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Nuclear Educational Networks: Experience Gained and Lessons Learned

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International Atomic Energy Agency

NUCLEAR EDUCATIONAL NETWORKS: EXPERIENCE GAINED AND LESSONS LEARNED

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INTERNATIONAL ATOMIC ENERGY AGENCY
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For further information on this publication, please contact:

Nuclear Knowledgement Management Section
International Atomic Energy Agency
Vienna International Centre
PO Box 100
1400 Vienna, Austria
Email: Official.Mail@iaea.org

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FOREWORD

Knowledge and education are essential to the success of the nuclear industry. The foundation of a successful nuclear industry is based on targeted and effective educational programmes in Member States to ensure a competent and qualified workforce. This not only includes the operating organizations, but also the extensive supply chain and industrial communities that serve and support the broader nuclear technology sector.

This publication provides an overview of established nuclear educational networks worldwide and analyses their underpinning mechanisms, benefits and lessons learned. By capturing international experience, this publication affords a better understanding of the contribution educational networking plays in capacity building, underlining the IAEA's role in promoting and facilitating collaboration among the network of educational institutions. This publication provides practical examples of the benefits, outcomes and lessons learned from the inception and planning of the network, through to its establishment and delivery, focusing particularly on the network's management and operation.

Appreciation is expressed to all who contributed to this publication. The IAEA officer responsible for this report was M.E. Urso of the Division of Planning, Information and Knowledge Management.

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1. INTRODUCTION

1.1. BACKGROUND

Ensuring an adequate and sustainable pipeline of qualified nuclear professionals to meet the specific national demands of the sector remains a continual challenge for many Member States (MSs). Educational networks have been utilized to overcome limited funding and/or resources for the establishment and delivery of national nuclear educational programmes. Cooperation among universities, training organizations and the industry has supported national and international networks leading to the expansion and enhancement of many nuclear educational programmes. Collaboration in the nuclear education arena can take many different forms, from small bilateral university and industrial partnerships to regional networks that bring together educational organizations and employers across a region and beyond. Many partnerships have been established in an ad-hoc manner and have grown organically into a mature network. Others have been created under national law and have larger aspirations, responsibilities, influence and sometimes associated operational costs. Wider networking across networks that operate at different scales in nuclear education has also been pursued, and, through the effective exchange of experiences and best practices, it has proven beneficial to improving and optimizing their efforts.

Identifying the lessons learned from the different phases of conception, through establishment to the operation of successful networks would be beneficial for others seeking to develop or improve their nuclear education programmes by embarking in collaborative efforts. This publication provides the background, context and drivers for developing and promoting nuclear educational networks. It captures existing best practices, mechanisms and tools including technological platforms that can aid existing collaborations and the establishment of new networks.

1.2. OBJECTIVE

The objectives of this publication are to:

- Present the benefits offered by network collaboration at various levels;
- Identify lessons learned, challenges and opportunities in developing and operating educational networks across the nuclear community;
- Analyse the underpinning mechanisms that have proven beneficial for existing networks;
- Describe the requirements necessary to establish sustainable nuclear educational networks.

By capturing international experience this publication provides a better understanding of the contribution educational networks can bring in capacity building, underlining the IAEA's role in promoting and facilitating collaboration among educational institutions through support to the networks.

Details of the specific network models, processes and descriptions can be found on the individual network websites. The purpose of this publication is to present a more complete overview of the education network community associated with the IAEA Nuclear Knowledge Management (NKM) organization, by bringing together in one document key information that describes each network.

1.3. SCOPE

This publication describes examples of practices, benefits, outcomes and lessons learned from existing nuclear educational networks, since their inception and planning, through to their establishment and delivery, including:

- Drivers;
- Governance aspects;
- Infrastructure requirements;
- Benefits;
- Risks and challenges;
- Good practices and lessons learned;
- Key success factors.

This publication is primarily intended for organizations wishing to establish new networks, or existing networks that are looking to improve their effectiveness in supporting nuclear education programmes.

Other organizations that support or are involved with higher education, such as national commissions and accreditation bodies, policy and decision makers (e.g. ministries concerned with education, science and technology), research and development institutions, regulatory bodies and industries in countries wishing to strengthen their nuclear education capacity for any particular nuclear technology, may also benefit from this publication.

It is noted that the review provided in this publication is not meant to be exhaustive of all existing nuclear educational networks. Its primary focus is on IAEA-fostered and partner networks that operate in the broad nuclear education arena. Many other partnerships and networks are active in promoting education and training (E&T), research and collaboration on specific nuclear topics, including through the support of IAEA, while various nuclear E&T consortia exist in different countries or at the sub-regional level. Some of these are mentioned in this publication or listed in Annex III.

1.4. STRUCTURE

Section 2 introduces some of the existing nuclear educational networks, describing the drivers that underpin their creation and their breadth of action. Section 3 illustrates the principal features characterizing the governance, operation and infrastructure of these networks. Section 4 analyses benefits, risks, lessons learned and good practices that have been highlighted by the networks under review. Section 5 summarizes some key conclusions derived from this analysis.

Additional information about these and other networks is provided in the Annexes: Annex I reports detailed case studies developed by individual networks, Annex II presents a summary table compiling and contrasting key features of the IAEA-fostered nuclear educational networks, Annex III lists other thematic and professional networks operating in the nuclear sector at large and Annex IV reports the collaboration agreement in place among IAEA-fostered nuclear educational networks and their partner networks.

2. NETWORKING IN NUCLEAR EDUCATION

2.1. DRIVERS AND NEEDS FOR NETWORKING

Many MSs are still challenged by the lack of qualified and experienced personnel to effectively support the various applications of nuclear science and technology. One of the underlying reasons for this is the limited availability of nuclear education programmes, in particular in developing and embarking countries that do not always have the necessary educational infrastructure, or a sufficient and sustained demand for a student pipeline.

In some countries national nuclear educational programmes may be lacking or non-existent; while in other cases, even when established programmes exist, there may be difficulties in retaining educational capabilities, or these may need to be upgraded or better aligned with the industry requirements.

Additional challenges commonly faced by individual academic institutions offering nuclear programmes include the ability to:

- Attract and retain new students on nuclear programmes when the overall recruitment to Science, Technology Engineering and Mathematics (STEM) topics is low;
- Secure the necessary financial resources;
- Ensure the necessary academic expertise is available to sustainably deliver the relevant courses [1];
- Maintain E&T and research facilities and warrant their availability for nurturing skills required for full competence development;
- Readily embrace innovative learning modalities and technologies.

Likewise, the nature of the nuclear industry demands that organizations operating in the sector warrant continuous professional development (CPD) of their employees, either by means of professional training delivered through internal programmes or through courses offered by associated educational institutions.

Educational networks can play an important role in addressing these challenges, with economics and human resource development being key drivers for their establishment.

It is recognized that institutions that work together can provide more efficient and cost-effective educational programmes, which can be established far quicker than by just one organization working independently. There may also be political drivers to spread funding across organizations or reduce the costs to students and to create more opportunities either geographically or technologically, so that all necessary courses and topics can be developed as required.

Educational networks can be used to leverage capabilities, exchange information and enable the mobility of students and lecturers, shaping and promoting careers in the nuclear sector, while integrating and facilitating the full utilization of available resources and facilities [1, 2]. University networks can further:

- Encourage experience sharing and peer learning;
- Support the enhancement and attractiveness of educational programmes;
- Help to share good pedagogical practices and innovative approaches;
- Offer a basis of negotiation for additional resources;
- Ultimately, support capacity building [3].

Particularly at the national level, educational networks can also spur communication and meaningful partnerships beyond universities, with the industry and government. Such alliances can help design and deliver robust and relevant educational programmes.

Close cooperation among industry, universities and government is a vital condition in the improvement of nuclear E&T.

Collaboration of universities with other stakeholders is a prerequisite to achieving courses and curricula that are well aligned with the national objectives, thus ensuring that graduates' knowledge and skills match the actual needs of the industry. These collaborations can also promote actions and initiatives at the government and industry levels in support of students' careers, and university-based research of significance to the nuclear sector [1].

Fostering synergies through coordination and networking can therefore be an effective means of assisting the sustainable development and retention of MSs' national educational programmes, ultimately improving the quality of nuclear education and training while facilitating and widening their access and attainment.

2.2. BREADTH OF NETWORK COLLABORATION: NATIONAL, REGIONAL AND INTERREGIONAL

Networks are dynamic systems of interconnected institutions that collaborate for common goals and interests, pooling and exchanging skills and resources and sharing knowledge for the members' benefit.

Forms of collaboration in support of the provision of nuclear education have been established at many levels and have different reach, from sub-national clusters through to national, regional and interregional alliances.

Networks can initially be established informally prior to partnership agreements and evolve in an organic way from small clusters [3] or can be constituted as more formal entities with a legal identity that may be created under national law. Bi- or multilateral forms of cooperation can be permanent structures or just temporary alliances, established for the development of specific projects [1, 3].

Typically, formal entities have strategic intentions and operate as a business function with permanent structures and management systems in place.

2.2.1. National networks

At the national level, networks can connect stakeholders in the education system and provide a platform for them to consult on priorities of national interest, work towards collaborative innovation, and formulate and test policies. Although national networks may differ in many ways in terms of size and scope of activities, generally they all strive to achieve some of the following benefits:

- Optimized development and utilization of education resources and efforts;
- Widening academic and industrial collaboration;
- Knowledge transfer and outreach;
- Enabling broader access to nuclear and radiological facilities for E&T and research;

— Developing harmonized approaches for education in nuclear science and technology by establishing reference curricula and facilitating recognition of degrees;
— Enhanced mobility for both students and teachers.

National networks can integrate different levels of education and educators, policy makers, industries and the public, spurring horizontal and vertical collaboration that can help in the systematic and coordinated implementation of national educational programmes [3].

2.2.2. International networks

As detailed in Section 2.3, several nuclear educational networks operate internationally, sharing values and generally promoting the same benefits as those identified for national networks.

Regional networks bring together educational institutions, employers and other organizations sometimes building on common cultural or linguistic aspects. Often fostered by international and intergovernmental bodies, interregional networks offer the widest geographical scope, sometimes connecting regional and national networks and unlocking the potential benefits of knowledge transfer and inter-cultural learning [3], with wider opportunities for mobility and cross-boundary exchange of students and lecturers. For networks operating at the international level, communication technology has an essential role to play in bridging geographical distances and possibly also differences in languages [3].

However, while embracing a larger geographical reach, regional and interregional networks mostly operate through horizontal collaboration among member institutions and their influence towards country policies may also have to take into account local interests to ensure their effectiveness.

2.3. EXISTING NETWORKS IN NUCLEAR EDUCATION

Networks have been long-established in nuclear education. Collaboration in nuclear education and training is advocated by the IAEA and held very high in its agenda. ‘To foster the exchange of scientific and technical information on peaceful uses of atomic energy’ is one of the key functions of the Secretariat, which is laid out in the Statute of the Agency, along with the exchange of training of scientists and experts in the field [4]. The key role plaid by the regional networks in ensuring the sustainability of nuclear education and training has been reiterated through a number of resolutions issued throughout the years by the General Conference.

Based on MSs’ demands, several nuclear educational networks were created at the turn of this century to address serious concerns then flagged by the international community on a dramatic impending decline in the availability of nuclear professionals and the deficiencies of sustainable pipelines to bridge the emerging gaps. For example, in the UK the poor situation in nuclear human resources even generated a concern that reactors may have to cease operation earlier than planned (see Annex I).

In seeking solutions to this looming outlook, cooperative approaches were then conceived, whereby networks of universities could team up to support or provide nuclear educational offerings through collective action. The establishment of educational networks enacted synergies that have, since then, supported MSs in retaining and boosting their nuclear education capacities and in enhancing their sustainability.

A first example of a coordinated approach to networking nuclear E&T at the national level was the Belgian Nuclear Education Network (BNEN), established in 2001, from which the

European Nuclear Engineering Network (ENEN) was founded, and which served as example and trigger for the creation of other national networks in the European region. ENEN example was then adopted in Asia, Latin America, Africa as well as the central Asian and Easter European areas through the support of the IAEA, with the establishment of the following regional networks:

— The Asian Network for Education in Nuclear Technology, ANENT, founded in 2004;
— The Latin American Network for Education in Nuclear Technology, LANENT, founded in 2010;
— The AFRA-Network for Education of Nuclear Science and Technology, AFRA-NEST, founded in 2013;
— The Regional Network for Education and Training in Nuclear Technology, STAR-NET, founded in 2015.

Along with these regional educational networks, like BNEN in Belgium, other national educational networks were created in the early 2000s, such as the University Network of Excellence in Nuclear Engineering (UNENE) in Canada and the Nuclear Technology Education Consortium (NTEC).

Through its long-established support to educational networks, the IAEA has also provided international forums that have brought these regional nuclear educational networks and partner national networks together on a regular basis since 2011. These platforms have further fostered regional and interregional exchange, the sharing of educational experience and resources, discussions on policies and strategies for nuclear E&T and the interchange of best practices and lessons learned at the global level. Figure 1 depicts the geographical reach of each of these networks.

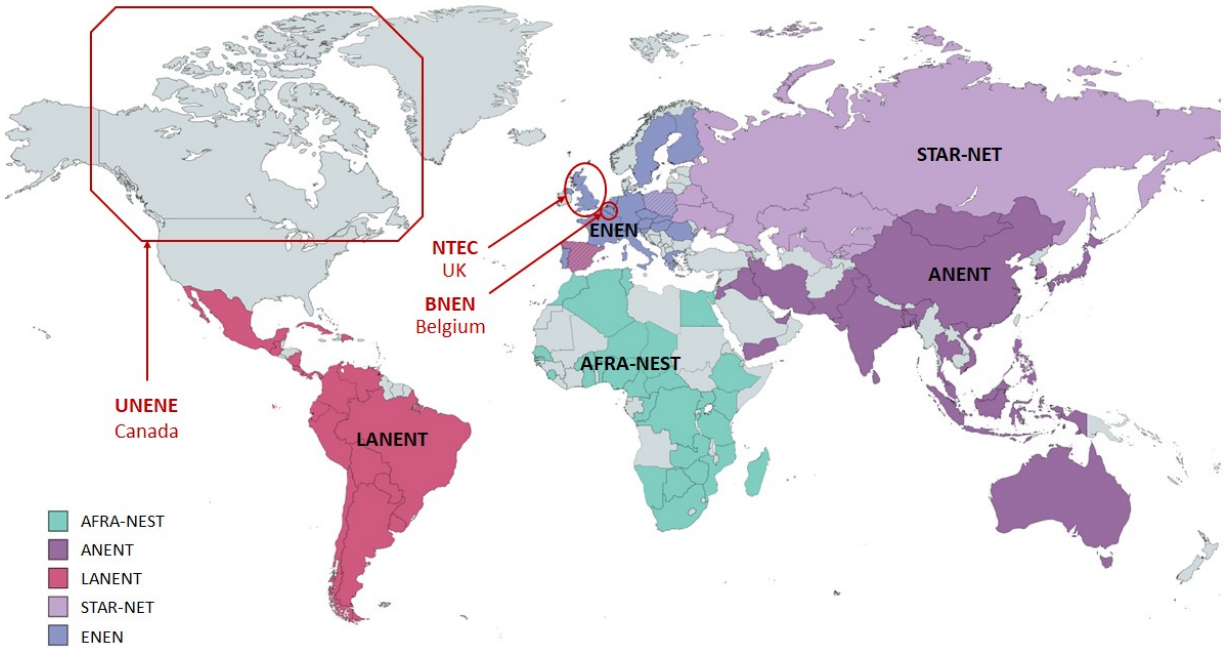

FIG. 1. Geographical reach of IAEA fostered networks and partner networks operating in nuclear education

Provided in the rest of this section is a high-level description of these regional educational networks, as well as other partner networks, which have a long-established collaboration with

the IAEA and its fostered networks. Further detailed information on all such networks is provided in Annex I and Annex II.

Beside the networks described here, other networks have been established globally to support particular areas of nuclear education, research or the broader sector.

For instance, through the International Nuclear Security Education Network (INSEN), the IAEA, educational and research institutions, as well as other stakeholders, cooperate to promote sustainable education on nuclear security[1].

Several other thematic and professional networks are fostered by IAEA to enable collaborative work of experts on their technical areas[2,3].

Support by the IAEA is also directed towards the establishment and operation of national networks in human resource and knowledge development (HRKD). HRKDs aim at connecting different stakeholders that operate in the nuclear field, targeting representatives from the government, academia and industry, thus promoting sustainable national nuclear education programmes. The first HRKD was created in Japan in 2010 (JN-HRD) and it has since been leading the establishment and adoption of this approach, sharing experiences and good practices to assist building new HRKDs in other MSs, in particular in embarking countries.

The OECD/NEA has also recently launched a partnership – the Nuclear Education, Skills and Technology (NEST) Framework – to support capacity building, knowledge transfer and technical innovation in its Member Countries[4].

Within Europe many nuclear networks have been founded and supported under the Euratom Framework programmes and more recently Horizon 2020.

Further partnerships and consortia active at the national or sub-regional level in support of nuclear education and training include:

— The Nuclear Science and Security Consortium (NSSC) operating in the United States of America (USA)[5];
— The Australian Institute of Nuclear Science and Engineering (AINSE)[6];
— The Consortium of Russian universities supporting Rosatom State Atomic Energy Corporation[7].

Scientific and learned societies operate at the national level in many countries and, sometimes, also at the international level to connect nuclear professionals, promote the exchange of information and know-how and, more broadly the application of nuclear science and technology.

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[1] https://www.iaea.org/resources/network/international-nuclear-security-education-network-insen

[2] https://www.iaea.org/services/networks/listing

[3] https://nucleus.iaea.org/sites/connect/Pages/default.aspx

[4] https://www.oecd-nea.org/jcms/pl_21786/nuclear-education-skills-and-technology-nest-framework

[5] https://nssc.berkeley.edu/

[6] https://www.ainse.edu.au/

[7] https://education-in-russia.com/

A comprehensive, but non-exhaustive, list of these and several other networks is provided in Annex III.

2.3.1. European Nuclear Education Network

ENEN was established in 2002 under the EURATOM Framework V programme, partly as a response to the OECD/NEA report of 2000 [5] that stated:

- "Although the number of nuclear scientists and technologists may appear to be sufficient today in some countries, there are indicators that future expertise is at risk;
- In most countries, there are now fewer comprehensive, high quality nuclear technology programmes at universities than before;
- The ability of universities to attract top quality students, meet future staffing requirements of the nuclear industry, and conduct leading-edge research is becoming seriously compromised".

This initiative was aimed at supporting universities to foster the exchange of students, lecturers, materials and information, and at facilitating collaboration between the universities and the end-users, including industries, regulatory bodies and research centres. These support and collaboration arrangements were necessary to start addressing the challenges faced by MSs in resourcing their nuclear programmes.

Following the success of this initial project, the European Nuclear Education Network Association was established in September 2003 as a non-profit organization, with the main objectives of preserving and further developing expertise in nuclear topics in higher education and training by:

- Promoting and further developing the collaboration of the nuclear education and training of the students, researchers and professionals;
- Ensuring that the high quality of nuclear education and training is maintained;
- Increasing the attractiveness of nuclear education and training for students, researchers and professionals;
- Promoting life-long learning and career development at post-graduate or an equivalent level.

2.2.3. Asian Network for Education in Nuclear Technology

The Asian Network for Education in Nuclear Technology[8] (ANENT) was launched in 2004, as a regional partnership, supported by the IAEA, to cooperate in capacity building and human resource development in the area of nuclear technologies. It aims at networking nuclear research institutes, universities, and other educational facilities and developing a web-based education and training system to complement existing mechanisms. This regional partnership is intended to disseminate knowledge and information on nuclear technology in a reliable and economic manner to the broader audience by networking people and utilizing information technology.

ANENT seeks to assist member countries in building capacity and developing human and scientific infrastructure through cooperation in E&T, NKM and related research, by utilizing

[8] https://www.anentweb.org/

the e-learning platform and advanced information and communication technology (ICT), through:

— Sharing information and knowledge relevant to nuclear E&T;
— Providing expert assistance and review services as needed;
— Serving as facilitator for communication within the network and with other regional networks.

ANENT's strategy rests upon the principles of cooperation, sharing of information and knowledge for capacity building as part of nuclear infrastructure development, better use of available resources, in the framework of ANENT, through:

— Promoting the utilization of the ANENT e-learning platform for education and training making optimum use of information technology;
— Integrating available educational resources in synergy with existing nuclear knowledge-based networks both within and outside the region;
— Facilitating experienced nuclear professionals to share their expertise with the younger generation and help attract talented youth to the nuclear profession in view of alternate competing career options.

2.3.2. Latin American Network for Education in Nuclear Technology

The Latin American Network for Education in Nuclear Technology[9] (LANENT) was established to contribute to preserving, promoting and sharing nuclear knowledge as well as fostering nuclear knowledge transfer in the Latin American region.

LANENT seeks to increase technical and scientific cooperation among its members to promote the benefits of nuclear technology and foster the progress and development of nuclear technology in areas such as education, health, the industry, the government, the environment, the mining industry, among others.

By means of LANENT, the participating institutions of this network, devoted to education and training of professionals and technicians in the Latin American region, may have access to major information on nuclear technology so as to make their human resources broaden their nuclear knowledge. Moreover, this network seeks to communicate the benefits of nuclear technology to the public with the aim of arousing interest in nuclear technology of the younger generations.

2.3.3. African Network for Education of Nuclear Science and Technology

The African Network for Education in Nuclear Science and Technology (AFRA-NEST) was established by the Africa Regional Cooperative Agreement for Research, Development and Training related to Nuclear Science and Technology (AFRA) to facilitate the implementation of its strategy on human resource development and NKM.

The main objective of AFRA-NEST is to facilitate operation and networking in higher education, training and related research in nuclear science and technology in the African region through:

[9] https://www.lanentweb.org

— Sharing information, resources and capabilities on nuclear E&T at national and regional level;
— Developing harmonized approaches for education in nuclear science and technology (NS&T) by establishing reference curricula and facilitating mutual recognition;
— Facilitating mobility: exchange of students, teachers and researchers;
— Enabling communication between member organizations and other regional networks.

2.3.4. Regional Network for Education and Training in Nuclear Technology

The Regional Network for Education and Training in Nuclear Technology - STAR-NET[10] was founded in September 2015 as an association under the Austrian Law of Associations with international memberships. Currently, STAR-NET unites 15 universities from 8 countries of East Europe and Middle Asia.

STAR-NET is established to promote, manage and preserve nuclear knowledge and to ensure the continued availability of talented and qualified human resources in the nuclear field in the countries in which educational organizations participate in this network, and to enhance the quality of the human resources for safe and sustainable use of nuclear technology for peaceful purpose.

STAR-NET is also engaged in closely cooperating with the IAEA.

STAR-NET complements existing international initiatives including the initiatives of the IAEA by focusing on the area of education and training and addressing issues related to nuclear technology, education, training and outreach.

2.3.5. National partner networks

As well as the regional educational networks, a number of national networks are in existence in the nuclear education community. Historically the IAEA has actively engaged with these networks such as the Belgian Nuclear Education Network, the University Network of Excellence in Nuclear Engineering in Canada and the Nuclear Technology Education Consortium in the UK, promoting their collaboration with IAEA-fostered networks. These national networks are briefly introduced below, and additional details are provided in Annex I through individual case studies.

BNEN, the Belgian Nuclear higher Education Network, is a consortium of six Belgian universities and the Belgian Nuclear Research Centre (SCK CEN) which coordinates the activities. BNEN has developed a Master-after-Master specialization in nuclear engineering.

NTEC is a consortium of UK universities, working together to deliver a combined curriculum taking advantage of the strengths in each partner, and developing the next generation of nuclear engineers.

UNENE is a not-for-profit partnership of leading nuclear industry organizations and universities based in Canada. It provides cooperative programmes in nuclear education, training and capacity-building through university research, to benefit the nuclear community and the society at large.

[10] https://www.star-net.online/en/

3. OPERATION, GOVERNANCE AND INFRASTRUCTURE

Nuclear educational networks share similar features across their modes of operation, governance and infrastructure. Some of these features are described in this section.

3.1. GOVERNANCE ASPECTS

Whether operating at national or regional level, typically any educational network is administered by an overseeing body, namely a Board, Coordination or Steering Committee that defines the Terms of Reference (ToRs), the goals and objectives, strategies, structure and processes of the network.

Presiding over (this committee and) the network is generally a president, network coordinator or chairperson, often assisted by a secretary. A programme director and further administrative support may be assigned, depending on the nature and size of the network. While some of the above-mentioned roles may be representative, it is important that a person (that may or may not cover one of these roles) is identified, who has a moderating or mediating role and holds the necessary authority to delegate tasks, request support from the network members and has access to the required resources. It is important that this person has recognized leadership capability to ensure effective communication across the network, to influence activities and participants, and to instill respect and trust across the network community members.

