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Feasibility Study for a New NPP

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FEASIBILITY STUDY FOR A NEW NPP

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Invited IAEA Expert

ICTP/IAEA Nuclear Energy Management School

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WHAT IS A FEASIBILITY STUDY?

- ✓ A feasibility study is an **analytical tool** used during a business development process to show how a business would operate under a set of **assumptions**.
- ✓ **Assumptions** often include such factors as:
  - Technology used (equipment, production process, etc.)
  - Financing (capital needs, volume and cost of goods, etc.),
  - Marketing (prices, competition, etc.)
- ✓ The study is usually the first time in a project development process that many key pieces and information about the project are assembled into one **overall analysis**.
- ✓ Main purpose of a feasibility study is to determine if a business opportunity is **possible, practical and viable**.

WHY FEASIBILITY STUDY?

- ✓ Developing any new business venture is difficult.
- ✓ Taking a project from the initial idea through the operational stage is a complex and time-consuming effort.
- ✓ A feasibility study presents and clarifies the risks associated with the project, so that involved stakeholders can evaluate them.
- ✓ The feasibility study evaluates the project's potential for success, comparable with similar technologies.
- ✓ A feasibility study enables to take a realistic look at both the positive and negative aspects of the project.

OBJECTIVES OF A FS

- To find out if the proposed project can be done:
  - ✓ ...is it possible?
  - ✓ ...is it justified?
- To suggest possible alternative solutions.
- To provide management with enough information to know:
  - ✓ Whether the project can be done ?
  - ✓ Whether the final product will benefit its intended users ?
  - ✓ What the alternatives are (so that a selection can be made in subsequent phases) ?
  - ✓ Whether there is a preferred alternative ?
- A management-oriented activity:
  - ✓ After a Feasibility Study, management makes a “go/no-go” decision.
  - ✓ Need to examine the problem in the context of broader business strategy.

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DEFINITION OF A FS FOR AN NPP

- ✓ A Feasibility Study for a Nuclear Power Plant is primarily a **justification document** for the acquisition of one or more nuclear generating plants to be integrated in the overall mix of electrical power generating plants.
- ✓ FS main purpose: to provide a summary of the elements necessary to support the authorities and other stakeholders in their key decisions and financial commitments required to launch a NPP new build project.

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SCOPE OF A FS FOR AN NPP

Feasibility Study for a NPP will have to:

- ✓ analyse the country's industrial infrastructure addressing the pre-requisites of a nuclear power option,
- ✓ carry out a comprehensive assessment of all aspects of the plant impact on society,
- ✓ analyse the availability and competence of human resources, the knowledge gap and training requirements,
- ✓ determine the approximate overall cost of the plant, its financing prospects and
- ✓ address its socio-economic and environmental impacts.

WHY IS A FEASIBILITY STUDY NEEDED?

A Feasibility Study is commissioned in order to assess, from an overall perspective:

- ✓ All aspects of the energy demand in a specific country or geographical area,
- ✓ To place the nuclear option in its rightful context
- ✓ To allow informed decisions & appropriate solutions
- ✓ To adopt safety driven solutions
- ✓ To establish the right level of investments
- ✓ Avoid costly mistakes and unnecessary risks

The FS is usually the first time in a project development process that many key pieces and information about the project are assembled into one overall analysis. Main purpose of a Feasibility Study is to determine if a business opportunity is Possible, Practical and Viable.

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GENERAL TOPICS OF A FS FOR AN NPP (1)

A FS for a NPP should provide answers to a number of specific questions:

- ✓ How can a new NPP be integrated to the existing electric power system (national grid)?
- ✓ What is the most suitable size and main features of the NPP?
- ✓ What is the preferred site and the possible issues associated with the selected site (might be a separated study or part of the pre-investment study)?
- ✓ Which type of nuclear reactor (technology) should be the basis for bids?

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GENERAL TOPICS OF A FS FOR AN NPP (2)

- ✓ How does cost and economics compare with alternative options?
- ✓ What are the organizational and manpower requirements to implement the project and to operate the NPP?
- ✓ What can the overall NPP project duration and schedule be?
- ✓ Is the project financially viable? Is it self-sustainable and what are the possible sources for financing?
- ✓ What type of contractual approach is most suitable for the plant acquisition?
- ✓ Can the international market for NPPs, fuel cycle and essential materials and services sustain the project during its operational life?

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GENERAL TOPICS OF A FS FOR AN NPP (3)

- ✓ Can the country's infrastructure support the project and what are the possibilities for national industrial and bulk supply participation?
- ✓ Can the nuclear safety criteria and regulation be implemented and how?
- ✓ What will the environmental impact be and is it acceptable?

- **Estimated time for the preparation of a Feasibility Study depends on the complexity of the project and varies usually in the range of 12 – 18 months.**
- **The information used is confidential and should be protected by confidentiality agreements.**

