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Economic Assessment of a NPP Project: Viet Nam's Practices and INPRO Methodology

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Introduction

- Since 1996, studies on planning and economic evaluation of the NP introduction in Viet Nam have been conducted through:
  - National Programme on Sustainable Energy Development (1996-2000);
  - IAEA TC project "Pre-Feasibility Study for the Introduction of NP in Viet Nam (VIE/0/009)“ (1997);
  - Project on Pre-Feasibility Study for Construction of the First NPP in Viet Nam (2002-2009); and
- At present, Feasibility Studies for Ninh Thuan 1 and Ninh Thuan 2 NPPs conducted by Russian and Japanese consultants, respectively.
- This presentation includes following contents:
  1. **Economic - Financial Analyses in Pre-FS**
  2. **An Approach on Economic - Financial Analyses in FS**
  3. **Using INPRO Indicators for the Obtained Result Evaluation**
  4. **Conclusions**

1. Economic and Financial Analyses in Pre-Feasibility Study

1.1. Analysis of NP Economic Competitiveness (1)

- Power Plants types have been taken into analysis

1.	CCGT 700 Mwe	680 USD/kW	Domestic gas
2.	CCGT 700 Mwe	680 USD/kW	Imported gas
3.	CCGT 900 Mwe	750 USD/kW	Imported LNG
4.	Gas-fired PP 600 Mwe	1,040 USD/kW	Domestic gas
5.	Coal-fired PP 500 MWe	1,380 USD/kW,	Domestic coal
6.	Coal-fired PP 500 Mwe	1,380 USD/kW,	Imported coal
7.	NPPs 1000 Mwe	3,600 - 4,000 USD/kW.	

- Hydropower accounted for 50.8% in 2002 and 34.2% in 2008, but it has not been taken into consideration as an alternative option for NP due to following reasons:
  - ✓ Hydropower production costs is lowest (3 - 3.5 US Cents / kWh);
  - ✓ Hydropower is a non-carbon energy source;

1.1. Analysis of NP Economic Competitiveness (2)

- ✓ In addition to electricity generation, hydropower brings another benefits, such as irrigation, flood control; and
- ✓ Hydro power potential is limited. In near future almost of hydropower capacities will be exploited. Therefore, hydropower is no longer an option for electricity generation expansion.

- Levelized Unit Energy Cost (LUEC) was used for PPs' Economic competitiveness analysis.
- The input parameters used for LUEC calculation: Capacity, Investment Rate (IR), Efficiency, Specific Consumption, Plant Lifetime, Own Use, O&M Cost, Discount Rate (DR), Capital Recovery Factor (CRF) (now FIRR), Heat Value, Fuel Cost, Fuel Cost Escalation, and Load Factor (LF).
- Sensitivity analysis has been carried out by in turn increasing by 10% of Construction Period, O&M Cost, Fuel Cost, Capital Investment Cost, LF, IDC, DR and decreasing Plant Lifetime by 10%;

1.2. Economic - Financial Analysis of NPP project (1)

- **Objectives**

- Economic efficiency analysis aims to assess the feasibility and efficiency of an investment project for the national economy. The obtained results are the basis for competent authorities to decide the investment in the project and/or to issue mechanisms and policies supporting for investment.
- Financial analysis is an assessment of financial feasibility of a project from the investors' viewpoints aimed at orienting investors on the modes for raising capital and financial mechanisms in order for the project reaching reasonable profitability level and long-term efficiently and sustainably operating .

1.2. Economic - Financial Analysis of NPP project (2)

- **Analysis of economic efficiency of a investment project** is a reports on economic cash flows, excluding taxes, and project's economic indicators, including: Economic Internal Rate of Return (EIRR), Economic Net Present Value (ENPV), Benefit/Cost Ratio (B/C), and Discounted Capital Investment Return Period (T).
- **Financial analysis includes:**

1) *Predictable Table of Business Results* expresses revenues, costs, and net income for the project lifetime at each year
2) *Table of Financial Cash Flows and Financial Indicators* expresses revenue cash flow, cost cash flow and net profit for project lifetime at each year taking into account the discount rate. Indicators for financial efficiency evaluation of a project includes FIRR, FNPV, B/C and T.
3) *A project is considered as feasible* if it meets the following acceptance limits: IRR > Interest Rate, NPV > 0, and B/C > 0.

