Project Final Report

Phase 1: 2013-2015, Phase 2: 2017 - June 2021

June 2021

RCA Regional Office

Project Final Report

(Phase 1: 2013-2015, Phase 2: 2017-June 2021)

RCA/UNOSSC Project on Electron Beam Applications for Value Addition to Food and Industrial Products and Degradation of Environmental Pollutants in the Asia-Pacific Region (Phase 1 & 2)

RCA Regional Office

June 2021

RCA UNOSSC

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EXECUTIVE SUMMARY

Background

RCA Regional Office has implemented the **"RCA/UNOSSC Project on Electron Beam Applications for Value Addition to Food and Industrial Products and Degradation of Environmental Pollutants in the Asia-Pacific Region (Phase 1 & 2)"** with the duration of three years (2013-2015) under the Phase 1 and four and a half years (2017-June 2021[1]) under the Phase 2. A total budget of USD 990,000 (UNOSSC: USD 630,000, RCARO: USD 360,000) has been allocated with the involvement of fifteen and sixteen participating RCA Government Parties under Phase 1 and 2 respectively. This project aims to facilitate the application of the electron beam accelerators for three areas of use - processing food and agricultural commodities to improve the food security and safety; adding the value to industrial products for reduction of environment pollution and better quality of the products; and treating environmental pollutants for immediate impact on improving the quality of air and water and living conditions. At the same time this project plays a role as a platform for strengthening the South-South and Triangular Cooperation in the region through optimal use of capacities of the participating countries and institutes, contributing to the sustained development.

This report is to describe the overall project progress of the seven (7) and a half years of implementation. The overview on the project activities are narrated in the two phases of the project, conducted at both regional and national levels, to illustrate the project outputs and outcomes. In order to better capture what has been done so far, the below reports under the project have been reviewed and analyzed as references.

- Reports of the Project Coordination and Review Meetings (2013-2021);
- Reports of the Regional Training Courses (RTCs) (2013-2019);
- Reports of the Expert Missions (2017-2019);
- Country Progress Reports (2013-2020);
- Project Progress Reports (2013-2021); and
- Report on the Results of the Surveys/Interviews on Project Achievements and Future Needs (2020).

1 The implementation period of project Phase 2 was originally until 2020. Considering to the COVID-19 pandemic outbreak and its impact on the project implementation, the project has been extended for six (6) months.

Summary of Achievements

South-South and Triangular Cooperation has been promoted and strengthened. The expert network has been established and reinforced throughout the implementation period, developing synergies among the participating countries. A total of eight (8) project meetings and three (3) technical workshops contributed to the strengthened dialogue, information exchange and cooperation among the experts providing scientific, technical, policy and strategic guidance to those in need. Forums have been formed as well as activities undertaken, in a form of bilateral, multilateral and regional basis, contributing to the South-South Cooperation.

Human and institutional capacities have been strengthened through training the trainers. Eight (8) Regional Training Courses were held training around a hundred-twenty (120) trainees, with lectures and on-site training provided. Group Fellowship Programme was implemented for two (2) months to fulfill the needs on long-term customized education. Regional experts were directly sent to the local communities to effectively and efficiently transfer the technology through six (6) Expert Missions. Dispatching the regional experts to the local communities and providing a customized programme was helpful in responding to the local issues and expanding the beneficiaries. A total of three-hundred-sixty (360) participants from the governmental, institutional and academia organizations as well as private sectors were involved.

To **disseminate the knowledge and skills gained to the local communities,** those who have been trained were asked to perform national activities as “trainers.” According to the reports submitted, these include, but are not limited to, the national HR building, R&D, promotional, and commercialization activities, involving more than 10,000 people throughout the project implementation period. Yearly reports have shown continuous increase of the number of activities and their participants indicating that the electron beam technology applications have expanded and will continue to increase further in the near future.

Without doubt, the project has served as an important channel to connect the RCA to the external partner, UN organization, and to complement the regular RCA Programme in meeting the regional and national development goals. By expanding the outreach to the region and providing diverse activities, the project has been successful in enhancing the capacity of the region in applying the electron beam technology to the respective fields.

Although the efforts made through the project have resulted in fruitful results, many countries are still in need of stronger manpower in building necessary infrastructure and absorbing the technology. Adequately trained workforce and technical experts are crucial in adopting, operating and managing the technology. In this regard, participating countries have strongly recommended to seek for possibilities for a follow-up project that will continue the expert network and provide further capacity building activities. Thus, a follow-up action plan is highly desired to foster the technological development in the region. At the same time, ways and means to support the South-South and Triangular Cooperation built throughout the project should be identified for the sustained development.

LIST OF ABBREVIATIONS/GLOSSARIES

ANPC(s)	Alternate National Project Coordinators
ARTI	Advanced Radiation Technology Institute
BAEC	Bangladesh Atomic Energy Commission
BATAN	National Nuclear Energy Agency of Indonesia
BGD	Bangladesh
EB	Electron Beam
EM(s)	Expert Missions
IAEA	International Atomic Energy Agency
IND	India
INS	Indonesia
KAERI	Korea Atomic Energy Research Institute
KAM	Cambodia
LC	Lead Country
LCC	Lead Country Coordinator
GP(s)	Government Parties
MAL	Malaysia
MON	Mongolia
MYA	Myanmar
NEP	Nepal
NZE	New Zealand

NPC(s)	National Project Coordinators
NPT(s)	National Project Teams
NTC(s)	National Training Courses
PAEC	Pakistan Atomic Energy Commission
PAK	Pakistan
PHI	Philippines
PNRI	Philippines Nuclear Research Institute
RCA	Regional Cooperative Agreement for Research, Development and Training Related to Nuclear Science and Technology for Asia and the Pacific
RCARO	RCA Regional Office
ROK	Republic of Korea
RTC(s)	Regional Training Courses
SLAEB	Sri Lanka Atomic Energy Board
SRL	Sri Lanka
THA	Thailand
TINT	Thailand Institute of Nuclear Technology
UNOSSC	UN Office for South-South Cooperation
UNOPS	United Nations Office for Project Services
VIE	Vietnam
VINATOM	Vietnam Atomic Energy Institute

01

INTRODUCTION AND DESCRIPTION

PROJECT BACKGROUND

Sterilization and Improvement of Agricultural Products

Consumer demand for safe, wholesome and nutritious foods is increasing on a worldwide scale. This demand, together with ever increasing global trade in foodstuffs, brings with it a number of related concerns: the possible contamination of foods by harmful micro-organisms; the need to protect crops from insect pests; and the need to support international trade and economic development. In response to these concerns, many countries have introduced stricter sanitary (human health) and phytosanitary (plant health) controls on the food industry. The increasing relevance of these controls for consumers and policy makers alike has resulted in a heightened interest in food irradiation as a valuable technique for dealing with food preservation and safety issues.

Currently, food irradiation has been permitted numerous food items worldwide. In these countries, food irradiation has been applied for sterilizing spice powder, herbs and frozen meat and fish, destroying insects of tropical fruits, and inhibiting sprout of garlics and potatoes. Also, in 2000s, it has been practically used in Asia-Pacific region countries including Korea, China, India, Japan, Vietnam, Thailand and Indonesia. According to a recent estimation based on literatures, it has reported that the amounts of irradiated foods are over 400,000 ton globally and Asia-Pacific region account for 48% of the irradiated foods.

Radiation Processing for Polymeric Materials and Its Industrial Applications

Radiation technologies have been applied to polymer processing with many different high energy radiation sources such as gamma rays, X-rays, electron beams, and ion beams. The irradiation of polymers is known to cause the formation of free radicals on the backbone of polymers. These radicals can be used in several reactions such as polymerization, crosslinking, degradation, and graft polymerization. The nature of the polymer and irradiation conditions are known to determine the degree or dominance of these reactions.

Radiation crosslinking has been widely used for the production of insulated wires and cables, plastic pipes, heat shrinkable tubes and films, plastic foams, hydrogels and automobile tires. Radiation degradation has been used for the production of plant growth promoters, oligosaccharides, and Teflon-based lubricants. Radiation grafting has been used for the preparation of battery separators, fuel cell membranes, ion exchange membranes, gas permeation membranes, membranes for the recovery of precious metals, biocompatible

materials, and surface adhesion promotions.

Treatment of Environmental Pollutants

Air and water pollution is leading to an increase in the rate of respiratory diseases among the affected population and consequential medical costs. Pollution of drinking water sources and groundwater is causing digestive diseases and a depletion of drinking water supplies. Due to the enormous social costs caused by the environmental problems in many Asian countries, there is a strong need to treat waste waters and process air pollutants before they are released into the environment.

In order to effectively treat these air and water pollutants, developed countries have adopted electron beams in addition to traditional chemical methods in order to effectively decompose, separate or remove toxic elements from chemical wastes, wastewater, sewage sludge and air pollutants discharged from industries, power plants and everyday living before they are released into the environment. Developing countries can also take great advantage from the use of electron beams in enhancing their water and air quality. The hygienic state and quality of daily life for the people in developing countries will be greatly enhanced through stable supplies of clean drinking water and conservation of ground water.

Electron Beam Technologies

Electron beam accelerators have emerged as a promising technology for the processing of agricultural and industrial products and in the treatment of environmental pollutants.

Electron beam technologies have been extensively developed and commercialized in Korea and other developed countries in the irradiation processing of food and agricultural products; irradiation of electric cable and automobile tires; the treatment of waste water discharged from textile industries and urban living; removal of chemical surfactants in underground water; removal of air pollutants such as SOx, NOx, VOC and dioxins; chemical decomposition of PCBs; and the sterilization of sewage sludge generated from fertilizer use.

By virtue of both its versatile applications and reduced cost, electron beam accelerators are now being developed and commercialized for many purposes.

PROJECT OBJECTIVES

The objective of this project is to improve the quality of environment and living conditions of the Asia-Pacific region through facilitation of the application of electron beam technologies. It is also to ensure the food security as well as to improve the quality of industrial products through the diffusion of knowledge and practical experiences on application of electron beam technology. Most importantly, this project aims to scale up results of the Phase 1 project (2013-2015) in-depth and horizontally by expanding the developmental impacts of the project and widening the scope and coverage of the beneficiaries. The project has specifically focused on the following goals:

1) To facilitate the application of electron beam accelerators for processing food and agricultural commodities to improve food safety and security; adding value to industrial products for reduction of environment pollution and better quality of the products; and treating environmental pollutants for immediate impact on improving the quality of air and water and living conditions;

2) To effectively scale up the knowledge and expertise gained through phase 1 project with the strategy of “training the trainers” of participating countries and dispatching experts from the region to the countries in need to meet local conditions and build up domestic technical and managerial capacities; and

3) To strengthen the South-South and Triangular Cooperation through optimal use of capacities of participating countries and institutes, specifically by exchanging knowledge, expertise and experiences, thus contributing to collective self-reliance and interdependent cooperation of the region that will continue after the project is accomplished.

RELEVANCE OF THE PROJECTS TO THE SDGS

The benefits that result from the implementation of the project are also incorporated in the 2030 Agenda for Sustainable Development which was agreed by 193 Member States of the United Nations to be achieved by 2030. This agenda has 17 Sustainable Development Goals that are closely related to the objectives the project and the following table shows specific SDG and potential electron beam applications for achieving the goals.

