

Risk Analysis on Project

A Case Study by Using @Risk to
Wind Power Generation

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Abstract

A wind power generation project is valued based on Discounted Free Cash Flow (DFCF) methodology. Key risk factors, including revenue associated (eg, the amount of electricity generated by wind and electricity spot prices), capital expenditure associated (eg, the NZ exchange rate linked to the imported wind turbines), and operating expenditure associated (eg, CPI and PPI fluctuation), are identified. Correlation constraints are added to capture the inter-relationships among some of the risk factors. The @Risk Best Fit is used to find the proper distributions for the key input factors. Interval (with certain confidence level) estimation on the output factor (ie, Net Present Value --- NPV) is calculated. Both deterministic and stochastic (via @Risk) sensitivity analyses are compared with each other. Advanced @Risk techniques, including goal seek, stress and sequential analyses are utilized to further investigate the sensitivities of the key input factors. Finally, the scenario results are summarized by using a simple decision tree diagram. Excel Macros, which incorporates many @Risk functions, are widely used to display the results and plot the graphs, so that users can run the model smoothly with little @Risk knowledge. It is also easy to convert this case study into a general business valuation model with minor modification.

Key Words:

Discounted Free Cash Flow
Stochastic versus deterministic sensitivity analyses
Visual Basic Application --- Excel Macros
@Risk V4.5 computer software
Precision Tree V1.0 computer software

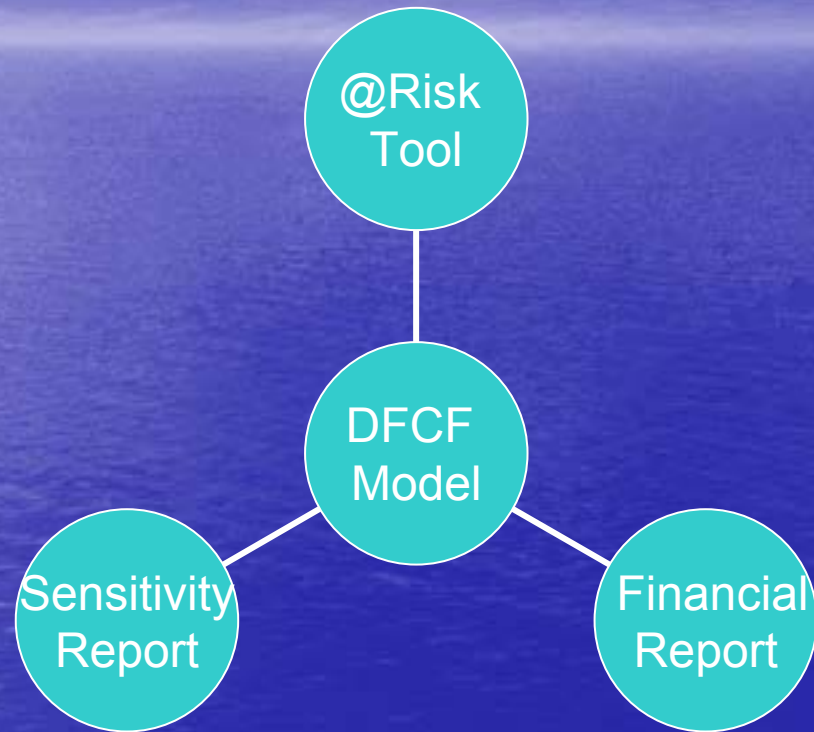
Presentation Contents

- Brief Review of the Wind Farm Project
- Deterministic Discounted Free Cash Flow Model (DFCF)
- Stochastic DFCF Model
- Sensitivity Analysis by Using @Risk
- Suggestions and Conclusions

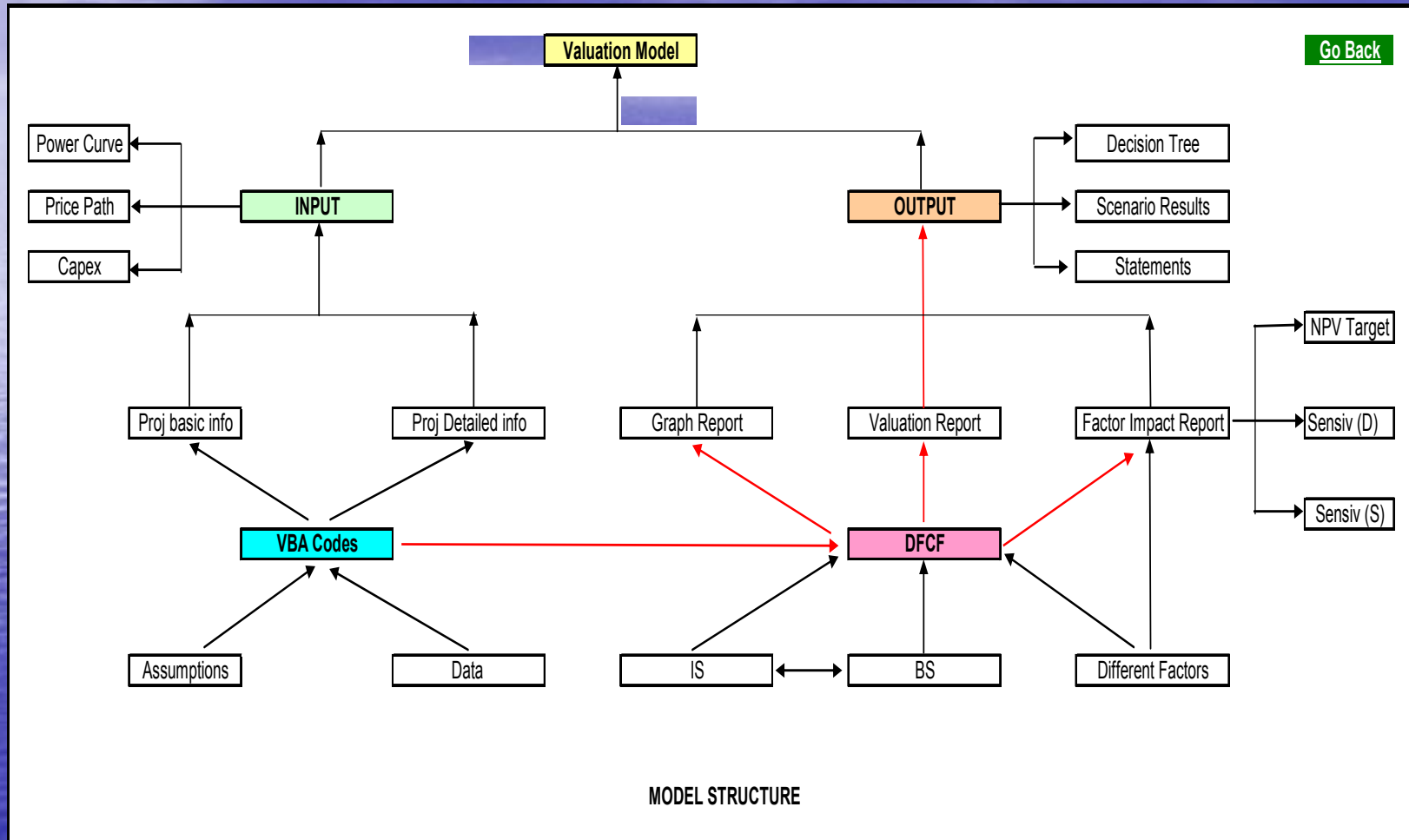
Project Brief Review

- Background
 - Investment Proposal
 - Feasibility Studies
 - Financial Analysis
 - ❑ Worth doing / Meet Required Rate of Return?
 - ❑ Likelihood to Earn / Lose Money
 - ❑ Major Risks and Their Impact
 - ❑ Decision Making
 - Model Description
 - ❑ Methodology --- Income Based DFCF Model + @Risk software
 - ❑ Model Structure

Building Blocks of the Model



Model Structure



Modeling Procedures

- Identification of Key factors
- Information Collection
- Deterministic DFCF Model
- Risk Specification
- Stochastic DFCF Model
- Sensitivity Analysis
- Decision Tree Diagram
- Reports

Deterministic DFCF Model

- Model Components
 - Revenue
 - Direct Revenue
 - Indirect Revenue
 - Cost
 - Capital Expenditure (Capex)
 - Operating Expenditure (Opex)
 - Others
 - Weighted Average Cost of Capital (WACC)
 - Inflation (CPI) and etc.

Valuation Structure

Calculation of FCF	Year Index	-1	0	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20
Category	Unit/Year	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020	2021	2022	2023	2024	2025	2026	2027	2028
Total Revenue	\$K	-	-	4,388	4,563	4,769	4,935	5,335	5,320	5,319	5,721	5,730	5,926	6,129	6,339	6,557	6,784	7,018	7,262	7,514	7,776	8,048	8,330
Energy Generation	\$K	-	-	3,747	3,907	4,099	4,250	4,635	4,604	4,588	4,974	4,966	5,145	5,331	5,524	5,724	5,932	6,148	6,373	6,605	6,847	7,098	7,359
Avoided Transmission Charges	\$K	-	-	230	235	240	245	251	256	262	268	274	280	286	292	299	305	312	319	326	333	340	348
Emission Reduction Value	\$K	-	-	412	421	430	439	449	459	469	479	490	501	512	523	535	546	558	571	583	596	609	622
Less cost of Sales																							
Direct Cost	\$K	-	-	1,097	1,141	1,192	1,234	1,334	1,330	1,330	1,430	1,432	1,481	1,532	1,585	1,639	1,696	1,755	1,815	1,879	1,944	2,012	2,082
Grid connection charges	\$K	-	-	66	68	69	71	72	74	76	77	79	81	83	84	86	88	90	92	94	96	98	100
Grid services charge	\$K	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Plant warranty costs	\$K	-	-	153	157	160	164	167	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Total Cost of sales	\$K	-	-	1,317	1,365	1,422	1,468	1,573	1,404	1,405	1,508	1,511	1,562	1,615	1,669	1,726	1,784	1,845	1,908	1,973	2,040	2,110	2,183
Gross Profit (\$K)	\$K	-	-	3,071	3,198	3,347	3,467	3,762	3,916	3,914	4,213	4,218	4,363	4,514	4,670	4,832	5,000	5,174	5,354	5,542	5,736	5,938	6,147
Gross Profit Ratio (%)	\$K			70%	70%	70%	70%	71%	74%	74%	74%	74%	74%	74%	74%	74%	74%	74%	74%	74%	74%	74%	74%
Less Operating Expenses	\$K																						
Mgt & Admin Costs incl insurance	\$K	-	-	132	136	139	143	146	150	154	157	161	165	169	174	178	182	187	192	197	201	206	212
Recurrent operating costs	\$K	-	-	265	271	278	285	292	240	246	252	258	265	271	278	285	292	299	307	314	322	330	339
Annualised non recurrent costs	\$K	-	-	132	136	139	143	146	150	154	157	161	165	169	174	178	182	187	192	197	201	206	212
Depreciation	\$K	-	146	585	587	588	589	615	616	617	618	807	808	809	811	812	813	815	816	817	819	820	822
Total Operating Expenses (\$K)	\$K	-	146	1,115	1,129	1,144	1,159	1,199	1,155	1,170	1,185	1,387	1,403	1,419	1,436	1,453	1,470	1,488	1,506	1,525	1,544	1,564	1,584
EBITDA	\$K	-	-	2,542	2,655	2,791	2,897	3,177	3,376	3,361	3,647	3,638	3,768	3,904	4,045	4,191	4,343	4,500	4,664	4,834	5,011	5,194	5,385
EBIT	\$K	-	(146)	1,956	2,069	2,203	2,308	2,562	2,761	2,744	3,029	2,831	2,960	3,095	3,234	3,379	3,530	3,686	3,848	4,017	4,192	4,374	4,563
Less Interest Need to Pay	\$K		396	1,653	1,485	1,316	1,144	1,111	925	734	549	1,114	902	690	475	260	42	-	-	-	-	-	-
EBT	\$K	-	(542)	303	583	888	1,164	1,452	1,835	2,009	2,480	1,717	2,058	2,405	2,759	3,119	3,487	3,686	3,848	4,017	4,192	4,374	4,563
Less Taxation																							
Taxation	\$K	-	(179)	100	193	293	384	479	606	663	818	567	679	794	910	1,029	1,151	1,216	1,270	1,326	1,383	1,443	1,506
NPAT	\$K	-	(363)	203	391	595	780	973	1,230	1,346	1,662	1,150	1,379	1,611	1,848	2,090	2,337	2,470	2,578	2,691	2,809	2,931	3,057
Free Cash Flow Calculation																							
Add back																							
Depreciation	\$K	-	146	585	587	588	589	615	616	617	618	807	808	809	811	812	813	815	816	817	819	820	822
Interest Paid As A Shield			396	1,653	1,485	1,316	1,144	1,111	925	734	549	1,114	902	690	475	260	42	-	-	-	-	-	-
Less																							
Movement in Working Capital	\$K																						
Capital Expenditure	\$K	5,855	17,386				1,000				7,500												
Capitalised Maintenance Cost	\$K	-	-	20	21	21	22	22	23	23	24	24	25	25	26	27	27	28	28	29	30	30	31
Free Cash Flow (FCF) Without TV	\$K	(5,855)	(17,386)	2,421	2,442	2,477	1,491	2,676	2,748	2,674	(4,695)	3,047	3,064	3,085	3,108	3,135	3,165	3,256	3,366	3,480	3,598	3,721	3,848
Free Cash Flow (FCF) With TV	\$K	(5,855)	(17,386)	2,421	2,442	2,477	1,491	2,676	2,748	2,674	(4,695)	3,047	3,064	3,085	3,108	3,135	3,165	3,256	3,366	3,480	3,598	3,721	21,546