It is important that all roles within the network are clearly defined, agreed and assumed by the members to ensure there exist personal ownership and accountability to meet the needs of the network. The relationships that exist across the network members are crucial to its effective success. The social, cultural and educational norms may differ across the members and these factors need to be taken into account in order to ensure that positive progress and evolution of the network aims and objectives can take place [3].

Setting down a shared vision and common objectives is very important for any network since its onset. A clear awareness of the shared benefits that cooperation can bring is the greatest driver in catalysing interest, engagement and participation of members.

It is considered good practice to have a network strategy, objectives and functions written down and agreed by the network members. Typically, these are laid out in the network Statute or ToRs, which can also be used to describe the roles and responsibilities within the network, the membership requirements and mechanisms, as well as other governance elements such as financial functions, required support and infrastructure, meetings and decisional processes. If the network is established as a legal entity, its legal status is also defined in the Statute or ToRs. Statutes remain highly contextual and dependent on the culture and needs of the network constituency, but, ideally, they are not too prescriptive. Examples of such ToRs can be found in Annex I.

In some cases, educational networks may seek a more formal position and constitute a legal entity, such as a limited company or association. The choice of whether to be a limited company, a charitable organization or a voluntary collaboration is typically based on the specific and sometime unique requirements of the MS or the region. It is worth noting, for example, that several of the national consortia and some of the regional networks considered in this review have established themselves as legal entities, which also enables greater flexibility in financial terms.

With respect to funding, although much effort is directed by members of networks on a voluntary basis, or as in-kind contributions of prominent institutional members, ensuring a sustained financial inflow is fundamental to warrant the networks' sustainability. Sufficient provisions are essential to cover initial costs that a network incurs at its establishment and in developing its infrastructure, and, later, to cover running costs throughout its operational phase. Such costs may vary significantly but, typically, investments required at the launch are larger than those needed to run a network. Networks draw their financial resources through different means or a combination of these, including:

— Membership fees;
— Revenue from the provision of services, such as E&T offerings, research and development, etc.;
— In-kind contributions;
— Donations from the industry;
— Funds awarded by the government (for national networks) or by intergovernmental organizations (for regional networks).

Notably, for the IAEA-sponsored networks, funding has been directed to support many of their activities from associated projects run under the remit of the IAEA Technical Cooperation (TC) Department. Through this mechanism, potential pre-requisites and MS requirements for education could be addressed and quality surveillance of products undertaken.

3.2. OPERATIONAL ASPECTS

The establishment, operation, governance and infrastructure of networks, including the allocation of roles and responsibilities and the unique aspects of governance models are influenced by a number of factors, such the different geographical scales at which the networks operate and the type and collective size of their membership.

In some cases, the network establishment follows a bottom-up approach where the participants who effectively drive the network originate from the front line of education delivery such as lecturers and instructors. This approach often gives rise to a horizontal type of influencing and collaborating network characterized by peer-to-peer interactions, learning lessons at ground level. In other cases, the networks can be driven from the top down and are supported by governmental or intergovernmental organizations that are seeking to shape and coordinate the programme delivery of the network to meet national or regional requirements.

Regional educational networks operating in the nuclear sector have been established under the auspices and support of intergovernmental bodies. ENEN was established under the EURATOM Framework V programme of the European Commission, while ANENT, AFRA-NEST, LANENT and STAR-NET are all fostered by the IAEA.

Top-down approaches can result in a more vertical network model, following a hierarchical or institutionalized structure that in national networks may also have an influence on policy making [3].

A network may be the result of an expansion of an educational cluster of universities or academic institutions that work together for their mutual benefit, or a commercial partnership between universities who share common interests and can profit from an expanded function. In some cases, the early stages of a network originate from educational 'Communities of Practice' that commonly share information and knowledge related to their specialist areas and topics.

Networks can be flexible entities operating on a temporary basis to undertake focused projects or can operate longer term. The structure and nature of their collaboration may evolve over time, as the needs, interests and priorities of their constituency change.

Often, based on the identification of different priorities and areas of common interest, workgroups are established that hold responsibility for developing activities within specific thematic areas and with identified scopes.

A common element in all these models is the deployment of an effective multi-stakeholder collaboration and consultation approach. The membership of nuclear educational networks is typically institutional but generally wide and inclusive of universities, research centres, government entities and other institutions involved with nuclear education and training. In some instances, networks membership is also open to individuals, or for some regional networks, at the other end of the spectrum, it embraces national networks.

Along with leading universities with nuclear technology programmes, well-established networks, in particular those operating nationally, have also represented in their membership many sectors of the industry, including utilities, regulatory bodies, national laboratories, waste management and owner/operators and private sector organizations.

This broader membership can support multi-stakeholder synergies that have larger ambitions, greater capacity to pursue the sector priorities and workforce needs and, especially at the national level, influence policy decisions.

Whatever the operational model deployed by the network, having an effective governance structure in place is important to alleviate the challenges related to establishing the performance characteristics and delivering success to the membership, helping identify opportunities for improvement and future goals.

3.3. INFORMATION AND COMMUNICATION TECHNOLOGY INFRASTRUCTURE

Information and communication technology (ICT) platforms are important means to support and strengthen communication among network members across countries and continents. They can facilitate distant coordination of synergic tasks, such as those conducted by work groups that are geographically spread, including through forums and blogs. Network ICT platforms can be used to support physical events and offer functionalities that help to bridge different linguistic backgrounds. In this respect, ICT platforms and their web-based online applications are very important enablers for networks' activities, especially when their membership is geographically distributed. In addition, platforms provide an essential channel to give visibility to the networks' activities and promote their programmes.

Typically, the ICT infrastructure can comprise several distinct but inter-connected tools and applications, which may include portals, repositories of various types, e-learning applications, learning management systems for the delivery of technology-mediated E&T, expert databases and communication platforms of different kinds, including social media. They can also be used to enhance the network education and training programmes through the sharing of resources and educational materials, their augmented browsing and use, and their enriched delivery in different modalities, including online courses, blended learning, etc. These virtual modalities are particularly valuable where there is a need to bring higher education to remote or isolated locations.

Developing and maintaining a network ICT infrastructure requires the support of ICT experts and developers and entail some administrative load. In some cases, the facilities of individual universities (or more generally any other network members) can be made available to the network and used, e.g. on a rotational basis.

Also, for IAEA-fostered networks, the successful deployment of learning management systems (LMSs) has been guided and supported by the IAEA. Throughout the years, the IAEA has promoted the development and use of regional instances of the Moodle-based Cyber Learning Platform for Network Education and Training (CLP4NET). Moodle is the open-source learning management system most widely used worldwide, which, through its multiple features, enables educators to create and tailor their learning environments.

Further features and examples of ICT tools and applications developed and used by networks are detailed in Annex I.

4. LESSONS LEARNED FROM EXISTING NUCLEAR EDUCATIONAL NETWORKS

There are a number of common elements and processes that support the effective and efficient running of the educational networks. Detailed in this section is a review of benefits, risks, lessons learned and good practices that have been highlighted by the educational networks, through case studies reported in full in Annex I.

4.1. BENEFITS

Network value-creation can be observed at several levels. The immediate beneficiaries of a network are meant to be the members themselves, which for nuclear educational networks include primarily academic and educational institutions [6]. The value that networks can unlock for members can be immediate or longer-term and can manifest in the form of:

- Human capital — Personal assets, such as useful skills, key pieces of information, or new perspectives;
- Social capital — Relationships and connections: knowledge as a collective asset distributed across the network;
- Tangible capital — Through privileged access to certain scientific, logistic and financial resources;
- Reputational capital — Collective intangible assets, including the reputation of the network;
- Learning capital — Transformed ability to learn.

More specifically, immediate benefits for the network members would include:

- Attracting and sustaining funding support from governments, intergovernmental institutions and the nuclear sector through the sharing of expertise, resources, services and equipment;
- By developing and delivering joint courses and educational material, member universities can optimize efforts, use of resources and teaching responsibilities; for example, they can focus on the delivery of a sub-set of educational programmes rather than having to develop them fully as individual institutions;
- Promoting knowledge-sharing, cross-fertilization of approaches and dissemination of best practices;
- Strengthening links and creating synergies and collective intelligence with other stakeholders including governments, the industry and higher education institutions;
- Developing collective marketplace research that enables the identification of the nuclear educational offer available in the country/region, vis-à-vis its needs or gaps;
- Enhancing opportunities for collaborative research work;
- Providing an effective forum to promote innovation in education;
- Promoting the use of common digital solutions which help inexpensive scale-up and a broader reach;
- Fostering peer-learning, competence development and continuous professional development, organizational learning and development;
- Maintaining themselves abreast with nuclear topics, and having a doorway to other university nuclear programmes;
- Enriching existing nuclear educational programmes whilst avoiding competition;

— Enhancing nuclear educational standards through benchmarking and, where possible, promoting harmonization and mutual recognition of courses and credits between educational institutions;
— Through the above, increased trust among members' competences and culture;
— Increasing connectivity and internationalization.

At the most basic level, the increased connectivity that networks can spur within their range of action is invaluable, as simply put by representatives: "we are already getting to know each other among the stakeholders of nuclear education and training in the region", "breaking out of isolation and being a part of something larger". This, without the networks, would not have been possible.

For their members, networks can be thought as central hubs for knowledge sharing at many levels.

Importantly, beside the networks' constituency, key beneficiaries of collaboration in nuclear education are the ultimate consumers of educational services.

On the one hand, at the level of regional and national infrastructure, networking can enhance nuclear education programmes, supporting the development of a large-scale industrial base necessary to serve the requirements of the nuclear energy and nuclear technology sector. Successful networks can help MSs align the nuclear educational offer with national and industry priorities, also facilitating and widening access to relevant E&T. As a result, the nuclear industry can receive a higher number of qualified graduates with the right skills and, sometimes, benefit from life-long learning offered by the networks to nuclear professionals. In turn, this facilitates the development and retention of academic offerings in the nuclear field, enhancing the long-term sustainability of national educational programmes. Ultimately, through joint efforts, educational networks can support nuclear programmes and help better educate and inform people about nuclear technology more effectively than any single organization.

On the other hand, individual students benefit from improved quality, widened access and marketability of nuclear E&T. Benefits can be enjoyed by the younger generations, as well as experienced nuclear professionals in their life-learning pursuit through:

— Greater opportunities and appeal of nuclear career options;
— Widened access to nuclear education through a greater offer and reduced costs;
— Upgraded experience through enriched educational programmes designed and delivered with the support of industry and research institutions;
— Facilitated attendance through courses designed with high modularity to optimize time management and easy access for working professionals and international students;
— Higher quality and more marketable qualifications, skills and competences;
— Enhanced and supported international exposure e.g. through exchange programmes, fellowships and internships.

4.2. CHALLENGES AND RISKS

The processes of setting up, establishing and maintaining an educational network can present challenges. Networking entails the participation from a broad range of educational communities, often with different needs and support requirements, which do not always or durably blend together in an effective or coherent manner. Each of these processes requires careful and well-directed governance arrangements, together with efficient and well-organized operational models, backed-up by reliable and dynamic ICT infrastructure capabilities. Some

of the challenges and risks encountered by the networks throughout their existence are detailed below, based on feedback received from the network community.

4.3.1. Governance aspects

- Changes in policies and industry needs may impact the demand and appeal for STEM and, in particular, for educational programmes in nuclear science and technology;
- Movement and rotation of senior managers can result in lack of continuity in the leadership and operation of the networks;
- Financial challenges that networks constantly face in their need to find economic resources and/or attract other forms of support (e.g. in-kind contributions);
- Weakening sense of purpose, identity and direction can significantly erode the functioning of networks [3]. There is little sense for networks to exist for their own sake;
- Lack of ownership, commitment, initiative, enthusiasm, motivation and participation among the members;
- Stagnant membership when networks are challenged in attracting new members and involving the (relevant) stakeholders;
- Difficulties in reaching consensus among partners, hindering the ability or timeliness in taking decisions;
- No self-reliance.

4.3.2. Operational aspects

- Diversity generally characterizing regional networks with linguistic and cultural differences, but also with evident disparities both in the deployment and use of nuclear technology and, similarly, in the development of nuclear education and training programmes;
- Difficulties in hearing, balancing and catering-for the requirements of (diverse) members [3];
- Weak coordination;
- Poor communication;
- Ineffective resource utilization (e.g. duplication of efforts and educational material);
- Deficiencies in tangible outputs or perceived results and in the appeal of products [3]. In networks that focus on the offer of common courses attracting only a low number of students is a major risk;
- Friction and internal network competition and disagreements (for instance in contents of common course curricula) that can deteriorate the cohesion among members [3]. Sometimes there is a need to protect individual competitiveness between members (e.g. fee-earning courses, appeal to the best academic talents and brain-drain issues);
- Lack of understanding of the benefits and importance of cooperation between universities;
- Matters related to copyright and intellectual property rights that may constitute barriers for disclosing material and using platforms.

4.3.3. ICT infrastructure issues

- Unsuccessful set-up, use and maintenance of own websites and portals, affecting the network's visible presence and the operability of its technology-enabled activities;
- Fast-evolving technology and high availability of technological open access resources;

— Potentially limited knowledge of the technology and experience in its application in E&T (e.g. e-learning) by users. Sometimes a shift of culture may be needed for those less prone to using digital technology;
— Potential differences in technological capabilities available in different countries, including serious limitations on internet access in some countries;
— Technological dependence, in the sense that, if the technology is not available, it will be difficult to spread the knowledge;
— Potential reliance on external IT expert support that requires additional financial resources.

4.3. GOOD PRACTICES

This section explores some noteworthy practices that networks have been consistently engaged in, including E&T services and products, outreach initiatives and stakeholder involvement, as well as actions to expand their cooperation.

4.3.1. E&T services and products

Through their collaborative efforts, networks have, first and foremost, engaged in supporting the sustainable delivery of nuclear E&T, with services and products that range from online and distance learning and the development and maintenance of the supporting systems and platforms, along with several other more classical pedagogical pursuits, including the provision of traditional courses, which in several cases, have been collectively delivered by multiple member universities.

As noted in Section 3.3, especially for networks with geographically scattered members, ICT platforms and web-based applications are instrumental in the accomplishment of networks' programmes.

Networks have pioneered the development and promotion of online and remote learning that, with the strong push to digitalization due to the pandemic conditions, have now become another important delivery option. Online and distance learning was actually pursued by many networks since their early days, some two decades ago, enabling the roll out of distributed training across countries and regions.

Often, instrumental to this has been the establishment of robust learning management systems (LMSs), web-portals and platforms, for technology-enabled E&T and collaboration.

The development of common LMSs and portals and shared materials for distance learning has helped to bridge differences and provide more equitable access to education and even learning opportunities within regions.

Online training has been delivered on disparate topics and in many modalities, be it self-managed or instructor led, synchronous or asynchronous, blended learning, etc. Many examples have been reported by the educational networks, including on-line textbook-based courses. Some of these courses are also aimed at focused development and life-long learning of networks' members and/or professionals working in the nuclear sector. Among others, the trainings developed and offered by networks on methods and tools for distance learning are noteworthy. Such platforms have promoted the exchange of teaching materials through online repositories and libraries. In addition, some networks have also set up virtual experiments and shared online laboratories that have acquired greater prominence during the Covid-19 outbreak. During these times of pandemic, education had to shift, to a great extent, to web-based

modalities for distance learning, and many educational resources were converted in electronic format, with an increased volume of content for online E&T reported also by networks.

Fostering the use of classical pedagogical methods has remained a strong point in the networks' programmes, especially in providing or supporting access to research facilities and hands-on experiments. In this respect, it is important to emphasize the contribution provided by research centres to the networks. For example, in Europe they have often compensated for a lack of resources, both in terms of personnel and facilities, at the universities.

By establishing a culture of collaboration between institutions among and within participating countries, networks have promoted nuclear knowledge sharing, preservation and transfer. Through the organization of conferences and symposia, specifically related to NKM and E&T, the networks have contributed to knowledge sharing and to raising awareness on these issues. Networks have also supported the implementation of services and activities offered by the Agency to promote NKM and capacity building globally, including regional NKM and Nuclear Energy Management (NEM) Schools as well as deploying knowledge management assist visits (KMAVs).

The development and provision of courses delivered by multiple universities has been at the heart of national networks' efforts.

Examples of network-specific courses collaboratively delivered include Masters programmes, e.g. in Nuclear Engineering implemented, e.g. by ENEN, NTEC and UNENE, and Master-after-master courses in Nuclear Engineering implemented by BNEN.

A common key element that has contributed to the success of these programmes is the close involvement of industry in all stages of their development, delivery, fruition and evaluation. In this respect, important identified features include:

- Modules designed in partnership with industry;
- Delivery style optimized for industry, so that courses can be completed while in full-time employment for CPD;
- Industry lecturers with practical real-world experience to support the delivery of the programme;
- In certain cases, CPD income is used to support other students;
- Courses delivered, when required, through distance learning.

Additionally, notable networks' initiatives and services towards E&T include:

- Fellowship programmes rolled out around different topics and through different modalities;
- Summer schools on topical areas;
- Exchange of training materials and courses;
- Mobility of students;
- Promotion of internship programmes – e.g. STAR-NET programme for Masters level students through international cooperation;
- Remote sharing of facilities between network members, including examples of applications of the internet reactor laboratory project and cross-border operator training with the remote use of research reactors in Latin America.

4.3.2. Stakeholder involvement and outreach

National networks have provided a platform and forum for multi-stakeholder collaboration in support of nuclear technology applications, catalysing networking between academia, research centres, industry and other nuclear stakeholders to address immediate priorities of the sector (e.g. see BNEN case study in Annex I).

In this respect, outreach has also been at the core of most networks' programmes, to increase understanding of the nuclear sector and its attractiveness towards related careers.

Further outreach to earlier education groups and, in particular, towards primary and secondary schools, is increasingly acknowledged as key, and related initiatives have been gaining traction among several networks through the development of educational materials on STEM and the applications of NS&T and their introduction in regular school curricular activities.

Some examples are:

— UNENE "Nuclear 101", allowing the use of educational material inventories for outreach courses for public education;
— LANENT Nucleando, a multimedia educational programme which includes a strong 'train the trainer' component, selected as one of the United Nations Sustainable Development Goals Good Practices[11];
— STAR-NET Train-the-Trainers for Belarusian Teachers.

Train-the-trainers programmes aimed at teachers are being deployed in several countries in the Latin American region and elsewhere, also virtually. These have a great potential for multiplier effect, as teachers become the vehicle to keep disseminating and passing on their acquired knowledge, skills and tools to other teachers, reaching out to very large numbers of students. With the onset of the Covid-19 pandemic, virtual train-the-trainer events have proven very successful, enabling far greater geographical reach than physical trainings. Some of these activities are specifically focused on girl pupils, to drive gender balance at the outset.

Other outreach initiatives promulgated by the networks include student competitions (some of which are web-based) such as the International Student Olympiad organized by STAR-NET, conferences and mentoring programmes.

4.3.3. Cooperation between networks and with other international bodies

Although regional educational networks are at different levels of maturity and have needs and attributes that are often contextual to their geographical reach and internal dynamics, active cooperation among networks has been recognized by their members as being highly beneficial to further broaden the scope of sharing good practices, resources and opportunities for capacity building and effective nuclear education.

In certain cases, the support of well-established networks has played an instrumental role in the creation of new networks. In the case of LANENT, for example, the collaboration with ENEN

[11] Streamlining nuclear science and technology into classroom curricula through Nucleando | Department of Economic and Social Affairs (un.org)

guided the initial shaping of the network, that could take on the experience of the sister network in Europe and adapt it to the reality of the Latin American region.

In addition to assisting individual educational networks, the IAEA also fosters cross-fertilization of good-practices and synergies across networks, through the provision of dedicated platforms and forums. Since 2011, dedicated meetings have been held on an annual basis for 'networking-networks'. In recent years, a wider attendance by institutions offering nuclear education worldwide has been promoted to increase the visibility of existing networks and to enable new links and leads for collaboration. Mutual exchange and the opportunity to learn from each other, in turn, have spurred interest among participants of these meetings in forming new bilateral alliances also at the institutional level.

During the 2013 'networking-networks' meeting, under the auspices of the IAEA, an interregional collaboration agreement was established among the existing regional educational networks to further strengthen their connection. The Agency acts as an enabler of this agreement to further promote the development of common activities and exchange of best practices across the networks as they developed. The collaboration agreement is subject to renewal every four years and includes a common workplan to support implementation of synergic activities. In early 2021, the agreement was further expanded to include partner networks and consortia operating at the national level. Copy of the collaboration agreement is reported in Annex IV.

Among other common activities spurred from this agreement, a notable initiative that has also born fruit in recent years is the interregional project ENER-CONNECT[12]. With the contribution of several networks, ENER-CONNECT has organized many webinars on various aspects of the peaceful application of nuclear science and technology, bringing together students, teachers, scientists and engineers interested in the peaceful use of nuclear energy. These have gained further prominence during the Covid-19 outbreak.

Another means offered by the IAEA to ease and support interactions among the networks has been the provision of dedicated spaces in Agency platforms, as already highlighted in Section 3.3. Recently, the IAEA's NKM Section has launched the Digital Hub[13] , a SharePoint-based platform intended to:

- Act as the major source of NKM information, guidance and advice and a forum for the exchange of best practices and new developments from MSs;
- Provide a 'one stop shop' approach to NKM key topics/areas of interest associated with NKM;
- Foster more efficient exchange of information and best practices across the world communities in the specific topic areas;
- Reach out to the wider communities using modern communication channels.

An area of the Digital Hub has been more specifically set up in support of the networks and is currently under development. It is meant to offer a repository of material and information for sharing and a space for communication and collaborative work among the networks. This dedicated space already includes descriptions of the regional and partner networks and their activities, and links to the respective websites. It also contains a page with links to existing

[12] https://www.ener-connect.com/

[13] https://nucleus.iaea.org/sites/connect/NKMHpublic/Pages/Home.aspx

junior networks and it will host a catalogue of outreach activities and educational offerings. Existing features that can be further developed include repositories for open educational resources, updated news and announcements, such as listings of relevant international conferences and events, along with extensive references to existing IAEA materials and tools that are of interest to the networks.

4.3.4. Development opportunities

To ensure their continued relevance, networks have to keep their offerings current, reflecting the changes the nuclear sector undergoes. Thus, continuous connection with the nuclear industry is of the essence, to enable flexibility to respond to a changing demand and the inclusion of new technologies or policies.

In this respect, need-assessments of both network partners and stakeholders through formal surveys are important to shape adequate responses and adaptations and have been undertaken by some of the networks.

For instance, successful programmes offered by networks adjust and evolve e.g. through the development of packages that are aimed at professional development and that include highly modular courses, including shorter modules amenable for micro-credentials.

To keep enhancing their visibility and build a sustainable membership basis, networks have to engage in continual outreach and sustained communication efforts with existing stakeholders and new organizations, such as supplier and vendor groups. For effective communication, beside the use of their own platforms and more traditional means, networks increasingly look at the adoption of diversified channels which include, among others, new media such as LinkedIn, Twitter, Facebook, Instagram and YouTube.

In promoting the network offerings, alumni can be enthusiastic supporters of the network programmes and represent a good asset to be leveraged by the networks in representing and promoting the programme benefits.

In terms of wider outreach, recent understanding and developments have shown how the engagement of high school and earlier education groups is both a critical and promising strand of work for the networks, which is worth expanding and may lead to the establishment of organized junior networks.

Further development opportunities continuously arise as a result of the growth and expansion of the networks and the promotion of their activities, but also spur from inter-networks collaboration and cross-fertilization of ideas and approaches.

4.4. KEY SUCCESS FACTORS FOR NETWORKS

There are a number of success factors that have been identified by the network community for the effective operation of the network or as a response to an identified challenge or risk (see Section 4.2). Sometimes these success factors are based on the unique circumstances and requirements of a particular network and can be influenced by the organizations and individuals that benefit from the network activities, but often they appear to be of general applicability.

