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Building Competencies in Strategic Planning for Sustainable Nuclear Energy Development

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Rationale for Model Curriculum on Strategic Planning for Sustainable Nuclear Energy Development

- **The IAEA General Conference [GC(65)11] requested the Secretariat to assist Member States in their efforts to ensure the sustainability of nuclear education and training in all areas of the peaceful use of nuclear energy.**
- **IAEA/INPRO has developed a set of basic principles, user requirements and criteria, and an assessment method which together comprise the INPRO methodology for the evaluation of the long-term sustainability of nuclear energy systems (NES).**
- **The INPRO methodology covers all areas relevant to NES sustainability, reactor types and fuel cycle facilities, all facilities of an NES, and all phases of an NES from the cradle to the grave.**
- **INPRO has developed a framework for analysing and assessing transition scenarios to sustainable nuclear energy systems.**
- **In this respect, INPRO has initiated an effort to develop a model curriculum for introducing courses/modules on strategic planning for sustainable nuclear energy development and introduce the necessary education programmes at university level.**

The need for competencies in Strategic Planning for Sustainable Nuclear Energy Development

- **The key challenge for sustainable energy development is to address the interactions among the four dimensions: economic, environment, social, and institutional, in a balanced way, and making relevant trade-offs. Nuclear energy has the potential to make a significant contribution to sustainable energy.**
- **Specific competencies (knowledge and practical skills) are needed on the planning and modelling of scenarios of the NES evolution and on the use of the INPRO methodology for performing sustainability assessment of NESs, in order to assist Member States in long-range and strategic planning for the development of nuclear energy programmes as part of their national energy mix.**
- **It is essential that knowledge on IAEA/INPRO methods and tools be delivered to young professionals, lecturers and students at technical universities and other relevant educational organizations, who will further be engaged in development and deployment of sustainable solutions for nuclear systems in the IAEA Member States.**

Competency (Plural Competencies) - A **statement** that defines a particular area of knowledge, skill, attitude or behaviour that is required to perform a particular role or task to a certain standard

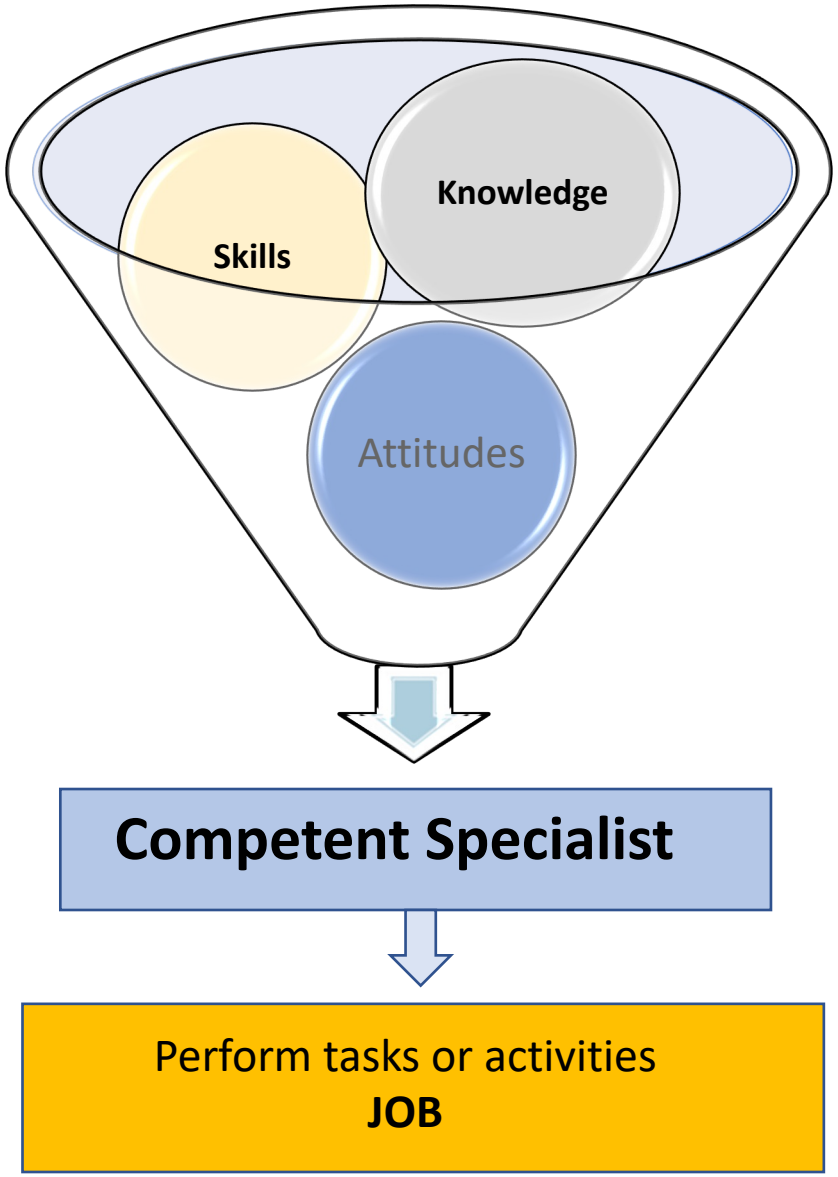
Competence - The **ability** to put skills, knowledge and attitudes into practice in order to perform a task or role in an effective and efficient manner to an established standard (**competent specialist**)

