



IAEA

60 Years

Atoms for Peace and Development

Approaches for Advanced Reactor Technology Assessment for Near Term Deployment

Matthias KRAUSE

Nuclear Power Technology Development Section

**First Meeting of the Technical Working Group for
Small Modular Reactors (TWG-SMR)**

April 23 – 26, 2018

OUTLINE

- IAEA Reactor Technology Assessment (RTA)
- Setting National (Nuclear Project) Priorities
- Key Elements and Topics
- Applying the RTA Framework
 - ***RTA IT Toolkit (beta)***



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RTA methodology and assessment example

- 2013 : newcomer / embarking countries applied → lessons learned
- 2019 : Revised NES

RTA Toolkit – BETA Version

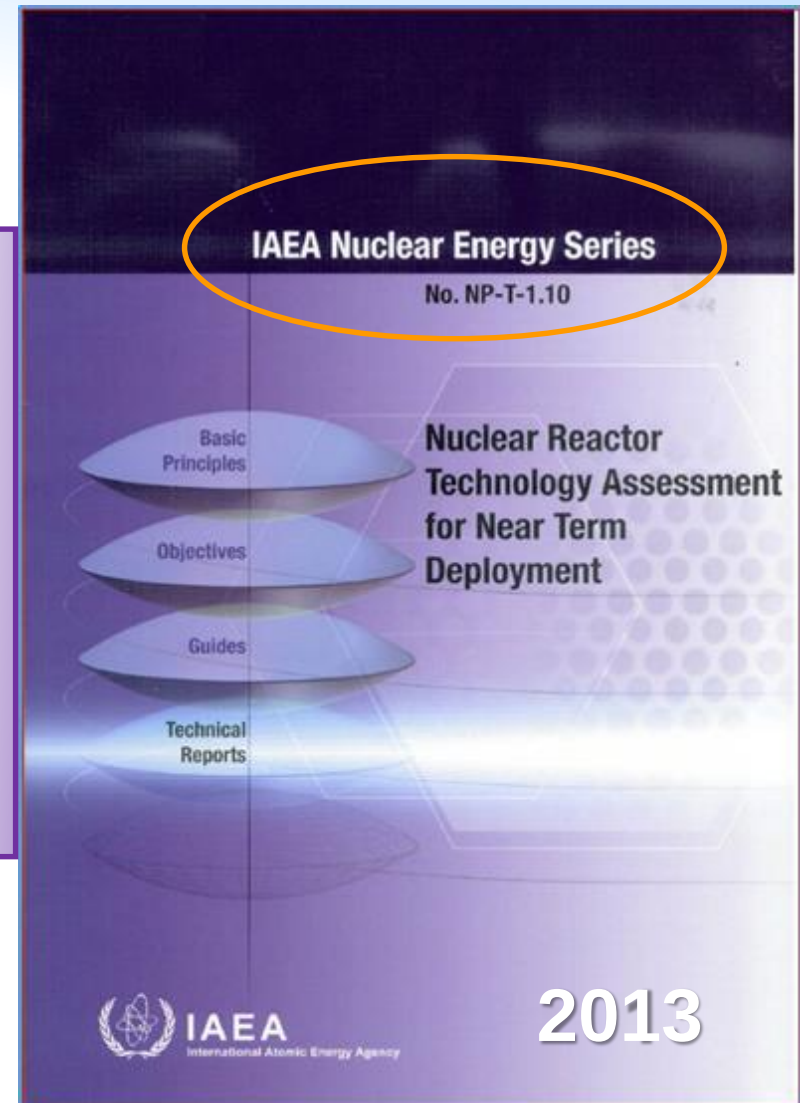
- Used in case study exercise
- Working materials → not for distribution

RTA workshop / training in Vienna 12 – 16 NOVEMBER, 2018

- RTA Toolkit Release
- Member State Feedback
- Group Case Studies



Revised Methodology



Integrated TA Methods

IAEA RTA is a decision making process for the evaluation of (nuclear) power plant technologies for selection and near term deployment

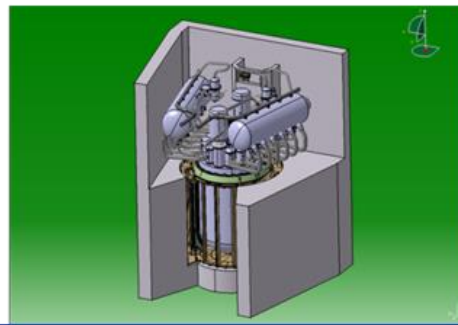
What is it?

When do I perform it?

Who should do it?

How is it to be done?

Why should it be done?



It is a formal process of specifying key elements that are based on country-specific protocols, assigning relative importance to each, and quantitatively evaluating each design in a consistent manner using reliable and comparable data.

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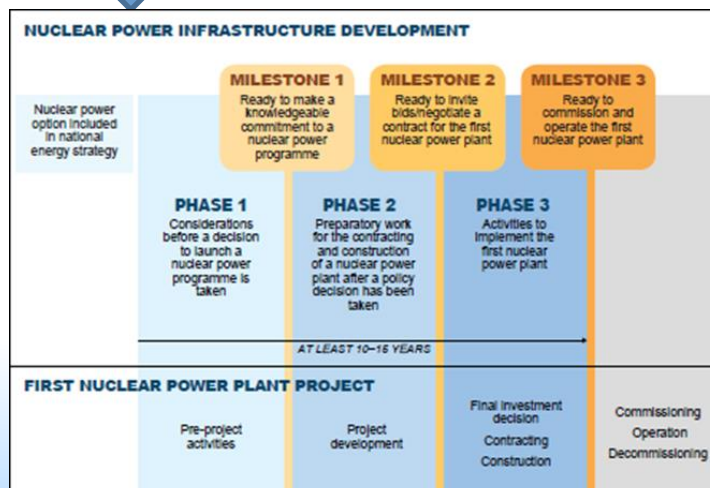
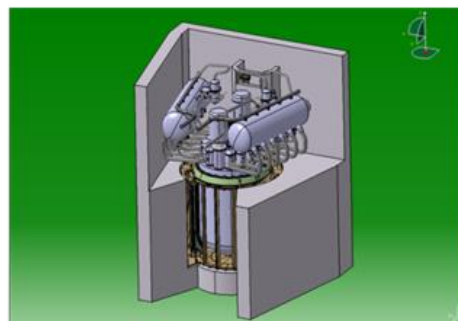
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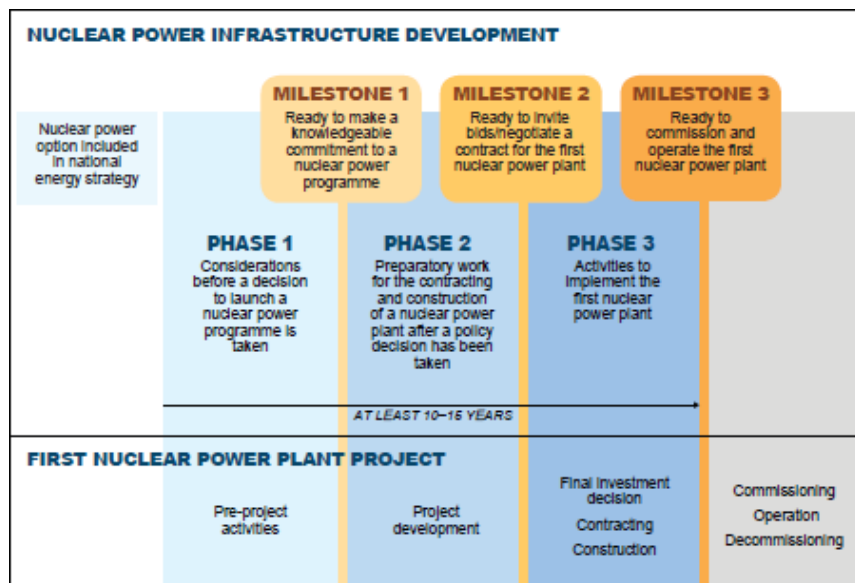
Why should it be done?