Results of Deterministic Model

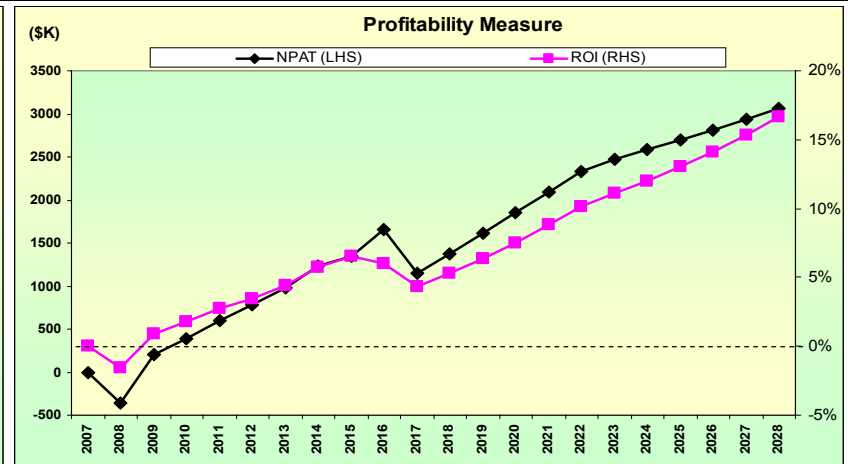
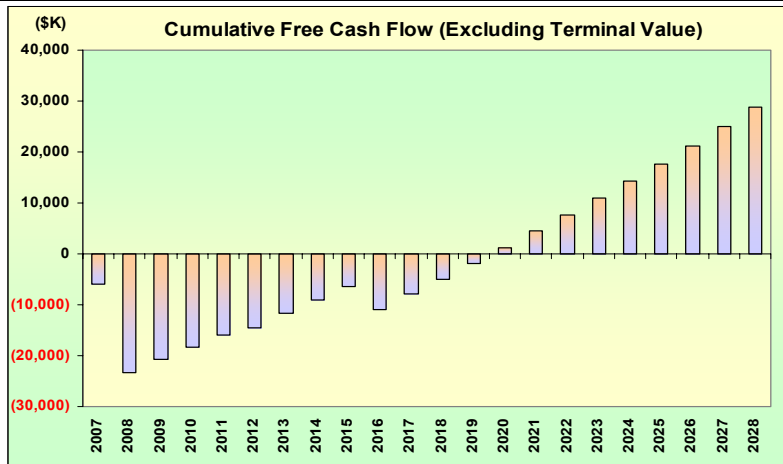
INPUT TABLE			OUTPUT TABLE						
			OUTPUT			SCENARIO			
Start Year of Project	2007		NO	Key Measurement	Unit	Selected	Median	Best	Worst
Start Year of Generation	2009		1	NPV	\$K	3,083	1,148	8,991	(6,990)
Project Life	20		2	PV	\$K	25,036	28,471	36,314	20,333
Generation Profile	Average	▼	3	IRR	%	9.4%	8.4%	11.2%	5.3%
PRE Revenue Included?	YES	▼	4	Pay Back Years	Years	12.6	13.2	11.0	17.1
Please Choose One of the Following Options			5	Average ROI	%	7.0%	6.0%	9.8%	1.1%
<input checked="" type="checkbox"/> Using Weighted Average Price at Otahuhu <input checked="" type="checkbox"/> Using Weighted Average Price at Hayward <input type="checkbox"/> Not Using Weighted Average Price			6	Average NPAT/Revenue	%	25.9%	22.9%	30.5%	5.3%
Carbon Tax On?	NO	▼	7	Initial Investment	\$K	23,420	29,150	29,150	29,150
Electricity Price Profile	Otahuhu Avg	▼	8	Total Investment	\$K	32,427	38,157	38,157	38,157
Terminal Value	Asset Based	▼	9	Fixed Assets at the End	\$K	17,698	20,527	20,527	20,527
Interest Tax Shield On?	YES	▼	10	Equity at the End	\$K	18,144	21,015	21,182	20,777
Capex	Case A - Base	▼	11	Terminal Value	\$K	17,698	20,527	20,527	20,527
Investment Type	Investment 1	▼	12	Total Dividend Paid	\$K	9,010	9,570	13,515	5,078
			13	Total Cash at the End	\$K	23,971	22,410	41,880	(1,752)
			14	Total Interest Paid	\$K	12,795	16,902	12,851	24,037
			15	NPV (for EVA)	\$K	(1,749)	(6,306)	7,006	(22,322)
			16	PV (for EVA)	\$K	4,106	982	14,294	(15,034)
			Decision making Under Current Scenario →			GREEN LIGHT ON --- The Project Is Worth Doing			

Instruction

	= INPUT data
	= Pre-set value
	= Make a selection

Steps to Run the Model

- 1) Input/select parameter values in this sheet;
- 2) Fill in or change assumptions in the "Assumption" sheet;
- 3) Go to the "Decision" sheet, make selections and then press the button to start the SCENARIO analysis;
- 4) Go to the sheets associated to perform the following analyses, including:
 - NPV Target --- Individual
 - NPV Target --- Group
 - Sensitivity Analysis (Deterministic)
 - Sensitivity Analysis (Stochastic)
- 5) Current case result is shown in the "Main" sheet, while the overall expected result is shown in the "Decision" sheet.



Financial Report (eg, Income Statement)

View Statement		Statement of Financial Position											Results Shown Only 10 Years	
Statement of Financial Position (12 Years)														
Category	Unit\Year	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018	
Sales Revenue	\$K	-	-	4,388	4,563	4,769	4,935	5,335	5,320	5,319	5,721	5,730	5,926	
Opex Before Interest & Tax	\$K	-	(146)	(2,432)	(2,495)	(2,566)	(2,627)	(2,773)	(2,559)	(2,575)	(2,692)	(2,899)	(2,965)	
Interest Expenses	\$K	-	(396)	(1,653)	(1,485)	(1,316)	(1,144)	(1,111)	(925)	(734)	(549)	(1,114)	(902)	
EBIT	\$K	-	(146)	1,956	2,069	2,203	2,308	2,562	2,761	2,744	3,029	2,831	2,960	
Taxation	\$K	-	179	(100)	(193)	(293)	(384)	(479)	(606)	(663)	(818)	(567)	(679)	
NPAT	\$K	-	(363)	203	391	595	780	973	1,230	1,346	1,662	1,150	1,379	

Further (Deterministic) Analyses

- 16 Financial Indicators
- NPV Target Analyses

Purpose --- Set output, how much should input factor change to meet the target

- Excel built in Goal Seek Function
- Excel built in Solver Function

- Deterministic Sensitivity Analyses

Purpose --- Given factor changing certain amount (eg, 10%), by how much will output change

- Advantage --- clear economic meaning
- Disadvantages --- static comparison, and not unit measure free

NPV Target Analyses

INPUT TABLE			
1	Traget	New NPV (\$K)	5,000
2		Maximise Target	NPAT
OUTPUT TABLE --- Individual			
NPV Report			
1	\$K	Original	3,083
2	\$K	New	5,000
3	\$K	Difference	1,917
No	Category	Factor Name	Grow/Drop to
1	Revenue Factors (Multiplier)	Energy Generated	110.9%
2		Revenue Multiplier	109.2%
3		Terminal Value	154.5%
4		Electricity Spot Price	109.2%
5		Transmission Avoided	268.7%
6		PRE Value	194.2%
7	Cost Factors (Multiplier)	Grid Connection Charges	-337.8%
8		Plant Warrant Charges	-469.6%
9		Capex 1st Two Years	86.6%
10		Capex 4th & 8th Years	21.4%
11		Exchange Rate	117.2%
12		Mgt & Insurance Costs	-114.6%
13		Recurrent Opex	-24.0%
14		Non Recurrent Opex	-114.6%
15	Other Factors (Additive)	Direct Cost Ratio	-5.96%
16		PPI Growth	5.88%
17		CPI Growth	-11.43%
18		WACC	-0.71%
19		Depreciation	-4.87%

OUTPUT TABLE --- GROUP				
Target Set = Maximum NPAT				
33,767	33,767	33,767	33,767	33,767
40,456	39,418	33,975	36,665	34,744
6,690	5,651	208	2,898	977
Output	Price	COG	Capex	Opex
110.0%				
102.2%				
90.0%				
	110.0%			
	90.0%			
	96.9%			
		90.0%		
		90.0%		
			96.2%	
			90.0%	
			110.0%	
				90.0%
				90.0%
				90.0%

Instruction

= INPUT Data

= Make a Selection

Two constraints are made:

- 1) Factor growth is set to between 90% and 110%;
- 2) NPV = New settings.

Explanation

This sheet tries to answer 2 major questions.

1) Individual Factor Impact
 Given NPV being set to a new value (in cell AD101), what the factor ratio will it be (compared to the original one) for each individual case?
 Note for those factors measured by %, the result is percentage point growth rather than the ratio (eg., if original WACC = 9%, the WACC = -0.5% means that WACC should decrease by 0.5 percentage point, so the new WACC = 9%-0.5%=8.5%).

2) Group Factor Impact
 The factors are classified into 5 groups:
 Output, Price, Direct Cost, Capex and Opex.
 Given the new NPV and the other groups unchanged, what the growth combination should be for the tested group to minimise the pay back years or to maximise the total (cumulative) NPAT?

Deterministic Sensitivity Analysis

Description

Deterministic Sensitivity means it compares the results under 2 status, ignoring the possibility of these 2 status occurring. It tries to answer the following question:
With certain percent (say, 1%) changes of a factor, what are the changes of the NPV and the other indices such as IRR and PBY?

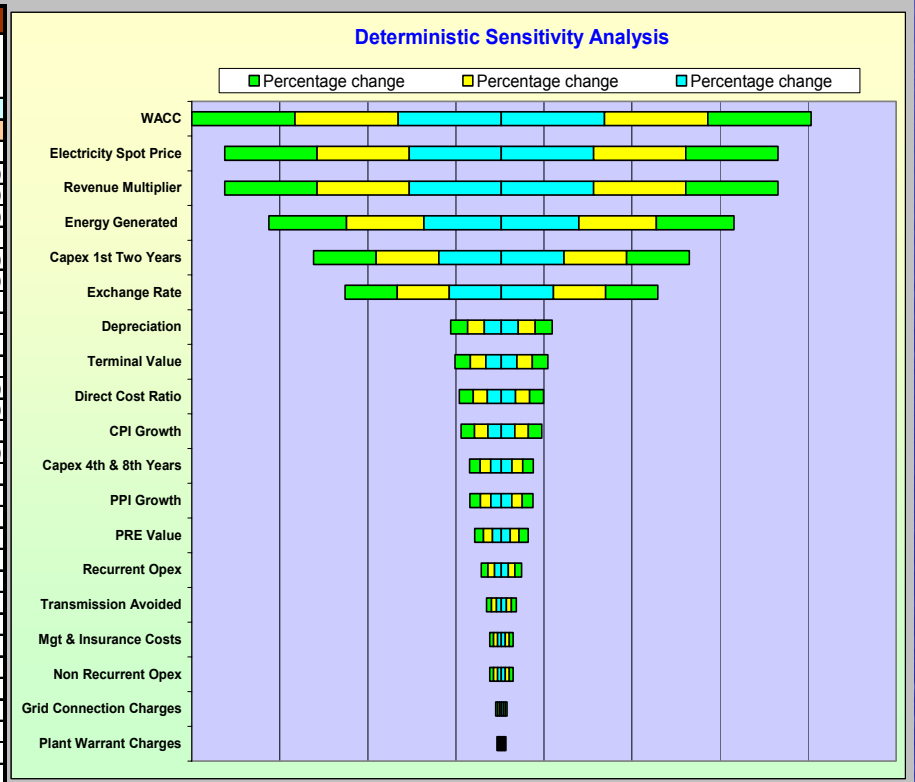
Although it doesn't consider the likelihood of the percentage changes, the changes in NPV have clear economic meaning. Therefore, the results shown in the range (S18:S45) in absolute values are used directly to construct the Tornado chart. This may differ from the results tested by the Stochastic Sensitivity Analysis since the results shown there are indices instead of actual measures on changes in NPV.