Competence = Knowledge + Skills + Attitude

Competency Framework - A Competency or Competence Framework is the structure within which knowledge, skill and attitude are organised.

Competency Graphic Display

SKILLS relates to the ability to do, physical domain



Knowledge relates to information, cognitive domain.

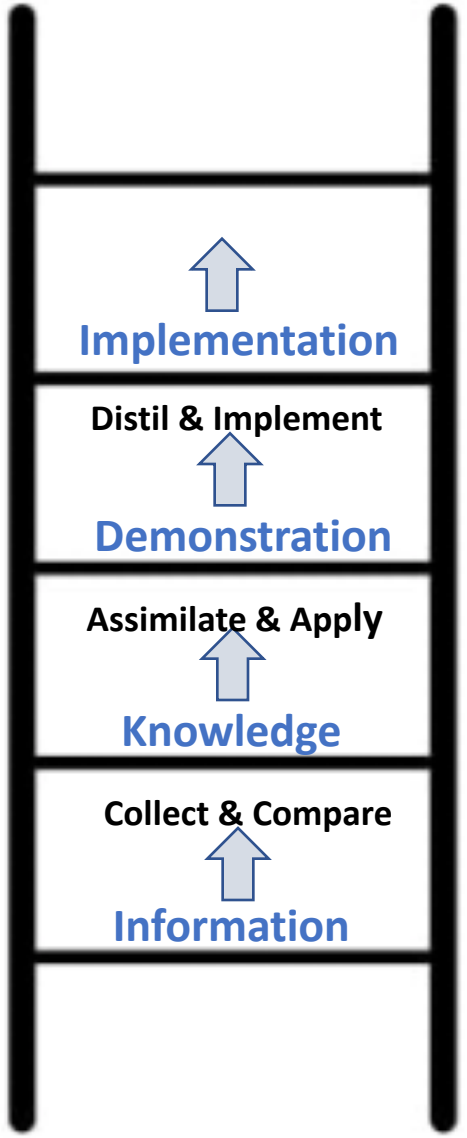
Attitude relates to manner, disposition, feeling, position, etc., with regard to a company, psychology domain