Essential outline of the milestones approach

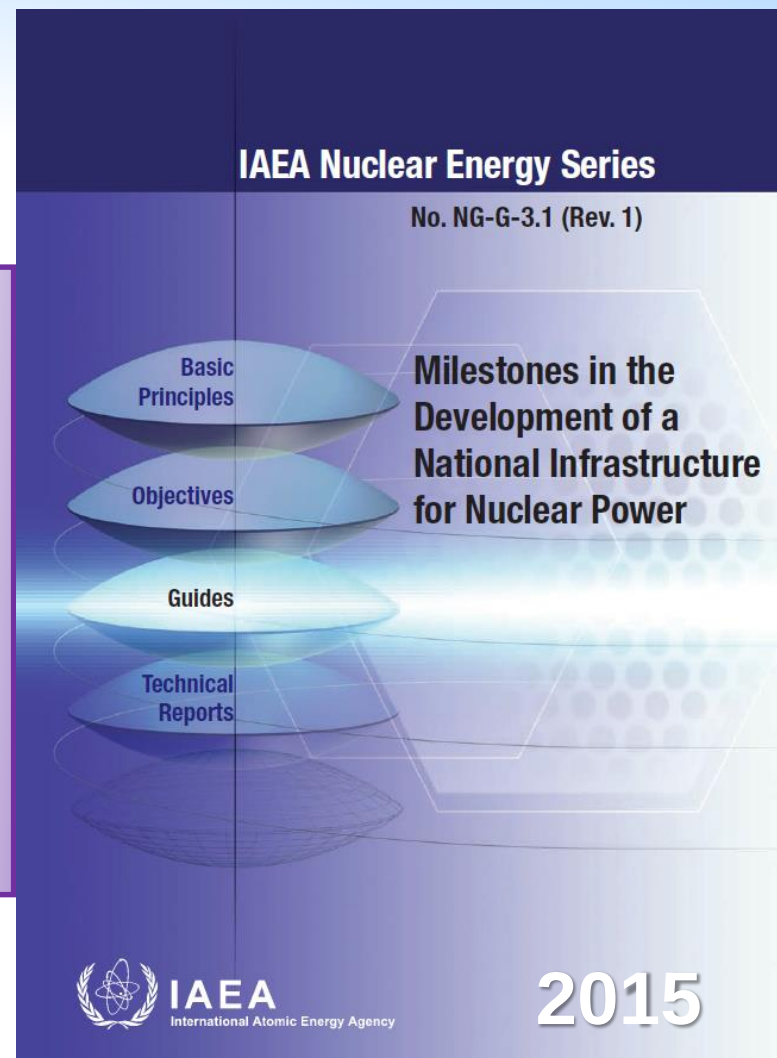
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Essential outline of the milestones approach



Milestone 1 — Ready to make a knowledgeable commitment to a nuclear power programme

The introduction of nuclear power requires long term commitments, both nationally and internationally. A time frame in the order of 100 years should be considered for a nuclear power plant, with waste disposal obligations extending significantly longer. The initial implementation period will be at least 10–15 years. It is of the utmost importance to fully understand these long term programmatic commitments before even considering a specific nuclear power plant project.



http://www-pub.iaea.org/MTCD/Publications/PDF/Pub1704_web.pdf

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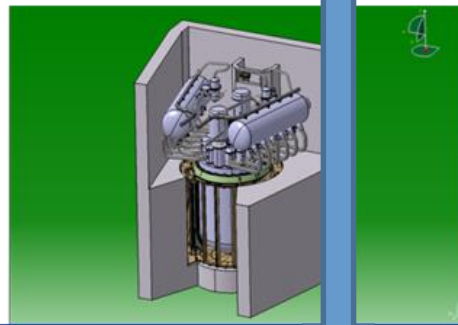
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Critical to RTA outcome

- **Ownership and the Assessment Task Team members are critical success factors**
 - Owner/Operator shall take full responsibility for the conduct and results of the RTA
 - Technical / Managerial Technology Assessment Task Team is assembled with its mission to report the results directly to the (top) decision-maker
 - Task Team with full expertise in design, engineering, construction, and operation of facility and its environs
 - Consultants should be used as required to supplement the Task Team with specific expertise, reporting to the Task Team Management

