IAEA 60 Years
Atoms for Peace and Development

Developing Roadmaps to Enhance Nuclear Energy Sustainability: Roadmap template and ROADMAPS Excel based tool

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IAEA
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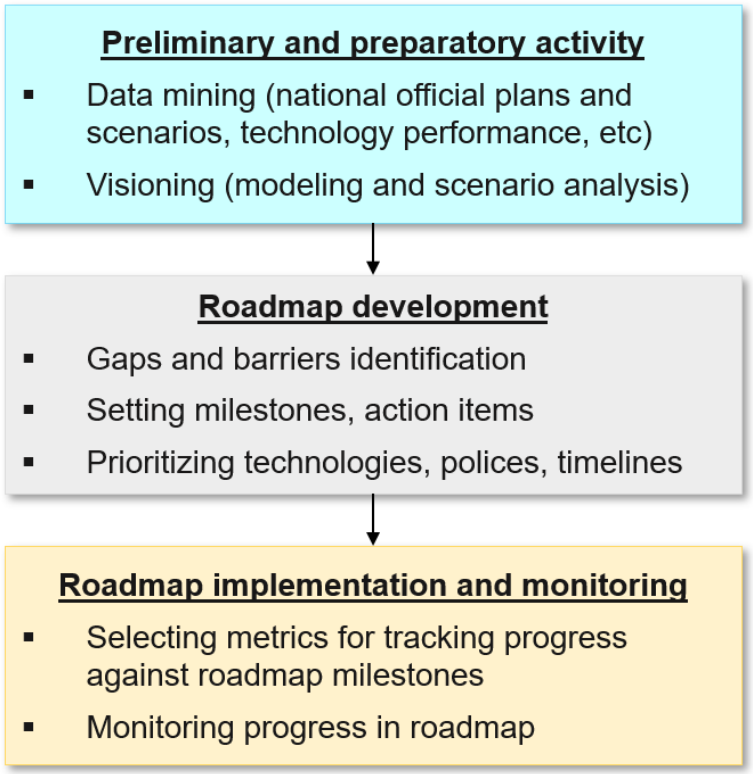
International Project on
Innovative Nuclear Reactors
and Fuel Cycles

Introduction

- Roadmaps help transforming visions to realities. They are like action plans and guides for achieving the goals or targets.
- A vision, fully understood and agreed by all stakeholders, gives a direction for developing the roadmap.
- This could be a very detailed Action Plan with timeline and resources needed. Actions have to be effectively coordinated and could include include their timings , sequence and interlinkage.
- There needs to be constant monitoring and tracking of progress against roadmap milestones during the implementation stage and if needed adjustment to the direction or action plan should be done.

Road mapping process

- Road mapping towards enhanced nuclear energy sustainability is an integrated framework allowing more effective use of the results of all previous INPRO activities in “Global scenarios” area
- It could be an added value for decision makers interested in long term NES deployment strategy justification.



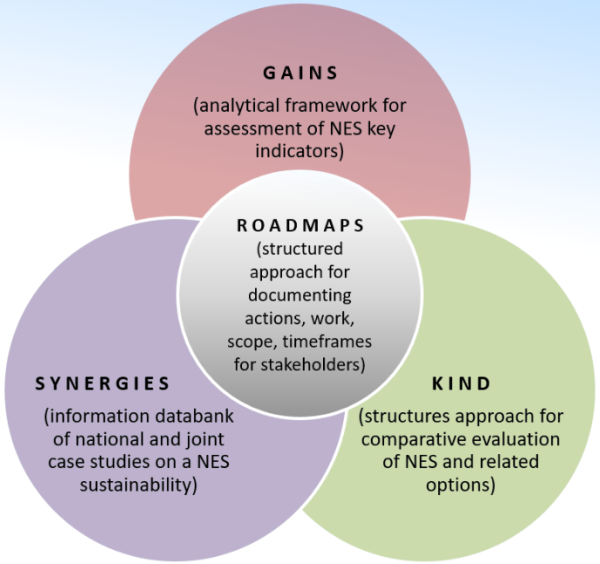
Road mapping tool

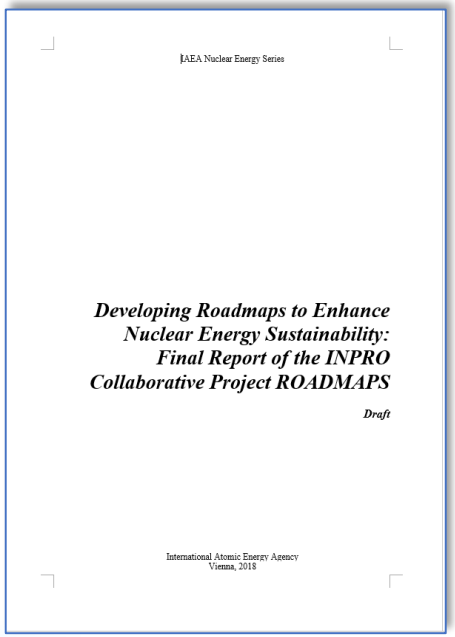
- When elaborating a roadmap towards enhanced nuclear energy sustainability, it is practical to acquire an appropriate tool, which can detail and specify the actions by particular stakeholders, the scope of work, the technologies, the timeframes and the institutional and other crosscutting mechanisms that could facilitate NES sustainability enhancement through both, *innovation in technology and collaboration (nuclear trade) among countries.*
- Most important here is visualization as it a characteristic feature of any roadmap to demonstrate interconnections, system evolutions and time-dependencies, etc. Overall, a roadmap needs to appear as a multi-layered time-based chart.
- When road mapping is done for NES, it is *inter alia* necessary to represent the existing and planned (or projected) reactor fleet and the requirements for products and services of the nuclear fuel cycle front-end and back-end within the selected timeframes.
- Overall, a road mapping tool needs to support roadmap development and implementation, making it possible to explore linkages, trade-offs and consequences, thereby facilitating finding solutions consistent with the sustainable development goals.

Road mapping towards enhanced nuclear energy sustainability

The INPRO collaborative project “Roadmaps for a transition to globally sustainable nuclear energy systems” (ROADMAPS) has developed:

- The *roadmap template* representing a structured approach for achieving globally sustainable nuclear energy, providing models for international cooperation and framework for documenting actions, scope of work, and timeframes for specific collaborative efforts by particular stakeholders;
- An approach for bottom-up integration of national roadmaps to derive a regional or a global projection of a pathway towards enhanced nuclear energy sustainability;
- The ROADMAPS Excel Tool (ROADMAPS-ET) supporting practical application of the above mentioned approaches and the analysis/visualization of the results of such applications;
- Examples of a trial application of the roadmap template and the integration approach in a series of case studies performed by project participants;
- The training materials and Webex-based consultants’ services provided by the INPRO Secretariat with respect to the above mentioned.




IAEA Nuclear Energy Series

Developing Roadmaps to Enhance Nuclear Energy Sustainability: Final Report of the INPRO Collaborative Project ROADMAPS

Draft

International Atomic Energy Agency
Vienna, 2018

Purpose of the roadmap template and its structure

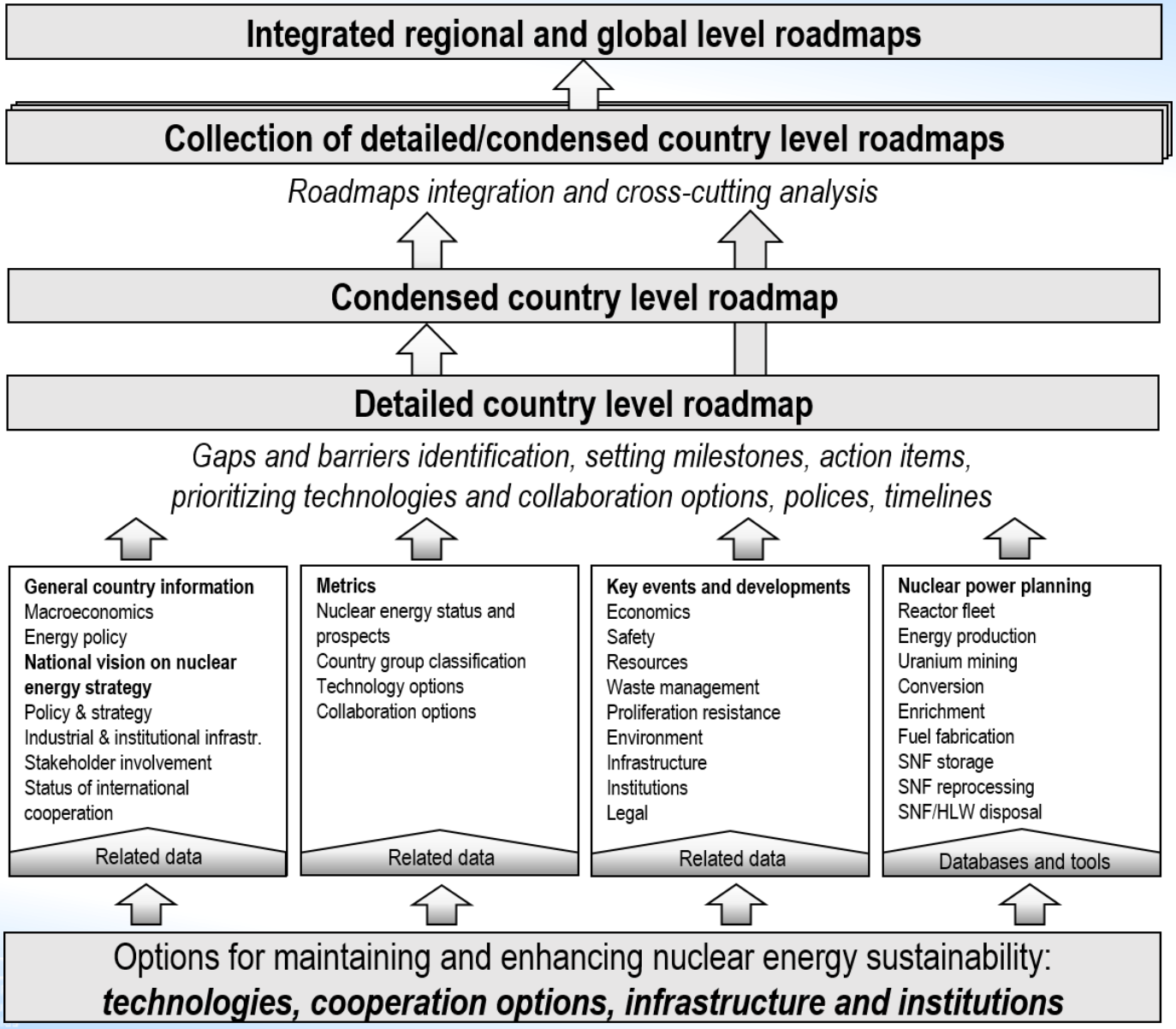
Purpose and features of the roadmap template

- The roadmap template can be used for strategic planning and analytical studies, as well as for preparation of reports for managers and even articles for the media regarding issues related to the enhancement of NES sustainability.
- The roadmap template is designed as a flexible, multipurpose and easy-to-use analytical tool. It embraces all categories of nuclear stakeholders, including technology holder, technology user and newcomer countries.
- The template employs Gantt charts directly intended for analysis of NES deployment strategies and for presentation of the results of this analysis at national, regional and global levels.
- Although the template contains a tool that makes it possible, if necessary, to perform supporting calculations, the template on the whole is a qualitative analytical instrument, the main objective of which is to standardize and structure the information submissions on issues relevant for NES sustainability enhancement.
- Roadmap template provides a concise, illustrative and interactive report per one or several screens. It represents a set of essential data and indicators grouped and arranged in such a way that all minimally necessary basic and key information is located on the same screen.
- The template is intended for a country-level roadmap. Several country level roadmaps can then be combined.

