementation.

Re-orienteering of or the added focus on the applications of nuclear technology in support of energy programmes would be a visible and significant contribution.

The applications of radiation processing focused towards enhancing the value of local resources would generate activities spilling down to farmers and local industries. The capability to use radiation method in making new materials can spur many side activities.

Key Focal Areas

As the priorities given by the results of survey, the following focus areas under the industrial sector are recommended:

(i) Non-destructive testing;
(ii) Radiation processing; and,
(iii) Industrial radiotracer applications.

The area of nucleonic control systems, which deals with only maintenance of the installed system by the suppliers, has been taken out in the future cycles.

Other emerging areas such as the applications of neutron beams in NDT/E, material characterization, material defect, and material fatigue studies could be considered as new activities under the emerging category. Common to all of the areas is the need for more automated operation as well as user-friendly applications. Automation and robotics, especially in the applications of NDT/E equipments, can reduce exposure and extend physical access to areas that are physically limiting such as confined spaces or hazardous areas.

User friendliness pertains to the use of computer programme for interpretation, better data acquisition and analysis, better positioning of radiation equipment in hazardous areas, as well as ease of experimental set-up.

Priority Area 1: Non-destructive evaluation for safety, increased productivity, and product quality control in industry

Non-destructive testing using nuclear radiation is an important non-power application widely used by industry for testing of a variety of components for quality control, quality assurance, and monitoring of plant integrity during construction, operation and maintenance. Major user industries of NDT like power generation and processing industries are governed by regulatory requirements for periodic plant shutdowns. NDT is one of the powerful tools to minimise these shut downs resulting in huge economic saving to industry.

The use of NDT by the oil and petroleum industry in the region is a vindication of its usefulness and economic value in the operation and maintenance of complex industrial processes and plants. As interests on nuclear power programme in many countries in the region are developing, NDT is expected to play more and expanded role in the energy-related industry. New methods such as digital radiography that is becoming more and more common would necessitate the development of capability in that area as well as the establishment of new protocols.

With the rapid globalisation of the industrial sector in the region, on a par with the developed countries, there has been a manifold growth in the applications of the established radiation based conventional radiography techniques for non-destructive testing and examination for quality assurance and vertical sustainability. However, this has also led to an increased demand on consumables like films and chemicals and an increased burden of highly toxic disposables. Despite the inherent benefits of the conventional radiographic techniques, the low throughput, increased radiation exposures and associated difficulties in maintaining archives of high volumes of exposed films. Digital Radiography [DR] provides long felt suitable alternative which provides excellent image quality, archival and manageability of huge data. Computed Tomography [CT] provides the image details like defect sizing, location, 2D and 3D imaging which are very vital but not provided by conventional radiography techniques. Some of the advanced countries have already begun to introduce regular DR and CT facilities in their NDT laboratories. However, the consistent technological transition requires familiarity in the advanced subjects and also an inclination to adapt the technology to the specific user needs. The implementation of the project will increase the visibility in use of advance nuclear techniques for increasing industrial product quality and productivity.

To adopt new technologies in the RCA region on a par with the advanced countries, it is now required to develop capacity building in the region by way of developing training modules, protocols and harmonisation of capabilities in the region. The project activities are thus designed to meet these requirements.

Core activities (duration maximum 4 years)

a) Tomography for NDT and process optimization.

b) The use of tomography requires better user interface, automation, and interpretation capability. This is possible area for further development.

c) Technology demonstrations and capacity building in low cost NDT tomography/DR system for defect size location and distribution including for process tomography.

d) In-service inspection of NPP for preventive maintenance and life extension.

e) Development of protocol for applying and harmonizing industrial digital radiography and tomography.

f) Development of regional training module in DR and CT for manpower development.

g) Supporting new-comer MSs.

h) Application of digital radiography in industrial system.

Supplementary activities

a) Use of neutron beams for special applications including neutron radiography.

Priority Area 2 - Applications of radiation processing/technology for grafted polymeric matrices and environmental preservation

Radiation processing either by gamma or electron beam has been widely used in many areas of the global economy. It has demonstrated to be a clean technology where no solvents, additives and crosslinkers are added. Among the well established technologies is sterilization, polymer crosslinking and grafting, tyre component curing, conservation of art objects, and irradiation of selected food items.