Listed below are some of these factors that have been identified as common or specific features reported by the networks [3]:

— Broad representation of stakeholders, which includes representatives from government, industry and research institutions;
— Clear purpose, mission and community values; in this sense, cooperation can be supported from outside but it has to be born from within the network membership;
— Committed leadership and facilitation;
— Strong management and continuity in the management team;
— Impact, quality assurance and evidence. For example, for network educational programmes, students' participation, satisfaction and gains in capabilities are key programme outcomes. Likewise, the positive feedback, direction and evaluation of key stakeholders, such as industrial members (or sponsors) are critical factors;
— Clear functioning structure and governance mechanisms – e.g. well-established communication processes, targeted scope in work group activities with agility and flexibility in the structure to allow dynamic decision-making;
— Reliable sources and robust mechanisms for financial support;
— Support and participation of senior management of institutions;
— ICT infrastructure, including increased and tested use of virtual technologies;
— Focus on complementarity rather than competition, since working in networks is of greater benefit to members and to education in general;
— Motivated, active and empowered participation of engaged individuals of member institutions. Ideally these can be fostered through the provision of time for dedicated activities, recognition, a platform where interests can be voiced and heard, and a climate of trust;
— Strong members (key network actors) that act as 'champions' and driving force for collaboration, offering their knowledge and capabilities to others in a direct and disinterested way and establishing a genuine environment of cooperation;
— Sometimes, cultural and linguistic uniformity has enabled more direct and effortless communication, fostering easier participation, exchange and mobility;
— Balanced approach between 'top-down' and 'bottom-up' governance models to suit the specific network constituency and interests;
— Sustained outreach and ability to attract and recruit new members;
— Broad collaboration with other networks and institutions.

4.5. EVALUATION

A systematic approach to business management would typically include an audit or evaluation process to review the ongoing activities and deliverables from a particular business unit, review the outcomes of the processes and seek to identify opportunities for improvement within the business cycle itself. In a similar manner, this systematic approach can be applied to the educational networks. Some networks have mechanisms in place to implement evaluation processes.

Operationally, networks generally have their activities (e.g. those of individual working groups, when these are in place) discussed and analysed on a regular basis, once or multiple times during the year, within their governing bodies or advisory committees, with formal reporting and action monitoring.

The metrics used varies depending on the activities. In some cases, the outcomes would be clear and simple, for example number of qualified individuals, number of e-learning materials and interactions and/or number of courses developed and delivered. For website activities, data from standard network analytics can be used, such as the traffic recorded in the site in terms of

number, geographical origin, traffic sources, content visited, dwell time, bounce rates, number of new and returning visitors, etc.

Well-established national networks offering education programmes, which are collectively delivered by the member universities, have systematic evaluation processes in place aimed at assessing such programmes. These are subject to periodical audits, as all standard university programmes. Such processes may also include benchmarking with other similar programmes. Sometimes these networks have external advisory groups that help fulfil this function. Likewise, student feedback is generally sought on course units and is systematically addressed, providing, as such, additional elements for continuous improvement.

In general, the networks may find useful to establish a specific set of performance indicators that are of interest to their primary stakeholders, to regularly monitor their performance. Some general data that have been adopted or may be used to establish a series of performance indicators include [6]:

- Joint projects;
- E&T mobility actions achieved for students and professionals;
- Alliances with international bodies and institutions;
- Awards and competitions organized to promote talent;
- Participation in E&T related events and conferences;
- Dissemination of opportunities for E&T;
- New joining network members;
- Activities and interactions, including participation to events, frequency and value (established through feedback);
- Co-authorships;
- Reuse of products;
- Lessons learned and information feedback.

In addition, there are a number of helpful evaluation models, such as the Kirkpatrick Four Levels Model [7], usefully applied to specific learning and development interactions, which, in some cases, could also be of benefit to the educational networks.

For higher level business objectives, it is often difficult to highlight or identify specific benefits from a learning and development or education interventions. Then, it may be more relevant to consider the broader social or cultural benefits that such network offerings can bring.

5. CONCLUSIONS

Important insights gained through the review of the educational network activities include:

- Experience in establishing, developing and expanding educational networks has clearly demonstrated the benefits offered to the educational communities at large, students and participants in MSs;
- By providing national and regional platforms, coordinated cooperative approaches yield better results than single entities and can benefit a larger pool of recipients, to support STEM and nuclear technology requirements;
- Educational networks can promote better alignment of educational offerings and the deriving competences with the actual industry demands, ultimately benefitting MSs in sustainably running their nuclear programmes;
- Support from leading governments, intergovernmental entities and educational institutions is vital for the success of educational networks;
- National educational systems need to be engaged in the approval and verification of formal educational programmes provided by networks;
- The engagement of industry in the educational networks is important to ensure a capacity building model that supports the nuclear programme demands of MSs;
- Direct involvement of the top management of member institutions is a very important factor for the successful creation and operation of the network;
- Sufficient investment has to be secured from both a financial and a management perspective in order to ensure the sustainability of educational networks;
- The priority focus for the outputs of educational networks is best placed around the students and participants who are effectively the customers of the educational services;
- The educational networks need to ensure they remain up to date with the ongoing developments of ICT and warrant its effective application;
- To maintain relevance and impact, it is important for the educational networks to apply flexible and innovative approaches that embrace online learning and computer-based training, in response to the MSs needs.

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ANNEX I. CASE STUDIES OF NUCLEAR EDUCATION NETWORKS

This Annex reports details of the IAEA-fostered nuclear educational networks and partner networks reviewed in this publication, as directly provided by individual networks through case studies. Further information is available on the individual networks' websites.

I–1. ANENT CASE STUDY

This case study has been contributed by X. Guo as Chairperson of ANENT on behalf of the network.

History

"ANENT is the acronym for Asian Network for Education in Nuclear Technology. Launched in 2004, the ANENT is a regional partnership, supported by the IAEA, to cooperate in capacity building and human resource development in the area of nuclear technologies. It aims at networking nuclear research institutes, universities, and other educational facilities and developing a web-based education and training system to complement existing mechanisms. This regional partnership is intended to disseminate knowledge and information on nuclear technology in a reliable and economic manner to the broader audience." [I–1]

Membership

'The ANENT membership is open to any organization that is involved in nuclear education and training for peaceful use of nuclear energy in the Asia-Pacific region. This includes academic institutions, research centers, governmental entities, and other related organizations. Organizations outside the region including international organizations may contribute to the ANENT as collaborating members.' [I–1]

An individual institution in one of the Asian MSs can acquire ANENT membership by upon request at a Coordination Committee meeting through an authorized national representative.

Currently 21 MSs in Asia and the Pacific region participate in ANENT: Australia, Bangladesh, China, India, Indonesia, Iraq, Islamic Republic of Iran, Japan, Jordan, Lebanon, Malaysia, Mongolia, Pakistan, Philippines, Republic of Korea, Sri Lanka, Thailand, United Arab Emirates, Vietnam and Yemen; as well as six collaborating international networks.

Statute

'The key strategy of ANENT is to promote self-sustaining regional cooperation to share human resources as well as education, training and research materials and facilities. Each participating member is expected to benefit from the strengths of others and to compensate each other's weaknesses. They would also benefit from shared facilities and resources such as educational and training materials and qualified experts and advanced educational, research and training facilities.' [I–1]

'Another element of the ANENT strategy is to promote self-sustaining mechanisms to achieve the following outcomes:

- Integration of available resources among the participating and collaborating members of the ANENT;
- Enhanced public awareness about the benefits of nuclear technology and its applications;
- Enhanced attraction of the interest of talented youth to nuclear professions;

— Enhanced transfer of experience and knowledge from senior nuclear professionals to the younger generation;
— Maximum possible use of information technology, in particular, web-based training and education support systems.' [I–1]

'The objectives of ANENT are to:

— Provide effective mechanisms for developing human resources;
— Strengthen scientific infrastructure;
— Develop a self-sustaining network of institutions in the Asia-Pacific region;
— Contribute to enhancing nuclear education, training, knowledge management and associated research and development activities in the region.' [I–1]

These objectives are achieved within the region through the integration and sharing of resources, materials and infrastructure available within the region; joint research activities; enhanced personnel mobility; promotion of harmonization of educational offerings; facilitation of the wider collaboration with other regional and global networks.

'The ANENT Coordination Committee is convened annually for meetings of all full and collaborating members, the latter as observers. Participants report on their respective activities and status in relation to nuclear education and training, discuss and identify issues to be addressed, develop action plans, and present, whenever appropriate, amended vision and objectives.' [I–1]

'With IAEA support, ANENT convenes and organizes the Coordination Committee meetings. In addition, the IAEA currently provides the ANENT with initial leadership and basic support, including technical and financial assistance, to help the region achieve self-sustained development and transfer of nuclear expertise and technology.' [I–1]

"Benefitting from the assistance provided through IAEA technical cooperation projects, ANENT organizes workshops and other training activities, as well as raising awareness conferences." [I–1]

Infrastructure

'Some of the ANENT members are in urgent need of practical and up-to-date information on nuclear energy and/or radiation applications to meet their growing demands. Other members are also expected to see their needs increasing. To facilitate effective exchange and sharing of information among the members, the ANENT web-portal has been put in operation in April 2005, playing a vital role in providing fundamental and operational information on ANENT, updating regional education and training data and materials, and promoting mutual communications.' [I–1]

Funding mechanisms and costs

The network is funded mainly by IAEA TC projects. Some member countries also provide services and support during the coordination meetings. Regular annual costs required for the operation of the network is about 200,000 euros.

Benefits

ANENT aims to 'facilitate the transfer of knowledge, experiences, skills, and know-how acquired by senior professionals to the next generation of researchers, engineers and operators. This objective is pursued by: (i) collecting professional expertise that exists in isolated pockets; (ii) organizing it into

harmonized educational materials and curricula; and (iii) providing educational opportunities such as fellowships, regional workshops and E&T courses.' [I–1]

The aspiration is that the advanced learning environment provided by the ANENT will help support qualified nuclear researchers and engineers, who will contribute to the sustainable development of the Asian region.

Risks

Nuclear science and technology applications are diverse and growing in the major sectors of socio-economic development of the participating MSs. One risk that the existing ANENT framework needs to consider and tackle could be the lack of commitment or limited involvement of some members. A good balance between developed and developing countries is also important.

Activities, focus and main results

Activity 1 Exchange of information and materials for education and training.

'To facilitate effective exchange and sharing of information among the members, the ANENT web-portal has been in operation since April 2005.' [I–1]

Activity 2 Facilitating exchange of students, teachers and researchers.

"No matter how well IT may be developed, the web-portal cannot replace in-person exchanges. ANENT supports expanding such direct exchanges […] within and beyond the region. Large synergy effects can be expected by combining direct human exchange with web-based education and training." [I–1]

Activity 3: Distance learning.

'Large differences exist between ANENT member countries — and between different areas in each member country, at the levels of IT infrastructure and learning environments as well as in the development of nuclear science and technology.' [I–1] To help bridging some of these differences and provide equal learning opportunities, distance learning systems could be commonly adopted within the region that were supported by the use of other relevant applications.

Activity 4: Consideration and advancements towards the establishment of reference curricula that could facilitate credit transfer and mutual recognition of degrees and qualifications.

Activity 5: Liaison and outreach.

ANENT has also focused on reaching out to potential members from within and outside the region.

Cooperation

Partnerships have been established within ANENT members and beyond Asia, e.g. through:

- A Practical Arrangement (PA) between the IAEA and the Korean Atomic Energy Research Institute in 2009 – to promote ANENT activities;
- A PA between ANENT and ENEN in 2009 – to implement and disseminate curricular and materials;

— A PA between Khalifa University of Science, Technology and Research and IAEA in 2010 – to install the Cyber Learning Platform (CLP) and enhance cooperation in E&T and research;
— The Cooperation Agreement with other networks.

Good practices and lessons learned

— Cooperation with universities and colleges is important for making high-quality materials shared through the network LMS;
— Monthly online meetings bring members closer, facilitating their communication.

Development opportunities based on lessons learned

ANENT LMS has been a good regional platform to implement e-learning courses in Asia and the Pacific region. The new features of the ANENT Learning Object Repository will enable it to serve as a centralized portal for capacity building activities among and beyond ANENT member countries. Collaboration between the networks is a key factor in promoting nuclear knowledge sharing and dissemination.

Key success factors

— Close collaboration with the IAEA and other networks;
— Benefits for member countries.

I–2. AFRA-NEST CASE STUDY

This case study has been contributed by N. Hashim as Interim Coordinator of the AFRA-NEST on behalf of the network.

History

AFRA-NEST was conceived during the ministerial conference of the African Regional Cooperative Agreement for Research Development and Training related to Science and Technology (AFRA) held in Aswan in 2007. AFRA-NEST was envisioned then to implement the AFRA strategy on human resources development and NKM. The network was formed and held its first General Assembly in Arusha, Tanzania in August 2013.

Membership

AFRA-NEST aims at forming a network of national networks on education in nuclear science and technology in Africa. Currently the network is open to institutional membership within the region of Africa and its membership has grown to represent 33 IAEA MSs in Africa. Its institutional members include organizations engaged in supporting education, research and training in the field of nuclear science and technology, and more specifically the following:

— National nuclear research institutions;
— Nuclear operating organizations;
— Universities;
— Regulatory bodies;
— Atomic energy commissions;
— Nuclear energy programme implementing organizations;
— Nuclear industry.

The network has provision for associate membership. This is for the organizations which are responsible for the coordination and development of programmes in nuclear energy and applications in the region.

Statute

The network statute comprises of ten articles specifying the following key elements of the network: name, objectives, functions and strategies, organization, membership, members subscription and other incomes, general assembly, structure and modification of the statute.

The General Assembly has the powers to amend the statute where necessary.

The main objective of the network is to facilitate networking in education, training, research and outreach in nuclear science and technology in the African region. This is achieved through, among others:

- Sharing of information and materials of nuclear education and training;
- Developing harmonized approaches for education and training in nuclear science and technology in Africa by establishing reference curricula and facilitating mutual recognition of degrees;
- Promoting effective cooperation and sharing of resources and capabilities at the national and regional level;
- Facilitating the exchange of students, teachers and researchers.

To advance these objectives the network fosters the:

- Use of ICT for web-based education and training;
- Recognition of Regional Designated Centres;
- Organization of harmonized and accredited programmes in the field of nuclear science and technology.

The following working groups are meant to advance the network activities in different areas:

- Information and communication technologies;
- Human health;
- Human resource development;
- Research reactors.

The network is administered by the High-Level Steering Committee of AFRA which is comprised of experts in the field of nuclear science and technology within the member states of AFRA. This committee further reports to the Technical Working Group through the chairperson of AFRA. Through the AFRA Focal Point in the Division for Africa within its TC Department, the IAEA provides scientific and administrative support of the network.

Infrastructure

One of the key instruments of the network is a Cyber Learning Platform for education and training in the field of nuclear science and technology in the region. The CLP was initially hosted in Ghana but later disbanded. Efforts supported by the IAEA are ongoing to re-establish the platform and its key role in integrating available E&T capabilities in the region. This is considered a key starting point to also revitalize the network functions and activities.

There is a need to enhance the capacity of the network member states to host and run their local platforms for digital learning. Such platforms would help strengthening the respective national networks by enabling resource sharing and capacity building in the field of nuclear science and technology.

So far, there is no physical infrastructure for the network. Setting up a regional office could benefit the operationalization of the network. Such an office would be suitable to bring together regional experts to share their knowledge and expertise in the field of nuclear science and technology.

Funding mechanisms and costs

So far, the network has been supported by the IAEA and AFRA. The statute of the network provides for network members to make their respective contributions as determined by resolutions of the General Assembly. Such contributions are very important for the sustainability of the network. The funds would cater for the operationalization of the activities of the network. These include, but are not limited to, regular meetings of the network, exchange of experts and students within the region, collaborative programmes of research, education and training.

Benefits

The network provides a framework for the sustainable development of nuclear science and technology in the region. This is mainly through sharing resources both human capital and infrastructural resources. Once the network will restore its full functionality benefits from its activities are expected to include:

- Enhanced collaboration between academia and industry;
- Easy access to facilities for research, education and training;
- Possible development of harmonized approaches for education and training.

Risks

Given that the network is striving to revive its functionality and activities, resource mobilization remains a challenge. In order to operationalize the activities of the network, there is a need for a sustainable source of income, which, ideally, would result from the contributions of members of the network.

Activities, focus and main results

Activities of the network have been initiated during the General Assemblies in 2013, 2015 and 2018. These meetings provided important opportunities for the members to showcase their capabilities, express their needs and explore areas of cooperation. Network activities have included seminars for national coordinators of the network, working group meetings, cooperative implementation of IAEA NEM and NKM School.

Cooperation

The main sponsor of the network is the IAEA. Through AFRA the IAEA has provided support towards the formation and the subsequent activities of the network. Through the financial and technical assistance by the IAEA, the network has held the General Assemblies and representatives from the IAEA have provided guidance in shaping up the network activities. Experiences from other

regional networks have been shared by the IAEA representatives during ad-hoc meetings. Cooperation with other regional networks is of particular value to the network.

Outreach, members affiliation and engagement

The network has relied heavily on IAEA support in getting further visibility and its main network activities have been communicated via the IAEA. In order to have active engagement of the members of the network, there has been an initiative to promote easier communication among the national coordinators. This is also meant to institutionalize the coordination of the network among the members and also to aid in succession planning. The network aspires to become active on social media in order to share information about its activities within the network member states.

I–3. LANENT CASE STUDY

This case study has been contributed by R. Barrachina and E. Picado as former and current President of LANENT on behalf of the network.

History

The availability of nuclear technology is essential not only to meet the growing demand for energy, but also in areas such as health, industrial and agricultural development, and environmental protection. In many countries of the region, nuclear technology can even become an important catalyst for introducing a culture of science and technology.

The penetration and use of nuclear technology are suboptimal in the region, even though many countries have a tradition of using it for energy production, industry, and especially for medical purposes. Some countries have active nuclear programmes, with plants in operation in Argentina, Brazil and Mexico. Other plants are approaching completion, or are under construction or planning, while some other countries may eventually embark in nuclear programmes for energy production. There are several research reactors in the region: in Argentina, Brazil, Chile, Colombia, Jamaica, Mexico and Peru. Some of them, like the IAN-RI in Colombia, are inactive; while RU-1 from the Uruguay Nuclear Research Centre was seized, and RV-1 from Venezuela was reversibly modified in 2001 for the installation and operation of the PEGAMMA gamma-ray sterilization plant. However, plans are underway for the construction of new reactors, such as the RA-10 in Argentina and the RMB in Brazil. These and other achievements have the potential to incentivize the creation of job opportunities for nuclear technology experts, and, with it, bring a greater need for consistent nuclear education, training and outreach programmes.

Naturally, the availability and application of nuclear technology require highly qualified human resources and a suitable training and education structure. Throughout their careers, whether they are developed in the industry, government or universities, professionals in the nuclear sector require access to adequate levels of education and training that ensure a competent performance of their tasks; that is, with the appropriate level of knowledge, skills and professional attitude to act effectively and safely. Even non-nuclear specialists working in the nuclear industry or using different types of nuclear technology also require a commensurate level of nuclear training. The characteristics of the work performed by each professional will determine the type of education and training necessary to maintain their competence enabling them to properly apply the required techniques and to guarantee the safe use of nuclear technology, as well as the protection of workers, the public and the environment.

Education and training are the basic pillars of this process. The differences between the two are subtle but important. Education is essentially a process whose central objective is the transmission and acquisition of knowledge taking place in academic institutions. Training, on the other hand, is a process oriented by the applications of said knowledge, which can occur in higher education institutions, as well as in the business or government sphere. The common denominator of both processes is the generation of qualified nuclear specialists for the operation and technical support of existing nuclear facilities and the development and installation of new facilities, industrial and medical applications of nuclear technology, work within the framework of regulatory authorities and research and development on current and future generation of new facilities.

Usually, when we consider the future needs of the nuclear sector, there is a tendency to think only of higher education. But the choice of careers in Science and Engineering is extremely low in the region and in particular students show very little interest in careers in the nuclear field. So, it is imperative to help young people to consider the possibility of a university or technical career in nuclear or related disciplines. In this sense, it would be of benefit to include a basic level of nuclear knowledge also in undergraduate educational levels in order to increase the number of students who choose to pursue nuclear careers.

Finally, a general exposure to basic knowledge about nuclear technology addressed to the general public and in particular to people indirectly associated with the nuclear industry, such as politicians, economists or journalists, is essential for States to be able to make informed and correct decisions on the use of nuclear technologies. These basic outreach activities are very important to consider, along with education and training as crucial tools in the process.

Finally, although it is assumed that higher education institutions (HEIs) represent the main players that, through the educational process, carry out the transmission of knowledge of related careers to students and to professionals in the sector, they are not the only actors in this process. Close cooperation between industry, universities and government has been recognized by most countries as a vital factor in improving nuclear education and attracting young talent.

Many of the resources needed for nuclear education and training are available in the Latin American and Caribbean region, even though there are differences according to the levels and types of application of nuclear technology in the MSs. Similar or complementary needs can be identified in this area that could be addressed through cooperation. Those countries with a more developed nuclear infrastructure need to secure the human resources necessary for the safe operation of existing facilities, future expansion of nuclear energy production and research and development work. Countries with less nuclear development could benefit from mutual cooperation and knowledge transfer from countries with active nuclear programmes, in order to achieve sustainable development and the strengthening of their capacities.

The shortage of qualified human resources in nuclear technology is a serious problem in some MSs, while others have well-developed educational systems and can provide education and training, as well as trained human resources. Shortages and disparities are worsened by the migration of qualified human resources from Latin America to more developed countries and the ageing of available human resources.

In early 2009, a consultative meeting was held at the Balseiro Institute in Bariloche, Argentina, in conjunction with a Regional Workshop on NKM. Invited experts from Argentina, Brazil, Korea, Spain and the USA provided initial advice on the possible modalities and mechanisms for the establishment of a regional educational network. During a second consultative meeting held at IAEA headquarters in Vienna in September 2010, experts from Argentina, Brazil, Mexico, Peru and Spain

addressed the strengths and needs of nuclear education and training in Latin America, prepared the ToRs for the establishment of a regional network and proposed the agenda for a related Technical Meeting that was held in Lima, Peru, in December 2010. Thus, LANENT was created on 8 December 2010. Representatives of seven Latin American countries participated in that meeting in Lima, Peru, organized by the IAEA together with the Peruvian Institute of Nuclear Energy.

Membership

LANENT is a network open to all institutions directly linked to education, training and the application of nuclear technology in the Latin American and Caribbean Region. Membership is open to universities, national educational networks, research centres, government entities and other institutions related to these activities. Other organizations and associations involved in these areas, inside and outside the region, can contribute to LANENT as collaborating members. A few years after its creation, the network already had among its members more than twenty institutions from eleven countries in the region, as well as Spain. Currently, LANENT has among its members 77 institutions (62 full members, 14 collaborators and the IAEA) from 18 countries in the region, as well as other collaborating members.

Statute

According to its ToRs, the operation of this network is governed by a General Assembly composed of representatives appointed by each full member, which meets approximately once a year. The General Assembly is the highest authority of LANENT; it evaluates, for example, the annual activity report, confirms the incorporation of new members, establishes the working groups and their action plans, analyses the annual budget and can modify the ToRs, if deemed necessary.

There is also a Coordinating Committee that comprises a representative for each country in the region with institutions that are full members of LANENT. It carries out the general supervision and coordination of the network activities, reviews the relevance of the requests for the incorporation of new members and proposes Working Groups and their annual action plans to the General Assembly.

The president and vice president, who are elected by the General Assembly from among the members of the Coordinating Committee, preside over the Coordinating Committee and the General Assembly. They also have the role of spokespersons on all matters related to LANENT. The Scientific Secretariat is appointed by the IAEA's NKM Section and acts as a support to the Coordinating Committee and the General Assembly.

At an operational level, LANENT activities are carried out by Working Groups comprising representatives of the members of the network. The working groups and their activities are analysed annually and may change in number, composition and theme according to the decisions of the General Assembly. Each group has a coordinator, who constitutes the link with the Coordinating Committee and is responsible for submitting an annual report of the network activities the General Assembly.

For example, during the second General Assembly meeting, working groups were set up to support: the website and educational portal, courses and careers, cooperation opportunities and educational material.

Infrastructure

The advent of the World Wide Web, together with the increased availability of broadband for the exchange of digital information, have enabled the development of new methods of education and

training. In many of these ‘distance learning’ systems, students or professionals in the nuclear sector do not have to attend the training institute or HEI, but instead access the course through the Internet. A variant of this new learning method is the so-called ‘blended learning’, where part of the educational process is carried out online, but integrated with the traditional classroom, enabling direct contact with tutors or laboratory work.

In general, distance courses are combined with audio-visual presentations, the development of practical work and online problem solving. Parallel to these methodologies, online forums allow communication between teachers and students, as well as discussions between students among themselves. Several distance learning projects in nuclear technology have been developed and put into practice by different institutions in the sector, although with uneven levels of success.