2030 Agenda for Sustainable Development	Potential EB Applications to Achieve the SDGs
Goal 2. End hunger, achieve food security and improved nutrition and promote sustainable agriculture.	● Food irradiation is an effective and efficient way of improving food safety and security by destroying harmful biological organisms. ● Irradiated foods (ready-to-eat) can be delivered to people who suffer from natural disasters for safe food consumption.
Goal 9. Build resilient infrastructure, promote inclusive and sustainable industrialization and foster innovation.	● This goal emphasizes enhancement of scientific research and upgrade of the technological capabilities of industrial sectors. ● Electron beam technologies add value to the quality of products with shortened process time and energy.
Goal 13. Take urgent action to combat climate change and its impacts. **Goal 14.** Conserve and sustainably use the oceans, seas and marine resources for sustainable development. **Goal 15.** Protect, restore and promote sustainable use of terrestrial ecosystems, sustainably mange forests, combat desertification, and halt and reserve land degradation and halt biodiversity loss.	● Electron beam treatment is an effective and environment-friendly approach of disinfecting drinking water, sewage, and sludge. ● Electron beam technology is highly environmental-friendly, not leaving as chemical residues in the products being irradiated. EB irradiation sources are electric-powered and therefore do not entail the handling, licensing, shipping, disposal or use of radioactive isotopes.
Goal 17. Strengthen the means and implementation and revitalize the Global Partnership for Sustainable Development.	● Project management meetings, regional training courses, expert missions, as well as upgraded communication tools will provide a means to promote regional cooperation and further strengthen South-south and triangular cooperation that is expected to be sustained even after the project ends.

2030 Agenda for Sustainable Development and Potential EB Applications

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PROJECT DEVELOPMENT AND IMPLEMENTATION

PROJECT DEVELOPMENT

In 2012, upon the approval of the 38th GCM in 2009, RCARO submitted a proposal of a RCA/UNDP project on the electron beam applications to the UNDP. The first phase on Electron Beam Applications for Value Addition to Food and Industrial Products and Degradation of Environmental Pollutants in the Asia Pacific region was approved and implemented from 2013 to 2015. Based on the needs and demands of the participating countries and upon the approval of the RCA and UNDP/UNOSSC, the project was extended to the second phase, with the duration of 2017-June 2021.

During the project Phase 1, sixteen (16) RCA Government Parties (GP)[2] participated in the project. With the aim of facilitating the electron beam technology for processing food and industrial products and degrading environment pollutants from various industries and urban living, the project has implemented four (4) policy meetings and five (5) Regional Training Courses at regional level, and promoted various types of activities at national level. The project made a contribution to increasing the awareness of electron beam technology and its applications and enhancing the capacity of human resources in the field. Especially for the countries with limited infrastructure, the project was successful in stimulating the demands for the technology and related facilities. At the Final Review Meeting of the project which was held in October of 2015 in Cambodia, the National Project Coordinators gathered at the Meeting made a recommendation as follows;

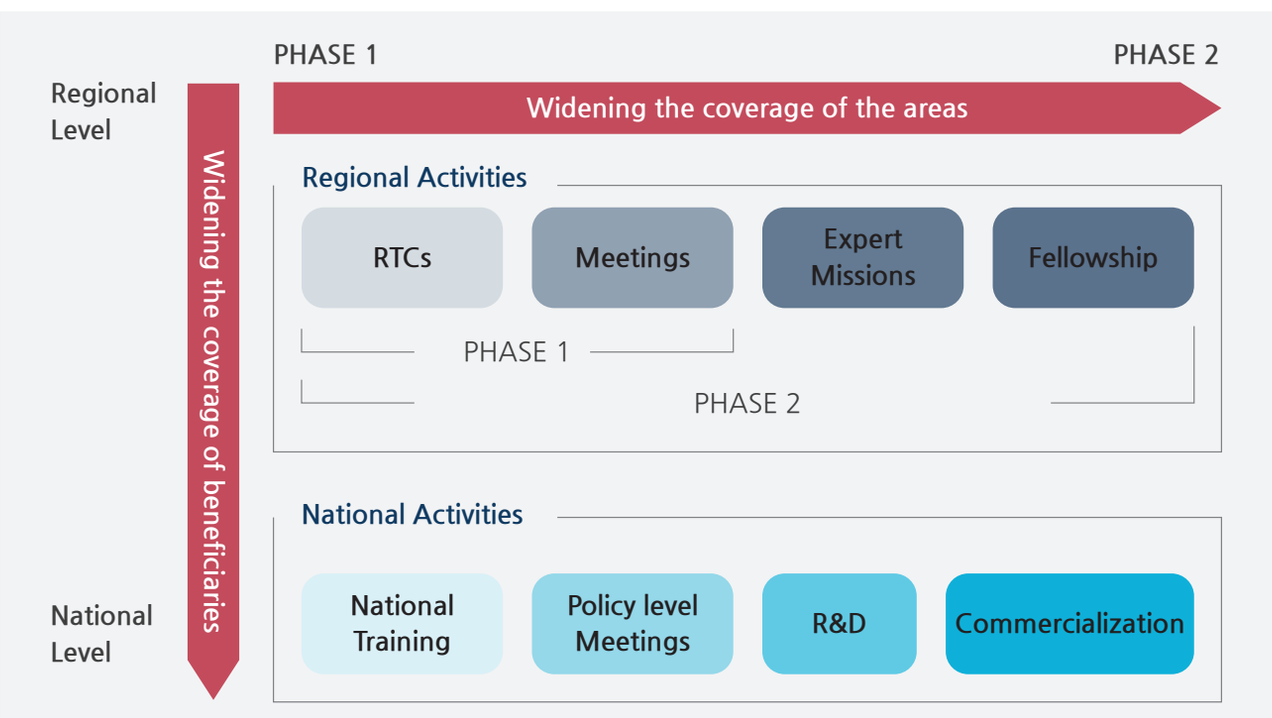
"The outcomes have shown a high interest in the use of electron beams at national level. A follow up project is recommended that utilizes the achievements made during this project and lifts use of electron beams to the next higher (level). It is recommended that the UNOSSC and the RCARO consider extending the project in view of the increasing demand for distribution and sharing of EB technology from the Government Parties considering increased establishment of EB facility in a few years."

RCARO, taking into consideration of the continued needs and demands of the region on the technology development and at the same time the necessity of scaling up the project to the next level, prepared a proposal on the Phase 2 (scaled-up project) in consultation with the relevant experts and submitted to the UNDP/UNOSSC. The Phase 2 was approved and fifteen (15) GPs[3] joined the project Phase 2.

2 Australia, Cambodia, China, India, Indonesia, Korea, Malaysia, Mongolia, Myanmar, New Zealand, Philippines, Pakistan, Singapore, Sri Lanka, Thailand, and Vietnam

3 Bangladesh, Cambodia, India, Indonesia, Korea, Malaysia, Mongolia, Myanmar, Nepal, New Zealand, Pakistan, Philippines, Sri Lanka, Thailand, and Vietnam

From 2017 till June 2021, under the project Phase 2, four (4) policy meetings in conjunction with three (3) technical workshops, three (3) Regional Training Courses, six (6) Expert Missions and one (1) Group Fellowship Programme have been implemented. Diversification of the project activities, namely missions and fellowship in addition to the meetings and RTCs, was considered a crucial factor in overcoming the limitations of the project Phase 1 and to directly respond to the pressing issues of the local communities. The implementation of these various activities has been successful in two-folds - first is to widen the coverage of the beneficiaries. Under the project Phase 1, RTCs could accommodate as many as around 70 trainees. Under the project Phase 2, around 400 participated in the capacity building activities through RTCs, Expert Missions and Group Fellowship. Second is to widen the coverage of the areas. Whereas the RTCs are only able to provide theoretical/hands-on training in a big group through a pre-programmed agenda, the Expert Missions and Group Fellowship, arranged according to the request of each recipient country, have been able to provide programmes built across the areas of policy-making, R&D, promotion, and capacity building.



Development of Project from Phase 1 to 2

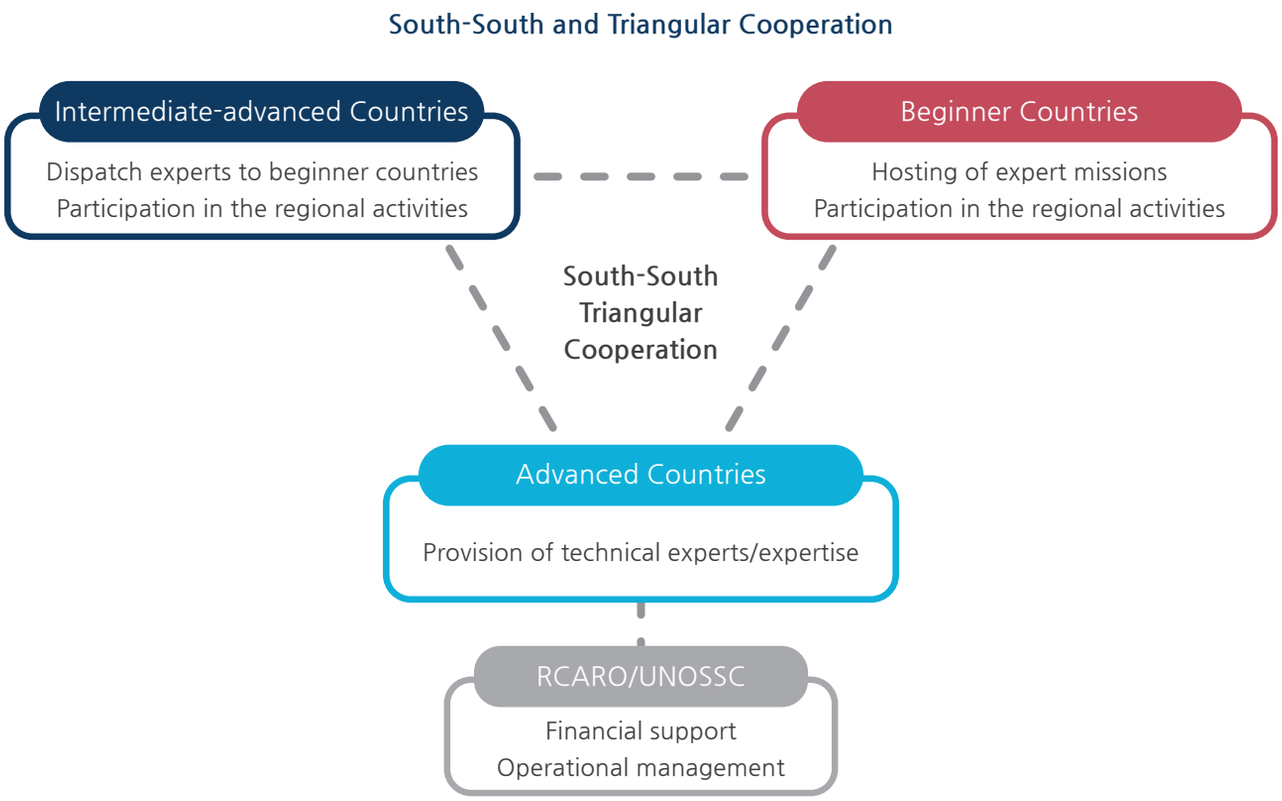
When the project Phase 1 has started, a number of participating countries found the electron beam technology new and advanced. The Phase 1 of the project focused on introducing and promoting the awareness of the electron beam technology and facilitating the demands on the technology in the region. National activities focused on the feasibility studies and promotional activities. Under the project Phase 2, expansion of the applications started, with an R&D increase. The number of the national activities and the number of the participants to the activities also increased rapidly year by year. Details on the analysis is shown in the later part of this report.

PROJECT IMPLEMENTATION STRATEGIES

Structured Approach to South-South and Triangular Cooperation[4]

RCA region covers countries with different levels of development in the field of nuclear technology. Some countries have solid and institutionalized capacities and are capable of sharing their experiences and know-how at many levels. On the other hand, some countries are at the beginning stage of adopting nuclear technologies, with limited human and institutional resources.