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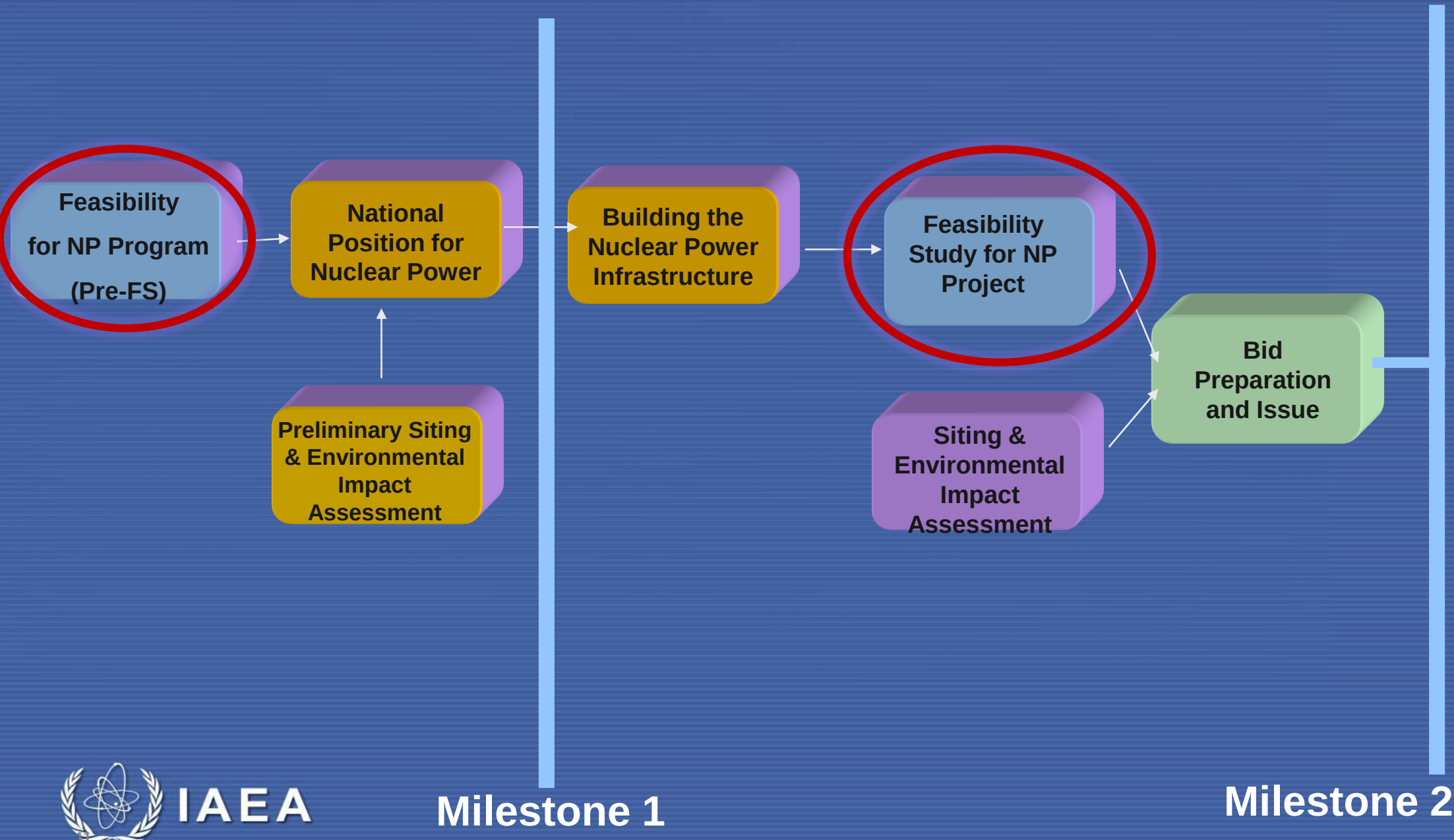
WHEN FS WILL BE DEVELOPED?



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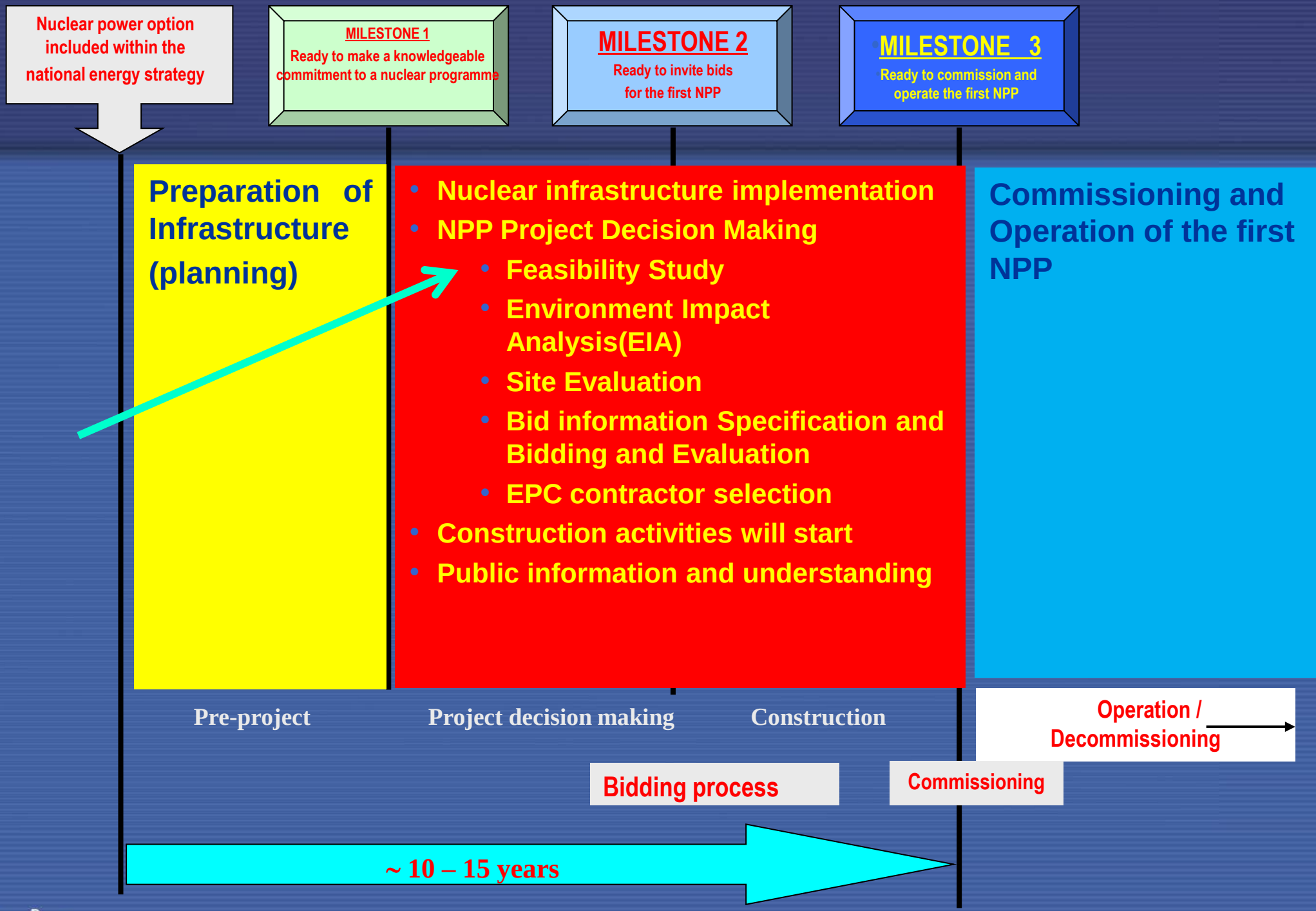
Nuclear power option included within the national energy strategy
MILESTONE 1
Ready to make a knowledgeable commitment to a nuclear programme
MILESTONE 2
Ready to invite bids for the first NPP
MILESTONE 3
Ready to commission and operate the first NPP
Preparation of Infrastructure (planning)
Nuclear infrastructure implementation
NPP Project Decision Making
Feasibility Study
Environment Impact Analysis(EIA)
Site Evaluation
Bid information Specification and Bidding and Evaluation
EPC contractor selection
Construction activities will start
Public information and understanding
Commissioning and Operation of the first NPP
Pre-project
Project decision making
Construction
Operation / Decommissioning
Bidding process
Commissioning
~ 10 – 15 years