Despite the fact that the Latin American community is familiar with the various forms of ICT, and undoubtedly has the will to develop these technologies, there is very little experience in terms of their direct application. Furthermore, the serious difficulties of accessing the Internet that exist in various countries of the region, including in the HEIs themselves could hinder the widespread use of ICTs for E&T and has to be taken into account. Despite these difficulties, by and large ICT can provide an effective way to overcome long distances and bring higher education virtually to isolated locations in the vast Latin American region. Thus, without the need to go all the way to a full version of distance learning, various databases and teaching materials can be made available electronically. For example, the IAEA has a long tradition of maintaining nuclear databases, such as through the International Nuclear Information System (INIS), as well as other nuclear educational tools (for example, reactor simulators, courses and conferences recorded on video, etc.) freely accessible to users in MSs. This is undoubtedly a good practice that could be extended to nuclear educational institutions in the region.

Latin America is the region of the world with the greatest cultural and idiomatic uniformity. In fact, two related languages, Spanish and Portuguese, are strongly dominant throughout the region. Due to this, any web-based instrument, whether applied to distance learning, the exchange of information and teaching material, the establishment of communities of practice, or even databases, is, ideally, bilingual, in Spanish and Portuguese.

A large number of nuclear experts in the region understand English, even fluently, and English, together with French, are used in some Caribbean countries. Yet, it is important to produce teaching materials in Spanish and/or Portuguese to reach as large a community as possible within the region. Naturally, having dissemination material in Spanish and Portuguese would be an urgent necessity, particularly when this is aimed at secondary school students and teachers or the general public.

Among the projects undertaken by LANENT working groups in its first years of operation, it is worth mentioning the launch of its website www.lanent-iaea.org, the objective of which was to provide an important channel for the exchange of information between participants of the network and of them with the community in general.

Based on the Practical Arrangements signed between the IAEA and the Argentine National Atomic Energy Commission (CNEA), the latter installed and operated a portal for nuclear education and training, CLP4NET, as a regional hub. CLP4NET was originally developed by the IAEA in 2010 at the request of the Khalifa University of Abu Dhabi, in the United Arab Emirates. At that time, in addition to LANENT, the Asian ANENT and African AFRA-NEST networks also took advantage of the benefits of this platform, with hubs at the Korean Atomic Energy Research Institute in South Korea and at the School of Nuclear and Related Sciences (School of Nuclear and Allied Sciences), of the University of Ghana, respectively.

Funding mechanisms and costs

The IAEA Board of Governors has successively approved Regional Projects that, even if not directly related to LANENT, have helped to move most projects initiated and developed by LANENT forward. These have been 'Regional Non-Agreement' projects, which were not operating under the framework of the IAEA's Regional Cooperation Agreement for the Promotion of Nuclear Science and Technology in Latin America and the Caribbean programme. These projects gave a strong impulse to the realization of LANENT's aforementioned activities. It is noted that these TC projects were developed, in practice, from two project proposals: one dedicated to education and training in the nuclear area and the other one to strengthening the INIS Centres in the Region.

Benefits

LANENT seeks to promote cooperation among the countries of Latin America and the Caribbean in order to guarantee the availability of qualified human resources and strengthen their capacity for the sustainability of nuclear technology application in the region. The identification of educational offers available and the detection of gaps in nuclear E&T were initiated by the networks, which promotes the exchange of information, teaching materials and virtual tools for education, training and application of the nuclear technology, the development of educational materials, the exchange of students and teachers, the mutual recognition of courses and credits between educational institutions, and collaboration between LANENT member organizations and other regional and global networks.

To achieve these objectives, LANENT has working groups dedicated to different tasks, such as the elaboration of a catalogue of the didactic material existing in the region, or the creation of a database of courses and careers related to nuclear technology that are offered in Latin America. Through the network, opportunities for cooperation between institutions, both at the level of courses and shared activities have been identified, and mobility of students and teachers is promoted at the regional level.

In this context, it is important to note how LANENT has fostered a culture of cooperation at the regional level by promoting important connections among the actors of nuclear education and training in the region.

Risks

Diversity is a key characteristic of the region. As mentioned above, while some countries in the region have very active nuclear programmes, including the construction or planning of new nuclear power plants, the use of nuclear technology is suboptimal in others, with uneven development of nuclear power plants, industry in general and nuclear technologies in particular. Similar disparities are also observed in nuclear education and training. Some countries have extensive experience and tradition, with adequate or even exceptional E&T facilities, while others lack them altogether. Furthermore, the strong economic, social and cultural inequalities that still persist, influence the academic performance of students in Latin America and the Caribbean.

Naturally, higher education institutions are the main actors in the educational process. Since nuclear technology education requires a very long-term investment and commitment, funding goes primarily to States. But governments are not alone in this endeavour. Close cooperation between industry, universities and government is a vital factor in improving nuclear education and training. In particular, it is essential that organizations and industries of the sector ensure the continuous training of their employees through internal professional training programmes or through courses at associated educational institutions. Importantly, industry can contribute to the training of its future employees through the offer of internships, thesis or diploma work, or even scholarships for students interested

in nuclear issues. Likewise, nuclear professionals can participate in the development and/or running of courses and conferences. In return, educational and training institutions could commit to actively promoting these contacts.

Unfortunately, the continuity and maintenance of programmes and plans in the nuclear sector, and of nuclear education and training activities in particular, have not necessarily been adequate in all countries of the region. However, this situation has or is being reversed, with a growing interest and greater concern for nuclear activities in general and science and engineering training in particular, in a context of serious and, sometimes, already chronic deficiencies. Among these noteworthy are, for example, the low academic level of middle-level students in Science and Mathematics, the high dropout rates during the first years of tertiary education, especially in the areas of Engineering and Sciences, the low mobility of students and the limited coordination of existing careers. All of this occurs within the framework of complex and, at times, rigid academic structures that make it difficult to achieve uniform standards and harmonize curricula and certificates.

Furthermore, the low interest shown by middle and higher-level students in technical disciplines in general, and in nuclear careers in particular, together with a serious dearth of nuclear courses in many degree programmes in Engineering and Sciences, demonstrate that existing outreach programmes have not been adequate or have not been in line with existing job opportunities and needs of the nuclear sector. Serious and sustained efforts are required for dissemination and outreach activities, mainly aimed at secondary school teachers and students. It is crucial to also address these activities to higher-level students, the general public and political leaders, with the aim not only of addressing issues of enrolment in nuclear courses, but also duly informing the public about the options, scope, precautions and benefits of using nuclear technologies.

The establishment of networks of educational institutions at the regional level is essential to achieve these goals, as it facilitates the exchange of information and good practices among members, complementing capacities and deficiencies of different actors. These efforts can be accompanied by the application of tools provided by information and communications technologies, which offer ways to bridge the wide geographical expanse of Latin America.

The above description demonstrates how important it is to understand the peculiarities of the region, since a network like LANENT cannot be conceived out of its context. As mentioned, the region is vast in size and it is also in population. Compared to the European Union, it is five times larger and has almost the same number of inhabitants, but less than a third of its nominal gross domestic product. Furthermore, communication is poor, and the population is very unevenly distributed. On the one hand, while vast areas have extremely low population density, cities such as São Paulo, Mexico City, Buenos Aires, Rio de Janeiro, Lima and Bogotá are among the twenty most populated cities on the planet. Existing economic, social and cultural inequalities impact the equitable access to education, complicating the academic performance and opportunities of young people.

Activities, focus and main results

Since its creation, one of the first areas of focus for LANENT was the establishment of a culture of collaboration between academic institutions that practically did not exist in the region. This did not only happen between institutions in different countries, but inside each country as well.

During and following the initial stages, it was important to count on the valuable advice of colleagues of the European network, ENEN, especially from Emilio Mínguez.

In the first meeting of the General Assembly held in Lima, Peru, on 8 December 2010 the regional network was established through the approval of its ToRs and the election of its first president. Although LANENT expected a low participation, that meeting was attended by 19 representatives from 7 countries (7 from Peru, 6 from Argentina, 2 from Chile, 1 from Cuba, 1 from Ecuador, 1 from Mexico, and 1 from Uruguay).

The success of this initial objective that aimed at the incorporation of new members can be seen in the fact that seven years later, in the International Symposium on Nuclear Education, Training, Outreach and Knowledge Management, held in the city of Buenos Aires in December 2017, more than 200 professionals from practically all countries of the region participated, with 176 exhibitions, including special guests from France and Spain. Currently, LANENT comprises 77 institutions (62 full members, 14 collaborators and the IAEA) from 18 countries.

For the development of the tasks and objectives established by the General Assembly and followed up by the Coordinating Committee, Working Groups dedicated to specific tasks are established. One of the most successful in these first ten years of work has been the working group dedicated to the network website and educational portal. This was created by collaborators from Argentina with a regional hub at the National Atomic Energy Commission in Buenos Aires. With up-to-date news, the website www.lanentweb.org is the principal information channel of the network members. Likewise, the educational portal, based on the CLP4NET system, has taken a very important impetus since the beginning of the Covid-19 pandemic and the need to redirect face-to-face educational activities to an online format.

Another very successful example of regional collaboration is the Nucleando project. This was initially designed by CNEA in Argentina and later developed within LANENT with the support of the IAEA. It is a multimedia educational programme aimed at young students from the region to stimulate interest in disciplines related to the peaceful uses of nuclear technology as well as STEM. To achieve this ambitious goal, the project calls for an indirect approach, to train trainers, that is, schoolteachers of initial and middle level. This way, the project takes advantage of a multiplier effect to reach a very large number of students. Teachers have a variety of educational kits developed with cutting-edge digital technologies, which allow them to teach in an engaging and innovative way. Many relevant topics are addressed, covering, beside nuclear energy, multiple applications of nuclear technology in different fields of human activity, including medicine, agriculture, pest control, etc. The training courses, which were initially held in different cities in Argentina, were later extended to the entire Latin American region. More recently, on the occasion of the beginning of the Covid-19 pandemic and under the emerging restrictions, a successful virtual training system was created and rolled out. It is noted that, from the first moment, the teachers who attended the training courses showed very positive reactions, with the intent of giving continuity to what they learned in their own classrooms. In summary, Nucleando is an example of an activity that began with a national scope, later extending to the regional level, and with an evident potential to be replicated in other areas of the world.

Among other examples that demonstrate the benefits of cooperation between countries and institutions in the region, is the realization of a course in blended-learning format carried out by the University Center for Nuclear Technology of the city of Córdoba in Argentina, with the Peruvian Institute of Nuclear Energy. In it, students from Peru were able to train in the operation of Nuclear Reactors, through the remote and supervised management of the RA-0 reactor in Argentina.

Another example is the digital book "Radiations in everyday life – Notebook guide for teachers", developed by Lourdes Torres and collaborators of the CNEA and the Balseiro Institute. It consists of

talks, experiment workshops for young people and courses for teachers of the three levels: Primary, Secondary and Higher. This book is available on-line, for the entire Spanish-speaking community.

Cooperation

As mentioned, the collaboration of the Vice-President of the European Network ENEN, Emilio Mínguez, was essential for the creation of LANENT in 2010. In fact, in a preparatory meeting held at the IAEA, with the presence of four representatives from Argentina, Brazil, Mexico and Peru, together with Emilio Mínguez, an analysis of strengths, weaknesses, opportunities and threats was undertaken, and the network ToRs were elaborated. The latter were adopted with few modifications by the first General Assembly and continue to govern LANENT's actions.

On the other hand, the attendance of ENEN authorities in the first meetings of LANENT and of LANENT in the meetings of ENEN allowed advantage to be taken of the long experience of ENEN to guide LANENT initial steps, adapting them to the reality of the region, and give shape and content to the newly formed network.

A separate and very special chapter deserves the constant and continuous assistance of the NKM Section of the IAEA, which was undoubtedly the driving force behind the creation and subsequent growth of the regional network. The effort and capacity shown by Ms Mónica Sbaffoni and Ms María Elena Urso in these initial and strengthening stages is highlighted.

The regional projects supported by IAEA TC Department to foster collaboration in NKM and educational activities were also of great importance and impact. While not directly related to LANENT, they were essential for several of the network undertakings.

In 2013, AFRA-NEST, ANENT, ENEN and LANENT signed a collaboration agreement underpinned by a common action plan to guide their collaborative work. More recently, this initiative has been extended to other national, regional and international networks. It is still early to assess the benefits of this ambitious coincidence of objectives and wills. The same can be said of the Networking Networks meetings promoted by the IAEA NKM Section, which due to the Pandemic were forced to move to a virtual format, and whose achievements could be evaluated in due course.

Outreach, members affiliation and engagement

The visibility of the regional network is achieved mainly through its social communication channels, both through the news posted on the LANENT website, as well as its Facebook and Twitter accounts. Still important is the direct communication between the representatives of member institutions by e-mail on the most relevant or urgent developments related to the regional network, a more direct and equally effective channel.

Sessions of the LANENT Coordinating Committee are also held regularly. It handles the overall supervision and coordination of the activities of the network, reviews the relevance of applications for the incorporation of new members and proposes guidelines for the action plans to the General Assembly. In this sense, it is the first line of collaboration, participation and accountability of member countries and institutions.

Finally, at the operational level, LANENT activities are carried out by Working Groups comprised of representatives of the network members. Each has a coordinator who acts as liaison and spokesperson before the Coordinating Committee and presenting an annual report of the activities to the General Assembly.

Evaluation and reporting

As mentioned above, the Working Groups and their activities are regularly analysed by the Coordinating Committee and the General Assembly, to which each coordinator presents a report of the activities carried out annually. The metrics used to evaluate the activities depend on their specific nature and therefore on the particular working group.

For example, the group in charge of the website presents standard network analytics information, such as the traffic recorded by the site in terms of number, geographical origin, traffic sources, content visited, dwell time, bounce rates, number of new and returning visitors, etc.

On the other hand, in specific projects, such as Nucleando, the number of teachers reached by the training courses, their degree of satisfaction recorded through anonymous evaluations, the number of acquisitions of the available material, and the use of it in the classroom are analysed.

Good practices and lessons learned

The absence of cultural or language barriers is an important asset of the region, which undoubtedly facilitates LANENT's cooperation activities. Other important assets are the existence of other proactive thematic networks and the availability of high-quality equipment for nuclear education, highly trained teachers, programmes and courses adapted to the needs of each country, as well as the drive to support cooperation for collective development. Most of the topics relevant to nuclear education are covered by the different countries of the region, despite some gaps in specific areas.

Key success factors

As mentioned, a great strength of the LANENT network is the cultural and linguistic uniformity of the region. For example, this allows students from one country to attend courses, workshops or even careers in other countries' institutions, in their mother tongue, or in a language with idiomatic affinity sufficient to enable direct and effortless communication. This also facilitates every outreach activity, which can reach virtually anyone in the region without the need for any translation or adaptation of the material used.

Another important factor has been the fact that some different countries and institutions have acted as driving forces for collaboration, offering their knowledge and capabilities to others in a direct and disinterested way, establishing a genuine environment of regional cooperation. This is an important aspect since it is not possible to impose cooperation between countries and institutions if they are not willing to join the collective efforts. Cooperation can be supported from outside, but it has to be born from within the network itself.

I–4. STAR-NET CASE STUDY

This case study has been contributed by A. Kosilov as Managing Director of STAR-NET on behalf of the network.

History

The Regional Network for Education and Training in Nuclear Technology STAR-NET was founded in September 2015 as an association under the Austrian Law of Associations with international memberships.

STAR-NET was established to promote, manage and preserve nuclear knowledge and to ensure the continued availability of competent and qualified human resources in the nuclear field in the countries of the region, and to enhance the quality of such human resources to ensure safe and sustainable use of nuclear technology for peaceful purposes.

The creation of this educational network was initiated by the region's universities and supported by the IAEA under the programme of the NKM Section. With the support of the IAEA, several working meetings were held in 2013 and 2014, during which the basic principles of the new network and statutory documents were developed, taking into account the experience of other nuclear education networks and IAEA recommendations.

Membership

Membership in STAR-NET is open to legal entities (universities, research centres, governmental organizations and other institutions involved in nuclear education activities), as well as individuals. Membership applications are subject to approval by the General Assembly. Other organizations, e.g. from outside the region or international organizations, may contribute to STAR-NET as collaborating members. Membership in STAR-NET is subject to a fee.

Initially, STAR-NET was created by 12 member-universities from 6 countries. Currently it has 15 member universities from 8 countries:

- Yerevan State University, Armenia;
- National Polytechnic University of Armenia, Armenia;
- Baku State University, Azerbaijan;
- Belarusian State University of Informatics and Radioelectronics, Belarus;
- Belarusian National Technical University, Belarus;
- Belarusian State University, Belarus;
- L.N. Gumilev Eurasian National University, Kazakhstan;
- East Kazakhstan State University n.a. Sarsen Amanzholov, Kazakhstan;
- D. Serikbayev East Kazakhstan State Technical University, Kazakhstan;
- AGH University of Science and Technology (Akademia Górniczo-Hutnicza im. Stanisława Staszica w Krakowie), Poland;
- National Research Nuclear University MEPhI, Russian Federation;
- Nizhny Novgorod State Technical University n.a. R.E. Alekseev, Russian Federation;
- The National Research Tomsk Polytechnic University, Russian Federation;
- Odessa National Technical University of Ukraine, Ukraine;
- Samarkand State University, Uzbekistan.

Statute

The STAR-NET Statute establishes the Regional Network for Education and Training in Nuclear Technology, STAR-NET as a non-governmental and non-profit organization; it is an international voluntary undertaking established by state and private universities, R&D centres, state and industry enterprises, training-related institutions and other entities involved in education activities in the field of peaceful use of nuclear technology.

Information and resources sharing schemes are set out through the network, with numerous activities ongoing in countries of the region that could potentially be linked through STAR-NET.

The creation of the network, and the benefits that this can unlock, for instance through distance learning and the use of shared facilities are fundamental pillars for achieving efficient cooperation in education and training. Joint activities are expected to strengthen national developments in education and training in nuclear technology.

It is important to enhance public awareness about the benefits and implications of using nuclear technology in its peaceful applications.

STAR-NET's objective is to facilitate cooperation in education and professional training, related research and outreach in nuclear technology through:

- Identifying the issues and needs in nuclear education in the region;
- Assessing educational resources and offerings in nuclear E&T in the region;
- Collaborating in projects related to nuclear education and nuclear technology;
- Exchanging information, teaching materials and advanced tools for education, training and outreach in relation to nuclear technology;
- Developing common curricula and facilitating mutual recognition of degrees;
- Developing educational and methodological materials;
- Promoting exchanges of students, teachers and researchers;
- Promoting collaboration among STAR-NET member organizations and other regional educational networks;
- Sharing best practices in nuclear education and educational resources.

STAR-NET strives to:

- Share knowledge and integrate available resources for the implementation of educational and training programmes by creating synergies with the IAEA and other existing mechanisms;
- Build public awareness of the benefits and risks of nuclear technology and its applications;
- Attract talented young people to work in the area of nuclear education and nuclear technology;
- Facilitate and extend the access to nuclear education and training;
- Encourage professionals in the nuclear field to share their experience and knowledge with younger generations;
- Foster, to the fullest possible extent, the use of modern information and communication technologies for training and education;
- Facilitate linkages and cooperation with other educational networks;
- Cooperate with industry and governmental organizations, research and academic institutions.

The scope of STAR-NET activities includes but is not limited to education (levels of Bachelor, Masters, specialist and postgraduate and PhD), professional training (continuous training, professional development training, etc.) as well as educational, research and development projects in all subjects in the area of nuclear science, technology and management.

STAR-NET's main activities are implemented through thematic groups, formed by the STAR-NET General Assembly. The focus of individual thematic groups and the universities responsible for the coordination of related activities are listed below:

— Group 1: Support of the STAR-NET web site. Coordinator: Belarusian State University of Informatics and Radioelectronics[14];
— Group 2: Educational Programmes and Modules, Training and Methodical Materials. Coordinator: National Research Nuclear University MEPhI;
— Group 3: Coordination of activities within Learning Management System STAR-NET LMS. Coordinator: STAR-NET coordination group;
— Group 4: Research, Scientific and Technical Activities. Coordinator: Nizhny Novgorod State Technical University;
— Group 5: Organization of Cooperation. Coordinator: National Research Nuclear University MEPhI.

The main STAR-NET governance bodies are the General Assembly, the Presidium and the Managing Director, as shown in Figure I–1 and described in the ensuing text.

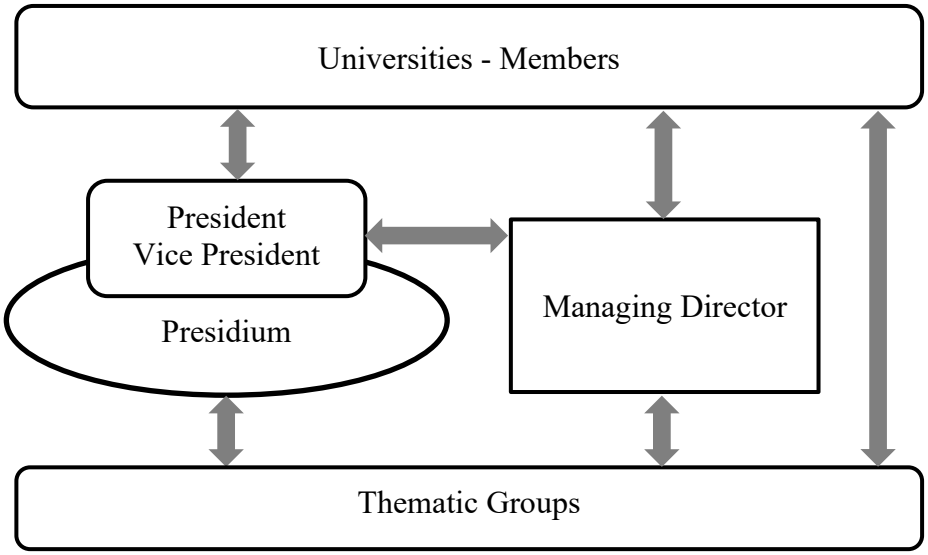

FIG. I–1. STAR-NET structure.

The General Assembly is held once a year to:

— Change or amend the STAR-NET Statute;
— Appoint members of the Presidium and of the Managing Director;
— Set up STAR-NET programme of work for the following year;
— Specify the annual membership fee;
— Approve STAR-NET long-term programme;
— Resolve on the dissolution of STAR-NET.

The Presidium is composed of the STAR-NET members: President, Vice-President and one representative from each participating country. The members of the Presidium, President and Scientific Secretary are appointed by the General Assembly for a term of two years.

The Managing Director, appointed by the General Assembly for a term of two years, is accountable for the day-to-day management of STAR-NET and for the establishment and implementation of all

[14] The coordinators of the thematic groups are listed as of September 2021. They may be changed by a decision of the STAR-NET General Assembly.

internal and operational procedures to ensure the effective and efficient functioning of the organization. This includes the launching and supervision of projects, financial affairs, internal and external information and communication needs, provision of confidentiality, staff matters, and reporting thereon to the General Assembly.

Infrastructure

The STAR-NET manages the public website[15] in English and Russian that contains all the necessary information about the network, its structure, member-universities, and thematic groups. It also contains STAR-NET news and news from member-universities.

The learning management system (platform) STAR-NET LMS[16], open for registered users, was successfully deployed and put into operation in 2017 with the support and in cooperation with the NKM Section of the IAEA. The STAR-NET LMS is based on Moodle, the open-source learning management system most widely used worldwide. Through its multiplicity of features, it enables educators to create and tailor their learning environments.

As of September 2021, the number of the STAR-NET LMS registered users from 14 countries is more than 1100 with about 10 000 visits per year.

The platform aims to support following STAR-NET activities, tasks, and products:

- Development of STAR-NET educational courses and materials;
- Support of STAR-NET events, e.g. meetings, trainings, workshops, internships promoted by member universities;
- Support activities of the STAR-NET thematic groups;
- Informational and promotional materials from the member universities;
- Educational courses developed and offered by the member universities for the general use of other member universities;
- Test environments (test courses) to help member universities to get more familiar with LMS functionalities and to develop their own educational courses;
- Learning Object Repository.

The STAR-NET management has established the Central Administration group responsible for the administration and operation of the STAR-NET LMS. A standard nomination form has been developed to facilitate the formation of the STAR-NET LMS Coordination Teams in the universities. This nomination form is completed by the universities and submitted to the STAR-NET management by the respective representative of a university-member.

The STAR-NET LMS Coordination Team provides support to university users. It consists of (at least) two team members with the following roles: Project Manager and Application Administrator(s). Optionally, the team may include other members (e.g. e-learning specialists, content managers, developers, etc.).

[15] http://www.star-net.online/en/

[16] http://lms.star-net.online

Most of the member universities have already formed STAR-NET LMS coordination teams that are responsible for the following functions at the university level:

- Content management of the university information section (informational and promotional materials about their university);
- Requests to STAR-NET LMS Central Administration to register new users;
- Development and management of educational courses within the university workspace (category) in the STAR-NET LMS;
- Enrolment of users to own (university's) courses in STAR-NET LMS with assignment of required user roles;
- Contributing learning objects and educational materials to the Learning Object Repository;
- Coordinating and conducting activities within their universities to develop, share and contribute educational courses, materials and learning objects for use by other member universities;
- Providing support to the users of STAR-NET LMS within their universities.