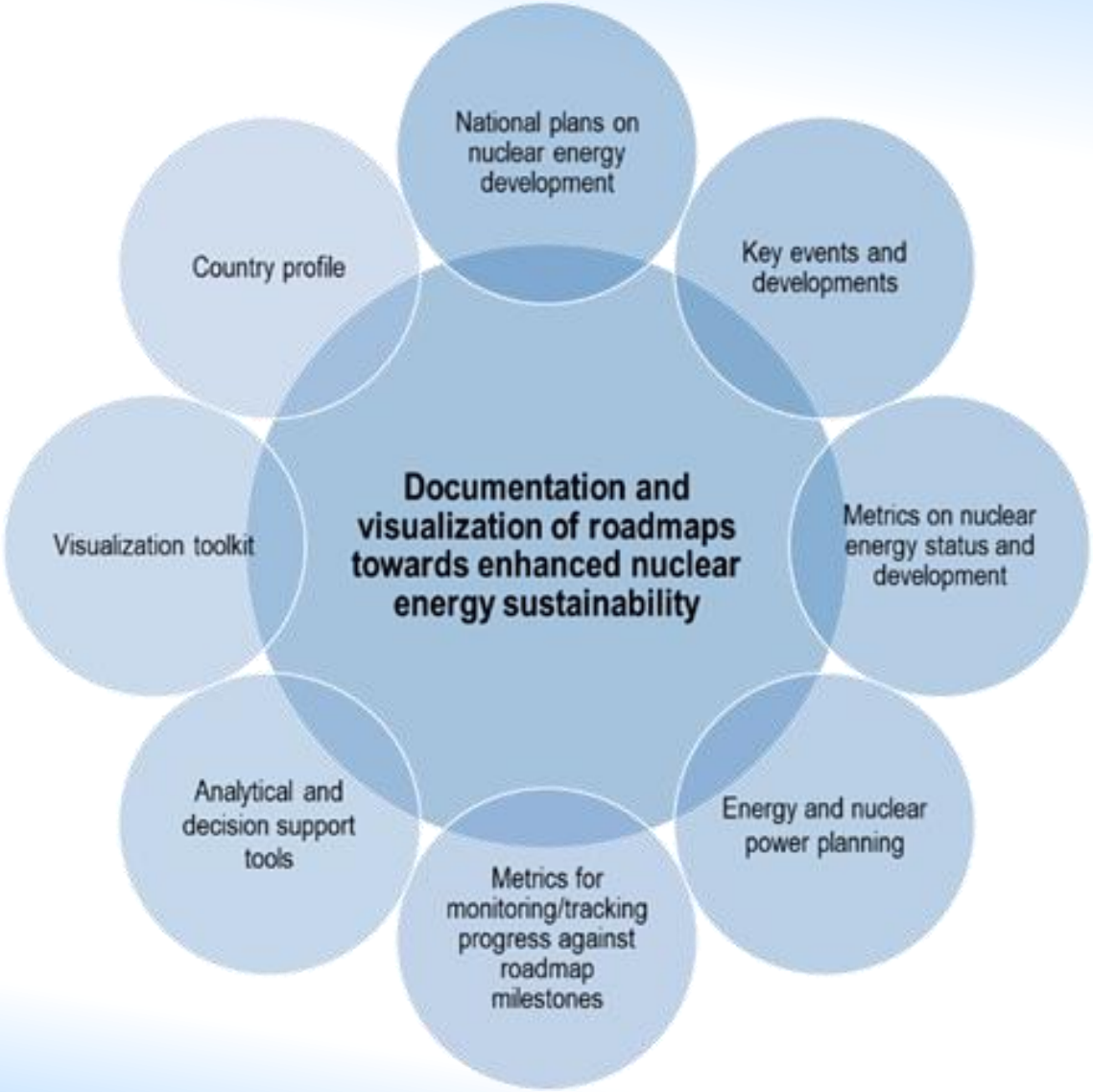
Structure of the roadmap template

- The roadmap template includes several structural elements, interrelated by a common logic and allowing characterizing the current situation in nuclear energy sector and plans or projections for nuclear power development in the time perspective under consideration.
- The main structural components of the roadmap template are as follows:
  - General country information;
  - National plans and perspectives on nuclear energy development;
  - Metrics on nuclear energy position and development;
  - Key tasks and developments;
  - Reactor fleet and nuclear fuel cycle evolution;
  - Progress monitoring;
  - Reactor database and information sources;
  - Nuclear power planning and scenario analysis tools;
  - Integration and cross cutting analysis.

Roadmap template diagram



Information sources and data flows



Country nuclear power profile

General country information

‘General country information’ includes general information on:

- macro-economic conditions and motivation for nuclear power deployment,
- strategy and development scenarios in the energy sector;
- nuclear energy as part of the national energy mix;
- share of nuclear energy in the national energy mix

Country	
Year	
Population, mln	
GDP, bln USD	
GDP per capita, 10^3 USD/c	-

This information can be used to analyze general situation in the country’s economy and to understand the prospects for further development or implementation of the country’s NES.

Total Primary Energy Supply, Mtoe	
Coal	
Oil	
Natural gas	
Nuclear	
Hydro	
Renewables	
Energy imports	
Energy exports	
Energy supply per capita, toe/c	-
Energy supply per unit GDP, toe/10^3 USD	-

Energy Demand by Sector	
Industry	
Transportation	
Agriculture	
Commercial & public services	
Residential	
Non-energy use and other	

Total Electricity Supply, TWh	
Coal	
Oil	
Natural Gas	
Nuclear	
Hydro	
Renewables	
Imports	
Export	
Electricity supply per capita, MW·h/c	-
Electricity supply per unit GDP, kW·h/USD	-

CO_2 Emissions, Mt	
Industry	
Transport	
Non-energy use	
Others	
CO_2 emissions per capita, t/c	-
CO_2 emissions per unit GDP, t/10^3 USD	-

National plans and prospects on nuclear energy development

The roadmap template presents both, the national plans and the projections of nuclear energy evolution over a period under consideration. It includes fundamentals of national decisions on nuclear power. The plans and projections need to comply with national nuclear energy strategy (when it exists) or/and with the country's general policy.

They also need to comply with the country's commitment to proceed according to international obligations, norms and standards. Starting from historical background of a national nuclear energy programme and NES, the roadmap template could reflect upon the following aspects:

- Nuclear energy policy and commitments to develop, implement and maintain a sustainable nuclear energy programme;
- A governmental nuclear energy strategy and industrial and institutional infrastructure;
- Stakeholders involvement and status of international cooperation in nuclear sector;
- Possible scenarios and projections of long term nuclear energy development beyond the official plans.
- Institutional infrastructure: legal nuclear framework, international legal instruments (treaties, conventions, safeguards agreements, etc.), bi-lateral/multi-lateral agreements, regulatory framework, human resources, etc.

Nuclear power

'Nuclear Power' section characterizes national nuclear power and includes four sub-sections: *Reactor fleet*, *NFC facilities*, *Nuclear fissile material stocks*, and *Spent nuclear fuel*:

- 'Reactor Fleet' sub-section indicates the total installed capacity of nuclear reactors combined in the following groups: HWR, PWR, BWR, AGR and GCR, FR and others (by default GW(e) are used as units).
- 'Nuclear Fuel Cycle Facilities' sub-section identifies the available capacities for uranium mining, conversion, enrichment, fuel fabrication, SNF storage and reprocessing facilities, SNF/HLW geological disposal; tons U or tons HM are used as units.
- 'Nuclear Fissile Material Stocks' sub-section specifies the available stocks of fissile materials (highly enriched uranium and civilian plutonium); tons are used as units by default.
- 'Spent Nuclear Fuel' subsection reflects the total amount of accumulated SNF produced by different reactor types; tons HM are used as units.

Reactor Fleet, GW	
HWR	
PWR	
BWR	
AGR & GCR	
FR	
Others	

Nuclear Fuel Cycle Facilities, capacity	
Uranium mining and milling, t U	
Conversion, t U	
Enrichment, t SWU	
Fuel fabrication, t HM	
SNF storage, t HM	
SNF reprocessing, t HM	
SNF/HLW disposal, t HM	

Nuclear Fissile Material Stocks, t	
HEU	
Plutonium (civilian)	

Spent Nuclear Fuel, t HM	
HWR	
PWR	
BWR	
AGR & GCR	
FR	
Others	

Metrics for nuclear energy status and development

The 'Metrics' section is to reflect that every country is in its own particular situation.

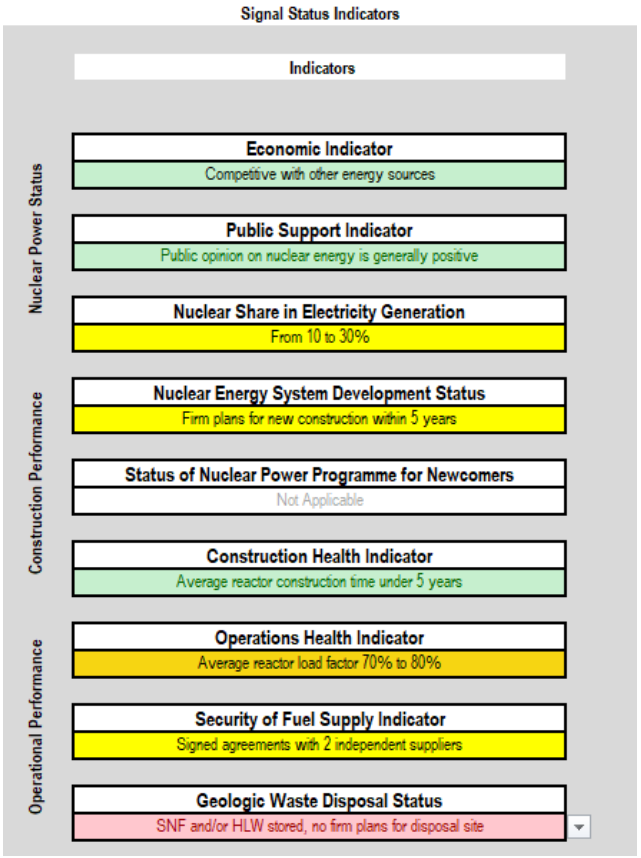
The metrics helps countries identify and understand areas where they are strong or weak regarding sustainability.

The metrics of individual countries could be aggregated and then the objective of such aggregated metrics would be to reveal regional or global NES sustainability status.

The following sections need to be filled out by selecting the most appropriate item from the drop-down lists:

- Signal Status Indicators
- Prospects for Nuclear Energy: Size and Growth
- Country Group Classification
- Technology Options and Domestic Technology Status
- International Collaboration and Collaboration Arrangement

Signal Status Indicators



Form of signal status indicators

- Competitive with other energy sources;
- Competitive in most markets;
- Competitive in limited markets;
- Loss of competitiveness.

- Public opinion on nuclear energy is generally positive;
- Public opinion on nuclear energy is mixed/improving;
- Public opinion on nuclear energy is mixed/declining;
- Public opinion on nuclear energy is generally negative.

- Not Applicable
- Greater than 30 %
- From 10 to 30%
- Less than 10%

- Not applicable;
- Reactors currently under active construction;
- Firm plans for new construction within 5 years;
- Plans for new construction, beyond 5 years;
- No plans for new construction.

- Not Applicable;
- The first nuclear power plant construction and commissioning;
- The decision is taken, building up the necessary infrastructure for a nuclear power programme;
- Active feasibility study;
- Expressing interest in nuclear energy program.

- Not Applicable;
- Average reactor construction time under 5 years;
- Average reactor construction time under 6 years;
- Average reactor construction time under 7 years;
- Average reactor construction time over 7 years.

- Not Applicable;
- Average reactor load factor over 90%;
- Average reactor load factor 80% to 90%;
- Average reactor load factor 70% to 80%;
- Average reactor load factor below 70%.

- Not Applicable;
- Active geologic disposal of SNF or HLW;
- Disposal site under construction;
- Disposal site selected;
- SNF and/or HLW stored, no firm plans for disposal site.

- Not Applicable;
- All needs (uranium, conversion, enrichment, fabrication) supplied by domestic facilities;
- Signed agreements with 3 or more independent suppliers;
- Signed agreements with 2 independent suppliers;
- 1 signed supplier agreement (monopoly);
- No confirmed fuel suppliers.

Prospects for nuclear energy: size and growth

This section specifies the existing and expected growth of nuclear power capacities, and total installed capacity of nuclear power, for different timeframes.

The following items describe the capacity growth:

- decrease
- stabilization
- small growth (below 0.1 GW(e)/year)
- medium growth (0.1–0.5 GW(e)/year)
- significant growth (>0.5 GW(e)/year)

The items characterizing the total installed capacities of nuclear power are as follows:

- small (0–10 GW(e))
- medium (10–50 GW(e))
- large (>50 GW(e))

To show the evolution of these options, four timeframes are considered:

- current (cy – abbreviation for 'current year')
- near-term (from current year to 2030)
- medium-term (2030–2050)
- long-term (2050–2100)

Nuclear Energy Growth

	c.y.	c.y. – 2030	2031 – 2050	2051 – 2100
Decreasing				
Stabilization	☑			
Small growth (below 0.1 GWe/year)		✓		
Medium growth (0.1 - 0.5 GWe/year)				
Significant growth (>0.5 GWe/year)				

Nuclear Energy Size

	c.y.	c.y. – 2030	2031 – 2050	2051 – 2100
No nuclear				
Small (0-10 GWe)	☑			
Medium (10-50 GWe)		✓		
Large(>50 GWe)				

'Prospects for Nuclear Energy: Size and Growth' section

The user has to select one of the two items from the drop-down list in the cell:

- the mark "þ" means that information is approved officially – 'official plans' (displayed as ☑),
- whereas the mark "ü" means intentions (experts' opinion) – 'prospect' (displayed as ✓).

Country group classification

Countries can be divided into groups in two ways

On one side (“General Classification”), the inputs can be: technology holder, technology user or newcomer.

On another side (“GAINS Classification”), the classification suggested in the INPRO collaborative project GAINS is applied.

General Classification

	c.y.	c.y. – 2030	2031 – 2050	2051 – 2100
Holder		✓		
User	☑			
Newcomer				

GAINS Classification

.	c.y.	c.y. – 2030	2031 – 2050	2051 – 2100
NG1				
NG2		✓		
NG3	☑			

The GAINS classification assumes grouping countries on a non-geographical basis according to their strategies regarding the nuclear fuel cycle:

- **NG1:** The general strategy is to recycle SNF – the group plans to build, operate and manage SNF recycling and permanent geological disposal facilities for high level waste (HLW).
- **NG2:** The general strategy is to either directly dispose of SNF, or reprocess SNF abroad – the group plans to build, operate and manage permanent geological disposal facilities for SNF and HLW and/or it works synergistically with NG1 group to have its fuel recycled.

NG3: The general strategy is to use fresh fuel, and send SNF abroad for either recycling or disposal, or the back-end strategy is undecided – the group has no plans to build, operate and manage SNF recycling or permanent geological disposal facilities for SNF or HLW. They may obtain fabricated fuel from abroad and may arrange to export their SNF.