[Print Results](#)

Any Enquiry?

Call William Zhu at 8410

Deterministic Sensitivity Analysis (Static Comparison of NPV)							
Instruction		Original Measures (\$K)			Difference		
Input growth rate below (Cell O16) then press the "SA(D)" button		NPV	IRR	PBY			
Growth Rate 10%		3,083	9.4%	12.6			
No	Factor	NPV	IRR	PBY	Δ NPV	Δ IRR	Δ PBY
1	WACC	739	9.4%	12.6	(2,344)	0.0%	-
2	Electricity Spot Price	5,178	10.2%	11.9	2,094	0.9%	(0.7)
3	Revenue Multiplier	5,178	10.2%	11.9	2,094	0.9%	(0.7)
4	Energy Generated	4,844	10.1%	12.0	1,760	0.8%	(0.6)
5	Capex 1st Two Years	1,660	8.7%	13.1	(1,423)	-0.7%	0.5
6	Exchange Rate	4,267	10.0%	12.0	1,184	0.6%	(0.6)
7	Depreciation	2,698	9.2%	12.3	(385)	-0.1%	(0.3)
8	Terminal Value	3,435	9.5%	12.6	352	0.1%	-
9	Direct Cost Ratio	2,764	9.2%	12.7	(319)	-0.1%	0.1
10	CPI Growth	2,777	9.2%	12.7	(306)	-0.1%	0.1
11	Capex 4th & 8th Years	2,842	9.2%	12.8	(242)	-0.1%	0.2
12	PPI Growth	3,321	9.4%	12.5	238	0.1%	(0.1)
13	PRE Value	3,285	9.4%	12.5	202	0.1%	(0.1)
14	Recurrent Opex	2,930	9.3%	12.6	(154)	-0.1%	0.1
15	Transmission Avoided	3,196	9.4%	12.5	113	0.0%	(0.0)
16	Mgt & Insurance Costs	2,994	9.3%	12.6	(89)	0.0%	0.0
17	Non Recurrent Opex	2,994	9.3%	12.6	(89)	0.0%	0.0
18	Grid Connection Charges	3,040	9.3%	12.6	(43)	0.0%	0.0
19	Plant Warrant Charges	3,050	9.3%	12.6	(33)	0.0%	0.0



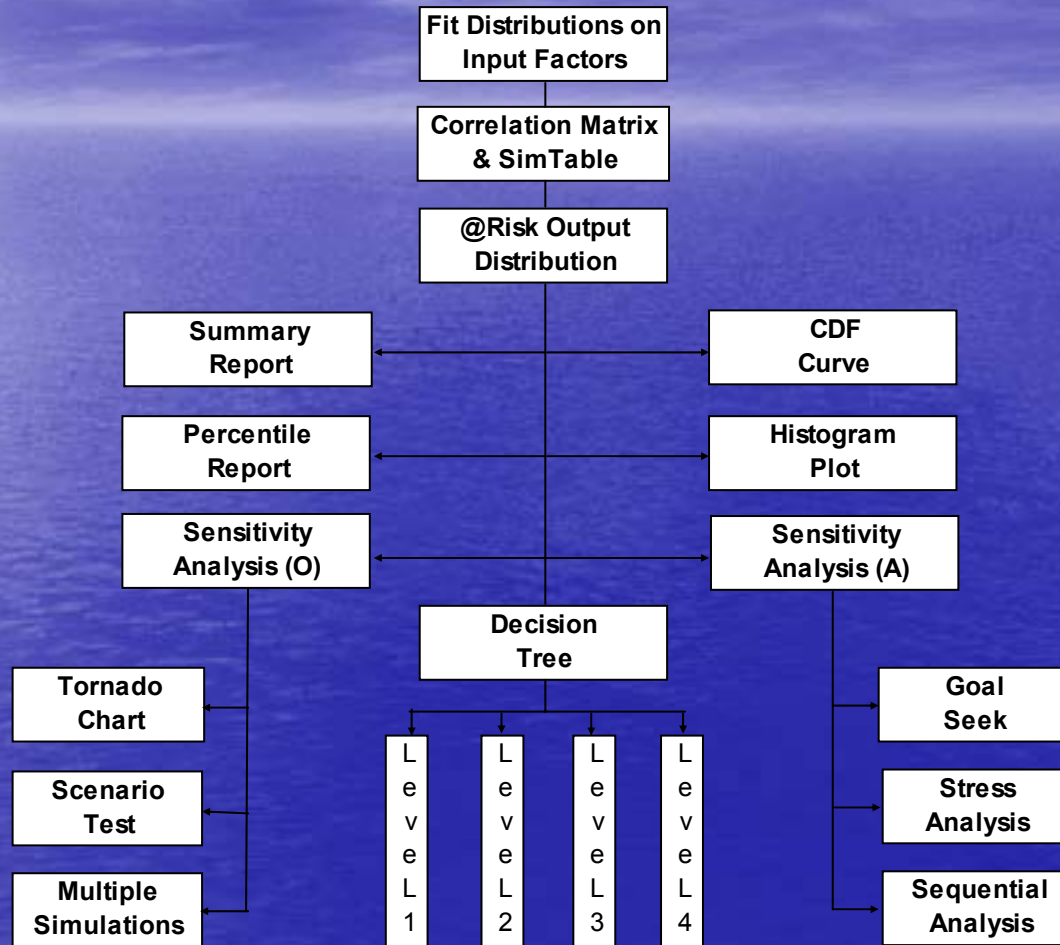
Major Risk Factors

- Revenue Related
 - ❖ Electricity Generation --- Energy Related
 - ❖ Electricity Spot Prices --- Sales Price Related
 - ❖ Government Regulation --- Policy Related
- Cost Related
 - ❖ Capex Associated --- Exchange Rates, Budget
 - ❖ Opex Associated --- Inflation, Interest Rates, etc.

Key Features of Using @Risk

- Best Fit techniques to find proper distributions for core input factors
- Correlation relationships among input factors
- Stochastic vs. Deterministic sensitivity analysis
- Advanced @Risk techniques
- A Decision Tree Diagram

Flow Chart of Using @Risk



Fit Distributions

- Wind Speed
- Electricity Spot Prices
- NZ/US Exchange Rates

❖ Wind Speed Distribution

- ❑ Empirical Studies --- Weibull (eg, Sathyajith Mathew and K. P. Pandey 2000)
- ❑ Direct Regression Model --- Weibull
- ❑ @Risk Fit Distribution Results --- Weibull
 - Excel Macros via @Risk are used to perform automatically
 - Top rank using χ^2 statistics indicates Weibull(A, B)
- ❑ The fitted Weibull, together with power curve, determines annual energy generation

❖ NZ Electricity Spot Prices

- ❑ Empirical Studies --- Log-logistic (eg, MICHAEL A. S. GUTH 2004)
- ❑ @Risk Fit Distribution Results --- Log-logistic

❖ NZ/US Exchange Rates

- ❑ Empirical Studies --- Beta General (eg, Kai-Li Wang and Christopher Fawson 2001)
- ❑ @Risk Fit Distribution Results --- Beta General

- Demonstration @Risk results by using macros.

Results of @Risk Fit Distribution

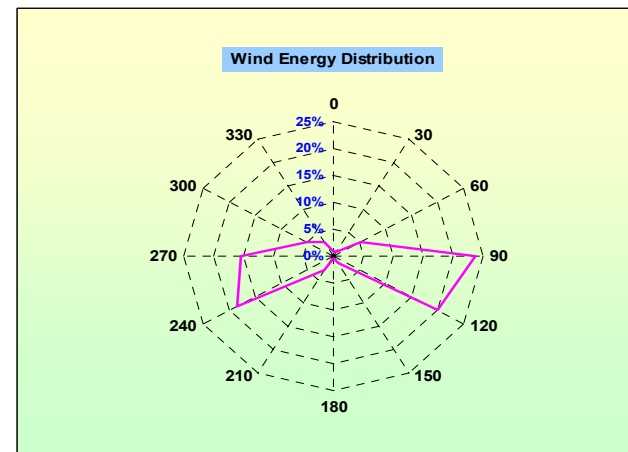
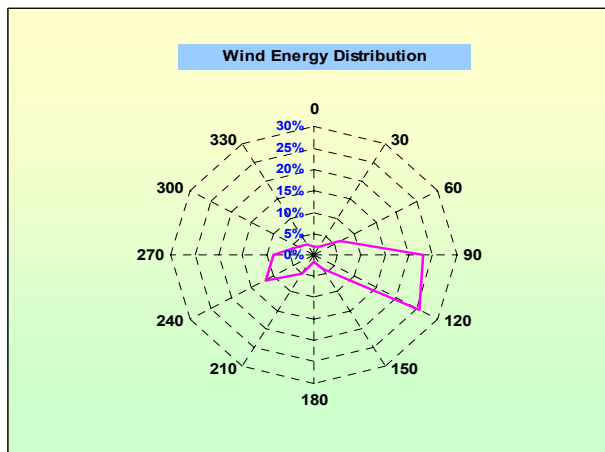
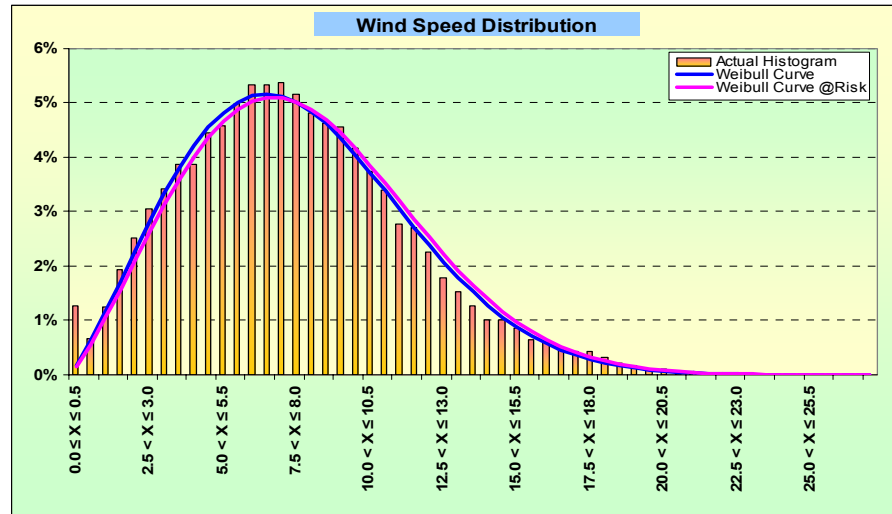
Distribution of Wind Speed (Rank by Chi Sq)	ChiSq	A-D	K-S	Start Fit Process (Tick Box Below ↓) <input type="checkbox"/> Find Best Fit
Weibull(2.2371, 9.0801) Shift=-0.28030	3,536	14.56	0.0139	
BetaGeneral(3.8331, 12.075, -1.0505, 35.523)	3,834	14.48	0.0153	
Gamma(8.3584, 1.3239) Shift=-3.3027	3,928	19.57	0.0153	
InvGauss(16.574, 311.470) Shift=-8.8112	3,988	20.39	0.0153	
Pearson5(36.670, 802.91) Shift=-14.745	4,070	21.44	0.0165	
Lognorm(16.686, 3.8243) Shift=-8.9221	4,317	20.92	0.0157	
Distribution of Elec Spot Price (Rank by Chi Sq)	ChiSq	A-D	K-S	Start Fit Process (Tick Box Below ↓) <input type="checkbox"/> Find Best Fit
LogLogistic(-9.1411, 56.691, 3.8650)	234	8.64	0.0349	
Pearson5(7.9535, 567.33) Shift=-26.642	371	24.81	0.0514	
ExtValue(41.090, 22.989)	434	30.95	0.0716	
Lognorm(66.498, 32.817) Shift=-11.516	440	31.18	0.0594	
InvGauss(69.937, 313.820) Shift=-14.481	481	38.74	0.0697	
Gamma(3.0791, 18.481) Shift=-1.4503	589	52.51	0.0823	
Distribution of Daily Exchg Rate (Rank by Chi Sq)	ChiSq	A-D	K-S	Start Fit Process (Tick Box Below ↓) <input type="checkbox"/> Find Best Fit
BetaGeneral(2.0136, 1.7190, 0.38657, 0.74440)	748	23.75	0.0547	
Triang(0.36853, 0.64280, 0.74551)	752	23.14	0.0622	
Weibull(5.8117, 0.43296) Shift=+0.18190	1,047	19.37	0.0417	
Normal(0.582191, 0.081363)	1,082	26.30	0.0464	
Logistic(0.585034, 0.047586)	1,479	27.19	0.0480	
Uniform(0.39208, 0.74427)	1,600	188.88	0.1602	

