International Atomic Energy Agency

Technology assessment and potential of nuclear reactors for seawater desalination

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Main Objective of Technology Assessment

Determine: which technology(s) of integrated nuclear power system (INPS) meet the country's needs and requirements.

(INPS may include the Nuclear Power Plant (NPP), associated fuel-cycle, desalination plant, and supporting technologies)

Aim of Technology Assessment

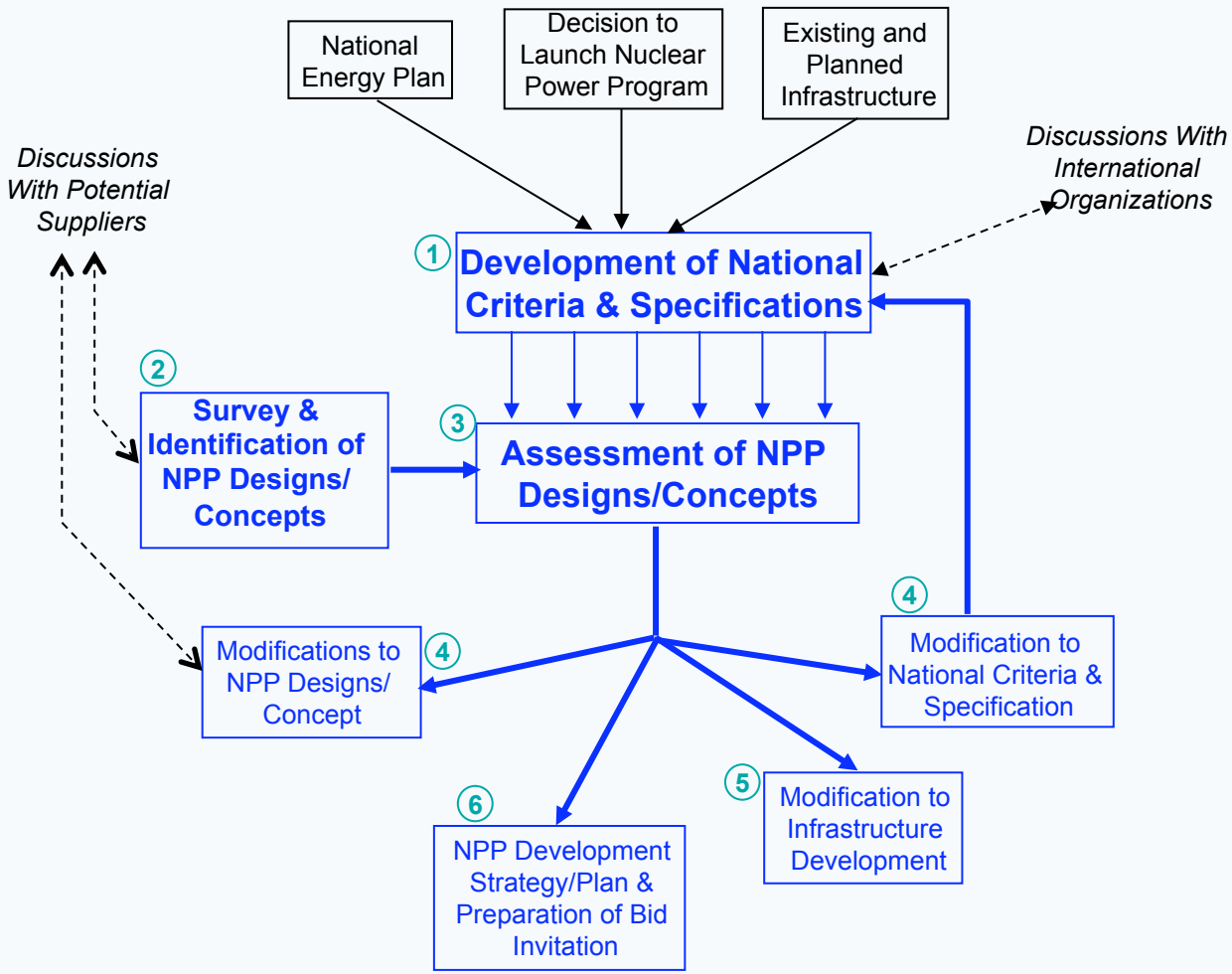
- **Provides technical basis for the NPP deployment strategy and the short-term deployment plan of the Owner/Country.**

- **Increases readiness of Supplier candidates to prepare Bids that are in accordance with the needs of the Owner/Country.**

Key Questions to Be asked in a Technology Assessment

- What kind of NPP (and ND) is needed and when?
- What kind of NPP designs are available?
- Do available NPP designs meet the needs of the country?
- How selected NPP designs and country's requirements be modified to achieve compliance?
- How to develop infrastructure required?
- What are strategies and future steps subsequent to the Technology Assessment?