PRE-FS AND FS

Key difference of Pre-FS and FS is between a **nuclear power program** and a **nuclear power project** .

- **Pre - Feasibility Study**
  - ✓ Program is part of strategy plans to evaluate and determine whether the nuclear program is desirable or feasible .
  - ✓ Identification of what additional infrastructure is required and how will it be developed.
- **Project Feasibility Study**
  - ✓ Project is focused on a specific project to evaluate and determine whether a selected nuclear reactor project is an appropriate choice, given the project details, associated economic, technical, and infrastructure, site

CONTENT OF PRE-FS STUDY

Pre-FS is a FS for the nuclear power program and should include:

- ✓ National energy supply planning
- ✓ Power system planning
- ✓ Nuclear power program planning
- ✓ Development of legal and organizational framework
- ✓ International agreements and arrangements
- ✓ National infrastructure survey
- ✓ National participation planning
- ✓ Manpower development planning (national level)
- ✓ NPP siting (site survey)

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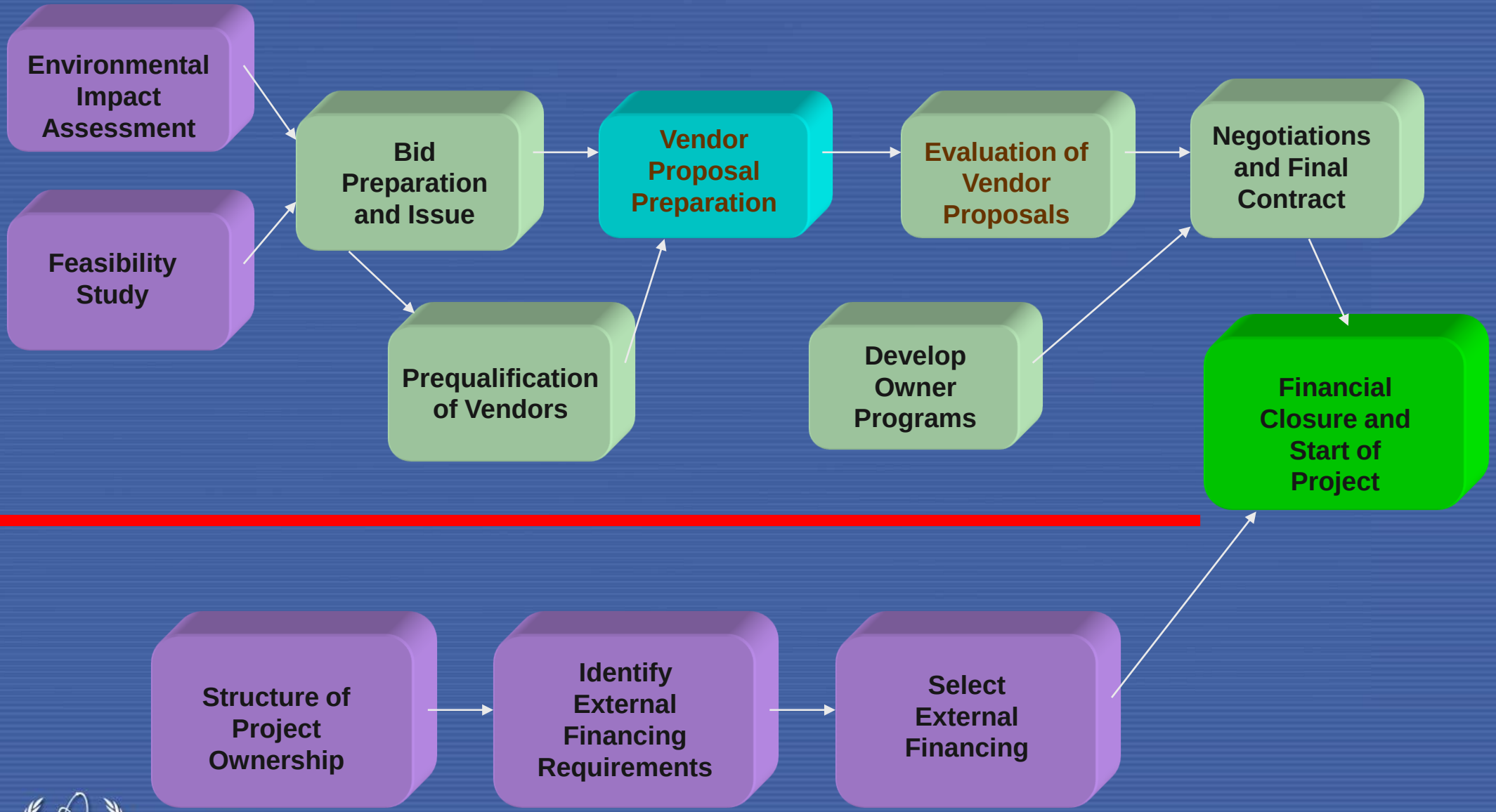
RESPONSIBILITY FOR PRE-FS AND FS

