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THE FINANCIAL IMPACT OF WIND PLANT UNCERTAINTY

BRUCE H. BAILEY, PH.D., CCM
PRESIDENT/CEO
AWS TRUEPOWER, LLC

463 NEW KARNER ROAD | ALBANY, NY 12205
awstruepower.com | info@awstruepower.com

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Topics

1. Steps Involved in Predicting Wind Plant Output
2. Sources of Losses and Uncertainty
3. Probabilities of Energy Exceedence
4. Roles of Debt and Equity and their Tolerance for Risk
5. Uncertainty Implications in Project Financing

The Wind Resource & Risk

- The economics of a wind project are very sensitive to the wind resource
- Energy to speed ratio: 5% change in speed ≈> 7-10% in energy production
- Expertise and experience required to understand and predict wind behavior
- Risk is on investors

Debt providers distance themselves from the risk

Equity investors accept the wind risk

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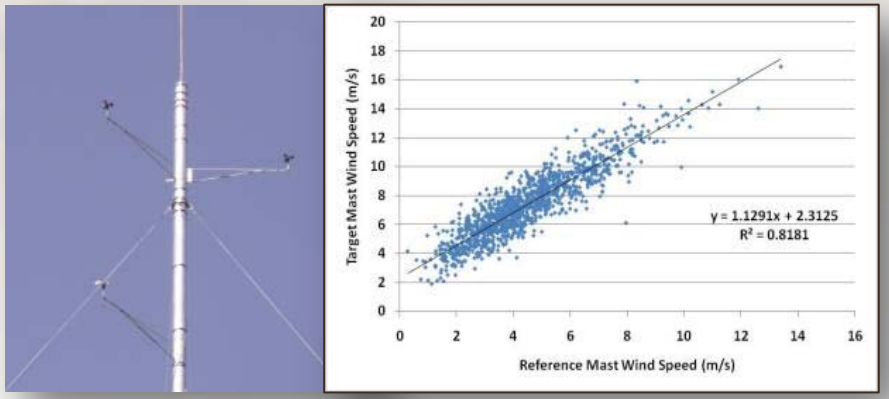
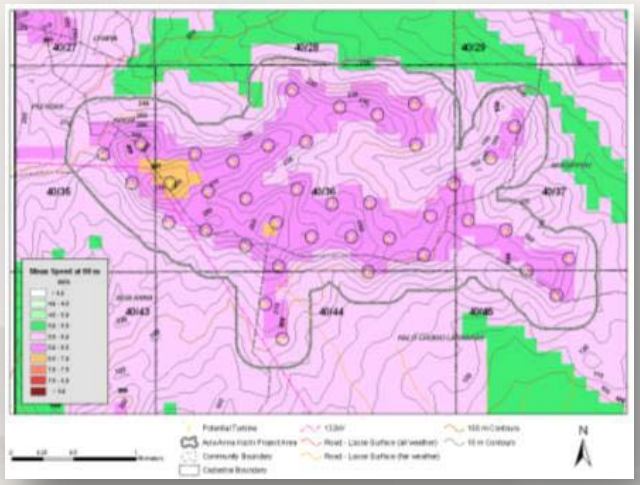
Steps Involved in Project Energy Prediction

- Acquire On-Site Met Data
- Estimate Long-Term Resource (MCP)
- Adjust to Hub Height
- Extrapolate Resource Across Project (Modeling)
- Calculate Gross Energy Production





- Apply Energy Losses
- Estimate Net Energy (P50)
- Uncertainty Analysis
- Calculate P75, P90, P95, P99
- 1st Year & Multi-Year Estimates

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Typical Energy Losses for NA Land-Based Wind Projects

Source	Typical
Wake Effect (internal to project, adjacent projects)	6.4 %
Availability (turbines, collection & substation, grid, restart)	6.2 %
Electrical (efficiency, weather package)	2.1 %
Turbine Performance (sub-optimum perf., power curve adjmt., hi-wind hysteresis)	4.0 %
Environmental (icing, blade degrad., hi/lo T shutdown, access, lightning)	2.7 %
Curtailments (directional, environmental, PPA)	0.0 %
Total Losses	**19.7%**