Technology options and domestic technology status (1)

The ‘Technology options and domestic technology status’ section specifies the technology options available domestically (indigenously) and those to which the country has access from abroad.

All potential technology options need to be provided under four time ranges: current, near-term, medium-term and long-term.

The technology options themselves are identical both for ‘National’ and ‘Abroad’ cases, and include the following:

- One-through nuclear fuel cycle;
- Recycle of spent nuclear fuel with only physical reprocessing;
- Limited recycling of spent nuclear fuel;
- Complete recycle of spent nuclear fuel;
- Minor actinides (MA) or MA and fission products (FP) transmutation;
- Final geological disposal of all wastes.

National Technology Options

	c.y.	c.y. – 2030	2031 – 2050	2051 – 2100
Once-through nuclear fuel cycle	☑			
Recycle of SNF with only physical processing				
Limited recycling of spent fuel		✓		
Complete recycle of spent fuel				
MA or MA & FP transmutation				
Final geologic disposal of all wastes				

Access to Technology Options Abroad

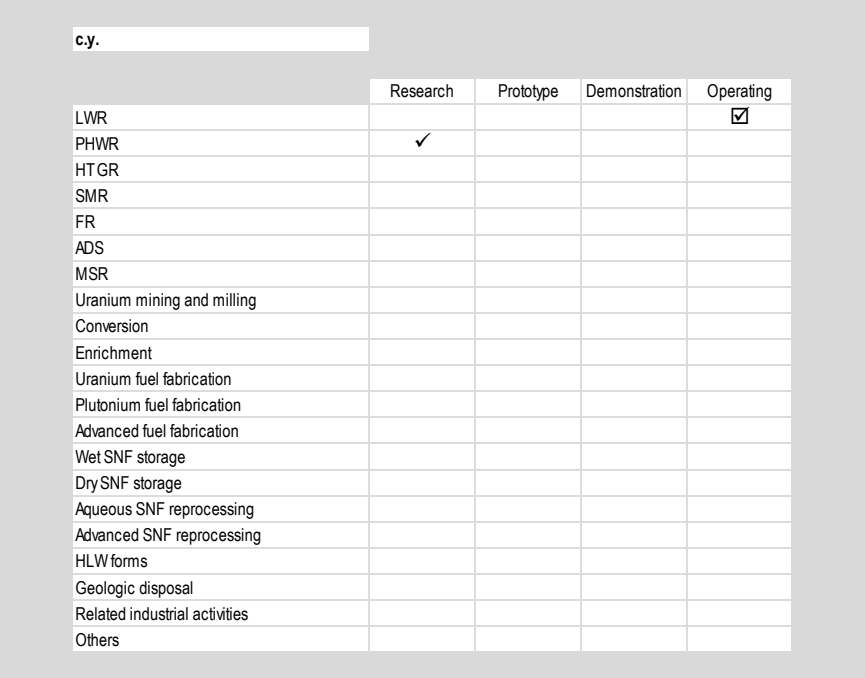
	c.y.	c.y. – 2030	2031 – 2050	2051 – 2100
Once-through nuclear fuel cycle				
Recycle of SNF with only physical processing	☑			
Limited recycling of spent fuel		✓		
Complete recycle of spent fuel				
MA or MA & FP transmutation				
Final geologic disposal of all wastes				

Technology options and domestic technology status (2)

The ‘Domestic technology status’ section includes four identical subsections specifying actual and expected national technological capabilities within the specific timeframes (current, near-term, medium-term or long-term); the identification of technology status (research, prototype, demonstration, operating) is also included.

The following technology options are included:

- LWR;
- HWR;
- HTGR;
- SMR;
- FR;
- ADS;
- MSR;
- Uranium mining and milling;
- Conversion;
- Enrichment;
- Uranium fuel fabrication;
- Plutonium fuel fabrication;
- Advanced fuel fabrication;
- Wet SNF storage;
- Dry SNF storage;
- Aqueous SNF reprocessing;
- Advanced SNF reprocessing;
- HLW forms;
- Geological disposal;
- Related industrial activities;
- Others.



c.y.

	Research	Prototype	Demonstration	Operating
LWR				☑
PHWR	✓			
HTGR				
SMR				
FR				
ADS				
MSR				
Uranium mining and milling				
Conversion				
Enrichment				
Uranium fuel fabrication				
Plutonium fuel fabrication				
Advanced fuel fabrication				
Wet SNF storage				
Dry SNF storage				
Aqueous SNF reprocessing				
Advanced SNF reprocessing				
HLW forms				
Geologic disposal				
Related industrial activities				
Others				

International collaboration and collaboration arrangement (1)

The ‘International collaboration’ section specifies country’s international activities by marking areas in which international collaboration takes place or is planned, within the different timeframes (current, near-term, medium-term and long-term).

The following possible collaborative activities are included:

- Participate in information exchange activities;
- Joint R&D programmes;
- Sharing of R&D facilities;
- Collaboration on NFC front end;
- NPP selling;
- NPP purchasing;
- Offer NPP operations services;
- Use NPP operations services;
- Offer NPP refuelling outage services;
- Use NPP refuelling outage services;
- Collaboration on NFC international centers;
- Share an NPP with another country;
- Offer NFC back end services;
- Use NFC back end services;
- Offer NFC full services;
- Use NFC full services.

Collaboration Strategy

	c.y.	c.y. – 2030	2031 – 2050	2051 – 2100
Participate in information exchange activities	☑			
Joint R&D programs		☑		
Sharing of R&D facilities				
Collaboration on NFC front end			✓	
NPP selling				
NPP purchasing				
Offer NPP operations services				
Use NPP operations services				
Offer NPP refuelling outage services				
Use NPP refuelling outage services				
Collaboration on NFC international centres				✓
Share an NPP with another country				
Offer NFC back end services				
Use NFC back end services				
Offer NFC full services				
Use NFC full services				

International collaboration and collaboration arrangement (2)

The ‘Collaboration Arrangement’ section illustrates country’s national, bi-lateral, multiple bilateral, and multi-lateral agreements for various NFC stages. The section is subdivided in four subsections in a similar way as the ‘Technology Options’ section, corresponding to selected time ranges.

The following possible collaborative activities are included:

- Produce uranium;
- Obtain uranium;
- Produce converted uranium;
- Obtain converted uranium;
- Produce enriched uranium;
- Obtain enriched uranium;
- Fabricate fuel;
- Obtain fuel fabrication service;
- Produce NPP design;
- Use NPP design service;
- Offer NPP operation service;
- Use NPP operation service;
- Offer SNF storage service;
- Use SNF storage service;
- Offer SNF reprocessing service;
- Use SNF reprocessing service;
- Offer SNF disposal service;
- Use SNF disposal service;
- Offer HLW disposal service;
- Use HLW disposal service;
- Others.

Collaboration Arrangement

c.y.

	National	Bi-lateral	Multi-lateral	Multiple bi-lateral
Produce/Offer uranium	☑			
Obtain uranium		☑		
Produce/Offer converted uranium			✓	
Obtain converted uranium				
Produce/Offer enriched uranium				✓
Obtain enriched uranium				
Fabricate/Offer fuel				
Obtain fuel fabrication service				
Produce/Offer NPP design				
Use NPP design service				
Offer NPP operation service				
Use NPP operation service				
National SNF storage/Offer SNF storage service				
Use SNF storage service				
National reprocessing/Offer SNF reprocessing service				
Use SNF reprocessing service				
National disposal/Offer SNF disposal service				
Use SNF disposal service				
National HLW disposal/Offer HLW disposal service				
Use HLW disposal service				
Others				

Key tasks and developments to enhance NES sustainability

Timelines and forks on the way to enhanced NES sustainability (1)

- Vision on NES development beyond the official national plan can be presented by different future scenarios (projections). In this case, there comes a fork in a country roadmap followed by several suggested scenario options.
- Developments in technological, infrastructural and institutional areas along with the development of collaborative mechanisms give an opportunity to enhance sustainability by stepwise achieving the desirable targets, for example, as set out in each subject area of the INPRO methodology for NES sustainability assessment.
- Forks in roadmaps indicate the need to perform comparative evaluation/prioritization of relevant options supporting the definition of more promising options for achieving the selected targets.
- Non-official plans and plans unknown also need to be specified in the timelines for key developments and events. Projections could be based on continuation of the official plans but, if current plans cannot be continued, it is better to indicate that plans are undetermined/undefined.

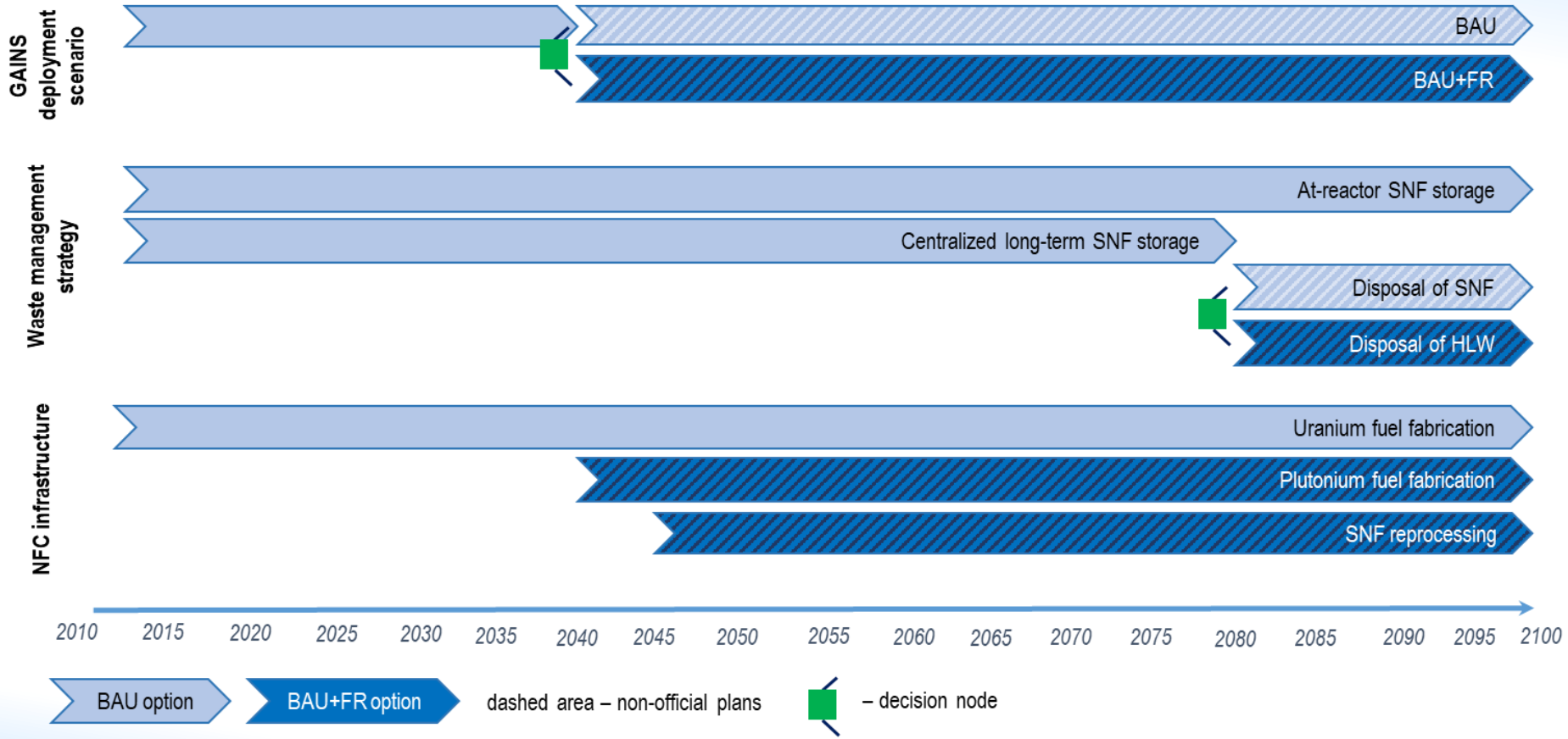
Timelines and forks on the way to enhanced NES sustainability(2)

- Timelines and forks can be presented in roadmaps by different means.
- The Gantt chart is an option for timelines based presentation (it is widely used in project management applications to illustrate project schedules.)
- Different elements on the Gantt charts can be used to clarify transition points, points in which decisions are to be made, and correlations between scenarios, etc.
- The same elements can be used for development of the condensed roadmaps.