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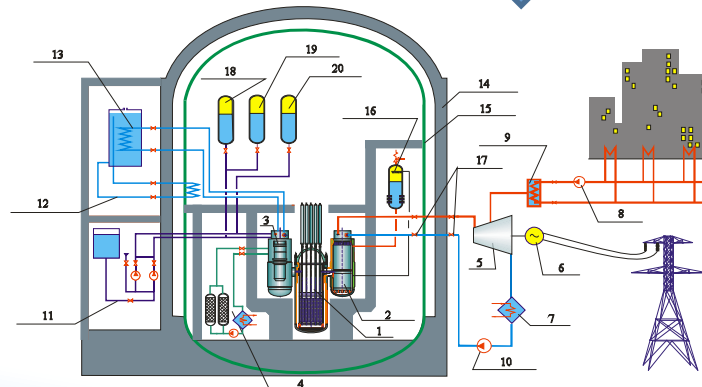
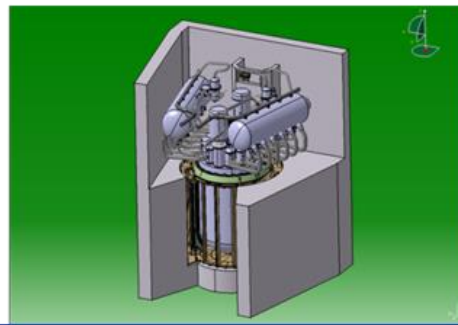
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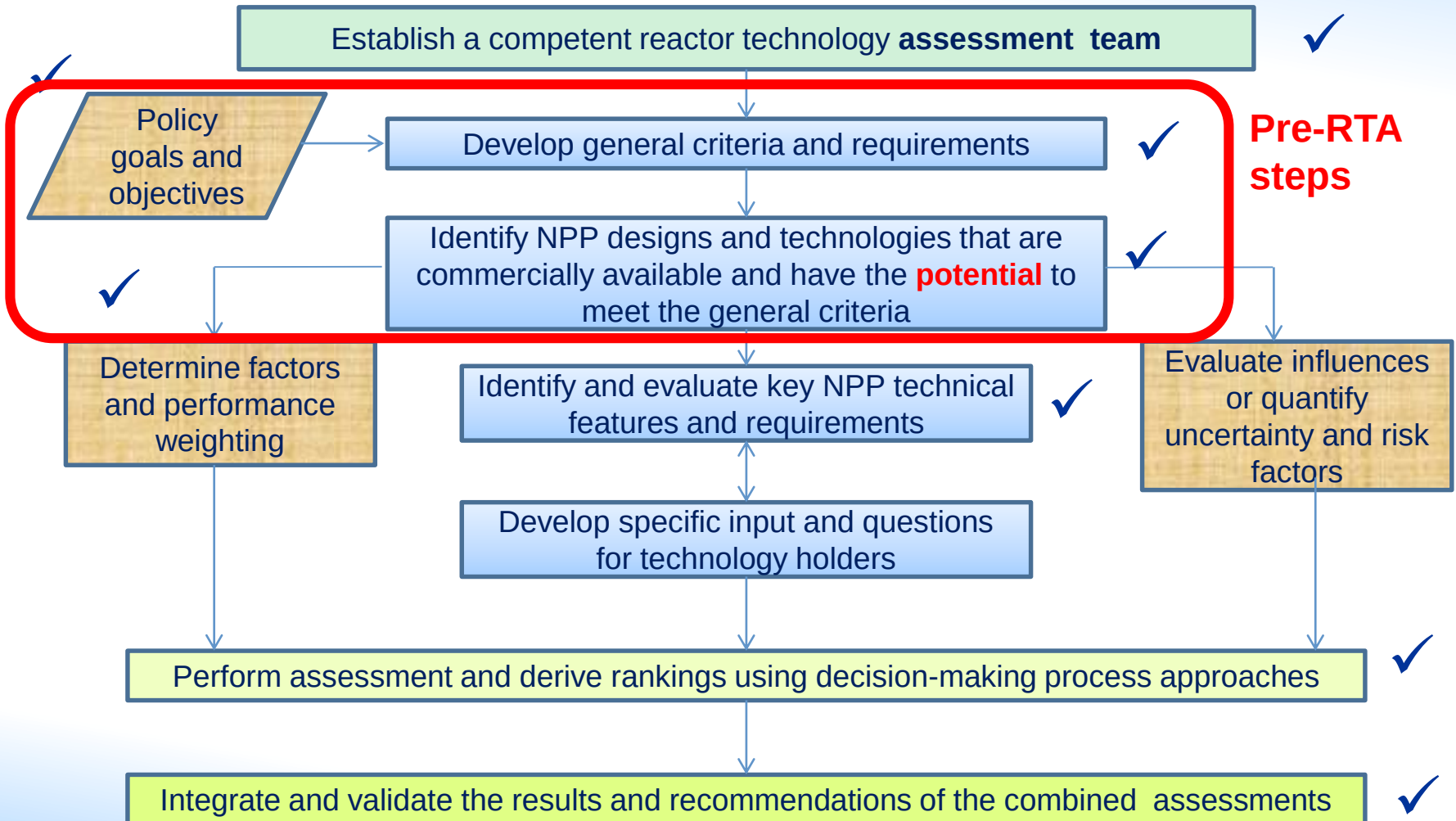
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RTA Process: Pg. 8, Fig.1.

General methodology follows the practice of a basic decision making evaluation of available technical options that have potential to satisfy national needs



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General methodology follows the practice of a basic decision making evaluation of available technical options that have potential to satisfy national needs



Setting the general criteria and requirements:

NP-T-2.1 identifies the needs as expressed by newcomer Member States in terms of development and deployment of new nuclear energy systems...

- *Derived* on the basis of input from a large number of experts, acting as 'technology users' and representing 35 developing countries.
- *Incorporates* the recommendations of experts from 'technology holder' countries, as well as lessons learned from international and IAEA activities, including user requirements programmes in technology holder countries.
- Covers the general technical and economic characteristics of nuclear power plants and fuel cycle options (including waste management facilities), as well as associated support services requested by potential users of future nuclear energy systems in developing countries.

IAEA Nuclear Energy Series

No. NP-T-2.1



Common User Considerations (CUC) by Developing Countries for Future Nuclear Energy Systems: Report of Stage 1