This project is based on the collaboration between the UNOSSC and the RCA. The "South-South and Triangular Cooperation", the concept under the RCA "Technical Cooperation among the Developing Countries", has been the core framework for the project to foster the effective and sustainable technology transfer.

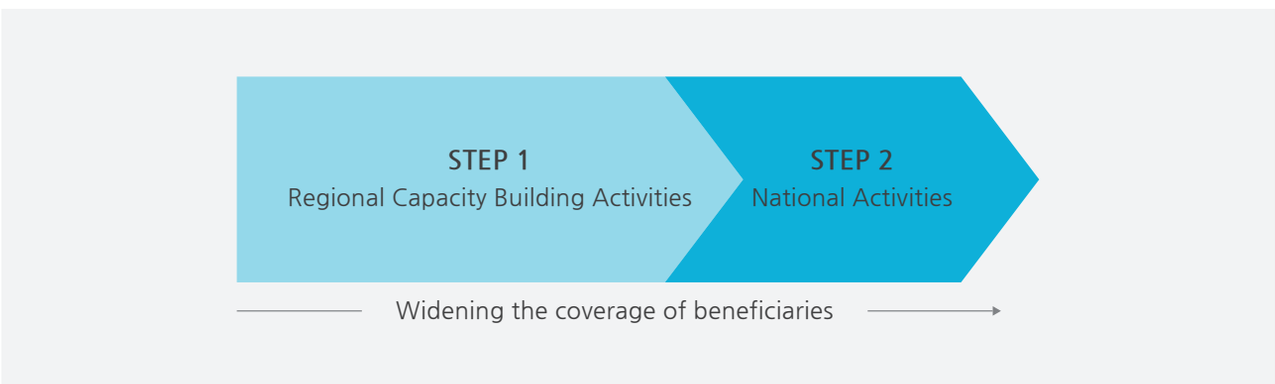


Structured Approach to South-South and Triangular Cooperation

4 South-south cooperation is a framework that involves two or more developing countries sharing knowledge, skills, expertise and resources. Triangular cooperation is "collaboration in which traditional donor countries and multilateral organizations facilitate South-South initiatives through the provision of funding, training, management and technical systems as well as other forms of support." (https://www.unsouthsouth.org/about/about-sstc/) Under the IAEA, the concept of "Technical Cooperation among Developing Countries (TCDC)" is promoted through Technical Cooperation (TC) Programme.

The project Phase 2 took its first step by conducting a comprehensive survey of each participating countries in order to explore, develop and specify approaches and strategic plans for the project. Country analysis was very important in identifying the shared development needs and issues. Following this, at every meeting where the project NPCs and experts gathered, yearly national achievements and best practices were shared, so that the participating countries are able to find the solutions and identify the available resources. This is also essential in systematically identifying the gaps of advancement of participating countries thus strengthening linkages between the institutions, and help them set a productive plan under the project. In turn, this process has further promoted the South-South and Triangular Cooperation under the project, leading to the sustainable development of the region.

Two-step Strategy, "Train the Trainers" for Capacity Building



Flow Chart of the Two-step Strategy

Aiming for the effective and efficient dissemination of the EB technology applications, the project has applied the "Two-Step Strategy." At the first level, designated participants from each participating country are trained at regional level. At the second level, trained participants disseminate the gained knowledge, skills, and new technology to end-users in their respective countries. This strategy proves to be effective by building capacity of each designated trainee and encouraging various national activities that would widen the coverage of beneficiaries.

Outreaching Local Communities through Expert Missions

Expert Missions introduced under the project Phase 2 have played a crucial role in connecting the regional project to the local communities, stimulating the dissemination of technology at national level effectively and efficiently. According to the national needs, dispatched experts prepared an agenda in advance, carried out consultations on building human and institutional capacities, delivered lectures, demonstrate experiments with machines available, and held workshops for various stakeholders, governmental or non-governmental, of the country.

Adoption of Long-term and Customized Education through Fellowship

Group Fellowship Programme was designed in response to the needs of the participating countries for a long-term and on-site training for up to six months. This programme was to help the young scientists and researchers broaden their professional knowledge and operational experience. At the same time, they are to be trained to be the trainers who will work as an educational hub for the local experts after the programme is completed. Based on the submitted research plan and action plan, the fellows were to be given with a highly specialized and customized training in the pre-identified area of interest.

By early 2020, three fellows have been selected to the programme. However, due to the travel restrictions resulting from the COVID-19, the programme has been transferred to online. A two-month training was given to the fellows with one-to-one distant mentoring by the experts.

Enhanced Knowledge Management Approach

To better capture, share and disseminate the knowledge, lessons learned and good practices gained through the project implementation, at regional level, RCARO put efforts on the knowledge management, participating in related events and publishing materials. The RCA website has been utilized to be a platform where project data is accumulated and shared by the experts of the region. Training materials and meeting presentations together with the reports were uploaded to be open to the experts all the time. In addition, RCARO participated in regional and international events and published materials to promote the project achievements. A promotional video and an online website were produced showcasing the project achievements at national and regional level.

Regional Activities in Phase 1 and 2

PHASE 1

2013

Project Kick-off Meeting
2-3 May, Thailand
(23 participants/15 countries)

RTC for Advanced Material
19-23 August, Korea
(10 trainees/10 countries)

RTC for Environment Treatment
7-11 October, Korea
(11 trainees/11 countries)

Annual Review Meeting
21-22 November, Philippines
(21 participants/13 countries)

2014

RTC for Advanced Material
14-25 April, Korea
(22 trainees/11 countries)

RTC for Food
16-20 June, Korea
(11 trainees/11 countries)

Annual Review Meeting
19-20 November, Myanmar
(17 participants/12 countries)

PHASE 2

2017

Project Coordination Meeting
10-11 May, Thailand
(24 participants/15 countries)

RTC for Environment Treatment
13-21 July, Korea
(13 trainees/12 countries)

Expert Mission to Myanmar
15-18 August
(118 participants)

Expert Mission to Malaysia
6-9 November
(77 participants)

2018

RTC for Food
5-13 March, Korea
(18 trainees/11 countries)

Expert Mission to Mongolia
8-11 May (28 participants)

Expert Mission to Sri Lanka
6-9 August (30 participants)

Mid-term Review Meeting/ Technical Workshop
16-18 August, Indonesia
(24 participants/14 countries)

2015

RTC for Environment Treatment
11-22 May, Korea
(23 trainees/12 countries)

Final Review Meeting
28-29 October, Cambodia
(21 participants/15 countries)

2019

Expert Mission to Vietnam
4-7 March (42 participants)

RTC for Advanced Material
10-14 June, Korea
(16 trainees/12 countries)

Expert Mission to Bangladesh
23-26 September
(71 participants)

Annual Review Meeting/ Technical Workshop
4-7 November, Korea
(32 participants/14 countries)

2020

Group Fellowship Programme
31 August-30 October, online
(3 trainees/3 countries)

Producing a Promotional Video
August-November

2021

Final Review Meeting and Workshop
8-9 June

03

PROJECT ACHIEVEMENTS

PROJECT OUTPUTS UNDER PHASE 1 AND PHASE 2

Expert Network Built

At the start of the project, the very first RCA network of electron beam experts was established with the invited GPs of sixteen (16). Throughout the project implementation of Phase 1 and 2, a total of eight (8) meetings were held, with three (3) meetings in conjunction with the technical workshops. At every meeting, the status of the region was analyzed to identify the shared development needs and issues. The experts presented on the yearly national achievements and best practices. The meetings were also an important place to identify the available resources in the region and strengthen the linkages between the institutes. The below shows a best practice of Sri Lanka with no EB facility receiving R&D assistance from Malaysia through this project.

"From this project, I met Malaysian researcher who helped me do irradiation experiment at Malaysian Nuclear Agency. I brought the cables to Malaysia and did irradiation research. ··· Preliminary study has been conducted on EB curing of wire and cable with the assistance of Malaysian Nuclear Agency and ACL Cables (the industrial partner of the project) has confirmed the success of the EB curing."

– NPC of Sri Lanka

Every meeting was a forum where the experts gather and share the best practices, where the South-South Cooperation takes place in a form of bilateral, multilateral and regional basis.

"Once Myanmar and Philippines asked for help in producing super-water absorbent and I shared research results with them. Field test results."

– NPC of Thailand

"(The National Project Team members like) the workshop where one can see the practical operation of the facility and on the spot he can ask some questions to enhance their knowhow about the EB facility."

– NPC of Pakistan

Developing Human Resources in the Region

During Phase 1 and 2, a total of eight (8) RTCs were held inviting around 120 trainees. The main training site was Advanced Radiation Technology Institute[5] of Korea Atomic Energy Research Institute, Korea. RTCs were held in food, industry and environmental areas, each RTC covering basic to advanced knowledge and provided demonstrations of experiments in facilities in ARTI, Korea.

The RTCs were a good platform to train the trainees but also to train the trainers. Each participant would take an important role of disseminating the knowledge and know-how gained through the courses back in their countries. Post-participation Reports were collected upon the completion of the courses at the end of the year, to follow up the post-activities the participants had undertaken. They have actively engaged in the national activities such as national seminars, workshops, and trainings, and also applied the skills to their R&D. The reports showed that the participants were highly satisfied with the courses and gained scientific and technical benefits in understanding the overall principles of EB acceleration and its applications.

Group Fellowship Programme was implemented in 2020 to respond to the long-term educational needs. Although it was designed to accommodate both the theoretical and on-site training, due to the outbreak of the COVID-19, a two-month online course was undertaken instead. The participants were provided with thirty-two (32) and four (4) real-time lectures by the experts.

Meeting the Local Needs and Expanding the Beneficiaries

Expert Missions under the project Phase 2 showed how the regional aspects could contribute to the local communities. Two experts per mission were dispatched to the countries for four (4) days. Prior to each Mission, the experts and NPCs had close discussions based on the request submitted.

Six Expert Missions were made to Myanmar, Malaysia, Mongolia, Sri Lanka, Bangladesh, and Vietnam as decided at the first coordination meeting of Phase 2. Overall, around three-hundred-sixty (360) local participants have participated in the Missions in the areas as follows;

5 ARTI, located in Korea, is a radiation specialized research institute with eminent R&D results in the field of radiation advanced materials engineering, environmental engineering, biotechnology, breeding research and radiation equipment. ARTI is a suitable host institute for training with its designation as an IAEA Collaborating Center for Nuclear Utilization Technologies since November 2009.

Year	Country	Requested Areas of Expertise
2017	Myanmar	Facility, industry
	Malaysia	Food, environment
2018	Mongolia	Industry, environment
	Sri Lanka	Industry, environment
2019	Vietnam	Industry, environment
	Bangladesh	Facility, environment

Expert Missions and Requested Areas of Expertise

The below is the NPC of Bangladesh, where an Expert Mission was conducted in 2019, mentioning about the biggest success of the project.

"Policymakers are fully convinced that EB technology has several advantages over existing gamma irradiation in processing polymers, sterilization, and treating industrial effluents and agreed to adopt the technology in the near future. ··· During the expert mission targeted goals were fully achieved. Through discussions with the experts the type of EB accelerator needed for Bangladesh was identified. ··· These achievements will enable us to undertake a project for establishing country's first EB facility at AERE under BAEC."

– NPC of Bangladesh

The Expert Missions have been regarded as the most favored activity under the project. The interactions with the experts from the requested expertise could assist the country facilitate the development.

"Expert Mission benefitted Malaysia the most, we can conduct large scale trainings and seminars for two focus groups. On-site problem solving was possible, to let the experts go and see and provide consultations. Two focus-group, two seminars, was very successful, with two experts with different fields of expertise."