Under the RCA, special attention has been given to the radiation processing of natural polymers since the region is rich in the variety of indigenous natural polymers; such as rubber, chitin/chitosan, carrageenans, alginates and silk. Work has been focused on developing applications in lower molecular weight polysaccharides in the area of agriculture as plant growth promoter and elicitor, utilization of specific properties of natural polymers as an additive to produce radiation processed hydrogels, development of methods for producing radiation crosslinked completely bio-degradable hydrogels, and exploration of possibility of using radiation modified materials or methods for environmental remediation. A number of developed products have been commercialized in different MSs (wound dressings, plant growth promoters and elicitors, shoe sore protectors, non-bedsore mat, and soap products). These are a clear indication of the potential of radiation processing in the developing new value-added materials from this region. Aside from being a clean technology, it is also cost effective and the process is relatively easy.

New focus area is on the use of electron beams. Attention has shifted towards the use of radiation technology beyond sterilization to the production of new materials such as matrices. The potential of this method in adding value to local resources by extending their uses in areas other than agriculture make radiation processing for material production as suitable focus area for the region. The capabilities of electron beams to produce new materials in several sectors, industry, agriculture, energy, environment, and medical qualifies itself to be considered as 'platform technology' upon which many areas can benefit. For use in sterilization, electron beam machines (EBM) also have the advantage of mobility and controllability in terms of turning the beam on and off as required. It is expected that its uses will increase in the future as the supply and transport of high activity radiation source placed certain limitations on gamma irradiators.

The development of new radiation processed products for various applications is an area that still offers many opportunities, particularly in radiation grafting of polymers. The current CRP on "Development of Novel Adsorbents and Membranes by Radiation-induced Grafting for Environmental and Industrial Applications" has been initiated and studies have shown that radiation-induced grafting is a powerful technique for the preparation of novel materials based on easily available and low cost synthetic and natural polymers. The new materials include special adsorbents and membranes that are applicable in environmental and industrial applications. Radiation grafting is used in situations where the requirements for bulk properties and surface properties cannot be readily met using a single polymeric material. Current studies show that "Radiation Grafting on Polymers" is developing in three main directions: polymeric adsorbents, polymeric membranes, and track-etched membranes. These materials have applications especially in recovery of high value metals; removal of undesired anions in a system; fuel cells; and selective filters for proteins, polysaccharides and metals.

Other promising applications are in environmental preservation including flue gas, waste water and sludge treatments. With the current worldwide trend of water shortage, countries are looking for new effective technologies for treating industrial waste water and recycling them for industry and agriculture. Electron beam treatment of waste water has clearly demonstrated its advantages of being able to eliminate effectively and completely pathogens, residuals from textile plants, cleaning refinery vessels, decompose halo-carbons and VOCs. The process may be done in combination of conventional processes. The main drawback of the technology is the high price of EBMs. Recently, the Republic of Korea has manufactured a transportable EBM. The unit could be useful for demonstrating field applications and the cost effectiveness of this technology. This new development will certainly give a large boost to the promotion of this technology.

Core activities

a) Development of matrices using radiation grafting technology for specific applications;

b) Development of protocols in electron beam treatment of industrial waste; and,

c) Use of mobile EBM – recognition of KAERI's mobile EBM as regional centre.

Supplementary activities

a) Development of protocol or manual for the use of developed products such as plant growth promoters, and hydrogel for wound dressing.

Priority Area 3 - Applications of radiotracers for industrial troubleshooting and process optimisation

Optimum parameters of processes that use mixing and fluid flow are well-suited to be determined and investigated using radiotracer methods. Radiotracers have been used for instance to determine residence time distribution of particles in combustion chambers, optimum mixing time in paper mill, and investigation of the effectiveness of lubricants . Optimum process parameters ensure consistent product quality, save cost, and enhance process efficiency and throughput. For troubleshooting, radiotracers have also been used for the detection of blockages and leaks in buried pipelines, detection of dead volumes, by-pass flows and recirculation flows in industrial systems.

With the advancement of industrial processes, the use of radiotracer for more complex systems such as fluidized catalytic cracking unit, trickle bed reactor, and coal gasifier is becoming more useful. Radiotracer applications are also useful in the design of systems for special applications that may not be available commercially. Such systems can be new combustors, bioreactors, and fermentation systems. Radiotracer applications can validate the design which was initially based on computer simulation and modelling methods, such as the computational fluid dynamic (CFD) programme.

The use of radiotracers is hindered by the limited capability to produce the radiotracer in national research reactor facilities. The expected positive result of a CRP on production of radiotracer using radioisotope generators, which is expected to be completed by 2011, can give positive results on the applications of radiotracers.