Comparable Results of Weibull Distrib

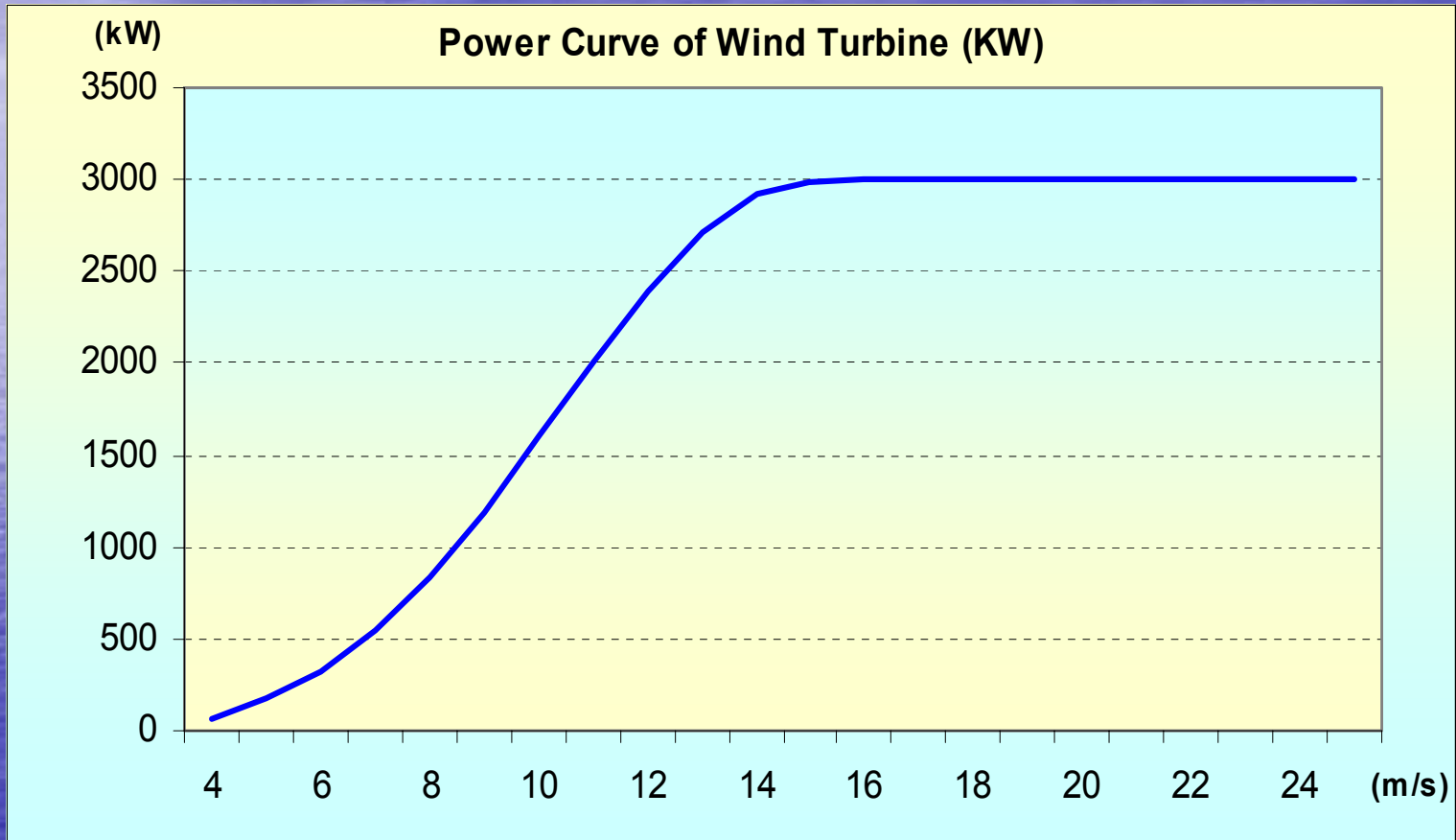
Linear Regression
(Find Directly the Parameters of Weibull Distribution)

INPUT TABLE	
Speed Interval Size	0.5
Direction Interval Size	30
Add @Risk WB Curve	<input checked="" type="checkbox"/>

OUTPUT TABLE	
Regression Results	Value
Slope	2.20
Intercept	-4.80
R ²	1.00
F-value	64094
σ _{Slope}	0.01
t-value of Slope	253.2
Sample Size	55
Weibull Parameters	
Shape parameter (α)	2.20
Scale parameter (β)	8.86
Mean of Weibull	7.84
Stdev of Weibull	3.77



Power Curve of Wind Turbine



Define @Risk Input Factors

- Distributions for Other Factors
- Growth trend is added for some factors
- @Risk distribution functions are built directly into Excel (as @Risk input factors)
- Lists of Input Factors

@Risk Input Table

Factor Distribution (@Risk Input Variables 1 --- Differ in Years)								Factor Distribution (@Risk Input Variables 2)			Parameters used for factor distribution 1			
NO	Year	Energy	SpotPrice	RevMultiple	PPI	CPI	ExRate	Capex	NO	Factor	Factor	Distribution	Parameter	Value
0	2007							5855	1	Energy		Normal	μ	51.64
1	2008						0.68	17565	2	SpotPrice			σ	15.29
2	2009	52	67.9	1.07	2.2%	2.5%			3	RevMultiple			α	4.09
3	2010	52	70.8	1.07	2.2%	2.5%			4	PPI			β	58.36
4	2011	52	74.3	1.07	2.2%	2.5%			5	CPI			γ	-10.46
5	2012	52	77.0	1.07	2.2%	2.5%	0.62	1000	6	ExRate			θ	0.77
6	2013	52	84.0	1.07	2.2%	2.5%			7	Capex			New α	4.09
7	2014	52	83.4	1.07	2.2%	2.5%			8	Pk Avoid	225		New β	9.46
8	2015	52	83.1	1.07	2.2%	2.5%			9	PRE	403		New γ	-10.46
9	2016	52	90.1	1.07	2.2%	2.5%	0.58	7500	10	Plant Warrant Charges	150		New θ	0.77
10	2017	52	90.0	1.07	2.2%	2.5%			11	Direct Cost Ratio	25%		Mean	0.00
11	2018	52	93.2	1.07	2.2%	2.5%			12	Grid connection	65		Stdev	5.31
12	2019	52	96.6	1.07	2.2%	2.5%			13	Mgt & Admin Costs	2.50			
13	2020	52	100.1	1.07	2.2%	2.5%			14	Recurrent Opex	0.00			
14	2021	52	103.7	1.07	2.2%	2.5%			15	Non Recurrent Costs	2.50			
15	2022	52	107.5	1.07	2.2%	2.5%			16	Terminal Value	17698			
16	2023	52	111.4	1.07	2.2%	2.5%			17	WACC	8.0%			
17	2024	52	115.5	1.07	2.2%	2.5%			18	Depreciation	2.5%			
18	2025	52	119.7	1.07	2.2%	2.5%								
19	2026	52	124.1	1.07	2.2%	2.5%								
20	2027	52	128.6	1.07	2.2%	2.5%								
21	2028	52	133.4	1.07	2.2%	2.5%								
22	2029													
23	2030													
24	2031													
25	2032													
26	2033													

Sensitivity Result (@Risk Output Variable)		
1	NPV Result	3,083

Spearman RkOrder Correl Matrix			
	SpotP	PPI	CPI
SpotP	1.00	0.30	0.30
PPI	0.30	1.00	0.95
CPI	0.30	0.95	1.00

Simple SpotP, PPI & CPI Correl Matrix			
	SpotP	PPI	CPI
SpotP	1.00	0.38	0.34
PPI	0.38	1.00	0.97
CPI	0.34	0.97	1.00

Other Parameters/Assumptions	
Assumed Stdev	5%
Available Energy (GWh/yr)	52
Revenue Multiplier	1.07

Parameters used for factor distribution 1			
Energy	Normal	μ	51.64
		σ	15.29
SpotPrice	Log-Logistic	α	4.09
		β	58.36
		γ	-10.46
		θ	0.77
		New α	4.09
		New β	9.46
		New γ	-10.46
		New θ	0.77
		Mean	0.00
		Stdev	5.31
RevMultiple	Normal	μ	1.07
		σ	0.25
PPI	Normal	μ	2.2%
		σ	0.01
CPI	Normal	μ	2.5%
		σ	0.01
EX Rate	Beta(G)	$\alpha 1$	2.48
		$\alpha 2$	2.11
		Min	0.37
		Max	0.76
		New $\alpha 1$	2.48
		New $\alpha 2$	2.11
		New Min	0.43
		New Max	0.74
		Mean	0.60
		Stdev	0.07
CapexNY1	Pert(B)	Min	80%
		Most Lkly	100%
		Max	120%
Capex Yr 0	Discrete Distribution	Base %	65%
		Worse %	20%
		Worst %	5%
		Best %	10%

Summary	
Distribution of Input factors	
1) Wind Speed --- Weibull Distribution	
2) Energy --- Normal Distribution	
3) Spot Prices --- Log-Logistic Distribution	
4) Exchange Rates --- Beta General Distribution	
5) Capex --- Pert General Distribution	
6) Other factors --- Normal Distributions	
Correlation Relationships	
1) Exchange Rates and Capex	
2) Spot Prices, CPI, and PPI Correlation Matrix	
Go to SenS Results	

Correlation Relationships

- Correlation exists
 - Negative relationship between Exchange rate and Capex
 - Positive relationships among Spot Price, PPI and CPI
- 2 groups of @Risk Correl Functions Used
 - InDec() used for Exchange Rates (Independent variable)
 - Dec() used for Capex (Dependent variable)
 - Correlation matrix (Defined as Spearman Rank Order Coeffs.) is defined in an Excel range and CorrelMat() is used for Spot Price, PPI, and CPI.

Estimated Distribution of NPV

- Define Target --- RiskOutput() + NPV
- Start Simulation(s)
- Characteristics
 - ❖ Automatically Running via Macros
 - ❖ A Built in CDF Graph (variant template)
 - ❖ Interval Probability is calculated and shown
 - ❖ Sensitivity graph is grouped by similar factors and plotted with a custom style
 - ❖ Standard @Risk template is built for saving key results

Key Stochastic Analysis Results

Description

Stochastic Sensitivity Analysis (SSA) uses "Monte Carlo" statistical technique to let computer do simulation by randomly selecting many scenarios (sample size is set to 10,000). This is different from the deterministic sensitivity analysis (DSA) which only compares 2 cases (static, so it is called deterministic). The main advantage of SSA against DSA lies in it provides the distribution of NPV (ie., it is easy to find what the chance will be for NPV sitting between say, 50K to 100K). There are some disadvantages though. The sensitivity ranking in SSA is an index rather than the actual changes in NPV, so it is a relative measure which hasn't got intuitive economic meaning. In addition, the SSA results are sensitive to the assumptions used in the input factor distributions. Finally, to launch SSA successfully, you have to install a computer software called "@Risk".

Instruction

Make sure "@Risk" is installed. Fill in Lower & Upper Bands in Cells Q14 and Q15 (green color), then press the

INPUT PARAMETERS (\$K)

Lower Band (\$K)	-	Sensitivity Analysis	Generation Simulation	Print Results
Upper Band (\$K)	30,000			
Click Here	→			

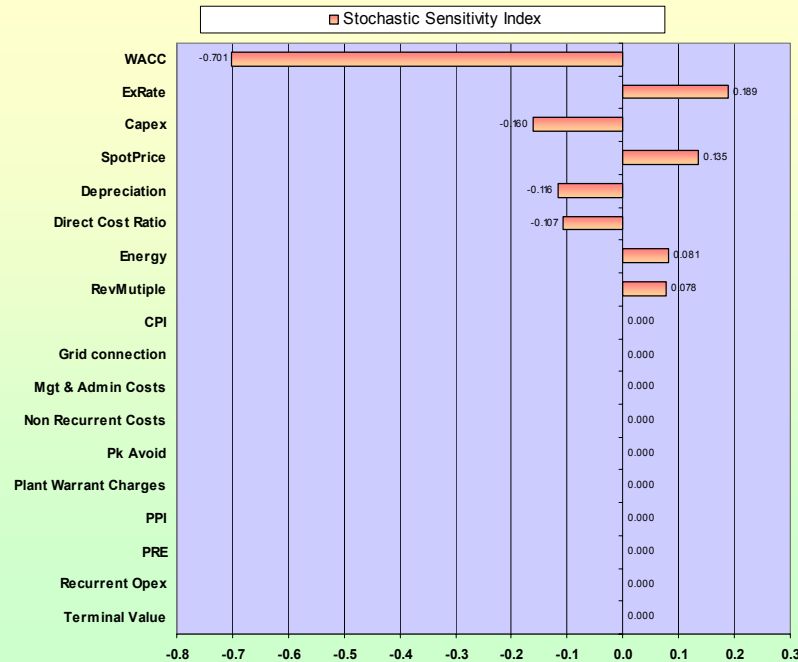
KEY OUTPUT

Probability of \$K 0 <= NPV <= \$K 30000 **78.1%**

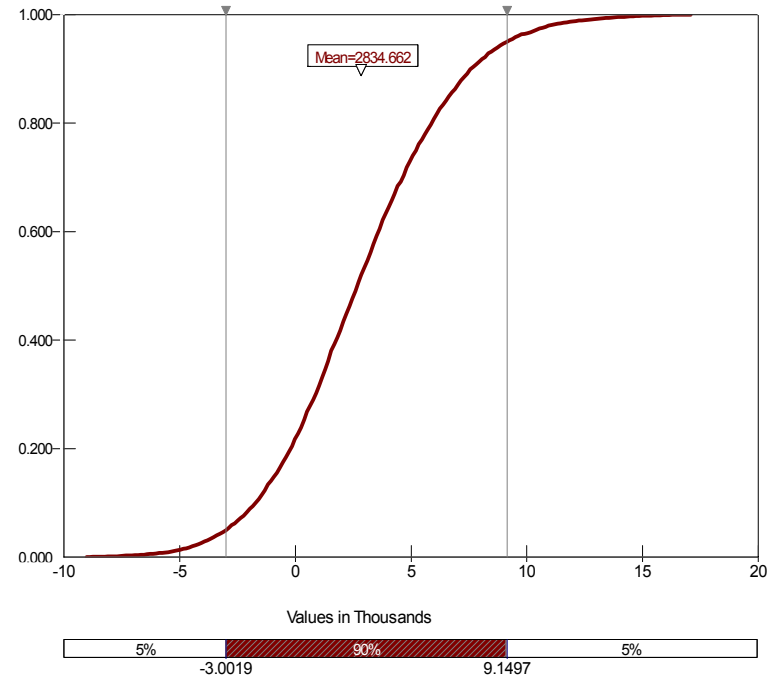
Any Enquiry? Contact William Zhu at Extn 8410

