Financial Assumptions Used in the H2A Analysis

This paper explains the financial assumptions used in the H2A analysis. A key assumption is the internal rate of return (IRR). Section 1 explains how the 10% (real) IRR was derived. Other financial assumptions are explained in Section 2.

1. Internal Rate of Return

In cases where the capital cost component is a large fraction of the total cost of producing hydrogen, the assumed internal rate of return (IRR) strongly affects the results calculated by the H2A discounted cash flow spreadsheet. The base case IRR that H2A uses is 10% (real) (12.1% (nominal)). This rate is linked to another H2A assumption -- used for calculation purposes -- of 100% equity financing.[1] The 10% real value was derived primarily from return on equity statistics (adjusted for inflation) for large company stocks over the long term (see Table 1, "Inflation Adjusted Rates).[2] Because returns already account for corporate taxes, this value is an after-tax return. The use of the 10% real IRR is intended to reflect a steady-state situation in the future in which hydrogen is no longer a novel concept and a significant demand for hydrogen exists.

Other sources were also examined. For example, H2A also investigated official Office of Management and Budget (OMB) guidance on discount rates. OMB estimated the **pre-tax** "rate of return to corporate capital" to be 9.1% (real) for the period from 1947 through 2001, and 9.9 percent over the most recent 10-year period – 1992 through 2001.[3] The after-tax value would be considerably lower.

Another source of relevant information is the database that the Energy Information Administration (EIA) compiles for major energy producers.[4] Tables 2 and 3 show after-tax return on investment or ROI (Table 2) and return on equity (ROE) values (Table 3) for both energy producers and S&P industrials for the 1987-2002 period from the series of EIA reports called *Performance Profiles of Major Energy Producers*.[5] These ROI and ROE values can also be used to help H2A set an IRR for the H2A analyses. Observations from these data include:

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[1] Although actual projects would probably be financed with a combination of debt and equity, H2A believes that firms typically assume 100% equity financing for paper studies and analyses. The H2A spreadsheet does include an option for assuming debt financing, in which case the user specifies the debt financing rate. Therefore, the IRR in the spreadsheet is equivalent to a return on equity (ROE).

[2] Based on long-term data back to 1926 compiled in *Stocks, Bonds, Bills and Inflation 2003 Yearbook*, Ibbotson Associates, 2003, the inflation-adjusted return on large company stocks, averaged over the 1926-2002 period, was approximately 9%. This is equivalent to a long-term rate of return on equity for large companies. For the base case calculations, the H2A project has been assuming 100% equity financing and a 10% discount rate that is slightly higher than 9% historical stock market return.

[3] From: "*Computing Average Rates of Return to Private Capital in the United States: 1947-2001*," August 5, 2003, obtained from Robert Anderson, OMB, (202) 395 3381.

[4] Data is reported in *Performance Profiles of Major Energy Producers*, a comprehensive annual financial review and analysis of major US-based energy-producing companies based on data collected in Form EIA-28. These data provide unique information across energy lines of business (e.g., refining versus petroleum product pipelines). The data collection activity responds to requirements of the Financial Reporting System set forth in P.L 95-91, the Department of Energy Organization Act of 1977. EIA supplemented the data collected by EIA in the FRS with data from company annual reports, U.S. Security and Exchange Commission disclosures, and various complementary energy industry data sets, etc. An example of an annual report can be found at:
http://tonto.eia.doe.gov/FTPROOT/financial/020601.pdf
There is a report like this for every year back to 1993. The financial tables are in Appendix B.

[5] Return on equity statistics were only available back to 1991.

- The petroleum industry averaged a ROI of about 7% (nominal) over the last 15 years; yearly values in that period ranged from 3.8 to 13.5. Adjusting for inflation, the average is equivalent to a real rate of between 4% and 5%.
- The ROI for refining operations was lower than the ROI for pipelines and exploration.
- Other energy industries had even lower returns than the petroleum industry.
- Energy producers had somewhat lower returns than the S&P industrials, which averaged around 8.7% nominal in recent years.
- ROE is naturally higher than overall ROI, because the cost of debt is factored into the overall ROI (and debt rates are lower than equity rates, because debt has a more guaranteed, or less risky, return). Nominal ROE values averaged about 11% for energy producers and about 12% for S&P industrials. (The annual values for both energy and other industries ranged between 1% and almost 20%.) Subtracting a rough value of 2.5% for inflation, this translates into real rates of 8.5% - 9.5%. These values are slightly lower than the value of 10% H2A is using for its IRR (given the way the spreadsheet is set up, the IRR is really equivalent to a ROE – see footnote 1 on previous page).