- ✓Pre-FS in Phase 1 – by NEPIO
- ✓FS for NPP project in Phase 2 before BIS shall be issued – by NPP Owner (TSO and Consultant)
- ✓Revised FS for NPP project (economical part) in Phase 3 after bids received - by NPP Owner (TSO and Consultant)

NEXT STEPS OF NPP PROJECT AFTER FS



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EXAMPLE OF FS CONTENT (1)

1. Executive summary
2. Electric system analysis
3. Unit capacity and grid integration
4. Site characterization
5. NPP Technology and fuel cycle
6. Environmental impact of the project
7. Licensing and authorization
8. Project implementation approach
9. National Participation
10. Organization, human resources and training
11. Project Cost Estimate
12. Economic Analysis
13. Financial planning
14. Public Information
15. Emergency preparedness of the site
16. Project risk summary
17. Conclusions and recommendations
18. References used in the Feasibility Study

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EXAMPLE OF FS CONTENT (2)

- Summary of FS
- Necessity of Investigation of NPP
- Site Study and Selection
- NPP Technology and Technic Solutions
- Nuclear Fuel and Managemer of Radioactive Waste and Spent Fuel
- Human Resource Development
- Radiation and Nuclear Safety
- Preliminary Emergency Preparedness
- Preliminary Environmental Impact Assessment
- Transfer of Technology, Localization of Design, Equipment/Material Supplies, and Construction of NPP
- Estimate Investment Cost
- Financial Preparation & Analysis
- Public Information
- International Cooperation
- Security & Physical Protection
- Conclusion and Recommendation

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WHY NEED TO HIRE A CONSULTANT ?

- ✓ Preparation of the Feasibility Study requires a strong background both in the technical and financial aspects of the project.
- ✓ The perceived objectivity of the evaluation is an important factor in the credibility placed on the study by potential members, lenders and other interested parties.
- ✓ A Feasibility Study is an important tool for the bidding process that has huge technical, financial and sometime political implications.
- ✓ For these reasons, it is important to hire a consultant with no formal ties to project, equipment manufacturers or marketers, so an unbiased evaluation of project operating potential and efficiency can be made.

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CONSULTANT SELECTION CRITERIA (GUIDE)

No	Criteria	Points
1	Previous experience in creating similar Feasibility Studies	0 - 20
2	Knowledge of the industry to be studied (Nuclear Power)	0 - 15
3	Qualifications of principal/key member team of Consultant	0 - 10
4	Understanding of the Project Owner structure	0 - 10
5	Proposed interaction/interfaces with the Project Owner designated representatives	0 - 15
6	Verbal presentation/communication skills of the Consultant team	0 - 10
7	Reasonableness of FS cost	0 -15
8	Miscellaneous	0 - 5
	TOTAL	0 - 100

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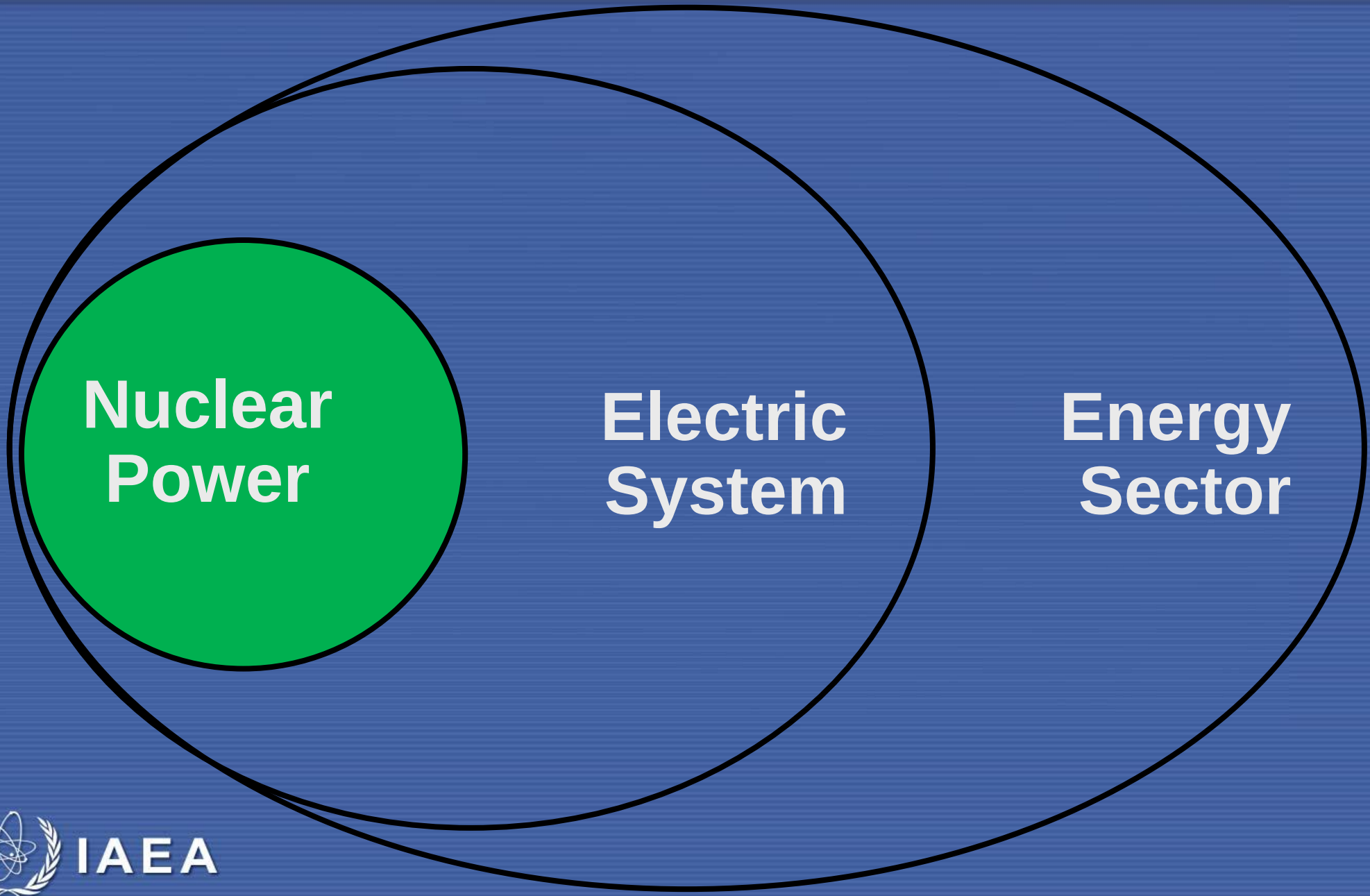
ENERGY & NUCLEAR POWER PLANNING