Stochastic Sensitivity Analysis and Cumulative probability Distribution of NPV

Stochastic Sensitivity Analysis



Cumulative Probability Distribution of NPV



Templates for Other Key Results

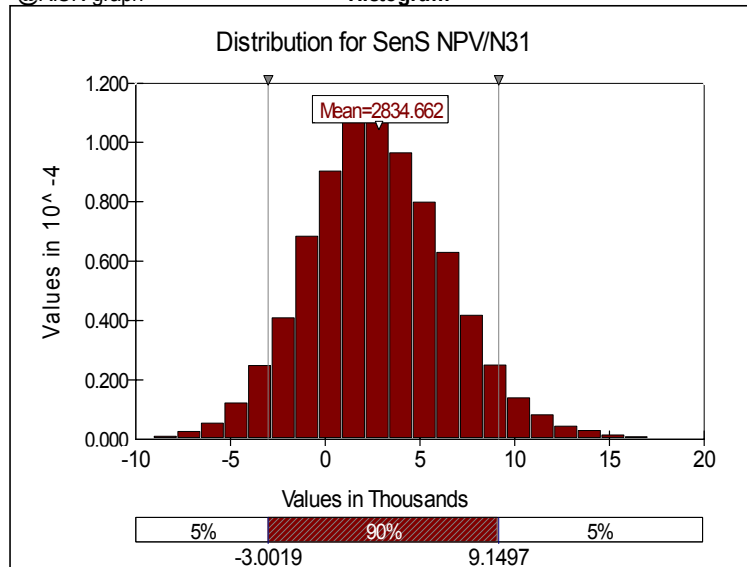
Descriptive Results		Percentile Distribution	
Statistic	Value	Percentile	Value
Mean	\$2,835	1th Percentile	(\$5,391)
Minimum	(\$9,020)	5th Percentile	(\$3,002)
Maximum	\$17,070	10th Percentile	(\$1,727)
StdDev	\$3,712	25th Percentile	\$344
Skewness	0.24	50th Percentile	\$2,676
Kurtosis	3.27	75th Percentile	\$5,200
		90th Percentile	\$7,564
		95th Percentile	\$9,150
		99th Percentile	\$12,470

Description

This template uses some @Risk statistical graph functions to generate useful information from the simulation. The percentile table results on the left hand side can be compared with the results (i.e., NPV > 0) shown in the "SensivS" sheet; while the original tornado graph shown below can be compared with the modified one in the "SensivS" sheet. Note also no cumulative distribution is displayed in this sheet since it has already been created in the "SensivS" sheet.

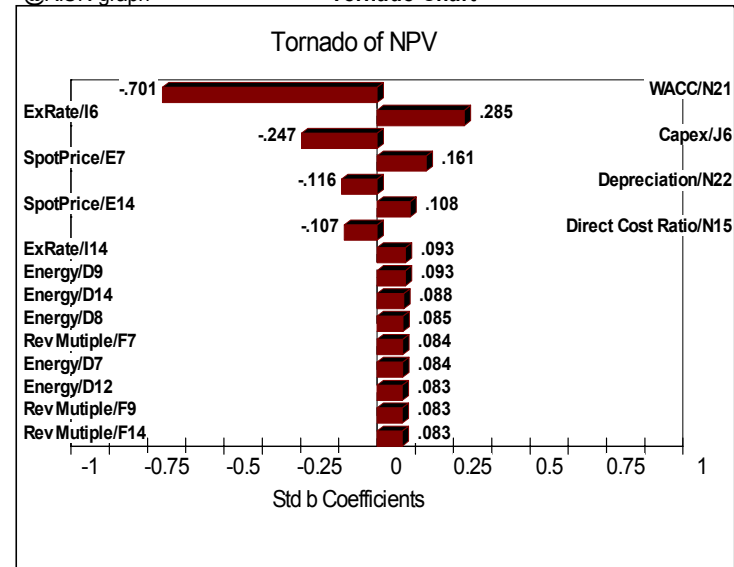
@RISK graph

-- Histogram



@RISK graph

-- Tornado Chart



Brief Discussion on Results

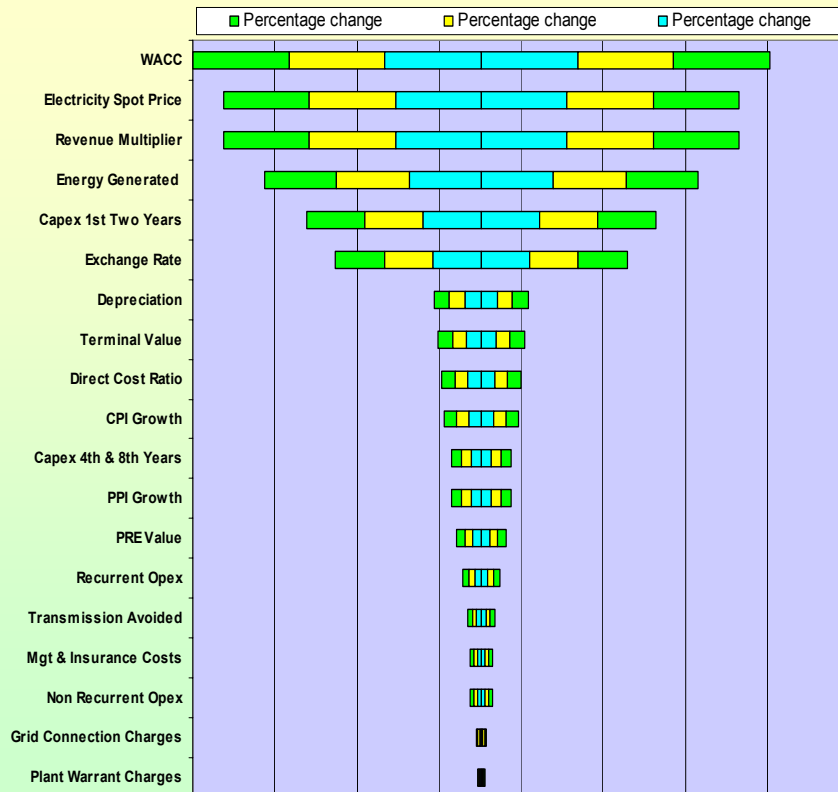
- Basic statistics of NPV (eg, mean = 2835)
- 90% Confidence Interval (-3002, 9150)
- Interval Probability (NPV > 0 : 78.1%)
- Percentile (See Results in the Template)
- Others (See Results in the Template)

Stochastic Sensitivity Analysis (O)

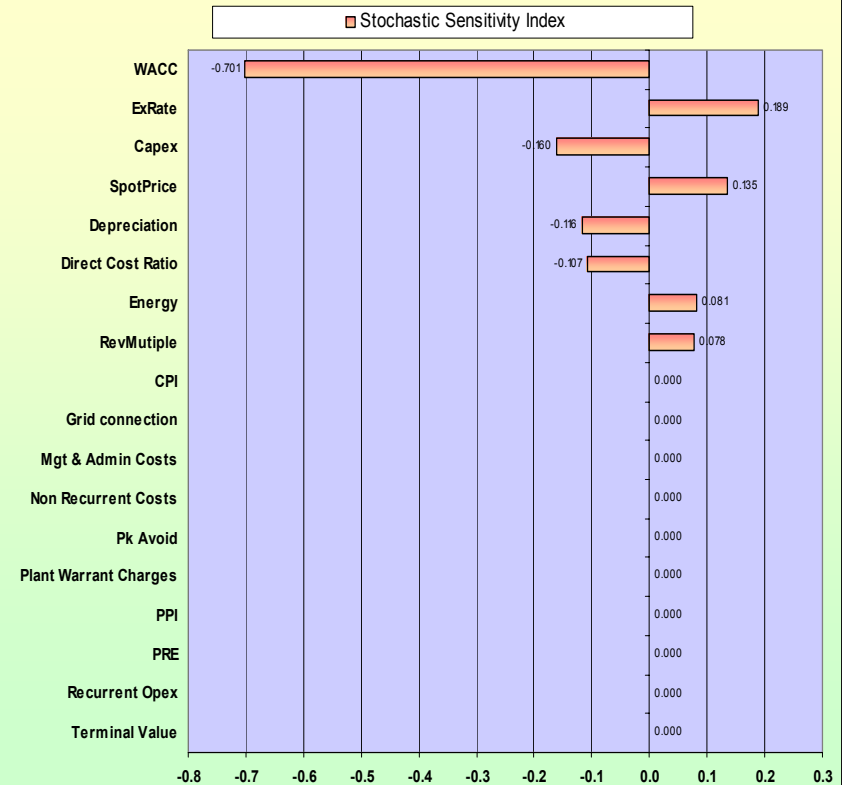
- Tornado Graph
 - Own style
 - Succinct by grouping similar factors together
 - Key results --- Identifying sensible factors
WACC, Exchange rate, Capex, Spot Price, Energy
 - Comparison with the Deterministic Results
 - ❑ Rank orders similar for WACC, Capex and Spot Price
 - ❑ Rank orders differ for Energy, Exchange Rate, Depreciation
- Scenario Analysis
- 3 Multiple Simulations --- RiskSimTable()
 - ❑ Energy level set to 100%, 110%, and 90%.

Tornado Graph Comparison

Deterministic Sensitivity Analysis



Stochastic Sensitivity Analysis



Three Multi-simulations

@RISK Output Details Report			
Output Statistics			
	X1 Energy	X1.1 Energy	X0.9 Energy
Outputs	SenS_NPV	SenS_NPV	SenS_NPV
Simulation	1	2	3
Statistics / Cell	\$N\$29	\$N\$29	\$N\$29
Minimum	- 9,020	- 7,357	- 10,666
Maximum	17,070	19,920	14,244
Mean	2,835	4,792	907
Standard Deviation	3,712	3,913	3,518
Variance	13,782,612	15,307,963	12,374,937
Skewness	0.238	0.264	0.209
Kurtosis	3.273	3.267	3.279
Number of Errors	6	6	6
Mode	1,438	5,060	902
5.0%	- 3,002	- 1,348	- 4,651
10.0%	- 1,727	- 38	- 3,444
15.0%	- 877	849	- 2,621
20.0%	- 218	1,567	- 1,979
25.0%	344	2,160	- 1,445
30.0%	876	2,698	935
35.0%	1,323	3,193	511
40.0%	1,750	3,633	84
45.0%	2,211	4,129	326
50.0%	2,676	4,608	775
55.0%	3,138	5,098	1,212
60.0%	3,575	5,568	1,617
65.0%	4,078	6,091	2,084
70.0%	4,644	6,673	2,617
75.0%	5,200	7,275	3,136
80.0%	5,892	7,982	3,781
85.0%	6,645	8,804	4,540
90.0%	7,564	9,816	5,404
95.0%	9,150	11,513	6,802
Filter Minimum			
Filter Maximum			
Type (1 or 2)			
# Values Filtered	0	0	0
Scenario #1	>75%	>75%	>75%
Scenario #2	<25%	<25%	<25%
Scenario #3	>90%	>90%	>90%

Scenario Analysis Results

@RISK Scenario Report (Simplified Sensitivity Report)