Funding mechanisms and costs

The objectives of STAR-NET are realized through the following:

- Membership fees;
- Generating revenue through the provision of services, like training, consultancy, research and development;
- Donations and other means of financial sponsorship.

Benefits

The benefits gained by participating organizations are manifold. STAR-NET promotes preservation of nuclear knowledge, dissemination of knowledge and good practice in nuclear technology field, enhances the professional development/competence of teachers, supports capacity building in universities to assure the required level of education and training in the critical fields in accordance with national needs and assists in the process of restructuring and reculturing educational organizations and systems through different mechanisms.

One of the primary aims of STAR-NET is to create opportunities for an ongoing exchange and collaboration of educational practitioners. Networking among institutions and individuals in education is therefore increasingly seen as a powerful stimulus to organizational learning and development. Innovative practitioners in education may join the network to share approaches to teaching and learning, university culture and university management and leadership. STAR-NET intends to:

- Stimulate creativity and innovation by providing increased opportunities for interaction of people from different disciplines and organizations;
- Create an environment that allows self-organization, development and learning;
- Support the different disciplines and expertise required for research and training in an increasingly competitive global market.

In summary, the main benefits for the parties involved in the network activities are:

- The opportunity to have a common platform for harmonizing nuclear education and training in member-universities;

— Sharing education and training curricula, materials, tools to enhance capacity of each institution;
— Organization of institutional virtual training events (lecturing, practical and laboratory, exercises, seminars, students' knowledge evaluation, etc.) on the basis of the STAR-NET LMS and access to such events for any STAR-NET member, upon request;
— Organization of common events (lectures, workshops, conferences, internships, fellowships, etc.) including virtual ones;
— Forming working groups for reviewing and preparing education and training materials and other common activities.

The most common benefits for individual participants from network activities include:

— Inspiration and support;
— Learning and skill development (using the STAR-NET LMS, participating in common courses, webinars, etc.);
— Access to information, funding, and other resources;
— Greater systemic/contextual awareness;
— Breaking out of isolation and being a part of something larger;
— Amplification of one's voice and efforts;
— New partnerships and joint projects.

Risks

— Lack of funding and university's involvement to support intended activities;
— Rotation and ageing of leaders and staff involved in the STAR-NET activities;
— Loss of desire to participate in the network activities or low engagement (universities and students);
— Lack of leaders' understanding of the importance of collaboration promoted by the network;
— Political complications in member-university's countries;
— Epidemic and other restrictions.

Activities, focus and main results

Beside the annual General Assemblies and the functional meetings, the activities performed within the framework of STAR-NET regional cooperation since its establishment to date (2016–2021) have been manifold. These have been hosted by various network members, often in conjunction with other institutions, including the IAEA. Some of these activities are listed below:

— Conferences on a wide range of topics, including 'Engineering Education' (2016 and 2018), 'Nuclear Reactor Physics' (2018), 'Technogenic Systems and Environmental Risk' (2018), Problems of Physics and Astronomy' (2018), Academic Forum for Nuclear Energy (2018);
— Internship programmes: 3 such programmes were run for Belarusian students in 2016, 2018 and 2021 and encompassed, among other elements, topics like IAEA safety standards, national nuclear infrastructure, knowledge management and research reactors, as well as technical visits;
— International Summer Schools on different topics, such as 'International Relations in the Information Technology Era' in 2020, and 'Engineering Computing in Nuclear Technology' in 2016, 2017 and 2021 (the latter was run virtually);
— International Student Olympiad on Nuclear Physics and Nuclear Technologies, held in 2016;
— Exchange of students – under bilateral agreements;

— Ongoing development of an inventory of educational programmes in nuclear technology available in the region;
— Support to the interregional project ENER-CONNECT through the participation of STAR-NET universities-members as webinar attendees and through the provision of network specialists as speakers;
— The International Specialized Exhibition on 'Education and Careers' for graduates, schoolchildren and students, held in Belarus in 2021;
— 'Train the Trainers' programme for Belarusian teachers (2016);
— Regional School held in 2021 in conjunction with the IAEA International Project on Innovative Nuclear Reactors and Fuel Cycles (INPRO) to Train the Trainers on Nuclear Energy System Modelling and Assessment Using the INPRO Methodology;
— Internship and Professional Development programmes for STAR-NET universities; three courses were conducted in 2017;
— Various other training activities, often organized jointly with other institutions and targeting networks members and/or external participants and including:

    - A fellowship on Nuclear Security held in 2016;
    - A practical course at TRIGA Mark-II research reactor for students (in cooperation with Atominstitut of the Vienna Technical University) in 2017;
    - Training workshop on methods and tools for distance learning, held in 2017;
    - Online courses on 'International nuclear cooperation. Technical aspects for STAR-NET universities', held in 2018, 2019 and 2021;
    - Six training courses on 'International approaches in development and safe use of nuclear technologies' organized in 2018 and 2019 in collaboration with the IAEA, the Atominstitut of the Vienna Technical University and the Vienna International Nuclear Competence Center.

Cooperation

STAR-NET aims at sustaining a close cooperation with the IAEA and commends existing international initiatives, including those fostered by IAEA, which focus on education and training to address challenges related to nuclear technology, E&T and outreach. In addition, the STAR-NET values the experience sharing of other established national and regional education and knowledge networks in Asia, Europe and Latin America.

Collaboration agreements with other organization:

— 2016: Practical Arrangements (PAs) with the IAEA. The PAs set the framework for cooperation between the Parties in the area of nuclear education and professional training, related research and outreach in nuclear technology;
— 2016: Cooperation Agreements with World Nuclear University;
— 2016: Cooperation Agreement with Nuclear Knowledge Management Institute, Austria;
— 2017: Collaboration Agreement with ANENT, LANENT, AFRA-NEST and ENEN;
— 2019: Collaboration Agreement with the Atominstitut of the Vienna Technical University;
— 2021: PA with the Preparatory Commission for the Comprehensive Nuclear-Test-Ban Treaty Organization (CTBTO). The PAs set the framework for cooperation in the areas of education, capacity-building, outreach and training in nuclear technology and disarmament.

Outreach, members affiliation and engagement

STAR-NET welcomes new members involved in nuclear education activities, which are ready to actively cooperate with other participated member universities according to the STAR-NET Statute. The visibility of the network is promoted through:

- The STAR-NET website;
- Presenting the network at different meetings and conferences;
- Sharing and distribution of the network information and news;
- Conducting interviews with other university members;
- Placing the network information at the member-university's sites;
- Sponsoring local events;
- Issuing certificates for students who were involved at STAR-NET activities;
- Hosting annual events in different places;
- Using the social networks (yet to be implemented).

All members have to submit annual reports at the STAR-NET General Assembly.

Evaluation/reporting

All activities of the network are presented to the General Assembly by the President, the Vice President, the Managing Director and the Heads of the Thematic groups. The General Assembly also considers issues related to financial and other resources to support the network activities. Based on the discussion, decisions are made on the results of the work during the year and the STAR-NET Action Plan for the next year.

Two internal auditors are responsible for auditing the statement of accounts on an annual basis and report their findings and conclusions to the General Assembly.

Good practices and lessons learned

In summary the main directions of activities within STAR-NET are:

- Collaboration of the STAR-NET members in organising and participating in international events organized by universities, including conferences, schools, meetings, student competitions, etc.;
- Collaboration within STAR-NET thematic groups;
- Annual General Assemblies – as the STAR-NET forums for wide exchange of ideas, best practices and planning;
- Fellowships programmes organized by STAR-NET for students and teachers in cooperation with the IAEA, CTBTO, Atominstitut of the Vienna Technical University and others;
- Online course 'International nuclear cooperation. Technical aspects' – 3 years of experience. Collection of recorded lectures (in Russian and in English), presentations, supporting materials, references. Pool of questions for organization of exams, appraisals;
- Using STAR-NET LMS platform by member universities for e-learning. For example, the Belarusian State University has shared the virtual practical laboratory course on physics of a nucleus and elementary particles, with more than 100 students taking the course each year. This entails partial lecturing, access to training instructions, implementation of laboratory works, knowledge evaluation. Another example is the LMS-supported Masters level course on NKM shared by the National Research Nuclear University, MEPhI, in Russian and English.

Development opportunities based on lessons learned

Areas for improvements and further development may include:

- Promote a regional IAEA TC project on nuclear education;
- Consolidate a unified educational environment via STAR-NET LMS and other means;
- Active cooperation with other regional networks;
- Increase contributions of the member universities to STAR-NET activities;
- Enhance collaboration in research activities;
- Increase the number of joint events - educational and scientific;
- Formation of a repository of educational materials and courses;
- Continue training faculty staff on use of the STAR-NET LMS platform.

Based on lessons learned and the positive feedback to STAR-NET universities, potential areas and means of further collaboration could be envisaged, as follows:

- Web-based networks activities, e.g. webinars, conferences for students and young professionals, etc.;
- LMS-based training courses;
- Offering training facilities for students at other universities;
- Exchange of training materials and courses;
- Exchange of students;
- Strengthen communication;
- Sharing best practices on the use of LMSs – training seminars;
- Support IAEA activities on nuclear education including International Nuclear Management Academy (INMA) programme within STAR-NET members.

Key success factors

- Understanding the importance of cooperation between the leading universities in the region in supplying qualified personnel for enterprises engaged in the peaceful use of nuclear energy;
- Direct involvement of top management of universities in the creation and operation of the network;
- Support of the IAEA and industry;
- Sufficient financial resources to support the network activities;
- Interest to the network activities from teaching staff – support of educational courses and activities through information and methodological exchange;
- Smooth operation of the STAR-NET LMS;
- Collaboration with other educational networks and organizations.

I–5. ENEN CASE STUDY

This case study has been contributed by G. Pavel, Executive Director of ENEN on behalf of the network.

History

The European Nuclear Education Network is an international non-profit organization established under Belgian law. Founded in 2003, ENEN was originally based in France and then moved to Belgium in 2018.

Membership

To date, ENEN has 83 members and partners from 25 countries, consisting of entities, of different types: research centres, companies in nuclear industry, universities, regulatory bodies, technical support organizations (TSOs), international institutions and other organizations involved in the application of nuclear science and ionizing radiation.

ENEN members are public or private corporate bodies with a legal status, which:

- Provide academic or professional education and training in the application of nuclear science and ionizing radiation, and/or commit themselves to support ENEN;
- Have a firmly established tradition of relations with some of the members in the fields of education, research and training;
- Are based in the European Union or in one of its associated or candidate member countries.

ENEN also welcomes international memberships (for international organizations and non-EU countries).

Statute

The mission of ENEN is the preservation and further development of expertise in the nuclear field by promoting higher education and training. Through the multilateral cooperation between its members ENEN pursues its mission by:

- Promoting and further developing collaboration in nuclear education and training of students, researchers and professionals;
- Ensuring high quality nuclear education and training;
- Increasing the attractiveness of nuclear topics for students, researchers and professionals and fostering their engagement in the field;
- Promoting life-long learning and career development at post-graduate or equivalent level.

The basic purposes of ENEN are to:

- Harmonise European Master of Science curricula in nuclear disciplines and promote PhD studies;
- Promote exchange of students and teachers participating in the frame of this network and beyond;
- Increase the number of students in the nuclear field by enhancing its appeal and providing incentives;
- Establish a framework for mutual recognition;
- Foster and strengthen the relationship between universities, research organizations, regulatory bodies, the industry and other organizations involved in the application of nuclear science and ionizing radiation.

These purposes are achieved through the implementation of the following activities:

- Discussion on educational objectives, methods and course contents among the members and with external partners, particularly national and European industries;
- Organization of internal audits on the quality of nuclear education curricula;
- Awarding the European Master of Science certificates in nuclear disciplines to the curricula satisfying the criteria set up by ENEN;

— Cooperation between the members for the enhancement of mobility of teachers and students;
— Organization of training and advanced courses, including using large research and teaching facilities or infrastructures;
— Cooperation with international and national governmental institutions, agencies and universities;
— Synergy with European Union initiatives in nuclear science and technology;
— Identification and development of solutions to specific issues and deficiencies which hinder the attainment of the aims of the network;
— Exchange of information between its members of ENEN, including course objectives, content, modes of presentation and other matters.

The main governance body of ENEN, the General Assembly of ENEN is convened once a year to:

— Discuss the general policy of the ENEN Association according to its objectives;
— Approve the proposed activities, action plan and annual budget;
— Decide on membership evaluations;
— Appoint the members of the Board of Governors, President and Vice-president.

Infrastructure

ENEN has currently two offices; one situated in Brussels and the second, hosted by the Joint Research Center of the European Commission, located in Geel, Belgium.

To facilitate the effective exchange and sharing of information among the members and with the public, the ENEN website (www.enen.eu) has been operating since ENEN's first years. A new version has been released in 2019.

Furthermore, ENEN runs a database (https://database.enen.eu/) and an 'application portal' (http://apply.enen.eu/) intended to showcase opportunities in the E&T sector (courses, job offers, PhD position, etc.) and to allow people to apply for these opportunities and, if available, for associated grants.

To complement these infrastructure and media, ENEN's social media accounts are active and responsive on Twitter, Facebook and LinkedIn.

Funding mechanisms and costs

The network is funded mainly by projects financed by the European Commission. The full portfolio of projects can be found on https://enen.eu/index.php/projects/, all in the framework of E&T, where ENEN is either the coordinator or partner of a supporting consortium. Minor income is also secured through the annual membership fees.

Benefits

The ENEN members benefit from sharing ideas and work through a vast community and securing resources at all levels to implement their initiatives.

At the same time, students can find extended E&T opportunities for their professional development. At present, through its varied membership, ENEN can provide a full spectrum of activities needed to build any particular competence. In the European Union, all higher education institution programmes are based on the EU standardized approach, by which all educational activities are assigned a number

of ECTS points quantifying the extent of involvement to be fulfilled by each individual in order to finalize a certain educational programme.

One other important facet of collaborative approaches is a better chance to secure funding for E&T initiatives. Usually, such EC funding is offered only to groups with a minimum number of entities with sufficient geographical distribution, to ensure an adequate spread of the activities.

Risks

The main risks the network is confronted with are associated with its members and connected networks. The prime factor to justify the existence of a network is providing enough reasons for the members to work together and collaborate on common actions. For ENEN, this has been the sustained support of the EC, which, by funding the network's common actions, provides the means to transpose members' ideas into reality and ensures the necessary financial stability. Also, collaboration with other networks has been an important factor. Exchange of experience allowed the network to diversify the approaches in attracting new members and keeping the existing ones. Nuclear science and technology applications are diverse and vary in many aspects. The sole risk that ENEN may face could be a limited commitment of members in participating in ENEN projects or initiatives. The existing ENEN framework has to be able to address this challenge.

Activities, focus and main results

Every year, upon proposal from the Board, the General Assembly approves a list of actions for the coming year, along with the related list of responsibilities. These actions are pre-selected by the Board based on suggestions by ENEN members, ENEN partners (e.g. through the Memoranda of Understanding) or the Executive Director. Each action is assigned to a Working Group.

Working groups dedicated to specific actions are set up and leaders nominated during the General Assembly. Along with the ENEN Management Area, five working areas are currently defined, within which the groups can operate. More areas may be constituted.

Each working area consists of all Working Group leaders belonging to that area. For each working area, a coordinator is selected by the leaders of the pertaining working groups. The coordinator reports to the Board and the General Assembly. The Board, together with the Executive Director, monitors the activities of the working groups. As mentioned, working groups are formally established by the General Assembly. However, if there is a strong need, a new working group may provisionally be established with the approval of the Board before the next General Assembly.

The coordinators of working areas, the leaders and the members of the working groups are appointed as individuals belonging to the ENEN members and partners

ENEN working areas are described in the ensuing text.

The ENEN Management Area manages cross-cutting issues of the ENEN Association.

The Teaching Academic Affairs Area is aimed at disseminating knowledge relevant to nuclear education, with the following scope:

— Evaluate applications for the European Master of Science in Nuclear Engineering certification;

— Promote student and faculty exchange by encouraging and supporting the organization of international exchange courses;
— Support the organization of high-quality nuclear related education;
— Evaluate ENEN exchange courses and award the International ENEN Course label, in collaboration with the ENEN Quality Assurance Committee.

The Advanced Courses and Research Area is aimed at promoting the organization of advanced courses and research activities in the nuclear field, with the following scope:

— Provide advanced and/or specialized courses to postgraduate students, PhD students and research members in the frame of ENEN, or in collaboration with other associations around the world;
— Promote the establishment of research in nuclear-related topics throughout Europe;
— Keep connections between universities and research laboratories for the organization and/or participation in advanced research programmes by ENEN members;
— Evaluate ENEN advanced courses, in collaboration with the ENEN Quality Assurance Committee.

The Training and Industrial Project Area facilitates and supports collaboration between associate and effective members of ENEN, with the following scope:

— Identify the industry needs for continuous professional development;
— Organize training sessions and courses on subjects of common interest for the associate members;
— Create and maintain a catalogue of training and industrial continued professional development courses organized by ENEN members;
— Facilitate the mobility of students and professors from different institutions and raise funds for this purpose;
— Facilitate integration of European and national industrial research projects.

Quality is regarded as a multidimensional concept, which embraces all functions and activities of ENEN. The Quality Assurance Area promotes the establishment of a quality policy and maintains its quality objectives. The scope of this area is to:

— Serve as a working group for the ENEN management on various quality issues related to policy making, setting objectives, identification and development of systems, processes, efficiency and continual improvement;
— Disseminate ENEN documentation on its activities including quality manuals, quality plans, specifications, guidelines, instructions, websites and records;
— Evaluate applications of new effective memberships and provide support of quality reviews of ENEN members;
— Support the organization of high-quality nuclear related education by ENEN members in collaboration with the ENEN Teaching and Academic Affairs Committee;
— Evaluate ENEN exchange courses and award the International ENEN Course label, in collaboration with the ENEN Teaching and Academic Affairs Committee;
— Support other quality assessment tasks and products as assigned by the ENEN board.

The Knowledge Management Area aims at identifying and monitoring deficiencies in scientific knowledge relevant to nuclear technology and safety, with the following scope:

— Prepare, maintain and implement an action plan by academia in order to preserve valuable scientific knowledge;
— Ensure efficient use of ICT for the dissemination of knowledge, for supporting teaching and learning and for accessing and maintaining databases;
— Provide access to simulators and specialized software;
— Publish books and produce CDs and DVDs of interest to ENEN members.

Cooperation

In addition to EU partners, ENEN has concluded Memoranda of Understanding and cooperation agreements with:

— Nuclear Engineering Department Heads Organization;
— International Atomic Energy Agency;
— European Nuclear Society;
— International Institute for Nuclear Energy;
— University Network of Excellence in Nuclear Engineering;
— World Nuclear University;
— Fusenet;
— World Federation of Science Journalists;
— Nugenia;
— Nuclear Energy Agency of the Organisation for Economic Cooperation and Development;
— Tokyo Institute of Technology;
— University of Fukui;
— RosatomTech;
— National Research Nuclear University “MEPhI”;
— Tomsk Polytechnic University;
— Lomonosov Moscow State University;
— Odessa National Polytechnic University;
— V. N. Karazin Kharkiv National University.

Before the COVID-19 pandemic, direct contact with these partners would be mainly through in person events. Since this modality is largely reduced, these links have been maintained via internet-supported platforms.

Continuous contact is one of the key pillars in maintaining the network competitiveness. Discussions and interactions are very beneficial to ENEN, as they enable ways of collaboration in various topics of common interest.

The ENEN also cultivates close partnerships with sister organizations, international partners and organizations such as the IAEA and its fostered regional networks.

Outreach, members affiliation and engagement

ENEN’s main website is www.enen.eu, which contains a database (www.enen.database.eu) for courses and opportunities; it also provides a platform dedicated to recruitment and applications through www.apply.enen.eu, and links to social media accounts on Twitter, Facebook and LinkedIn. Furthermore, ENEN has recently acquired and is currently deploying a Learning Management System.

Evaluation/reporting

The effectiveness of the ENEN Network is assessed by reviewing on a yearly basis the initiatives and actions which it has coordinated, participated in, supported and disseminated, towards the achievement of its mission: the preservation and the further development of expertise in the nuclear field by higher education and training. These reviews are presented in its General Assembly, where they are discussed with the Members. The main activities of the year are described, from ENE internal functioning and management to the outcome and impact of actions undertaken throughout the year, which may derive from projects, own or shared initiatives or from particular collaborations with Members or other institutions. In turn, this meeting also serves as an input of ideas and opportunities towards future activities to be considered by the Network.

The fundamental metrics that are assessed can be summarized in the following categories:

- International official projects that ENEN coordinates or participates in;
- E&T mobility actions managed and supported for trainees (students and professionals);
- Agreements with international institutions and organizations;
- Applications processed of the ENEN European Master of Science in Nuclear Engineering Certification;
- Awards and competitions organized to promote talent;
- Participation in E&T related events and conferences;
- Dissemination of opportunities for E&T;
- Newly joining member institutions to the network.

Good practices and lessons learned

- Cooperation and communication with universities, research centres and industry are important for delivering high-quality outputs which translates into better qualified individuals;
- Annual meetings facilitate commitment and communication among members.

ENEN would emphasize the importance of communication and its frequency, in particular the number of interactions with other networks, using web-based applications.

An important good practice to highlight has to do with the continuous engagement with member institutions to foster strong links that allow the sharing of experiences and to detect and establish possible requirements that need to be tackled in the field of nuclear E&T. An important advantage of building up a network is to boost the initiatives that are carried out within the Members and promote them towards the target audiences.

Mobility actions have proven very successful to support people to attend E&T events across a wide range of nuclear fields. In addition to competitions and awards, these initiatives allow for the attraction of talent towards the nuclear fields and the continuous development of professionals already within the sector. In this sense, ENEN also serves as a network for people, connecting them with E&T opportunities around Europe.

Interacting with main stakeholders such as companies from industry, research centres and international bodies such as the EC also allows ENEN to keep up to date in the recent trends and opportunities that could help the network achieve its mission.

A lesson learned would be to attempt diversifying as much as reasonably possible the income streams that finance the various actions, in order to minimize the impact when funding may not be obtained.

For example, a continuation project of ENEN Plus (which has supported around 600 mobility E&T actions) was proposed but unfortunately not awarded, which made the continuation of granting high numbers of mobility initiatives more challenging.

Development opportunities based on lessons learned

For further development and to widen the scope of the actions of the Network as well as to assure the long-term continuity of its operations, ENEN attempts to diversify the sources of income by approaching new funding opportunities both within the EC and outside. Expansion of operations with collaborations outside Europe is also a target (ENEN already has ties with a set of international member organizations) and would support the diversification objective.

In general, and in accordance with the ENEN mission for the preservation and the further development of expertise in the nuclear fields by higher E&T, the development of the Network is always driven towards reaching and supporting as many people as possible as to attract, develop and maintain talent in the nuclear field. To achieve this, participation in nuclear and E&T related projects is kept as a high priority together with the support of E&T opportunities within the Network and beyond when possible and their dissemination to society. For this reason, strengthening the communications and dissemination capabilities of ENEN through social media channels is envisaged.

Key success factors

One of the main factors that contribute to the success of the ENEN operations is the wide range of expertise in nuclear fields possessed by the network's members. This has allowed ENEN to provide answers to industry needs at all levels. Students have been able to establish contact with key lecturers that offer them the appropriate set of education, training and knowledge to address future challenges found at their future jobs. Experts have found in ENEN a good platform to exchange knowledge and expertise with colleagues sharing the same concerns and interests. International organizations find in ENEN a good pool to spread the knowledge and get participation to their initiatives. Additionally, it is important to consider the common actions developed by members from both academia and industry, as both categories shape the entire sector and go hand in hand to ensure a sustainable future regarding talent attraction and development.

Proposing and collaborating in projects that allow direct or indirect funding for the community also contribute to the sustainability of ENEN. These have enabled the exchange of expertise both for educators and for students and researchers and have led to a successful collaboration framework. The community is understood as individuals with potential to develop their career in the nuclear field. This contributes significantly and directly to the ENEN mission.

I–6. BNEN CASE STUDY

This case study has been contributed by M. Coeck as Director of SCK CEN Academy for Nuclear Science and Technology, which coordinates BNEN on behalf of the network.

History

BNEN was created in 2001 by five Belgian universities and SCK CEN as a joint effort to maintain and further develop a high-quality programme in nuclear engineering in Belgium. The current consortium was established in 2006 when the sixth partner university joined the programme as detailed below.