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ELECTRICAL SYSTEM ANALYSIS (1)

- To provide a sound techno economical background and framework for assessing the requirements to ensure adequate supply of electricity
- Usually undertaken by the national utility or governmental organization, not by NPP owner
- To make projections for the expected demand for electricity and identify the requirements for new generating capacity to satisfy the demand
- May carry out over different time frame
  - Short term frame – usually less than five years
  - Medium term frame – up to ten years
  - Long term frame – more than ten years

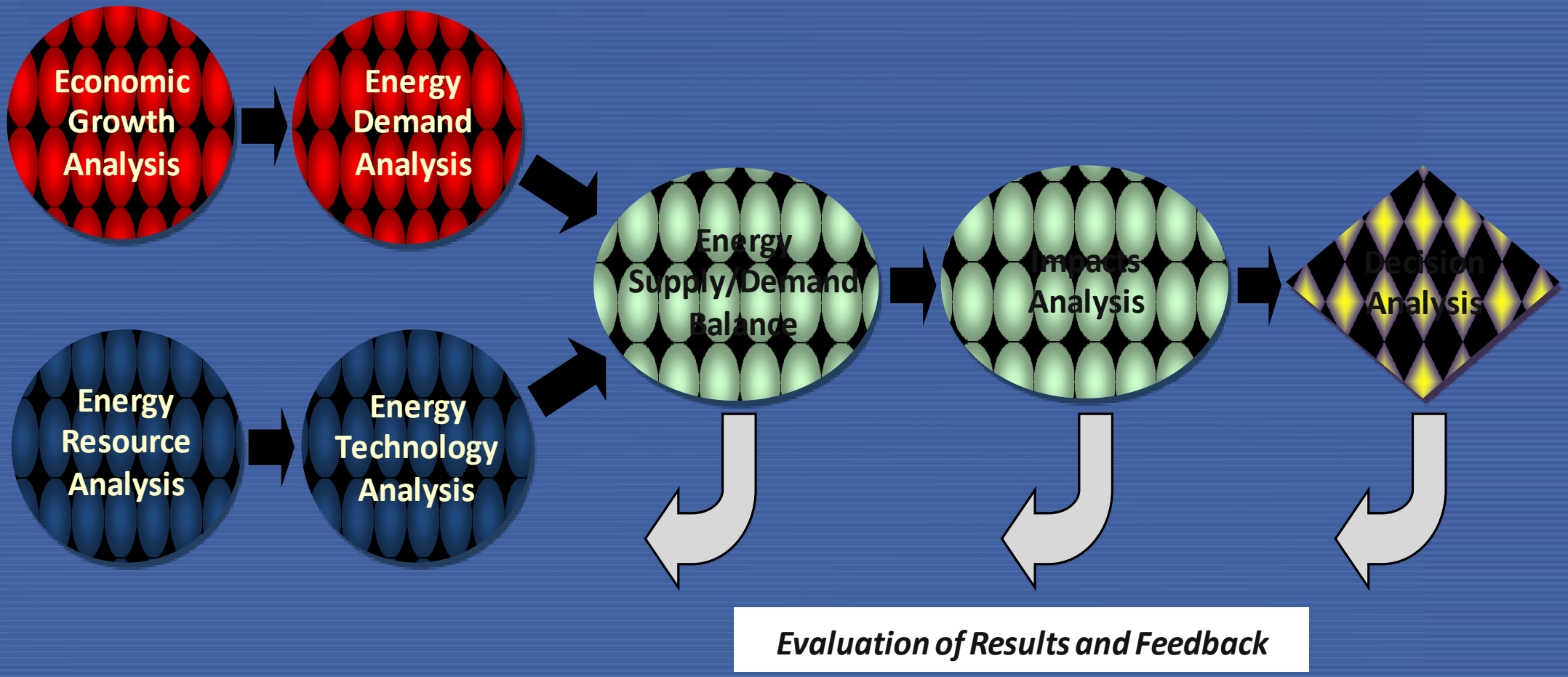
ELECTRICAL SYSTEM ANALYSIS (2)

- To include the following system analysis within the framework of the long term analysis
  - Analysis of electricity demand and electricity demand projections(Basic scenario)
  - Analysis of electricity supply system (Existing and future system expansion
  - Electricity market structure and organization
  - Electric system expansion plans program including generation, transmission and distribution system
  - Nuclear power project evaluation
- Long term projection of electricity demand, peak demand and load shape are critical determinants of future generation requirements

ELECTRICAL SYSTEM ANALYSIS (3)