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Typical Energy Production Uncertainty Values Over 10-yr Loan Period

Uncertainty Sources	Mean	Max	Min
Field Verification	0.5%	1.0%	0.2%
Measurements	2.4%	4.8%	1.6%
Long-Term Average	3.2%	4.8%	2.1%
Evaluation Period Wind Resource	1.9%		
Wind Shear	2.6%	6.4%	0.0%
Wind Flow Modeling	4.0%	8.0%	2.4%
Wind Speed Frequency Distribution	1.0%	1.5%	0.6%
Total Plant Losses	3.5%	4.8%	3.2%
Total Energy Uncertainty	**7.5%**	**13.5%**	**5.2%**

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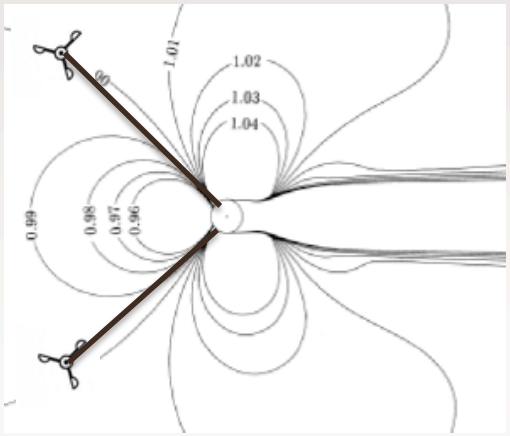
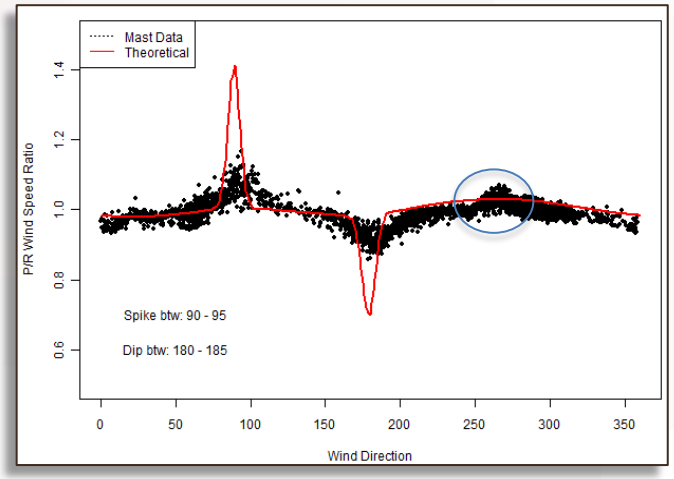
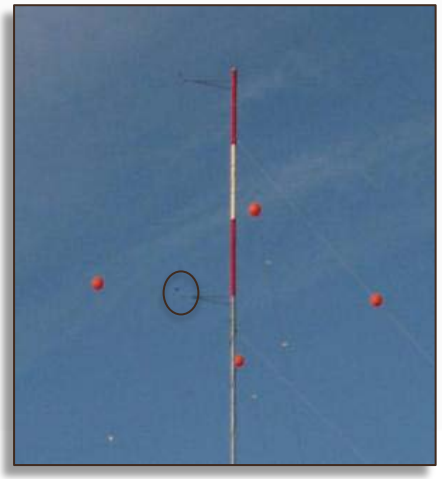
Example of Parameter Granularity

Wind Measurement

- Anemometer calibration
- Flow distortion from tower
- Flow distortion from boom
- Flow distortion for other equipment
- Turbulence
- Off-Horizontal Flow
- Data recovery
- Other







Uncertainty values are assigned to every attribute based on site-specific information