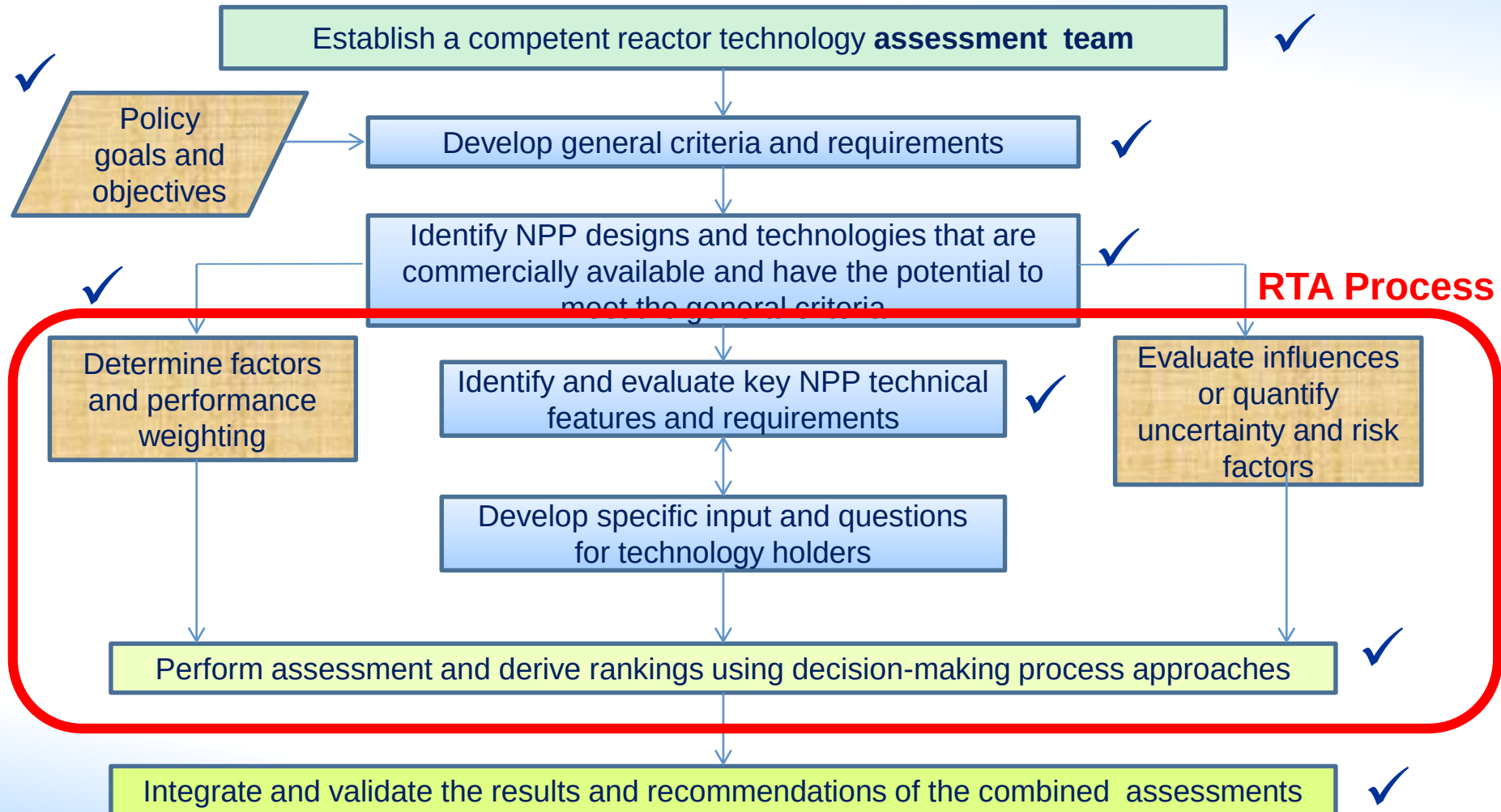


IAEA
International Atomic Energy Agency

2009

RTA Process: Pg. 8, Fig.1.

General methodology follows the practice of a basic decision making evaluation of available technical options that have potential to satisfy national needs