Elements for presentation of key points in roadmaps

'Decision node' indicates an independent decision to be made	'Chance node' shows multiple uncertain outcomes, which depend on the decisions of third-parties and stakeholders	'Transition node' assumes transition to the next scenario	'Links' present connections between different scenarios
			

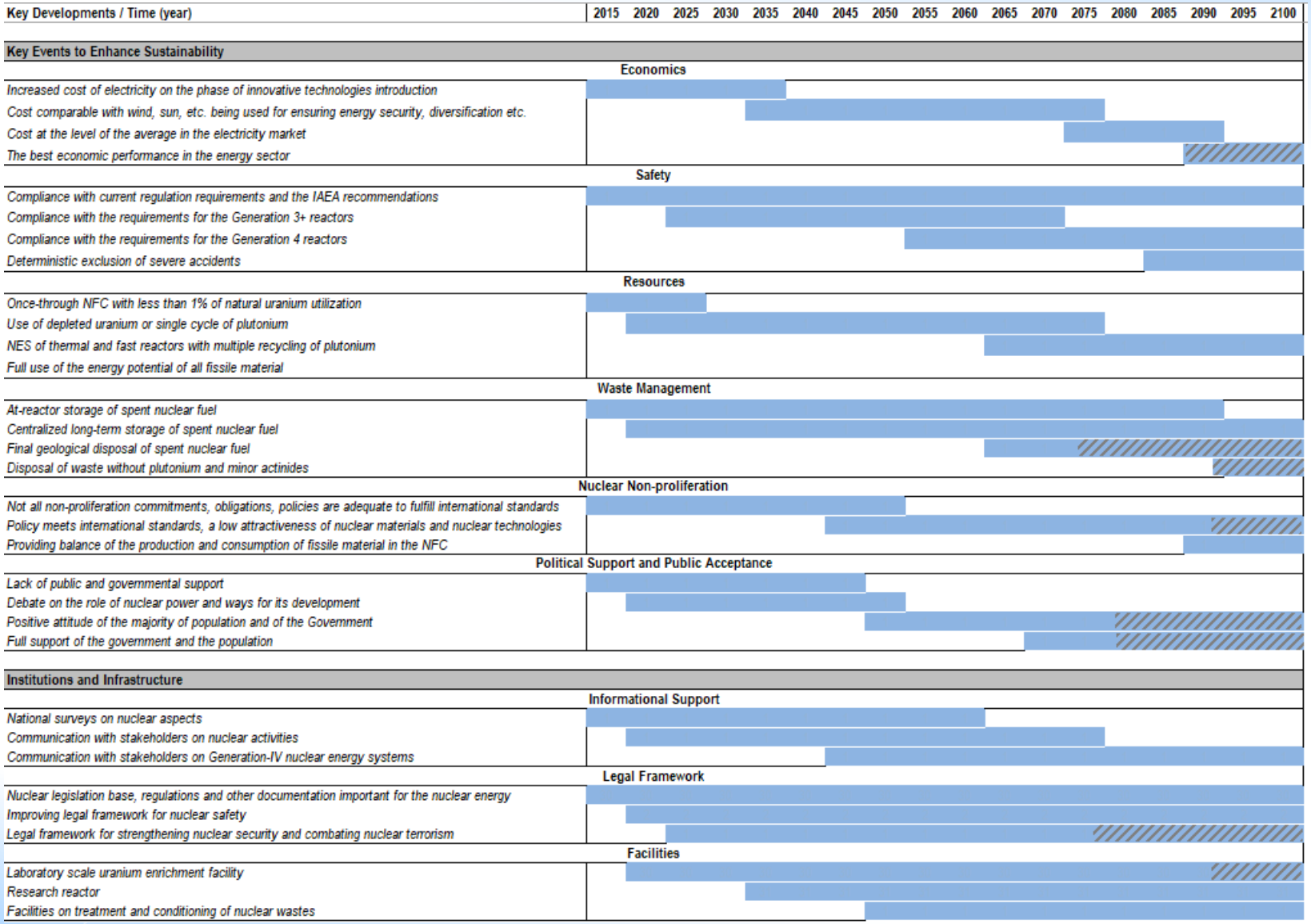
Example of technology related fork presentation in a roadmap



Key tasks and developments

- Key tasks and developments, the implementation of which contributes to enhanced NES sustainability, are specified in the roadmap template using Gantt charts for different time intervals.
- Roadmap template should visualize timelines of important aspects of nuclear industry development in the country, which should be identified by the experts.
- The establishment of the key tasks and developments of the national nuclear energy programme in order to maintain and enhanced sustainability, requires significant information support and some calculation tools.
- Development of technological, infrastructural and institutional areas along with development of cooperative mechanisms gives an opportunity to enhance sustainability by stepwise achieving the desirable targets.
- 'Key tasks and developments' section is a qualitative instrument able to describe the key milestones, developments and tasks, the implementation of which contributes to enhance sustainability of the system.

Example: presentation of 'Key Developments'



Nuclear reactor fleet and relevant nuclear fuel cycle facilities

General comments

- A section on *'Nuclear reactor fleet and relevant nuclear fuel cycle facilities'* is the core of the roadmap template. It directly responds to the main road mapping objective, which is to develop a structured approach for enhancing globally sustainability of nuclear energy, providing models for international cooperation and framework for documenting actions, scope of work, and timeframes for specific collaborative efforts by particular stakeholders.

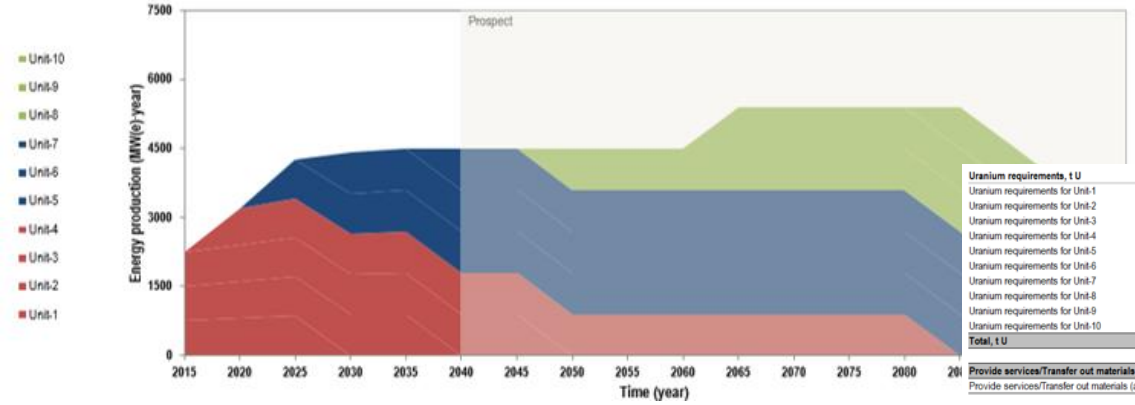
- The inputs in this section make it possible to perform a material flow analysis to evaluate the supply and demand requirements in all stages of the nuclear fuel cycle. In turn, this makes it possible to evaluate sufficiency of the existing and projected production capacities for nuclear reactors and nuclear fuel cycle facilities.

- This section of the roadmap template incorporates the following basic sub-sections: reactor fleet and energy production, specifying the total installed capacities and energy production of a considered reactor fleet; uranium mining and milling, conversion, enrichment, fuel fabrication, spent fuel storage, spent fuel reprocessing and geological disposal of spent fuel or HLW.

- To provide for some flexibility in specifying the reactor park and relevant nuclear fuel cycle facilities or requirements the roadmap template makes it possible to select among several sets of the assumptions to take into account changes in the parameters over time (increase/decrease in fuel enrichment requirements, annual loading into the reactors, involvement of fissile materials from stocks, etc.) and to consider the parameters specific for certain systems (for example, the accumulation and consumption of plutonium in a closed nuclear fuel cycle).

Presentation example

Energy production, MW(e)·year	2015	2020	2025	2030	2035	2040	2045	2050	2055	2060	2065	2070	2075	2080	2085	2090	2095	2100
Unit-1	750	800	850															
Unit-2	750	800	850	880	900													
Unit-3	750	800	850	880	900	900	900											
Unit-4		800	850	880	900	900	900	900	900	900	900	900	900	900				
Unit-5			850	880	900	900	900	900	900	900	900	900	900	900	900			
Unit-6				880	900	900	900	900	900	900	900	900	900	900	900	900		
Unit-7						900	900	900	900	900	900	900	900	900	900	900	900	900
Unit-8								900	900	900	900	900	900	900	900	900	900	900
Unit-9											900	900	900	900	900	900	900	900
Unit-10															900	900	900	900
Total, MW(e)-year	2250	3200	4250	4400	4500	4500	4500	4500	4500	4500	4500	4500	4500	4500	4500	4500	3600	3600

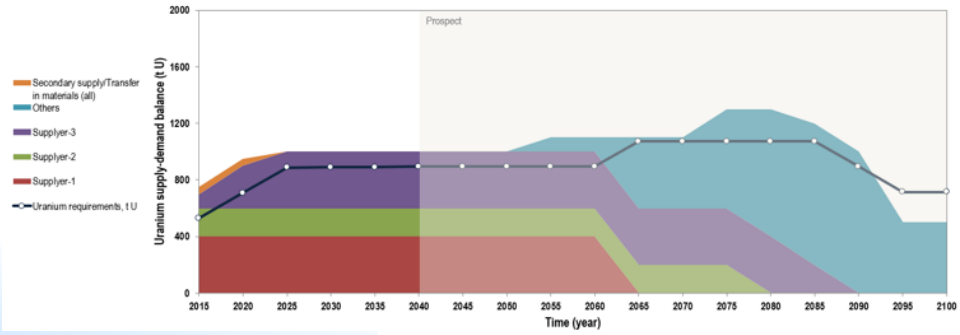


Each section contains two areas:

1. Gantt chart area for visualization of data presented in the table form with the utilization of Excel conditional formatting;
2. Stacked area for visualization of associated data with or without lines.

Uranium requirements, t U	2015	2020	2025	2030	2035	2040	2045	2050	2055	2060	2065	2070	2075	2080	2085	2090	2095	2100
Uranium requirements for Unit-1	175	175	175															
Uranium requirements for Unit-2	175	175	175	175	175													
Uranium requirements for Unit-3	179	179	179	179	179	179	179											
Uranium requirements for Unit-4		179	179	179	179	179	179	179	179	179	179	179	179	179				
Uranium requirements for Unit-5			179	179	179	179	179	179	179	179	179	179	179	179	179			
Uranium requirements for Unit-6				179	179	179	179	179	179	179	179	179	179	179	179	179		
Uranium requirements for Unit-7						179	179	179	179	179	179	179	179	179	179	179	179	179
Uranium requirements for Unit-8								179	179	179	179	179	179	179	179	179	179	179
Uranium requirements for Unit-9											179	179	179	179	179	179	179	179
Uranium requirements for Unit-10															179	179	179	179
Total, t U	529	708	886	890	890	894	894	894	894	894	1073	1073	1073	1073	1073	894	716	716
Provide services/Transfer out materials																		
Provide services/Transfer out materials, t U	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Provide services/Transfer out materials (all)																		
Supply																		
Primary supply/Utilize services, t U	700	900	1000	1000	1000	1000	1000	1000	1100	1100	1100	1100	1300	1300	1200	1000	500	500
Supplyer-1	400	400	400	400	400	400	400	400	400	400								
Supplyer-2	200	200	200	200	200	200	200	200	200	200	200	200	200					
Supplyer-3	100	300	400	400	400	400	400	400	400	400	400	400	400	400	200			
Others									100	100	500	500	700	900	1000	1000	500	500
Secondary supply/Transfer in materials, t U	50	50	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Secondary supply/Transfer in materials (all)	50	50																
Total supply, t U	750	950	1000	1000	1000	1000	1000	1000	1100	1100	1100	1100	1300	1300	1200	1000	500	500
Surplus (supply - demand)																		
Surplus, t U	221	242	114	110	110	106	106	106	206	206	27	27	227	227	127	106	-215	-215

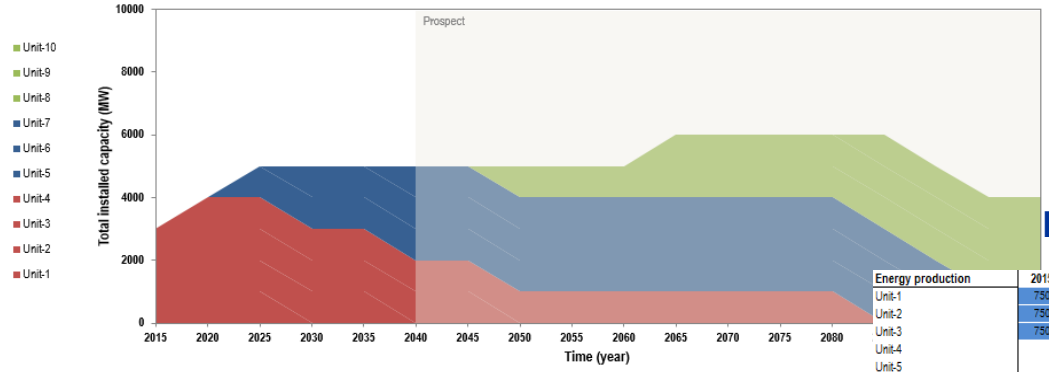
Official plans or prospects need to be marked both in the Gantt chart and in stacked areas visualization.