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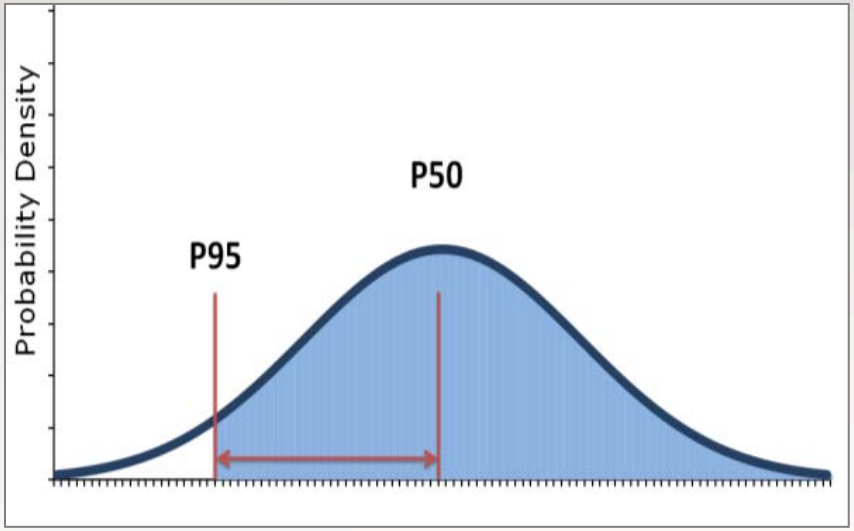
Energy Estimates and Probability of Exceedance

- Probability of exceedance: the level of confidence that a plant's actual energy production will be at least a certain value
- The P-Values are used to set the valuation, return and debt capacity of the project
- P50 = Project Return (best case)
- Other P-values measure the risk
- To understand how these values are used, must understand Project Finance



Probability of Exceedance	Lifetime Average Energy Production (GWh)	Lifetime Average Capacity Factor (%)
P50	384.7	36.6
P75	360.9	34.3
P90	339.6	32.3
P95	326.7	31.1
P99	302.7	28.8

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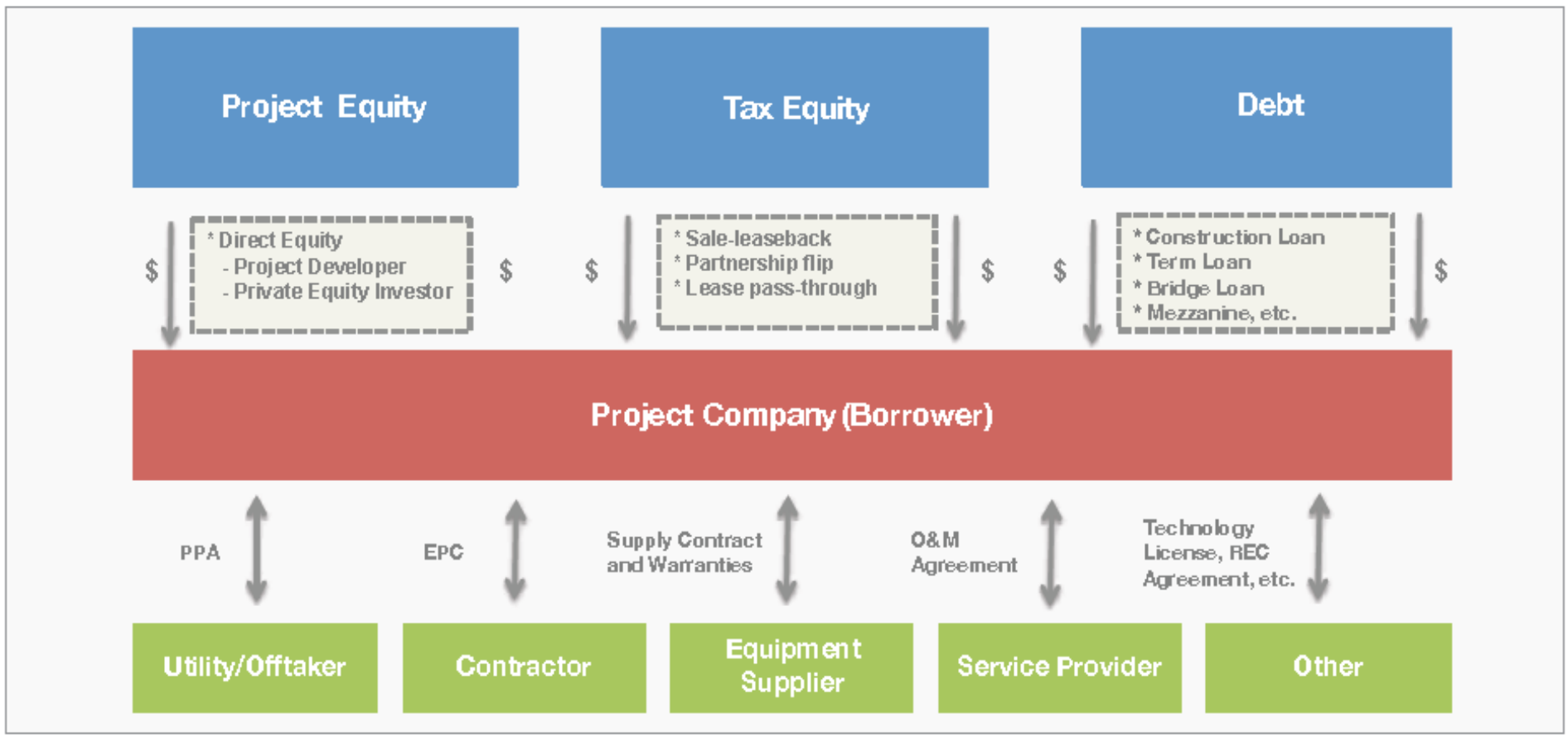
Project Finance Overview