Advanced radiotracer applications require expertise in result interpretation, experiment design, and nuclear instrument development for of data acquisition, analysis, interpretation, and automation. As each application is unique, capability to design the field applications of radiotracers, interpret the results, and automate the various stages of the process become important. The area of tomography applications mentioned under NDT projects is also useful element in radiotracer applications.

<u>Core activities</u>

a) Automation of on-going techniques such as gamma scanning;
b) Enhancement of radiotracer techniques for use in advanced industrial systems such as trickle bed reactors, fluidized catalytic cracking unit, and coal gasifier;
c) Field testing of RTG for tracer applications; and,
d) Validation of computational fluid dynamic (CFD) codes using radiotracers

<u>Supplementary activities</u>

a) Protocol development for harmonization of tracer applications

<u>Recommendations</u>

a) Detailed project design and formulation of supplementary activities should be carried out in a separate meetings by experts in the area;
b) The use of RRUs as resources for newly joined MSs;
c) Promotions of the results of selected CRPs as RCA projects; and,
d) Documentation of technologies used in the form of protocol and manual at the end of the project

Annex 1

Composition of the Expert Group for Development of RCA Strategic Priorities for 2012-2017

1. Agricultural Sector .

Leader

Dr. Frank Bruhn (National RCA Representative of New Zealand).

Has served as NR of New Zealand since 2002. Was a member of the RCA Working Group Meetings on Medium Term Strategy for 2006-2011 and for 2012-2017.

Members

Prof. Lui Luxiang, (CPR)
Professor, Director of Department of Plant Mutational Genetics and Biotechnology Breeding, Institute of Crop Science, Chinese Academy of Agricultural Sciences
Has been involved with the RCA Programme since 2002, has served as an IAEA expert on numerous occasions, functions as the Lead Country Coordinator of the RCA Project on Plant Breeding.

Prof. Oswin Perera (SRL)
Professor of Farm Animal Production and Health, University of Peradeniya, Sri Lanka. Served as an IAEA Technical Officer for a total period of 14 years. Has been an IAEA expert on numerous occasions since 1985. Was Chairman of the Atomic Energy Authority of Sri Lanka from 2006-2007.

2. Industrial Sector

Leader

Dr. Nahrul Khair bin Alang Md Rashid (Former National RCA Representative of Malaysia: 1997-2007). Served as a member of the Working Group on Developing RCA Medium Term Stategy.

Members

Dr. Gursharan Singh (IND)
Head Isotope Applications Division, Bhabha Atomic Research Centre, India. Was the RCA Lead Country Coordinator for the Industrial Thematic Sector. Has served as an IAEA expert since 1990.

Ms. Lucille Abad (PHI)
Senior research specialist, Philippine Nuclear Research Institute. Served as Lead Country Coordinator of the RCA Project on Radiation Processing. Has been involved in IAEA activities since 2002.

3. Environment

Leader

Dr. Alumamda Dela Rosa – (National RCA Representative of the Philippines) Director of the PNRI since 1997. Has served as the Chairperson of SAGTAC.

Members

Dr. Manzoor Ahmed (PAK)
Head, Isotope Hydrology Group, Pakistan Institute for Nuclear Science and Technology (PINSTECH). Has served as an IAEA expert since 2002. Is the Lead Country Coordinator of the RCA Project on development of water resources.

Dr. Andreas Markwitz (GER)
Principal Scientist. GNS Science. New Zealand. Was the Lead Country Coordinator of the Environment Thematic Sector and is the Lead Country Coordinator of the RCA project on monitoring air pollution. Has served as an IAEA expert since 1999.

4. Human Health

Leader

Dr. Asif Salahuddin – (National RCA Representative of Pakistan)

Director General, International Affairs and Training Pakistan Atomic Energy Commission, Was a Member of the RCA Working Group Meeting on Medium Term Strategy for 2012-2017.

Members

Prof. T. Nakano (JPN)

Professor, Department of Radiology and Radiation Oncology, Gunma University, Japan. Was the Lead Country Coordinator of the Thematic Sector of Human Health. Is the Lead Country Coordinator of the RCA Projects on Radiation Oncology. Has been involved in RCA activities since 1997.

Dr. Graham Stevens (AUL)

Consultant Radiation Oncologist, Auckland Hospital, New Zealand. Is the National Project Coordinator of the RCA project on PET. Has served as a consultant in NAHU and as an IAEA expert.