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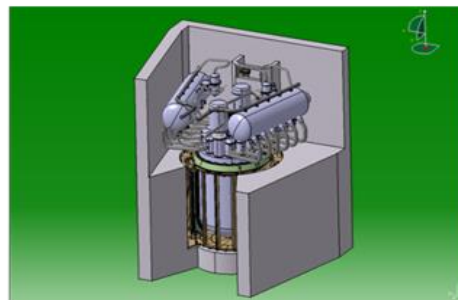
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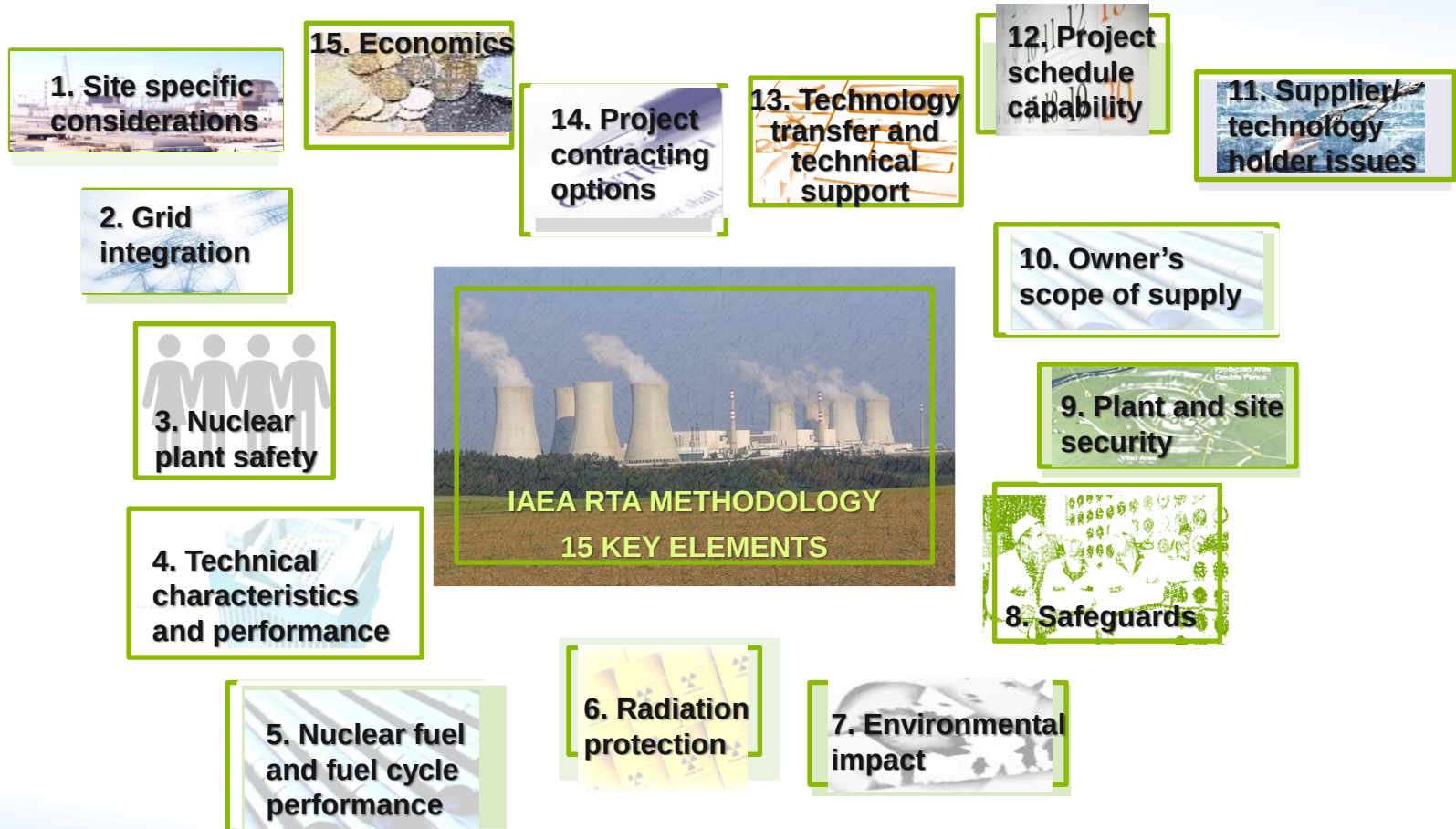
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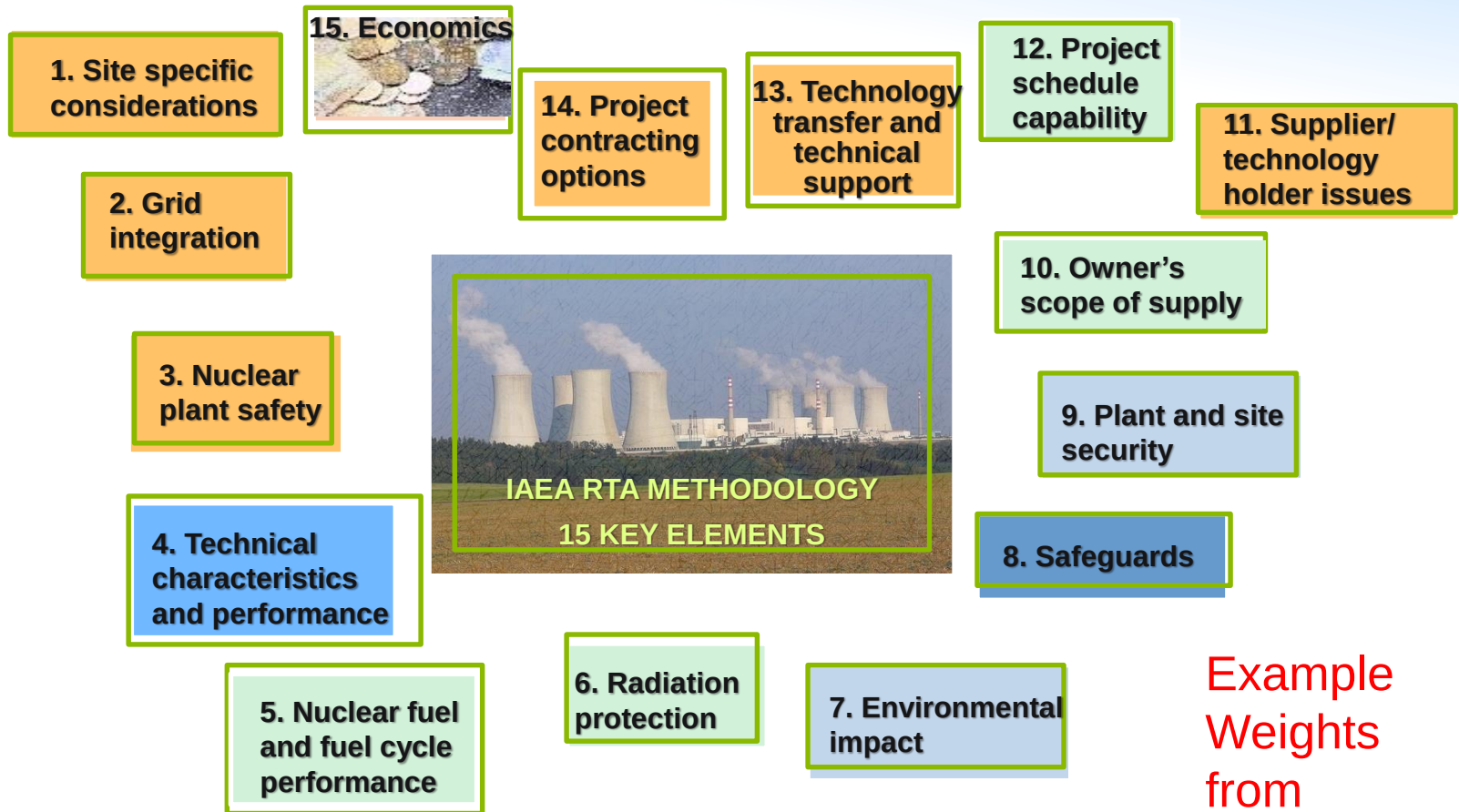
Quantitative RTA (**weighting** and **scoring**):