– ANPC of Malaysia

"The national seminar (during the Expert Mission) was the very first ever national seminar held on the 'radiation processing technology.' 80 people, representatives from the Parliament, stakeholders, researchers and public and private sectors participated."

– NPC of Myanmar

Enhanced Knowledge Management Approach

To better capture, share and disseminate the knowledge, lessons learned and good practices gained through the project implementation at regional level, RCARO published the Project Final Report at the end of the project Phase 1 and a leaflet for promotional purposes during the project Phase 2. In addition, a promotional video and an online exhibition website were produced in order to showcase the project achievements at national and regional level. RCARO participated in the Global South-South Development (GSSD) Expos to promotion of the project. In GSSD Expo held on 28-30 November 2018, in New York, USA, RCARO joined the side event to share the achievements of the project.

Detailed yearly activities under the project are given below.

OVERVIEW OF PROJECT ACTIVITIES UNDER PHASE 1

Activities in 2013

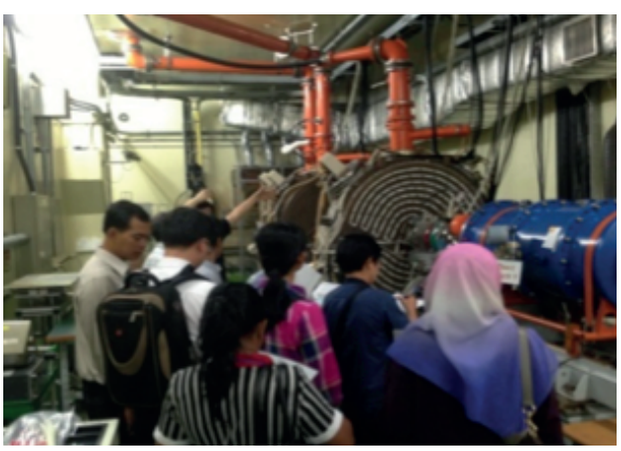
According to the work plan, project activities were undertaken as follows;

- Kick-off Meeting was held on 2-3 May in Phuket, Thailand with 23 participants including the Lead Country Coordinator (LCC), 15 NPCs, Deputy Secretary-General of Office of Atoms for Peace of Thailand, UNDP and RCARO.
- Two Regional Training Courses (RTCs) were conducted: (1) RTC on Electron Beam Applications for Value Addition to Industrial Products for one week on 19-23 August 2013 inviting ten 10 trainees from 10 countries and (2) RTC on Electron Beam Applications for Environmental Remediation for one week on 7-11 October 2013 inviting 11 trainees from 11 countries.
- Annual Review Meeting was held on 21-22 Nov. in Cebu, Philippines inviting 21 participants from 13 Member States and director of the Philippine Nuclear Research Institute.

In 2013, according to the work plan of the project, a kick-off meeting was held on 2-3 May in Phuket, Thailand, inviting National Project Coordinators (NPCs) and alternate NPCs who were nominated by the participating countries for project implementation. 23 participants attended in the meeting, including 18 NPCs and alternate NPCs from 15 countries, LCC, and participants from the Office of Atoms for Peace of Thailand, UNOSSC and RCARO.

Kick-off Meeting held in May 2013, in Phuket, Thailand

Country reports received by the NPCs were analyzed by the LCC. The analysis was presented at the meeting to establish the work plan of the project. The meeting confirmed the work plan for 2013 including the details of Annual Review Meetings and Regional Training Courses such as date, venue and qualification of the participants.



Regional Training Courses held in August 2013, in ARTI, Korea

Two RTCs in industry and environment areas were conducted. From 19 to 23 August 2013, “RTC on basic knowledge and hands-on experiment on electron beam applications for value addition to industrial products” was conducted. The objective of the course was to provide basic knowledge and experimental experience on electron beam applications in the industry area. The participants acquired knowledge and practical experience on radiation chemistry, experimental experience on advanced material, and experimental design methods on advanced material. Later in 2013, from 7 to 11 October, “RTC on basic knowledge and hands-on experiment on electron beam applications for degradation of environmental pollutants” was conducted. Lectures on basic radiation chemistry in environmental remediation, radiation microbiology for environmental remediation, and radiation application for environmental remediation were given. It included air pollution treatment, water and wastewater treatment, as well as waste

treatment and recycling using radiation technology. The two training courses were a great success with excellent feedback received from most of the participants. It transferred the basic concepts and fundamental knowledge on electron beam irradiation and its applications for industrial products and environmental remediation.

Annual Review Meeting held in November 2013, in Cebu, Philippines

Later in 2013, the Annual Review Meeting was held on 21-22 November in Cebu, Philippines, with a total of 21 participants including LCC, NPCs and nominated participants from 13 participating countries and Director of Philippine Nuclear Research Institute (PNRI) and RCARO. Representatives presented on the national achievements and outcomes in 2013 and work plan for 2014. The meeting reviewed a draft annual report for 2013 and set a detailed work plan for 2014.

Activities in 2014

According to the work plan, project activities were undertaken as follows;

- RTC on Basic and Advanced Knowledge and Hands-on Experiment on Electron Beam Applications for Advanced Material was conducted for 22 trainees from 11 participating countries for two weeks on 14-25 April 2014.
- RTC on Basic and Advanced Knowledge and Hands-on Experiment on Electron Beam Applications for Food Products was conducted for 11 trainees from 11 participating countries for one week on 16-20 June 2014.
- Annual Review Meeting was held on 19-20 Nov. in Yangon, Myanmar, inviting 17 participants from 12 countries.

Regional Training Courses held in April and June 2014, in ARTI, Korea

In 2014, RTCs on basic and advanced knowledge and hands-on experiment on electron beam applications for advanced material and for value addition to food products were conducted on 14-25 April and 16-20 June respectively. The RTC on advanced material was in continuation with the RTC conducted in 2013. 2014 RTC focused more on advanced knowledge on radiation chemistry, radiation technique, and experimental application of EB for hydrogels. The RTC on food applications put emphasis on the experimental food chemistry, food microbiology and experiment, food rheology and sensory evaluation test, dosimetry for phytosanitary and other experimental applications.

Annual Review Meeting held in November 2014, in Yangon, Myanmar

The Annual Review Meeting was held on 19-20 November in Yangon, Myanmar, with a total of 17 participants including LCC, NPCs and nominated participants from 12 participating countries, RCARO and observers from the Ministry of Science and Technology of Myanmar. At the meeting, representatives presented on the national achievements and outcomes in 2014 and work plan for 2015. The meeting reviewed a draft annual report for 2014 and set a detailed work plan for 2015.

Activities in 2015

According to the work plan, project activities were undertaken as follows;

- RTC on Basic and Advanced Knowledge and Hands-on Experiment on Electron Beam Applications for Degradation of Environmental Pollutants in the Asia Pacific region was conducted on 11-22 May 2015 inviting 23 participants from 12 participating countries.
- Final Review Meeting was held on 28-29 October 2015, Siem Reap, Cambodia, inviting 21 participants from 16 countries.

Regional Training Course held in May 2015, in ARTI, Korea

In 2015, one RTC was conducted under the title of “basic and advanced knowledge and hands-on experiment on electron beam applications for degradation of environmental pollutants.” The contents of the training course included basic to advanced lectures such as basic radiation chemistry, radiation chemistry in environmental remediation, and radiation detection and measurements. Also lectures on environmental analysis, air pollutants treatment, water and wastewater treatment, and waste treatment and recycling were given.

Final Review Meeting held in October 2015, in Siem Reap, Cambodia

Final Review Meeting was held on 28-29 October 2015 in Siem Reap, Cambodia with a total of 21 participants including LCC, Regional Coordinator of UNOSSC, and NPCs from participating Government Parties. NPCs presented final report of their national activities and outcomes during the implementation period of the project. The meeting reviewed and evaluated the overall outcomes of the project. Also, the meeting discussed follow-up actions for further distribution and development of the EB technology after completion of the project. Opinions on the extension of the project were raised, considering the increase in the establishment of EB facilities and in the use of the EB technology. The meeting also drafted the final progress report which would be consolidated with national final reports.

OVERVIEW OF PROJECT ACTIVITIES UNDER PHASE 2

Activities in 2017

In 2017, the project was successfully implemented according to its work plan as follows:

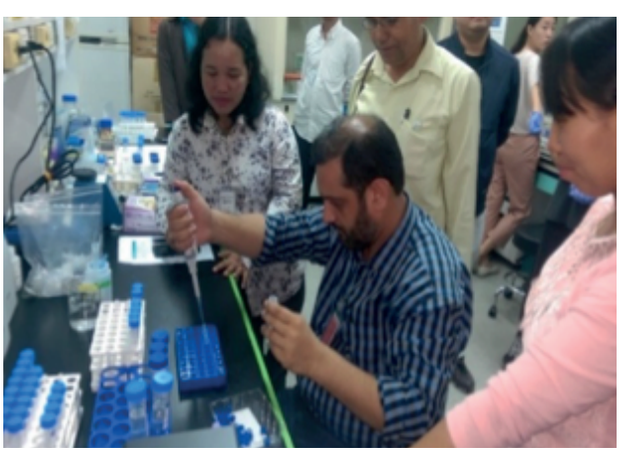
- Country Report Analysis was undertaken from March to May 2017 targeting 15 participating countries.
- Project Coordination Meeting was held on 10-11 May 2017, Phuket, Thailand, inviting 24 participants from 15 countries including National Project Coordinators (NPCs) and Alternate NPCs and representatives from Office of Atoms for Peace (OAP), UNOSSC and RCARO.
- Regional Training Course (RTC) in Advanced Knowledge and On-site Training on Electron Beam Applications for Degradation of Environmental Pollutants in the Asia Pacific region was conducted on 13-21 July 2017, in Jeongeup, Korea, inviting 13 trainees from 12 participating countries.
- 1st Expert Mission to Myanmar was held on 15-18 August 2017 involving 118 participants that include representatives from the parliament, Ministry of Education, private sectors of food industry and universities.
- 2nd Expert Mission to Malaysia was held on 6-9 November 2017 involving 77 participants from research institutes and universities.

According to the Work Plan, Project Coordination Meeting, Regional Training Course, and two Expert Missions have been undertaken in 2017. Beforehand, the project began with the Country Report Analysis on the participating countries' development status in the field of EB technology applications in order to identify shared development needs and issues and to develop specified approaches and strategic plans for the project Phase 2. The countries provided information and data on available human resources, facilities, focused research areas and activities, national

plans as well as requested areas for Expert Missions and RTCs. The analysis was presented at the Project Coordination Meeting, held on 10-11 May in Phuket, Thailand, providing a comprehensive picture of the regional status.

Project Coordination Meeting held in May 2017, in Phuket, Thailand

Project Coordination Meeting invited 24 participants from 15 countries, including national project coordinators, representatives from Office of Atoms for Peace (OAP), UNOSSC and RCARO. The meeting confirmed the details of the work plan, specified contents and qualifications of trainees for regional training courses, and target countries for six Expert Missions to be held - Myanmar, Malaysia, Mongolia, Sri Lanka, Vietnam and Bangladesh - based on the country report analysis and requests submitted by the countries.



Regional Training Course held in July 2017, in ARTI, Korea

RCA/UNOSSC Regional Training Course in Advanced Knowledge and On-site Training on Electron Beam Applications for Degradation of Environmental Pollutants in the Asia Pacific region was held from 13 to 21 July 2017, in Advanced Radiation Technology Institute (ARTI), Jeongeup, Korea, inviting 13 participants from 12 participating countries. Results of satisfaction survey and post-participation reports showed that trainees were highly satisfied with the course

and gained scientific and technical benefits in understanding overall principles of electron beam acceleration and its applications on the subject, specifically on the irradiation for the treatment of wastewater, air and soil treatment, including detailed toxicity analysis and hands-on experiments on the detection. It was also shown that they have actively engaged in various activities such as workshops, seminars, experiments, and meetings at national level with the knowledge and skills gained at the RTC, involving around 600 local experts, workers, policy makers, and the public.