Technology Assessment Process



Scope of Technology Assessment

The scope is coutry-specific and depends on several factors, like

- **the status of nuclear activities**
- **the status of infrastructure development**
- **the nuclear power introduction approach, e.g.**
  - **bidding process**
  - **bilaterally negotiated delivery contract**

NOTE: TA objective is NOT to compare possible NPP designs with each other and arrange them into order of superiority.

That is the task of the *bid evaluation*.

Major Activities of TA Process

- Development of the General Criteria for INPS based on
  - national energy plan,
  - national infrastructure,
  - local conditions,
  - regulatory requirements, and
  - other relevant national strategies.
- Survey and identification of NPP designs and associated INPS technologies that are commercially available and may potentially meet the General Criteria;
- Assessment of the selected NPP designs against the General Criteria;
- Expand the General Criteria with additional details.

Development of General criteria (GC)

- GC are basis for the General Requirements that will be utilized in establishing general technical requirements to be included in the potential bid invitation specifications.

- During the TA process, the General Criteria can be improved and revised based on feedback from the results of the assessment.

- GC should be compiled in a single document.

Areas to be covered by the General Criteria

- Sustainability of the nuclear power programme
- Demand for power generation capacity
- Electrical grid characteristics
- Site characteristics
- Environmental impact
- Nuclear safety, regulatory framework and licensability
- Radiation protection
- Nuclear fuel cycle policy
- Nuclear waste management
- Safeguards
- Security, physical protection and emergency planning
- National participation, Industrial development and human resource development strategies
- Overall economics
- Financing

Identification of NPP Candidates

Information sources

- **IAEA status reports on NPP designs, e.g;**
  - ***Status of advanced light water reactor designs 2004*** **(IAEA-TECDOC-1391)**
  - ***Status of innovative small and medium sized reactor designs 2005*** **(IAEA-TECDOC-1485)**
- **Presentations in nuclear magazines and workshops/conferences;**
- **Direct contacts to vendors.**

Topics of Questionnaire to Vendors

- NPP type, size and technical performance;
- NPP safety and licensing;
- Fuel cycle;
- Financing and contracting; and
- Others

Typical Contents of TA Studies

- Comparison of the NPP design to the General Criteria to identify the significant differences;
- Preliminary assessment of NPP design aspects;
- Preliminary assessment of plant location at the site;
- Discussions with the Regulatory Body;
- Preliminary project implementation assessment covering also necessary infrastructure development and national participation;
- Survey of Vendor's capabilities;
- Cost estimates

Main Results of TA Studies

- Plant size range;
- Tentative dates of construction start and commissioning;
- Location at the site;
- Revised set of general technical specifications;
- NPP designs meeting the national criteria and specifications in general and necessary design modifications to them;
- Capabilities of Supplier candidates;
- Potential project implementation models;
- Fuel and waste management options;
- Needs for infrastructure development;
- Possibilities of national participation;
- Economics; and
- Financing options.

Optional Contractual Approaches

Main types of contractual approach:

- **Turnkey approach, where a single supplier or a consortium of suppliers takes the overall technical responsibility for the whole works;**
- **Split-package approach, where the overall technical responsibility is divided between a relatively small number of suppliers, each building a large section of the works; and**
- **Multi-contract approach, where the owner or his architect-engineer assumes overall responsibility for engineering the plant, issuing a large number of contracts.**

- **Based on the results generated by TA, the selection of the type of contract is one of the basic decisions to be taken concerning the realization of an NPP.**
- **Turnkey is the most common approach in the case of the first NPP in the country.**

Strategy for NPP Deployment

- Contracting strategy,
- Project management and human resources strategy
- Fuel supply strategy
- Used fuel and radioactive waste management strategy
- Financing strategy

All should be consistent with the contracting strategy.

