Carolina Piedmont Chapter
IAEA Technology Assessment and Nuclear Power Projects

Charlotte, NC October 15, 2019

Broadening Horizons: Consulting on Behalf of the International Atomic Energy Agency

Dr Stephen P. Schultz

Consultant to the Advisory Committee on Reactor Safeguards, U.S. NRC
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Introductions: Dr Stephen P. Schultz

Charlotte, NC October 15, 2019

Work Experience

Consultant to the Advisory Committee on Reactor Safeguards (ACRS), U.S. Nuclear Regulatory Commission
ACRS Member (2012 – 2016) Chair, Fukushima Subcommittee, 06/2012 to 01/2016

Nuclear Engineering Consultant, IAEA 12/2010 to 12/2011
Reactor Technology Assessment Program Development & Documentation

Retired from U.S. Utility Industry in 2010:

1977 to 1997	Yankee Atomic Electric Company
1997 to 1999	Duke Engineering & Services
1999 to 2010	Duke Energy Corporation

Education/Training

MBA, Management, Northeastern University, 1991
ScD, Nuclear Engineering, Massachusetts Institute of Technology, 1977
MS, Nuclear Science and Engineering, Rensselaer Polytechnic Institute, 1970
BS, Engineering, Harvey Mudd College, 1969
AS, Math and Physical Science, College of Marin, 1966

Certifications

Registered Professional Engineer, North Carolina

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Work Highlights

Yankee Atomic Electric Company, Massachusetts, USA

Developed and licensed the FROSSTEY Code for nuclear fuel thermal performance modeling
Supervised teams in Fuel Performance, Methods Development, BWR Transient Analysis, Probabilistic Safety Assessment, LOCA and Containment Analysis (1979 to 1988)
Vice President, Nuclear Engineering, Environmental Engineering, and Environmental Laboratory (1988 to 1997)

Duke Engineering & Services, Massachusetts, USA

General Manager, Nuclear and Fuels Services (1997 to 1999)

Duke Energy Corporation, North Carolina, USA

Engineering Manager, Nuclear Design and Radiological Engineering, (1999 to 2010)

Engineering New Hire program lead for central office and 3 sites

ANS Fellow, Lifetime Member, Patron Member (2010-2019)
ANS Board Member (2012-2015), Finance Committee (2015-2020), Investment SC Chair

EPRI and NEI Advisory Committees

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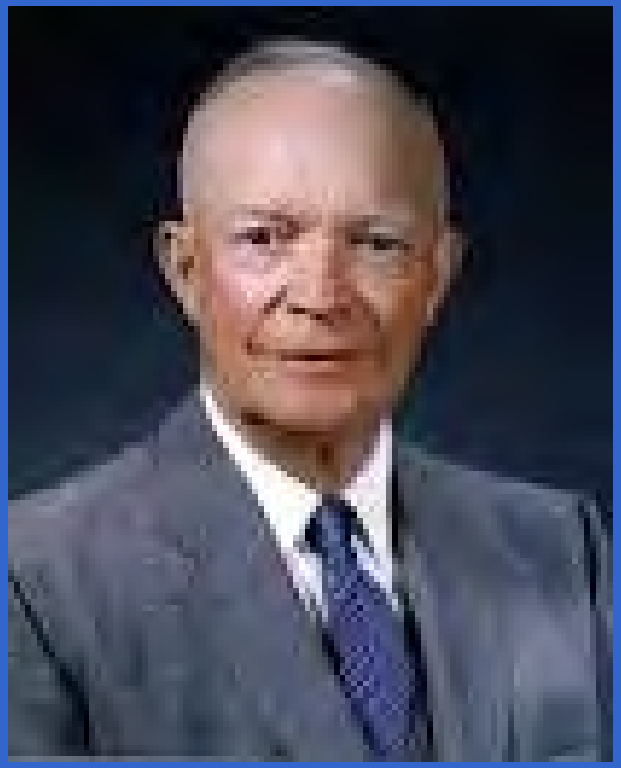
Welcome to the IAEA