Expert Mission to Myanmar: Awareness Seminar, August 2017

Two Expert Missions to Myanmar and Malaysia were conducted on 15-18 August and 6-8 November respectively, based on the requests submitted by the target countries. Two experts were dispatched to each country. In Myanmar, where the EB technology development is at its beginning stage, the Mission focused on 1) the promotion of the EB technology and its applications and 2) technical consultation on the establishment of EB facilities and manpower. During the Mission, a ministerial level awareness seminar was hosted inviting representatives from the parliament, ministries, universities and institutes and was broadcasted by national TV channels. Dispatched experts played a role in delivering technical and professional information on the utilization of radiation processing technologies to the decision makers through presentations. In addition, technical meetings on the establishment of EB infrastructure was conducted with local experts and technicians that included on-site consultations on the installation of the facilities, addressing the budget issues, and building human and institutional capacities.

Expert Mission to Malaysia: Visit to Research Institute and Delivery of Lectures, November 2017

In Malaysia, where active R&D and commercialization activities are on-going, the Mission consisted of technical workshops, separated into two groups of expertise, environment treatment and agriculture. The workshops provided lectures and on-site consultations by dispatched experts, providing technical advice and recommendations on specified topics for currently running R&D activities as well as potential new research areas.

Activities in 2018

According to the work plan, the project activities were successfully implemented as follows:

- Regional Training Course (RTC) on Advanced Knowledge on Shelf-life Extension and Phytosanitary Measures on Foods was conducted on 5-13 March 2018, in Jeongeup, Korea, inviting 18 trainees from 11 participating countries.
- Expert Mission to Mongolia was held on 8-11 May 2018 involving 28 participants from Nuclear Energy Commission, Water Services Regulatory Commission, Water Supply and Sewerage Authority, hospitals and universities etc.
- Expert Mission to Sri Lanka was held on 6-9 August 2018 involving 30 participants from Sri Lanka Atomic Energy Board, Board of Investment, Atomic Energy Regulatory Council, and University of Colombo etc.
- Mid-term Review Meeting in conjunction with Technical Workshop on Electron Beam Applications was held on 16-18 October 2018, in Bali, Indonesia, inviting 24 participants from 14 participating countries and UNOSSC.

Regional Training Course held in March 2018, in ARTI, Korea

Regional Training Course on Advanced Knowledge on Shelf-life Extension and Phytosanitary Measures on Foods was held from 5 to 13 March, in Advanced Radiation Technology Institute (ARTI), Jeongeup, Korea, inviting 18 participants from 11 participating countries. The course provided advanced knowledge and hands-on experiments on subjects such as radiation chemistry and radioisotope handling, phytosanitary for foods and radiation dosimetry, and evaluation of irradiated food quality. Results of the satisfaction survey and post-participation reports showed that trainees were highly satisfied with the course and gained scientific and technical benefits in understanding the overall principles of electron beam acceleration and its applications on the subject.

Site Visits during Expert Mission to Mongolia, May 2018

Site Visits during Expert Mission to Sri Lanka, August 2018

Expert Missions to Mongolia and Sri Lanka were completed in May and August respectively, involving over 50 local participants. According to the national requests, two experts from the fields of industry and environment treatment were dispatched at each Expert Mission. Both Expert Missions included open seminars on the industrial applications and treatment of wastewater for local experts and site-visits to facilities where the dispatched experts provided on-site consultations.

Project Mid-term Review Meeting and Technical Workshop held in October 2018, in Bali, Indonesia

Mid-term Review Meeting was held on 16-18 October 2018, in Bali, Indonesia, in conjunction with Technical Workshop on Electron Beam Applications, inviting 24 participants from 14 participating countries and UNOSSC. The workshop reviewed recent issues related to the EB applications in the region according to the thematic sector and introduced best practices on the establishment of EB facilities and the commercialization of their products. During the meeting, the project achievements to date at regional and national level were presented and details of the work plan for 2018-2019 were confirmed.

Activities in 2019

From January to December 2019, project activities were undertaken according to its work plan as follows;

- Expert Mission to Vietnam was held on 4-7 March 2019 involving 42 participants from Research and Development Center for Radiation Technology (VINAGAMMA), local universities and other related private sectors.
- Regional Training Course (RTC) on Advanced Knowledge and On-site Training on Electron Beam Applications for Advanced Materials was conducted on 10-14 June 2019, in Jeongeup, Korea, inviting 16 trainees from 12 participating countries.
- Expert Mission to Bangladesh was held on 23-26 September 2019 involving 71 participants from Bangladesh Atomic Energy Agency (BAEC) and private sectors.
- Annual Review Meeting/Technical Workshop was held on 4-7 November 2019 in Jeonju, Korea, inviting 32 participants from the participating countries, UNOSSC and RCARO.

Expert Mission to Vietnam: Technical visit to Saigon Paper Joint-stock Company, March 2019

Expert Mission to Vietnam was held on 4-7 March 2019 involving two (2) Korean experts and forty-two (42) national stakeholders from VINAGAMMA, local universities, and other related private sectors. Prior to the Mission, according to the request by the host country, the programme was set up to focus on the applications of EB technology on the industrial and environment treatment areas. The experts shared their know-hows and experiences through a national workshop, technical visits and on-site consultations, and meetings. The Mission was successful in providing evaluation on the possibility of the utilization of EB technology for treatment of textile wastewater and crosslinking of wire and cable and in providing a discussion on possible further collaboration between Vietnamese and Korean institutes. According to the end-of-mission report from Vietnam, it was reported by the National Project Coordinator that the mission supported infrastructure as well as human resource development related to the EB technology.

Regional Training Course held in June 2019, in ARTI, Korea

RCA/UNOSSC Regional Training Course on Advanced Knowledge on Advanced Knowledge and On-site Training on Electron Beam Applications for Advanced Materials was held from 10 to 14 June 2019, in Advanced Radiation Technology Institute (ARTI), Jeongeup, Korea, inviting sixteen (16) participants from twelve (12) participating countries. The course provided advanced knowledge through lectures and experiments on the application of electron beam technologies for advanced materials by recognized experts. The topics included applications on the bio-materials, heavy metal absorbance and nano materials and radiation chemistry. By utilizing the newly built Electron Beam Process Demonstration Research Building at ARTI, KAERI, the trainees participated in the practice and hands-on experiments for development of advanced materials. Results of satisfaction survey showed that trainees were highly satisfied with the course and gained scientific and technical benefits in understanding the overall principles of electron beam acceleration and its applications on the subject.

Expert Mission to Bangladesh: Discussion with Policy Makers, September 2019

Expert Mission to Bangladesh was held from 23 to 26 September 2019. Two Korean experts, one with technical background of environment treatment and the other with experiences of facility establishment, were dispatched. Seventy-one (71) participants of Bangladesh Atomic

Energy Agency (BAEC) and private sectors participated in the Mission through national seminars, facility visit, and meetings. Meetings with entrepreneurs as well as policy makers were conducted to introduce the feasibility and advantage of EB technology for various applications. It was reported that the Mission was successful in drawing attention of the policymakers especially on establishing an EB facility at AERE, BAEC.

Annual Review Meeting/Technical Workshop held in November 2019, in Jeonju, Korea

Annual Review Meeting in conjunction with Technical Workshop was held from 4 to 7 November of 2019, inviting thirty-two (32) participants from participating countries, UNOSSC, and RCARO. During the Technical Workshop, lectures and on-site seminars were conducted in Advanced Radiation Technology Institute (ARTI). At the Meeting, overview of project achievements in 2019 at regional level and national level was presented and details of the work plan 2020 were discussed. Most importantly, the Meeting was briefed with the plans for the Group Fellowship Programme 2020 and welcomed the first fellowship activity under the project. Further, the Meeting recommended for seeking possibilities for the extension of the project, noting the needs for further capacity building activities to support those countries in need of developing institutional and human resources in the field.

Activities in 2020

In 2020, two project activities had been planned to be undertaken as follows;

- Group Fellowship Programme was implemented from September to October (a two-month programme), inviting three fellows to an online platform “RCA e-Learning Campus” to provide online tutoring on theoretical parts of the programme.
- Project Promotional Video was produced that contains the achievements and impact of the project, using visual materials and interviews.
- Project Final Review was undertaken. The participating countries submitted their yearly country reports to the RCARO to be consolidated into a final progress report of the project.

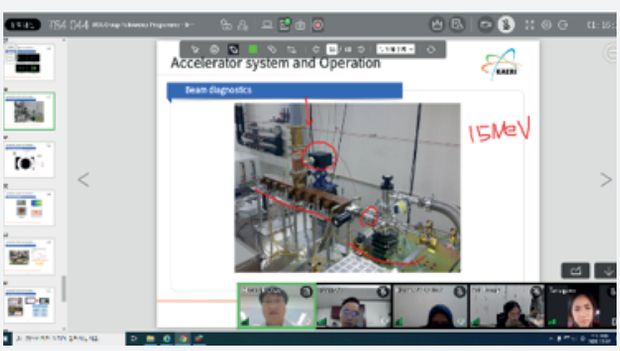
Under the Group Fellowship Programme, Selection Committee was organized in order to go through the selection process of the participants. As a result, three participants from Indonesia, Thailand, and Vietnam were selected. In the midst of the preparations for the programme, the outbreak and rapid spread of the COVID-19 begun and RCARO had to prepare for alternative work plans.

Fellows, experts, and others involved in the Group Fellowship Programme have agreed that coming to Korea for a six-month stay would be extremely difficult at the moment, with all the travel restrictions of the fellows and health care difficulties in Korea. For 2020, it was decided that the fellows take an online course for about two months on the theoretical parts of the programme. The programme was re-designed to include thirty-two (32) and four (4) real-time lectures by the experts. The contents included principles of radiation and radioactivity, safety issues, understanding the equipment and its applications.

Over the weeks, the participants have shown 100% attendance. Their assignments have been submitted to the lecturers to be reviewed. All three passed the tests and their completion certificates have been issued. Over a series of satisfaction surveys and interviews, the participants showed a high satisfaction with the course with an average of 4.7 out of 5.0. According to the results, it was highlighted that the participants have favoured the real-time lectures over pre-recorded lectures, indicating that face-to-face interactions still play an important role in such an environment.

Promotional video was produced based on the achievements of the project Phase 1 and 2. Prior to the production, achievements of the project have been analysed and were shared with the relevant experts. The video contains an introductory part of the project with animation and the interviews by the stakeholders.

Project review has been conducted via requesting the member countries to submit their yearly achievements. A total of twelve (12) countries sent their country reports of 2020. It was found that mostly the countries have difficulties in conducting the planned activities due to the shutdown of the institutes resulting from the COVID-19 pandemic. Most of the activities have been postponed as they require on-site experiments. Some cases have shown that using IT technologies could help, for example, the Philippines conducted a virtual tour of E-beam facility during a national event.