Reactor fleet and energy production

Example of 'Reactor Fleet' presentation

Total installed capacity	2015	2020	2025	2030	2035	2040	2045	2050	2055	2060	2065	2070	2075	2080	2085	2090	2095	2100
Unit-1	1000	1000	1000															
Unit-2	1000	1000	1000	1000	1000													
Unit-3	1000	1000	1000	1000	1000	1000	1000											
Unit-4		1000	1000	1000	1000	1000	1000	1000	1000	1000	1000	1000	1000	1000				
Unit-5			1000	1000	1000	1000	1000	1000	1000	1000	1000	1000	1000	1000	1000			
Unit-6				1000	1000	1000	1000	1000	1000	1000	1000	1000	1000	1000	1000	1000		
Unit-7						1000	1000	1000	1000	1000	1000	1000	1000	1000	1000	1000	1000	1000
Unit-8								1000	1000	1000	1000	1000	1000	1000	1000	1000	1000	1000
Unit-9											1000	1000	1000	1000	1000	1000	1000	1000
Unit-10															1000	1000	1000	1000
Total, MW	3000	4000	5000	5000	5000	5000	5000	5000	5000	5000	6000	6000	6000	6000	6000	5000	4000	4000



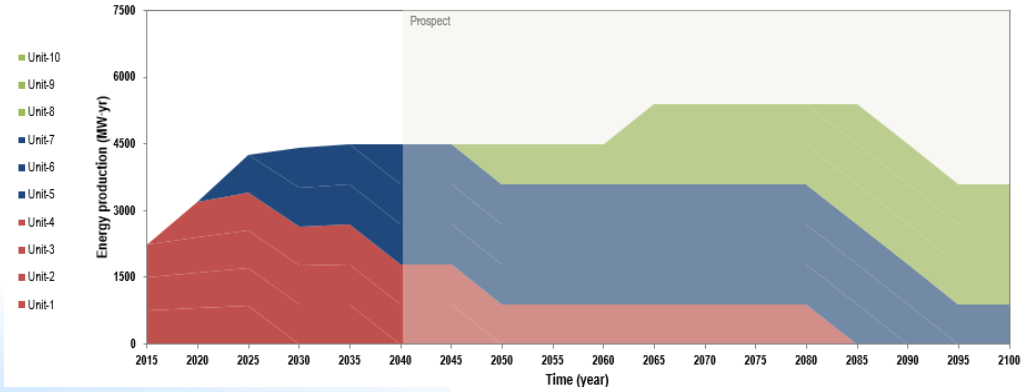
In the Gantt chart, the prospects are indicated by white color numbers; meanwhile, black color numbers indicate official plans.

In the stacked areas visualization, the prospects time range is illustrated by a shaded screen.

Example of 'Energy Production' presentation

Energy production	2015	2020	2025	2030	2035	2040	2045	2050	2055	2060	2065	2070	2075	2080	2085	2090	2095	2100
Unit-1	750	800	850															
Unit-2	750	800	850	880	900													
Unit-3	750	800	850	880	900	900	900											
Unit-4		800	850	880	900	900	900	900	900	900	900	900	900	900				
Unit-5			850	880	900	900	900	900	900	900	900	900	900	900	900			
Unit-6				880	900	900	900	900	900	900	900	900	900	900	900	900		
Unit-7						900	900	900	900	900	900	900	900	900	900	900	900	900
Unit-8								900	900	900	900	900	900	900	900	900	900	900
Unit-9											900	900	900	900	900	900	900	900
Unit-10															900	900	900	900
Total, MW-yr	2250	3200	4250	4400	4500	4500	4500	4500	4500	4500	5400	5400	5400	5400	5400	4500	3600	3600

Total installed capacity and energy production by a given nuclear reactor fleet averaged within the corresponding time steps.

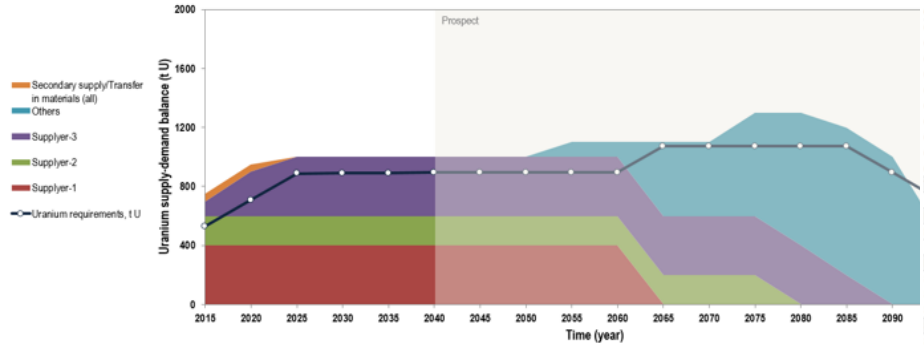


Uranium mining and conversion

Example of ‘Uranium Mining and Milling’ presentation

Uranium requirements, t U	2015	2020	2025	2030	2035	2040	2045	2050	2055	2060	2065	2070	2075	2080	2085	2090	2095	2100
Uranium requirements for Unit-1	175	175	175															
Uranium requirements for Unit-2	175	175	175	175	175													
Uranium requirements for Unit-3	179	179	179	179	179	179	179											
Uranium requirements for Unit-4		179	179	179	179	179	179	179	179	179	179	179	179	179				
Uranium requirements for Unit-5			179	179	179	179	179	179	179	179	179	179	179	179	179			
Uranium requirements for Unit-6				179	179	179	179	179	179	179	179	179	179	179	179	179		
Uranium requirements for Unit-7						179	179	179	179	179	179	179	179	179	179	179	179	179
Uranium requirements for Unit-8							179	179	179	179	179	179	179	179	179	179	179	179
Uranium requirements for Unit-9										179	179	179	179	179	179	179	179	179
Uranium requirements for Unit-10														179	179	179	179	179
Total, t U	529	708	886	890	890	894	894	894	894	894	1073	1073	1073	1073	1073	894	715	715
Provide services/Transfer out materials																		
Provide services/Transfer out materials, t U	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Provide services/Transfer out materials (all)																		
Supply																		
Primary supply/Utilize services, t U	700	900	1000	1000	1000	1000	1000	1000	1100	1100	1100	1100	1300	1300	1200	1000	500	500
Supplyer-1	400	400	400	400	400	400	400	400	400	400								
Supplyer-2	200	200	200	200	200	200	200	200	200	200	200	200	200					
Supplyer-3	100	300	400	400	400	400	400	400	400	400	400	400	400	400	200			
Others									100	100	500	500	700	900	1000	1000	500	500
Secondary supply/Transfer in materials, t U	50	50	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Secondary supply/Transfer in materials (all)	50	50																
Total supply, t U	750	950	1000	1000	1000	1000	1000	1000	1100	1100	1100	1100	1300	1300	1200	1000	500	500
Surplus (supply - demand)																		
Surplus, t U	221	242	114	110	110	106	106	106	206	206	27	27	227	227	127	106	-215	-215

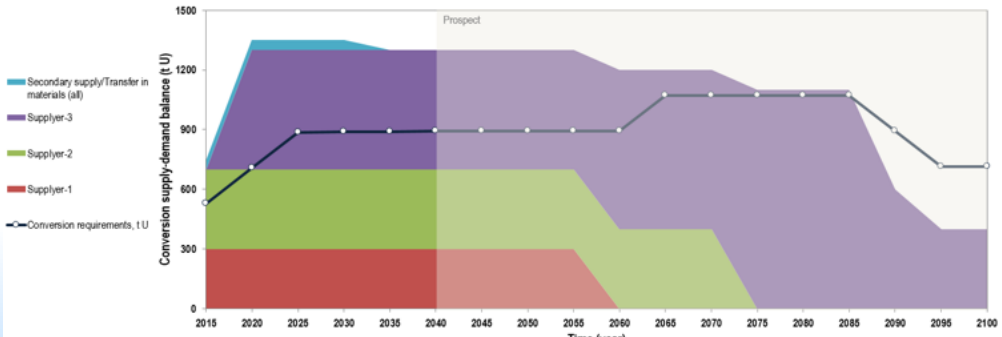
Natural uranium consumption in tons of uranium and all existing primary and secondary supply options for natural uranium production



Example of ‘Conversion’ presentation

Conversion requirements, t U	2015	2020	2025	2030	2035	2040	2045	2050	2055	2060	2065	2070	2075	2080	2085	2090	2095	2100
Conversion requirements for Unit-1	175	175	175															
Conversion requirements for Unit-2	175	175	175	175	175													
Conversion requirements for Unit-3	179	179	179	179	179	179	179											
Conversion requirements for Unit-4		179	179	179	179	179	179	179	179	179	179	179	179	179				
Conversion requirements for Unit-5			179	179	179	179	179	179	179	179	179	179	179	179	179			
Conversion requirements for Unit-6				179	179	179	179	179	179	179	179	179	179	179	179	179		
Conversion requirements for Unit-7						179	179	179	179	179	179	179	179	179	179	179	179	179
Conversion requirements for Unit-8							179	179	179	179	179	179	179	179	179	179	179	179
Conversion requirements for Unit-9										179	179	179	179	179	179	179	179	179
Conversion requirements for Unit-10															179	179	179	179
Total, t U	529	708	886	890	890	894	894	894	894	894	1073	1073	1073	1073	1073	894	715	715
Provide services/Transfer out materials																		
Provide services/Transfer out materials, t U	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Provide services/Transfer out materials (all)																		
Supply																		
Primary supply/Utilize services, t U	700	1300	1300	1300	1300	1300	1300	1300	1300	1200	1200	1200	1100	1100	1100	600	400	400
Supplyer-1	300	300	300	300	300	300	300	300	300									
Supplyer-2	400	400	400	400	400	400	400	400	400	400	400	400						
Supplyer-3		600	600	600	600	600	600	600	600	800	800	800	1100	1100	1100	600	400	400
Secondary supply/Transfer in materials, t U	50	50	50	50	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Secondary supply/Transfer in materials (all)	50	50	50	50														
Total supply, t U	750	1350	1350	1350	1300	1300	1300	1300	1300	1200	1200	1200	1100	1100	1100	600	400	400
Surplus (supply - demand)																		
Surplus, t U	221	642	464	460	410	406	406	406	406	306	127	127	27	27	27	-294	-315	-315

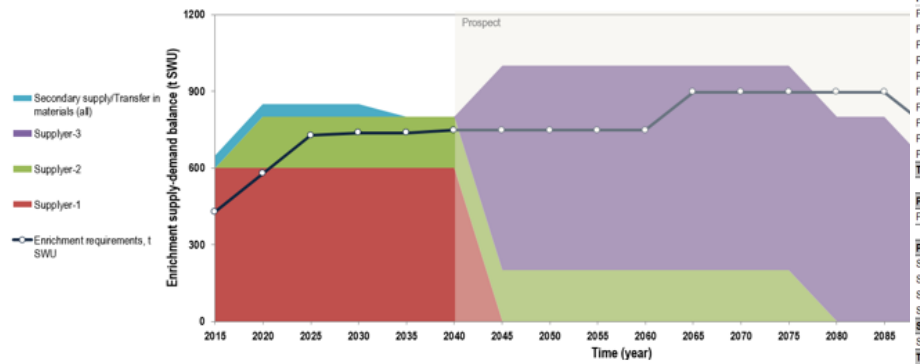
Domestic requirements and possible export commitments for uranium conversion services for each reactor or reactors group as well as possible options to meet the conversion demand



Enrichment and fuel fabrication

Example of ‘Enrichment’ presentation

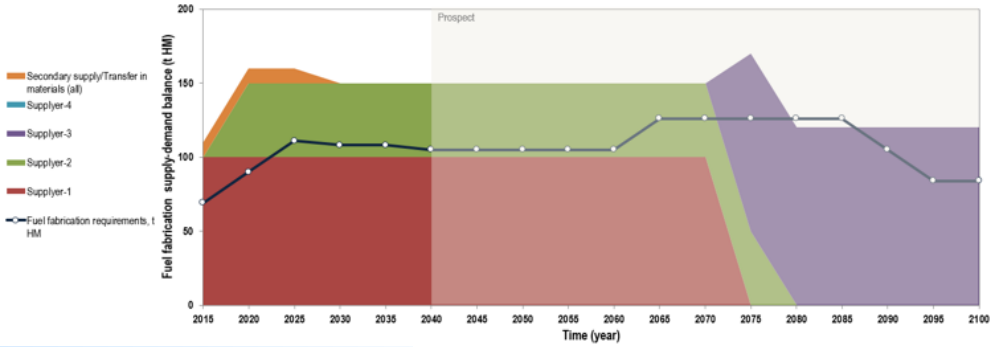
Enrichment requirements, t SWU	2015	2020	2025	2030	2035	2040	2045	2050	2055	2060	2065	2070	2075	2080	2085	2090	2095	2100
Enrichment requirements for Unit-1	139	139	139															
Enrichment requirements for Unit-2	139	139	139	139	139													
Enrichment requirements for Unit-3	149	149	149	149	149	149	149											
Enrichment requirements for Unit-4		149	149	149	149	149	149	149	149	149	149	149	149	149				
Enrichment requirements for Unit-5			149	149	149	149	149	149	149	149	149	149	149	149	149			
Enrichment requirements for Unit-6				149	149	149	149	149	149	149	149	149	149	149	149	149		
Enrichment requirements for Unit-7						149	149	149	149	149	149	149	149	149	149	149	149	149
Enrichment requirements for Unit-8								149	149	149	149	149	149	149	149	149	149	149
Enrichment requirements for Unit-9											149	149	149	149	149	149	149	149
Enrichment requirements for Unit-10															149	149	149	149
Total, t SWU	428	577	727	737	737	747	747	747	747	747	896	896	896	896	896	747	598	598
Provide services/Transfer out materials																		
Provide services/Transfer out materials, t SWU	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Provide services/Transfer out materials (all)																		
Supply																		
Primary supply/Utilize services, t SWU	600	800	800	800	800	800	1000	1000	1000	1000	1000	1000	1000	800	800	600	400	200
Supplyer-1	600	600	600	600	600	600												
Supplyer-2		200	200	200	200	200	200	200	200	200	200	200	200					
Supplyer-3							800	800	800	800	800	800	800	800	800	600	400	200
Secondary supply/Transfer in materials, t SWU	50	50	50	50	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Secondary supply/Transfer in materials (all)	50	50	50	50														
Total supply, t SWU	650	850	850	850	800	800	1000	1000	1000	1000	1000	1000	1000	800	800	600	400	200
Surplus (supply - demand)																		
Surplus, t SWU	222	273	123	113	63	53	253	253	253	253	104	104	104	-96	-96	-147	-198	-398