Short Term Deployment Plan

- Preparation of the Bid Invitation Specifications (BIS): 6-12 months
- Preparation of the bids:6-8 months
- Bid evaluation: 6-12 months
- Contract negotiation and finalization: 6-12 months.

PS: Total time from start of the BIS preparation til the signature of the delivery contract: 2 – 4 years.

Preparation of the Bid Invitation Specifications (BIS)

The Owner:

- **has the full responsibility for the preparation of the BIS and for its contents.**
- **may use existing User Requirement Documents as a reference.**
- **has to establish a basic organizational unit (15-25 competent professionals with efficient administrative support) which is in charge of the preparation of the BIS.**
- **may obtain assistance from well qualified consultants as an advisory function.**

Contents of the BIS

- The BIS should contain all the information needed by the bidders for the preparation of their bids.

- This information should be structured to facilitate the subsequent bid evaluation and contract preparation.

RoTh: Avoid repetition and overlap which may lead to confusion.

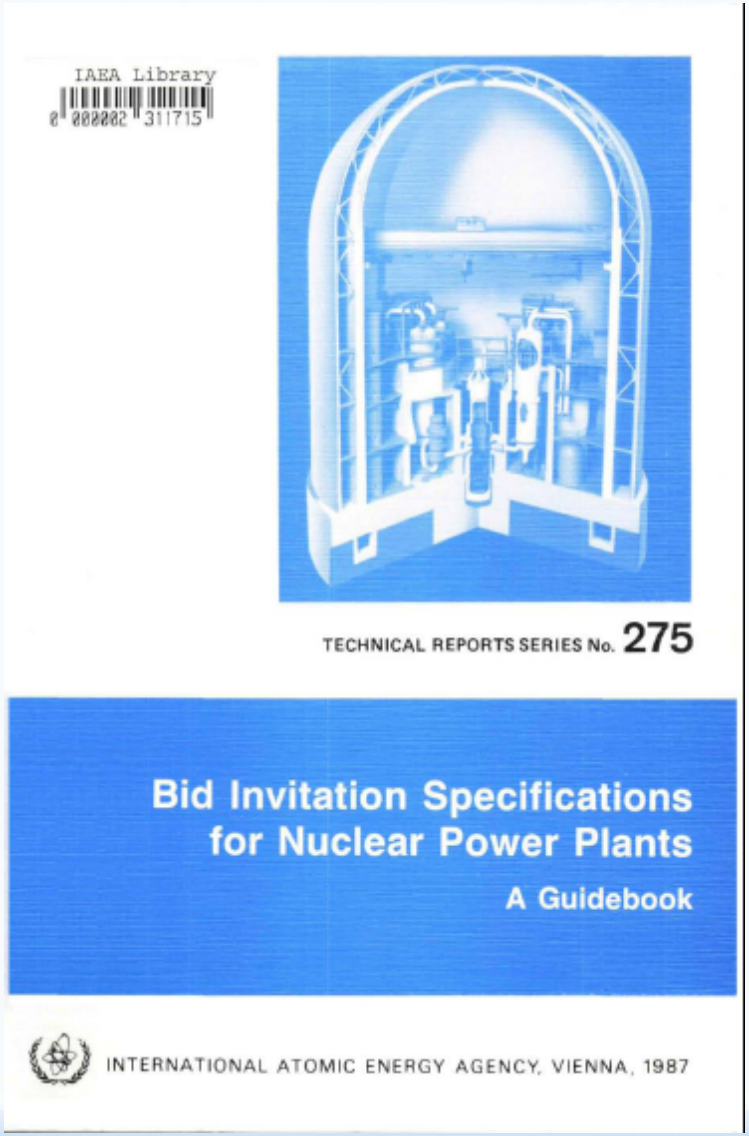
Information Provided by the Owner in the BIS

1. Invitation letter
2. Administrative instructions
3. General information
4. Technical requirements and criteria
5. Scope of supply and services
6. National participation and technology transfer
7. Bid evaluation criteria
8. Draft contract: Terms and conditions
9. Commercial conditions