- Project Finance involves:
  - An industrial asset with a single purpose
  - Owned by a legally independent entity
  - Corporate sponsors (Equity)
  - Highly leveraged (Debt)
    - Non-recourse or limited recourse (read: risky!)
  - Completely dependent on the revenue it generates (and the revenue depends on the resource!)

Capital Structure

Capital Structure: How the project is financed



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Debt vs. Equity

CHEAPER

Interest Rate ≈ 5-7%

Debt

- A loan that must be paid back with interest
- Interest rate provides lender's return
- Size debt based on project risk and potential return

HIGHER POTENTIAL RETURN

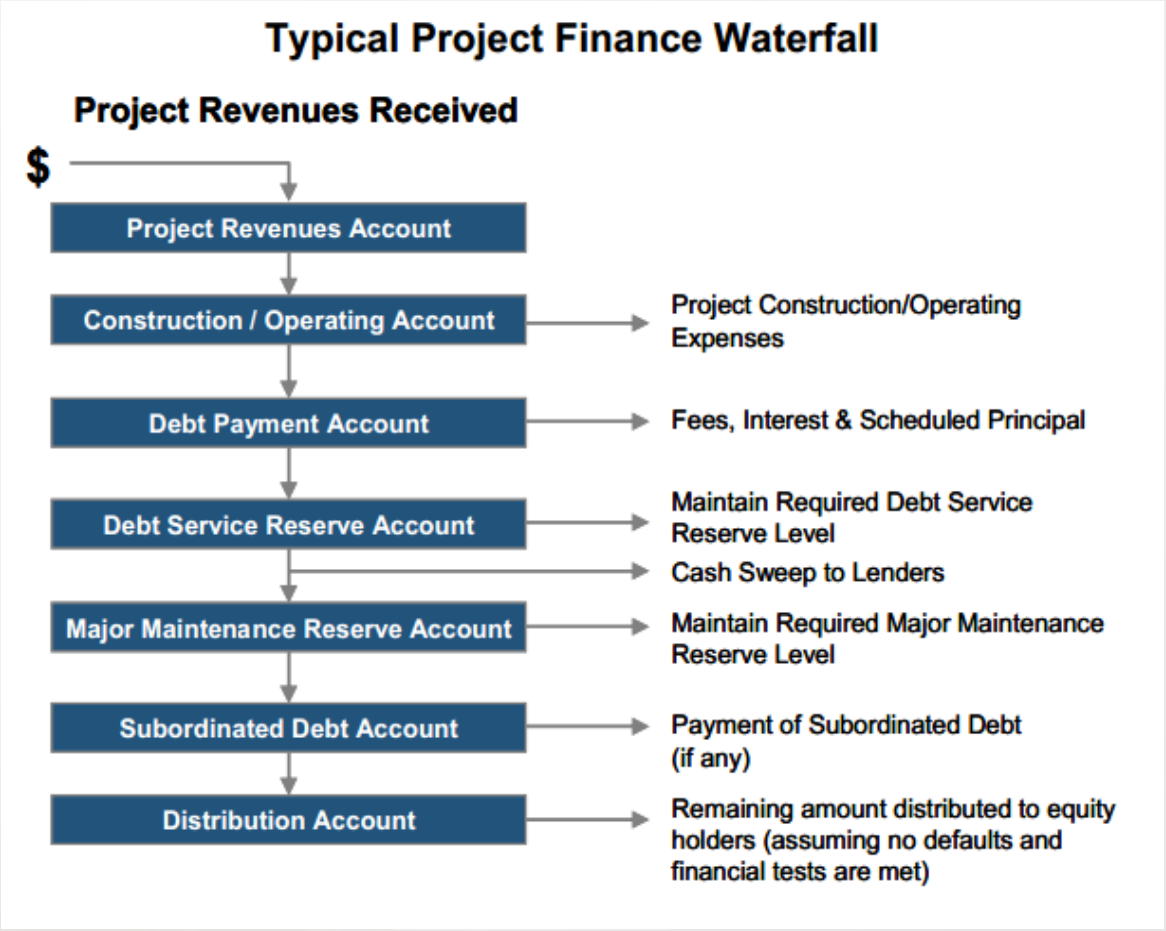
IRR ≈ 8-12%

Equity

- An investment into the project company
- Assumes risk with company, shares reward
- Dividends are paid annually
- Value based on project return

Sizing the Debt for Wind Projects

- Cash waterfalls determine who gets paid – Senior Debt ALWAYS gets paid, Equity holders get paid last



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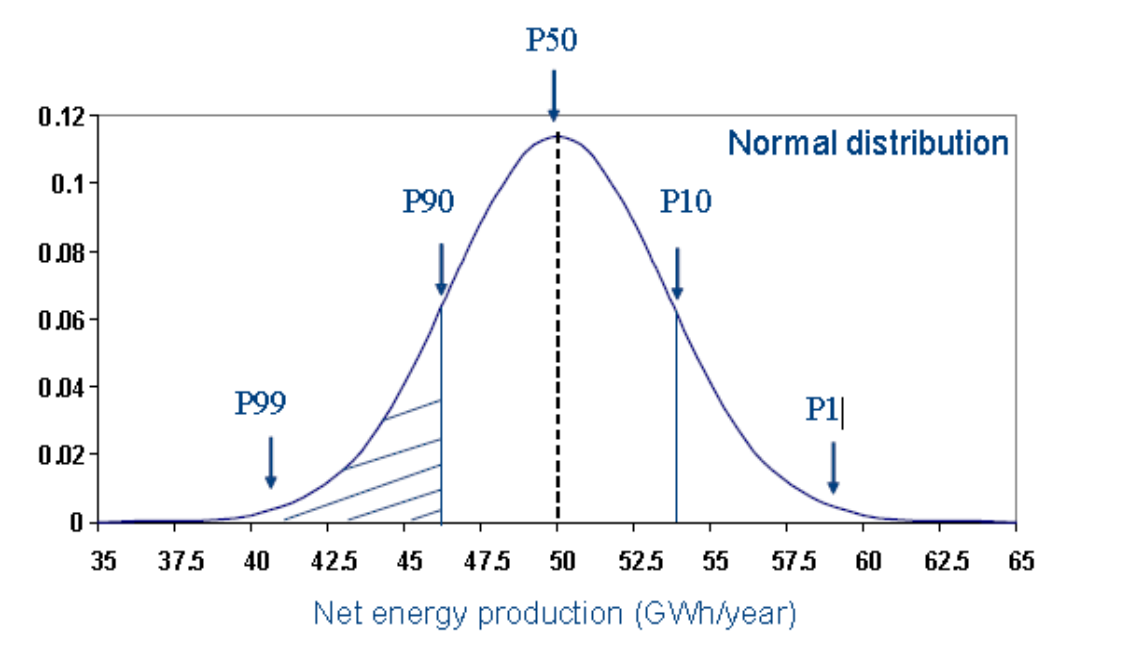
Debt and Equity on Wind Projects