- **Electricity supply system analysis will include;**
  - Overview of fuel sources, prices of fuels, fuel and electricity dependency and import/export
- **Electricity market structure and organization will review the following issues;**
  - Electricity industry overview, market participants, tariff structure and
  - Legal, regulatory and investment environment, barriers to competition, climate change
- **Electricity system expansion planning will include;**
  - Energy strategy aspects, diversifying fuel types, energy independency, national goals and strategy for promotion of renewable energy, infrastructure costs, risk and uncertainties of fuel supply

STEPS IN ELECTRICAL SYSTEMS ANALYSIS



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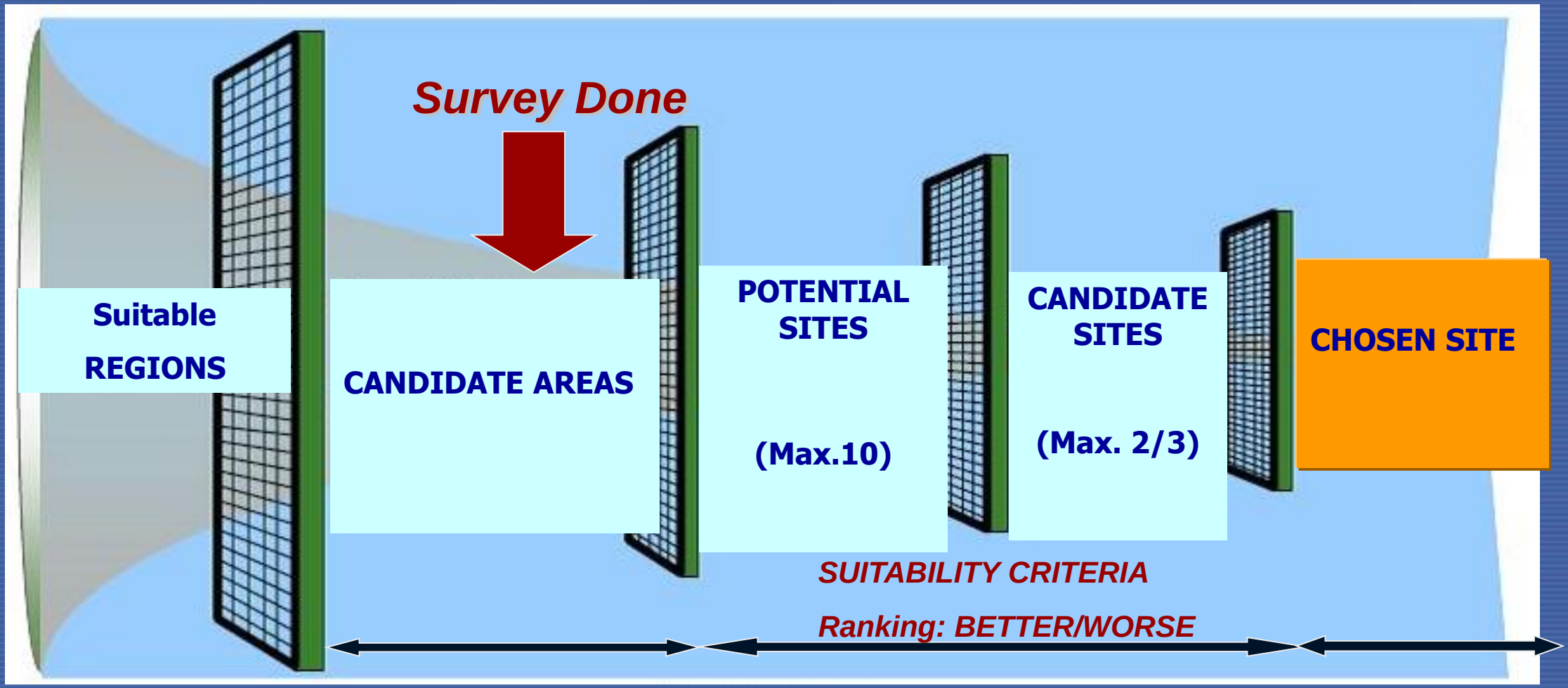
IAEA AVAILABLE TOOLS

- **MESSAGE (OPTIMIZATION)**
  - ✓ CONSIDERS THE FULL ENERGY SYSTEM
  - ✓ MINIMIZE DISCOUNTED PRESENT VALUE OF ALTERNATIVE ENERGY SYSTEM EXPANSION
- **WASP MODEL (OPTIMIZATION)**
  - ✓ CONSIDERS THE ELECTRIC SYSTEM
  - ✓ MINIMIZE DISCOUNTED PRESENT VALUE OF ALTERNATIVE POWER SYSTEM EXPANSION PLANS
- **ENPEP-BALANCE (EQUILIBRIUM)**
  - ✓ CONSIDERS THE FULL ENERGY SYSTEM
  - ✓ FINDS SUPPLY/DEMAND EQUILIBRIUM
- **EMCAS MODEL (AGENT-BASED)**
  - ✓ CONSIDERS THE ELECTRIC SYSTEM INCLUDING GENERATION, TRANSMISSION AND ELECTRICITY MARKETS
  - ✓ SIMULATES DECISIONS OF POWER SYSTEM PARTICIPANTS

UNIT CAPACITY AND GRID INTEGRATION

- **Station capacity should take into account the implication of the necessity**
  - To strengthen the electrical connection to the nodal points the electric grid
- **Unit capacity is usually maximum electrical power to be delivered to the transmission system and will consider;**
  - Flexibility of the electrical output and the power controllability and maneuverability range, integrated regional target
- **Integration to the grid review possible candidate sites from the point of view of the connection to the grid**
  - Grid capacity and grid connection, load following limitations

SITE SELECTION PROCESS (1)



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SITE SELECTION PROCESS (2)