Scenario Report

Select Index

MedianSD

Cell	Name	MedianSD			MedianSD			MedianSD		
		Sim 1 >75%	Sim 1 <25%	Sim 1 >90%	Sim 2 >75%	Sim 2 <25%	Sim 2 >90%	Sim 3 >75%	Sim 3 <25%	Sim 3 >90%
\$J\$5	Capex	-	-	-	-	-	-	-	-	-
\$I\$6	ExRate	-	-0.715	0.595	-	-0.693	0.562	0.502	-0.752	0.615
\$J\$6	Capex	-	1.476	-	-	-	-	-	1.476	-
\$D\$7	Energy	-	-	-	-	-	-	-	-	-
\$E\$7	SpotPrice	-	-	-	-	-	-	-	-	-
\$F\$7	RevMutiple	-	-	-	-	-	-	-	-	-
\$G\$7	PPI	-	-	-	-	-	-	-	-	-
\$H\$7	CPI	-	-	-	-	-	-	-	-	-
\$D\$8	Energy	-	-	-	-	-	-	-	-	-
\$E\$8	SpotPrice	-	-	-	-	-	-	-	-	-
\$F\$8	RevMutiple	-	-	-	-	-	-	-	-	-
\$G\$8	PPI	-	-	-	-	-	-	-	-	-
\$H\$8	CPI	-	-	-	-	-	-	-	-	-
\$D\$9	Energy	-	-	-	-	-	-	-	-	-
\$E\$9	SpotPrice	-	-	-	-	-	-	-	-	-
\$F\$9	RevMutiple	-	-	-	-	-	-	-	-	-
\$G\$9	PPI	-	-	-	-	-	-	-	-	-
\$H\$9	CPI	-	-	-	-	-	-	-	-	-
\$D\$10	Energy	-	-	-	-	-	-	-	-	-
\$E\$10	SpotPrice	-	-	-	-	-	-	-	-	-
\$F\$10	RevMutiple	-	-	-	-	-	-	-	-	-
\$G\$10	PPI	-	-	-	-	-	-	-	-	-
\$H\$10	CPI	-	-	-	-	-	-	-	-	-
\$I\$10	ExRate	-	-	-	-	-	-	-	-	-
\$J\$10	Capex	-	-	-	-	-	-	-	-	-
\$D\$11	Energy	-	-	-	-	-	-	-	-	-
\$E\$21	SpotPrice	-	-	-	-	-	-	-	-	-
\$F\$21	RevMutiple	-	-	-	-	-	-	-	-	-
\$G\$21	PPI	-	-	-	-	-	-	-	-	-
\$H\$21	CPI	-	-	-	-	-	-	-	-	-
\$N\$21	WACC	-0.919	0.812	-1.378	-0.944	0.832	-1.378	-0.908	0.792	-1.377
\$D\$22	Energy	-	-	-	-	-	-	-	-	-
\$E\$22	SpotPrice	-	-	-	-	-	-	-	-	-
\$G\$26	PPI	-	-	-	-	-	-	-	-	-
\$H\$26	CPI	-	-	-	-	-	-	-	-	-

Stochastic Sensitivity Analysis (A)

Using @Risk Advanced Techniques to do the following 3 Important Analyses

- ❖ Goal Seek
- ❖ Stress Analysis
- ❖ Sequential Analysis

Interface of Sensitivity Analysis (A)

Stochastic Goal Seek
On average, by how much should a factor change to meet the new target (eg; new NPV)?

Stress Analysis
Impact of input factors on the target NPV under special cases, that is, stress input distributions (restricts samples) between a specified pair of percentiles.

Sequential Analysis -- ie; Advanced Sensitivity Analysis in @Risk
A batch mode auto-reports of target, given input factors follow a certain type of changes (comparable with Stress Analysis and Multi # Simulation, but with greater flexibility)

All those 3 advanced analyses remain testing the sensitivities of the target variable to the changes of input factors. However, unlike the ordinary @risk sensitivity test, the results here have explicit economic meaning, since they directly measure the changes of the target variable rather than ranking the β coefficients.

Energy Generated

ExRate

Lower Percentile	75%
Upper Percentile	100%
Individual Report	NO

SpotPrice Value in Exel Table

See Value Distrib	-15
See Value Distrib	15

Assumptions Used for Sequential Analysis					# of Steps/Sim in Sequential Analysis					9
Percentile of Distributions					Values for Distributions					
No	Energy	SpotPrice	ExRate	Capex	No	Energy	SpotPrice	ExRate	Capex	
1	1.0%	1.0%	1.0%	1.0%	1	36.5	-20.0	0.56	15000	
2	5.0%	5.0%	5.0%	5.0%	2	40.0	-15.0	0.59	16500	
3	10.0%	10.0%	10.0%	10.0%	3	43.5	-10.0	0.61	18000	
4	25.0%	25.0%	25.0%	25.0%	4	47.0	-5.0	0.64	19500	
5	50.0%	50.0%	50.0%	50.0%	5	50.5	0.0	0.66	21000	
6	75.0%	75.0%	75.0%	75.0%	6	54.0	5.0	0.69	22500	
7	90.0%	90.0%	90.0%	90.0%	7	57.5	10.0	0.71	24000	
8	95.0%	95.0%	95.0%	95.0%	8	61.0	15.0	0.74	25500	
9	99.0%	99.0%	99.0%	99.0%	9	64.5	20.0	0.76	27000	
10					10					
11					11					
12					12					
13					13					
14					14					
15					15					
16					16					
17					17					
18					18					
19					19					
20					20					
21					21					
22					22					
23					23					
24					24					

INPUT TABLE for SenS Goal Seek				
1	Target	New NPV (\$K)	5,000	
OUTPUT TABLE for SenS Goal Seek				
NPV Report				
1	\$K	Original	3,083	
2	\$K	New	5,000	
3	\$K	Difference	1,917	
No	Category	Factor Name	Chg to/by	# Sim
1	Revenue Factors (Multiplier)	Energy Generated	112.25%	5
2		Revenue Multiplier	110.30%	5
3		Terminal Value	158.10%	6
4		Electricity Spot Price	110.30%	5
5		Transmission Avoided	290.19%	8
6		PRE Value	206.31%	7
7	Cost Factors (Multiplier)	Grid Connection Charges	-393.6%	9
8		Plant Warrant Charges	-549.10%	9
9		Capex 1st Two Years	85.23%	5
10		Capex 4th & 8th Years	11.83%	11
11		Exchange Rate	118.81%	7
12		Mgt & Insurance Costs	-141.47%	8
13		Recurrent Opex	-39.64%	7
14		Non Recurrent Opex	-141.51%	8
15	Other Factors (Additive)	Direct Cost Ratio	-6.71%	7
16		PPI Growth	6.35%	8
17		CPI Growth	-14.38%	13
18		WACC	-0.78%	8
19		Depreciation	N/A	N/A

Compared with Deterministic Goal Seek Results

Goal Seek

- Goal Seek
 - ❖ Purpose --- same as in the deterministic case, but under stochastic environment
 - ❖ Feature --- Macro based automatic search
 - ❖ Results Compared to the deterministic case
- Results
 - ❖ Most of the results are close each other
 - ❖ Grid, Warranty, Mngt, and Non-Rec-opex Differ
 - ❖ No result for Depreciation

Stress Analysis

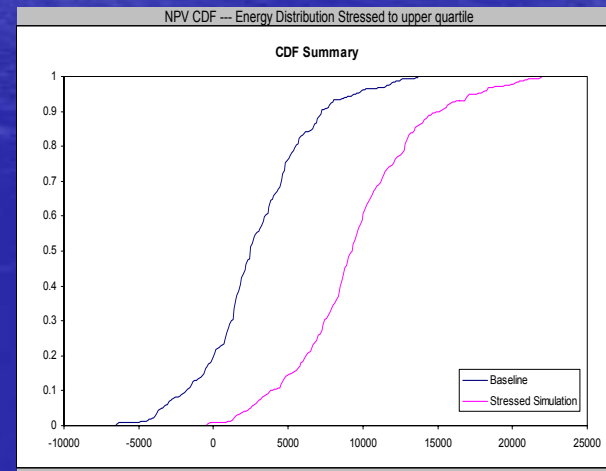
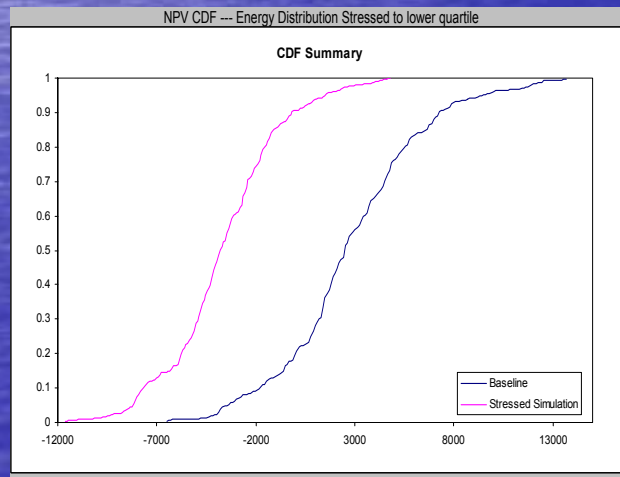
- Purpose of Stress Analysis
 - ❖ Intuitive Explanation --- optimistic vs. pessimistic likelihood on input factors
 - ❖ Statistical Explanation --- constrain distribution by “stressing” it to a pre-defined range so that Monte Carlo simulations only sample data from that range
- Stress Analysis on 4 Key Input Factors
 - Energy, Spot Price, Exchange Rate, and Capex*
- Stress Results

Results of Stress Analysis

- Key Results

Stress Results (Range 0% ~ 25%. For Capex, the range corresponds to 75% ~ 100%)						
Factor	Mean (B)	Mean (S)	90% CI (B)	90% CI (S)	Prob NPV>0 (B)	Prob NPV>0 (S)
Energy	3083	-3616	(-3002, 9150)	(-8168, 1533)	78.1%	9.4%
Sport Price		1950		(-3911, 8240)		75.6%
Exchge Rate		1011		(-5034, 7448)		59.6%
Capex		2482		(-3849, 9302)		77.6%
Stress Results (Range 75% ~ 100%. For Capex, the range corresponds to 0% ~ 25%)						
Factor	Mean (B)	Mean (S)	90% CI (B)	90% CI (S)	Prob NPV>0 (B)	Prob NPV>0 (S)
Energy	3083	9517	(-3002, 9150)	(2509, 17428)	78.1%	99.1%
Sport Price		4411		(-2312, 11420)		87.3%
Exchge Rate		4483		(-1117, 10437)		92.6%
Capex		3203		(-3041, 9922)		83.4%

- Some Graphs (See the Excel file for details)

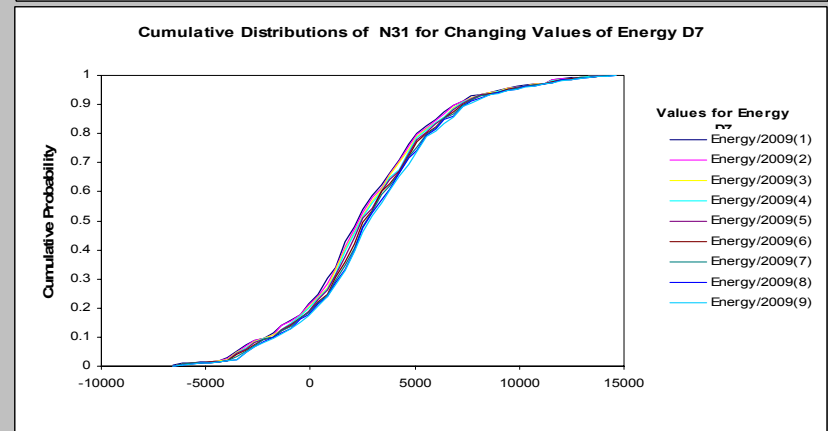
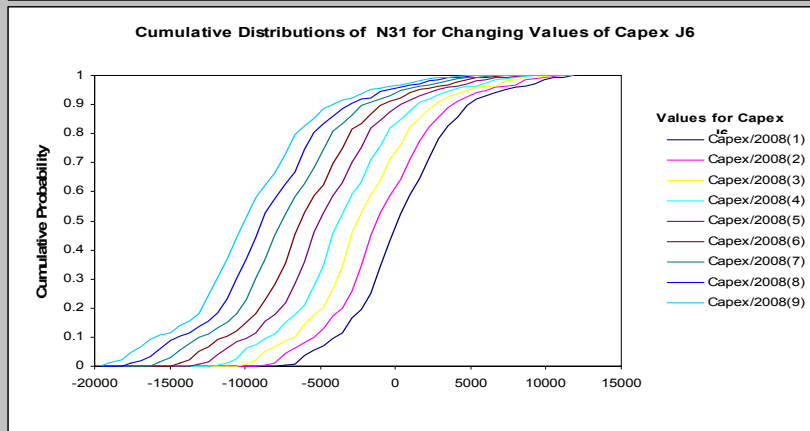
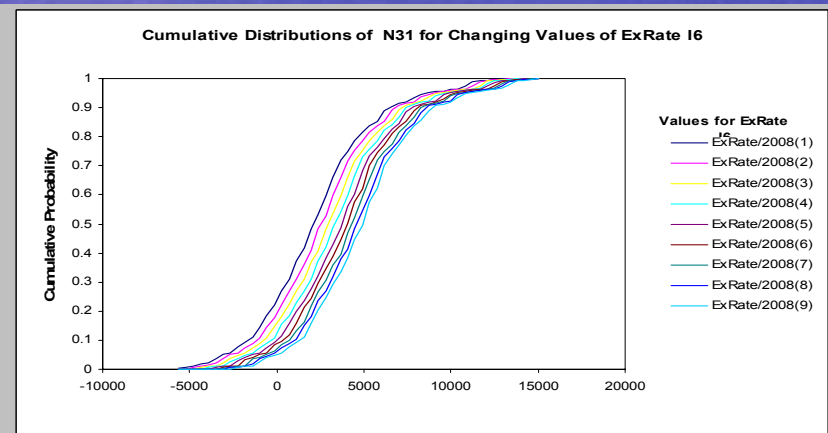
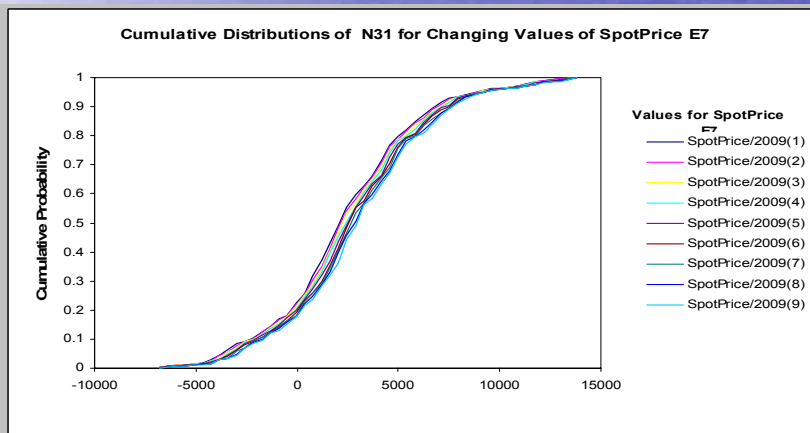