Real-time Lecture during the Group Fellowship Programme

Video Production

Activities in 2021

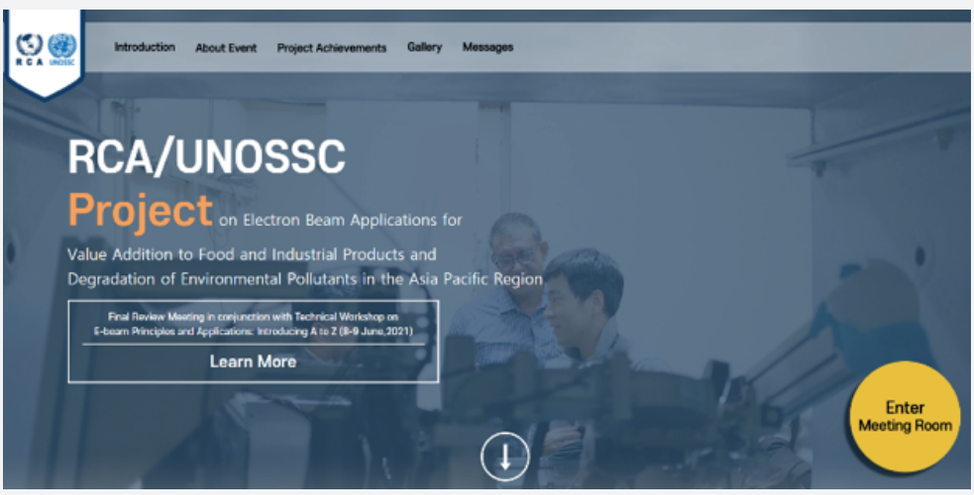
From January to June 2021, one project activity was undertaken as follows;

- Final Review Meeting/Technical Workshop was held on 8-9 June 2021, virtually, inviting 54 participants from the participating countries, UNOSSC and RCARO.

In response to the COVID-19 pandemic, Final Review Meeting and Technical Workshop on Electron Beam Applications was held virtually. Prior to the event, RCARO developed a dedicated website for the online exhibition of project achievements (rcaunossc.org) where the project overview and national/regional project achievements are displayed.

During the event, which comprise of two sessions, the final review meeting and technical workshop, the RCA/UNOSSC partnership and project overview and its progress were presented. National and regional achievements, implications and ways forward were shared and discussed. During the Workshop, lectures on e-beam basics, equipment, and applications were given.

A total of fifty-four (54) participants from thirteen (13) countries, UNOSSC, and RCARO participated in the virtual event.



Online Exhibition

04

PROJECT OUTCOMES

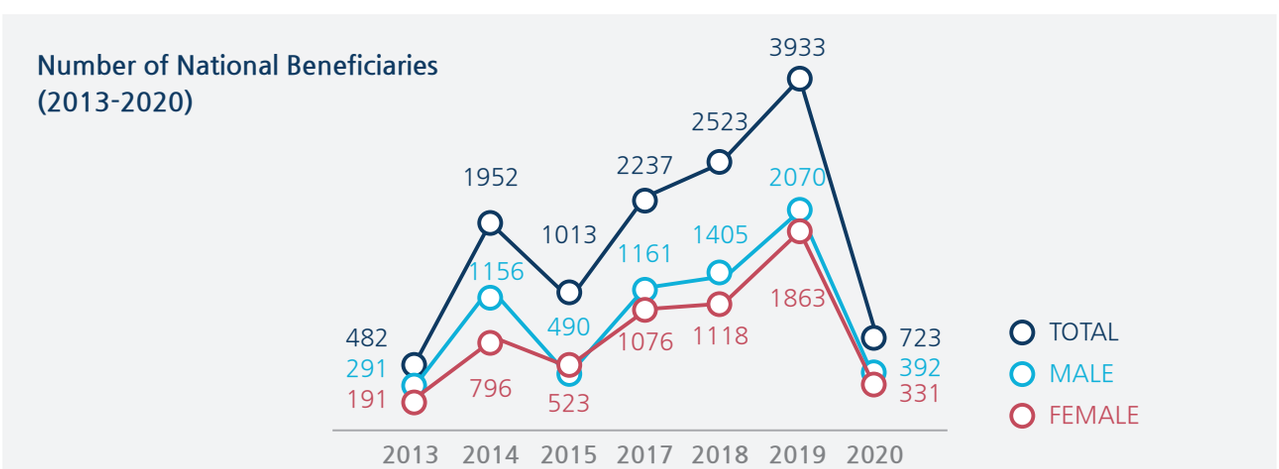
NATIONAL ACTIVITIES UNDER PHASE 1 AND 2

Overview of National Activities

At the end of each year, the participating counties were requested to submit reports on the national activities undertaken with the knowledge and skills gained through regional activities. The National Project Teams carried out activities to disseminate the knowledge and skills to their local institutes and industries, such as R&D activities, national training courses, scientific meetings, seminars and expert missions, involving 3,447 participants (1,510 females and 1,937 males) under the project Phase 1 and 9,416 (4,388 females and 5,028 males) under the project Phase 2.

The participants to these activities include various national stakeholders - meetings with the private sectors, workshops with the governmental officers, seminars with other researchers, educational programme for the university students and promotional activities targeting the public. These activities help the country foster the technology absorption and innovation, strengthening the national capacity.

The graph shows the number of participants involved in the national activities increase as the project proceeds (with a slight high pitch in 2014). Considering that the number per year is not accumulative, it can be seen that the expansion of electron beam technology related activities has continued to gradually. However, there is a rapid decline in 2020, indicating that the COVID-19 pandemic imposed a great barrier in carrying out national activities.



Graph on Number of National Beneficiaries (2013-2020)

Under the project, the female participation stays slightly lower than male participation but the gender balance is quite equally balanced.

National Activities undertaken under the project Phase 1

At the kick-off meeting of the project Phase 1, **promoting the technology**, especially for the safety of radiation technology for food products, was raised as a substantial and essential part of the project. Thus, national activities to promote the EB technology and its safety were carried out in the participating countries throughout the project implementation, involving not only the scientists and experts in the field but also the government officials and the general public. India, Malaysia and Singapore held various seminars for increasing awareness of its safety and regulatory aspect and for technical sharing on EB technology. Mongolia has conducted an education program and an open seminar in Nuclear Research Center, National University of Mongolia to promote and disseminate the gained skills and knowledge in 2015.

Exhibitions in Sri Lanka, 2014-2015

Seminars and meetings arranged for government officials **fostered information sharing and policy making** regarding the EB technologies and facilities. For Myanmar and Pakistan, a number of meetings were continuously held for the establishment of EB facility. **Promotional activities** for general public such as exhibitions and awareness programs were a great success to promote the technology. For example, Sri Lanka held two exhibitions at the governmental level, inviting around 35,000 participants including end users, experts and general public.

Presentation on Electron Beam Technologies in Seminar for Officials in Myanmar in 2014

R&D activities were carried out in various areas. In **agricultural sector**, Indonesia carried out research on the effect of EB irradiation on cocoa, edible mushroom and OPEFB (Oil Palm Empty Fruit Bunch). Thailand conducted research for herb, beans and natural rubber latex irradiation in 2014, and for herb irradiation and development of natural and synthetic polymers in 2015. In Australia, research was completed on the radiation tolerance for more than ten new crops during the course of the project. In **industrial sector**, Vietnam has designed and constructed a device for expansion of the applicable area density for 10 MeV electron beam and used 10 MeV accelerator for producing grafted nano-silver cottons used in hospitals in 2013-2015. As for the Philippines, with the completion of the establishment of EB facility at the PNRI in 2014, research and development studies were initiated such as R&D projects on radiation grafting and on the effects of EB on the shelf-life of honey alginate dressing in 2015. New Zealand published a handbook for the EB annealer.

Irradiation Processing of Cocoa Using Electron Beam in Indonesia in 2014

Cottons with Grafted Nano-silver (140pp) (Left) and Sheets with Grafted Nano-silver
Used in the Emergency Department of the Binh Dinh Hospital for Testing in Vietnam

Initiatives to **commercialize the technology** were shown. The Philippines, in cooperation with Philippine General Hospital, patients with a scald burn were cured with the honey alginate

dressing developed by the PNRI. In Malaysia antimicrobial grafted film was introduced for commercial use in packaging breads, which contributed to the food safety without directly irradiating the food itself.

The project also facilitated **establishing EB facilities** in the participating countries: 5 EB facilities have been/will be established in China; India set up two accelerators in private wire & cable industry; and the Philippines completed the establishment of an EB facility. The facility will provide the start of many applications and gain benefits using the EB technology. China has also constructed a pilot-scale wastewater treatment plant by EB technology, and has initiated to establish an industrial-scale facility for textile and dyeing wastewater treatment. In certain countries where EB application technology has been recently introduced, there have been constant endeavors to establish EB facilities. In case of Sri Lanka, 16 Coal Power Plants are planned to be established where EB flue gas treatment is applied to reduce the emission of toxic gasses and reduce fuel cost. Myanmar initiated its national project with the IAEA for establishing an Electron Beam irradiation facility.

EB Facility in PNRI, Philippines (Left) and a 78/male Patient with a Scald Burn Healing with Honey Alginate Dressing in Philippine General Hospital

National Activities undertaken under the project Phase 2

The National Project Teams continued their efforts on promoting the technology and its usage through diverse national activities under the project Phase 2. **Human resource capacities were strengthened** through in-house seminars, trainings, and workshops in Bangladesh, India, Indonesia, Malaysia, Mongolia, Myanmar, Nepal, Pakistan, Philippines, Sri Lanka, Thailand, and Vietnam. In Sri Lanka in 2017, the participant of the RTC conducted three awareness programmes in universities and schools, in which he delivered lectures to a total of 150 students and teachers on the subject of radiation processing activities including EB technology and its applications. In Myanmar, Thailand, India, and Pakistan, special training was organized for university students under the theme of EB applications. **Public awareness was enhanced** by participating in national events such as conferences and exhibitions in Indonesia, Malaysia, and

the Philippines. In the Philippines, to educate the media practitioners - the key players in promoting the technology - an awareness seminar, “Radiation for Everyone” was held in 2019, inviting twenty (20) media practitioners.

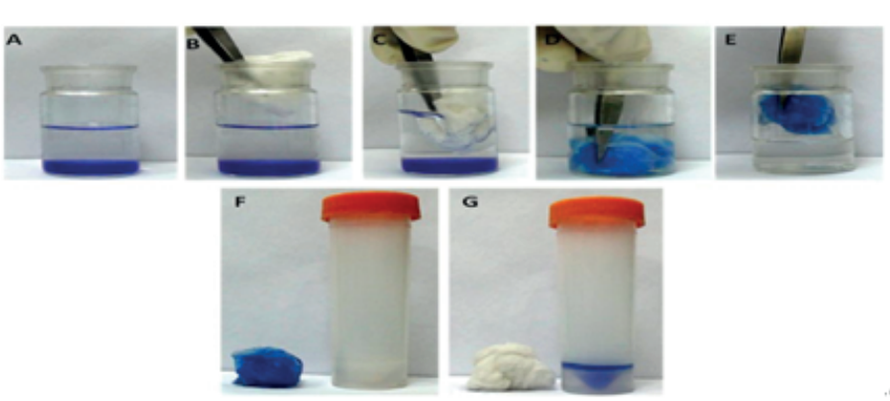

Awareness Programmes Pakistan (left) in 2017 and in the Philippines (right) in 2019


Knowledge Sharing Seminar at University in Myanmar in 2019


National Seminar and Exhibition on Food Irradiation in Indonesia in 2019


National Seminar and Exhibition on Food Irradiation in Malaysia

Under the project Phase 2, it was noticeable that active R&D activities have been undertaken in the area of **environment treatment**, specifically on the removal of water pollutants. India, Malaysia, and Thailand succeeded in the development of grafted absorbents that can selectively absorb targeted pollutants from water. Other countries showed strong demands for new R&D in this area, for example, Sri Lanka, Vietnam and Mongolia have been conducting feasibility studies on the utilization of irradiation technologies to mitigate the environmental pollutants.



