REINHOLD ENVIRONMENTAL Ltd.

2014 NOx-Combustion Round Table & Expo Presentations

February 10 & 11, 2014, in Charlotte, NC / Hosted by Duke Energy

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CLEANER AIR THROUGH INNOVATION

Decision Modeling Improves Certainty

Nancy Stephenson
Reinhold NOx Symposium
February 11, 2014

Decision Modeling

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- Finance and Statistics Refresher
- Understanding Risk and Uncertainty
- Using Probability Models for Decision Making
- Developing Risk Curves

Certainty

A decision without risk because all information is known ahead of time

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Time Value of Money

Present Value

$PV = FV / (1+r)^n$

- **PV** is Present Value
- **FV** is Future Value
- **r** is the cost of capital for your corporation
  (not necessarily today's interest rate)
- **n** is the number of years
- Which is better spending $1,000,000 today or $1,500,000 in 5 years
  - (For your budget this year it is probably to wait 5 years, but let's look at the math

Present Value Example

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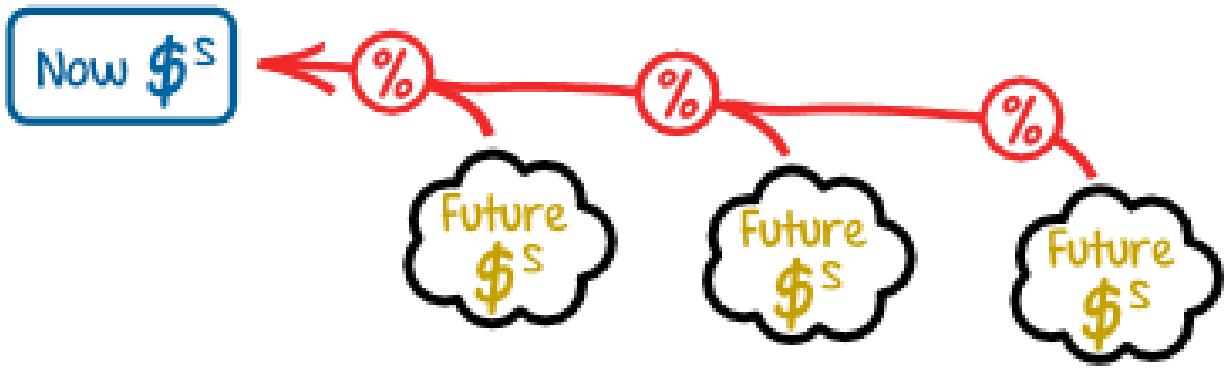
- Present Value today of $1,000,000 today = $1M
- Present Value today of $1,500,000 five years from now is
  - First question is what is your company's cost of capital - this has to do with how much debt and/or equity your company has. Much different number for different companies. For this we will use 6%
- PV = $1,500,000/(1+.06)^5 = $1,120,887

So better to spend the $1M this year

Net Present Value

- Net Present Value (NPV) – The cash value today of an investment decision determined by summing the Present Value, interest adjusted, of future expected expenses and costs resulting from the decision



- However, NPV analysis fails to consider that strategy can be adapted and revised in response to unexpected market and technological developments that cause cash flows to deviate from their original expectations.

Calculating NPV

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	Year 0	Year 1	Year 2	Year 3	Year 4	Year 5	Total
Total Expenses	2,500,000	500,000	500,000	2,500,000	500,000	500,000	7,000,000
Total Present Value	2,500,000	462,963	428,669	1,984,581	367,515	340,292	6,084,020

Use the PV formula to determine the Present Value for each year

OR

Use Excel and the NPV formula. NPV(rate, value1, value2, value3..)