Origen of the IAEA

1953 Atoms for Peace

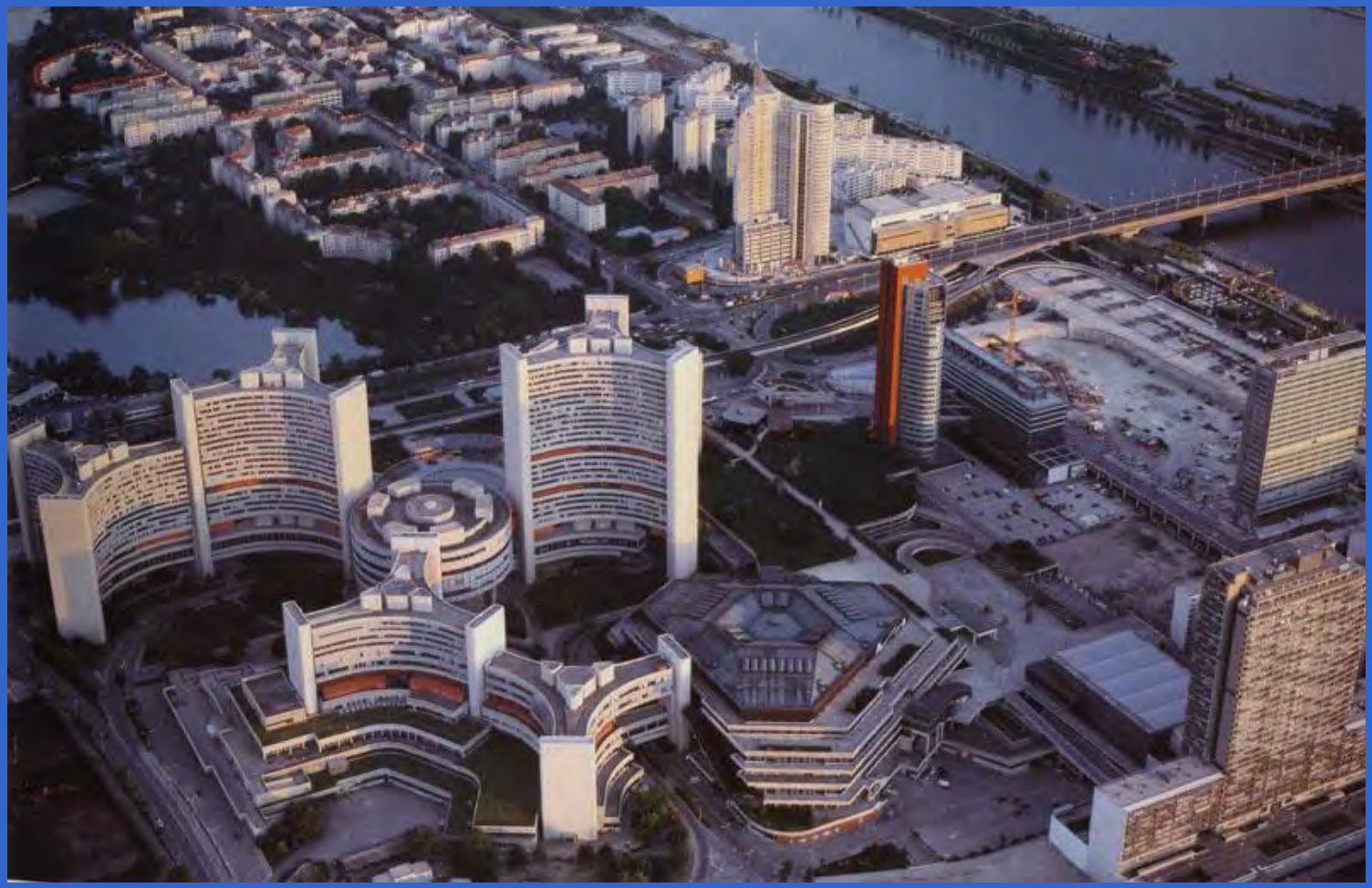
1957 Adoption of the IAEA Statute

"The Agency shall seek to accelerate and enlarge the contribution of atomic energy to peace, health and prosperity throughout the world. It shall ensure, so far as it is able, that assistance provided by it or at its request or under its supervision or control is not used in such a way as to further any military purpose."



Dwight D. Eisenhower

The Vienna International Center



Basic Functions and Services

Safeguards and Verification

- Basics of IAEA Safeguards
- Safeguards implementation
- Safeguards legal framework
- Assistance for States

Basic Functions and Services

Nuclear Safety and Security

- Human and organizational factors
- Governmental, legal and regulatory framework
- Nuclear installation safety
- Radiation protection
- Security of nuclear and other radioactive material
- Radioactive waste and spent fuel management
- Transport
- Emergency preparedness and response

Basic Functions and Services

Nuclear Technology and Applications

- Energy
- Health
- Addressing environmental issues
- Water
- Food and agriculture
- Industry
- Nuclear science

IAEA Facilities at the VIC

IAEA Program and Plans to Support Technology Assessment and Selection

2011 Steps to develop and deliver the “Reactor Technology Assessment for Near Term Deployment” report:

- ✓ Develop Draft Report to incorporate IAEA and industry experience from 2007 to present for internal review
- ✓ Issue reviewed Report for Consultancy review and input
- ✓ Integrate Consultancy input and incorporate process approach alternatives into final draft
- ✓ Workshop with Member States and vendors to introduce and demonstrate Technology Assessment features [5-9 December]
- ✓ Develop Final Report for review and publication

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Reactor Technology Assessment Development / Data Gathering in Vienna (2011)

Presentations in Technical Events and Workshops

- 2-day Technical Meeting on **Technology and Economic Assessment of Nuclear Desalination**, March
- 3-day Consultancy Meeting on **Status of Innovative Small and Medium Sized Reactor Technology and Designs for Near Term Deployment**, May
- 5-day Interregional Workshop on **Advanced Nuclear Reactor Technology for Near Term Deployment**, July
- 3-day Consultancy Meeting on **Development of Guidelines on the Feasibility Study to Expand or Introduce Nuclear Power Plants**, July
- 3-day Joint Meeting: 16th Meeting of the **Technical Working Group on Advanced Technologies for Light Water Reactors** and the 12th Meeting of the **Technical Working Group on Advanced Technologies for Heavy Water Reactors**, July
- 2-day Consultancy Meeting on the **Application of the Methodology of Nuclear Reactor Technology Assessment for Near Term Deployment for Small/Medium Reactors**, September
- 5-day **Technical Meeting on Nuclear Reactor Technology Assessment for Near Term Deployment**, December

Technology Assessment and Selection
What is it?