Sequential Analysis

- Purpose of Sequential Analysis
 - ❖ Intuitive Explanation --- testing different scenarios as input factors changes steadily
 - ❖ Statistical Explanation --- Sampling input distributions (rather than “stressing” them) sequentially so that allows multiple Monte Carlo simulations to step through each case. This is comparable to what RiskSimTable() function does but with more flexibilities.
- Sequential Analysis on 4 Key Input Factors
Energy, Spot Price, Exchange Rate, and Capex
- Sequential Results

Results of Sequential Analysis

Key Results of Sequential Analysis		
Factor	Value change	NPV Changes in 90% Conf. Interval
Spot Price (yr 09)	+/- \$20 around its trend	(-3745, 8931) → (2860, 9300)
Exchange Rate (08)	US 0.56c → 0.76c	(-3134, 8512) → (-64, 10968)
Capex (yr 08)	\$27m → \$15m	(-17469, -1867) → (-5556, 7245)
Energy (yr 09)	36.5 GWh → 64.5 GWh	(-3582, 9064) → (-2960, 9626)



A Simple Decision Tree

- Reasons to Use Decision Tree
 - ❖ Many cases/scenarios exist
 - ❖ Easy to get lost without condensing them together
 - ❖ Try to find the overall expected value of NPV
- Factors/Cases for Building Decision Tree
 - ❖ Investment Types --- 3 decision nodes;
 - ❖ Energy generation --- 3 chance nodes;
 - ❖ Policy issue --- 2 chance nodes;
 - ❖ Spot price due to load growth --- 3 chance nodes.
So in total, there are $3 \times 3 \times 2 \times 3 = 54$ cases
- The NPVs for these 54 cases are calculated (via a VBA) in the model, and together with the probabilities for those 8 nodes, are linked directly into the decision tree.

Interface of Calculating 54 Cases

← Press the Button

NPV Result (\$K) **544**

Terminal Value	Asset Based	▼
Tax Shield	YES	▼
Price Node	Otahuhu	▼
Capex	Case A - Base	▼
Electricity Price After 2017	Assumed Grth	▼
PRE Revenue Included?	NO	▼

Explanation

The scenario analysis tries to calculate different NPVs under different options and/or assumptions that a user chooses. Because there are too many options/selections in this model, ONLY certain key risk related factors (or options) are chosen for the scenario test. They are:

- Investment Decisions (3 options)
- Electricity Generation Profile/Probability (3 possible results)
- Carbon Tax On/Off Profile/Probability (2 possible results)
- National Electricity Load Growth Profile (3 possible results)

Therefore, there are $3 \times 3 \times 2 \times 3 = 54$ scenarios in total. It is these 54 cases that form the basis for the best, median and worst scenarios in the "Main" sheet. They are also used for building the **Decision Tree** (in a separate Excel workbook --- somehow, it seems not to work if built within this workbook, might be due to the reason that we only have a trial version of Precision Tree software).

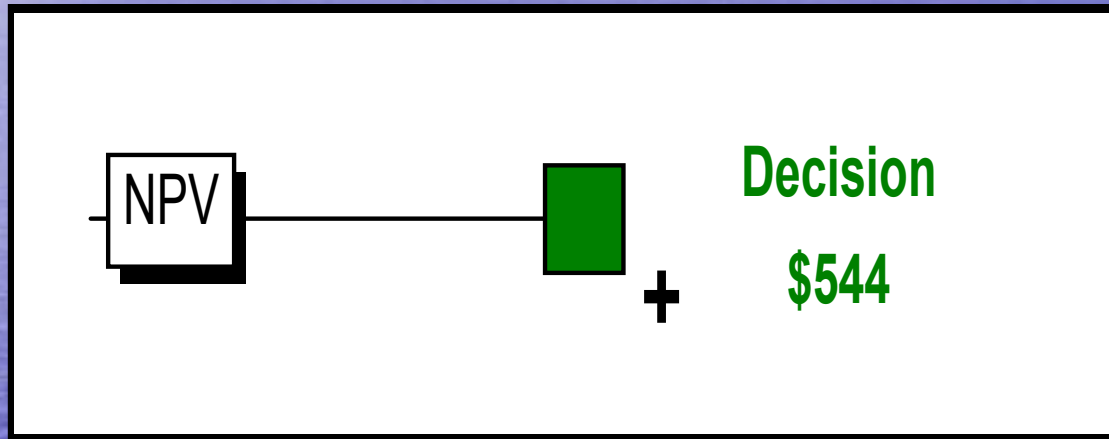
Note however, the NPV calculation is also associated with the other options/assumptions, which are listed on the left hand side of this sheet. These options themselves (5 for TV, 2 for TS, 2 for PN, 4 for capex, 2 for EPA, and 2 for PRE) combined have $5 \times 2 \times 2 \times 4 \times 2 \times 2 = 320$ outcomes. If they were included in the scenario analysis, it would lead to $54 \times 320 = 17280$ cases! To avoid losing concentration and to allow the decision tree to be reasonably readable, the model constructor deliberately separates these options from the major scenario analysis, and lets users to decide which options he/she wants to use beforehand.

FINAL DECISION

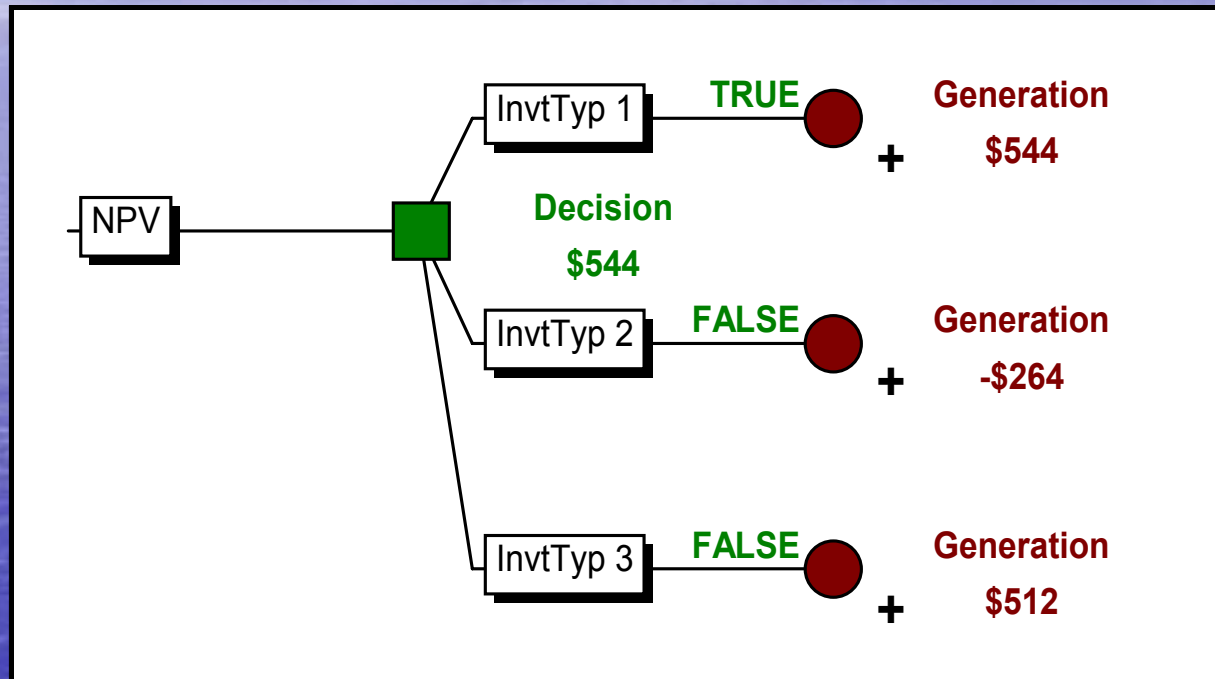
Based on those 6 options being chosen, the expected NPV under those 54 scenarios discussed above is \$K 544. Therefore, it arrives the final decision ---