So for this case it equals

NPV(.06, 2500000, 500000, 500000, 2500000, 500000, 500000)

OR

NPV(.06, B2.B7) = $6,084,020

Use Statistics Appropriately

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- **Median** – Half the values are less than this and half are more than this
- **Mode** – Most frequently occurring value
- **Mean** – Average of the values
- **Range** – Difference between highest and lowest
- **Deviations from Mean** – Sum of squares determines the “dispersion” of the data
- **Standard Deviation** -- Square root of the average of the deviations from the mean

Standard Deviation

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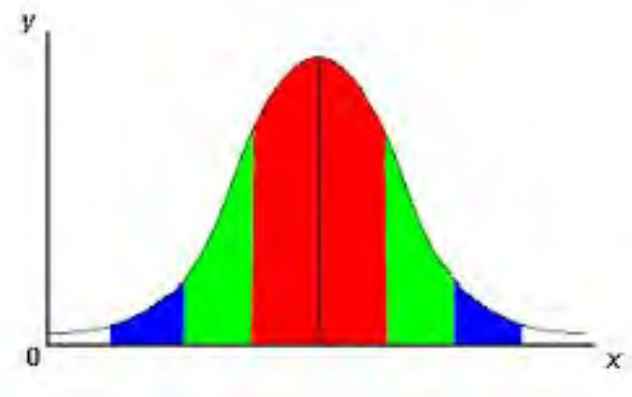
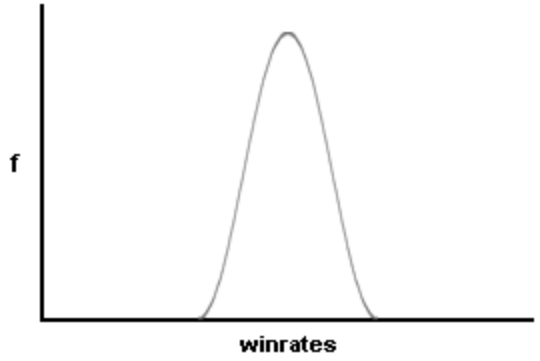
- *68% of data within 1 std dev.*
- *95% of data within 2 std dev*
- *99% of data within 3 std dev*

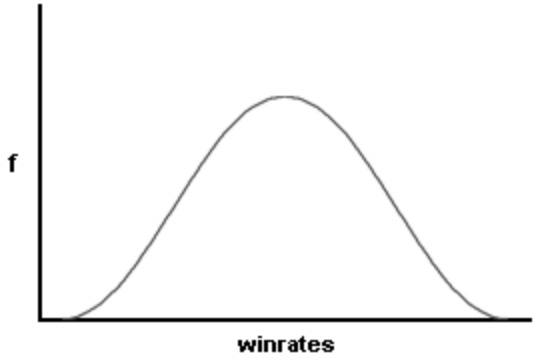


Low Standard Deviation



A "thin" curve means that your winrates remain close to the mean average.

High Standard Deviation



A "fat" curve means that there is a wider spread of your winrates.

Risk: the Degree of Uncertainty

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- **Uncertainty** is a situation where a decision can lead to more than one possible outcome
- **Risk** exists because of the inability of the decision maker to make a perfect forecast

Risk Stratification

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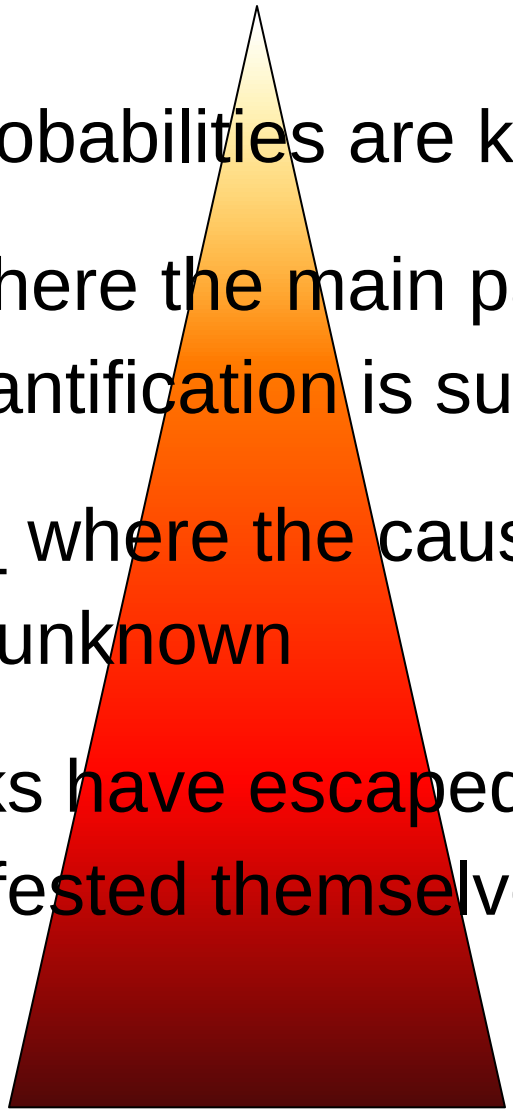