Purpose

- **OVERALL**: Determines NPP technology to fulfil energy delivery needs using a systematic process beginning with Policy Objectives
- Assists in refining Infrastructure development
- Develops specific questions to obtain the information from vendors that is required to perform the Technology Assessment
- Develops technical requirements for the bid specification
- Provides the technical core for performing the bid evaluation
- Delivers documented decision-making rationale for the technology choice

Content

- The structured technical evaluation documenting the Policy Objectives and requirements and how well they will be met

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Technology Assessment and Selection
The "give" and the "take"

- **What does the IAEA process approach provide:**
  - A decision-making tool kit for Technology Assessment and Selection
  - Approaches for information gathering and assessment that are designed to be technology-neutral
  - A process that should allow increased level of detail as it moves from requirements for the bid specification to performing the bid evaluation to monitoring project implementation
- **What does the IAEA process approach expect:**
  - The Technology Assessment and Selection is performed and completed by the Member State
  - The Member State has responsibility and authority for technology decisions that are made at any stage in the process

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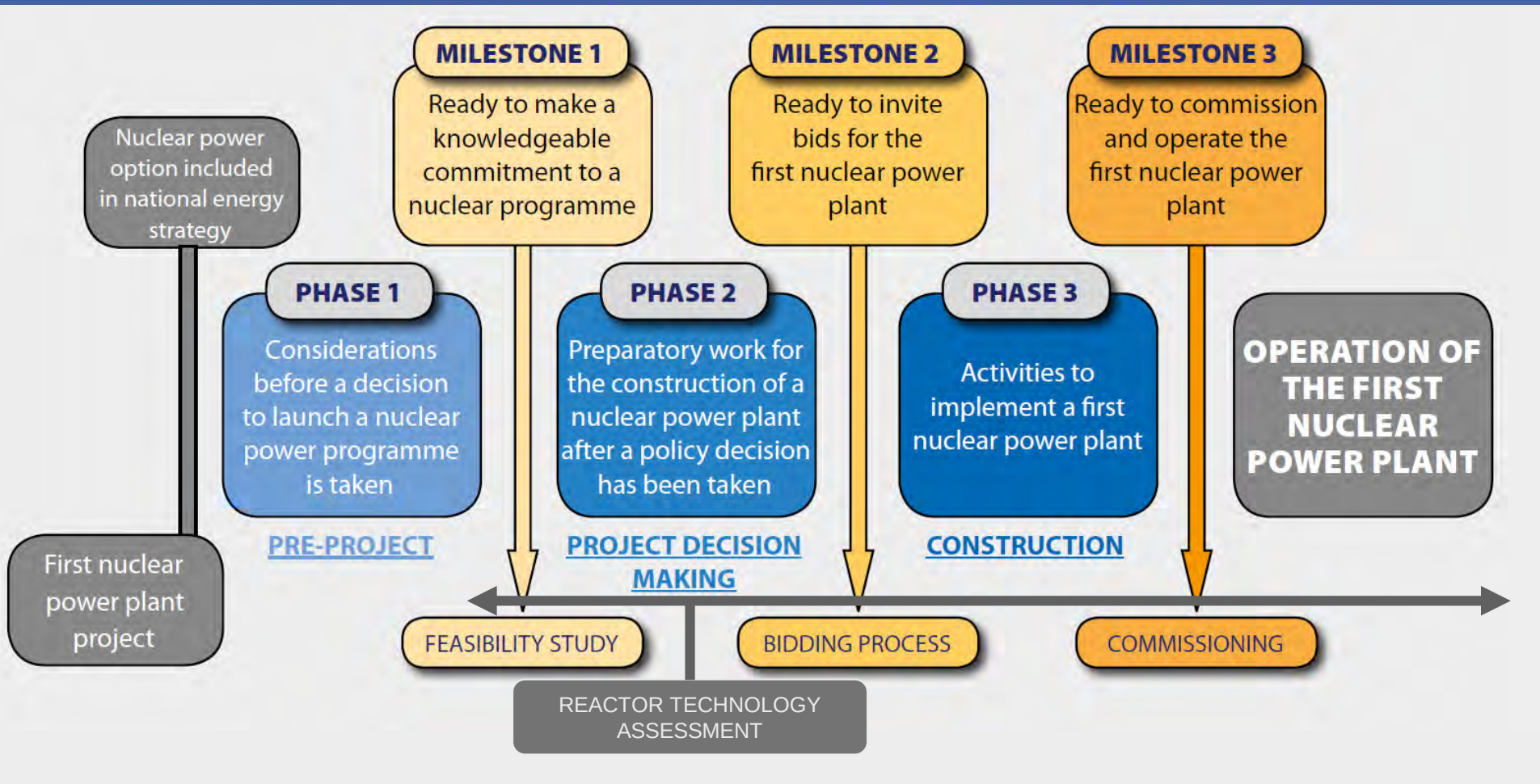
Technology Assessment within Infrastructure Development

When do I perform it?



