NGNP Project Economic Model Development Initiative

Revision 0, January 14, 2008

Introduction:

The following summarizes the objectives, structure, methods and default data for the economic model to support economic analyses by the Alliance Working Group. The development of this model was proposed and discussed in the Working Group meeting of November 8, 2007.

The NGNP Project Model will be developed to evaluate the economic viability in deploying the High Temperature Gas Reactor (HTGR) technology as a commercial power plant technology. There are three principal model objectives: 1) provide a consistent basis and method of analysis, 2) establish and maintain the set of economic assumptions specific to HTGR deployment, 3) evaluate the economic advantages and disadvantages in the development and application of HTGR sub-technologies, and 4) provide for common economic measures to be used in external communications. Any Alliance member will be able to use this model, in addition to their internal models, to support their internal evaluations of the HTGR technology.

The objectives of developing the NGNP Project Model are similar to those of the H2A model [1][1] which is being developed under the direction of the DOE:

> *H2A, which stands for Hydrogen Analysis, was formed in 2003 to better leverage the combined talents and capabilities of analysts working on hydrogen systems, and to establish a consistent set of financial parameters and methodology for cost analyses. The foundation of H2A is to improve the transparency and consistency of the approach to analysis, to improve the understanding of the differences among analyses, and to seek better validation of analysis studies by industry. To accomplish this, a group of analysts identified the following objectives of H2A:*
>
> *1. Establish a standard format and list of parameters for reporting analysis results. Do this for production, delivery, and forecourt (filling station).*
> *2. Seek better validation of public analyses through dialog with industry.*
> *3. Enhance understanding of the differences among current and publicly available analyses and make these differences more transparent.*
> *4. Establish a mechanism for facile dissemination of all public analysis results.*
> *5. Improve the understanding of the purpose of hydrogen production and delivery analyses and identify analysis gaps.*
> *6. Work to reach consensus on specific analysis parameters for production, delivery, and forecourt.*

The structure and assumptions of the H2A model have been used as a benchmark for the proposed NGNP Project Model. Comparisons are made in the following with the H2A model where appropriate.

Development Team:

As agreed in the November 8, 2007 Working Group meeting Dan Mears, Technology Insights, Steve Melancon, Entergy and Ted Marston, Marston Consulting, represent the Working Group. Larry Demick, NGNP Project Technical Advisor and Phil Mills, NGNP Project Engineering Director (Acting) represent the BEA NGNP Project. John Baker, BEA Cost Estimator, and Marty Plum, BEA Economist have been added to this Team as the principal contributors from BEA for development of the model and default input data.

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[1] Numbers in brackets refer to the references listed at the end of this document

Methodology:

A discounted cash flow methodology will be used to calculate the internal rate of return (IRR) of potential commercial deployments of the HTGR technology. This is similar to the methodology that supported the NGNP Project Economic analyses prepared for the Pre-Conceptual Design Report [2] and that applied in the H2A central hydrogen production model. Although modeling similar to the H2A model will be used, the NGNP Project Model will not be included as part of the H2A system. The NGNP Project Model is for a narrower audience than the H2A model, (e.g., the Working Group) and will allow for the evaluation of more products and more applications than the H2A model (see below).

Structure:

The NGNP Project Model will include project life cycle modules for capital construction, capital maintenance, cost of operations, revenues, and facility decommissioning, decontamination, and demolition. Additionally, modules will be provided for key economic and financial issues such as capital financing, interest rates, inflation rates, escalation rates, and operating parameters such as availability, capital replacement, and labor performance. These modules will include default data, where appropriate, with the provision that default data can be overridden by the user.

The structure will include provisions for completing analyses for a given project definition with differing objectives. These include:

1. Calculating the IRR for the project given base[2] prices for products and values for the key economic parameters (For this case IRR is calculated to achieve a net present value (NPV) = 0).
2. Calculating the net present worth for a given IRR, or
3. Calculating the required base price for a product, (e.g., hydrogen) to achieve an input IRR.

For each analysis the model will calculate and present IRR, NPV, base and escalated product pricing and annual revenue, annual costs, actual and discounted cashflow and simple payback period. The model will provide the capability for completing parametric analyses over ranges of key parameters, (e.g., required IRR, percent financed, interest rates, escalation and inflation rates, costs, period of operation) To support parametric analyses the model will include provisions for presentation of results in directly useable form, (e.g., graphically for insertion in documents or presentation materials).

HTGR Products:

The current projected HTGR products include electricity, steam, hydrogen and oxygen in application specific combinations. The ability to account for CO_2 credits is also provided in the revenue stream. Individual modules will be provided for developing the costs and revenue factors for each of these products.

Assumptions:

Table 1 below compares the principal assumptions of the NGNP Project model with the H2A model and recommendations for default values for the NGNP Project model where applicable.

[2] In this context base refers to the price in the reference year; in the calculation of project IRR the price is escalated over the project period at the given rate.