- Risk: where probabilities are known
- Uncertainty: where the main parameters are known, but quantification is suspect
- Indeterminacy: where the cause or risk interactions is unknown
- Ignorance: risks have escaped detection or have not manifested themselves

Define Parameters of Risk and Uncertainty

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- *Economic Conditions*
  - *Electric Demand*
  - *Natural Gas Prices*
  - *Interest Rates*
  - *Inflation*
- *Market Conditions*
  - *Competition*
- *Regulations*
  - *Emissions – NOx, SOx and Mercury*
  - *Renewable Energy*
- *Operating*
  - *Fuels – Costs, Composition*
  - *Ammonia – Cost, Usage*
  - *Pressure Delta*
  - *Forced Outage – Lost Power, Downtime, Maintenance*

Process for Creating a Decision Making Model

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1. Select 2 or more Alternative expense options to evaluate
2. Determine the future estimated expenses over time for each alternative
3. Create one time based spreadsheet for each alternative and determine its NPV
4. Identify the range of possible outcomes associated with the expenses
    1. Expected Expense Spending
    2. Best Case Expense Spending
    3. Worst Case Expense Spending
5. Assign a probability of occurrence for each of the expense above
6. Can perform a sensitivity analysis to determine most significant expense
7. Create a probability weighted cost risk curve for each Alternative
8. Plot the curves and compare
9. Determine acceptable levels of risk exposure
10. Create contingency plans for a major parameters

Create a $ Cost Spreadsheet Individual Expense Parameters

Each Decision Alternative

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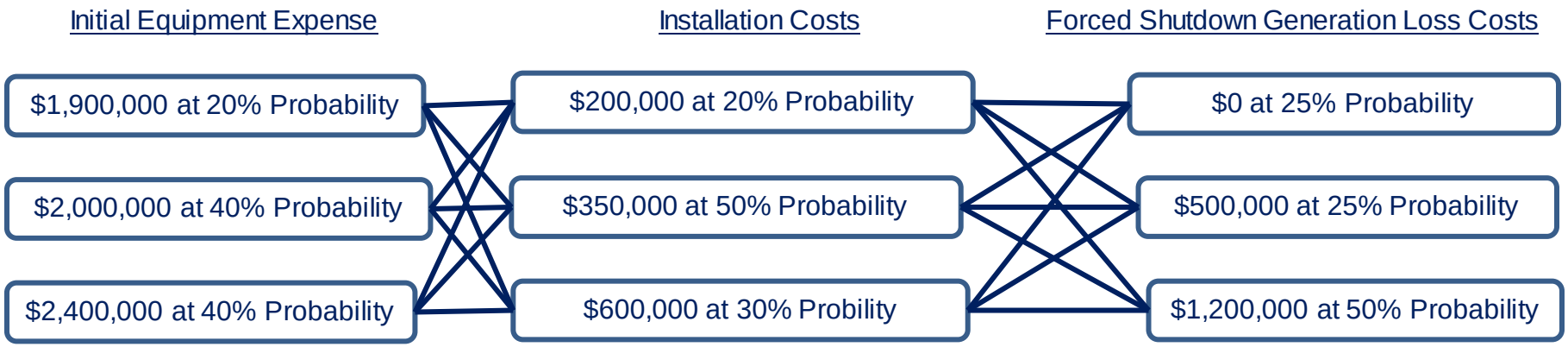
Alt 1: NPV of current Catalyst Management Strategy in $000					
	Year 1	**…**	**Year 4**	**…**	**Year 10**
Equipment Investment	1500		2000		2500
Maintenance Expense Increase	50		50		50
Operating Expense Increase	100		150		200
Inspections	20		20		20
Testing	20		20		20
Installation Costs	250		250		250
Shutdown Cost	500		500		500
Total Cost	2440		2990		3540
Present Value	**2,440**		**2,198**		**1,385**

Simplify or Expand Decision Matrix



- Simple - Using 3 variables, apply range and probability for 27 possible outcomes
- Example, the probability of the Equip Expense at $1,900,000, Install Costs at $350,000 and Generation Loss at $0 occurs probability 20% * 50% * 25% = 2.5%

Run all the 27 scenarios through the spreadsheet model

This yields the **probability distribution** which is **the risk curve**.