Knowledge – Demonstration – Implementation

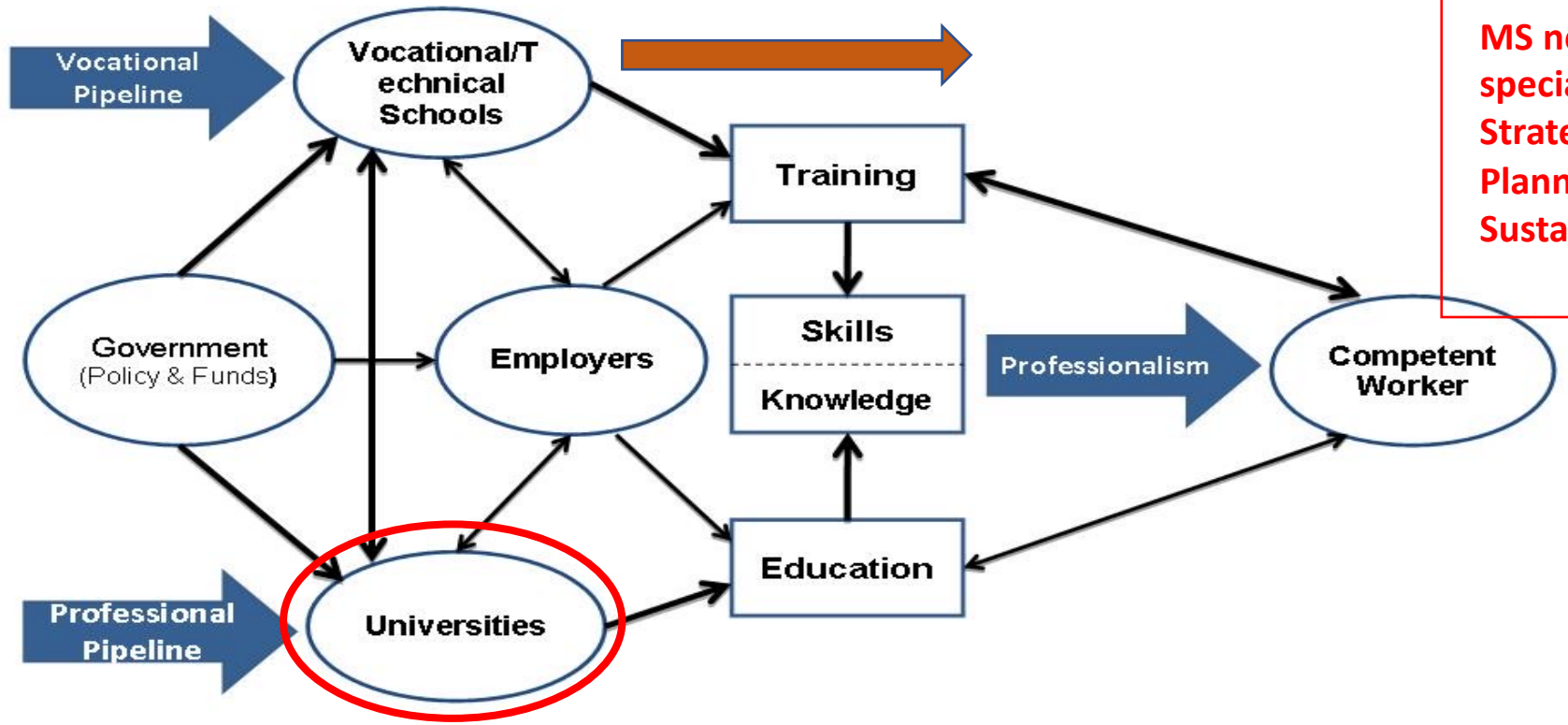
The Knowledge Ladder

Each student should

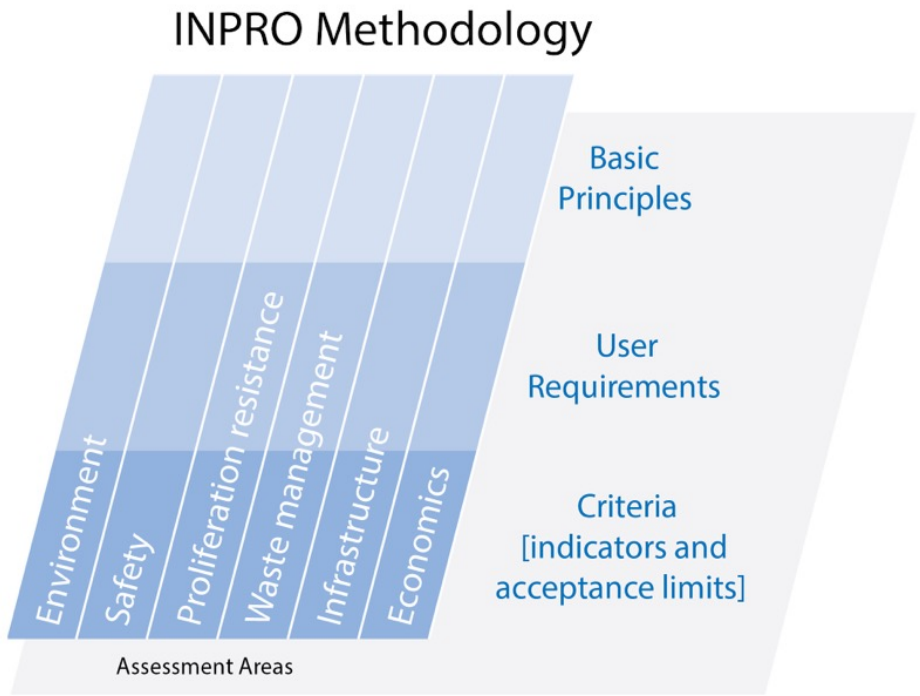
- **know a specified level of knowledge (Knowledge)**
- **be able to demonstrate application of the knowledge (Demonstration)**
- **know when to implement the knowledge (Implementation)**



Government-University-Industry Interaction to produce Competent Specialists



MS needs for specialits for Strategic Planning for Sustainable NES



The educational course, based on the INPRO methodology and assessment tools in various areas, will contribute to the development of a holistic approach among students in the application of innovative nuclear technologies and their relationship with the energy system in general and the nuclear energy system (NES) in particular.