Near Term Schedule:

12/28/07	Team reached agreement on the approach and the Team members
01/10/08	Cost and schedule estimates were prepared for completing the task. A draft presentation was prepared for discussing the proposed approach, cost and schedule in the next Working Group meeting in January. A Rev 0 project description document was prepared
1/16/08	Distribute the project description paper to the Working Group members for consideration prior to the January meeting
1/23/08	Present and discuss the proposed approach and reach agreement to go forward with model development during the January Working Group meeting

Development Schedule:

3/15/08	Submittal of the first draft of the model and default input data for Team member review and comment
3/15/08 – 4/1/08	Team review and comment
04/01/08 -- 04/15/08	Reconciliation of reviewer comments
04/15/08	Submittal of model and default input data for Alliance Working Group concurrence
5/01/08	Alliance Working Group Concurrence

Model Development Costs:

The NGNP Project will cover the costs for participation of BEA personnel in developing the model within the NGNP Project Engineering FY08 Budget. The costs for the other members of the Team will be handled under the current arrangements for support of Working Group activities.

References:

1. H2A Central Hydrogen Production Model Users Guide, Version 1.0.10, July 2005 and attachments
2 Next Generation Nuclear Plant, Pre-Conceptual Design Report, November 2007, Rev 1

Table 1 -- H2A & NGNP Project Model Economic Assumptions & Recommended Initial Values

Parameter	H2A Model	Recommended NGNP Project Model	Recommended Initial Value
Analysis Methodology	Discounted Cash Flow (DCF) model that calculates a levelized H2 price that yields a prescribed Internal Rate of Return (IRR) – Specific values are applied for other revenue streams	DCF model that calculates an IRR based on current year prices for facility and operations costs and product (H2, O2, electricity and/or steam) prices adjusted annually by separate escalation / inflation rates for each cost component and revenue stream. Alternatives are provided for (1) calculating a levelized price for a selected product stream for a prescribed IRR or (2) calculating the present value for a given IRR.	DCF model that calculates an IRR based on current year prices for facility and operations costs and product (H2, O2, electricity and/or steam) prices adjusted annually by separate escalation / inflation rates for each cost component and revenue stream. Alternatives are provided for (1) calculating a levelized price for a selected product stream for a prescribed IRR or (2) calculating the present value for a given IRR.
Reference Financial Structure	100% equity with 10% IRR (uninflated) — Include levelized H2 price - Plot for 0 to 25% IRR - Model allows calculation of IRR as a function of initial equity and financing parameters, (e.g., interest rates, period)	The model permits application of a financing structure that includes variable spend and revenue profiles, interest rate during construction, financing period and financing rate.	**Depends on the specific application**
Reference Year Dollars	2005, to be adjusted at half-decade increments (e.g., 2005, 2010)	The cost estimate assumes present year dollars;	**2008**
Technology Development Stage	All Central and Forecourt economic analyses are based on costs estimates for mature, commercial facilities	Applicable for both developmental and mature, commercial facilities	**The spend profile will reflect the technological maturity of the project, (e.g., by specifying the cost and schedule for development required before construction and operation can proceed).**
Inflation Rate and Escalation Rate = (1+IR) * (1 + Real ER) – 1	1.9% (per OMB circa 2003), but with resultant price of H2 in reference year constant dollars	Variable inputs depending on the application. Separate rates can be applied to each cost and revenue component.	**3.3% inflation rate based on CPI data. Reference escalation rates, e.g.: Nat Gas = 5%, Coal = 3.5%, U3O8 = 4%, SWU = 3%, H2 = 4.5%, Power = 4%, Steam = 4%, O2 = 3.3%, CO2 = 4.5%** **IRR or price in constant, reference year dollars.**

Parameter	H2A Model	Recommended NGNP Project Model	Recommended Initial Value
Income Taxes	Income Taxes — 35% Federal; 6% State; 38.9% Effective	Tax rates are variable.	**Income Taxes — 35% Federal; 6% State; 38.9% Effective**
Property Tax and Insurance	2%/year of the total initial capital cost	Variable input rate	**1%/year for each factor for a total of 2%/year of the total initial capital cost**
Working Capital Rate	15% of the annual change in the total operating costs	Not included in the current model – minor effect for Nuclear, but noticeable for Nat Gas and Coal cases	**None**
Facility Life	40 years for Central with case exceptions; 20 years for Forecourt with case exceptions	Variable input	**40 years**
Depreciation and Schedule	MACRS — 20 years for Central with case exceptions; 7 years for Forecourt	Variable	**MACRS – 20 years**
Construction Period and Cash Flow	Varies per case for Central; 0 for Forecourt	This can be varied depending on the project.	**This will depend on the specific application**
Planned Replacement Capital	Post startup capital costs spread over time based on specific replacement estimates. Depreciation is based on MACRS schedule and 7 years or the same as the replacement period if it is shorter than 7 years.	Same	**This will depend on the specific project, item, technology and expected lifetimes.**
Unplanned Replacement Capital	Specified percentage of initial depreciable capital cost meant to handle unplanned replacement capital expenses that occur during an operating year of the plant. Depreciation is based on MACRS schedule and 7 years.	Same	**Specified percentage of initial depreciable capital cost meant to handle unplanned replacement capital expenses that occur during an operating year of the plant. Depreciation is based on MACRS schedule and 7 years.**
Project Contingency	% adjustment to the total initial capital cost such that the result represents the mean or expected cost value. Periodic replacement capital and operating costs include project contingency.	Variable % adjustments on all costs to represent mean or expected values and high confidence values	**10% on all costs to represent expected values** **30% on all costs to represent high confidence, e.g. 90%, values**