Create a “Tornado Chart” to capture what really causes the variance in expense

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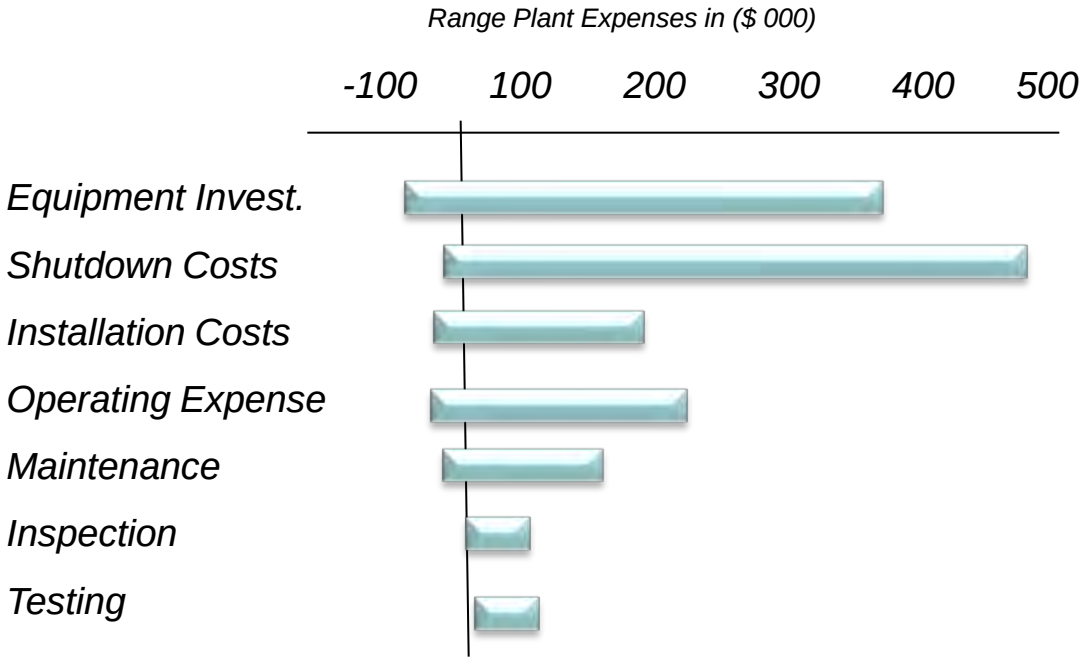
Example: For **Equipment Investment** Determine based on current strategy, what the annual cost will be and then the expected range of costs based on historical data and future forecasts to meet new regulations and operating strategies

Recalculate NPV with these extreme estimates.

Do the same for other variables.