1.2. Economic - Financial Analysis of NPP project (3)

Table 1. Results of Project Economics Analysis

Indicators	Values
Discount Rate (%)	10
Economic Electricity Price (Marginal Cost) (US Cent/kWh)	8.0
Economic Net Present Value - ENPV (million USD)	565
Economic Internal Rate of Return - EIRR (%)	10.52
Benefit/Cost Ratio - B/C	1.06
Discounted Capital Investment Return Period – T (year)	27

1.2. Economic - Financial Analysis of NPP project (4)

Table 2. Results of Project Financial Analysis

(Electricity Price at Bus Bar : 7.10 US Cent/kWh)

Indicators	Values
Weighted Average Cost of Capital - WACC (%)	7.31
Financial Net Present Value - FNPV (million USD)	1638
Financial Internal Rate of Return - FIRR (%)	9.32
Benefit/Cost Ratio (B/C)	1.23
Discounted Capital Investment Return Period – T (year)	22
Levelized Unit Energy Cost - LUEC (US Cent/kWh)	6.45

2.3. Economic - Financial Analysis of NPP project (5)

Table 3. Sensitivity Analysis

Indicators	Values
1. Capital Investment increased 10%	
- Levelized Unit Energy cost (US Cent/kWh)	6.25
- Electricity Price (US Cent/kWh)	7.27
2. Commercial Electricity Amount decreased 10%	
- Levelized Unit Energy cost (US Cent/kWh)	7.06
- Electricity Price (US Cent/kWh)	7.80
3. Fuel Price in Base Year increased 10%	
- Levelized Unit Energy cost (US Cent/kWh)	6.54
- Electricity Price (US Cent/kWh)	7.19
4. Combination of increased Capital Investment and decreased Commercial Electricity Amount	
- Levelized Unit Energy cost (US Cent/kWh)	7.20
- Electricity Price (US Cent/kWh)	8.00

1.3. Conclusions on the Economic - Financial Analysis (1)

1) Generally, NPPs are difficult to compete economically with domestic coal-fired PPs. However, Ninh Thuan NPPs can become competitive with other electricity generation sources when Viet Nam has to import fuel for electricity generation in some particular conditions;
2) With DR = 10%, LF > 85% NPPs can be competitive with PPs using imported fuels (gas, LNG, and coal of price > 110 USD/tonne);
3) Comprehensive analyses show that at national level, due to bringing many other benefits, NP is considered as a solution for sustainable development (energy security, environment protection, social and macroeconomic impacts...). Therefore, the use of discount rate lower than 10% for NP projects could be applied as a Government's support for NP development.

2.4. Conclusions on the Economic - Financial Analysis (2)

4) If taking into account market prices of fuels being pushed up due to depletion at the moment that NP occurred, then with discount rates from 5% - 8 %, and LF > 77.5%, NPPs can be competitive with gas-fired and coal-fired PPs;
5) Financial analysis for the project investors shows that with electricity price of 7.10 US Cent/kWh at basic financial plan, the financial performance of project investors achieves feasibility with given analysis conditions;
6) When selected parameters increased about 10%, the financial criteria for project investors are feasible only when the electricity price increased from 7.19 US. Cent/kWh to 8.0 US Cents/kWh; and
7) Economic-financial efficiency of NP will be significantly increased when there are many NPPs built and operated.

2. An Approach on Economic - Financial Analyses in Feasibility Study

2.1. Economic – Financial Analysis (1)

- **Total investment cost**

- **Total investment cost = Direct cost** (equipment cost, building cost and civil engineering cost) **+ Indirect cost** (owner's cost and interest during construction)
- Direct cost is directly concerned to the work for the plant system and the buildings. Depending on terms and conditions, the initial core fuel and contingency are added to this cost, which is called the EPC cost.
- **Total investment cost = EPC cost** (equipment cost, building cost and civil engineering cost, initial core fuel, contingency) **+ Indirect cost** (owner's cost and interest during construction)

2.1. Economic – Financial Analysis (2)

- Generation cost at the evaluation period is calculated to obtain the approximate value of an actual cost

Generation cost = Σ [Ct + Ot + Ft + Dt] / Σ [Et]

Ct = Capital cost in the year t

Ot = Operation and maintenance cost in the year t

Ft = Fuel cost in the year in t

Dt = Decommissioning cot in the year t

Et = Electricity generation in the year t

- For economic – financial analysis, calculation is also made in the method of LUEC. This method is based on the present value approach - a method of discounting the assumed amount of the electric power generation and the necessary cost during the operation period.