Requirements and export obligations of a country in the uranium enrichment services for the considered reactor fleet and possible primary and secondary sources of enriched uranium including import possibilities

Example of ‘Fuel Fabrication’ presentation

Fuel fabrication requirements, t HM	2015	2020	2025	2030	2035	2040	2045	2050	2055	2060	2065	2070	2075	2080	2085	2090	2095	2100
Fuel fabrication requirements for Unit-1	24	24	24															
Fuel fabrication requirements for Unit-2	24	24	24	24	24													
Fuel fabrication requirements for Unit-3	21	21	21	21	21	21	21											
Fuel fabrication requirements for Unit-4		21	21	21	21	21	21	21	21	21	21	21	21	21				
Fuel fabrication requirements for Unit-5			21	21	21	21	21	21	21	21	21	21	21	21	21			
Fuel fabrication requirements for Unit-6				21	21	21	21	21	21	21	21	21	21	21	21	21		
Fuel fabrication requirements for Unit-7						21	21	21	21	21	21	21	21	21	21	21	21	21
Fuel fabrication requirements for Unit-8								21	21	21	21	21	21	21	21	21	21	21
Fuel fabrication requirements for Unit-9											21	21	21	21	21	21	21	21
Fuel fabrication requirements for Unit-10															21	21	21	21
Total, t HM	69	90	111	108	108	105	105	105	105	105	126	126	126	126	126	105	84	84
Provide services/Transfer out materials																		
Provide services/Transfer out materials, t HM	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Provide services/Transfer out materials (all)																		
Supply																		
Primary supply/Utilize services, t HM	100	150	150	150	150	150	150	150	150	150	150	150	170	120	120	120	120	120
Supplyer-1	100	100	100	100	100	100	100	100	100	100	100	100						
Supplyer-2		50	50	50	50	50	50	50	50	50	50	50	50					
Supplyer-3													120	120	120	120	120	120
Supplyer-4																		
Secondary supply/Transfer in materials, t HM	10	10	10	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Secondary supply/Transfer in materials (all)	10	10	10															
Total supply, t HM	110	160	160	150	150	150	150	150	150	150	150	150	170	120	120	120	120	120
Surplus (supply - demand)																		
Surplus, t HM	41	70	49	42	42	45	45	45	45	45	24	24	44	-6	-6	15	36	36



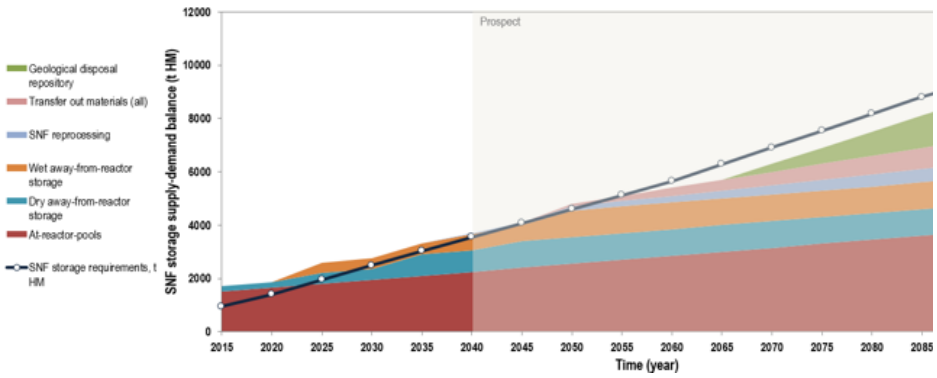
Fuel fabrication activities, including requirements in fuel fabrication services and export obligations for the considered reactor fleet and available domestic and overseas fuel fabrication capacities

SNF storage and reprocessing

Example of 'Spent Fuel Storage' presentation

SNF storage requirements, t HM	2015	2020	2025	2030	2035	2040	2045	2050	2055	2060	2065	2070	2075	2080	2085	2090	2095	2100
SNF storage requirements for Unit-1	320	440	560	560	560	560	560	560	560	560	560	560	560	560	560	560	560	560
SNF storage requirements for Unit-2	320	440	560	680	800	800	800	800	800	800	800	800	800	800	800	800	800	800
SNF storage requirements for Unit-3	305	410	515	620	725	830	935	935	935	935	935	935	935	935	935	935	935	935
SNF storage requirements for Unit-4		105	210	315	420	525	630	735	840	945	1050	1155	1260	1365	1365	1365	1365	1365
SNF storage requirements for Unit-5			105	210	315	420	525	630	735	840	945	1050	1155	1260	1365	1365	1365	1365
SNF storage requirements for Unit-6				105	210	315	420	525	630	735	840	945	1050	1155	1260	1365	1365	1365
SNF storage requirements for Unit-7						105	210	315	420	525	630	735	840	945	1050	1155	1260	1365
SNF storage requirements for Unit-8								105	210	315	420	525	630	735	840	945	1050	1155
SNF storage requirements for Unit-9											105	210	315	420	525	630	735	840
SNF storage requirements for Unit-10															105	210	315	420
Total, t HM	945	1395	1950	2490	3030	3555	4080	4605	5130	5655	6285	6915	7545	8175	8805	9330	9750	10170
Provide services/Transfer in materials																		
Provide services/Transfer in materials, t HM	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Provide services/Transfer in materials (all)																		
Supply																		
Primary supply/Utilize services, t HM	1700	1850	2600	2750	3300	3700	4100	4700	4900	5100	5300	5500	5700	5900	6100	6300	6500	6700
At-reactor-pools	1500	1650	1800	1950	2100	2250	2400	2550	2700	2850	3000	3150	3300	3450	3600	3750	3900	4050
Dry away-from-reactor storage	200	200	400	400	800	800	1000	1000	1000	1000	1000	1000	1000	1000	1000	1000	1000	1000
Wet away-from-reactor storage			400	400	400	600	600	1000	1000	1000	1000	1000	1000	1000	1000	1000	1000	1000
SNF reprocessing						50	100	150	200	250	300	350	400	450	500	550	600	650
Geological disposal repository												300	600	900	1200	1500	1800	2100
Transfer out materials, t HM	0	0	0	0	0	0	0	100	200	300	400	500	600	700	800	900	1000	1100
Transfer out materials (all)								100	200	300	400	500	600	700	800	900	1000	1100
Total supply, t HM	1700	1850	2600	2750	3300	3700	4100	4800	5100	5400	5700	6000	6300	6600	6900	7200	7500	7800
Surplus (supply - demand)																		
Surplus, t HM	755	455	650	260	270	145	20	195	-30	-255	-585	-915	-1245	-1575	-1905	-2130	-2250	-2370

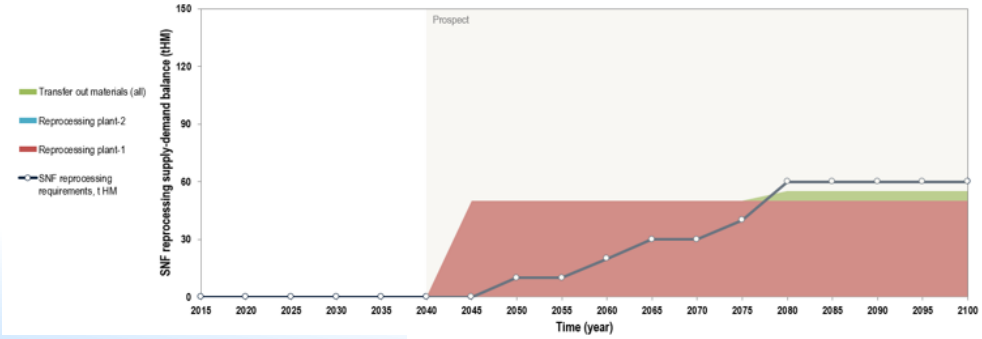
The supply-demand balance for SNF storage services in terms of the cumulative flows of SNF to be stored.



Example of 'Spent Fuel Reprocessing' presentation

SNF reprocessing requirements, t HM	2015	2020	2025	2030	2035	2040	2045	2050	2055	2060	2065	2070	2075	2080	2085	2090	2095	2100
SNF reprocessing requirements for Unit-1																		
SNF reprocessing requirements for Unit-2																		
SNF reprocessing requirements for Unit-3																		
SNF reprocessing requirements for Unit-4																		
SNF reprocessing requirements for Unit-5																		
SNF reprocessing requirements for Unit-6								10	10	10	20	20	20	20	20	20	20	20
SNF reprocessing requirements for Unit-7									10	10	10	20	20	20	20	20	20	20
SNF reprocessing requirements for Unit-8														20	20	20	20	20
SNF reprocessing requirements for Unit-9																		
SNF reprocessing requirements for Unit-10																		
Total, t HM	0	0	0	0	0	0	0	10	20	30	30	40	60	60	60	60	60	60
Provide services/Transfer in materials																		
Provide services/Transfer in materials, t HM	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Provide services/Transfer in materials (all)																		
Supply																		
Primary supply/Utilize services, t HM	0	0	0	0	0	0	50	50	50	50	50	50	50	50	50	50	50	50
Reprocessing plant-1							50	50	50	50	50	50	50	50	50	50	50	50
Reprocessing plant-2																		
Transfer out materials, t HM	0	0	0	0	0	0	0	0	0	0	0	0	0	5	5	5	5	5
Transfer out materials (all)														5	5	5	5	5
Total supply, t HM	0	0	0	0	0	0	50	50	50	50	50	50	50	55	55	55	55	55
Surplus (supply - demand)																		
Surplus, t HM	0	0	0	0	0	0	50	40	40	30	20	20	10	-5	-5	-5	-5	-5

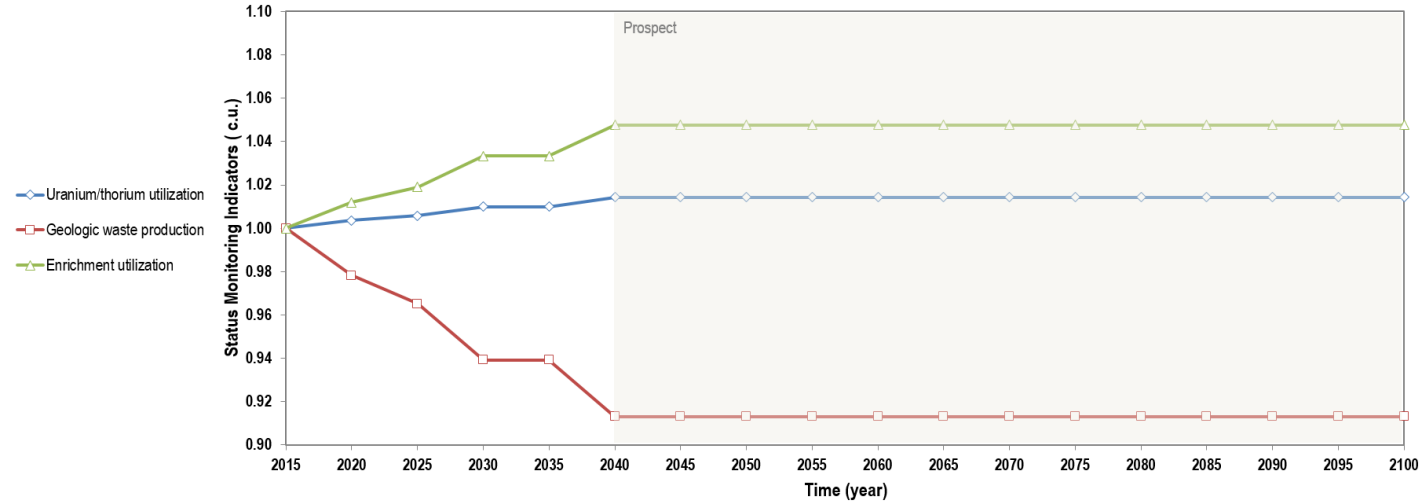
The supply-demand balance for SNF reprocessing services in terms of averaged flows for certain periods



Progress monitoring

- The roadmap template incorporates provisions for progress monitoring regarding NES deployment strategy towards enhanced sustainability. It is based on a set of quantitative indicators specified by experts in line with the specific objectives.
- Tracking/monitoring of NES deployments strategy against roadmap milestones involves:
  - The monitoring indicators that characterize the expected enhancement of NES sustainability in different areas owing to technological and institutional innovations and/or increased collaboration with other countries. The key points (or milestones) that, when reached, indicate that certain sustainability enhancements have been achieved;
  - The desired (or target) values of monitoring indicators that characterize reaching the key points (milestones).