- **NPP site investigation is normally done at early stage of nuclear energy introduction and expansion program**
  - Stage 1 : Site survey to determine the potential NPP sites
  - Stage 2 : Short listing and ranking to identify potential candidate sites from stage 1 are ranked for suitability
  - Stage 3 : Site characterization/assessment to select the preferred site
- **Natural and external events will be evaluated for;**
  - Earthquakes, meteorological events, flooding, geological hazards, man-induced events, cooling water availability, electrical grid disturbance and availability

SITE SELECTION PROCESS (3)

- **Potential effects of the nuclear facility in the region**
  - Atmospheric dispersion of radioactive material, dispersion of radioactive material through surface water, including sea and oceans, dispersion of radioactive material through ground water, ambient radioactivity
- **Population distribution within the region will be described including current and future projections**
  - The most census data and their extrapolations into the future, the nearest population center of 25,000 residents
- **Uses of land and water in the region**
- **Preliminary site layout and site preparation**
  - Preliminary site layout, economic competitiveness and constructability for plant layout alternatives, access road and heavy equipment transportation route, site preparation and excavation, construction phase resources, physical infrastructure requirements

SITE SELECTION PROCESS (4)

- **Summary of site characteristics and supporting facilities**
  - Confirm the acceptability of the preferred site
  - Describe all physical characteristics of the site
  - Identify the design basis for natural and human induced external events
  - Address the radiological impact on the population and on the territory during normal and accident conditions
  - Describe the exact site location, a preliminary layout of the nuclear power plant, administrative facilities, worker camp facilities, property boundaries
  - Establish and describe a suitable cooling water source

NPP TECHNOLOGY AND FUEL CYCLE (1)

- **Nuclear power technology market survey**
  - Data base resources and references assembled to develop the market survey information
  - Results of the market survey describing the candidate technologies for NPP and fuel cycle
- **NPP safety and performance assessment**
  - Safety Fundamentals, concepts and principles
  - Safety Requirements, Safety Guides
- **Fuel cycle evaluation and impact assessment**
  - Fuel cycle implications, Fuel supply risks, the fuel cycle evaluation

NPP TECHNOLOGY AND FUEL CYCLE (2)

- **Radioactive and conventional waste management**
  - Spent fuel management, radioactive waste storage,
- **Interim waste storage**
  - Spent fuel storage – wet storage, dry storage
  - Interim storage of radioactive waste
- **NPP technology and fuel cycle technology recommendations**
  - Summary description of the assessment of NPP technology and fuel cycle technology
  - Summarize the results and recommendations as suggested in the reactor technology assessment document

ENVIRONMENTAL IMPACT OF THE PROJECT

- **Environmental impact assessment report**
  - Identify and assess the possible direct and indirect environmental impacts
- **Cooling water demand**
  - Provide the preliminary choice of NPP cooling water technology or range of technologies
- **Environmental protection requirements of financial institution**
  - Export credit agencies (ECAs) that are members of the Organization for economic cooperation and development (OECD) require submission of an Environmental Impact Assessment (EIA) or comparable environmental documentation

LICENSING AND AUTHORIZATION

- To describe the national legislation particularly the important aspects such as nuclear safety, security, safeguards and liability for nuclear damage
- To describe the Nuclear Safety Regulatory Authorities with particular emphasis on their primary mandates to uphold public safety, preserve the environment and be totally independent of commercial interests
- To describe legislative frame work adopted by the country for the implementation of 1st NPP
- Licensing process and requirements
  - Description of the NPP licensing process and associated requirements in all of its phases
  - Typical (generic) schedule for the licensing of 1st NPP

PROJECT IMPLEMENTATION APPROACH (1)

- **Ownership structure**
  - The owner structure depends on several factors and possible types of ownership structures are utility as a sole owner, shared ownership model, finish business model
- **Contractual approach**
  - A number of approaches can be considered by newcomer countries such as turn-key contract [Engineering, procurement & construction contract and multiple contracts(BOO, BOT)
- **Procurement program**
  - The tender is usually split into packages either for large bidders to offer a scope of supply encompassing all packages together, or for smaller bidders to separately offer to supply individual packages
  - Nuclear island, conventional power plant (secondary circuit), BOP (the auxiliary facilities)

PROJECT IMPLEMENTATION APPROACH (2)

- **Project schedule**
  - Project preparation - Gathering the necessary information, Preparation of the overall implementation plan, Establishment of the financial model, Tendering activities, Selection of the main and subcontractors, Licensing activities.
  - Project preparation - Detail design, Procurement and manufacturing, Construction, and system installation, Commissioning and power ramp up.
- **Project management**
  - Concept of project implementation as a single EPC or turn-key contract or The owner/utility divides the implementation of the new units into work and service packages (nuclear island, conventional power plant parts, network connections, etc.)
  - Project management tasks, Preparation of the site, Implementation planning, Procurement of the equipment and materials, Construction of new units, Commissioning

PROJECT IMPLEMENTATION APPROACH (3)

- **Risk matrix**
  - risk analysis for quantitative risk, Business risks due to human factors, the risk of production failure, risk of injury, industrial accidents, the risk of poor contractor performance, the risk of injury and delays during the commissioning, risk of decommissioning a plant
- **Risk management plan**
  - The risk management plan contains an analysis of likely risks with both high and low impacts, as well as mitigation strategies and corrective action to avoid multiple occurrences and help the project avoid being derailed should common problems arise

NATIONAL PARTICIPATION

- **National industry survey**
  - A realistic assessment of the national and local capabilities to supply commodities, components and services for further economic, financial and commercial studies
- **Establishment of the strategy for national participation**
  - To introduce overall policy of the nuclear power program for a short and long term localization strategy encouraging national participation
- **Localization plan**
  - The localization plan represents an action plan within the overall national participation strategy and described and should be included in the Bid Invitation Specification for the first NPP
- **Technology transfer and goals**
  - Agreement between the owner and supplier to transfer skill, knowledge, technologies, operation procedures and methods