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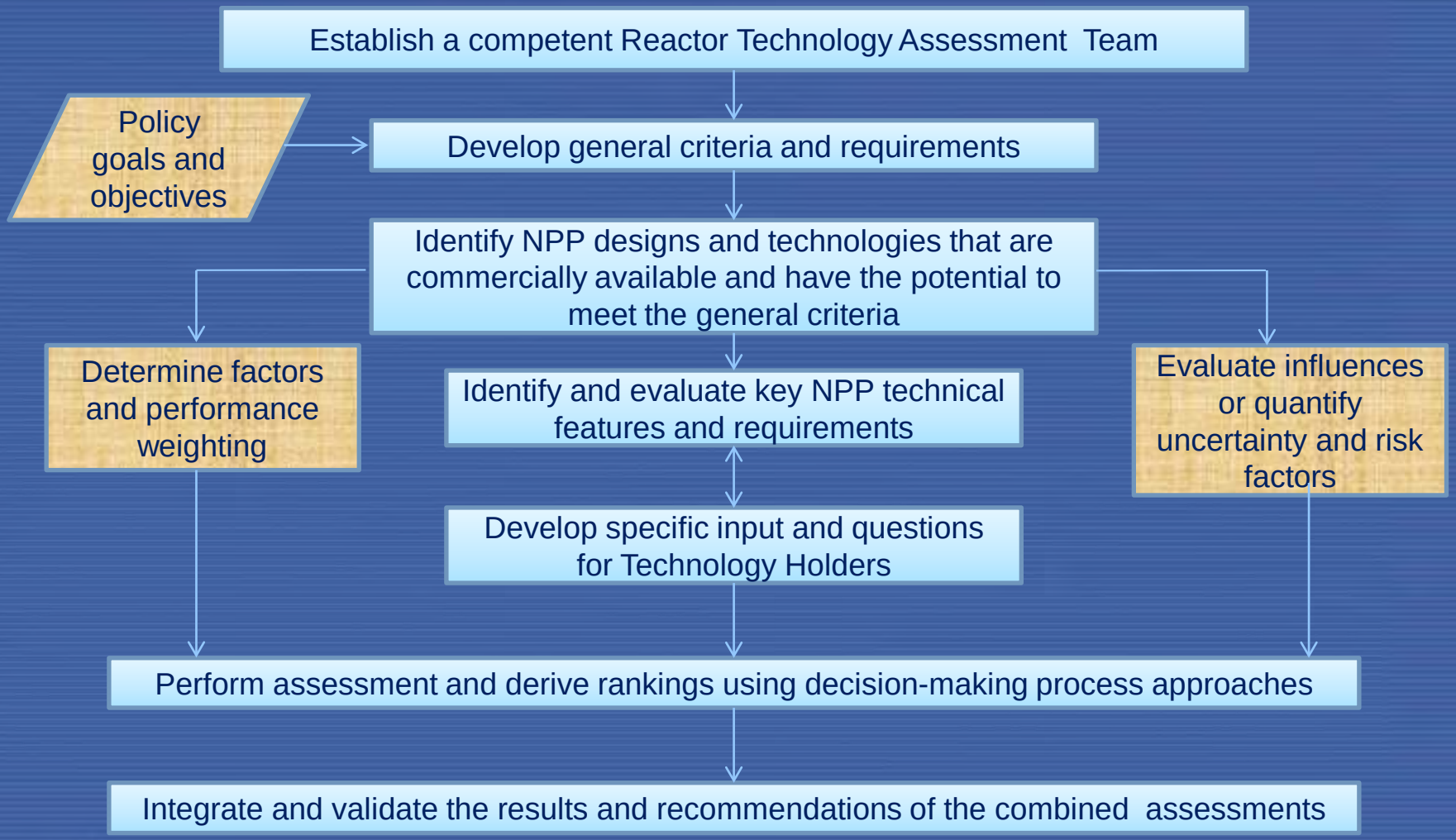
Technology Assessment and Selection Process

High-Level Task Flowchart



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Consultants Meetings: Contributors to Drafting and Review

Contributors

• John Cleveland	IAEA
• Mark Harper	IAEA
• Sahak Margossian	IAEA
• David Modeen	Electric Power Research Institute, USA
• David Nicholls	Eskom Nuclear Division, South Africa
• Atam Rao	IAEA and Consultant, Altran Technologies
• Stephen Schultz	USNRC, USA

Review Meetings

16-18 August, 2011 and 13-17 February 2012

Technology Assessment and Selection

Evaluation Process Approaches

- Develop importance factors associated with the Key Criteria and the key technical features and their requirements
- **Choose the evaluation process approach to be used:**
  - **Multi-Attribute Utility Theory and Kepner-Tregoe methodology are recommended straight-forward approaches for evaluation of complex problems and systems**
    - **(1) Importance weighting factors are determined for each of the general criteria and key technical elements**
    - **(2) The performance evaluation process is structured for the general criteria and key technical elements and features for each candidate technology**
    - **(3) Weighting factors are applied to the key technical features performance evaluation scoring for each candidate technology**
- Determine and evaluate associated risks and uncertainties:
  - Country-specific issues such as human resources development
  - Political, geo-political, and commercial considerations
  - Short term versus long term goals, objectives, and opportunities
- Process the integration of these evaluations to derive rankings

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Technology Assessment and Selection Process:
Establish Relative Importance (Step 3): Examples

- Example Quantitative Importance Rating for the Key Elements in the Assessment:

25	Economics of construction and operation; Funding availability
20	Plant nuclear safety
20	Industrial involvement opportunities -- National Participation and Localization
15	Performance throughout operation: economic, reliable, as expected
10	Strategic technical issues
10	Project duration and estimation of risk
100	

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Technology Assessment Process

Key Features for Technology Assessment

Site Considerations and Grid Integration (High)	Technical Characteristics and Performance	Major Systems and Components	Nuclear Fuel Performance (Medium)
Radiation Protection (Low)	Environmental Impact (Low)	Safeguards (Not a Differentiator)	Plant and Site Security (Low)
Physical Protection of Plant Systems (Low)	Severe Accident Releases (Medium)	Owners Scope of Supply (Medium)	Supplier/Vendor Issues (High)
Project Schedule Capability (Medium)	Technology Transfer and Technical Support (High)	Project Contracting Options (High)	**Economics** •**Capital Costs (High)** •**O & M Costs** •**Fuel Costs** •**Decommissioning**

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Technology Assessment Process