The H2A team engaged a set of Key Industrial Collaborators (KIC) in the process of reviewing key assumptions being used in the discounted cash flow analysis and received input from them during several meetings. Several KIC members have consistently expressed concern that the 10% real IRR assumption is too low and does not appropriately reflect the risk associated with hydrogen projects or the rates of return expected by their management. Some suggested that H2A use discount rates on the order of 15%-25% in the calculations. On the other hand, some other KIC members voiced agreement with the H2A's approach of estimating a long-term cost of hydrogen[6] in the "real world," where the average return would reflect a mixture of projects, some with high rates of return and others with lower rates of return. Some contend that, over the long run, a commodity product (similar to gasoline) would earn a rate of return similar to the rates of return historically obtained by the chemical and petroleum industries, and that a rate of return of 15-25% would not be sustainable over a long time period for a commodity product. However, these same KIC members would likely agree that when making a decision on a **specific project** with a high risk, use of an IRR of 15%-25% would be appropriate.

The H2A team concluded that the IRR used in any analysis should reflect the purpose of the analysis; there is no single "right answer" to the question of what IRR should be used. The final decision was to use a base case IRR of 10% that is in general agreement with OMB guidance, but to also examine a wide range of IRRs and present the results of the calculations graphically, so that users of the information can choose an IRR appropriate for their uses and can easily find the hydrogen cost corresponding to any given IRR. A series of IRR "cases" is therefore estimated for each hydrogen technology. The resulting point estimates are used to develop a smoothed curve representing the cost of hydrogen along the full continuum of IRR values between 0% and 25%. This graph is automatically generated in the H2A Central and Forecourt Spreadsheet Models. (Note: In all cases, the inflation rate is assumed to be 1.9%.)

The case using a 10% real IRR will continue to be the reference value used to estimate the cost of hydrogen that reflects long-term average returns in a national hydrogen economy where hydrogen is a commodity product. Since the H2A effort is providing a working spreadsheet tool, any user can change the after-tax IRR value in the spreadsheet and easily compute the corresponding cost of hydrogen for that assumption. Similarly, sensitivity analyses that examine the sensitivity of various parameters can be run

[6] The H2A spreadsheet calculates a hydrogen cost that includes all operating costs, as well as capital recovery and a real return on the capital investment equal to the IRR.

around any IRR case.

2. Other Financial Parameters

A number of other financial parameters also affect the results of a lifecycle costing exercise such as the one conducted by H2A. Table 4 provides information on the assumptions used for other key parameters, including:

- Depreciation schedule
- Plant Lifetime and Analysis Period
- Inflation Rate
- Tax Rate
- Plant Size and Capacity Factor