Graph the Risk versus Cost Curve

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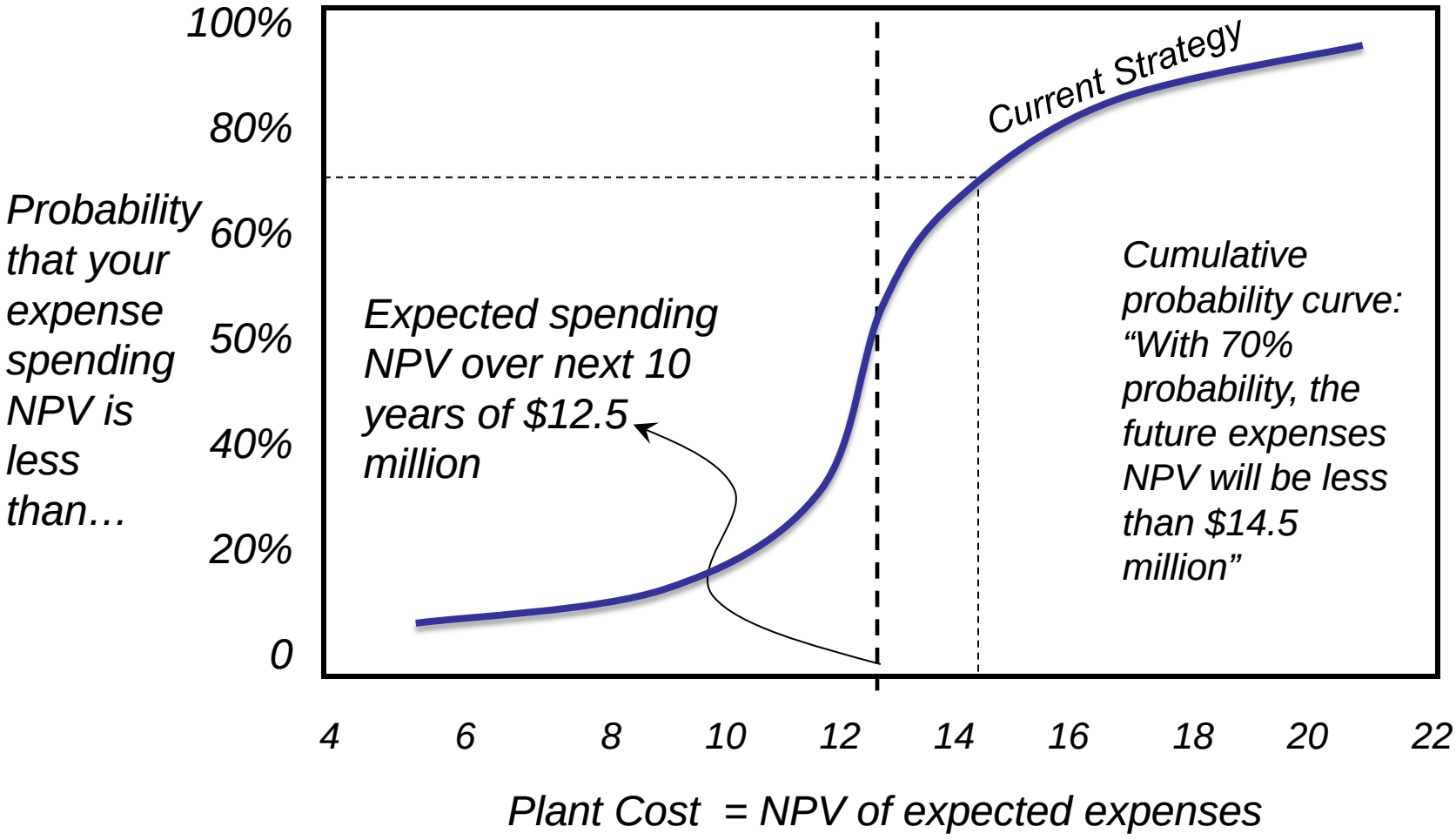