Separation and recollection of under water oil using modified cotton in India

Towards the **sustainable agricultural development**, R&D activities as well as collaborative works between the institutes and farmers continued. In the Philippines, Farmer's Field Day was held in 2019 to enhance the farmers' awareness about the role of EB irradiated Carageenan Plant Growth Promoter (PGP) in increasing the plant yields. Indonesia was successful in applying chitosan to hens as an animal feed supplement which led to daily production increase. Myanmar conducted research on Plant Growth Promoter (PGP), carrying out case studies.

Research Activities (Plant Growth Promoter PGP Research) in Myanmar

Network building and knowledge sharing with the private/public sectors led to **more opportunities for the end-users and facilitation of the EB applications.** In 2018, small & medium enterprises and the Government of Myanmar held a meeting on understanding of EB applications on food, industrial and medical products to the end users. Participants to the RTC held in 2018 from Sri Lanka, a plant quarantine officer and a nuclear researcher, utilized the knowledge and skills earned for planning and conducting the quarantine system for the irradiated fruits. Malaysia conducted a capacity building programme for Small-Medium Industry (SME) entrepreneurs in rural area in 2019 and provided mushroom tea (irradiated) production training package through which 125 people have benefitted. In 2020, Indonesia continued its efforts in discussing the potential of the application of EB technology with industries, government regulators, lecturers and NGO through Forum Group Discussion.

Pakistan **established a new EB facility** and Thailand has installed four EB accelerators to be operational during the project implementation period. In 2020, Indonesia established one electron beam facility (medium energy) for sterilization of medical devices, food preservation, and modification of products and Vietnam established one electron beam facility (high energy) for radiation treatment of pet food. Other countries continued their efforts for persuading relevant national authorities for the installation. Myanmar is under progress for adopting a 2.5 MeV EB accelerator, expecting its installation in the near future. Bangladesh and Sri Lanka also made efforts to convince the relevant national authorities for funds to establish EB facility within the next five years.

South-south cooperation was strengthened through collaborative activities undertaken by the participating countries. Sri Lanka brought the wires and cables to Malaysia for the data collection for feasibility study on industrial application of EB and succeeded in persuading the industrial partner, ACL Cables. Indonesia provided Mongolia with irradiated oligochitosan and biofertilizer to be used for an experiment on the growth of sweet pepper and tomato plants. The experiment showed sweet pepper fruit with 100% increased of yield while tomato plants with 263% increase. India educated fellows from Myanmar through on-site training in food irradiation and value addition to polymeric materials for industrial applications.

EB Curing of Wire and Cable Samples conducted in Malaysia upon the request from Sri Lanka

Production of UVC irradiation chamber for hospital usage in Malaysia

Since early 2020, **the COVID-19 pandemic** has resulted in many restrictions to the national activities. Adjusting to new normal life, many countries endeavored to overcome the situation by setting the activities in virtual forms. Philippines was successful in conducting virtual tour of e-beam irradiation facility during the Atomic Energy Week celebration. Moreover, new research activities such as producing vaccine and sterilizing personal protective equipment (face mast, hazmat gown, etc.) have started. In 2020, in Indonesia, responding to these needs, joint research began on the usage of high energy radiation on vaccination and sterilization of protective equipment. In Malaysia, production of face shields for front liners and UVC irradiation chamber for hospital usage was conducted. Thailand, in collaboration with related institutes, developed WIN-masks (washable nano-masks).

ANALYSIS ON ACTIVITY TYPES AND AREAS (PHASE 2)

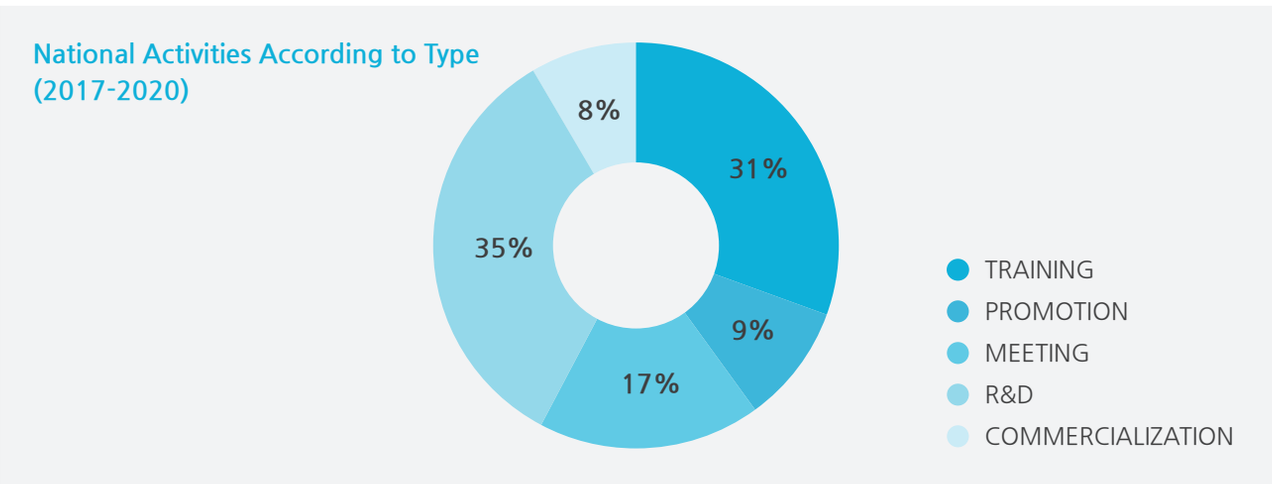
With the data gathered under the project Phase 2, RCARO has done an analysis on the recent trend of national activities according to the areas and types. A total of three-hundred-nineteen national (319) activities have been undertaken from 2017 to 2020 in thirteen (13) countries as shown in the below table. Among the countries, Malaysia showed the most active implementing rate in the national activities.

When the number of activities are compared yearly, from seventy-two (72) in 2017, eighty-seven (87) in 2018 to one-hundred-eleven (111) in 2019, the number increases. Together with the increase in the total number of participants, this trend of increasing shows that the electron beam related activities are expanding during the three years' time. However, the number goes less than half of the previous year in 2021. Due to the COVID-19 pandemic, countries have reported there have been restrictions on carrying out national activities.

Country	2017	2018	2019	2021	Total
BGD	1	3	6	-	10
IND	2	2	3	1	8
INS	8	12	9	10	39
MAL	23	22	29	8	82
MON	4	4	5	2	15
MYA	8	9	24	10	51
NEP	1	2	4	-	7
NZE	1	1	-	-	2
PAK	4	4	4	2	14
PHI	3	5	9	4	21
SRL	11	11	7	8	37
THA	4	6	6	1	17
VIE	2	6	5	3	16
Total	**72**	**87**	**111**	**49**	**319**

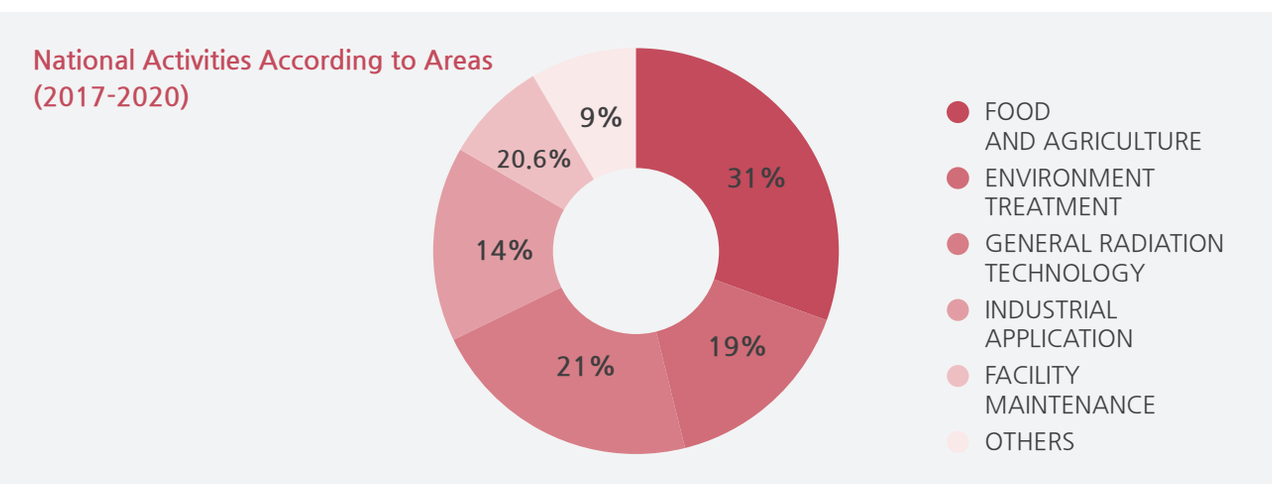
Data on the Number of National Activities Conducted in Each Country

When the activities were categorized into the types, namely, training, promotion, meeting, R&D and commercialization, the division of the activities showed that the participating countries put most efforts in the R&D sector.



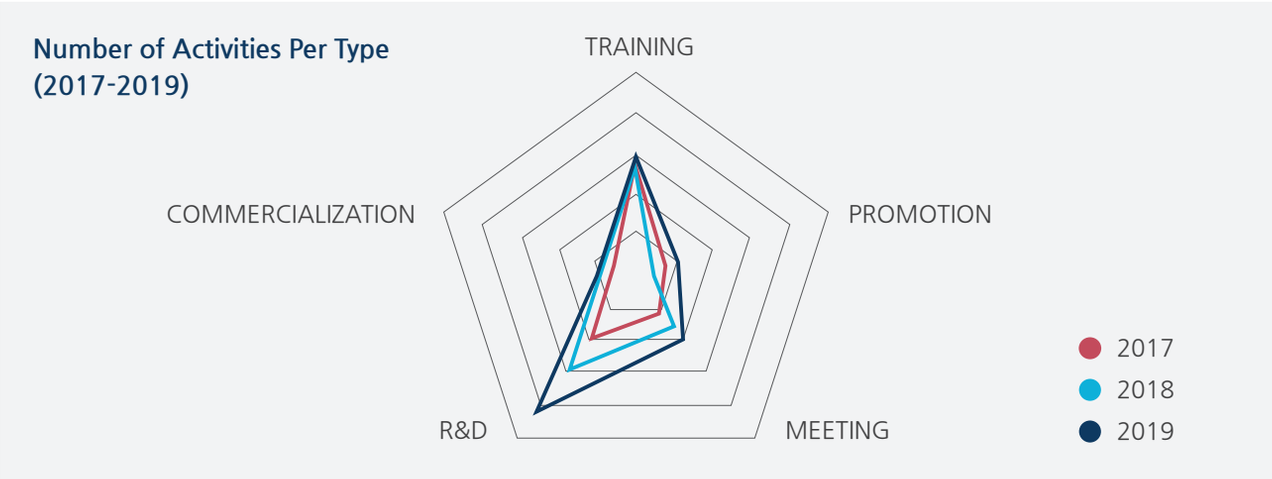
National Activities Classified According to the Types of Activities (2017-2020)

Activities, when classified according to the applied areas, the diagram showed that the regional focus is on the “food and agriculture” sector.



National Activities Classified According to the Areas of Applications (2017-2020)

Not only the R&D classified in activity types takes up the biggest portion, it shows the most rapid increase among the other types. When the activities are classified into types according to the implementation years, one can see that the expansion of R&D is faster than the others.