Table 1. Inflation Adjusted Total Returns

Year	Treasury Bills Table A-25	Large Company Stocks Table A-20	Long-term Gov't Bonds Table A-23	Long-Term Corporate Bonds Table A-22
1926	0.0483	0.1331	0.094	0.9
1927	0.0531	0.4041	0.1124	0.0973
1928	0.0457	0.4501	0.0108	0.0384
1929	0.0454	-0.0859	0.0322	0.0307
1930	0.0898	-0.2008	0.1138	0.149
1931	0.1171	-0.3737	0.0466	0.0848
1932	0.1255	0.0235	0.3026	0.2354
1933	-0.0021	0.5321	-0.0058	0.0982
1934	-0.0183	-0.034	0.0784	0.1158
1935	-0.0273	0.4339	0.0194	0.0644
1936	-0.0102	0.3232	0.0623	0.0547
1937	-0.0271	-0.3698	-0.0278	-0.0035
1938	0.0284	0.3487	0.0855	0.0916
1939	0.005	0.0007	0.0645	0.0446
1940	-0.0094	-0.1064	0.0508	0.0241
1941	-0.088	-0.1942	-0.0801	-0.0637
1942	-0.0825	0.1011	-0.0555	-0.0612
1943	-0.0273	0.2204	-0.0104	-0.0032
1944	-0.0174	0.1728	0.0069	0.0257
1945	-0.0188	0.3343	0.083	0.0178
1946	-0.1507	-0.222	-0.1546	-0.1391
1947	-0.078	-0.0303	-0.1067	-0.1041
1948	-0.0185	0.0272	0.0067	0.0139
1949	0.0296	0.2097	0.084	0.0521
1950	-0.0434	0.245	-0.0542	-0.0347
1951	-0.0414	0.1714	-0.0926	-0.0809
1952	0.0077	0.1733	0.0027	0.0262
1953	0.0119	-0.016	0.0299	0.0277
1954	0.0137	0.5339	0.0772	0.0591
1955	0.0119	0.3107	-0.0166	0.001
1956	-0.0039	0.0359	-0.0821	-0.0941
1957	0.0011	-0.134	0.0431	0.0552
1958	-0.0022	0.4088	-0.0772	-0.0391
1959	0.0143	0.103	-0.037	-0.0243
1960	0.0117	-0.0099	0.1212	0.0748
1961	0.0144	0.2604	0.003	0.0412
1962	0.0149	-0.0983	0.0559	0.0664
1963	0.0144	0.2081	-0.0043	0.0054
1964	0.0232	0.1511	0.0229	0.0354
1965	0.0197	0.1033	-0.0119	-0.0233
1966	0.0136	-0.1298	0.0029	-0.0306
1967	0.0113	0.2032	-0.1186	-0.0776
1968	0.0046	0.0605	-0.0476	-0.0205
1969	0.0045	-0.1377	-0.1054	-0.1338
1970	0.0098	-0.0141	0.0627	0.1221
1971	0.0099	0.106	0.0955	0.0741
1972	0.0041	0.1505	0.022	0.0372
1973	-0.0172	-0.2156	-0.091	-0.0704
1974	-0.0374	-0.3446	-0.0699	-0.136
1975	-0.0113	0.2821	0.0204	0.0713
1976	0.0026	0.1816	0.114	0.132
1977	-0.0155	-0.1307	-0.0699	-0.0474
1978	-0.0169	-0.0226	-0.0936	-0.0834
1979	-0.0259	0.0453	-0.1283	-0.1543
1980	-0.0103	0.1781	-0.1454	-0.1348
1981	0.053	-0.1271	-0.065	-0.0934
1982	0.0642	0.1688	0.3513	0.3725
1983	0.0482	0.1803	-0.0303	0.0237
1984	0.0567	0.0222	0.1108	0.1242
1985	0.0381	0.2736	0.2621	0.2536
1986	0.0498	0.1715	0.2314	0.1851
1987	0.0101	0.0079	-0.0682	-0.0448
1988	0.0185	0.1187	0.0503	0.0602
1989	0.0356	0.2565	0.1287	0.1107
1990	0.0161	-0.0874	0.0007	0.0064
1991	0.0246	0.2667	0.1575	0.1632
1992	0.0059	0.0464	0.0501	0.0631
1993	0.0014	0.0705	0.1508	0.1016
1994	0.012	-0.0133	-0.1017	-0.0822
1995	0.0298	0.3403	0.2841	0.2406
1996	0.0182	0.1912	-0.0412	-0.0186
1997	0.0349	0.3133	0.1391	0.1106
1998	0.0319	0.2654	0.1127	0.09
1999	0.0195	0.1788	-0.1134	-0.0987
2000	0.0242	-0.1208	0.175	0.0917
2001	0.0224	-0.1323	0.0211	0.0896
2002	-0.0071	-0.2391	0.151	0.1363
Average	**0.0080**	**0.0897**	**0.0285**	**0.0428**

Source: *Stocks, Bonds, Bills, and Inflation 2003 Yearbook,* Ibbotson Associates, 2003

Table 2. After-Tax Return on Investment* (%) for Lines of Business for Major Energy Producers reporting to DOE on Form EIA-28

	1987	1988	1989	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	1987-2002 Average	1991-2002 Average
Petroleum (including foreign)	6.2	7.3	6.7	9.5	7	5.6	6.4	5.6	5.7	10.1	10.8	3.9	7.2	14	12.2	6.5	**7.8**	**7.9**
US Petroleum	4.9	6.3	5.8	7.9	4.9	4.4	4.9	5.2	4	9.9	10.3	3.8	7	13.5	13.1	5.7	**7.0**	**7.2**
Oil and Gas Production	4.1	2.8	2.9	8.5	5.1	5.9	5.3	5.5	4.4	14.1	12.9	0.5	7.6	18.3	13.1	10.5	**7.6**	**8.6**
Refining/Marketing	2.9	14.7	11.5	5.1	2	-0.4	3.4	3.6	1	4.4	6.7	7.9	6.5	9.6	14.5	-2.7	**5.7**	**4.7**
Pipelines	12.8	9.6	10.2	11.2	10.7	8.4	6.4	7.6	9.1	6.9	6.8	4.4	6.4	5.9	9.7	5.2	**8.2**	**7.3**
Coal	5.1	6.7	5	3.3	8.7	-9.3	7.6	4	6.9	9.9	7.2	26.4	9.5	1.7	9	-8.5	**5.8**	**6.1**
Nuclear and Other Energy	0.5	-2.5	-2.3	2.6	2.8	1.8	4.1	4.8	6.1	7.9	7	13.2	7.6	11	9	-6.8	**4.2**	**5.7**
Non-Energy**	12.2	20.3	17.3	7.8	2.9	2.1	4.7	10.5	19.4	15	11.1	4.5	5.8	7.2	-6.6	4.7	**8.7**	**6.8**