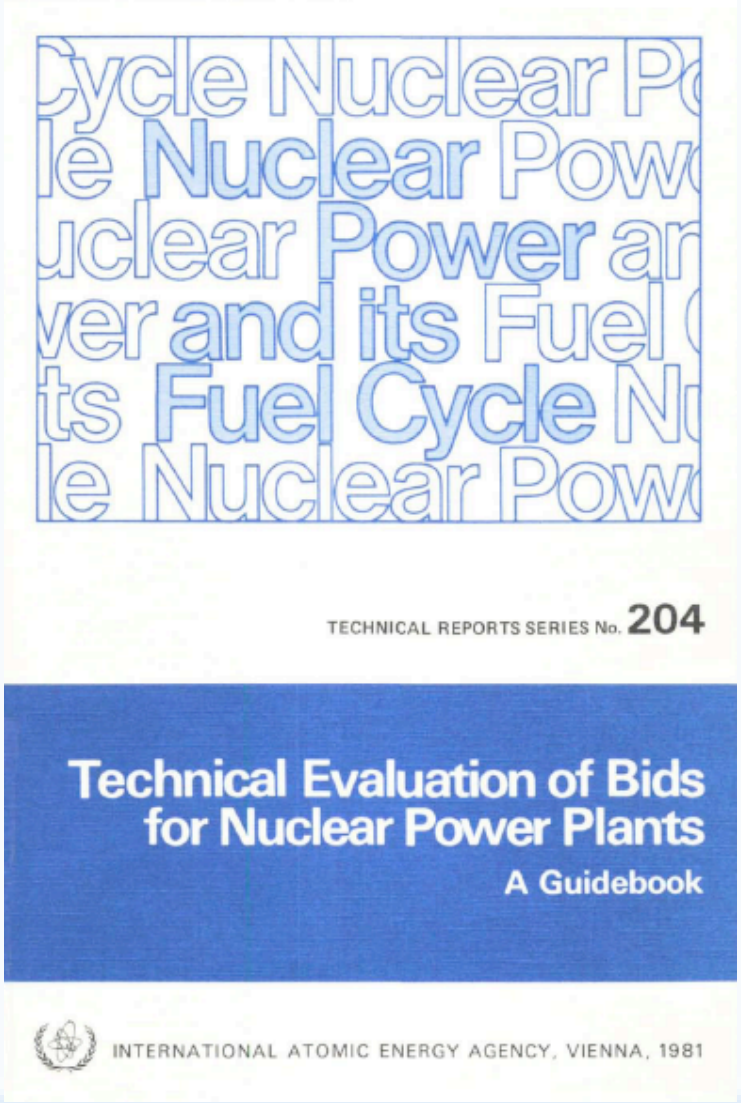
INFORMATION REQUESTED FROM THE BIDDERS

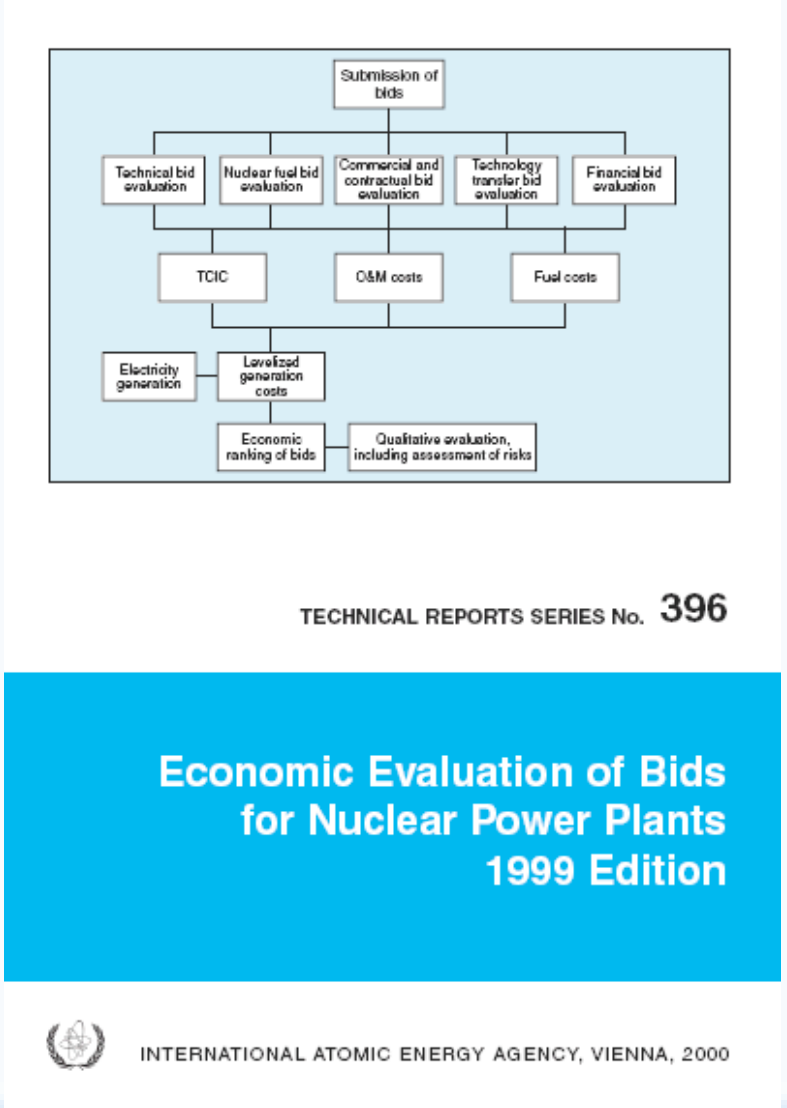
1. General information
2. General technical aspects
3. Technical descriptions
4. Scope of supply and services
5. Alternatives and options
6. Quality assurance programme
7. Training
8. Project schedule
9. National participation and technology transfer
10. Guarantees and warranties
11. Deviations and exceptions
12. Commercial conditions