Increase in the Number of National Activities Classified According to the Types (2017-2019)

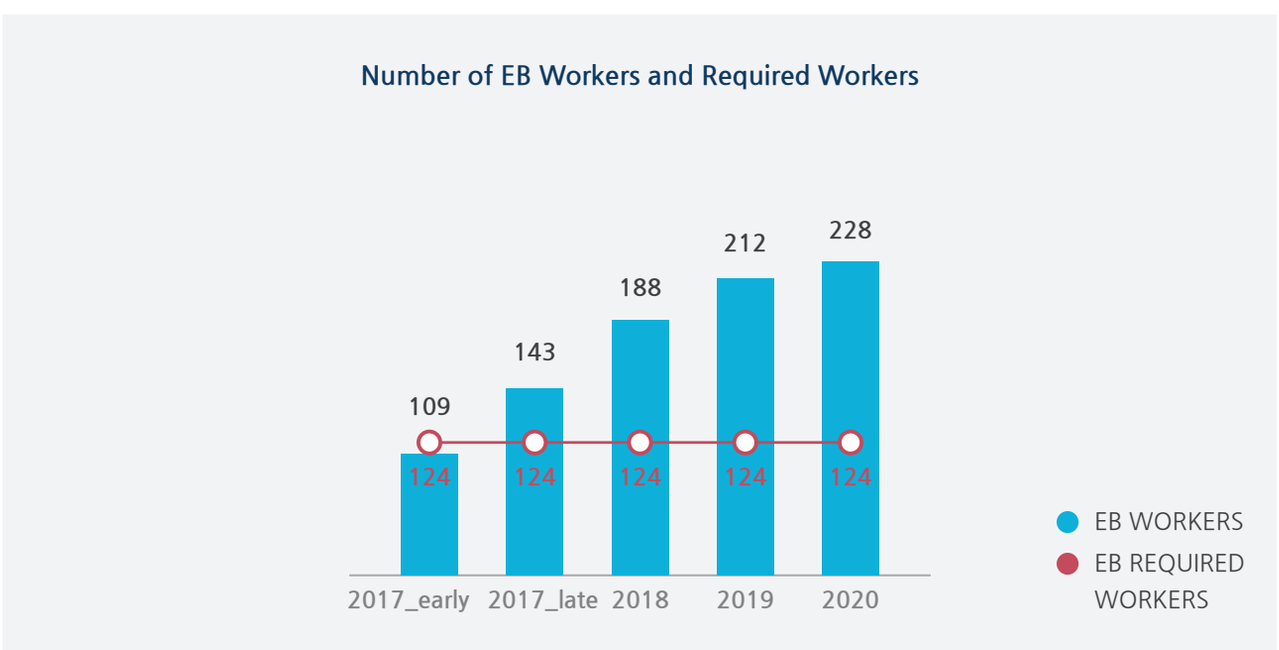
DEVELOPMENT IN INFRASTRUCTURE

At the start of the project Phase 2, when the countries were asked the current status and foreseen (<5 yrs) of facilities and existing and required number of workers, it was shown that fourteen (14) additional facilities are foreseen with additional fifteen (15) workers required.

Facilities			Workers	
Existing	Foreseen (<5 yrs)	Total	Existing	Estimated Workers Required
55	14	69	109	124

Number of Facilities and Workers (Existing vs Foreseen or Required)

In order to track down whether the estimated number has been reached, the participating countries were asked with the increase in the number of facilities and workers at the end of each year during the project Phase 2. It was noticeable that the number of existing workers has already exceeded the estimated workers required in late 2017, and continues to increase afterwards. On the other hand, the number of foreseen within five (5) years was never reached during the three years' time. This reflects the reality that the high cost of the accelerators is a big challenge to the countries, and the needs for strengthening the infrastructure continue.



Number of Required Workers vs Existing Workers per Year

This is predicted that establishing a facility is expensive and involves long-term efforts by stakeholders at different levels. According to the interview, it was clearly shown that those countries without facilities find securing the funds for the facilities a big challenge.

"The largest challenges are the cost and complexity of the technology, that's why beside the strong willingness of the stakeholders they want more clarification for safe investment."

– NPC of Pakistan

05

ANALYSIS ON THE SURVEYS AND INTERVIEWS

ANALYSIS ON THE SURVEYS AND INTERVIEWS

In order to understand and analyze the project achievements at national level and to survey the national needs and demands for the future follow-up activities, RCARO conducted surveys and interviews targeting the NPCs/ANPCS of participating countries. Nine (9) countries agreed to participate in this analysis and from April to May 2020, the interviews and surveys were conducted through emails and video-conferences with the objectives as follows;

- to analyze how the project has been helping the stakeholders meet the national priorities;
- to understand the gap between the expectations and results under the project; and
- to survey the national demands and needs of EB technology applications, to be reflected in the next project.

Overall, the respondents all agreed that the project has been very successful in promoting the EB technology and strengthening the infrastructure in respective country. Thailand has an increase of facilities, from one to four EB accelerators throughout the implementation period. Malaysia was able to draw stronger engagement of the industries to commercialize the EB application. Bangladesh, with the help of the experts dispatched during the Expert Mission, is currently preparing for a feasibility study on the establishment of the EB facility. Below is the response from NPC of Sri Lanka.

"The Phase 1 project was helpful to improve the preliminary theoretical knowledge on EB applications. ··· Phase 2 project was beneficial to expand the knowledge on EB technology through advance training courses, comprised of both theoretical knowledge and few hands-on experiences. In addition to that, RCARO provided opportunity to get the expert assistance to improve knowledge to research team and end-users such as Wire and Cable Industry, National Water Supply and Drainage Board, etc. by conducting Expert Mission to Sri Lanka."

– NPC of Sri Lanka

When asked which of the project activities has benefitted the country the most, the respondents stressed out the significance of each activity and different aims each activity pursues. NPC of Vietnam, who has participated in the Expert Mission to Myanmar as an expert and also played a role of a focal point arranging the Expert Mission to Vietnam, mentioned,

"Among the project activities under the project, Meetings and Workshops, RTCs, Expert Missions, and Fellowship, all of the above activities have been necessary for the participating countries, because each mission has an important role for the local participants and NPT for raising the awareness of the EB applications."

– NPC of Vietnam

Nonetheless, among the activities, RCARO received highly satisfactory feedback on the Expert Mission from the beneficiaries. Respondents underlined that the Expert Missions could be arranged according to the specific needs of the countries. In line with that, the countries could host large-scale events such as workshops, seminars, and meetings that could draw the attention of the national stakeholders. In addition to the Expert Missions, the workshops/meetings where NPCs gather and share the issues were regarded as an important activity. As the NPC of Myanmar highlighted, during the meetings, "we strengthen the existing application area to explore the new areas. Sharing the national status and situation helps."

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– NPC of Vietnam

The NPCs were also asked with the questions on the further needs. Most of the countries raised the issue of the limited seats for the capacity building activities. NPC of Sri Lanka strongly recommended to continue fellowship programme which would provide "an opportunity to facilitate advanced radiation processing experiments that couldn't be performed in the country due to the lack of technical infrastructure." NPCs of Myanmar and Pakistan suggested to shorten the period of programme and increase the number of seats. NPCs of Bangladesh, Mongolia and Thailand emphasized that further support for the hands-on training is needed, regardless of the EB facility existence.

The NPCs put stress on the establishment of a platform for R&D activities for the countries. Under Phase 1 and 2, the project activities focused on the capacity building. However, encouraging the exchange of experts among the countries and performing the collaborative R&D on the shared issues were suggested.

"Doing the R&D for the same topic/issues using EB/gamma technologies while continuing the individual training/group training is suggested."

– NPC of Indonesia

The NPCs showed strong interests in forming a stronger network of experts, supporting the South-South and Triangular Cooperation. Malaysian respondent stressed the needs for a platform that would allow more effective information sharing, besides the meetings and workshops.

"There is imbalance of the capability of the participating countries. If we have a system, we put all the success stories of the project and develop a platform. ··· For example, Malaysia wants to help a country there is no official platform. We have the expertise and willingness, it is possible."

– ANPC of Malaysia

"There should be more collaboration between the recipients and providers, utilizing the South–South model."

– NPC of Thailand

Through the close discussions with the NPCs, the project achievements and ways forward became clear. When the project was initiated in 2013, the electron beam was a new and innovative technology to many of the participating countries. During project Phase 1, activities on the promotion of the technology and its applications for beginner countries and building infrastructure for the intermediate-advanced countries were undertaken. During project Phase 2, application has expanded rapidly, and the needs and demands of the countries have diversified. Still, it was clearly shown that the continued needs for the capacity building for the experts continue. Interestingly, while we keep the capacity building activities, NPCs highlighted the needs for R&D portion in the project, which is in fact in line with the analysis of the national activities data that shows a rapid expansion in the R&D part at national level.

06

SYNTHESIS AND IMPLICATIONS

LIMITATIONS

Involvement of Countries from Different Development Levels

In regards to the management of the project, involving fifteen (15) countries with different levels of counties was quite challenging. Training activities had to satisfy all countries involved, so it was crucial to analyze the needs and demands of each country. Also when activities invite most of the participating countries, it was important that the enough time as well as budget is secured well in advance for preparations administratively and logistically.

Challenges in Technology Transfer

Technology and knowledge transfer not only incorporates education of the personnel but also includes building up capacity at national level to operate and modify the imported technology efficiently. Unfortunately, the high cost of the building the facilities and human capacity has led to rather slow technology transfer and absorption. Even after the completion of the feasibility studies and development of a national plan, the project has witnessed that supporting EB technology at national level takes a longer time than expected.

Covid-19 Pandemic and Changes in Work Plan 2020 and 2021

Due to the travel restrictions resulting from the Covid-19 pandemic, changes in the work plan was inevitable. Under the Group Fellowship Programme, three fellows have been selected but were not able to come to the training site because of the travel restrictions. Participating countries have reported that due to the lockdown in countries it was not easy to conduct activities such as R&D and others.

LESSONS LEARNED

Encouraging National Key Players

One of the key success factors is that the project has a firm expert network with a history of almost eight (8) years of project implementation. The continued network building has allowed close communications and interactions, fostering the South-South cooperation among the countries. For example, NPC of Sri Lanka was able to conduct irradiation of cables in Malaysian Nuclear Agency with the help from the ANPC of Malaysia. This kind of activities happen outside the regular work plans, and should be encouraged for the increased ownership of the project as well as sustained development in the region.

Bringing the Regional Project to National Level

Diversification of the project activities in Phase 2 effectively scaled up the project in-depth and horizontally by widening the scope and coverage of the beneficiaries. The number of the direct beneficiaries has more than doubled (from 160 to 400). It is noticeable that the beneficiary countries of Expert Missions found the Missions very satisfactory in that the experts bring their expertise to the local communities with the programmes specifically focused on the national needs.

Utilization of IT Technologies in Responding to the COVID-19 Pandemic

It was difficult to predict the outbreak of the COVID-19 pandemic and its impact on the project. To minimize the impact of the COVID-19 to the work plan, the RCARO utilized relevant IT technologies and encouraged the project stakeholders for active participation to the online activities. Group Fellowship Programme in 2020 and Final Review Meeting/Technical Workshop in 2021 were successfully completed using the IT platforms and tools.

EB Applications Continue to Grow

From the analysis of the project achievements and the surveys/interviews taken, it was shown that there are still continued needs for further development of the technology and its applications. They all agreed the importance of the regional project in developing the human and institutional resource in the respective country. It is noteworthy that although the region consists of the countries with different levels of development and different types of needs, the common and shared issues still exist regional projects can be the platform for the self-study and self-growth of the region, by learning from and leaning on each other.

"The technological gap among the countries is true because the government policies and developmental needs of each country are different. But needs for the knowledge and awareness of EB technology are unity."

– NPC of Vietnam

Project Final Report

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