The consortium is coordinated by SCK CEN and offers a master-after-master interuniversity programme of the 60 European Credit Transfer and Accumulation System (ECTS). The lectures and practical sessions are organized at SCK CEN in Mol and taught in English.

The BNEN partners were aware that at the European level a problem existed to keep up the expertise in the nuclear engineering field and that the many efforts from the European Commission and the international agencies to obtain international collaborative programmes in nuclear science had to be supported in Belgium.

It has been agreed by the Universities and SCK CEN that it is of utmost importance for the nuclear safety and the energy provision of Belgium, that all academic expertise is joined in one effort to establish one unique academic programme preparing the personnel for its future functions in the nuclear industry, research centres and regulatory and supervisory bodies.

The nuclear industry, the regulatory body, the TSOs and the Belgian waste management organization need expertise and have been willing to support the collaborative programme in Belgium.

BNEN was an inspiring model for ENEN.

Several formal audits/visitations of the BNEN programme have taken place, with positive outcome and resulting in obtaining the EUR-ACE[17] accreditation by the Commission des Titres d'Ingénieur (CTI)[18] in 2016.

As an outcome of one of the audits/visitations, the BNEN programme has been revised and the programme is now divided into the following three core blocks:

- A set of introductory courses allowing refreshing or first contact with the basic concepts of nuclear physics, material sciences and the principles of energy production through use of nuclear phenomena;
- A core block of nuclear engineering applied to power generation and reactor use, theory of reactors and neutronics, thermal hydraulic problems encountered in reactor exploitation, the nuclear fuel cycle and the specific material corrosion problems;
- A block of elective courses that allow students to deepen certain topics of their choice (new).

Membership

The current consortium was established in 2006 when the sixth partner university joined the programme.

The partners are, in alphabetical order:

- Katholieke Universiteit (KU) Leuven;
- The Belgian Nuclear Research Centre;
- Université Catholique de Louvain;
- Université de Liège;
- Université libre de Bruxelles (ULB);

[17] EUR-ACE® is a framework and accreditation system that provides a set of standards that identifies high-quality engineering degree programmes in Europe and abroad.

[18] An independent French evaluation organization https://www.cti-commission.fr/

— Universiteit Gent;
— Vrije Universiteit Brussel.

These partners are among the main engineering universities in Belgium. The network is stable and no growth is foreseen as there are no additional institutions that could bring additional input from their expertise to the current curriculum.

The partners do not pay a fee.

Statute

BNEN has the following committees: Steering Committee (SC), Teaching Committee and Academic Committee.

The management of the interuniversity BNEN Programme is vested in the BNEN SC and discharged as described in the ensuing text.

As a general rule, the SC consists of one delegate of each Partner. Each Partner informs in writing the other Partners of the delegate it nominates as member of the SC and his or her proxy. Each Partner is free to replace its delegate or his or her proxy on the condition of informing the other Partners in writing about the newly nominated delegate or his or her proxy.

The appointed delegate has the formal voting right. A delegate can be replaced by one proxy, who may cast the vote on behalf of the absent delegate. Proxies may participate in the SC meetings together with the appointed delegate, but the former will then only have an observer status and are not allowed to vote. The student delegate and the assistant delegate can be present at SC meetings on invitation, but without voting rights. The BNEN Secretariat participates de-facto in the SC meetings.

The SC elects every two years by formal (and secret, if requested) votes, a chairman and a vice-chairman. Election and re-election will only be accepted if obtained by majority of the Partners.

The university members of the SC, complemented with one delegate of the students and one delegate of the assistants, together create the BNEN Teaching Committee. Both the students' and assistants' delegates can be replaced by one proxy. SCK CEN is invited as observer to BNEN Teaching Committee meetings.

The university members of the SC form the BNEN Academic Committee, of which SCK CEN is an observing member. The BNEN Academic Committee:

— Agrees on the acceptance of the students;
— Looks after and renew, if necessary, the rules to be applied by the BNEN Examination Committee;
— Looks after the contents of the BNEN Programme and, if an amendment in the BNEN Programme is required, start the procedure;
— Decides on awarding exemptions to students.

The SC:

— Manages the BNEN Programme and draft and agree on internal rules of the Consortium BNEN;
— Reviews the objectives and tasks laid down in the agreement and give general direction to the BNEN Administration manager;

— Strives for external funding and sponsoring and decide on the redistribution of such funds received, taking into account specific costs that have to be covered, and possible retains of the receiving Party.

The SC meets as a matter of principle at least twice a year. The meetings are convened by the Chairman. A special meeting is held within a reasonable time after receipt of a written request from a minimum of three members of the SC or from the SCK CEN coordinator.

Each delegate member of the SC can bring one observing non-voting person (e.g. experts, etc.) to the SC meetings, unless decided otherwise by the SC.

The SC operates and reaches its decisions to the greatest extent possible by unanimous agreement. However, when a formal vote is requested by a member or is part of the rules as outlined in this Agreement, each Partner has one vote. Voting is organized by the Chairman and decisions of the SC is adopted by a two-thirds majority of the votes cast, the quorum being 50% of all the members, except when unanimity is explicitly required.

The same procedures apply for the BNEN Teaching and Academic Committees.

The working language of the SC is English.

Responsibilities

For the purpose of the BNEN Programme, the universities of the Flemish Community of Belgium act as individual institutions, but they agree to organize the common programme and to issue a joint diploma together with all six university partners.

In accordance with the Decree of the 7th of November 2013, the universities of the French Community of Belgium agree to jointly organize the common programme, through a 'referent university' and to issue a joint diploma together with all six university partners.

The establishments authorized in the French Community of Belgium designated ULB as the referent university, from the start of the first admission campaign following the signature of the agreement. In this capacity, ULB is responsible for centralizing the administrative and academic management of both the programme and the students for all partners in the French Community of Belgium. The status of referent institution can be assigned to another institution when the agreement is renewed.

Each (referent) university provides the other universities, not later than 15 November, the list (including, as a minimum, the surnames, forenames and nationality of the students and the number of credits in the students' annual programme) of the students enrolled in the programme so that each institution can carry out an administrative registration. Each (referent) university commits to communicate, as soon as possible, any changes related to this list.

SCK CEN nominates one coordinator of the Consortium BNEN, who will interface with the Steering Committee, the universities, the professors and the students.
SCK CEN also runs the BNEN Secretariat, coordinated by the BNEN Administration Manager from SCK CEN.

Students have the choice to enroll in one of the partner universities of the Flemish Community of Belgium or at the referent university of the French Community of Belgium.

In the implementation of the BNEN Programme, the universities, assisted herein by SCK CEN, commit themselves to the BNEN Programme. Amendments to this BNEN Programme can only be initiated by unanimous agreement of the members of the BNEN Academic Committee. The BNEN Academic Committee takes the initiative to organize timely inter-university consultation, in order to be able to submit the proposal of the altered BNEN Programme for approval to the respective university authorities. Approved changes are laid down in a revised version of the BNEN Programme.

The task of coordination of the quality assurance and accreditation will be assumed by the KU Leuven on behalf of the universities of the Flemish Community of Belgium. On behalf of the universities of the French Community of Belgium, the referent university assumes the required quality coordination actions.

The universities (in their individual capacity or via the referent university) assume responsibility for all students they register for the BNEN Programme and award to these students, on the condition of successful completion thereof, the degree, certified by a joint diploma on behalf of the universities. The diploma is signed by the Rector of each participating university and is issued in three languages: French, Dutch and English.

The registration fee for the BNEN Programme is the official registration fee of the respective university at which the student registers.

All teaching assignments, with regard to the different subjects of the BNEN Programme, are assigned to members of the academic staff, to guest professors or to a participating university appointed by their academic institution, subject to prior mandatory positive advice of the BNEN Steering Committee. If necessary, teaching assignments can, also subject to prior mandatory positive advice of the Steering Committee, be assigned to persons not yet pertaining to the academic staff of one of the participating universities, provided that one of the participating universities commits itself to appoint or nominate this person within one of the categories of academic staff with teaching qualifications according to the university Decree it comes under, and in accordance with its own procedural rules.

The students are subject to the general examination regulations of the respective university they are registered at insofar as they are not amended by specific examination regulations agreed upon by the universities in view of this BNEN Programme. The rules for awarding credits and for successful completion of the BNEN Programme are applied by the BNEN Academic Committee, acting as formal Examination Committee. After decision, the results are communicated to the universities and the students. SCK CEN provides facilities, office equipment, as well as supplies and materials required for the completion of the BNEN Programme.

The universities commit themselves not to duplicate the BNEN Programme at the Masters level.

Figure I–2 and Table I–1 show how BNEN members share teaching responsibilities.

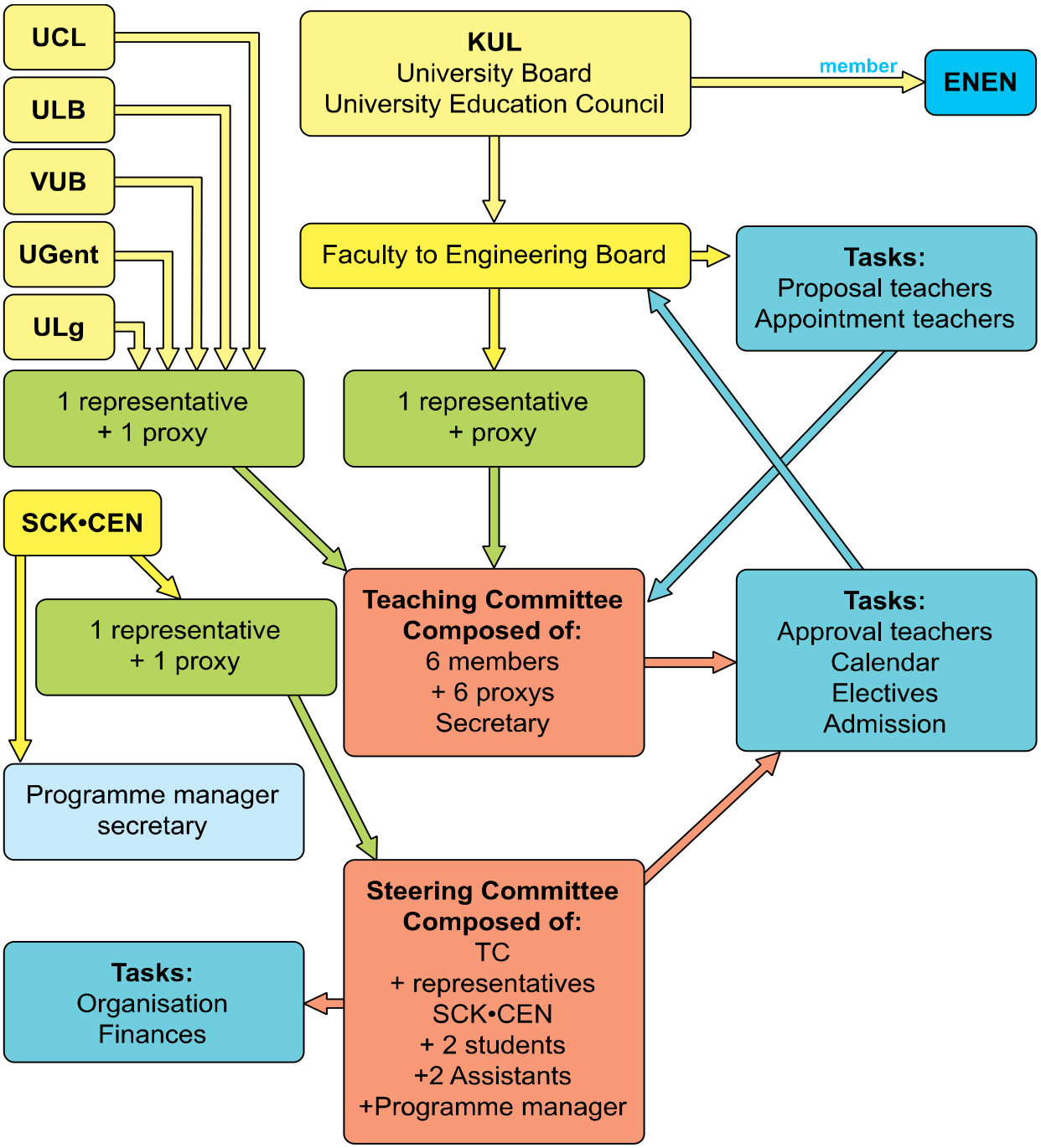

FIG. I–2. BNEN governance and distribution of responsibilities (Courtesy of SCK CEN).

TABLE I–1 BNEN PROGRAMME MODULES AND DISTRIBUTION OF TEACHING RESPONSIBILITIES[19]

Academic year 2021-2022	**ECTS**	**KU Leuven**	**UGent**	**VUB**	**UCL**	**ULB**	**ULg**	**Responsible (University)**
COMPULSORY MODULES	31							
Introduction to nuclear energy	3	3						William D'Haeseleer (KU Leuven)
Introduction to nuclear physics and nuclear measurements	3					3		Nicolas Pauly (ULB)
Nuclear materials	3	2					1	Marc Scibetta (ULiège, SCK CEN) Rik-Wouter Bosch (KU Leuven, SCK CEN) Eric Van Walle (KU Leuven, SCK CEN)
Nuclear fuel cycle	3						3	Hubert Druenne (ULiège) Christophe Bruggeman (ULiège, SCK CEN)
Radiation protection	3		3					Klaus Bacher (UGent)
Nuclear thermal hydraulics	5				5			Yann Bartosiewicz (UCLouvain)
Nuclear reactor theory	6	2	2	2				William D'Haeseleer (KU Leuven) Jean-Marie Noterdaeme (UGent) Peter Baeten (VUB, SCK CEN)
Safety of nuclear power plants	5		3			2		Hubert Druenne (UGent) Pierre-Etienne Labeau (ULB)

[19] Katholieke Universiteit Leuven (KU Leuven); The Belgian Nuclear Research centre (SCK CEN); Université Catholique de Louvain (UCLouvain); Université de Liège (ULiège); Université libre de Bruxelles (ULB); Universiteit Gent (UGent); Vrije Universiteit Brussel (VUB).

TABLE I–1 BNEN PROGRAMME MODULES AND DISTRIBUTION OF TEACHING RESPONSIBILITIES, cont.

Academic year 2021-2022	**ECTS**	**KU Leuven**	**UGent**	**VUB**	**UCL**	**ULB**	**ULg**	**Responsible (University)**
ELECTIVE MODULES (9 ECTS to be chosen from the list below)	9							
Advanced nuclear reactor physics and technology	3				3			Hamid Ait Abderrahim (UCLouvain, SCK CEN)
Advanced nuclear materials	3	2					1	Marc Scibetta (ULiège, SCK CEN) Rik-Wouter BOSCH (KU Leuven, SCK CEN) Eric Van Walle (KU Leuven, SCK CEN)
Advanced radiation protection radiation ecology	3		3					Klaus Bacher (UGent)
Advanced courses of the nuclear fuel cycle	3						3	Hubert Druenne (ULiège) Christophe Bruggeman (ULiège, SCK CEN)
Nuclear and radiological risk governance	3		1		2			Fernand Vermeersch (UCLouvain, SCK CEN) Greet Maenhout (UGent)
Advanced course elective topic	3			3				Peter Baeten (VUB, SCK CEN)
Master thesis	20							

Infrastructure

Facilities

BNEN is organized at the technical site of SCK CEN in Mol, 100km northeast of Brussels in Belgium. The lectures take place in a dedicated classroom in the conference centre of SCK CEN (Lakehouse), located in a wooded area and near the SCK CEN restaurant and library services. SCK CEN offers a variety of accommodation options: houses, villas, studios and dormitories.

Exercises and hands-on sessions in the specialized laboratories and installations (including BR1 and VENUS research reactor) of SCK CEN complement the theoretical classes and strengthen the

development of nuclear skills and attitudes in a research environment. Various technical visits are organized to research and industrial nuclear facilities.

Communication

All correspondence concerning the programme goes through the BNEN secretariat (bnen@sckcen.be). Correspondence with the students and professors/assistants is mostly done by e-mail. BNEN also runs a website, with a restricted area for the students where they can find information related to the programme, including online course material. It's the responsibility of the BNEN secretary, in collaboration with the professors and more specific the chair of BNEN, to keep the website updated.

For the BNEN Steering Committee meetings the BNEN secretary sets up an online SharePoint environment where the members of the SC can consult all files necessary to discuss the various agenda points.

Due to the exceptional circumstances caused by the COVID-19 pandemic, online tools were used to continue teaching (e.g. Adobe Connect). This online teaching was coordinated by SCK CEN.

Funding mechanisms and costs

BNEN is sponsored by the Belgian industry and to a lesser extent by the Belgian government. As a second sponsor, SCK CEN delivers a considerable amount via in-kind contributions (infrastructure, teaching, practical lessons, etc.).

Benefits

BNEN offers an academic high-quality programme with experts from various backgrounds (academia, industry, research labs). It is linked with university research, benefits from human resources and infrastructure of SCK CEN and is encouraged and supported by the stakeholders of the nuclear sector.

Courses are held in English and run in a modular way: teaching in blocks of one to three weeks for each module allows optimal time management for students and lecturers, facilitates participation in individual modules, and allows easy access for international students.

The main beneficiaries are the students and young professionals.

The programme is also open for international and Erasmus students.

Risks

- A major threat to the nuclear academic programme is the changing attitude towards nuclear electricity production by the authorities, nationally and internationally, leading to a fluctuating inflow of new students;
- Less involvement by the 6 university faculties;
- The need for a very complex organization with many partners may be questionable, considering the rather low number of students;
- The rather high cost for the low number of students;
- The high academic level, while industry focusses more on hands-on practices;
- The retirement of experts/professors in the field.

Activities, focus and main results

The BNEN programme concentrates solely on the master-after-master in Nuclear Engineering (60 ECTS).

Students have the choice to enroll in one of the partner universities of the Flemish Community of Belgium or at the 'referent university' of the French Community of Belgium. Figures I–3 and I–4 provide some statistics of enrolled students and graduates:

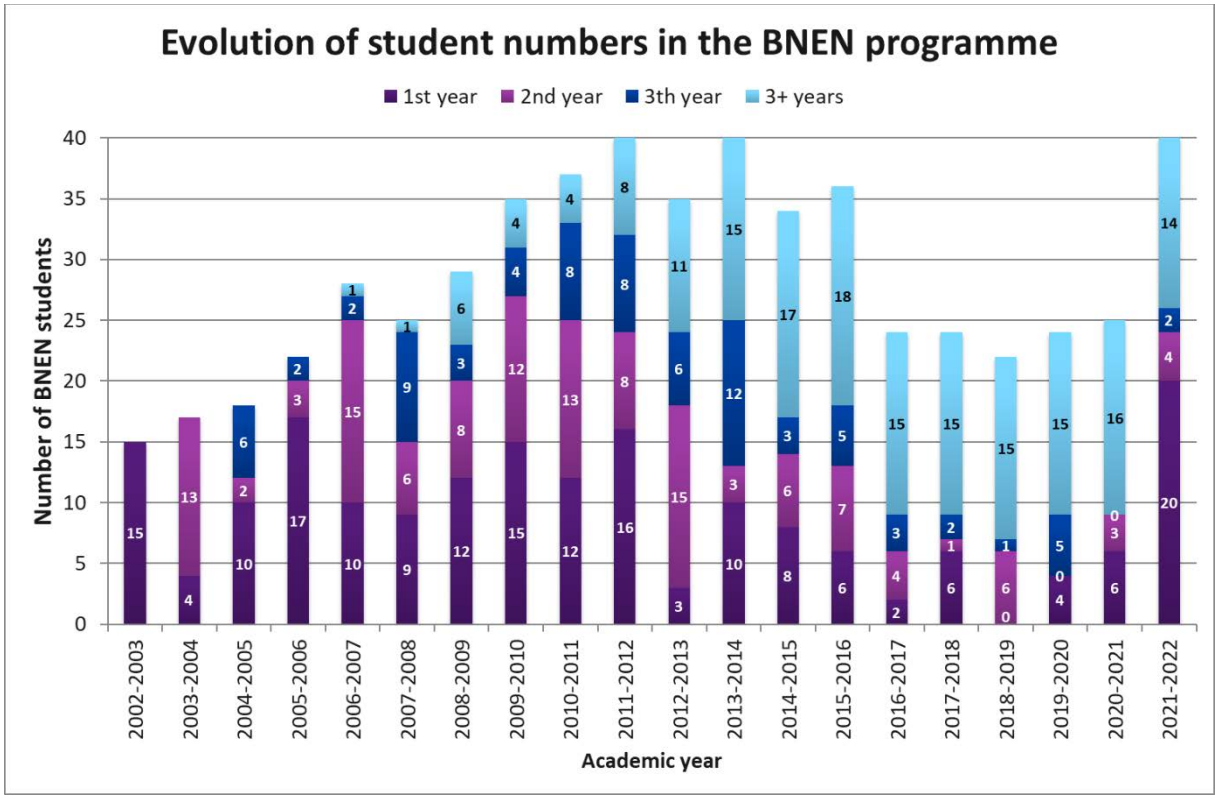

FIG. I–3. Evolution of the number of students enrolled in the BNEN programme (Courtesy of SCK CEN).

Cooperation

BNEN is one of the founders of ENEN and was an example for many other European national nuclear engineering/educational networks.

As part of the SCK CEN Academy, this programme links to the programmes at the CEA National Institute for Nuclear Science and Technology (INSTN). The SCK CEN Academy also signed a collaboration agreement with the World Nuclear University and practical arrangements with the IAEA. It is a member of the OECD NEST initiative and active in many EC E&T projects.

Outreach, members affiliation and engagement

BNEN is a master-after-master programme. As part of its course catalogue, the programme is supported and promoted at various Belgian partner universities.

SCK CEN organizes every two years a 'nuclear careers day', where BNEN is part of the presentations/job career booth.

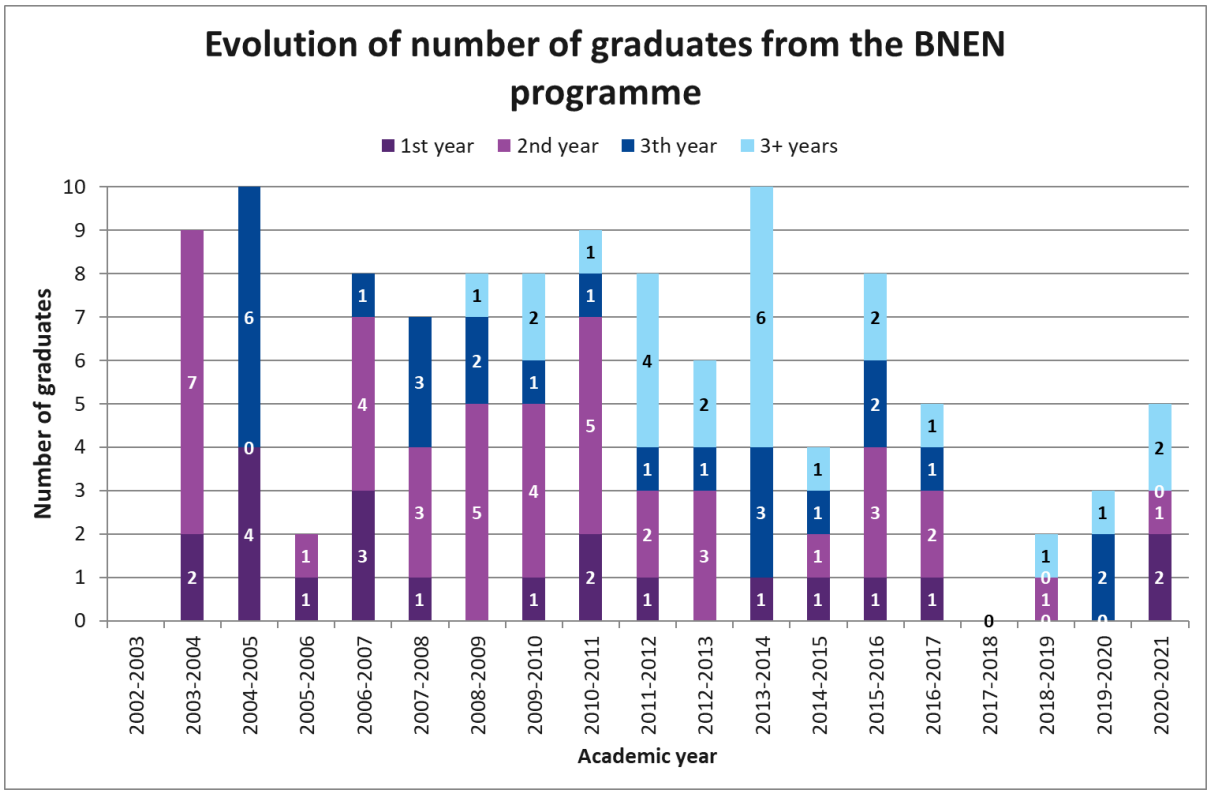

FIG. I–4. Evolution of the number of students graduated from the BNEN programme (Courtesy of SCK CEN).