Purpose of the course

- **The curriculum and associated educational modules support capacity building and national human resource development in the nuclear energy sector.**

The specific objectives of the Course are:

- **To provide knowledge and practical skills** on the planning and modelling of scenarios of the NES evolution and on the use of the INPRO methodology for performing sustainability assessment of NESs;
- **To familiarize the students with the INPRO concept of NES sustainability in different areas**, such as: economics, infrastructure, waste management, environment, proliferation resistance, reactor and fuel cycle safety, and provisions for further sustainability development and improvement by which substantial enhancements of sustainability in particular assessment areas could be evaluated and quantified;
- **To develop understanding of sustainability issues** in a planned NES and ability to perform nuclear energy system analysis and assessment of the selected areas using the INPRO methodology criteria.

Target audience

- **Master level students of Nuclear Science, Nuclear Technology and Nuclear Engineering**

- **The course is also useful for students studying international relations, political science and management, as well as a base for training on nuclear energy strategic planning and sustainability assessment (as part of a continuing education programme) for managers and technical professionals working in the nuclear industry.**

Prerequisites for the course

- **Prerequisite for the proposed course is a Bachelor degree in nuclear sciences or engineering.**

- **It is recommended that the course be included in the master programme, when a basic or intermediate level of nuclear knowledge has been acquired. At this point the student should be able to comprehend the value of managing this knowledge as asset.**

- ***Specific requirements for each educational modules.***

Competency Areas

Group 1 - Energy planning and strategies for sustainable development

Group 2 - Planning for nuclear energy sustainability

Group 3 - Innovations in nuclear energy sector in meeting sustainable energy development challenges

Group 4 – Nuclear energy systems modelling and analysis

Group 5 - The methodology for assessing sustainability of nuclear energy systems (the INPRO Methodology)

The course composition

- **Part 1. Core modules**
- **Part 2. Advanced modules**

Part 3. Research project module

Core modules

Module 1
Energy planning and strategies for sustainable development

Module 2
Planning for Nuclear Energy Sustainability

Module 3
Innovations in Nuclear Energy Sector in Meeting Sustainable Energy Development Challenges

Advanced modules

Module 4
Introduction to the INPRO methodology for assessing sustainability of nuclear energy systems