More Detailed Guidance on BIS Preparation

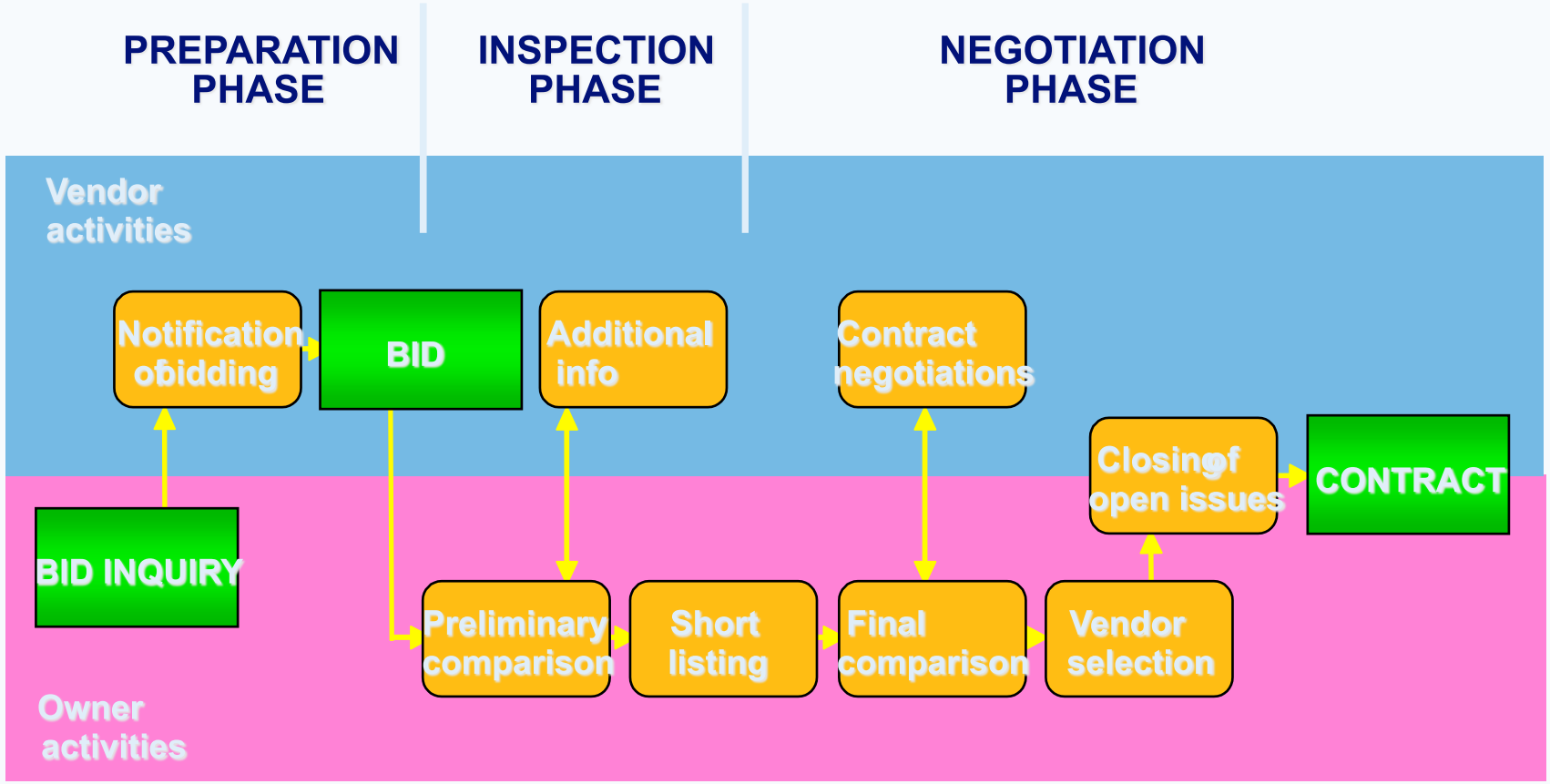


Guidance for Bid Evaluation





EXAMPLE OF BID EVALUATION PROCESS



Typical Content of the Contract

1. Introduction
2. Elements of the draft contract
3. Definitions
4. General clauses
5. Object of the draft contract
6. Planning and execution of the work
7. Information, inspection, testing and control
8. Assignment of the work and subcontracting
9. National participation and technology transfer

cont.

Typical Content of the Contract (cont.)

10. Training of personnel
11. Changes and additional work
12. Transport and customs clearance
13. Risks and transfer of title
14. Liability
15. Insurances
16. Quality assurance
17. Licensability and licensing
18. Delivery times
19. Documentation

cont.

Typical Content of the Contract (cont.)

20. Spare and wear parts, consumables and special tools
21. Alternatives and options
22. Guarantees or warranties
23. Take-over
24. Prices, price adjustments and terms of payment
25. Force majeure
26. Termination and suspension of the contract
27. Guarantee of title and proprietary information
28. Execution of the contract
29. Applicable law
30. Arbitration

Technology assessment and Choice of desalination process

Selection of the most appropriate desalination process depends on:

- Evaluation of available water resources (quantity & quality)
- Co-generation to optimize cost
- Availability of energy resources (including waste heat)
- Plant size:
  - MSF for large scale applications (10-60 000 m3/d)`and high water quality
  - MED (20 000 m3/d)
  - RO (40 000 m3/d) lower quality, low energy consumption

Primary considerations

1- Water, energy, and process selection

- Feedwater quality required
- Energy requirements, available sources, cost of energy (i.e. residual steam, spent heat, electricity…etc.)
- Plant capacity

Primary considerations

2-Fouling, scale formation, and plant availability - Water, energy, and process selection

- **Feed water chemistry**
- **Seasonal variations**

- **Continuous scaling and fouling is a major impediment of desalination process**

- **Well designed desalination plant Incorporates well designed and appropriate pre-treatment system which minimizes fouling**

Primary considerations

3- Disposal of brine and environmental considerations

- Disposal in an appropriate and environmentally friendly manner

4- Physical location of plant and cost of distribution

- Desalination as part of the municipal water supply networks.
- Selection of optimum location of DP, feed source, tie-in point.
- Incorrect positioning, results in additional capital cost and operating cost

Primary considerations

5- Manufacturing specifications

- Selection of materials for construction
- Selection of equipment

Both affect maintenance cost, general operability, and availability of DP

6- Plant life time

- Define Minimum required, avoid plant failure, avoid consequent overhaul after few years of operations

How to launch a desalination project?