- Decision matrix contains 15 key elements for each technology option to be assessed
- Relative importance (**weight**) is assigned to each of the 15 key elements and corresponding key topics
- Each of technology options are evaluated comparatively (**scored**) on the basis of known data or engineering judgement and scored for all key topics under the 15 key elements
- Technology option with the **highest total score** is the overall preferred technology option, i.e. recommendation to decision maker(s)

RTA 15 Key Elements



RTA 15 Key Elements - LNPP



Example
Weights
from
NP-T-1.10

High

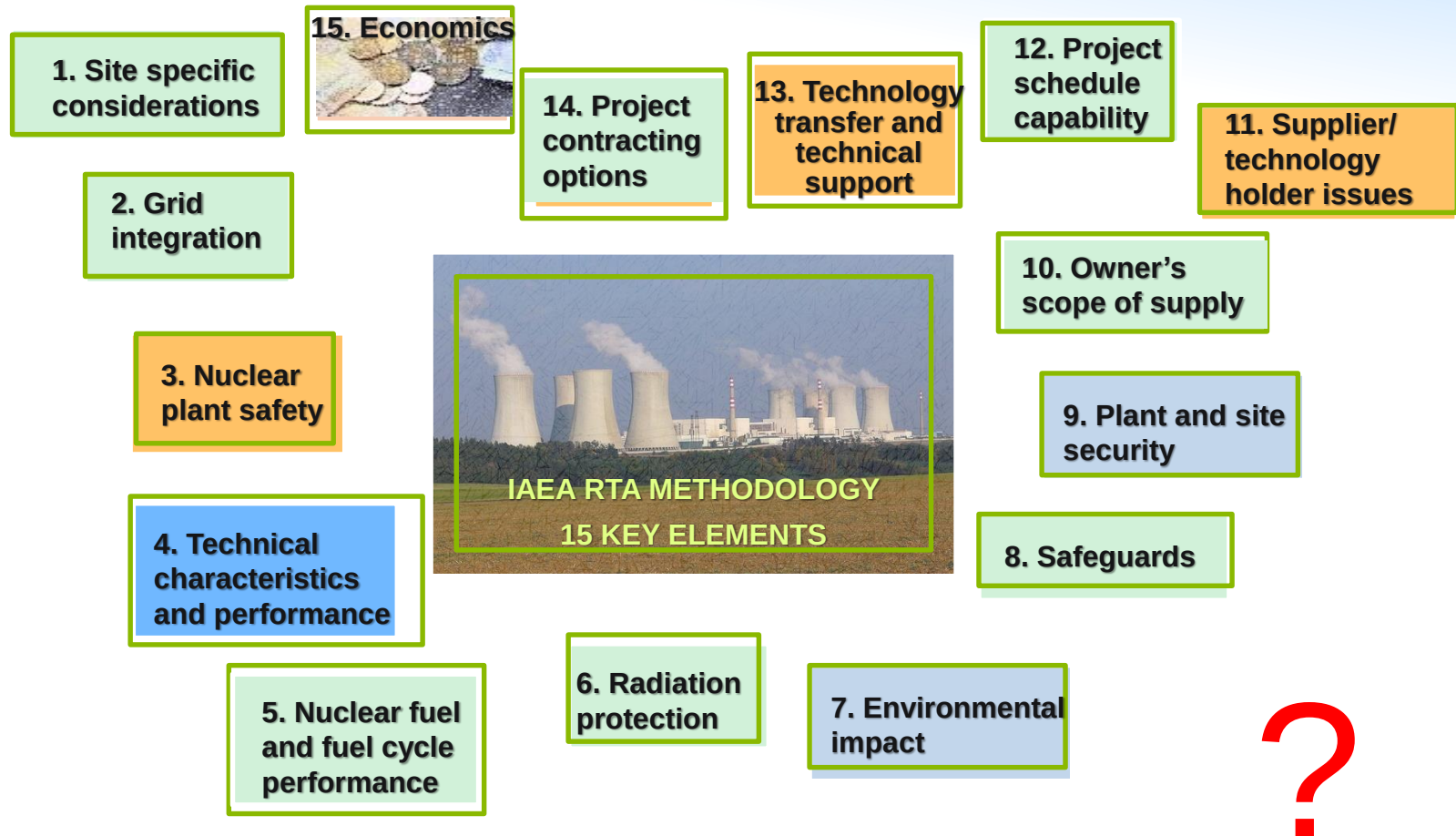
Medium

Low

Not strong
differentiator

Per key topic

RTA 15 Key Elements - SMR



High

Medium

Low

Not strong
differentiator

Per key topic

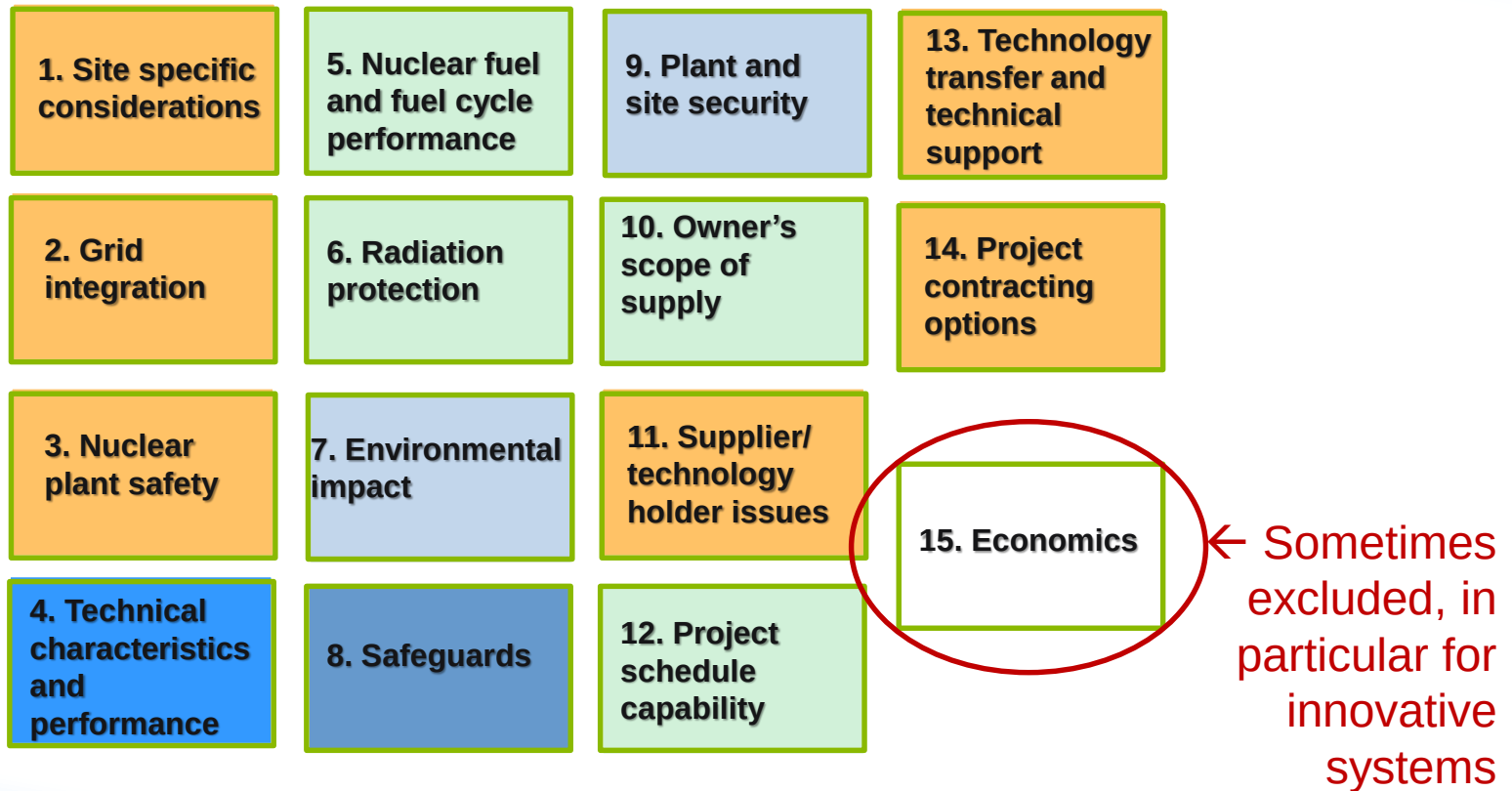
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Applying the RTA Framework

SMALL MODULAR REACTORS



Main Information Sources

Technical:

- ARIS (IAEA), NPP Design Descriptions (vendor), PSAR/FSAR (USNRC)

Economical:

- IEA, WNO, IAEA, public studies, etc.
...BUT highly dependent on the build country!

Historical (design and operating history):

- PRIS (IAEA), Technology User Groups, various public sites (WNO etc.)

Assessing Nuclear Options

RTA can be done with or without economics aspect.

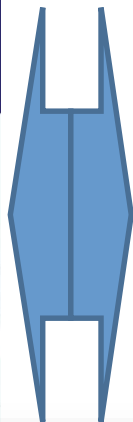
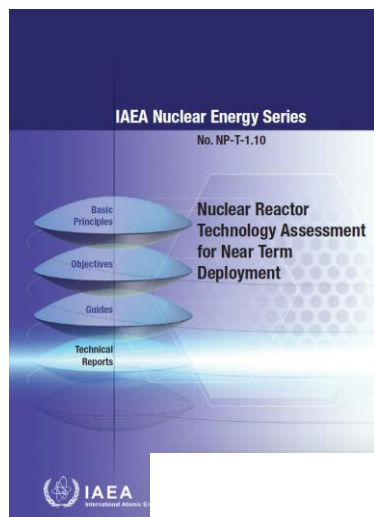
- IAEA RTA includes economics as Key Element 15
- New ARIS template attempts to collect more detailed information from vendors, but not LCOE.

LCOE must be calculated by operator!