ORGANIZATION, HUMAN RESOURCES AND TRAINING

- **Construction workforce and logistics**
  - To review size the required workforce of the owner / operator's organization
- **NPP owner's organization during construction, commissioning, O&M**
  - Owner/operator usually establishes at the start of the preparatory phase. In turnkey contracts with main responsibility delegated to the main contractor
- **Staffing requirements**
  - An effective workforce plan for the owner/operator should cover both the organization and the human resources required to support operations of the plants at the national level
- **Education and training requirements**
  - To address the availability of human resources, the long term sustainability of a skilled work force

PROJECT COST ESTIMATE

- Lifetime **Project cost** breaks down as:
  - ✓ **Total capital investment costs (TCIC)**
    - **Costs of acquiring and building NPP**
  - ✓ **Nuclear fuel cycle costs**
    - **Cost of nuclear fuel**
  - ✓ **Operation & maintenance (O&M) costs**
    - Wages and salaries for engineering & technical support staff, and for operation, maintenance & administration staff as well as costs of consumables, materials, operating equipment and purchased services
  - ✓ **Decommissioning and Waste Management Cost**

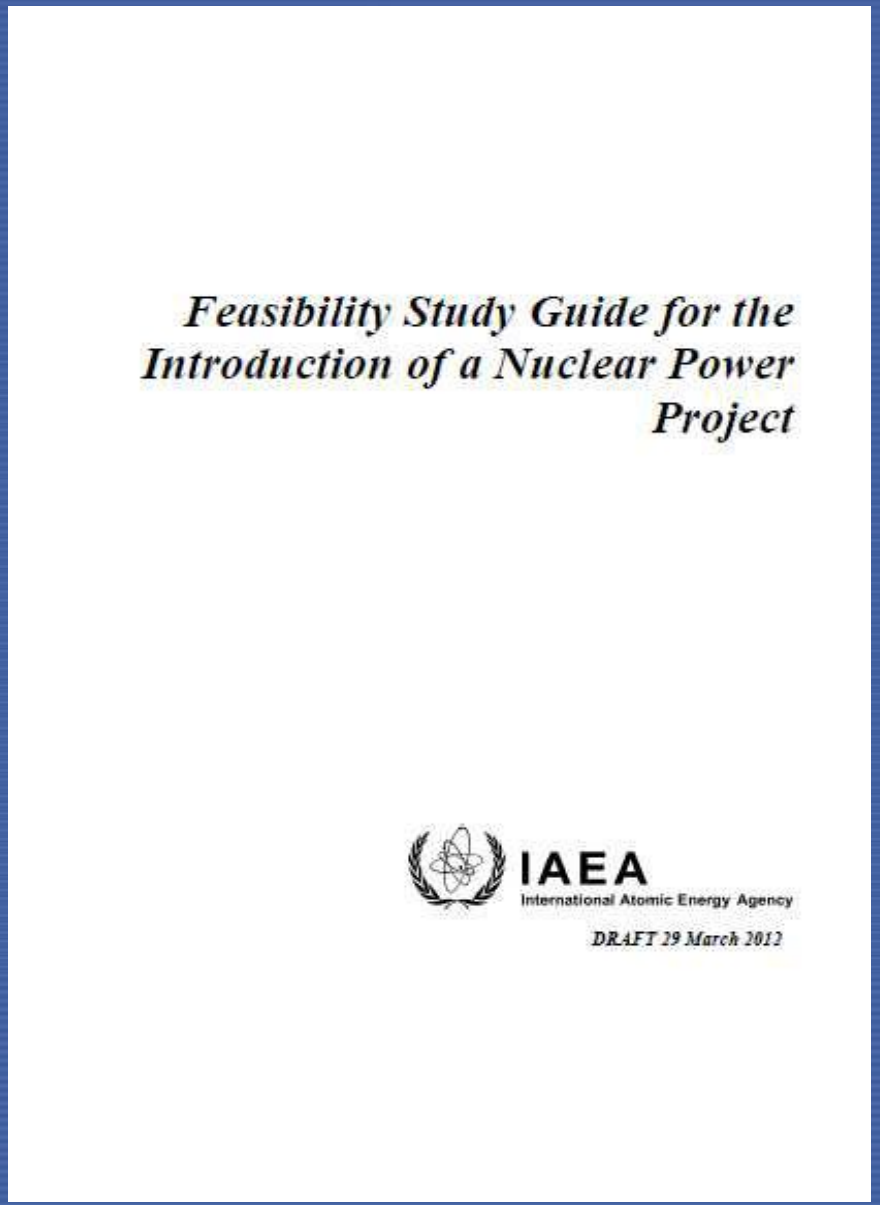
ECONOMIC ANALYSIS

- Economic analysis is a systematic analysis approach and take into account the opportunity costs of the resources employed and attempt to measure in monetary terms the private and social costs and benefits of a project to a society or an economy
- Some issues and typical problems in economic analysis should be faced and resolved
  - Monetary value of benefits, Discounting, Environmental externalities, Other externalities
- Project performance indicators
  - Net Present Value, Benefit/Cost Ratio (C/B), Internal Rate of Return (IRR), Levelized Unit Electricity Cost (LUEC)
- Sensitivity and risk analysis
  - Sensitivity analysis, Risk analysis, Scenario analysis, Other Resources on economic analysis

NPP FINANCING

- ✓ Goal of the “Financing” section in a Feasibility Study is the development of a **financial plan for the NPP** for the plant owner and the project major stakeholders.
- ✓ A sound financial plan is necessary to attract financial Institutions and the NPP Vendor interest in order to entice them to bid on the project.
- ✓ Financial plan should define the **sources of financing** (government, local loans, external loans, etc.) and the levels of equity and of borrowed money (loans).
- ✓ Financial plan should also evaluate the **cost of financing** (interest during construction, other specific fees, etc.) which need to be taken into account in order to determine the best possible solution, such as the ratio equity/loan.
- ✓ The financial study output should offer the formulation of a number of credible scenarios and a proposal for the financing of the NPP project with due consideration to risks and pre-conditions.

IAEA GUIDANCE DOCUMENT FOR FS




Thanks !