Status Monitoring (Quantitative Indicators)	2015	2020	2025	2030	2035	2040	2045	2050	2055	2060	2065	2070	2075	2080	2085	2090	2095	2100
Uranium/thorium utilization	1.00	1.00	1.01	1.01	1.01	1.01	1.01	1.01	1.01	1.01	1.01	1.01	1.01	1.01	1.01	1.01	1.01	1.01
Geologic waste production	1.00	0.98	0.97	0.94	0.94	0.91	0.91	0.91	0.91	0.91	0.91	0.91	0.91	0.91	0.91	0.91	0.91	0.91
Enrichment utilization	1.00	1.01	1.02	1.03	1.03	1.05	1.05	1.05	1.05	1.05	1.05	1.05	1.05	1.05	1.05	1.05	1.05	1.05

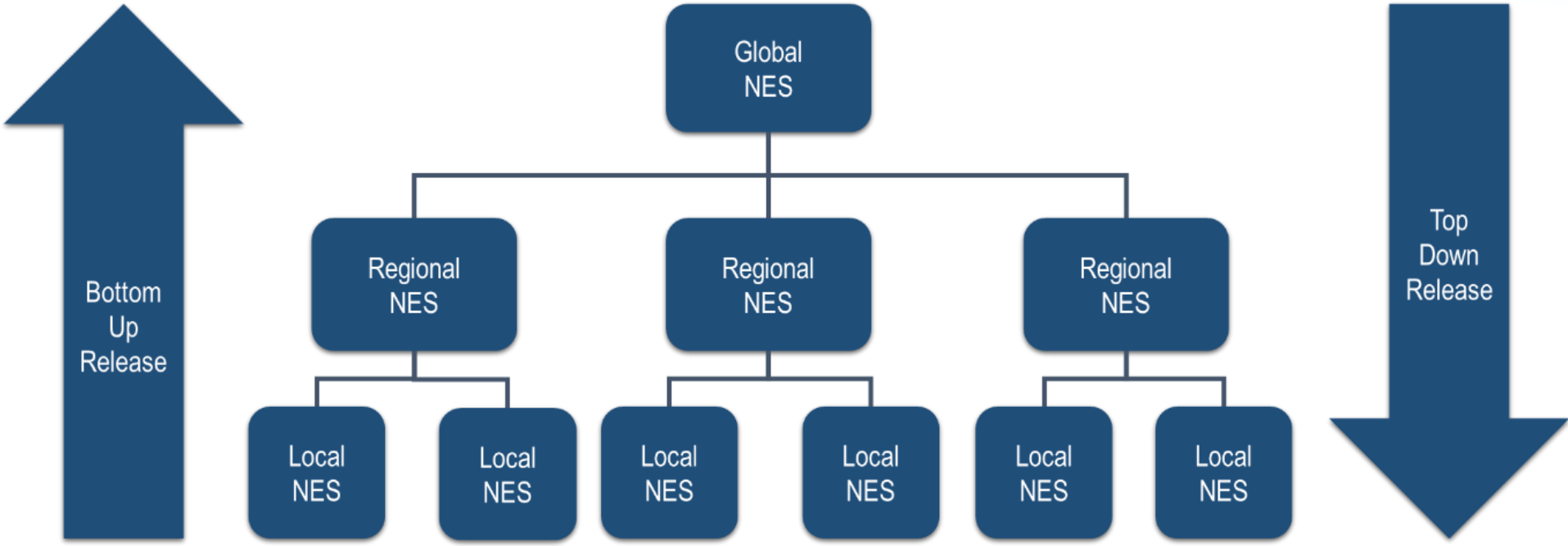


Integration, cross-cutting analysis and condensed presentation of roadmaps

Collections of roadmaps

- In principle, top-down and bottom-up approaches can be applied for aggregation of roadmaps.
- A top-down approach starts with building a combined regional, multi-regional or global NES. This NES can be further broken down into its constituents – national or regional NES. In the top-down approach, major assumptions regarding the combined NES are formulated without going into details of the constituent national or regional NES.
- A bottom-up approach is the piecing together of national or regional NES to arrive at a combined, aggregated regional or global NES. In the bottom-up approach, national or regional NES which are constituents of the combined NES can be specified in detail from the outset. Then they are combined together until a complete aggregated upper-level NES is developed up.
- Within the collaborative project ROADMAPS, the following has been noted regarding roadmaps aggregation:
  - The metrics in all of the roadmaps under aggregation needs to be kept standard; then it can be summarized in a straightforward way;
  - The key and developments and the nuclear fuel cycle requirements can be used for crosscutting analyses performed by countries considering collaboration (trade) as an approach to enhance sustainability of a national NES. Different from *'Metrics'* the abovementioned generally provides for keeping a certain freedom in data presentation.

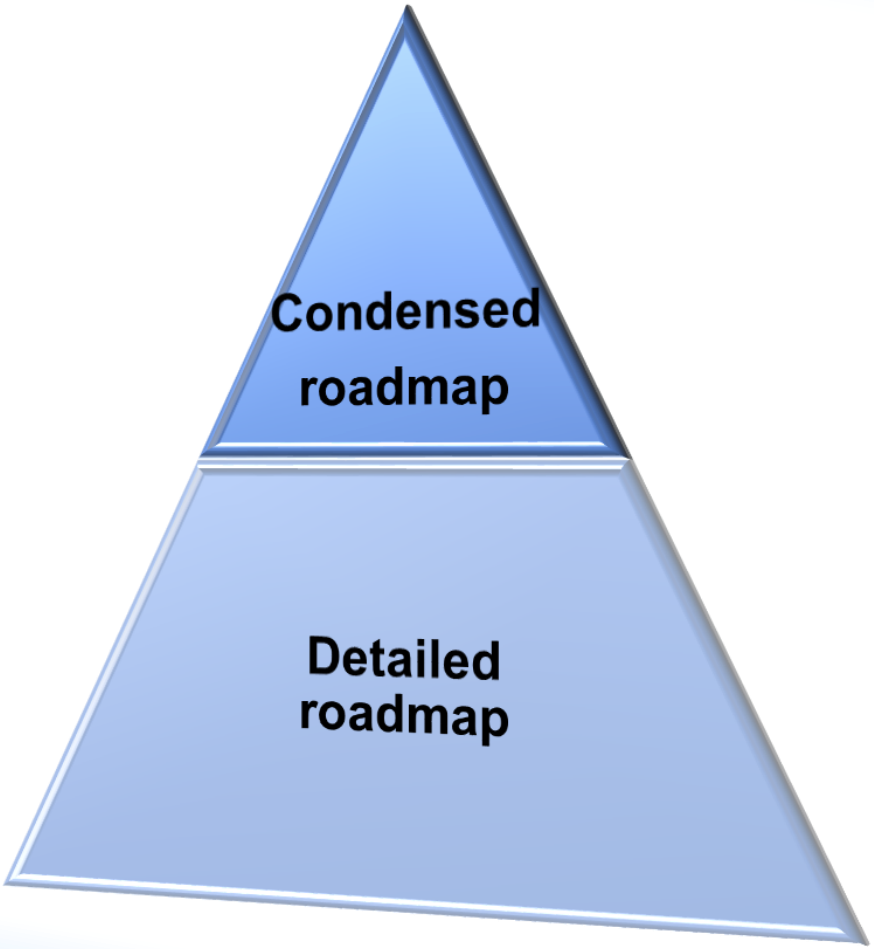
Illustration of bottom-up and top-down approaches to roadmaps aggregation



Condensed roadmap

- The roadmap template includes detailed information on national plans and projections for enhancing nuclear energy sustainability, such as long term nuclear power profile(s), material flows in the nuclear fuel cycle, etc.
- Along with the detailed roadmap, it appears reasonable to provide a condensed roadmap version, which would present a concise, illustrative, and interactive report in one figure based on the detailed roadmap.
- Such condensed presentation of the roadmap allows interested stakeholders, first of all, decision makers, to faster and more effectively understand the main aspects of the elaborated detailed action plan.
- Moreover, the limitations on data and information disclosure can be a significant issue, while the detailed roadmap can contain certain information and data that are sensitive or confidential.
- For this reason, the condensed roadmaps can also be useful for communications to broader public or targeted new foreign partners, etc.

Roadmap visualization approaches



Condensed Roadmap

Condensed roadmap presents a concise, illustrative, interactive report in one figure

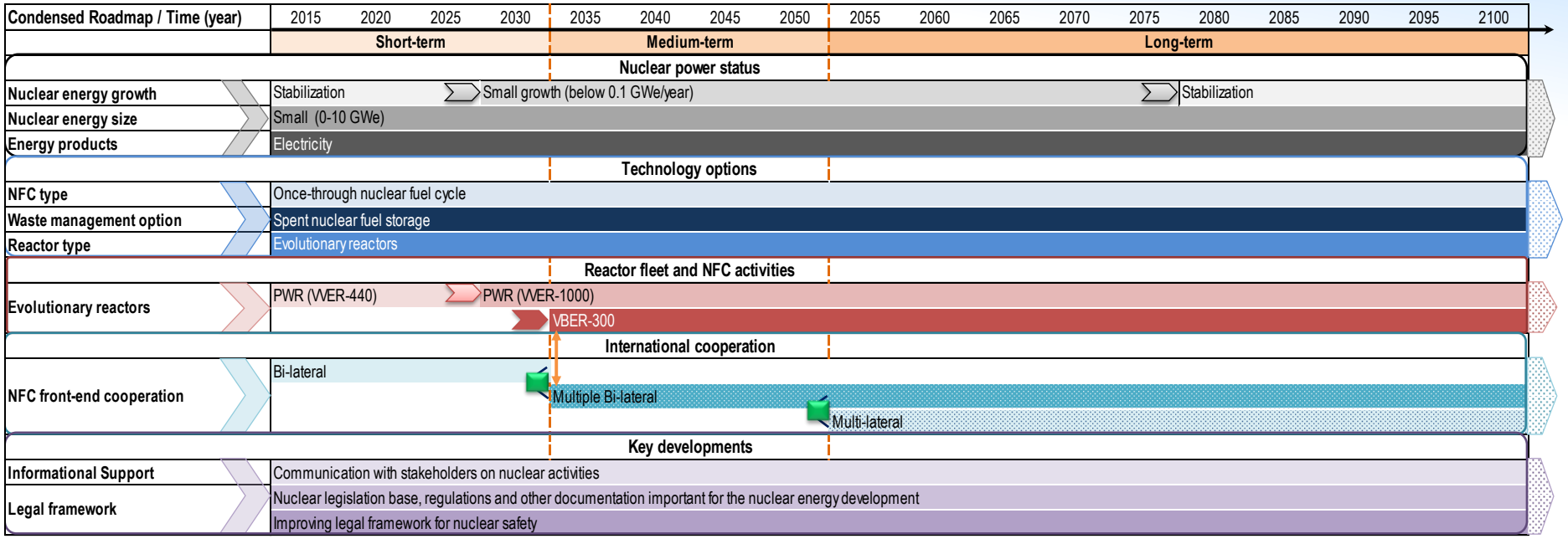
Detailed Roadmap

Detailed roadmap presents a comprehensive information concerning a roadmap towards enhanced nuclear energy sustainability (nuclear power profile, technological and collaboration options, NFC material flows, etc.)

Condensed roadmap construction

- The condensed roadmap can include several key structural elements combined by common logic to characterize the current state and plans/projections for NES development in the short, medium and long term.
- The ‘Timeline’ displays chronological order of NES deployment scenario within short, medium and long-term periods.
- The ‘Elements’ are the main components needed for NES sustainability enhancement chosen by experts from a country to present the official plans and projections for national NES evolution.
- Basically, the Element presents an information sub-section, which can describe either the growth and the scale of a NES, or the directions of the nuclear fuel cycle development, or collaboration with other countries and forms of its implementation, etc.
- The ‘Element’ item is to characterize the evolution (e.g., development or deployment) of an element over particular periods of time, including technical parameters, economic performance and infrastructure and institutional arrangements.