- Consider possible site(s)
- Collect relevant data
- Determine pre and post treatment requirements for water source and distribution networks
- Apply for permits (regulatory authority)
- Detail analysis of water source
- Determine estimated capital and operating cost for DP

Steps to launch a desalination project

- Determine best options for brine disposal
- Prepare feasibility report including suitability of site(s)
- Submit for approval

Status
of Nuclear power plant development

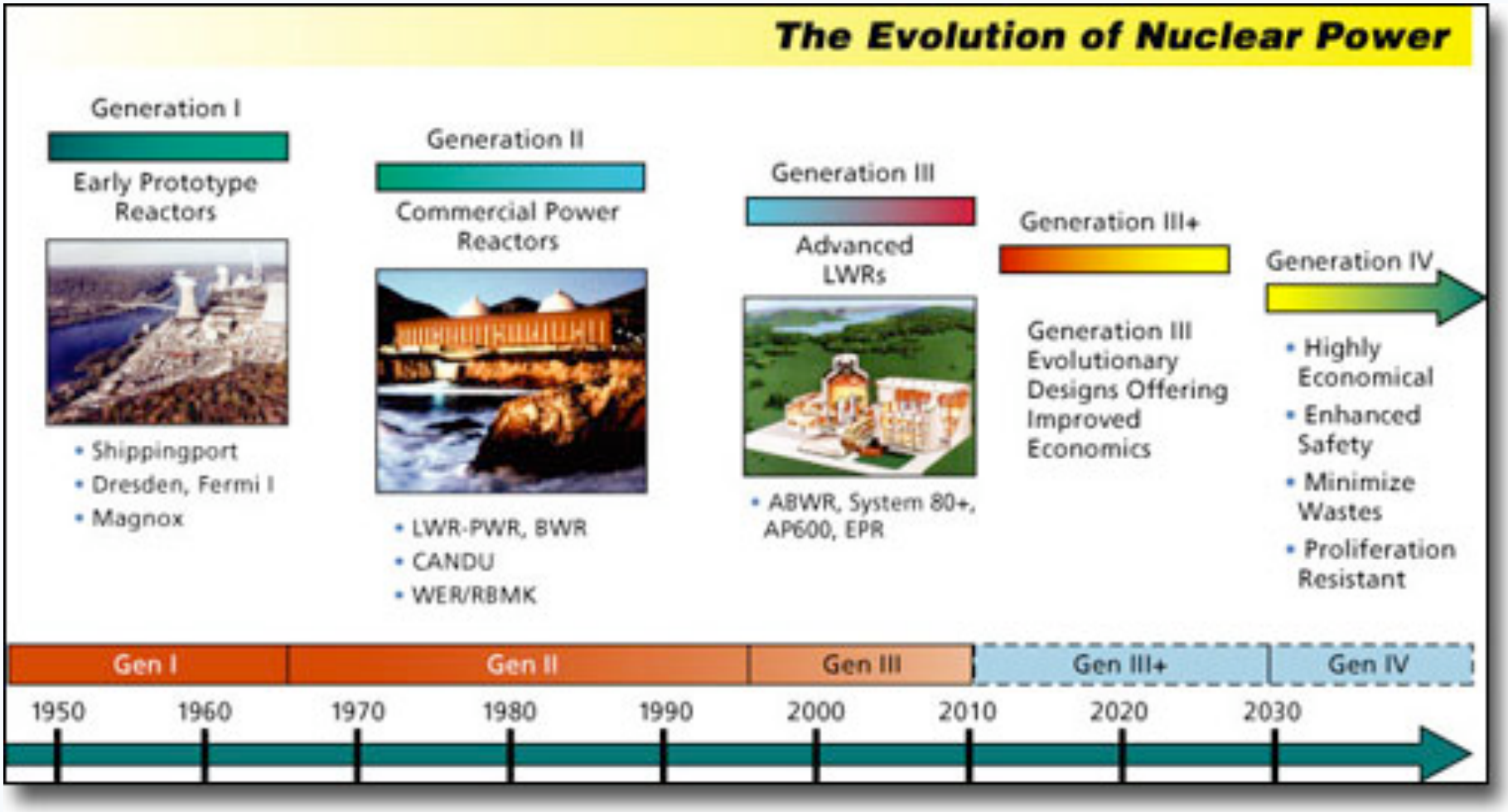
Conceptual designs are always cheaper than real designs!