New ARIS template was sent to 10 SMR designers

<i>Build Project Costs (excluding licensing)</i>	<i>Estimate or Range, based on Reference Site Design and Location</i>	
Construction Time (n th of a kind)		months from first concrete to criticality
Design, Project Mgmt. and Procurement Effort		person-years (PY) [DP&P]
Construction and Commissioning Effort		PY [C&C]
Material and Equipment Overnight Capital Cost		Million US\$(2015) [M&E], if built in USA
- Site Development before first concrete	/	% of [C&C] in PY / % of [M&E] in \$
- Nuclear Island (NSSS)	/	(e.g. 25 / 10) (30 / 40)
- Conventional Island (Turbine and Cooling)	/	(20 / 25) (20 / 10)
- Balance of Plant (BOP)	/	(5 / 15) (-----)
- Commissioning and First Fuel Loading	/	(to add up to 100 / 100)
Factory / On-Site split in [C&C] effort	/	% / % of total [C&C] effort in PY (e.g. 60 / 40)

RTA IT-Toolkit (beta)



Selection of Reactors


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International Atomic Energy Agency
Atoms for Peace and Development

Toolkit for Reactor Technology Assessment
Developed by the Nuclear Power Technology Development Section
Division of Nuclear Power, Department of Nuclear Energy
INTERNATIONAL ATOMIC ENERGY AGENCY (IAEA)

Trial Version - March 2018

Select the type of reactor:
☒ Large reactor ☐ SMR

Select the number of reactors to be assessed: 5

Select reactors to be assessed from the boxes below:

ABWR (BWR) AP1000 (PWR) APR1400 (PWR) HPR1000 (PWR) Other

ABWR (BWR)
ACR-1000 (HWR)
AHWR (HWR)
AP1000 (PWR)
APR+ (PWR)
APR1400 (PWR)
EC6 (HWR)
EPR (PWR)
ESBWR (BWR)

Reactor X

Evaluator Identification

Name: User Organisation/Country: IAEA

OK



RTA Toolkit – Version 6

User Manual

March 2018

Nuclear Power Technology Development Section (NPTDS)
Division of Nuclear Power, Department of Nuclear Energy

Excel spreadsheet with macros (software that performs specific tasks and calculations)

FOREWORD

This manual is a practical guide for installation and use of the reactor technology assessment (RTA) toolkit – version 6. The toolkit is developed based on the IAEA Nuclear Energy Series, No. NP-T-1.10, *Nuclear Reactor Technology Assessment for Near Term Deployment* (2013). The toolkit is Excel based software.

The manual is split in two volumes:

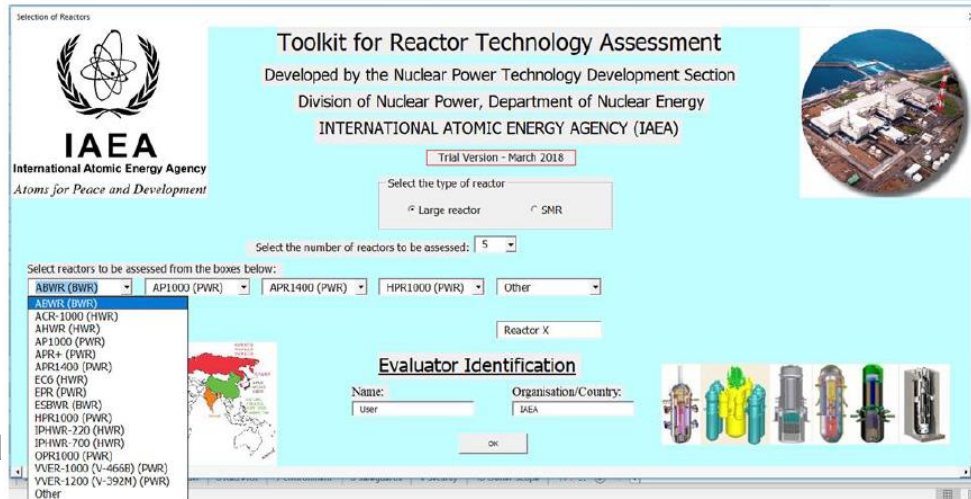
Volume I: RTA Toolkit – Version 6 Installation Guide

Volume II: RTA Toolkit – Version 6 User's Guide

Volume I provides detailed information regarding toolkit required Excel version, steps for toolkit installation, and steps for trusting the toolkit.

Volume II provides detailed specifications for toolkit input and data layouts for the fields, toolkit execution, representative examples and discussion on output values.

RTA IT-Toolkit: Selection of Reactor Technologies

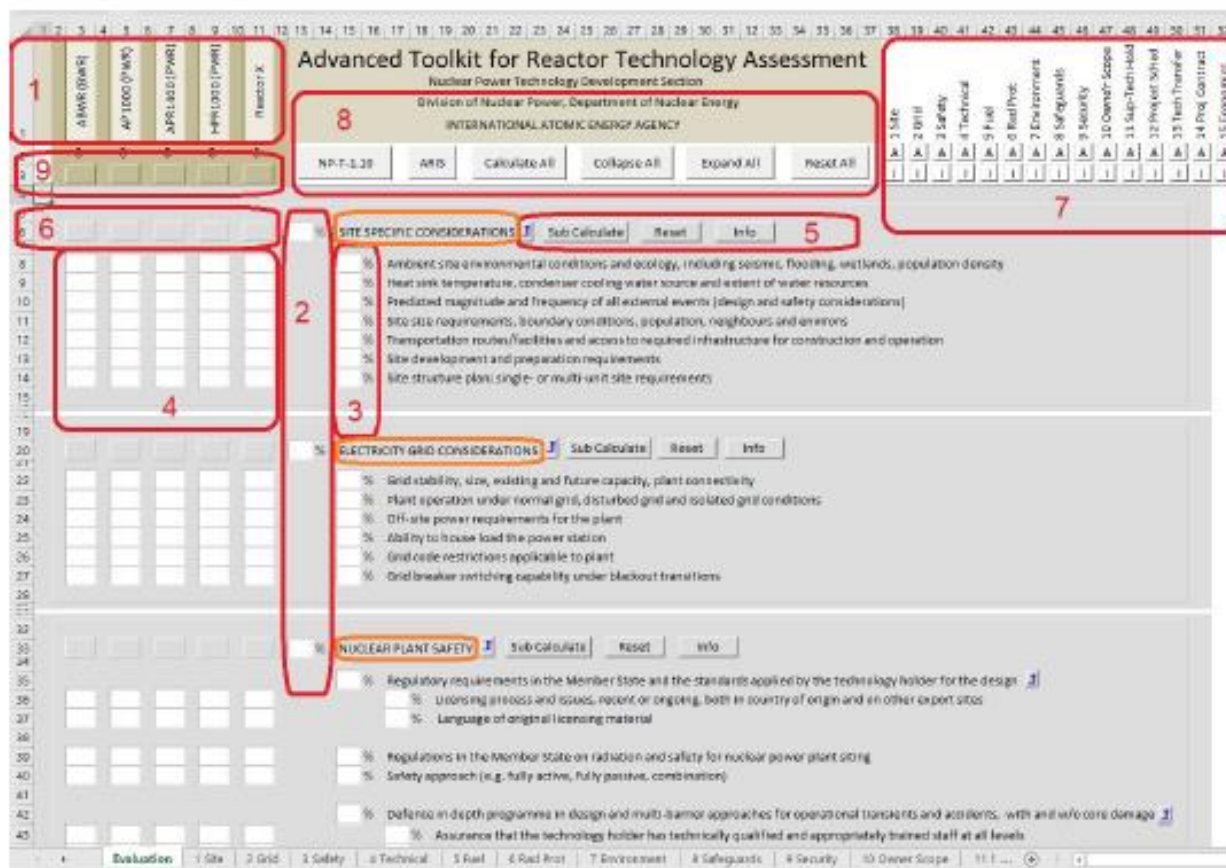


Drop-down menu

Available reactor types (Manual, Pg. 16)