Module 5
Methods and tools for planning sustainable energy development

Module 6
Methods and tools for modelling and analysis of nuclear energy systems

Research project module

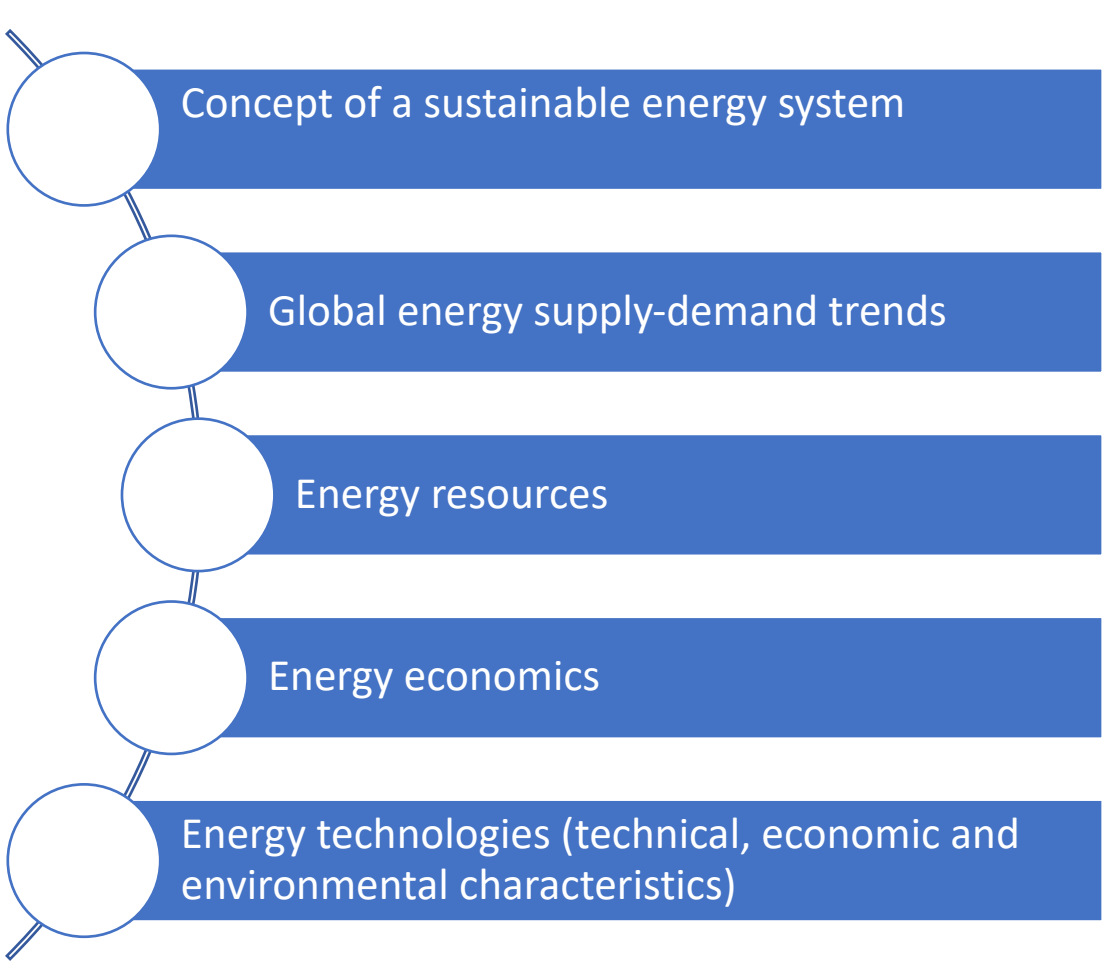
Module 7

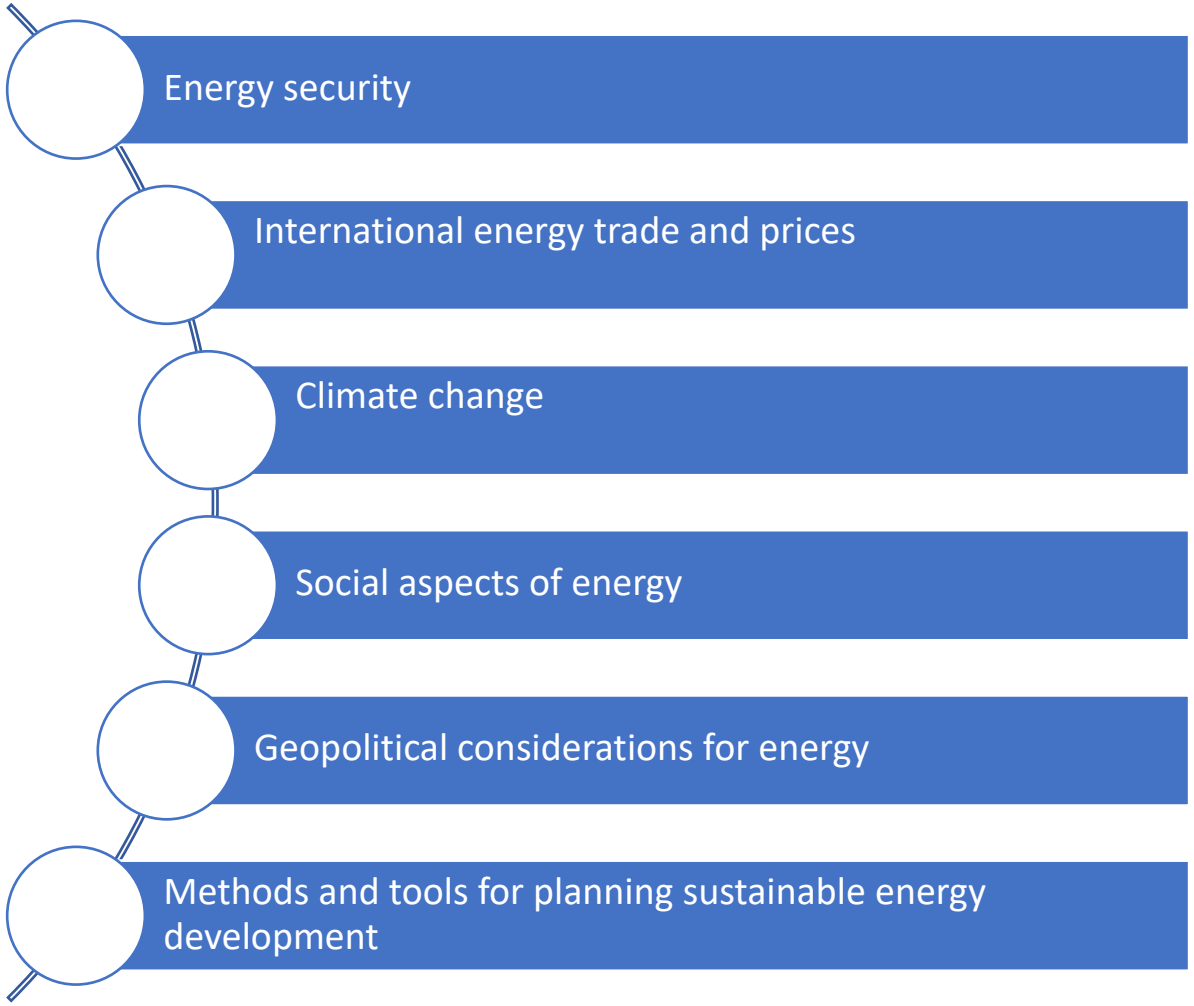
Research projects on planning and assessment of energy and nuclear energy systems.