Application of ROADMAPS template to NES of Armenia

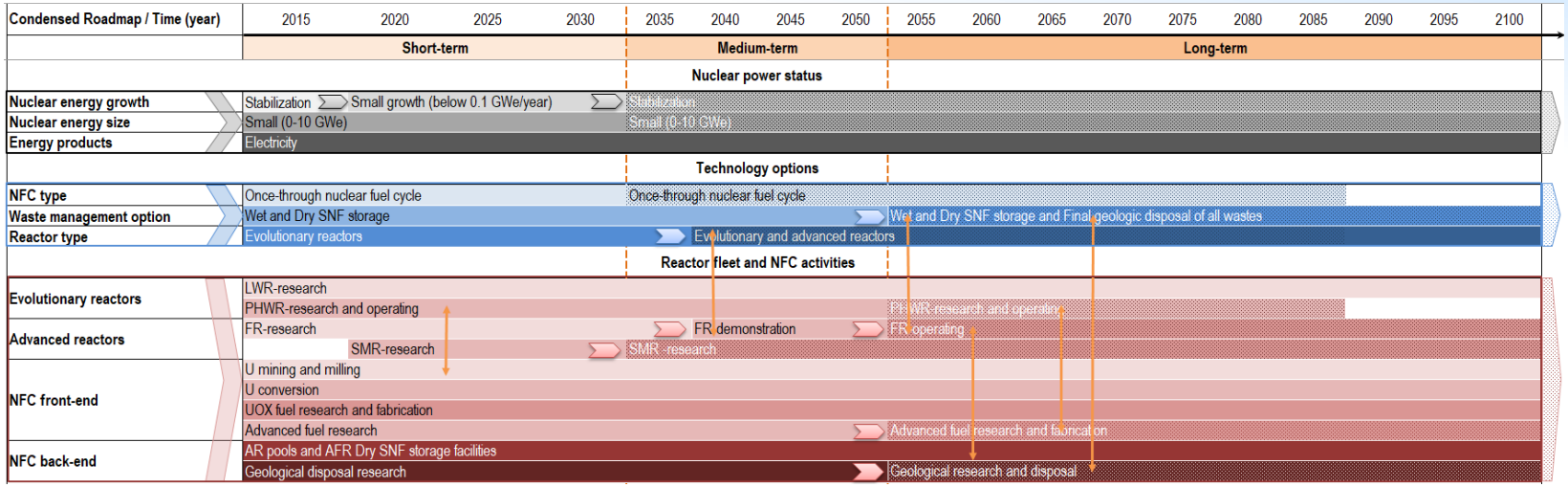


Application of roadmaps template to NES of Belarus

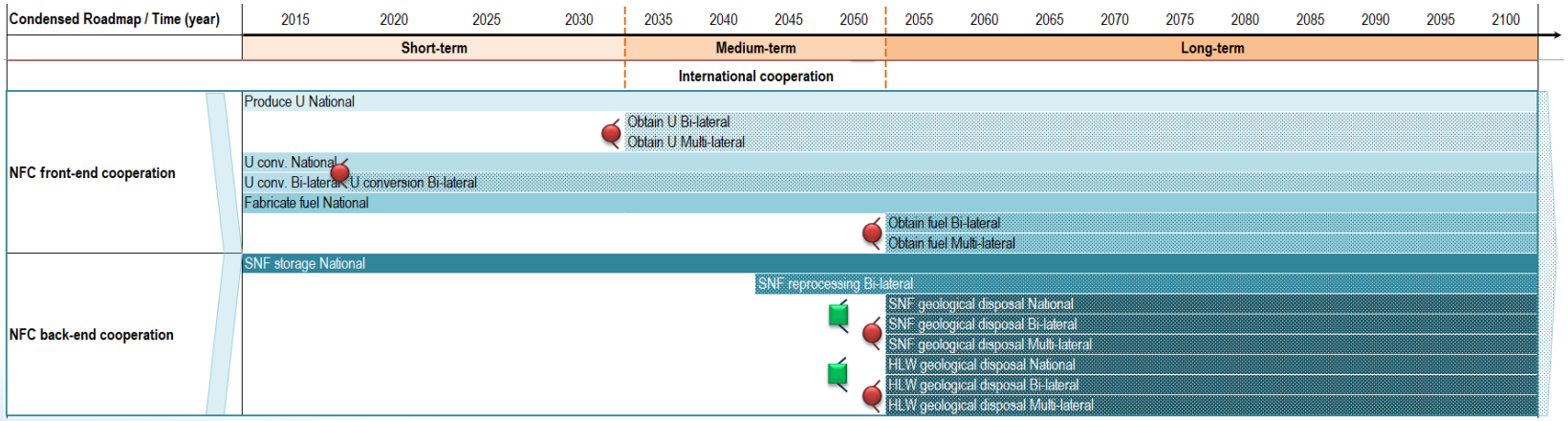
Economic Indicator
Competitive with other energy sources
Public Support Indicator
Public opinion of nuclear energy is generally positive
Exisiting Nuclear Energy System Status
Reactors currently under active construction
Status of Nuclear Power Programme for Newcomers
The first nuclear power plant construction and commissioning
Construction Health Indicator
Average reactor construction time under 7 years
Operations Health Indicator
Not Applicable
Security of Fuel Supply Indicator
1 signed supplier agreement (monopoly)
Geologic Waste Disposal Status
SNF and/or HLW stored, no firm plans for disposal site

Condensed Roadmap/Time	2015 2020 2025 2030	2035 2040 2045 2050	2055 2060 2065 2070 2075 2080 2085 2090 2095 2100
	Short-term	Medium-term	Long-term
Nuclear power status			
Nuclear energy growth	Stabilization		New NPP units
Nuclear energy size	Small (2.4 GWe)		Small (2.4 GWe)
Energy products	Electricity		Electricity
Technology options			
NFC type	Once-through nuclear fuel cycle		Once-through nuclear fuel cycle
Waste management option	AR pool & export of SNF	Final geologic disposal of HLW	
Reactor type	LWR		LWR
Reactor fleet and NFC activities			
Evolutionary reactors	WWER-1200		WWER-1200
NFC back-end	AR SNF storage facilities	AR and AFR SNF storage facilities	
International cooperation			
NFC front-end cooperation	Bi-lateral		Bi-lateral
NFC back-end cooperation	Bi-lateral		Bi-lateral
Key developments			
Informational Support	Republican Unitary Enterprise "Belarusian nuclear power plant"; Regulatory Body – The Ministry for Emergency Situations of the Republic of Belarus; Department of Nuclear and Radiation Safety of the Ministry for Emergency Situations of the Republic of Belarus; Department of Nuclear Energy of the Ministry of Energy of Belarus		
Infrastructure	Republican Unitary Enterprise "Belarusian nuclear power plant"; Regulatory Body – The Ministry for Emergency Situations of the Republic of Belarus; Department of Nuclear and Radiation Safety of the Ministry for Emergency Situations of the Republic of Belarus; Department of Nuclear Energy of the Ministry of Energy of BelarusDepartment of information and public relations in the structure		
Legal base	Law on the use of Atomic Energy; Law of the Republic of Belarus "On Protection of the Public and Territories in Emergency Situations of Natural and Technogenic Character"		

Application of the ROADMAP template to NES of Romania

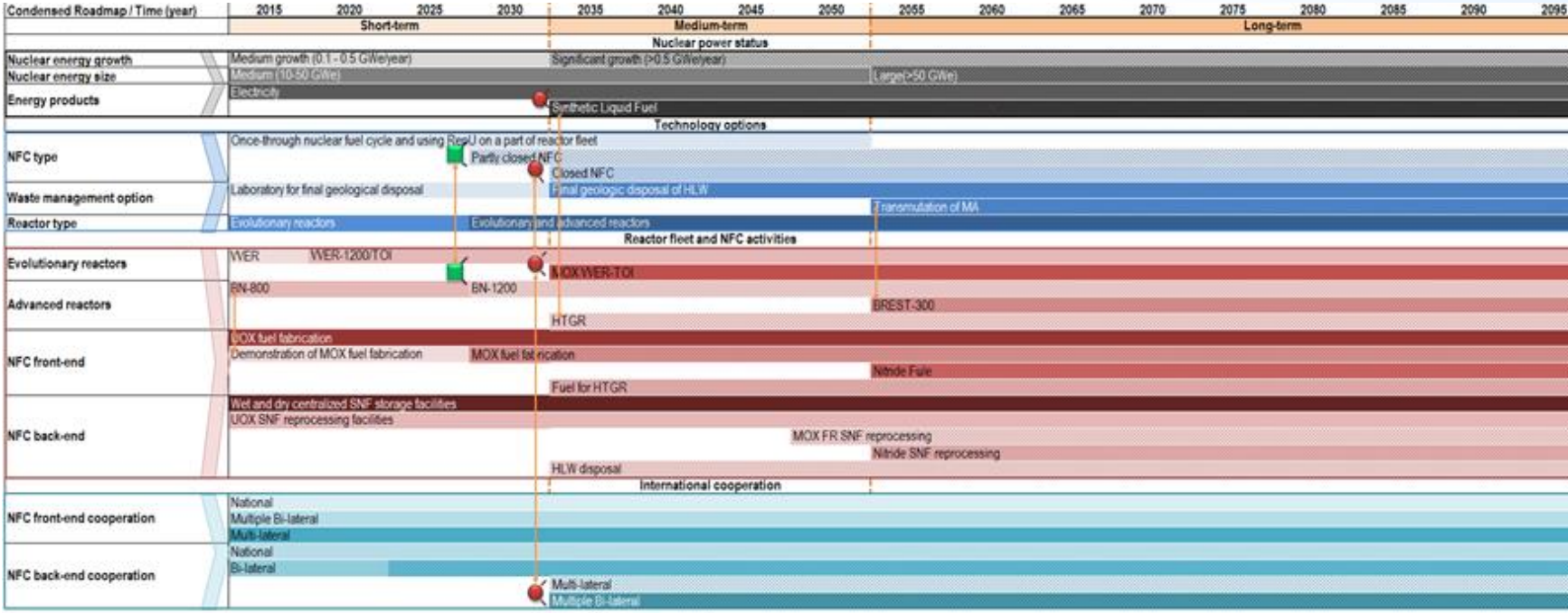


(a) Nuclear power status, technology options, reactor fleet and NFC activities



(b) Status of international cooperation in NFC activities

Application of the ROADMAP template to NES of the Russian Federation



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Thank you!

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Back-up viewgraphs

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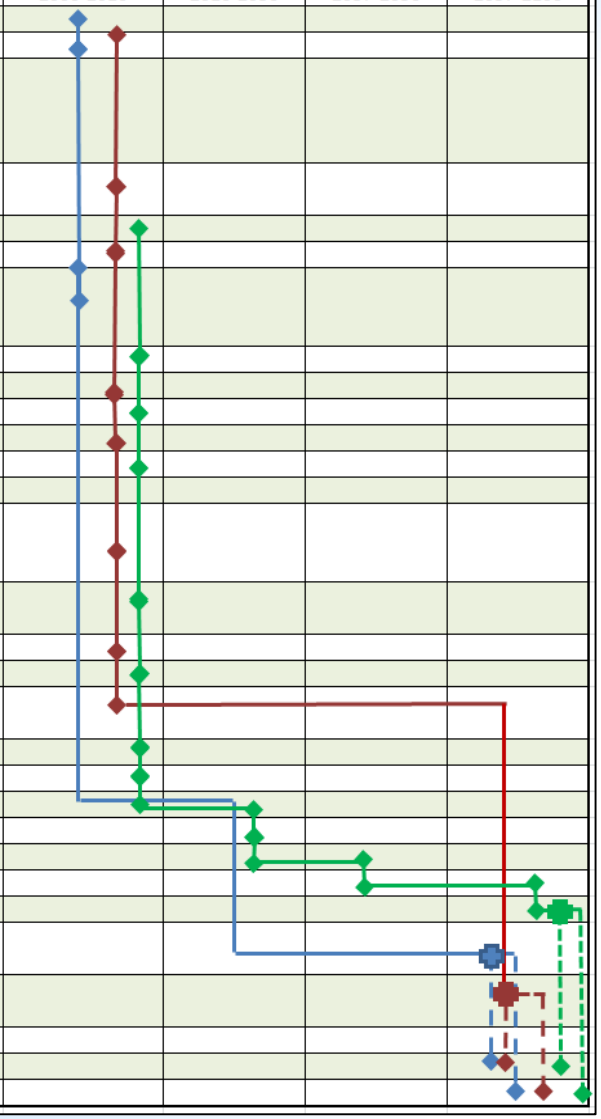
International Project on
Innovative Nuclear Reactors
and Fuel Cycles

A trial roadmap visualization for Thailand

Key events	Dates	2000-2016	2016-2036	2037-2056	2057-2100
Sociological monitoring: yes-31%, no-26%	2007				
Sociological monitoring: yes-17%, no-83%	2011				
Legal framework on nuclear liability, safety, radiation & environmental protection, operation, waste management and decommissioning, security & non-proliferation	2016-2018				
The courses on NP in a university; retraining of energy specialist	2016				
Decision on NPP financing	2022				
Establishment of a regulatory & oversight body	2022				
Communication with stakeholders via Information centre near NPP site and Press centre in the Minis try of Information, etc	From 2022				
Directorate for NPP construction is established	2022				
Law on the Use of Atomic Energy	2016				
Start of implementation of nuclear programme	2021				
Receiving licenses for NPP siting	2024				
Country NPP as sessment	2016-2020				
INPRO Assestment	2020-2022				
General Contract & contracts on site investigation, design/working documentation, works at the site	2024-2025				
Completion of construction of manufacturing base at the NPP site	2027				
Receiving licenses for NPP construction	2027				
Start of NPP construction (concrete for Unit 1)	2028				
Signed a construction contract for two units covering fuel supply, training & other service	2029				
Start of the Unit 2 construction	2029				
The unit 1 commissioning	2035				
The Unit 2 commissioning	2036				
Start of construction of the Dry Storage of SNF	2039				
Commissioning of the Dry Storage of SNF	2044				
Start of the Unit 1 decommiss ioning	2095				
Start of the Unit 2 decommiss ioning	2096				
Sociological monitoring on SNF final disposal decision	2040-2045				
Governmental decision on final disposal, licenses on the site and facility construction	N/A				
Governmental decis ion on sending SNF abroad	N/A				
Domestic disposal facilities	N/A				
Disposal facilities abroad	N/A				



Application of ROADMAPS template to NES of Ukraine

Conclusion

- Roadmap template is an analytical tool intended to represent the status, prospects, benefits and risks associated with NES deployment scenarios targeted to evaluate different measures of maintaining and enhancing the NES sustainability.
- The template provides some flexibility to represent a variety of options for the NES deployment scenarios specifications and a capability to identify the merits and demerits of possible measures to maintain and enhance the NES sustainability in different circumstances.
- Roadmap template may be implemented for strategic planning, analytical studies, preparation of reporting documentation for the management and summaries for the media regarding the issues related to the transition to sustainable NESs.
- Roadmap template incorporates recent methodological achievements and the best practices in the area of elaboration and representation of national nuclear roadmaps towards sustainable NESs, and extends relevant standard technology roadmap functionality.