The BNEN programme is part of the SCK CEN Academy for Nuclear Science and Technology, and the programme is promoted in the Academy newsletter, on the website and in other social media (LinkedIn).

Evaluation/reporting

Several formal audits/visitations of the BNEN programme have taken place, with positive outcomes, resulting in the EUR-ACE accreditation by the Commission des Titres d'Ingénieur in 2016.

Good practices and lessons learned

A quality assurance programme is in place (visitation), as it is done for all university education in Belgium.

Every two years a stakeholder meeting is organized. This way the programme can be kept up to date and targeted towards the needs of the end-users and stakeholders.

Development opportunities based on lessons learned

Despite the rather rigid academic structure and curriculum, the programme has been adapting over the past years to the needs of the target public and stakeholders. Elective courses are introduced offering students the possibility to tailor part of the programme to their interest, needs and/or career opportunities.

Key success factors

20 years ago, the number of students specializing in nuclear engineering in Belgium varied between 0 and 1 at each university, which is clearly not enough to keep the programmes alive at individual universities. Thanks to the BNEN programme, the collective effort of the main Belgian universities and the Belgian Nuclear Research Centre SCK CEN, nuclear engineering education still exists in Belgium.

I–7. NTEC CASE STUDY

This case study has been contributed on behalf of the network by K. Whittle as representative of the Nuclear Technology Education Consortium and J. Roberts as former NTEC Nuclear Fellow.

History

NTEC was formed in the UK in 2005 in response to the national decline in nuclear education courses and student numbers and a fear that reactors may have had to cease operation earlier than planned due a lack of the required personnel. The University of Manchester led the formation of the network following consultation with UK nuclear organizations and the UK universities that were still providing some level of nuclear education or research. The eleven educational organizations that formed the network were:

— City University;
— Imperial College London;
— Lancaster University;
— The University of Liverpool;
— The University of Manchester;
— The University of Sheffield;
— University of Birmingham;
— University of Highlands and Islands;
— University of Leeds;
— Nuclear Department of the Defence Academy;
— Westlakes Research Institute.

With three universities (Liverpool, Manchester and Sheffield) awarding degrees, maintaining quality assurance across the network was a challenge, as each degree-awarding partner had to process all of the necessary consortium material. With students moving between each partner for the different courses, a very competent managerial and administrative team was required.

Membership

The membership has declined slightly, with NTEC now having seven members:

— The University of Liverpool;
— The University of Manchester;
— The University of Sheffield;
— University of Birmingham;
— University of Central Lancashire;
— University of Leeds;
— Nuclear Department of the Defence Academy.

The 2021/22 fee structure for students is:

— MSc £19,285;
— Full time Home UK self-funding students have their fees reduced to £11,845;
— Postgraduate Diploma £16,020;
— Postgraduate Certificate £9,600;
— Single module (CPD);
— £2,980 – if assessment taken;
— £1,955 – for attendance only, if no assessment is taken.

Statute

The NTEC Management Team resides at the University of Manchester and is provided with guidance by the Steering Group, which comprises of a member from each of the partner universities as well as student representatives. It is advised by the External Advisory Board, which consists of representatives from the stakeholder organizations and governed by a Board of Governance comprising of each of the degree-awarding universities. Figure I–5 provides a schematic representation of this governance structure.

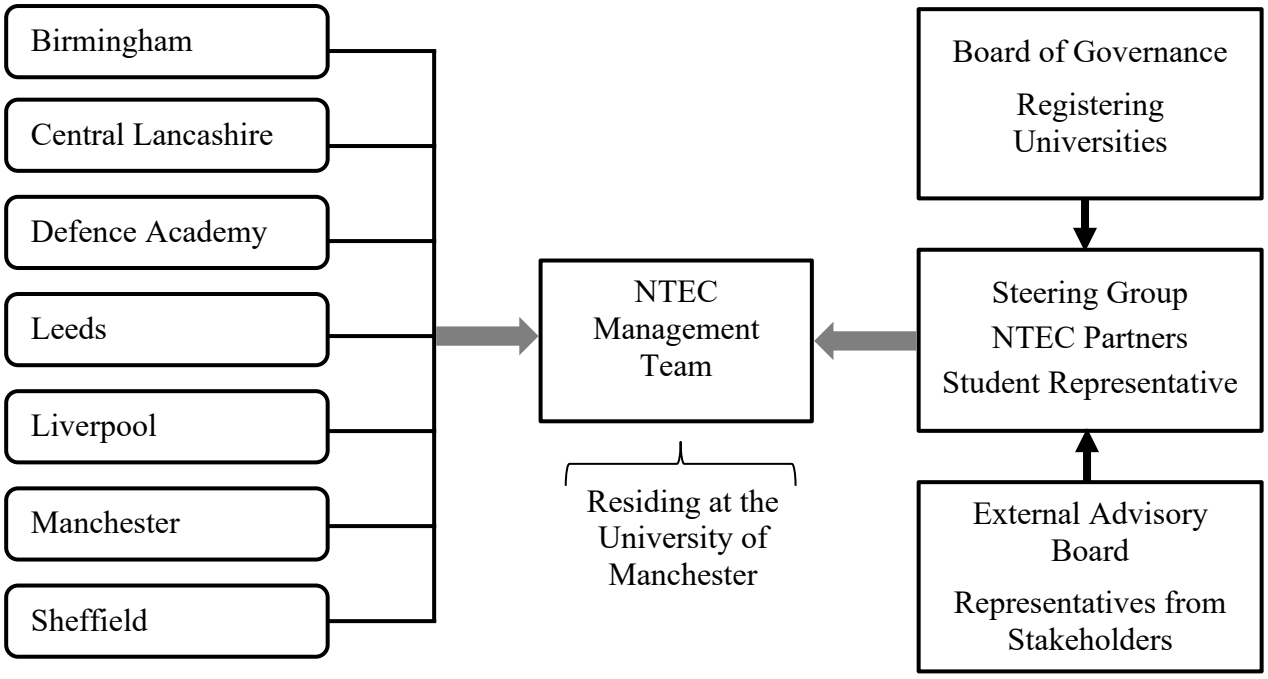

FIG. I–5. NTEC governance structure.

Infrastructure

Student recruitment is done through the degree-awarding university's admissions systems. The most popular courses are available via distance learning with the delivering university being responsible for the delivery platform used, as well as the content. The University of Manchester's blackboard platform hosts all the teaching material.

Funding mechanisms and costs

After an initial award of £1M from the Engineering and Physical Sciences Research Council for the establishment of NTEC and to cover the fees for ten students for each of the first three years, NTEC is now self-funded with the only source of income being fees paid by course participants, both university students and those in full-time employment (attending for CPD).

Benefits

The key beneficiaries are the students with access to a greater number of courses than one university could offer. The universities also benefit, as they are able to deliver a sub-set of a Masters programme rather than having to develop a full programme. Finally, the nuclear industry, as they have a far higher number of skilled graduates to employ compared to the situation prior to the establishment of the network.

Risks

The main risk to the network's success is a change in policy for both the operation and development of the new build of nuclear reactors in the UK. The UK has an ageing workforce so requires new graduates for the operation of its existing fleet, which itself is also ageing hence will need qualified graduates to decommission its nuclear reactors. The development of new reactors would need qualified graduates in both the construction and operation phases. If there was a change in government policy towards nuclear power, as it happened in Germany, jobs in the nuclear sector would be less appealing and therefore the number of student applications would decline.

Activities, focus and main results

The main activity of the network is the delivery of the master's programme in nuclear science and technology. This has resulted in over 1400 students studying on the programme.

Cooperation

NTEC has been a keen supporter of networking networks facilitated by the IAEA. Nationally NTEC cooperates closely with many UK nuclear organizations, many of which provide representatives for the External Advisory Board, lecturers for some of the courses, project placements and employment opportunities for the graduates.

Outreach, members affiliation and engagement

NTEC does not actively seek new members except where there is reason to expand the modules offered by NTEC, which cannot be provided by one of the current partners. As well as IAEA initiatives, NTEC supports UK government activities for the export of nuclear expertise and products. These activities take place nationally as well as internationally in countries such as Canada, China, Taiwan, Japan and India.

Evaluation/reporting

The quality of the NTEC master's programme is maintained through mandatory student feedback on all the course units, that has to be responded to by each course unit leader. Each module is also subject to periodic peer review. Students' applications are monitored closely and, when needed, the advertising of the programme is increased. In addition, Liverpool, Manchester and Sheffield as degree

awarding bodies also regularly review the course, its quality and content, ensuring they are fit for purpose.

Good practices and lessons learned

NTEC has succeeded due to a constant management philosophy and team. As is usual in universities, the senior leadership team at department and faculty level often change but the current NTEC programme manager has been involved since its inception. Due to the complex nature of the programme delivery and finances, having stable day-to-day management has been invaluable.

Development opportunities based on lessons learned

NTEC continually communicates with the UK nuclear industry to maintain the relevance of the courses offered. New courses have been developed in response to demand and existing courses evolve to include new technologies or policies.

Key success factors

One of the main reasons for the success of NTEC is the exceptional management of the programme which creates the conditions for the students to focus on the content of the programme rather than the logistics. The management team also support the delivery of the programme, again allowing the lecturers to focus on the content. It has also been important that the network is a true partnership rather than a lead organization with supporting organizations.

I–8. UNENE

This case study has been contributed by J. Hopwood, President of UNENE on behalf of the network.

History

The University Network of Excellence in Nuclear Engineering – UNENE, founded in 2002, is a network of Canadian and partner international universities offering nuclear engineering, science and technology research and education programmes. Its members also include Canadian industry participants, the federal government and Canada's national nuclear science and technology institutions.

With its partners and funding organizations, UNENE works to advance nuclear knowledge, build capacity and heighten visibility of Canada's strength as a global partner and to elevate the role of nuclear in advancing global sustainability, prosperity and a clean energy future.

UNENE was established to address the need for a sustainable capability in post-graduate nuclear engineering education and capacity building through university research. At that time, no post-graduate nuclear engineering degree programmes were active in Canada, and no single university felt in a position to launch such a programme on their own. The main nuclear industry organizations in Canada (e.g. utilities, national laboratory, regulatory body) met to seek solutions to this and conceived the approach whereby a network of universities could team up to provide an M.Eng. programme in nuclear engineering through collective action. With the M.Eng. programme as a start, the universities and industry organizations recognized that capacity building through student experience in university research could also be developed this way and so UNENE was created involving the industry and universities, to advance high qualified personnel development through both education and research. The organizations met under the auspices of the Atomic Energy of Canada Ltd, which, at that time,

held a national role in supporting nuclear technology, and formed UNENE as a not-for-profit partnership of industrial and university members.

Membership

UNENE membership is Canada-based, with all sectors of the industry represented, including utilities, the regulatory body, national laboratory, waste management and owner/operator and private sector organizations, along with leading universities with nuclear technology programmes. Recently UNENE has admitted its first international university associate member from Romania (see detailed member list below). Industrial members contribute annual fees which are used to fund research programmes and UNENE operations and administrative activities. New members can be admitted by approval of the UNENE members at an annual meeting. Universities do not contribute fees. Research programmes are chosen through a proposal review process lead by UNENE's Research Advisory Committee. UNENE members are listed below:

Industrial Members:

- Canadian Nuclear Labs;
- Bruce Power;
- Ontario Power Generation;
- Canadian Nuclear Safety Commission;
- CANDU Owners Group;
- The Canadian Nuclear Waste Management Organization;
- Kinectrics;
- SNC-Lavalin-Nuclear (formerly Candu Energy Inc.).

University Members:

- McMaster University;
- Queen's University;
- Ontario Tech (University of Ontario Institute of Technology);
- University of Saskatchewan;
- University of Toronto;
- University of Waterloo;
- University of Western Ontario;
- Ecole Polytechnique;
- University of New Brunswick;
- Royal Military College;
- University of Guelph;
- University of Windsor;
- University of Regina;
- Polytehnica University of Bucharest.

Statute

UNENE's activities are governed by its established by-laws, and by the laws of Canada governing not-for-profit organizations. UNENE's objectives in its by-laws are to:

- Establish a sustainable supply of qualified nuclear engineers and scientists to meet the current and future needs of the Canadian nuclear industry through university education, university-based training and by encouraging young people to choose a career in the nuclear industry;

— Create and sustain nuclear research by establishing new research professorships and through enhanced funding for nuclear research at Canadian universities;
— Create and sustain a respected body of nuclear experts to provide independent assessments and advice on various aspects of nuclear energy issues;
— Fund nuclear research at Canadian universities;
— Foster improved nuclear industry performance through research and education;
— Advance nuclear knowledge;
— Build capacity;
— Heighten visibility of Canada's university excellence;
— Any other matter ancillary or supplemental to the foregoing.

UNENE is governed by its members. Each member nominates a representative to the UNENE Board of Directors, which provides the direction to UNENE's staff, who are led by a President, charged with the operation of the organization. The Board has two advisory committees covering research and education respectively. Research programmes are chosen through a proposal review process lead by UNENE's Research Advisory Committee.

Infrastructure

UNENE is a small-scale organization with a permanent staff consisting of a President, Secretary-Treasurer, Education Programme Director and Administrative coordinator. UNENE has offices located in the campus of McMaster University and obtains support from McMaster with regard to information technologies and leading university administration matters.

Funding mechanisms and costs

As a whole, UNENE is funded by annual subscriptions from its industrial members. These subscriptions are used to fund research programmes at member universities, along with the operational and administrative costs of the R&D programme, the educational programme and UNENE's outreach and collaboration activities.

UNENE's M.Eng. programme is the main element of education and training, and this programme is primarily funded through student course fees, which are comparable to other post-graduate course fees at Canadian universities. The course revenue from these fees is divided between UNENE, the 'instructor' university, and the 'student' university. UNENE provides funding from the annual subscriptions to cover ongoing operational costs for the M.Eng. programme.

Benefits

Industry members obtain direct benefits from ongoing formal education for their developing staff through the M.Eng. programme. Industry members also benefit from direct training activities by UNENE at their job sites, e.g. Health Physics courses at Bruce Power.

Indirect benefits arise from the overall development of students throughout the nuclear industry, and through the promotion of ongoing nuclear education as a life-long learning benefit.

UNENE students benefit from upgrading their experience and qualifications with a degree or training that is strongly aligned with the needs of the Canadian nuclear sector.

Universities benefit financially from student fees but, more importantly, participating in M.Eng. and other programmes keeps the universities up to date in nuclear course topics and provides a doorway to other university nuclear programmes.

Risks

Risk of insufficient students.

Universities depend on having sufficient student enrollment to sustain individual courses and programmes overall. UNENE's M.Eng. programme enrollment dropped from approximately 100 students in 2006 to 12 students in 2015. With this low level there was a risk of having insufficient students in individual courses to maintain them on the university course calendars, which also meant that UNENE was subsidizing student participation at an unsustainable level. UNENE addressed this with an aggressive recruitment campaign among the network industrial members, which enabled enrollment to increase to 26 in 2020, which is considered a solid base level of participation.

There is also a risk of disagreement among universities, notably on course contents. UNENE's M.Eng. programme has a common curriculum among five participating universities, each of which has individual nuclear courses of different types, although the UNENE M.Eng. programme itself is unique. There is a risk that individual universities may have conflicting views about appropriate course contents, leading to lack of support. UNENE counters this by relying on pre-established course content for foundational courses, supplemented by instructors bringing the courses up to date, and gathering feedback from UNENE's Education Advisory Committee.

Activities, focus and main results

M.Eng. programme

The UNENE M.Eng. programme is focused on core nuclear engineering subjects, with four mandatory courses, along with a total of six additional elective courses. The full list of courses is presented in Table I–2.

As an alternative, students can undertake a project that replaces two elective courses, with a proposed project scope that has a project sponsor from the industry and approval by the UNENE Education Programme Director. UNENE's M.Eng. programme typically graduates 4-8 students per year. The majority of students are already in employment in the nuclear industry, while a high proportion of those students not yet employed do join the nuclear industry after completion of the programme. Student satisfaction with the programme is high, as recorded in course evaluations and surveys. UNENE alumni are now starting to progress into more senior positions in their careers and act as advocates for the programme.

Other training

Arising from its M.Eng. programme and starting with an IAEA initiative, UNENE has prepared a set of online introductory courses corresponding to key M.Eng. courses that can be made available for orientation. Also based on the M.Eng. programme, UNENE offers tailored training courses that can be delivered at the client job site for focused professional development.

Education planning and outreach

UNENE has had to adapt its programming during the COVID-19 pandemic to deliver all courses online. UNENE is recognizing that education, and nuclear education specifically, is evolving rapidly, both in teaching delivery and in the uses for E&T programming. UNENE is planning a member and stakeholder survey followed by a comprehensive needs assessment to determine UNENE future role, covering both the M.Eng. programme and other training and introductory programmes.

TABLE I2 UNENE PROGRAMME COURSES AND TEACHING RESPONSIBILITIES

UNENE Programme Courses	**Responsible University**
Core (Mandatory) Courses	
Nuclear Reactor Physics	McMaster
Nuclear Reactor Safety Design	McMaster
Nuclear Reactor Heat Transport System Design	McMaster
Nuclear Plant Systems and Operations	Ontario Tech
Elective Courses	
Nuclear Fuel Management of the Reactor Core	Ontario Tech
Control, Instrumentation and Electrical Systems in CANDU based NPPs	Western
Nuclear Fuel Waste Management	Western
Project Management for Nuclear Engineering	Western
Engineering Risk and Reliability	Waterloo
Introduction to Operational Health Physics	McMaster
Nuclear Fuel Engineering	McMaster
Power Plant Thermodynamics	McMaster
Reactor Chemistry and Corrosion	McMaster
Nuclear Materials	Queen’s
Nuclear Regulation	McMaster
Small Modular Reactors and Advanced Technologies	Ontario Tech

Cooperation

Cooperation between UNENE universities

As noted, five UNENE universities cooperate to support the UNENE M.Eng. programme. Each university can enroll students in the programme, and the universities share out the teaching responsibilities. Universities meet with UNENE to review the operation of the programme, student enrollment and administrative issues. Direction of UNENE's overall education programme is via the Education Advisory Committee, which represents all of UNENE's university and industrial members.

Cooperation with other networks

UNENE has developed cooperation agreements with NTEC in the UK and with ENEN. UNENE has also joined the IAEA sponsored Network of Regional Networks and is an active contributor to this forum. Recently UNENE has also signed the Networks' Collaboration Agreement (see Annex IV).

Cooperation with IAEA

UNENE cooperates closely with the IAEA through a number of means: sponsoring and participating in the plan for the first Canadian IAEA Nuclear Energy Management School, supporting IAEA's INMA programme and the development of the Nuclear Technology Management degree programme at member universities, supporting IAEA Technical Meetings and Technical Documents in nuclear education.

Outreach

M.Eng. student recruitment

UNENE publicizes its programme and develops student capabilities through student outreach activities, including student poster sessions and student conference sessions at UNENE's annual R&D workshop for members. UNENE meets regularly with its industrial members to promote their staff participating in M.Eng. and training programmes.

Outreach to wider nuclear industry

At the national and international level, UNENE speaks regularly to the wider Canadian nuclear sector through quarterly stakeholder meetings hosted by the Canadian Government. UNENE also is proactive in encouraging participation in IAEA education-related initiatives and has started a dialogue with the OECD-NEA. UNENE encourages student participation in international programmes.

Evaluation/reporting

Audit by the Institutional Quality Assurance Process

UNENE's M.Eng. programme is subject to periodic programme audit every seven years, in line with the University regulations of the Province of Ontario. This audit was undertaken in 2020–21, with a self-study evaluation by UNENE, and a review by the committee of independent academics. The audit noted that UNENE's M.Eng. programme was fully satisfactory, with good student and instructor feedback and a proactive programme administration.

The audit committee noted the challenge of continuing to obtain enough students and advocated for an active recruitment and outreach programme. The committee also recommended that UNENE

expands its programme to a wider range of curricula and build in programming to reflect future developments in nuclear such as the prospective deployment of Small Modular Reactors (SMRs). UNENE is continuing to develop responses and has already set up an introductory course to SMRs, to be rolled out in summer 2022.

Operationally, UNENE reports on its education programme three times per year to the UNENE Education Advisory Committee, with formal minutes and action monitoring.

Good practices and lessons learned

Over the recent years, UNENE has observed the impact of a number of programming initiatives and adaptations, while maintaining its core programming.

Good practices:

- Consistent programme with five universities:
  UNENE has been able to successfully maintain a consistent curriculum supported by all five M.Eng. member universities;
- Using instructors with practical industry experience:
  UNENE takes advantage of experienced professors who are experts in their fields, but also have real-world industry experience, which is greatly appreciated by students and their employers;
- Using examples from Canadian nuclear activities:
  The instructors are able to use examples in their teaching that have direct applicability to student future careers;
- Successful adaptation to on-line learning:
  UNENE has courses available for distance learning. During the pandemic, courses have been exclusively on-line, continued to receive good student and instructor evaluations and kept up enrolment. This gives support to further developing on-line and blended education delivery.

Lessons learned:

- Need to publicize programme:
  UNENE has acted very much as an internally focussed organization addressing immediate member priorities. Building a sustainable student base requires greater outreach to other stakeholder organization, such as supplier and vendor groups, and further outreach to high school and earlier education groups, to represent the benefits of nuclear education;
- Need to keep the curriculum up-to-date:
  UNENE needs to continually adapt its curricula to remain relevant for the rapidly changing nuclear industry;
- Use alumni to advocate:
  UNENE M.Eng alumni are enthusiastic supporters of the programme but have not yet been organized to represent the programme benefits;
- Make use of investment in M.Eng to add E&T initiatives:
  The UNENE M.Eng programme represents an investment in curricula and teaching materials and experience. This can still be used more to bring a greater range of educational and training activities to clients.

Development opportunities based on lessons learned

- Innovate in online learning:
  Learn from recent advances in online learning deliver and digital platforms and experiment with enhancements to teaching styles;
- Build additional programmes using experience with M.Eng.:
  Consider both shorter modules for micro-credentials and also packages aimed at professional development training;
- Assess needs of both network partners and stakeholders and respond:
  Carry out E&T survey and then a detailed needs assessment to identify adaptations.

Key success factors

- Student participation:
  Key programme outcomes are gains in student capabilities and student satisfaction with programme delivery;
- UNENE industrial member feedback:
  The key stakeholders in UNENE's programmes are its industrial members, who backstop the investment in UNENE's programme operations, administration and development. Their direction and programme evaluation (particularly through the Education Advisory Committee) are very important.

REFERENCE

[I-1] INTERNATIONAL ATOMIC ENERGY AGENCY, Asian Network for Education in Nuclear Technology (ANENT), IAEA Non-serial Publication, IAEA, Vienna (2007).

ANNEX II. IAEA-FOSTERED NETWORKS OVERVIEW

Table II–1 below reports, side by side, information and features of each regional IAEA-fostered nuclear educational network, as reported at the time of preparation of this publication. Further details are provided in Annex I and in the respective network websites.

TABLE II–1 SUMMARY OF IAEA FOSTERED NETWORKS

	ANENT	**AFRA-NEST**	**LANENT**	**STAR-NET**
Relations with the IAEA	A regional partnership supported and facilitated by the IAEA (non-profit, not legal entities)			A legal entity registered in Austria, Practical Arrangement with the IAEA
Objectives	Assist member countries in building capacity and develop human and scientific infrastructure through cooperation in E&T, NKM and related research by utilizing the e-learning platform and advanced ICT – through: - Sharing information and knowledge relevant to nuclear E&T; - Providing expert assistance and review services as needed; - Serving as facilitator for communication within the network and with other regional networks.	Facilitate cooperation and networking in higher education, training and related research in NS&T in the region through: - Sharing information, resources & capabilities on nuclear E&T at national and regional level; - Developing harmonized approaches for education in NS&T by establishing reference curricula and facilitating mutual recognition; - Facilitating mobility: exchange of students, teachers and researchers; - Enabling communication between member organizations and other regional networks.	Promote, manage and preserve nuclear knowledge and help maintaining qualified HR in the field in the region. To facilitate and improve cooperation in E&T in NS&T through: - Identifying the educational offerings and detecting gaps; - Developing and exchanging information, teaching materials and virtual tools for E&T & outreach in NS&T; - Facilitating mobility: exchange of students, teachers and researchers; - Promoting mutual recognition of courses and credits among educational institutions.	Promote, manage and preserve nuclear knowledge and help maintaining qualified HR in the field in the region. To facilitate and improve cooperation in E&T in NS&T through: - Identifying the educational offerings and detecting gaps; - Developing and exchanging information, teaching materials and virtual tools for E&T and outreach in NS&T; - Facilitating mobility: exchange of students, teachers and researchers; - Promoting mutual recognition of courses and credits among educational institutions.