Description of the Educational Modules

- **Short description**
- **Learning objectives**
- **Prerequisites**
- **Learning outcomes**
- **Outline of module topics**
- **Suggested teaching delivery methods and student performance assessment**
- **Bibliography**

Module 1. Energy planning and strategies for sustainable development – Main Topics





Module 1. Energy planning and strategies for sustainable development – Learning Objectives and Prerequisites

Establish an understanding of the technical, economic, environmental, social and geopolitical considerations in the development of sustainable energy strategies for a country or a region.

Familiarize students with an evaluation of potential roles of various energy resources and technologies in meeting future energy needs for sustainable development.

Prerequisites:

The students are expected to possess a basic knowledge of mathematics, physics and energy technologies. An engineering background is advantageous but not mandatory.

Module 1. Energy planning and strategies for sustainable development

LEARNING OUTCOMES UPON COMPLETION OF THE MODULE

No	Expected learning outcomes
1	**Explain the main aspects that need to be considered in evaluating the energy choices for national energy strategies for sustainable development plans.**
2	**Express familiarity with energy resources, energy technologies and their technical, economic and environmental characteristics.**
3	**Demonstrate understanding of energy economics and methodology for economic comparison of various energy options.**
4	**Illustrate awareness of the geopolitical considerations for energy security and international energy trade.**
5	**Demonstrate familiarity with the methods and tools available for conducting evaluation of various energy technologies in terms of their technical, economic and environmental characteristics, and for developing sustainable energy strategies.**

Module 2. Planning for Nuclear Energy Sustainability – Main Topics

- Introduction to sustainable nuclear energy systems
- Nuclear power reactors and fuel cycles
- Economics of nuclear power
- Risks and benefits of nuclear energy
- Role of nuclear power in combating climate change
- Public acceptance of nuclear energy
- Geopolitical considerations for nuclear energy
- International obligations and norms for peaceful uses of nuclear energy
- Overview of INPRO methodology for analysing and assessing sustainability of nuclear energy systems

Module 2. Planning for Nuclear Energy Sustainability – Learning Objectives

1. Familiarise students with the concept of sustainable nuclear energy systems based on the UN concept and developed by INPRO

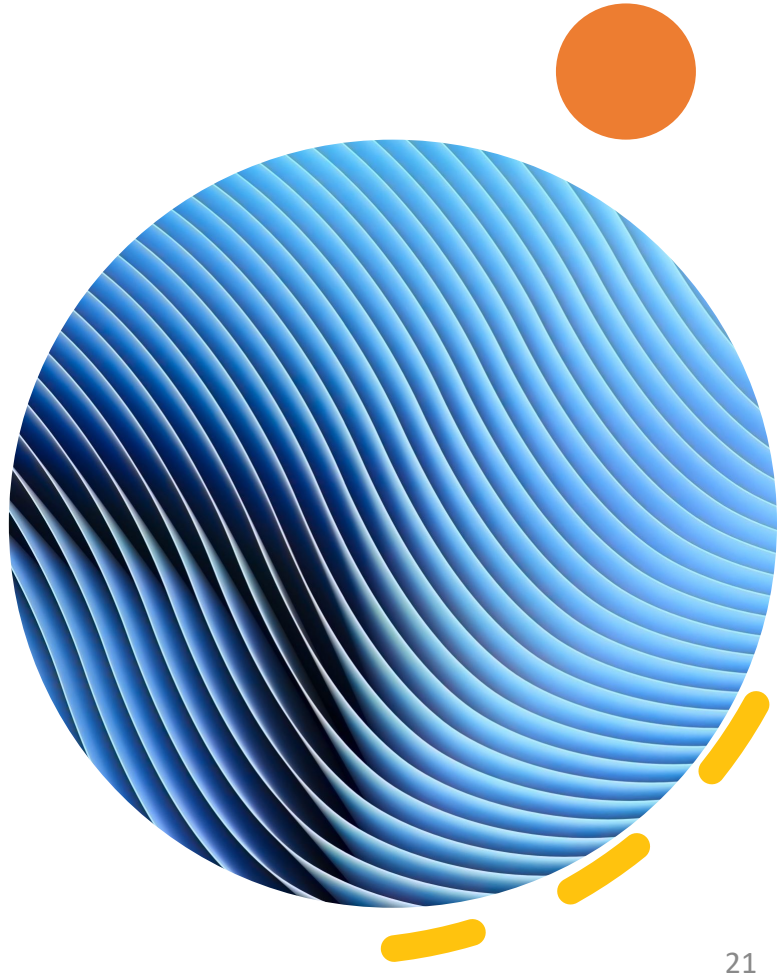
2. Develop an understanding of the technical, economic, social, environmental and geopolitical aspects of nuclear energy