GREEN LIGHT ON --- The Project Is Worth Doing

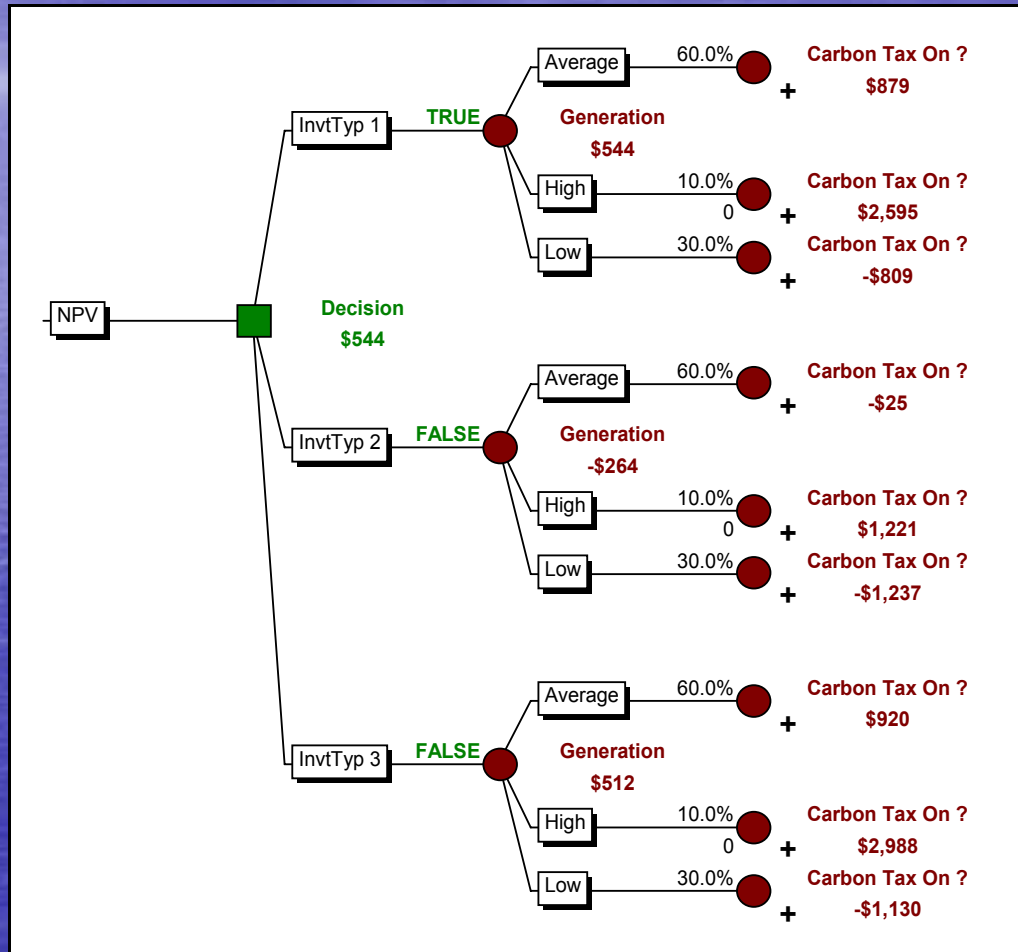
Decision Tree --- Target



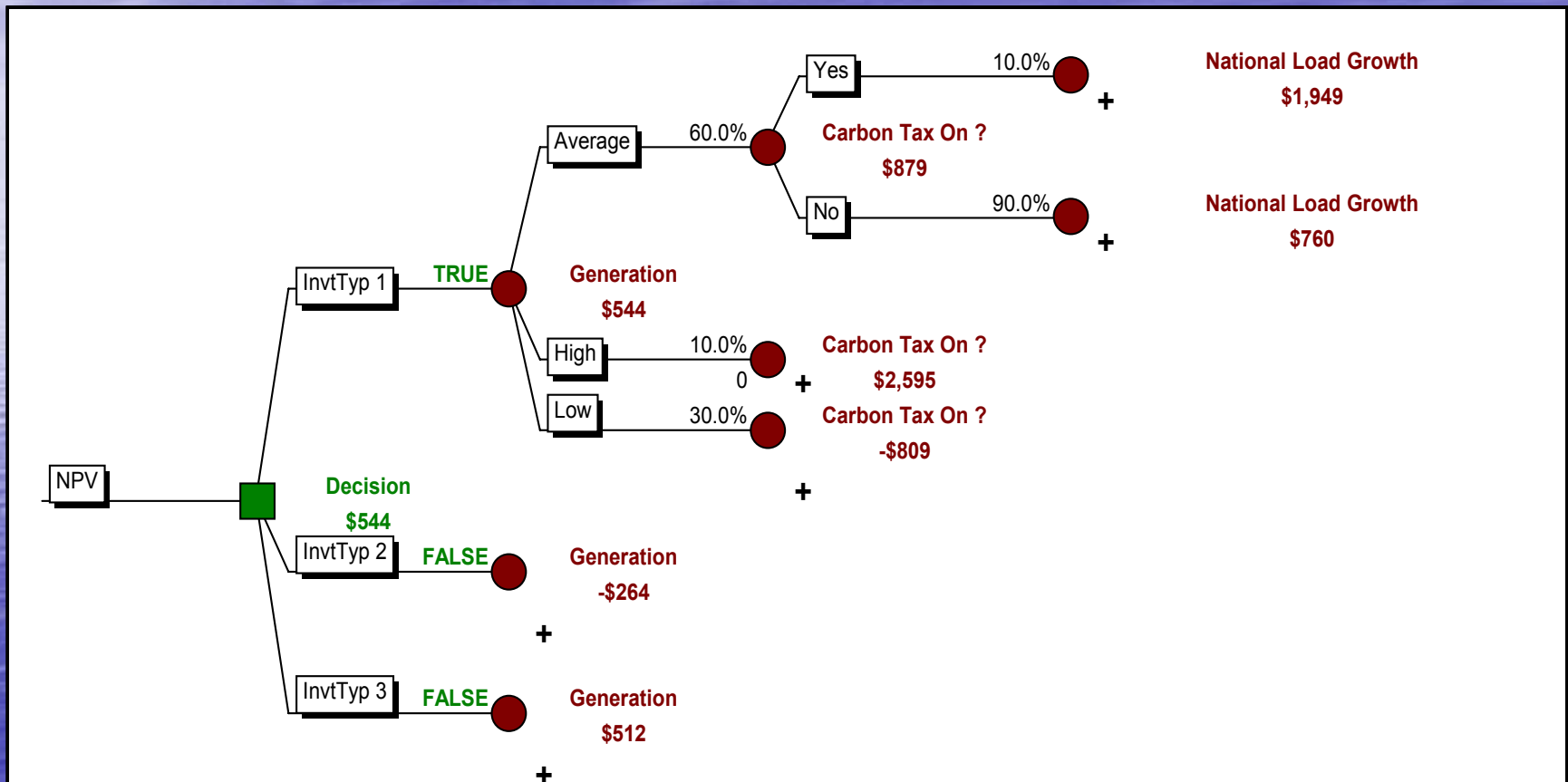
Decision Tree --- 1st Layer



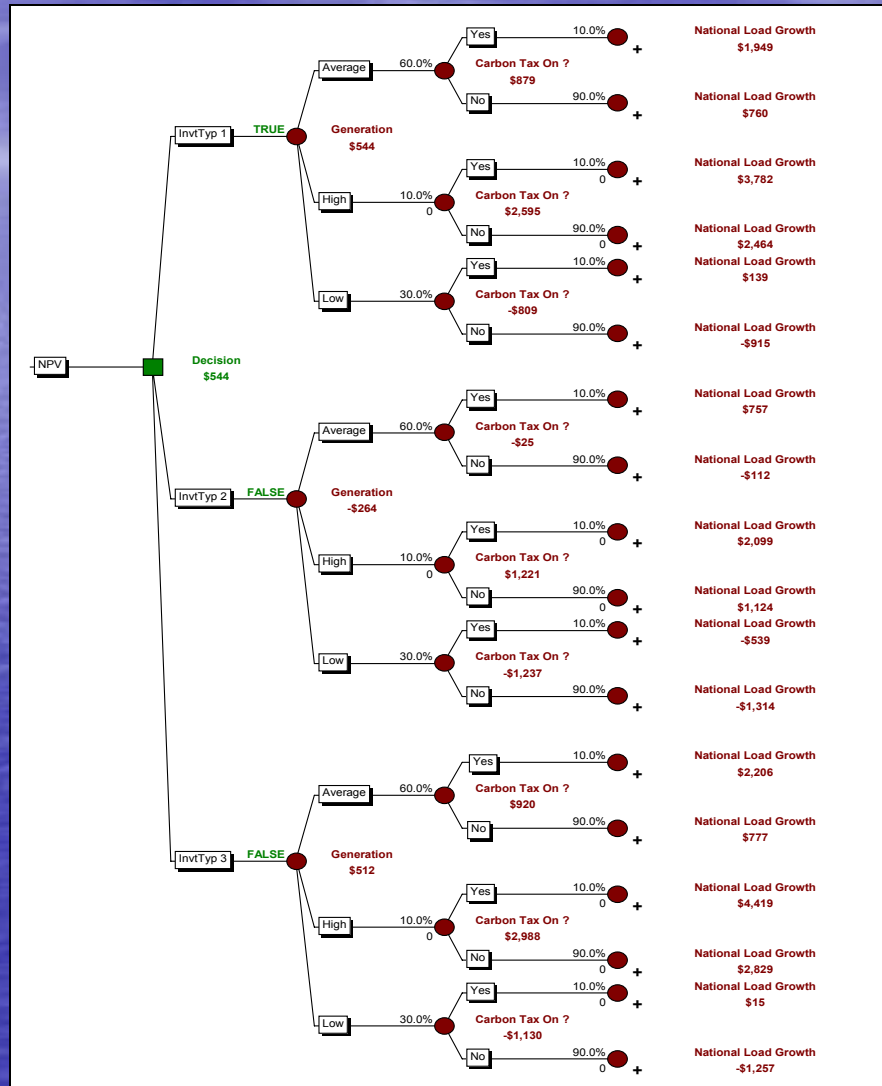
Decision Tree --- 2nd Layer



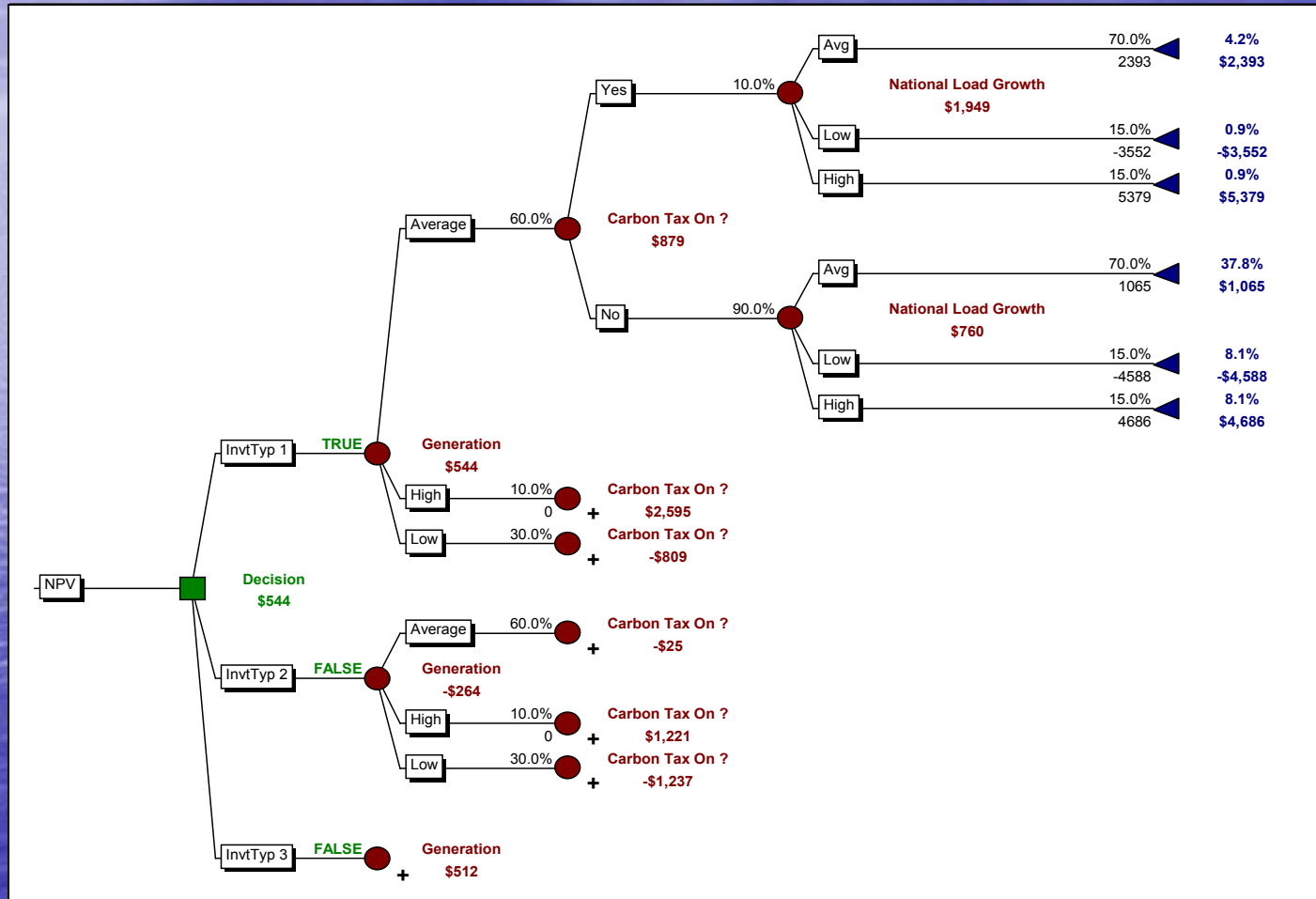
Decision Tree --- 3rd Layer (Part)



Decision Tree --- 3rd Layer (Full)



Decision Tree --- 4th Layer (Part)



Project Summary

- Fifty-four cases exist for the project, but the overall NPV (ie., the expected NPV) reaches \$544K. It therefore, confirms that the project worth doing.
- The NPV for the **Case Selected** equal \$3,083K.
- For the case selected, there are 90% chance that the NPV sits between - \$3,002K ~ \$9,150K, with 78.1% chance it is greater than zero.
- Factor analyses show that WACC, Exchange Rates, and Capex are most sensible to the NPV, with Spot Prices and Energy Generation followed by.
- To raise the current NPV up from \$3,083K to \$5,000K, it need to either generate more energy by 12% or to push the electricity spot price up by 10%.
- If, say the NZ exchange rates fall into the upper quartile of the forecast range, the chance of $NPV > 0$ will rise from 78.1% to 92.6%. Alternatively, it will drop to 59.6% if the exchange rates move to the opposite direction (ie., the lower quartile of the forecast range).

Conclusion

❖ Presentation Review

- ❑ An income based FCF model is discussed for a proposed wind farm project
- ❑ Risk factors are identified and analyzed by using @Risk software
- ❑ Stochastic vs. deterministic sensitivity analyses are discussed and compared
- ❑ Advanced stochastic sensitivity analysis is explored
- ❑ A simple decision tree is provided for summarizing different scenario results
- ❑ Excel macros are built into the model so that users can run the associated tests without knowing much about @Risk

Conclusion

❖ Further Extension

- ❑ Target more @Risk output factors (eg, IRR)
- ❑ Incorporate @Risk Optimizer into the model
- ❑ Investigate in detail on the Decision Tree
- ❑ Randomize other factors (eg, interest rates)
- ❑ Add more financial features (eg, hedge)

❖ Suggestions and Questions