Risk and Uncertainty Areas for Consideration

Relationship Considerations (High)	Relationship with Designer / Vendor	Relationship with Suppliers	Strength of Vendor/Supplier Relationship
Technical Support Available (Varied)	Vendor Long Term Technical Support (High)	Experienced Utilities: Willing to Help (High)	User/Utility, including Owners Groups (Low)
Potential Risk Contributors (High)	Project Schedule Risk	Long Term Fuel Supply Security	Project Financing Assistance/Assurance (Very High)
National Issues (Highly Owner/Operator Specific)	Country-to-Country Relationships	National Energy Policy	Localization National Participation Nuclear Fuel Cycle

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Technical Characteristics and Performance Example Weighting Factor Ranges

• Size	High
• Plant Lifetime	Low
• Proven Technology / Licensability	High
• Standardization	Medium
• Simplification	Medium
• Constructability	Low
• Operability / Manoeuvrability	f(locale)
• Inspectability / Maintainability	Medium
• Plant Availability & Capacity Factor	High
• Sustainability – Achieve Planned Lifetime	Low
• Reliability	Medium
• Nuclear Safety & Regulatory Issues	High

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Technology Assessment and Selection Process:
Establish Importance & Valuations (Steps 5-7): Examples

- Example technical features that will be scored and then linked to the key elements and their Importance Rankings in the Assessment
- Selected Key Element: Plant Nuclear Safety:
  - Core Damage Frequency
  - Large Early Release Frequency
  - PRA maturity and pedigree
  - Offsite power reliance and availability of non-electric pumps, valves,
  - Containment design for accidents and severe accidents
  - Active versus passive safety system design and operation (and experience)
  - Response to and control capability for accidents with onsite and offsite releases
  - Capability to respond to extreme external events

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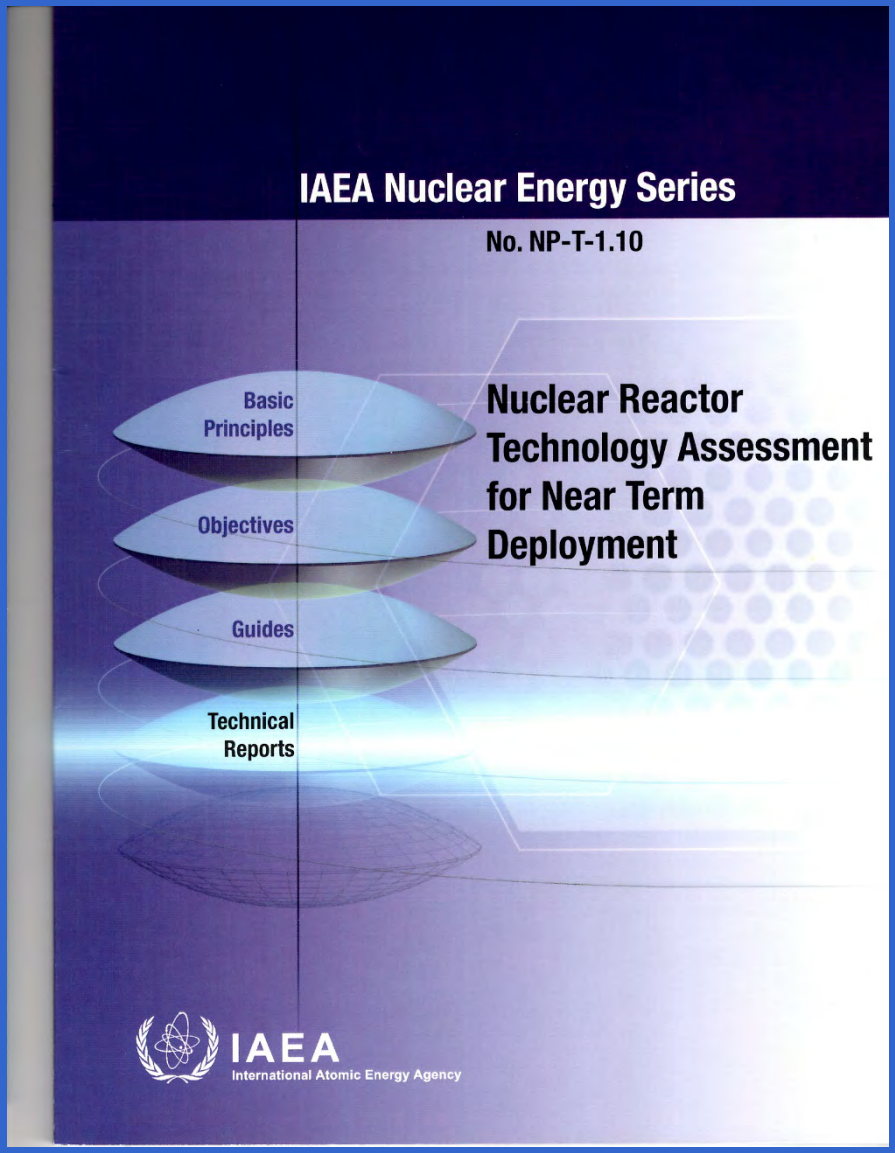
Report for the IAEA Approach Complete – What's Next ?