3. Explain the international obligations and norms for peaceful application of nuclear technologies

4. Describe the INPRO methodology for analysing and assessing sustainability of nuclear energy systems

Module 2. Planning for Nuclear Energy Sustainability – Prerequisites

- **Possess a basic knowledge of mathematics, physics, and nuclear power technologies; an engineering background (including a bachelor's degree in nuclear engineering) is advantageous.**
- **<u>Successful completion of core module 1</u> 'Energy planning and strategies for sustainable development' of the model curriculum or a module or course with similar content.**



Module 2. Planning for Nuclear Energy Sustainability

LEARNING OUTCOMES UPON COMPLETION OF THE MODULE

Expected learning outcomes (1)

1	**Explain the concept of sustainable nuclear energy systems as developed by INPRO and presented in relevant IAEA publications.**
2	Relate the INPRO concept of sustainable energy systems to the sustainable energy development for achieving Sustainable Development Goals (SDGs).
3	Perform exercises on dynamic NES modelling using NES simulators and economic analysis at NPP level with NEST tool.
4	Describe the technical and economic features of various nuclear power technologies, including their respective fuel cycles, using the module teaching materials.
5	Summarize potential benefits and major risks induced by the use of nuclear energy. .
6	Illustrate the importance of public acceptance of nuclear energy using examples from different countries and stating main factors influencing public acceptance of nuclear power.

Module 2. Planning for Nuclear Energy Sustainability

LEARNING OUTCOMES UPON COMPLETION OF THE MODULE

Expected learning outcomes (2)

7	**Describe sensitivities related to nuclear technologies and material..**
8	List main national responsibilities and obligations for peaceful uses of nuclear energy.
9	Summarize the essence of international conventions governing peaceful uses of nuclear energy.
10	Describe briefly the INPRO methodology for analysing and assessing sustainability of nuclear energy systems, using the IAEA publications and module teaching materials.
11	Summarize potential benefits and major risks induced by the use of Demonstrate valuing the planning for the sustainability of a nuclear energy system.

Module 6. Methods and Tools for Modelling and Analysis of Nuclear Energy Systems – Main Topics

- Introduction to INPRO approaches and tools for modelling and analysis of nuclear energy systems
- INPRO framework for NES scenario modelling and analysis
- Basics for NES mass flow and economic analysis
- NES Simulators - simple models of a nuclear energy
- Modelling of nuclear energy systems with MESSAGE-NES
- NES road mapping and ROADMAPS-ET
- Multi-criteria decision making for judgment aggregation
- Social aspects of energy
- Comparative evaluation of NES options with the use of multiple-criteria decision analysis (MCDA): the KIND approach and tool
- NESA Economics Support Tool

Module 6. Methods and Tools for Modelling and Analysis of Nuclear Energy Systems – Learning Objectives

- Familiarize the students with the approaches for modelling and analysis of nuclear energy systems as developed by INPRO.
- Explain the basis for mass flow analysis and multi-criteria decision making for judgment aggregation.
- Familiarize the students with the INPRO approach for comparative evaluation of nuclear energy options and scenarios.

- Describe the INPRO approach for NES road mapping;
- Introduce INPRO tools for NES scenario analysis, comparative evaluation of NES options and NES economic analysis.