$LUEC = \Sigma [(Ct + Ot + Ft + Dt) \times (1+r)^{-t}] / \Sigma [Et \times (1+r)^{-t}]$

r = Discount rate

2.1. Economic – Financial Analysis (3)

- The financing plan for NPP project was conducted based on the Total Investment Cost and on the Generation Cost. Additionally, any financing cost is taken into account. Corporate income tax rate and depreciation rules which were specified by Viet Nam were considered, e.g. :

  - Corporate Income Tax

1^{st} - 4^{th} year	0 %
5^{th} - 13^{th} year	5 %
14^{th} - 15^{th} year	10 %
After 16^{th} year	25 %

  - Depreciation (machinery): 20 years
  - Depreciation (building): 40 years

- IRR and NPV, Debt Service Coverage Ratio (DSCR) were used as evaluation methods. For the IRR, Project IRR was calculated to evaluate the actual project, and Equity IRR to evaluate the rate of return for net investment.

2.1. Economic – Financial Analysis (4)

- Discount rate to obtain the present value were calculated by weighted average method:

Discount rate = [rE × E/(D+E)]+ [rD×(1-T) × D/(D+E)]

rE = Cost of Equity: Social economy discount rate in Viet Nam

rD = Cost of Debt: Buyer's Credit + Annualized rate of insurance Cost

D = Amount of Debt

E = Amount of Capital

T = Effective Tax Rate

- **Sensitive study**
  - Discount rate vs NPV;
  - Interest rate for debt vs IRR and NPV;
  - Impact on to IRR and NPV when changing Electricity selling price, Investment cost, Fuel cost, O&M cost

2.2. Data and Results (1)

❖ Data

- At one site, 2 units will be built with 1 year interval.
- Reactor type: 3+ generation
- Construction period
- Domestic / Foreign Investment Ratio
- Total Capacity (MW)
- Availability (Capacity factor)
- Electricity selling price
- Investment cost for 2 units
- Fuel cost (including initial fuel cost)
- O&M cost
- Decommissioning cost

2.2. Data and Results (2)

- Depreciation/year/2 units (Machinery/20 years)
- Depreciation/year/2 units (Building/40 years)
- Interest rate on debt
- Repayment period
- Discount rate
- Evaluation period

❖ **Results**

- Levelized Unit Energy Cost lower than Selling Price
- PIRR and EIRR, NPV, B/C, DSCR met conditions to confirm that the project is considered to be financially healthy project.
- when the discount rate becomes 8% and higher or the interest rate becomes higher than 6%, NPV becomes negative value, which means the project looses economic viability.

3. Using INPRO Indicators for Evaluation of the Obtained Results

INPRO Economic basic principle BP: *Energy and related products and services from nuclear energy systems shall be affordable and available.*

3. Using the INPRO Indicators for Evaluation (1)

User Requirement	Criterion	Indicator (IN) and Acceptance Limit (AL)
UR1 (Cost of energy): *The cost of energy supplied by nuclear energy systems, taking all relevant costs and credits into account, C_N, should be competitive with that of alternative energy sources, C_A that are available for a given application in the same time frame and geographic region/jurisdiction*	**CR1.1** cost competitiveness	**IN1.1**: Cost of energy. **AL1.1:** $C_N \leq k*C_A$ (C_N = cost of nuclear energy, and C_A = cost of energy from alternative source; factor **k** is usually ≥ 1 and is based on strategic considerations.)

- **Comments:** If applied AL1.1 with k>1, Cost of Energy of Ninh Thuan NPP will become competitive. This is consistent with policies of Viet Nam on security of energy supply, long term stability in energy costs, diversity of energy supply technologies, industrial development of industry, science and technology, and environment protection…

3. Using the INPRO Indicators for Evaluation (2)

User Requirement	Criterion	Indicator (IN) and Acceptance Limit (AL)
UR2 (Ability to finance): *The total investment required to design, construct, and commission nuclear energy systems, including interest during construction, should be such that the necessary investment funds can be raised.*	**CR2.1** attractiveness of investment	**IN2.1:** Financial figures of merit.
		AL2.1: Figures of merit for investing in a NES are comparable with or better than those for competing energy technologies.
	CR2.2 investment limit	**IN2.2:** Total investment.
		AL2.2: The total investment required should be compatible with the ability to raise capital in a given market climate.

