OVERVIEW OF MODERN BUSINESS VALUATION TECHNIQUES AND THEIR APPLICATIONS IN THE ANALYSIS OF INVESTMENTS IN ENERGY TECHNOLOGIES

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Summer Power Capacity 1999-2009 (Gigawatts)

	Fossil Fuels				Nuclear	Renewable					
Year	Coal	Petroleum	Natural gas	Total		Hydro	Biomass	Geothermal	Solar	Wind	Total
1999	310.74	58.63	181.14	550.72	97.41	78.26	4.84	2.85	0.39	2.25	88.59
2000	310.20	60.71	204.70	575.92	97.86	78.25	5.01	2.79	0.39	2.38	88.81
2001	309.78	64.74	236.76	611.62	98.16	77.85	4.90	2.22	0.39	3.86	89.22
2002	311.05	58.62	296.55	666.47	98.66	78.30	4.87	2.25	0.40	4.42	90.24
2003	308.55	59.65	339.13	707.58	99.21	77.89	4.85	2.13	0.40	6.00	91.26
2004	308.83	58.01	355.19	722.38	99.63	76.97	4.58	2.15	0.40	6.46	90.56
2005	309.00	57.44	367.54	734.27	99.99	76.85	4.62	2.29	0.41	8.71	92.88
2006	309.21	56.77	371.97	738.40	100.33	77.10	4.77	2.27	0.41	11.33	95.89
2007	309.12	54.84	377.11	741.52	100.27	77.53	5.23	2.21	0.50	16.52	102.00
2008	309.65	56.38	381.82	748.05	100.75	77.57	5.49	2.26	0.53	24.65	110.51
2009	310.56	55.89	389.04	755.70	100.75	77.59	5.71	2.35	0.60	33.54	119.80

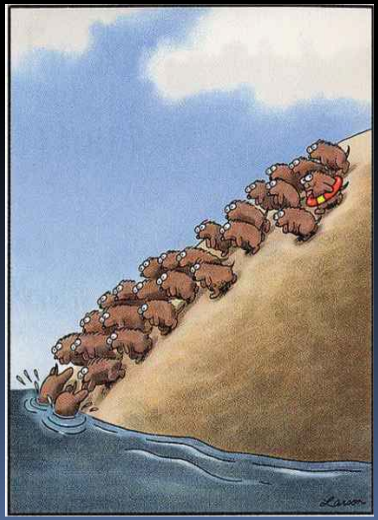
Source: Energy Information Administration

Determining the Power Capacity Mix

- The power capacity mix results from a series of investment decisions by
  - Utilities
  - Households
  - Government
- Investment decisions are driven by monetary and non-monetary objectives
- Business valuation (capital budgeting) techniques guide decisions driven by quantifiable monetary objectives

Informal Tools for Making Capital Budgeting Decisions

- "Gut Feeling"
  - Extensive experience
  - Awareness of framing, confirmation and other biases
- Imitation
  - Past decisions of the organization
  - Current decisions of other organizations



Formal Tools for Making Optimal Capital Budgeting Decisions

- Static Techniques – Do not model future decisions
  - Payback Period
  - Internal Rate of Return (IRR)
  - Net Present Value (NPV)

Formal Tools for Making Optimal Capital Budgeting Decisions

- Dynamic Techniques – incorporate flexibility to make future decisions
  - Decision Tree Analysis
  - Real Option Analysis
  - DTA/ROA hybrids

Payback Period

- How long does it take to get the initial cost back in a nominal sense?
- Computation
  - Estimate project cash flows
  - Subtract future cash flows from the initial cost until the initial investment has been recovered
- Decision Rule – *Accept if the payback period is smaller than some preset cutoff*

Net Present Value (NPV)

- The difference between the present value of the incremental cash inflows and cash outflows of a project
  - Present value calculations require a discount rate (cost of capital, required rate of return)
- Decision Rule: *If the NPV is positive, accept the project*

IRR – Definition and Decision Rule

- Definition: IRR is the return that makes the NPV = 0
- Decision Rule: *Accept the project if the IRR is greater than a pre-specified hurdle rate (required rate of return)*

Dealing with Uncertainty

- Two major ways to incorporate uncertainty in static capital budgeting methods
  - Increase cost of capital/hurdle rate
  - Simulate a variety of scenarios based on distributions for parameters driving cash flows
- Uncertainty can only have adverse effects on the value of the project, because all decisions are made at $t = 0$