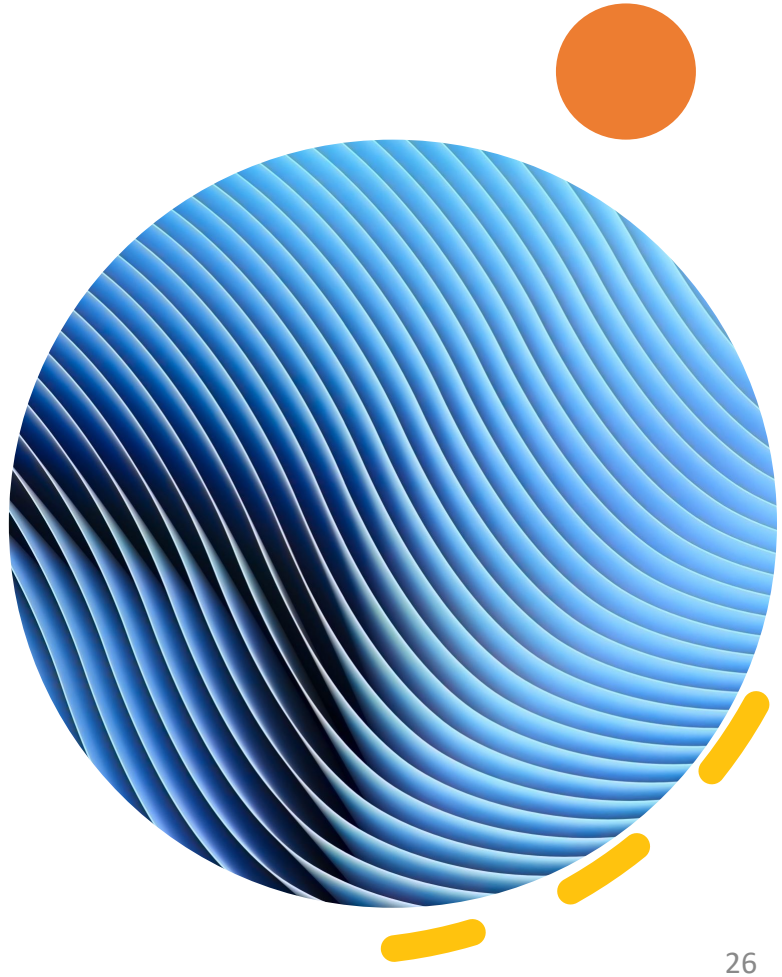
Module 6. Methods and Tools for Modelling and Analysis of Nuclear Energy Systems – Prerequisites

Possess a basic mathematics educational background and knowledge of the nuclear physics and technology basics.

Basic knowledge of Microsoft Excel software.

Some specialized prerequisite knowledge is advantageous but not mandatory, e.g., knowledge in linear programming, multi-criteria decision analysis, probability theory, fundamentals of energy planning and economics of nuclear energy, reactor physics, neutron physics, radioecology and radioactive waste management, infrastructure (including legal aspects) of nuclear power programmes, and programming basics.

Successfully complete a core module 2 'Planning for Nuclear Energy Sustainability' of the model curriculum; and optionally a core module 1 'Energy planning and strategies for sustainable development' and an advanced module 5 'Methods and Tools for planning sustainable energy development'.



Module 6. Methods and Tools for Modelling and Analysis of Nuclear Energy Systems

LEARNING OUTCOMES UPON COMPLETION OF THE MODULE

Expected learning outcomes

1	**Describe the INPRO approaches to modelling and analysing nuclear energy system.**
2	Using the module teaching materials, describe the framework for modelling and analysis of NES scenarios and main elements of the framework.
3	Perform exercises on dynamic NES modelling using NES simulators and economic analysis at NPP level with NEST tool.
4	Illustrate familiarity with MESSAGE-NES for modelling nuclear energy scenarios.
5	Illustrate familiarity with presenting nuclear development plans with ROADMAPS-ET.
6	Demonstrate knowledge of approaches and tools for NES comparative evaluation considering various key factors and multi-criteria analysis methods to select the preferred nuclear energy system.
7	Perform exercises on NES comparative evaluation using the IAEA tool KIND-ET and its extension.
8	Based on application of the INPRO tools and approaches to the case studies, formulate the main challenges for sustainable nuclear energy development and deployment, the role of innovation and international cooperation in long term sustainability of nuclear energy, and strategic planning for the NES deployment.

The course implementation

- The suggested educational modules provide a basis for different master's degree courses
- IAEA support for the Curriculum implementation
  - IAEA tools for energy analysis and planning
  - Training on IAEA methods, models and software tools in the subject field
  - Providing training/teaching materials for educational organizations for developing, using, customizing or adapting teaching material employing the model curriculum
  - Designing of educational courses using the model curriculum, and in the development or customization of teaching material
  - Piloting selected parts of educational courses that employ the model curriculum
  - Implementing educational courses with the model curriculum (e.g. through involving experts in specialized areas)
  - Organizing internships at the IAEA for practical study of subjects associated with the model curriculum
  - Performing scientific visits and fellowships
  - Providing access to INPRO resources on the IAEA Cyber Learning Platform for Nuclear Education and Training (CLP4NET)
  - Providing IAEA relevant publications (either through downloads at www.iaea.org/publications, or through an order request to the IAEA).

IAEA Document: Model Curriculum On Strategic Planning For Sustainable Nuclear Energy Development

CONTENTS

Thank you for your attention!