Prof. T. Tamaki
Assistant Professor
Gunma University Heavy Ion Medical Center. Has been extensively involved in RCA Projects on Radiation Oncology since 2005.

5. Other Areas

Dr. John Easey (AUL)

Former IAEA RCA Coordinator. IAEA consultant on development of RCA Regional profile and Regional Strategic Priorities.

Mr. P. Dias

RCA Focal Person.

Annex 2

EXECUTIVE SUMMARY OF THE RCA REGIONAL PROFILE

The Working Group Meeting (WGM) on Extending the RCA Medium Term Strategy was conducted in Vienna 27-31 July 2009. One of its recommendations concerned the issue of determining the priority areas for the RCA Programme. The WGM proposed that a survey be conducted to determine the needs and priorities of the RCA Member States and that a consultant develop a Regional Profile based on the information obtained through the survey and on information on past RCA activities from various sources. The establishment of this Regional Profile would then be used contribute to the development of RCA Strategic Priorities for 2012-2017.

Following the endorsement of the WGM recommendations and proposals by the National RCA Representatives (NRs) at the 38th RCA General Conference Meeting held on 12 September 2009 at the IAEA Headquarters in Vienna, the RCA Focal Person sent a Questionnaire on 18 September 2009 to all NRs, which was designed to assist in understanding the effectiveness of the past projects and their contribution to addressing needs in specific technical areas and identifying priority areas for the future RCA Programme. Nine NRs provided responses to the questionnaire, although they did not all address the full spectrum of questions on the various thematic sectors and areas.

Dr John Easey of Australia, accepted the contract to be the consultant to develop the regional profile, which covered the period 7 December 2009 and 29 January 2010. The two main subjects for analysis were the 119 RCA projects listed in TC-PRIDE and the completed questionnaires returned by the NRs.

As stipulated by the MTS WGM, Dr Easey compiled information on each of the current and past RCA projects such as: Project title; Implementation period; Budget; Objectives; Project achievements; prepared short summaries of the main achievements of each project areas; prepared tables and charts summarising the details of participation of the Member States in regional events; and provided information on the current trends in each project area. This information has been presented in the report annexes on each of the 23 identified technical areas.

He analysed the information on project area priorities, project benefits and project sustainability provided by the NRs in the questionnaires and has presented the results in a series of tables. The overall trend of the responses in questionnaires provided positive indicators about the performance of the projects and the technical situation at the national level in Member States. Most Member States have reported consistently that they have benefited from the projects. In general the majority had the support infrastructure for national programmes and, where appropriate, underpinning of these programmes from national societies / professional bodies and protocols, guidelines or standards. A large majority had identified linkages to end users and a significant proportion of these had reported that they have involvement with them. The main area of need appeared to be the availability of trained human resources and physical infrastructure, where there were numbers of reports of this being under some stage of development. On the questions related to sustainability, almost all responding Member States indicated that they had additional human resource development requirements that needed to be satisfied. In many cases this was linked to requests for additional technical assistance especially in the form of awards of scientific visits or fellowships. A number of responses also indicated that assistance was required with a range of procurement from spare parts to consumables through to major equipment, even though such support for procurement and for scientific visits or fellowships fell outside of the agreed provisions of the RCA programme.

A number of the responses requested assistance in the awareness and promotion of the technologies with either endusers and/or with other Government Departments or Ministries or other stakeholders to make them more aware of the nuclear technologies and their advantages.

Because of variations in the NRs' methodology for ranking priorities, the consultant devised and trialled a numerical method to assist in grading the relative ranking of priorities for the technical areas. The results from this trial were consistent with other measures and appear to provide an objective means of assigning such rankings. He recommended that NRs adopt a common methodology to assist in future decision making on ranking priorities.

Some gaps and weaknesses in project areas were identified from the questionnaire responses and recommendations were made that the deficiencies be rectified when the projects were being designed for the 2012-2013 RCA programme. The recommendations related to a perceived need for greater emphasis on MSs at the project design stage so that the full extent of all the participating MSs requirements could be addressed and maximise the sustainability of the outcomes. This would include actions such as: improvements in human resource development outcomes through heightened greater consideration of training, including design of training materials to meet the needs not just for regional training events but also for follow up national training programmes being conducted by the MSs; targeted assistance for MSs with limited physical infrastructure through enhanced and programmed use of Regional Resource Units (RRUs); enhanced use of TCDC; and provision of support for awareness and promotion activities to key stakeholders.