

Cost Estimating Guidelines: The First Step Toward “Level Playing Field” Economic Analysis of Advanced Nuclear Technologies

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The Economic Evaluation Process for Competing Technologies in the Early R&D Stages:

- **Should emphasize:**
 - Costs driven by technology, such as equipment costs
 - Related factors driven by technology, such as site and building sizes
 - Development/deployment risks associated with each technology
- **Should de-emphasize:**
 - Macroeconomic factors
 - Costs that are technology independent, such as construction labor rates

Cost Estimating Guidelines Do the Following:

- Provide the same guidance to all concept design/estimating teams before the design and estimating process commences
- Form the basis for “level playing field” evaluation of competing concepts
- Put the emphasis on design/cost variables that discriminate between competing technologies
- Provide common values for use by cost estimators, thus saving time and \$ in the estimating process.
- Provide a common cost estimating format for all design/estimating teams, thus making side-by-side comparisons between competing concepts possible
- Establish common figures-of-merit for economic evaluation
- Serve as the basis for economic model development

Cost Estimating Guidelines Have Been Used by Several DOE Programs

- **Advanced Reactors program (ALMR & MHTGR) (1993)**
- **New Production Reactor Program (1988-1992)**
- **Fissile Materials Disposition Program (Plutonium) (1994-present)**
- **DOE Powerplant Economic Analysis (Coal vs. Gas vs. Nuclear)**

The Generation IV Economic Modeling Working Group (EMWG) Was Tasked With Cost Guidelines Preparation for Eventual Evaluation of the Six Generation IV Reactor System Concepts

- **EMWG Started By Examining Applicability of 1993 Guidelines Prepared for ALMR & MHTGR Evaluations**
- **It was soon realized that new guidelines had to recognize several differing factors:**
 - **International flavor of program**
 - **Concepts to be evaluated have not all enjoyed extensive design/cost estimation by Architect/Engineering firms**
 - **Compared to Gen III and Gen III+ concepts, any cost data available is likely to be at high "roll-up" level**
 - **"Top down" as opposed to "bottom up" type cost estimating is likely to be used for initial estimates**
 - **A new cost estimating format for the R&D program and any prototype reactor had to be added**

The Guidelines are a Predecessor to an Integrated Gen IV Reactor Systems Integrated Model

- EMWG model to initially consider electricity generation
- Model for nuclear-generated hydrogen to follow
- Modularity of reactor systems an important consideration
- Nuclear Fuel Cycle supporting reactor systems must also be modeled: this is where AFCI support will be needed
- Marketing and deployment issues to be considered in later EMWG Integrated Model modules
- Present figures of merit for each Gen IV concept are:
 - Projected Levelized Unit Electricity Cost (LEUC in \$/MWh)
 - Projected Aggregate Cost of the R&D and demonstration programs (\$M)

A “Code-of-Accounts” provides a uniform format for cost estimates

- **COA structures exist to cover all major life cycle cost elements:**
- **Up-front costs:**
 - RD&D
 - Design/Construction
 - Start-up
- **Other life cycle costs**
 - Operations
 - D&D

Code-of-Accounts (cont'd)

- **The R&D Code-of-Accounts in the draft Guidelines has a generic RD&D COA which covers fuel cycle RD&D associated with any given reactor concept (Table 3.1)**
- **Design/Construction/Start-up COAs are based on nationally and internationally recognized COAs:**
 - **For domestic reactors the EEDB (Energy Economic Data Base) format has been commonly used**
 - **For international reactors the IAEA modified the EEDB to fit the needs of developing countries (bid evaluation)**
 - **The Gen IV Guidelines use a hybrid EEDB/IAEA system amenable to concepts still in the RD&D stage of their life cycles**

COA for Up-front Costs:

- **02 Direct Costs**

- **020 Land and land rights**
- **021 Buildings and structures on the plant site**
- **022 Reactor Plant equipment (Nuclear island)**
- **023 Turbine/Generator plant equipment**
- **024 Electrical equipment**
- **025 Water intake and heat rejection**
- **026 Miscellaneous plant equipment**
- **027 Non-fuel special materials (i.e. heavy water)**
- **028 Simulator(s)**