Table 3. After-Tax Return on Stockholder's Equity**

Energy (FRS Companies reporting on From EIA-28)				8.8	1.1	9.6	10	12.7	18	17	6.4	11.1	19.6	13.9	7		**11.3**
S&P Industrials (excluding Energy)				8.2	2.5	9.4	16.1	15.7	17.7	17.3	18.1	18.1	15.4	6.3	1.3		**12.2**

* Return on Investment = net income divided by net investment in place * 100
** Return on Stockholder's Equity = net income divided by stockholder's equity * 100
** For comparison, EIA compares energy companies to non-energy companies. The data for non-energy companies comes from Compustat (Standard and Poors), not from EIA-28.

Table 4. Key Financial Assumptions/Parameters for Economic Analysis

Parameter	Explanation	Value
Discount rate/IRR and % of equity debt financing	The discount rate or IRR is a key assumption in net-present-value calculations. For the base case calculations, the H2A project assumes 100% equity financing and a 10% (real) discount rate. Sensitivity runs are made with a range of other rates up to 25% real.	10% (real) based on 100% equity financing. (Sensitivity runs to be conducted using 0% to 25% real)
Depreciation schedule and period	All technologies will use the Modified Accelerated Cost Recovery System (MACRS). MACRS is an IRS convention that allows capital to be depreciated on an accelerated schedule, allowing the owner to take more tax deductions earlier in the depreciation period, thus lowering the net present value of the cost of the plant (compared to when straight-line depreciation is used). If MACRS is chosen, the annual depreciation factors are based on the following: • Modified* 200% double declining balance for 3, 5, 7, and 10 year recovery periods • Modified* 150% double declining balance for 15 and 20 year recovery periods *Changes to straight-line once it yields a higher depreciation amount Because hydrogen production is not yet a bonafide independent industry, the IRS hasn't yet provided a depreciation period specific to hydrogen, so these are assumptions that can be varied.	The depreciation period will be taken from IRS Regulation 946 when available. For hydrogen-specific equipment, the depreciation period will be assumed to be 20 years for central hydrogen production plants, and 7 years for forecourt plants.
Plant life and economic analysis period	The net present value calculations are conducted over an assumed plant life and then the present value is levelized to estimate the cost of hydrogen (the calculation assumes the project achieves the internal rate of return represented by the discount rate discussed above). Plant life will vary from technology to technology. The analysis period represents the number of years of costs you want to include in the lifecycle cost calculations. If comparing two different projects/technologies, it is best to use the same analysis period in the two spreadsheets so that you compare them on a common basis. In the H2A analysis period, the forecourt and central plants use different analysis period, so caution should be used in comparing central versus forecourt values.	40 years for central production 20 years for forecourts
Inflation rate	The H2A discounted cash flow analysis includes the effects of inflation. Operating costs are converted into nominal terms to ensure accurate estimation of tax deductions. Total annual cost streams are then discounted back to real dollars. The spreadsheet also allows the cost of hydrogen to be presented for out-years on a real basis.	1.9% (Bush Administration projection)[7]
Tax rate	The H2A base-case analysis assumes an effective income tax rate of 38.9% –Federal Tax rate 35% –State Tax rate 6% –Since State tax is an expense when calculating Federal tax, effective rate is 35% + 6%(1-35%) = 38.9%	38.9%
Plant Capacity and Capacity Factor	This H2A analysis uses the "natural" plant capacity and capacity factor for the technology. It will vary based on the technology.	Varies

[7] The long-term inflation rate was estimated by subtracting the 30-year real discount rate (3.2%) .from the 30-year nominal discount rate (5.1%) in the Office of Management and Budget Circular No. A-94 Appendix C (Discount Rates for Cost-Effectiveness, Lease Purchase and Related Analyses) found at: http://www.whitehouse.gov/omb/circulars/a094/a94_appx-c.html