Vienna - The Votive Church Towers

Around and About Vienna

Beautiful Architecture Abounds

Gardens at the Hofburg Palace

Cycling along the Danube

Vienna Rathaus at Christmas

Christmas Markets in Vienna

A Night at the Opera

New Years 2012

Reactor Technology Assessment for Near Term Deployment

Sharing the IAEA Approach

- 3-day **Training Workshop on Technology Assessment**, in Vienna, July 2012

- 5-day **Member State Mission to Malaysia on Reactor Technology Assessment for Near Term Deployment**, October 2012

Member State Mission to Malaysia

Member State Mission to Malaysia

Member State Mission to Malaysia

Member State Mission to Malaysia

Member State Mission to Malaysia

Member State Mission to Malaysia

Reactor Technology Assessment for Near Term Deployment

Sharing the IAEA Approach

- 5-day **Technical Meeting on Assessing Nuclear Power Technologies for Near Term Selection and Deployment**, June 2013

  Introducing the IAEA Tool-Kit Approach and Exercises

- 4-day **Member State Workshop on Technology Assessment for Bangladesh**, Dhaka, March 2014

- 5-day **Interregional Workshop on Tools and Methodology for Reactor Technology Assessment**, Republic of Korea, April 2014

Reactor Technology Assessment Regional Workshop – Republic of Korea

Reactor Technology Assessment for Near Term Deployment

Sharing the IAEA Approach

- 4-day **Technical Meeting on Technology Assessment for New Nuclear Power Programmes**, September 2015

- 3-day **IAEA/CFE/ININ Interregional Course on Technology Assessment and Nuclear Power Projects**, Mexico City, February 2016

RTA Technical Workshop - Introducing the IAEA Tool-Kit Approach and Exercises

RTA Technical Workshop - Introducing the IAEA Tool-Kit Approach and Exercises

The Vienna International Center

Post-Fukushima Safety Standard Revisions

IAEA Consultancy Project: Specific Safety Guide Revision

Design of the Reactor Core for Nuclear Power Plants

NS-G-1.12

Requirements:

1. Revise circa 2000 Safety Guide: Consideration lessons-learned from the at Fukushima accident
2. Revise document addressing identified gaps in IAEA Specific Safety Requirements, SR-2/1, Revision 1

Involvement: December 2014 through September 2017

IAEA, Design of the Reactor Core for Nuclear Power Plants, IAEA Safety Standard, Specific Safety Guide Series SSG-52, to be published in 2019.

IAEA Consultancy Project: Specific Safety Guide Revision

CONTRIBUTORS TO DRAFTING AND REVIEW

KAMIMURA, K.	S/NRA, Japan
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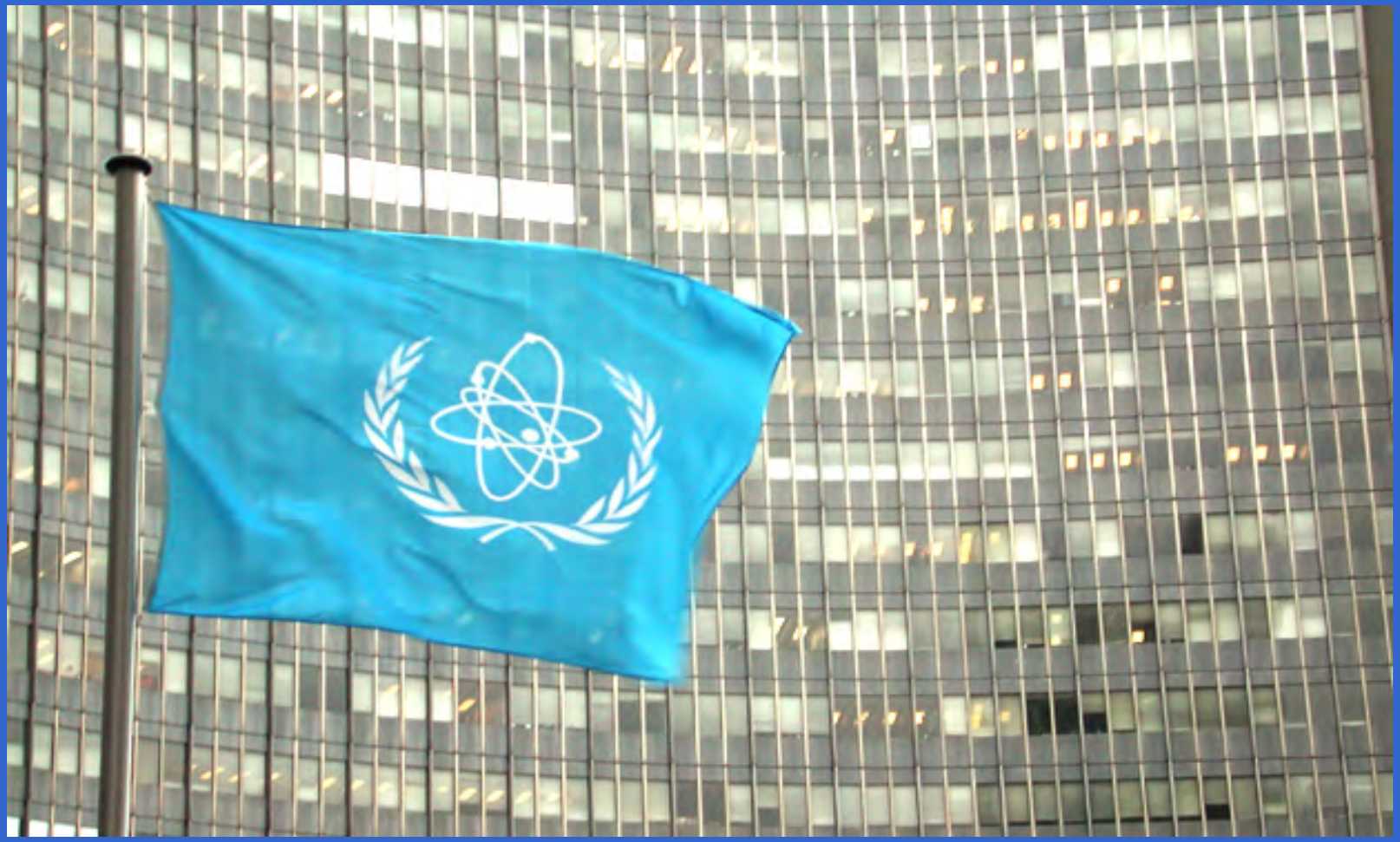
ZHANG, J.	TRACTEBEL, Belgium

Parting View of the IAEA

Last Week in Vienna

Thank you for your attention!