- **03 Indirect Costs**

- **030 A/E and equipment vendor home office design services**
- **031 Management of Acct 30 services**
- **032 A/E and equipment vendor on-site services**
- **033 Management of Acct 32 services**
- **036 Start-up costs accrued by A/E and equipment vendors**

COA for Up-front Costs (cont'd):

04 Other Indirect Costs

040 Training, technology transfer, and other services

041 Special construction and worker-related items and services

05 Supplemental Costs

052 Contingency on above accounts

055 First core fuel load

Sum of 02, 03, 04, 05, and 07 is “Overnight Cost”

06 Financial costs

061 Interest during construction (IDC)

063 Contingency on IDC (to reflect schedule risk)

07 Owner’s (Utility’s) Costs

070 Owner’s start-up costs

Sum of “Overnight Cost” and Acct 06 is the “Total Capital Investment”

COA Structure for Other Life Cycle Costs

RECURRING FUEL COSTS (RELOADS)

12 Costs for materials and services for front end of fuel cycle (reloads)

121 Uranium supply

122 Conversion services

123 Enrichment services

124 Fuel assembly fabrication

125 Non-U fissionable materials

14 Costs for materials and services for back end of fuel cycle

140 Reprocessing of irradiated fuel assemblies

141 Credits for U, Pu and other materials

142 Final disposal of spent fuel assemblies

143 Final Waste disposal

COA Structure for Other Life Cycle Costs

NON-FUEL O&M COSTS

08 Recurring Costs:

800 Fully-burdened wages and salaries for staff

810 Consumable items and materials

820 Repair costs, including interim replacements

830 Charges on Working capital

840 Purchased/contracted services

850 Insurance premiums

860 Regulatory fees

870 Payments to fund to finance D&D

880 Radioactive waste management (non-fuel)

890 Miscellaneous costs including G&A

09 Non-recurring Costs

900 Capital Replacement costs (large, high-cost items)

Cost Model Assumptions

- **Plant produces same annual output over production lifetime**
- **Constant dollar costing**
- **Corporate income and property tax ignored**
- **All non-capital costs are annualized and assumed equal over life of plant**
- **Capital amortized over production life of plant**
- **D&D treated by sinking fund approach**
- **Unit product cost (\$/MWh) broken down into capital , non-fuel operations, and fuel components**

These simplifications 1.) enable international use, 2.) allow use of cost algorithms in design optimization, and 3.) are appropriate for concepts in early RD&D stage of life cycle

Costs/Factors Which Can Be Fixed For Reactor “Level Playing Field” Economic Analysis

- **Common site(s): Can have different international locations**
- **Construction labor man-hour costs and productivity**
- **Discount rate**
- **Base year for constant dollar costing**
- **Wages & salaries for operations personnel**
- **Construction commodity unit costs**
- **Unit costs of fuel cycle materials and services**
- **Rules for handling Nth of a kind facilities vis-à-vis 1st of a kind facilities**
- **Methodology for contingency determination and desired level of cost confidence**
- **Production rate and cost figure of merit**

Methodology Discussed Here for Reactors Is Applicable to Fuel Cycle Facilities

- **Reactor equipment accounts become process equipment accounts**
- **Many other account descriptions can be maintained, i.e. electrical, heat removal, etc**
- **Unit figure of merit may change from \$/MWe to \$/kgHM**
- **Economic models developed for AFCI may provide crucial inputs to Gen IV modeling system**
- **Fuel cycle facilities conceptualized for AFCI may serve many potential Gen IV reactors**

Conclusions/Recommendations

- **NOW is the time to establish cost estimating guidelines and figures of economic merit**
- **Make sure all technology advocates and their subcontractors understand them**
- **We (AFCI) need to help define those fuel cycle technologies and facilities that will support Gen IV Reactor Systems**
- **Facility costs are needed to establish unit fuel costs**