Large reactors	SMRs
ABWR (BWR)	4S (LMC-SMR)
ACR-1000 (HWR)	ACP100 (WC-SMR)
AHWR (HWR)	CAREM-25 (WC-SMR)
AP1000 (PWR)	EM2 (GC-SMR)
APR+ (PWR)	GTHTR300 (GC-SMR)
APR1400 (PWR)	HTR-PM (GC-SMR)
EC6 (HWR)	HTMR100 (GC-SMR)
EPR (PWR)	KLT40S (SMR-ship)
ESBWR (BWR)	NuScale (WC-SMR)
HPR1000 (PWR)	PFBR (LMC-SMR)
IPHWR-220 (HWR)	PRISM (LMC-SMR)
IPHWR-700 (HWR)	RITM-200 (SMR-Icebreaker)
OPR1000 (PWR)	SMART (WC-SMR)
VVER-1000 (V-466B) (PWR)	SVBR (LMC-SMR)
VVER-1200 (V-392M) (PWR)	Other
Other	

RTA IT-Toolkit: Excel Layout



The screenshot shows the 'Advanced Toolkit for Reactor Technology Assessment' interface. It is an Excel spreadsheet with various sections and controls. Red boxes and numbers highlight specific areas:

- 1**: A list of reactor designs (AP1000, AP1000 (PWR), AP1000 (PWR), AP1000 (PWR), Reactor X).
- 2**: A grid for inputting percentages for 15 key elements.
- 3**: A grid for inputting percentages for a single key element.
- 4**: A grid for inputting scores for criteria per key element.
- 5**: Buttons for 'Sub Calculate', 'Reset', and 'Info' for the 'SITE SPECIFIC CONSIDERATIONS' section.
- 6**: A grid showing calculated scores for values.
- 7**: A set of buttons for navigating through the toolkit layout (1 Site, 2 Grid, 3 Safety, 4 Technical, 5 Fuel, 6 Rad Prot, 7 Environment, 8 Safeguards, 9 Security, 10 Owner Scope, 11 Tech Transfer, 12 Project Sched, 13 Prog Contract, 14 Economics).
- 8**: Buttons for 'NPT-L2B', 'ARIS', 'Calculate All', 'Collapse All', 'Expand All', and 'Reset All'.
- 9**: A grid for output values.

The interface includes sections for 'SITE SPECIFIC CONSIDERATIONS', 'ELECTRICITY GRID CONSIDERATIONS', and 'NUCLEAR PLANT SAFETY', each with a list of criteria and checkboxes for evaluation.

FIG. 2 Toolkit Layout:

1 – Selected reactor designs, 2 – Percentages for 15 key elements, 3 – Percentages for single key element, 4 – Scores for criteria per key element, 5 – Buttons for single key element, 6 – Calculated scores for single key element, 7 – Buttons for navigating through toolkit layout, 8 – Buttons for six links, 9 – Output values;

Blocks 1, 7, 8, and 9 are always visible.

Manual, Pg. 17

RTA Scoring

- Scores are integers between 1 and 5 entered for each reactor design per each key topic within the assessed key elements (
- Scores indicate the degree or extent to which the reactor satisfies the given key element/topic scope:

Score	Reactor design satisfies the key topic to:
5	Large extent
4	Greater than “medium” extent, but not to a large extent
3	Medium extent
2	Lesser than medium extent, but greater than a little extent
1	Minimum extent

Risks and Uncertainties

Both technical and non-technical risks/uncertainties decrease with the maturity of the design.

- They can be treated in RTA with sensitivity analyses.
- Their early identification is essential in seeking the relevant additional input from vendors or experts.

Typically, non-technical risks and uncertainties are larger, RTA Section 5.4. gives examples, but they are closely linked to national goals. Examples are the importance of **inter-governmental relations** and the **synergy** of NPP deployment and overall national infrastructure development needs.

Conclusions – RTA for NPP / SMR

- The RTA methodology is equally applicable to SMR and large NPP projects.
- Depending on the intended application, available information, and level of overall technology maturity / operating experience, the RTA Key Element weights could be significantly different.
- Sensitivity studies should always be performed to evaluate which are the most sensitive elements and assumptions, in order to seek more information or clarification. Expert consultants can help.

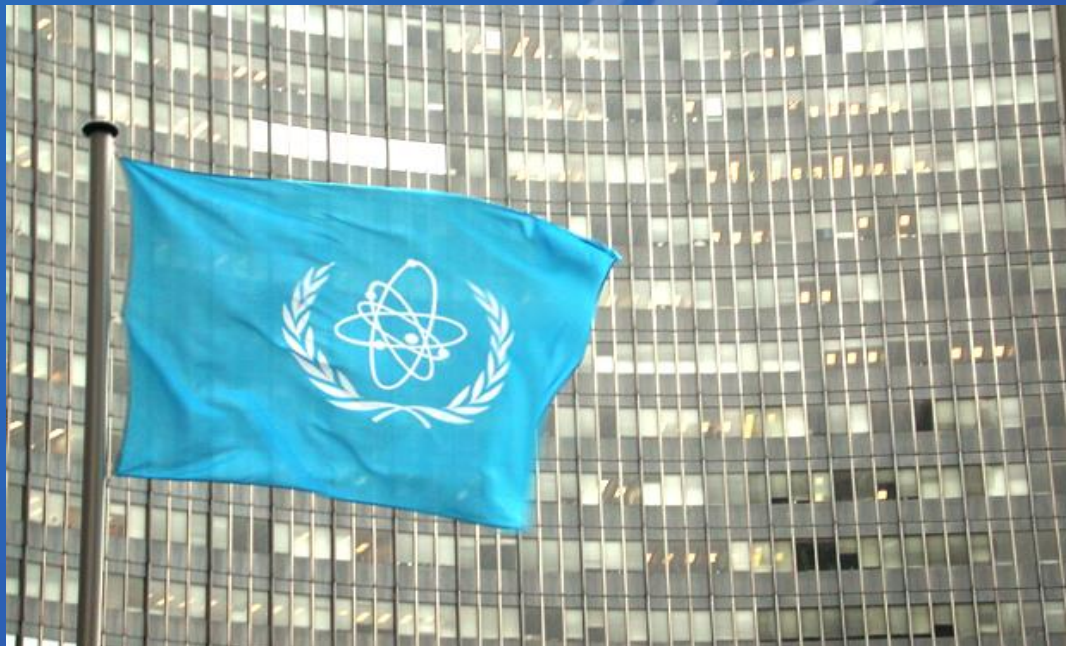




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Thank You!