Compare 2 Risk versus Cost Curves

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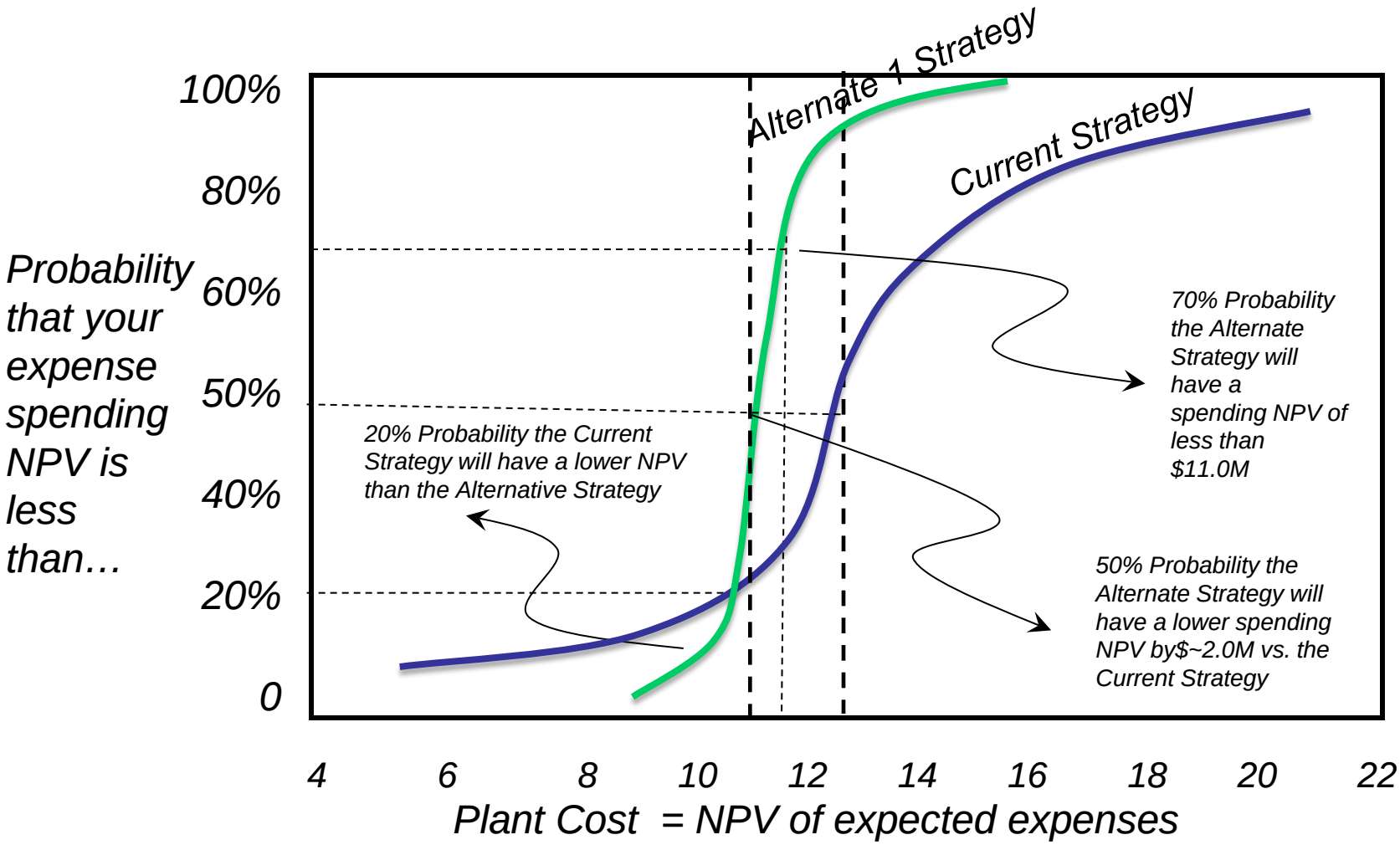
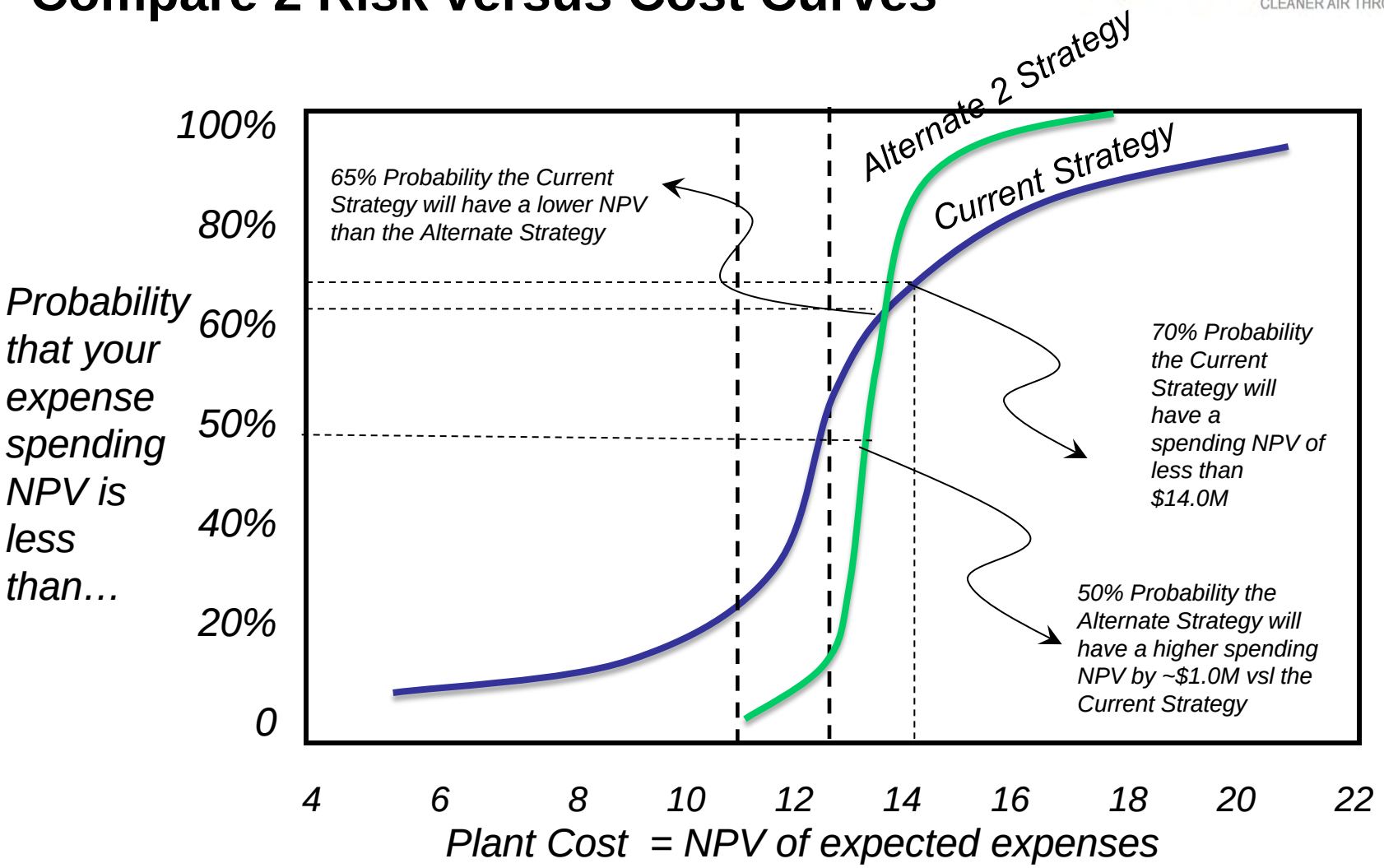