- **Comments:**

- AL2.1: Financial figures of merit have not been calculated for competing energy technologies. But, the economic analysis shows that the project is feasible with the economic indicators EIRR>10%. NPV>0, B/C>1 for electricity price of 8.0 US Cent/kWh.
- AL2.2: The total investments required are committed to be supplied by Russian and Japanese Governments.

3. Using the INPRO Indicators for Evaluation (3)

User Requirement	Criterion	Indicator (IN) and Acceptance Limit (AL)
UR3 (Investment risk): *The risk of investment in nuclear energy systems should be acceptable to investors.*	**CR3.1** maturity of design	**IN3.1:** technical and regulatory status.
		AL3.1: Technical development and status of licensing of a design to be installed or developed are sufficiently mature
	CR3.2 construction schedule	**IN3.2:** Project construction and commissioning times used in economic evaluation.
		AL3.2: Times for construction and commissioning used in economic evaluation are sufficiently accurate, i.e. realistic and not optimistic.

- **Comments:**

- AL3.1: The proposed technologies are AES-91, AES-92, AES-2006 (Moscow), and AES-2006 (Saint Petersburg) for Ninh Thuan 1; and Japanese consultant proposed technologies of ABWR, MPWR+, ATMEA1, AP1000 for Ninh Thuan 2. They are sufficiently mature.
- AL3.2: Time for construction and commissioning used in economic evaluation are sufficiently accurate.

3. Using the INPRO Indicators for Evaluation (4)

User Requirement	Criterion	Indicator (IN) and Acceptance Limit (AL)
	CR3.3 uncertainty of economic input parameters	**IN3.3:** A sensitivity analysis of important input parameters for calculating costs and financial figures of merit has been performed.
		AL3.3: Sensitivity to changes in selected parameters is acceptable to investor.
	CR3.4 political environment	**IN3.4:** Long term commitment to nuclear option.
		AL3.4: Commitment sufficient to enable a return on investment.

- **Comments:**
- AL3.3: Sensitivity to changes in selected parameters is acceptable to investor;
- AL3.4: Vietnamese Government committed to return on investment

3. Using the INPRO Indicators for Evaluation (5)

User Requirement	Criterion	Indicator (IN) and Acceptance Limit (AL)
UR4 (Flexibility): *Innovative nuclear energy systems should be compatible with meeting the requirements of different markets.*	**CR4.1** flexibility	**IN4.1**: Are the innovative NES components adaptable to different markets?
		AL4.1: Yes.

- **Comments:**
- Technology vendors will supply NES components adaptable to Vietnamese market.

4. Conclusions

4. Conclusions (1)

1. In order to come a decisions on policy for NP development and the implementation of a NP project, the analysis of economic competitiveness and financial figures of merit of NP is an essential part of Pre-Feasibility Study and Feasibility Study for introduction of Nuclear Power in Viet Nam;
2. Economic - financial analysis is applied not only for assessment the role of nuclear power among electricity supply options but also for comparative assessment for nuclear power technology selection;
3. Though Vietnamese and foreign consultants have conducted analyses independently with the INPRO methodology, but their approaches all are similar;
4. Application of the INPRO methodology to obtained analytical results in Pre-FS and FS shows that Ninh Thuan Nuclear Power Project is feasible;

4. Conclusions (2)

5. INPRO methodology provides a set of criteria, indicators and acceptance limits, which help experts and policy makers to easily verify/check the feasibility of a nuclear power project;
6. When analysis of economic competitiveness of nuclear power and alternative energy sources, the choice of k value in the Acceptance Limit AL1.1 may depend on the attitude/policy of support or anti nuclear power.
7. Any bias in favor of or against nuclear power, which can be reflected by the selection of k value, will lead to losses on economics (opportunity cost) due to making wrong decision; and
8. The accuracy (uncertainty) of input data for economic – financial analysis of a nuclear power project is one of the problem to be considered in Pre-FS. Practices shown that the difference of input data between Pre-FS and FS is significant and it could be an impediment for the implementation of a nuclear power project.

Thank you for your attention