IAEA Careers and Consulting Opportunities

- Opportunities in IAEA Programs
  (www.iaea.org/employment)
- Argonne National Laboratory
  (www.international.anl.gov/careers)
- Brookhaven National Laboratory
  (www.bnl.gov/ISPO/)

IAEA Careers and Consulting Opportunities

- IAEA Staff Positions
- Junior Professional Officers
- Internship Program
- Expert/Lecturer Technical Cooperation Programme – Open
- Consultant / Consultancy Opportunities

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IAEA Careers and Consulting Opportunities

- Benefits for Staff Positions

:

- Dependent Spouse Allowance
- Single Parent Allowance
- Relocation Expenses
- Settling-In Grant
- Education Grant
- Pension
- Health Insurance
- Life Insurance
- Rental Subsidy
- Family Visit
- Home Leave
- Annual Leave
- Repatriation Grant (after five years of service)

Comments on the IAEA Post-Fukushima Response

Technology Assessment and Selection Process:
Basic Steps in Practice (Slide 1)

1. Establish a competent Technology Assessment Team/Group
   - Organization & HR
2. **Develop the key criteria and requirements based on relevant policy goals and objectives, such as**
   - **National energy plan**
   - **National infrastructure: the grid, site, and environmental characteristics**
   - **Local conditions: industry, economy, workforce, and demography**
   - **Regulatory and safety requirements, emergency planning needs**
   - **Economics: plant costs and financing expectations**
   - **Security, physical protection and safeguard requirements**
   - **Performance requirements**
3. Assure that the relative importance of each of the selected policy goals and objectives has been established
4. Identify NPP designs and technologies that are commercially available and have the potential to meet the general criteria

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Technology Assessment and Selection
Who should do it?

- **Ownership and the Assessment Task Team members are critical success factors**
  - Owner/Operator shall take full responsibility for the conduct and results of the Technology Assessment
  - 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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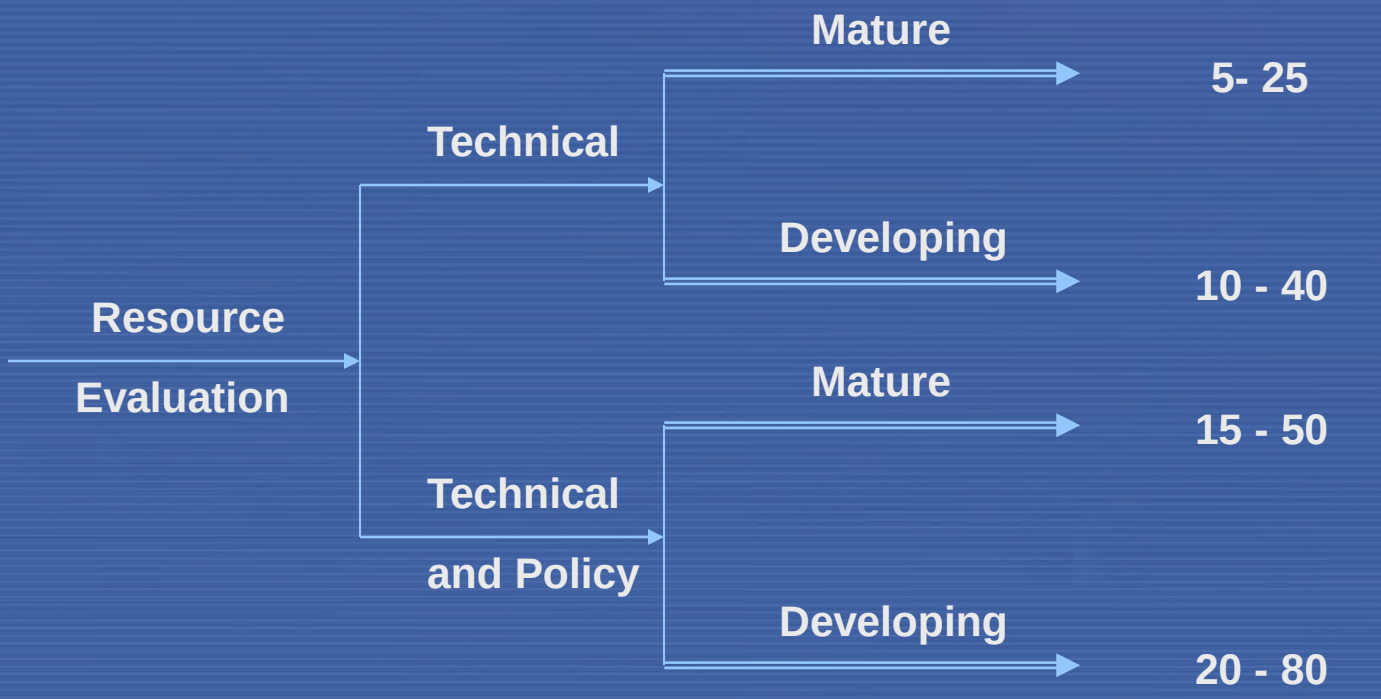
Personnel Resource Estimates
Technology Assessment Work Scope Types