Finally, select the "best" strategy considering the risk versus return profile!

Compare 2 Risk versus Cost Curves



Finally, select the "best" strategy considering the risk versus return profile!

Evaluation Criteria and Costs

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Evaluation Criteria and Costs:	A	B	C
Purchase Cost	$2,000,000	$1,000,000	$5,000,000
Operating Life in Hours	3	2	10
Purchase Cost Contingency - Uncertainty	5%	20%	10%
Installation Cost	$500,000	$500,000	$1,000,000
Annual Inspections and Testing	$10,000	$20,000	$50,000
Annual Operating and Maintenance Expense Increase	$50,000	$50,000	$350,000
Plant Cost of Shutdown	$500,000	$500,000	$500,000
Contingency Costs / Uncertainty in Operating Life	$50,000	$50,000	$150,000
Cost of Capital	6.0%	6.0%	6.0%
Inflation Rate	2.5%	2.5%	2.5%
Risk Adjusted NPV of Alternative Decision	**$11,757,616**	**$12,355,825**	**$12,143,878**

Set up 3 NPV Models

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A

	Year 0	Year 1	Year 2	Year 3	Year 4	Year 5	Year 6	Year 7	Year 8	Year 9	Year 10	Total
Purchase Cost	2,000,000	-	-	2,153,781	-	-	2,319,387	-	-	2,497,726	-	8,970,894
Purchase Cost Contingency - Uncertainty	100,000	-	-	107,689	-	-	115,969	-	-	124,886	-	448,545
Installation Cost	500,000	-	-	538,445	-	-	579,847	-	-	624,431	-	2,242,724
Annual Inspections and Testing	10,000	10,250	10,506	10,769	11,038	11,314	11,597	11,887	12,184	12,489	12,801	124,835
Annual Operating and Maintenance Expense Increase	50,000	51,250	52,531	53,845	55,191	56,570	57,985	59,434	60,920	62,443	64,004	624,173
Plant Cost of Shutdown	500,000	-	-	538,445	-	-	579,847	-	-	624,431	-	2,242,724
Contingency Costs / Uncertainty in Operating Life	50,000	51,250	52,531	53,845	55,191	56,570	57,985	59,434	60,920	62,443	64,004	624,173
Total Expenses	3,210,000	112,750	115,569	3,456,819	121,419	124,455	3,722,616	130,755	134,024	4,008,850	140,809	15,278,067
Total Present Value	3,210,000	106,368	102,856	2,902,412	96,176	93,000	2,624,297	86,960	84,089	2,372,832	78,627	11,757,616
Financial Value Risk Adjusted Value of Action 1	**11,757,616**											