	ANENT	AFRA-NEST	LANENT	STAR-NET
Strategy	ANENT Strategy rests upon the principles of cooperation, sharing of information and knowledge for capacity building as part of nuclear infrastructure development, better use of available resources, in the framework of ANENT, through: - Promote the utilization of the ANENT e-learning platform for education and training making optimum use of information technology; - Integrate available educational resources in synergy with existing nuclear knowledge-based networks both within and outside the region; - Facilitate the experienced nuclear professionals to share their expertise with the younger generation and help attract talented youth to the nuclear profession in view of alternate competing career options.	AFRA-NEST strategy relies on the recognition process of Regional Designated Centres, the coordinated work of the Working Groups and the use of ICT for web-based education and training for further facilitating the sharing of information in E&T and the organization of harmonized and accredited programmes in the field of nuclear science and technology.	LANENT builds upon its regional reality, the greatest cultural and idiomatic uniformity, with two related languages, Spanish and Portuguese. This regional strength allows the exchange of information and teaching material, the establishment of communities of practice, or even as a database, avoiding languages barriers. Along with education and training, two basic outreach activities are crucial tools in the process of raising awareness on the benefits of the nuclear technology or the use of these technologies: reaching the undergraduate educational levels, introducing a basic level of nuclear knowledge and the general public as well as to people indirectly associated with the nuclear industry, such as politicians, economists or journalists. LANENT encourages the mutual cooperation and knowledge transfer from countries with active nuclear programmes, in order to achieve sustainable development and the strengthening of their capacities for the countries with developing infrastructure.	Share knowledge and integrate available resources for implementation of educational and training programmes by looking for ways to create synergy with the International Atomic Energy Agency (IAEA) and other existing mechanisms: - Build public awareness of the benefits and risks of nuclear technology and its applications; - Attract talented young people to work in the nuclear sector; - Facilitate and extend access to nuclear education and training; - Encourage professionals in the nuclear field to share their experience and knowledge with younger generations; - Foster, to the fullest possible extent, the use of modern information and communication technologies for training and education; - Facilitate linkages and cooperation with other educational networks; - Cooperate with industry and governmental organizations, research and academic institutions.

	ANENT	AFRA-NEST	LANENT	STAR-NET
Membership	21 Countries Australia, Bangladesh, China, India, Indonesia, Iraq, Islamic Republic of Iran, Japan, Jordan, Lebanon, Malaysia, Mongolia, Pakistan, Philippines, Republic of Korea, Sri Lanka, Thailand, United Arab Emirates, Vietnam and Yemen and six collaborating international networks.	32 Countries (32 officially nominated AFRA-NEST National Coordinators) Algeria, Benin, Botswana, Burkina Faso, Burundi, Cameroon, Central African Republic, Chad, Congo, Democratic Republic of the Congo, Egypt, Ethiopia, Ghana, Kenya, Madagascar, Malawi, Mauritius, Morocco, Mozambique, Namibia, Niger, Nigeria, Senegal, Seychelles, Sierra Leone, South Africa, Tunisia, Uganda, United Republic of Tanzania, Zambia, Zimbabwe.	77 Institutions 62 full members 14 collaborating members (and IAEA) – from 18 countries Argentina, Bolivia, Brazil, Chile, Colombia, Costa Rica, Cuba, Dominican Republic, Ecuador, Guatemala, Mexico, Nicaragua, Panamá, Paraguay, Perú, Spain, Uruguay, Venezuela.	14 Institutions (Universities) from 8 Countries Armenia, Azerbaijan, Belarus, Kazakhstan, Poland, Russian Federation, Ukraine, Uzbekistan.
Governance and communication	ANENT is a partnership of IAEA MSs in the region. A person officially nominated by the national authority is ANENT Country Representative and has the function to coordinate ANENT activities among the ANENT institutional members in the MS. The Country Representative is member of the ANENT Coordination Committee	Regional Coordinator (currently vacant) and Assistant Regional Coordinator elected at the General Assembly.	LANENT is a network of institutions directly associated with E&T and outreach in NS&T (universities, national educational networks, research centres, governmental entities and other institutions). Other organizations and associations interested in NS&T – E&T and outreach, in the region and beyond, may contribute as collaborating members. Operation of the network is managed by a General Assembly, a Coordinating Committee, a President, a Vice-President and a Scientific Secretariat.	Membership is open to legal entities (universities, research centres, governmental organizations and other institutions involved in the nuclear education activities) and individuals by application subject to approval by the General Assembly. Other organizations, e.g. from outside the region or international organizations, may contribute to the STAR-NET as collaborating members.

	ANENT	AFRA-NEST	LANENT	STAR-NET
Main results and activities focus	- LMS and network web-portal development; - E-learning (including training through fellowships and material development).	National networking through IAEA methodologies.	- LMS and network web-portal - E-learning (including training through e-learning on e-learning courses); - KM awareness raising (Conferences, NKM Schools and increasing interest on KMAVs).	The scope of STAR-NET activities includes but is not limited to education (levels of bachelor, master and specialist and postgraduate and PhD), professional training (continuous training, professional development training, etc.) as well as educational, research and development projects in all subjects in the area of nuclear science, technology and management.
Budget	IAEA TC	IAEA TC AFRA-NEST membership fee to be paid through the AFRA membership fee financial arrangement	IAEA TC	Membership fees and services
Network platforms	Website: https://www.anentweb.org/	Not operational	Website: https://www.lanentweb.org/en LMS: https://www.lanentweb.org/es/portal-educativo-0	Website: https://www.star-net.online STAR-NET LMS: http://lms.star-net.online

ANNEX III. LIST OF NUCLEAR NETWORKS

In addition to the nuclear educational networks covered in Annex I and Annex II, there are several other networks that are or have been active in the nuclear sector; some of these are enumerated in this Annex, including their acronyms, names, period of operation and websites (when available). Specifically, Table III–1 lists networks (that have been) aimed at promoting education and training. Table III–2 refers to networks that have facilitated collaborative research in specific nuclear topics. Networks supported by the IAEA are considered in Table III–3, while Table III–4 lists other networks that are (or have been) active in different region on various scientific and technical nuclear areas. While this Annex offers a comprehensive overview of networks around various nuclear areas, the lists provided are not meant to be exhaustive.

TABLE III–1 LIST OF NUCLEAR EDUCATIONAL AND TRAINING NETWORKS

Acronyms	**Name**	**Region**	**Start date**	**End date**	**Website**
Educational and Training Networks					
AINSE	Australian Institute of Nuclear Science and Engineering	Australia	1958		https://www.ainse.edu.au/
CHERNE	Cooperation for Higher Education on Radiological and Nuclear Engineering	Mixed	2002		http://www.cherne.ntua.gr/
CINCH A-CINCH	Cooperation in Education in Nuclear Chemistry	Europe	2017		https://www.cinch-project.eu/
CIRTEN	Consorzio Interuniversitario per la Ricerca TEcnologica Nucleare alias Intra-University Consortium for Nuclear Technology Research	Europe Italy	1994		http://www.cirten.it/
EERRI	Eastern Europe Research Reactor Initiative	Europe	2008		
ENETRAP	European Network on Education and Training in Radiological Protection	Europe	2006	2018	https://enetrap.sckcen.be/

TABLE III–1 LIST OF NUCLEAR EDUCATIONAL AND TRAINING NETWORKS, cont.

Acronyms	Name	Region	Start date	End date	Website
ENSTTI	European Nuclear Safety Training and Tutoring Institute	Europe	2010	2020	https://enstti.eu/wp/
EUTERP	European Training and Education in Radiation Protection	Europe	2006		http://www.euterp.eu/
FuseNet	The European Fusion Education Network	Europe	2010		https://fusenet.eu/
GENTLE	Graduate and Executive Training and Lifelong Education	Europe	2013	2016	https://cordis.europa.eu/project/id/323304
INSTN	National Institute for Nuclear Science and Technology	Europe France	1956		https://instn.cea.fr/en/
I2EN	International Institute of Nuclear Energy	Mixed	2010		https://www.i2en.fr/en/
NANSS	Nordic Academy for Nuclear Safety and Security	Europe			https://www.nanss.uu.se/about-nanss/
NSSC	Nuclear Science and Security Consortium	US	2011		https://nssc.berkeley.edu/
PETRUS	E&T on Geological Disposal of Radioactive Wastes	Europe	2013	2016	https://enen.eu/index.php/portfolio/petrus-iii-project/
TRASNUSAFE	Training Schemes on Nuclear Safety Culture	Europe	2010	2014	https://cordis.europa.eu/project/id/249674
None	Consortium of Russian universities supporting Rosatom State Atomic Energy Corporation	Russian Federation	2001		https://uniatom.mephi.ru

TABLE III–2 LIST OF NUCLEAR RESEARCH NETWORKS

Acronyms	Name	Region	Start date	End date	Website
Research Networks					
ACSEPT	Actinide Recycling by Separation and Transmutation	Europe	2008	2012	https://cordis.europa.eu/project/id/211267
ACTINET-I3	ACTINET integrated Infrastructure Initiative	Europe	2009	2013	https://cordis.europa.eu/project/id/232631
ADRIANA	Advanced Reactor Initiative and Network Arrangement	Europe	2010	2011	https://cordis.europa.eu/project/id/249687
EAN	European ALARA Network	Europe	1996		https://www.eu-alara.net/
ESARDA	European Safeguards Research and Development Association	Europe	1969		https://esarda.jrc.ec.europa.eu/index_en
EURADOS	European Radiation Dosimetry Group	Europe	2006		https://eurados.sckcen.be/
F-BRIDGE	Basic Research for Innovative Fuel Design for GEN IV systems	Europe	2008	2012	https://cordis.europa.eu/project/id/211690
MELODI	Multidisciplinary European Low Dose Initiative	Europe	2010		http://www.melodi-online.eu/
NUCLEAR	Nuclear Universities Consortium for Learning, Engagement and Research	Europe UK	2011	2019	
NUGENIA	Nuclear Generation II & III Association	Mixed	2011		https://snetp.eu/nugenia/
NULIFE	Nuclear Plant Life Prediction	Europe	2006	2012	https://cordis.europa.eu/project/id/36412
SARNET	Severe Accident Research Network	Mixed	2009	2013	https://cordis.europa.eu/project/id/231747

TABLE III–3 LIST OF IAEA-SUPPORTED NETWORKS

Acronyms	Name	Region	Start date	End date	Website
IAEA-Supported Networks					
ANSN	Asian Nuclear Safety Network	Mixed	2002		https://ansn.iaea.org/default.aspx
dBN	beta-Delayed Neutron Emission network	Mixed			https://nucleus.iaea.org/sites/connect/bDNpublic/Pages/default.aspx
CGULS	Coordination Group for Uranium Legacy Sites	Mixed	2012		https://nucleus.iaea.org/sites/connect/CGULSpublic/Pages/default.aspx
DISPONET	International Low Level Waste Disposal Network	Mixed			https://nucleus.iaea.org/sites/connect/DISPONETpublic/Pages/default.aspx
DSRSNet	Disused Sealed Radioactive Sources Network	Mixed			https://nucleus.iaea.org/sites/connect/DSRSpublic/Pages/default.aspx
ENVIRONET	Network of Environmental Management and Remediation	Mixed			https://nucleus.iaea.org/sites/connect/ENVIRONETpublic/Pages/default.aspx
EuCAS	European and Central Asian Safety Network	Mixed	2016		https://gnssn.iaea.org/main/EuCAS/Pages/default.aspx
GFNI	Global Forum for Nuclear Innovation	Mixed	Under development		https://nucleus.iaea.org/sites/connect/GFNIpublic/Pages/default.aspx
GNIP	Global Network of Isotopes in Precipitation	Mixed	1960		https://www.iaea.org/services/networks/gnip
GNIR	Global Network of Isotopes in Rivers	Mixed	2002		https://www.iaea.org/services/networks/gnir

TABLE III–3 LIST OF IAEA-SUPPORTED NETWORKS, cont.

Acronyms	Name	Region	Start date	End date	Website
GNSSN	Global Nuclear Safety and Security Network	Mixed	2007		https://gnssn.iaea.org/main/pages/default.aspx
IDN	International Decommissioning Network	Mixed	2007		https://nucleus.iaea.org/sites/connect/IDNpublic/Pages/default.aspx
iNET-EPR	International Network for Education and Training for Emergency Preparedness and Response	Mixed	2019		https://gnssn.iaea.org/main/iNet-EPR/Pages/default.aspx
INLN	International Nuclear Library Network	Mixed	2005		https://www.iaea.org/resources/library/inln
INSEN	International Nuclear Security Education Network	Mixed			https://www.iaea.org/resources/network/international-nuclear-security-education-network-insen
IPN	International Predisposal Network	Mixed			https://nucleus.iaea.org/sites/connect/IPNpublic/Pages/default.aspx
LABONET	International Network of Laboratories for Nuclear Waste Characterization	Mixed	2011		https://nucleus.iaea.org/sites/connect/LABONETpublic/Pages/default.aspx
MSN	Management System Network of Excellence	Mixed			https://nucleus.iaea.org/sites/connect/MSNpublic/Pages/default.aspx
NFE Net	Nuclear Fuel Engineering Network	Mixed			https://nucleus.iaea.org/sites/connect/NFEpublic/Pages/default.aspx

TABLE III–3 LIST OF IAEA-SUPPORTED NETWORKS, cont.

Acronyms	Name	Region	Start date	End date	Website
NSSCs	International Network for Nuclear Security Training and Support Centres	Mixed	2012		https://www.iaea.org/services/networks/nssc
RSLS	International Working Forum on Regulatory Supervision of Legacy sites	Mixed	2010		https://nucleus.iaea.org/sites/connect/RSLSpublic/Pages/default.aspx
SFM Net	International Network on Spent Fuel Management	Mixed	2016		https://nucleus.iaea.org/sites/connect/SFMpublic/Pages/default.aspx
UPC Net	Network on the Uranium Production Cycle	Mixed	2010		https://nucleus.iaea.org/sites/connect/UPCpublic/Pages/default.aspx
URF	Underground Research Facilities Network	Mixed	2001		https://nucleus.iaea.org/sites/connect/URFpublic/Pages/default.aspx
VETLAB	Veterinary Diagnostic Laboratory Network	Mixed	2010		https://www.iaea.org/services/networks/vetlab

TABLE III–4 LIST OF OTHER NETWORKS OPERATING IN THE NUCLEAR SECTOR

Acronyms	Name	Region	Start date	End date	Website
Other Nuclear Networks					
AFoSaN	African Food Safety Network	Africa			http://www.africanfoodsafetynetwork.org/
ALATI	Latin American Association of Irradiation Technologies	Latin America	2014		http://www.alati.la/
ALASBIMN	Latin American Association of Biology and Nuclear Medicine Societies	Latin America	1964		http://www.alasbimn.net/
EFNUDAT	European Facilities for Nuclear Data Measurements	Europe	2006	2010	https://cordis.europa.eu/project/id/36434
ERINDA	European Research Infrastructures for Nuclear Data Applications	Europe	2010	2013	https://cordis.europa.eu/project/id/269499
FSA	Food Safety Asia network	Asia	2016		http://www.foodsafetyasia.org/
HERCA	Heads of Radiation Protection Authorities	Europe	2007		https://www.herca.org/
IGDTP	Implementing Geological Disposal Technology Platform	Mixed	2009		https://igdtp.eu/
IRPA	International Radiation Protection Association	Mixed	1965		http://www.irpa.net/
JN-HRD Net	Japan Nuclear Human Resources Development Network	Asia Japan	2007		https://jn-hrd-n.jaea.go.jp/en/

TABLE III–4 LIST OF OTHER NETWORKS OPERATING IN THE NUCLEAR SECTOR, cont.

Acronyms	Name	Region	Start date	End date	Website
LBDNET	Latin American Network of Biological Dosimetry	Latin America	2007		https://www.facebook.com/people/Red-Latinoamericana-de-Dosimetr%C3%ADa-Biol%C3%B3gica-LBDNet/100063040160533/
MyNE-HCKD	Malaysia Nuclear Energy Human Capital & Knowledge Development Network	Asia Malaysia	2018		
NERIS	European Platform on Preparedness for Nuclear and Radiological Emergency Response and Recovery	Europe	2009		https://www.eu-neris.net/
SNETP	Sustainable Nuclear Energy Technology Platform	Europe	2007		http://www.snetp.eu/
TEA	Thorium Energy Alliance	Mixed	2009		https://thoriumenergyalliance.com/
None	Turkish National Nuclear HRKD network	European Türkiye	2017		
WNA	World Nuclear Association	Mixed	1975		https://www.world-nuclear.org/

ANNEX IV. COLLABORATION AGREEMENT AMONG NUCLEAR EDUCATIONAL NETWORKS

COLLABORATION AGREEMENT

AMONG NUCLEAR EDUCATIONAL NETWORKS:

AFRA-NEST, ANENT, ENEN, LANENT, STAR-NET

BNEN, NTEC and UNENE

February 2021

This Collaboration Agreement is made between the following Regional Networks: the Asian Network for Education in Nuclear Technology (ANENT), the Latin-American Network for Education in Nuclear Technology (LANENT), the African Network for Nuclear Education, Science and Technology (AFRA-NEST), the European Nuclear Education Network Association (ENEN) and the Regional Network for Education and Training in Nuclear Technology (STAR-NET) and the National Networks: the Belgian Nuclear higher Education Network (BNEN), the Nuclear Technology Education Consortium (NTEC) and the University Network of Excellence in Nuclear Engineering (UNENE). This Agreement replaces the original Collaboration Agreement between the regional educational networks signed in 2017 and extends it to include BNEN, NTEC and UNENE.

ANENT, LANENT, and AFRA-NEST are regional networks, founded with the objectives to foster nuclear education and training and international partnerships in achieving high quality education and training up to global standards, as well as in maintaining capacities in teaching and retaining expert knowledge in nuclear science and technology.

ENEN is a non-profit international organization under the Belgian Law, aiming at the preservation and further development of expertise and in nuclear field by higher education and training.

STAR-NET is a non-profit association under the Austrian Law of Associations with international memberships, aiming to promote, manage and preserve nuclear knowledge and to ensure the continued availability of talented and qualified human resources in the nuclear field.

BNEN, the Belgian Nuclear Education Network, is a consortium of six Belgian universities and the Belgian Nuclear Research Centre SCK CEN which coordinates the activities. Through the multilateral efforts of its member universities, BNEN offers a Master-after-Master specialization in nuclear engineering.

NTEC is a consortium of UK universities, working together to deliver a combined curriculum taking advantage of the strengths in each partner, and developing the next generation of nuclear engineers.

UNENE is a not-for-profit partnership based in Canada of leading nuclear industry organizations in cooperation with nuclear universities, that provides cooperative programmes in education, training and capacity-building through university research, to benefit the nuclear community at large and society.

The nuclear educational networks have identified benefit in working together, sharing good practices, resources and opportunities for capacity building and effective nuclear education. The collaboration of educational networks contributes to the promotion, management and preservation of nuclear knowledge, and helps to ensure that talented and qualified human resources are available for the safe and sustainable use of nuclear technology.

Scope of Collaboration

The objective of this Collaboration Agreement is to sustain a framework of collaboration between Regional and National Networks in nuclear education, training, related research and outreach. The framework identifies three main areas of collaboration: human resource development, outreach and educational tools and technology. These areas of collaboration may include the activities below, which, when agreed, will be added to a Networks' Collaboration Work-plan:

- Collaboration on nuclear education and training, including leadership and management skills, for university students and nuclear professionals;
- Collaboration on research and development projects, including nuclear education and nuclear technology;
- Exchange of information, teaching materials and advanced tools for education, training and outreach in relation to nuclear technology;
- Development of mechanisms for benchmarking and peer-review;
- Collaboration on the development and application of innovative and modern educational technologies in nuclear education;
- Exchange of students, teachers and researchers;
- Sharing best practices in nuclear education and educational resources.

The development and review of the work plan, conducted under the collaboration framework, shall be done annually and agreed by all the Networks.

Non-Binding

This Collaboration Agreement is non-binding. Accordingly, nothing in this Collaboration Agreement gives rise to legal or financial obligations upon the signatory Networks. To the extent that any activity gives rise to any legal or financial obligation, it shall be subject to a separate agreement to be concluded prior to such activity being undertaken.

Use of Names and Emblems

Documentation relating to activities undertaken under this Collaboration Agreement may include the respective names and emblems of the signatory Networks. The names and emblems are, and remain, the property of the respective Network. Joint use of the names and emblems of the signatory Networks is restricted to activities conducted under this Collaboration Agreement.

Information Sharing

The signatory Networks protect the confidentiality of information classified by the other signatory Networks as restricted or confidential, while supporting the dissemination of information openly provided or exchanged under this Collaboration Agreement.

Intellectual Property

The Networks consult each other, as appropriate and if circumstances so require, on issues relating to intellectual property and rights thereto including the necessity of separate agreements.

Settlement of Disputes

Any disputes arising out of or relating to the interpretation or implementation of this Collaboration Agreement are expected to be amicably settled between the Networks.

Modification

Modifications of this Collaboration Agreement, or waiver of any of its provisions, will be valid only when mutually confirmed in writing by all of the Networks.

Duration

This will remain valid for a period of four (4) years after signature by all networks and can be extended by the written consent of the signatory Networks.

Termination

Any Network that is a signatory of this Collaboration Agreement may terminate its participation by giving sixty (60) days written notice to all other Networks. When notice of termination is given, all remaining signatory Networks will take immediate steps to adapt the activities under this Collaboration Agreement accordingly.

LIST OF ABBREVIATIONS

AFRA	Africa Regional Cooperative Agreement for Research, Development and Training related to Nuclear Science and Technology
AFRA-NEST	AFRA-Network for Education of Nuclear Science and Technology
AINSE	Australian Institute of Nuclear Science and Engineering
ANENT	Asian Network for Education in Nuclear Technology
BNEN	Belgian Nuclear higher Education Network
CLP	Cyber learning platform
CLP4NET	Cyber Learning Platform for Network Education and Training
CNEA	Argentine National Atomic Energy Commission
CTBTO	Comprehensive Nuclear-Test-Ban Treaty Organization
CPD	Continuous professional development
ECTS	European Credit Transfer and Accumulation System
ENEN	European Nuclear Engineering Network
E&T	Education and training
HEIs	Higher education institutions
HRKD	Human resource and knowledge development
ICT	Information and communication technology
INIS	International Nuclear Information System
INMA	International Nuclear Management Academy
INPRO	International Project on Innovative Nuclear Reactors and Fuel Cycles
INSTN	National Institute for Nuclear Science and Technology
IT	Information technology
JN-HRD	Japan human resources development
KM	Knowledge management
KMAVs	Knowledge Management Assist Visits
KU	Katholieke Universiteit

LANENT	Latin American Network for Education in Nuclear Technology
LMS	Learning management system
MS	Member State
NEM	Nuclear energy management
NEST	Nuclear education, skills and technology
NKM	Nuclear knowledge management
NSSC	Nuclear Science and Security Consortium
NS&T	Nuclear science and technology
NTEC	Nuclear Technology Education Consortium
PA	Practical Arrangement
SC	Steering Committee
SCK CEN	The Belgian Nuclear Research Centre
SMR	Small Modular Reactor
STEM	Science, technology engineering and mathematics
TC	Technical Cooperation
ToRs	Terms of Reference
TSO	Technical support organization
ULB	Université libre de Bruxelles
UNENE	University Network of Excellence in Nuclear Engineering

LIST OF CONTRIBUTORS TO DRAFTING AND REVIEW

Barrachina, R.	Latin American Network for Education in Nuclear Technology
Caratas, D.	International Atomic Energy Agency
Coeck, M.	Belgian Nuclear Education Network
Drury, D.	International Atomic Energy Agency
Guo, X.	Asian Network for Education in Nuclear Technology
Hashim, N.	African Network for Education in Nuclear Science and Technology
Kosilov, A.	Regional Network for E&T in Nuclear Technology – STAR-NET
Pavel, G.	European Nuclear Education Network
Picado, E.	Latin American Network for Education in Nuclear Technology
Roberts, J. W.	International Atomic Energy Agency
Timoshchenko. A.	Regional Network for E&T in Nuclear Technology – STAR-NET
Urso, M.E.	International Atomic Energy Agency
Whittle, K.	Nuclear Technology Education Consortium

Consultants' Meetings

Consultants' Meeting, 13–16 October 2020

Consultants' Meeting, 9–11 November 2021

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Technical Meeting, 13–16 October 2020

Technical Meeting, 2–6 August 2021

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