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Note 1: Technical Assessment versus Full Scope Reactor Technology Assessment

Technology Assessment and Selection Process: Basic Steps in Practice (Slide 1)

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Technology Assessment and Selection Process: Developing Key Criteria Elements (Step 2)

- The programmatic objectives and key criteria elements are compiled for use within the Technology Assessment process, especially in communications with NPP supplier candidates
- These may be based upon the IAEA Common User Considerations, combined with available sources such as URD (Utility Requirements Document), EUR (European Utility Requirements), or USNRC Design Control Documents
- These key criteria are derived from and directly connected to the policy goals and objectives that shall be defined and prioritized for the nuclear programme or project
- The policy goals and objectives and the resultant key criteria should also form the basis for the technical requirements used for the bid invitation specifications and bid evaluation

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Technology Assessment and Selection Process: Develop General Criteria (Step 2): Examples

- Example Key Elements of the General Criteria:
  - Economics of construction and operation; Funding availability
  - Performance throughout operation: economic, reliable, as expected
  - Plant nuclear safety
  - Strategic technical issues
  - Project duration and estimation of risk
  - Industrial involvement opportunities -- National Participation and Localization
- Other potential strong differentiators or discriminators:
  - Proven technology
  - Unit size

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Technology Assessment and Selection Process:
Basic Steps in Process (Slide 1)

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Technology Assessment and Selection Process:
Establish Relative Importance (Step 3): Examples

- Example Relative Importance Ranking for the Key Elements in the Assessment:
  - Economics of construction and operation; Funding availability
  - Plant nuclear safety
  - Industrial involvement opportunities -- National Participation and Localization
  - Performance throughout operation: economic, reliable, as expected
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Technology Assessment and Selection Process: Basic Steps in Process (Slide 2)

5. **Identify and evaluate key technical features and requirements that are tied to the policy goals and objectives**
6. **Develop specific input requirements and associated questions for technology holders to obtain consistent information required to perform the assessment**
7. **Determine factors and importance weighting associated with the key assessment elements and technical features**
8. Evaluate influences or quantify uncertainty and risk assessment factors
9. Perform assessment and derive rankings using decision-making process approaches
10. Integrate and validate the results of the combined assessments

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Technology Assessment Process

Key Features for Technology Assessment

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Radiation Protection (Low)	Environmental Impact (Low)	Safeguards (Not a Differentiator)	Plant and Site Security (Low)
Physical Protection of Plant Systems (Low)	Severe Accident Releases (Medium)	Owners Scope of Supply (Medium)	Supplier/Vendor Issues (High)
Project Schedule Capability (Medium)	Technology Transfer and Technical Support (High)	Project Contracting Options (High)	**Economics** •**Capital Costs (High)** •**O & M Costs** •**Fuel Costs** •**Decommissioning**

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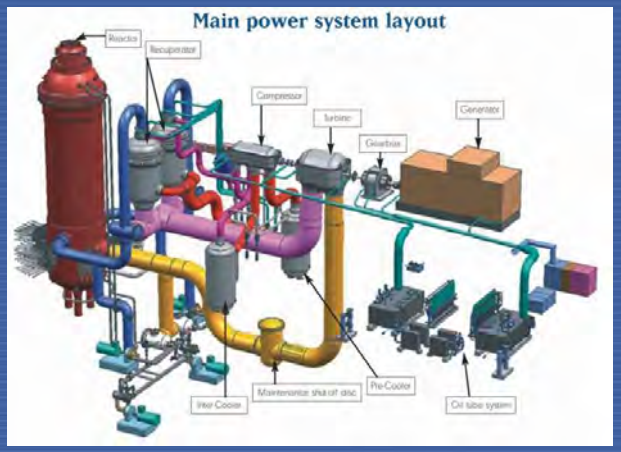
Key Discussion Questions

What is it?	When do I perform it?	Who should do it?	How is it to be done?	Why should it be done?



IAEA program to support Technology Assessment

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Key Features for Technology Assessment Technical Characteristics and Performance

- Size
- Plant Lifetime
- Proven Technology and Licensability
- Standardization
- Simplification
- Constructability
- Operability and Manoeuvrability
- Inspectability and Maintainability
- Plant Availability and Capacity Factor
- Sustainability – Operation for Planned Lifetime
- Reliability
- Nuclear Safety and Regulatory Issues

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Technology Assessment and Selection Process:
Perform Assessment and Derive Rankings

- Apply decision-making methodology for the comparative assessment
  - Qualitative Evaluation
  - Kepner-Tregoe Process
  - Multi-Attribute Utility Theory
- Assign the importance weightings for key elements and key features and derive the scoring for key factors
  - Importance Weightings: $IW_{Element(i)}$, $IW_{Feature(j)}$, $Score_{Feature(j)}$
- Integrate the results for the assessment of each candidate technology

$$\text{Candidate Technology Rating} = \sum_{i,\,j} IW_{Element(i)} \times IW_{Feature(j)} \times Score_{Feature(j)}$$

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Technology Assessment Benefits

When you have completed the Technology Assessment process, you will have **identified** the following:

- Important design features and critical factors in the decision-making process
- Programmatic features which are required to achieve success
- Future strategies to improve success

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IAEA Reactor Technology Assessment Programme

- The Assessment Process and Approach
  - **Background**
  - **Definition**
  - **Development**

- **Deliverables**
  - **Technical Meetings and Workshops**
  - ***Nuclear Reactor Technology Assessment for Near Term Deployment***

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