B

	Year 0	Year 1	Year 2	Year 3	Year 4	Year 5	Year 6	Year 7	Year 8	Year 9	Year 10	Total
Purchase Cost	1,000,000	-	1,050,625	-	1,103,813	-	1,159,693	-	1,218,403	-	1,280,085	6,812,619
Purchase Cost Contingency - Uncertainty	200,000	-	210,125	-	220,763	-	231,939	-	243,681	-	256,017	1,362,524
Installation Cost	500,000	-	525,313	-	551,906	-	579,847	-	609,201	-	640,042	3,406,309
Annual Inspections and Testing	20,000	20,500	21,013	21,538	22,076	22,628	23,194	23,774	24,368	24,977	25,602	249,669
Annual Operating and Maintenance Expense Increase	50,000	51,250	52,531	53,845	55,191	56,570	57,985	59,434	60,920	62,443	64,004	624,173
Plant Cost of Shutdown	500,000	-	525,313	-	551,906	-	579,847	-	609,201	-	640,042	3,406,309
Contingency Costs / Uncertainty in Operating Life	50,000	51,250	52,531	53,845	55,191	56,570	57,985	59,434	60,920	62,443	64,004	624,173
Total Expenses	2,320,000	123,000	2,437,450	129,227	2,560,846	135,769	2,690,489	142,642	2,826,695	149,864	2,969,796	16,485,777
Total Present Value	2,320,000	116,038	2,169,322	108,501	2,028,430	101,454	1,896,688	94,865	1,773,503	88,704	1,658,319	12,355,825
Financial Value Risk Adjusted Value of Action 2	**12,355,825**											

C

Alternative 3	Year 0	Year 1	Year 2	Year 3	Year 4	Year 5	Year 6	Year 7	Year 8	Year 9	Year 10	Total
Purchase Cost	5,000,000	-	-	-	-	-	-	-	-	-	-	5,000,000
Purchase Cost Contingency - Uncertainty	500,000	-	-	-	-	-	-	-	-	-	-	500,000
Installation Cost	1,000,000	-	-	-	-	-	-	-	-	-	-	1,000,000
Annual Inspections and Testing	50,000	51,250	52,531	53,845	55,191	56,570	57,985	59,434	60,920	62,443	64,004	624,173
Annual Operating and Maintenance Expense Increase	350,000	358,750	367,719	376,912	386,335	395,993	405,893	416,040	426,441	437,102	448,030	4,369,213
Plant Cost of Shutdown	500,000	-	-	-	-	-	-	-	-	-	-	500,000
Contingency Costs / Uncertainty in Operating Life	150,000	153,750	157,594	161,534	165,572	169,711	173,954	178,303	182,760	187,329	192,013	1,872,520
Total Expenses	7,550,000	563,750	577,844	592,290	607,097	622,275	637,831	653,777	670,122	686,875	704,046	13,865,906
Total Present Value	7,550,000	531,840	514,279	497,298	480,878	465,000	449,646	434,799	420,443	406,560	393,136	12,143,878
Financial Value Risk Adjusted Value of Action 2	**12,143,878**											

Take Away
Catalyst Management

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- Certainty of Decisions can be Improved -- Rational Modeling
- Expenses and Risk Variables can be broken down, reasoned with ranges and probabilities of occurrence
  - New Catalyst Costs
  - Regenerated / Attrition Catalyst Costs
  - Alternate/Supplemental Technologies & Costs
  - Installation Costs & Timing
  - Lost Generation Costs
  - On-going Maintenance or Isolated Costs
  - Regulatory Non-Compliance Costs (NOx, SOx, Mercury)
- Experienced Catalyst Managers Provide
  - Multiple Alternatives with associated Certainty Analysis via Risk Curves
  - Risk Curves to Plant and General Management to Support Decision Process
  - Ways to Deliver Higher Assurance when Range of Outcomes and Complexities Exist