- Must evaluate the expected production (return) and the annual variability (uncertainty)
- Equity Investors use P50 to evaluate NPV and IRR
- Debt suppliers use annual P99 to evaluate debt capacity



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Sizing the Debt for Wind Projects

- Debt capacity is measured by evaluating the projected annual cash flow and the associated variability (or uncertainty)
- Debt providers will use Debt Service Coverage Ratio (DSCR) to evaluate the projects ability to pay back the principle and interest on an annual basis

$$DSCR = \frac{Annual\ Net\ Operating\ Income}{Annual\ Principle\ Payment + Annual\ Interest\ Payment}$$

$$Annual\ Net\ Operating\ Income = Income\ - Operating\ Expenses$$

Sizing the Debt for Wind Projects

- Debt providers will perform several stress cases on the project using different P-Values and DSCR ratios
- Typically, a 1.0 DSCR on the P99 annual energy value (called breakeven value)
- Ensures that under "worst-case wind year" the project can still service the debt

$$1.0\ DSCR = \frac{(Annual\ P99\ Value\ x\ Energy\ Price) - Operating\ Expenses}{Annual\ Interest + Annual\ Prinicple}$$

- Also will stress with DSCR 1.4 on P50, or 1.2 on P90

Impact of Uncertainty on Wind Projects

- P-Values play very large role in sizing the debt on the project
- The amount of leverage a project can secure will directly impact the return on investment for ALL parties
- Under-leverage means more equity needs to be put in, can't use cash elsewhere
- Over-leverage is dangerous if project can't service the debt
- If the project misses debt payments, strict covenants may be enforced (Ex. Cash sweeps = no dividend payments)

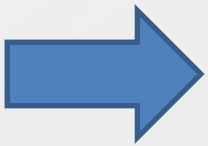
Example: Proposed Project

- A 100 MW plant
- Net Capacity Factor of 40%
- Total CapEx of $180 million
- Financing off the P99 using a DSCR of 1.0
- Project Life is 20 years
- PPA price $6/MWh
- No PTC
- Debt Interest Rate is 5.0%
- 13 year loan term
- Inflation is 2%

Impact of Uncertainty on Wind Projects

Uncertainty Sources	Scenario 1	Scenario 2
Field Verification	0.3%	0.3%
Measurements	1.5%	1.5%
Long-Term Average	2.0%	2.0%
Evaluation Period Wind Resource	1.2%	1.2%
Wind Shear	1.6%	1.6%
Wind Flow Modeling	5.0%	2.5%
Wind Speed Frequency Distribution	1.0%	1.0%
Total Plant Losses	4.2%	4.2%
Total Energy Uncertainty	11.5%	8.5%

	Scenario1 GWh	Scenario 2 GWh	Delta GWh
P50	350.84	350.84	0.00
P75	323.51	330.71	7.20
P90	298.92	312.59	13.67
P95	284.20	301.74	17.54
P99	256.59	281.40	24.81



	Scenario 1	Scenario 2
Total Equity Investment	$74 Mil	$61 Mil
Total Debt Investment	$106 Mil	$120 Mil
Debt Percentage	59%	66%
Project IRR	8.8%	9.8%

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Impact of Uncertainty on Wind Projects

- Accurately predicting the wind resource and energy output ensures the long term fiscal health of the project
- Reducing uncertainty during development (i.e. better quality data & modeling, more measurements) can lead to risk reduction in eyes of lenders and increase debt capacity on the project
- Example: On a 100MW plant, a 3% reduction in uncertainty (P99) can lead to a 7-10% increase in the plant's debt capacity and a significant increase in the IRR.

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Thank You

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