Most existing NPPs are Water-Cooled Reactors

REACTOR	NUMBER OPERATING	% OF OPERATING	% OF CAPACITY	UNDER CONSTRUCTION
LWR[a]	359	82	88.3	24
HWR[b]	44	10	6.0	4
GCR	18	4	2.4	0
LMR	2	0.4	0.2	2
LWGR[c]	16	3.6	3.1	1

[a] light water cooled and moderated
[b] heavy water moderated, water cooled
[c] light water cooled, graphite moderated

Classification of nuclear reactors…

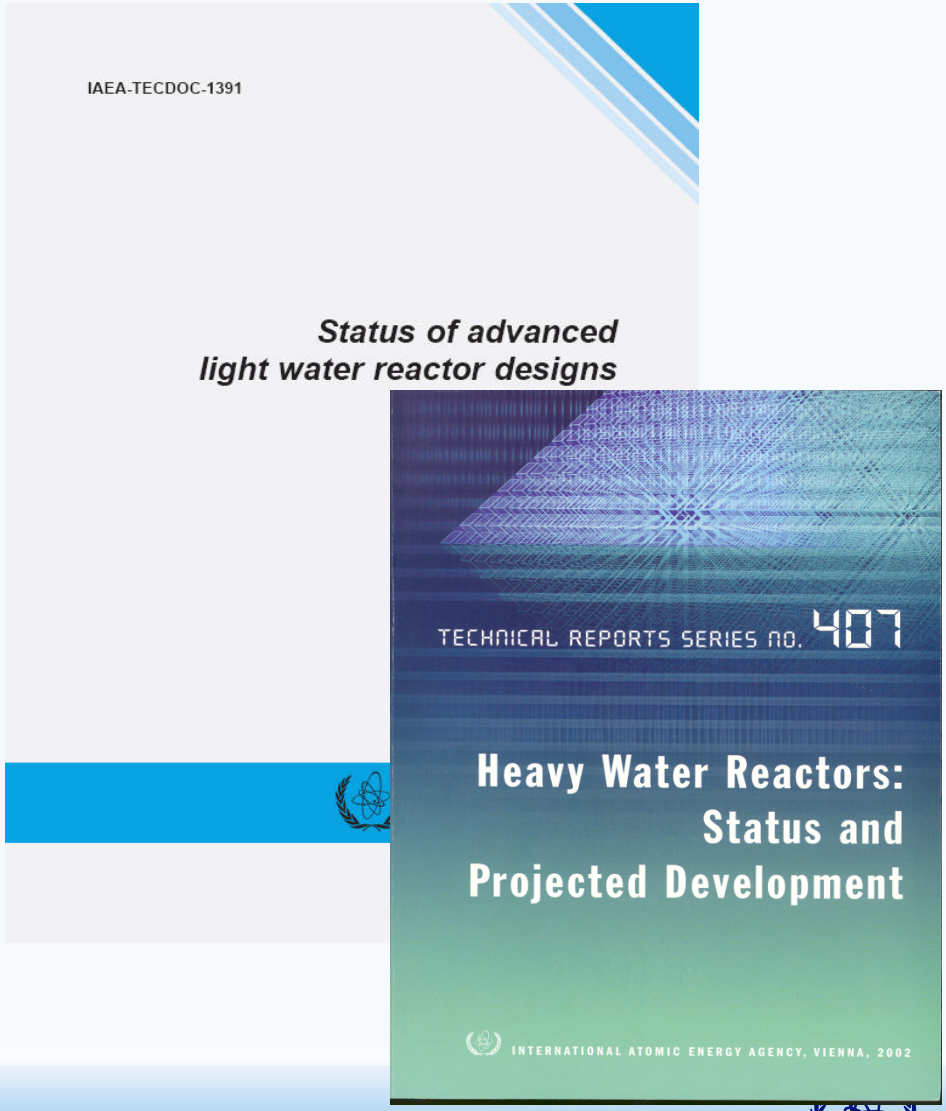


Evolutionary = Generation III & III+

- **Current NPP** → **Generation II**
- **Advanced NPP**
  - **Evolutionary NPP** → Generation III, Generation III+
  - **Innovative NPP** → Generation IV

IAEA publishes technical descriptions of advanced plant designs

- Development goals & safety objectives
- Evolutionary and innovative
- Electricity or co-generation
  - Descriptions – each design:
    - Systems
      - Nuclear
      - Power conversion
      - I&C
      - Electrical
      - Safety
    - Summary level technical data
    - Design measures to enhance economy and reliability
- Next: Web-based Status Report including all reactor lines



Conclusion

Technology Assessment is:

- Not a feasibility study
- An important process to identify the best technology and best contract.

GOOD LUCK

…Thank you for your attention

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