Dynamic Project Evaluation Tools

- Recognize that some decisions can be made in future periods after uncertainty is reduced
- Decision Tree Analysis (DTA)
  - Response to project-specific developments
- Real Option Analysis (ROA)
  - Response to market-wide developments

Existing Energy Applications of DTA/ROA Analysis

- Oil and gas exploration
  - Offshore drilling
  - Shale gas extraction
- Investments in renewable energy sources
  - Wind
  - Solar
- Distributed Generation technologies
- Hybrid power plants

Types of Real Options in Energy Projects

- Input Mix
  - A power plant that can use coal or natural gas
- Abandonment/Termination
  - Initial research phase of algae project determines that economics are unattractive and project is abandoned with minimal outlays
- Temporary shutdown
  - Natural gas power plants
  - Oil sands extraction

Types of Real Options in Energy Projects

- Expand/Contract
  - Nuclear power plant can add more reactors or shut down existing ones
  - Add more wind turbines to existing installations
- Deferment
  - Defer building of nuclear power plant until political situation is resolved
  - Delay development of oil field until prices are high enough
- Sequential (compound) options
  - Entry in one market enables entry in another market down the road

NREL Real Option Analysis

Renewable Energy Technologies
& Real Options Analysis

Model Comparison

Aspects of the renewable energy problem	NPV	Real Options
Uncertain fossil and RE electricity generation prices	✓	✓
Option to begin to switchover to RE at any time		✓
Option to start up RE at any time once capacity is built		✓
Uncertain time to complete switchover to RE		✓
Uncertain cost to complete switchover to RE		✓
Option to postpone or abandon switching		✓
Once RE is installed, option to install further RE		✓*
RE costs are lowered by RE R&D	✓	✓
Rate of RE cost reduction uncertain	✓	✓
Option to vary RE R&D over time, reacting to the market		✓*
Can calculate the value of the option to switch to RE		✓
Can find optimal level of RE R&D given option to switch		✓
Can tell us when to begin to switch to RE		✓

*Not included in our real options model.

National Renewable Energy Laboratory

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*www.nrel.gov/**analysis**/seminar/docs/3-8-01grahamdavis.ppt*

An Example of Real Option Analysis of Space-Based Solar Power (SBSP)

- SBSP concept dates back to Glaeser (1968)
- Solar energy is converted into electricity in space by large photovoltaic arrays or combined cycle turbo machinery
- It is then transmitted via microwave to a ground receiver where it is converted into either base-load electric power, low-intensity charging power, or synthetic fuels

Previous SBSP Business Valuation Analyses

- Consensus
  - Large uncertainty about revenues and costs
  - NPV/IRR close to zero or negative
  - Unattractive risk profile – payoffs in distant future while large upfront investments
- Problems with existing studies
  - Large reference systems (1-10 gigawatt power) relying on photovoltaics in geostationary orbit
  - All use static DCF methods – NPV/IRR that do not recognize flexibility

Atanasov and Lenard (2010)

- Start with two niche markets
  - Space radar (base estimates of $100/kWh)
  - Power for forward operating bases (base estimates of $15/kWh)
- Make relatively small investment in R&D over four years
- Depending on prices after four years, enter the Space Radar market
- If everything works fine and prices in six years are favorable, enter the FOB market
- The ability to decide whether to enter the market depending on future market conditions is very valuable (Real Options)
- The Real Option Value of the Project is estimated at $1 Billion (the NPV is negative)

Decision Tree in AL2010

Yes, prob. = 90%

No, prob. = 10%

Yes, prob. = 80%

No, prob. = 20%

Yes, prob. = 20%

No, prob. = 60%

Real Options in AL2010

- Two real options (assume that they are independent of each other)
  - Enter space radar market
  - Enter FOB power market
- Evaluate the two options in each terminal node of the Decision Tree
  - Abort Project (no options)
  - Space Radar Only (only space radar option)
  - Heavy Antenna (both space radar and FOB power option)
  - Light Antenna (both space radar and FOB power option)

Implications from the Analysis

- Real options add significant value to a SBSP venture
- Real options also reduce risk
- Taking real options into account makes the considered SBSP venture attractive for private investors
- DTA/ROA also can evaluate investments in technological flexibility and guide R&D and technological design

Relevance for Participants in This Forum

- Both algae biofuel and offshore wind projects are subject to large technological and market uncertainty
- On one hand, these projects are long-term and naturally offer plenty of real options, which add value
- On the other hand, the recognition of real options should guide project design and development
  - Staging
  - R&D priorities
  - Market entry