Parameter	H2A Model	Recommended NGNP Project Model	Recommended Initial Value
Process Contingency	% adjustment to the total initial capital cost such that the result incorporates the mean or expected overall performance. Periodic replacement capital and operating costs include process contingency.	For the present – included above	**Included above**
Land Cost	5000$/acre purchased for Central; $0.5/sqft/month for long-term lease for Forecourt	Not considered in the current cost model, but can be included when established	**Depends on the specific application**
Capacity Factor	90% for Central, with case exceptions; 70% for Forecourt	Variable input by operating year for each application.	**Depends on the specific application and the specific revenue stream**
Average Burdened Labor Rate for Site Construction Crew	Buried in Capital Cost	Varies per site; Reference commercial application applies Gulf Coast site; Reference NGNP applies INL site	**TBD for both**
Average Burdened Labor Rate for O&M Staff	50$/hour for Central; 15$/hour for Forecourt (2005$)	Variable inputs by FTE depending on the position	**TBD for FTE positions**
G&A Rate	20% of the staff labor costs above	Variable input	**TBD %**
Co-produced and Cogenerated Electricity Price	$30/MWh with sensitivities based on 20$/MWh low and 50$/MWh high (2005$)	Variable input including escalation rate (2008$)	**$60/MWh for purchase of offsite power with appropriate escalation factor Price of produced power may be cost based or apply same purchase price**
CO2 incentive (when CO2 sequestration is not plausible).	not included in Base cases, sensitivity included at 100$/tonne C (27.3$/tonne CO2) for Central and Forecourt	Variable input including real escalation rate	**$30/tonne CO2 with appropriate escalation factor**
O2 Credit	Not included in Base cases, sensitivity included at 20$/tonne for Central and Forecourt.	Variable input including real escalation rate	**$30/tonne with appropriate escalation factor**
H2 Price	Calculated to achieve a required IRR.	Can be input as a base value for calculation of IRR or NPV for a given IRR. Can be calculated to achieve a required IRR similar to the H2A model.	**$2.5/kg default as a base value for calculation of IRR or NPV.**

Parameter	H2A Model	Recommended NGNP Project Model	Recommended Initial Value
Steam Price	Not included	Variable input including real escalation rate	**$8/1000 lbs default for base price**
Salvage Value	10% of initial capital, with case exceptions; 0% for Forecourt	Assumes no salvage, recognized as conservative	**None**
Decommissioning	10% of initial capital, with case exceptions; 0% for Forecourt	Variable	**4-year DD&D period, estimated at 15% of the original inflated capital cost of the nuclear facility. A sinking fund contribution is made each year to provide end of life funding for DD&D. Inflation of the DD&D costs will be considered in developing the annual contribution to the sinking fund and the annual earned interest rate.**
Hydrogen Pressure at Central Gate	300 psig. If higher pressure is inherent to the process, apply pumping power credit for pressure >300psig.	Not considered	**Same as H2A where applicable**
Central Storage	Buffer only as required for efficient operations	Not considered	**Same as H2A where applicable**
Hydrogen Purity	98% minimum; CO < 10ppm, sulfur < 10ppm	Not Considered	**Same as H2A, where applicable**
Sensitivity Variables and Ranges	Based on applying best judgment of 10% and 90% confidence limit extremes to the most significant baseline cost and performance parameters	Not currently in the economic model.	**Monte Carlo analyses will be applied with similar confidence limits to estimate cost probability distributions.**

435.77
12/03/2007
Rev. 03

NEXT GENERATION NUCLEAR PLANT PROJECT INFORMATION INPUT SHEET

1. Document Information

Document ID: Initiative | Revision ID: | Project Number: 23843

Document Title/Description: NGNP Project Economic Model Development Initiative | Sub-Project No.:

Date of Record: 01/14/08

Document Author/Creator: Phillip Mills | **OR**

Document Owner: Phillip Mills | Date Range:

Originating Organization: INL | From: | To:

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Keywords: Legacy Record

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Folder: Engineering

Type: Reports

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