L. E. PEABODY & ASSOCIATES, INC.
Economic Consultants

Overview of

Power Plant Financial Risk Assessment:

How to Measure the Exposure of Plant Cash Flows to Market Risks

Spring 2016





Introduction

This presentation describes how L.E. Peabody & Associates, Inc. uses **dispatch simulation** to identify and quantify risk around power plant cash flows caused by market uncertainties. Our approach utilizes **Monte Carlo simulation** techniques and follows the **"Real Option" theory** for valuations. Once cash flow risk is identified and quantified it can be managed based on a client's tolerance for risk using hedging techniques.

This presentation relies on the audiences' basic understanding of power plant economics and how power plants dispatch against market power prices.

The presentation highlights the specific steps taken to measure cash flow risk. These steps include:

1. Start with Power Plant Financial Planning Model
2. Identify Components Affected by Market Uncertainty
3. Model Economic Dispatch Decision
4. Model Uncertainty Variables Used In Dispatch Decision
5. Add Uncertainty Variables to Modeled Dispatch Decision
6. Correlate Uncertainty Variables in Modeled Dispatch Calculation
7. Simulate Dispatch Decision with Correlated Uncertainty Variables
8. Flow Simulation of Dispatch Decision Through Cash Flow Model
9. Generate Distribution of Cash Flows
10. Identify Range of Possible Cash Flows

1. Start with Power Plant Financial Planning Model

Most companies have financial planning models by power plant that can be used as a starting point for a risk assessment.

Plant Cash Flow = Gross Margin – Fixed O&M Expense – Capital Expenditures

Where…

Gross Margin = Revenues – Variable Expenses

Where…

Variable Expenses = Fuel Transportation + Fuel Supply + Emissions Allowances ("EA") + Other variable O&M

All dollars in millions

Item	2016	2017	2018	2019	2020	2021	2022	2023	2024	2025
Revenues										
Energy	$ 98.6	$ 94.7	$ 108.7	$ 107.7	$ 108.0	$ 114.2	$ 109.8	$ 126.1	$ 124.8	$ 125.2
Capacity	10.4	20.8	41.7	41.7	41.7	41.7	41.7	41.7	41.7	41.7
Hedges	10.0	2.0	(5.0)	5.0	-	10.0	2.0	(5.0)	5.0	-
Ancillary Services	3.0	3.1	3.1	3.2	3.2	3.3	3.4	3.4	3.5	3.6
Other	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0
Total Revenue	**$ 123.0**	**$ 121.6**	**$ 149.5**	**$ 158.5**	**$ 153.9**	**$ 170.2**	**$ 157.9**	**$ 167.2**	**$ 176.0**	**$ 171.4**
Variable Expenses										
Fuel Supply	$ 22.4	$ 20.9	$ 25.2	$ 24.3	$ 25.4	$ 26.9	$ 25.9	$ 29.7	$ 29.4	$ 29.5
Fuel Transportation	48.5	47.1	54.6	54.6	55.3	58.5	56.2	64.5	63.9	64.1
Emissions	3.0	3.0	12.0	12.0	12.0	12.0	12.0	12.0	12.0	12.0
Other Variable O&M	3.3	3.4	3.4	3.5	3.6	3.6	3.7	3.8	3.8	3.9
Total Variable Costs	**$ 77.2**	**$ 74.4**	**$ 95.2**	**$ 94.3**	**$ 96.2**	**$ 101.0**	**$ 97.8**	**$ 110.0**	**$ 109.2**	**$ 109.5**
Gross Margin	**$ 45.8**	**$ 47.3**	**$ 54.3**	**$ 64.2**	**$ 57.6**	**$ 69.2**	**$ 60.1**	**$ 57.2**	**$ 66.9**	**$ 61.9**
Fixed Expenses										
Direct Fixed Expenses	$ 12.0	$ 14.0	$ 11.0	$ 12.0	$ 13.0	$ 13.0	$ 13.0	$ 13.0	$ 13.0	$ 13.0
Property Taxes	5.0	5.0	5.0	5.0	5.0	5.0	5.0	5.0	5.0	5.0
Insurance	2.0	2.0	2.0	2.0	2.0	2.0	2.0	2.0	2.0	2.0
Other Fixed O&M	2.0	2.0	2.0	2.0	2.0	2.0	2.0	2.0	2.0	2.0
Total Fixed Costs	**$ 21.0**	**$ 23.0**	**$ 20.0**	**$ 21.0**	**$ 22.0**	**$ 22.0**	**$ 22.0**	**$ 22.0**	**$ 22.0**	**$ 22.0**
Operating Margin	**$ 24.8**	**$ 24.3**	**$ 34.3**	**$ 43.2**	**$ 35.6**	**$ 47.2**	**$ 38.1**	**$ 35.2**	**$ 44.9**	**$ 39.9**
CAPEX	**$ 10.0**	**$ 20.0**	**$ 5.0**	**$ 7.0**	**$ 15.0**	**$ 10.0**	**$ 20.0**	**$ 5.0**	**$ 7.0**	**$ 15.0**
Cash Flow	**$ 14.8**	**$ 4.3**	**$ 29.3**	**$ 36.2**	**$ 20.6**	**$ 37.2**	**$ 18.1**	**$ 30.2**	**$ 37.9**	**$ 24.9**

Will be used in an example below …

2. Identify Components Affected by Market Uncertainty

Market uncertainty is driven by market prices, which in turn drive power plant revenues and costs.

Driven by uncertain power prices

Relationship of **power prices** to **fuel prices** and **EA prices** determines how often the plant will dispatch.

Driven by uncertain fuel prices

Driven by uncertain EA prices

Cash flows are uncertain because the market variables that determine how often the plant dispatches and how much gross margin is generated are uncertain

All dollars in millions

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Hedges	10.0	2.0	(5.0)	5.0	-	10.0	2.0	(5.0)	5.0	-
Ancillary Services	3.0	3.1	3.1	3.2	3.2	3.3	3.4	3.4	3.5	3.6
Other	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0
Total Revenue	**$ 123.0**	**$ 121.6**	**$ 149.5**	**$ 158.5**	**$ 153.9**	**$ 170.2**	**$ 157.9**	**$ 167.2**	**$ 176.0**	**$ 171.4**
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Other Variable O&M	3.3	3.4	3.4	3.5	3.6	3.6	3.7	3.8	3.8	3.9
Total Variable Costs	**$ 77.2**	**$ 74.4**	**$ 95.2**	**$ 94.3**	**$ 96.2**	**$ 101.0**	**$ 97.8**	**$ 110.0**	**$ 109.2**	**$ 109.5**
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3. Model Economic Dispatch Decision

Inputs to Dispatch Decision:

- Plant Heat Rate (btu/kWh)
- Market **Power Price** Projections ($/MWh)
- Market **Fuel Price** Projections ($/MMBtu)
- Fuel Transportation Costs ($/MMBtu)
- Emissions Rates (lbs/MMBtu)
- Market **EA Price** Projections ($/ton)

Dispatch Decision:

If, on a $/MWh basis …

Power Price > **Fuel Price** + Fuel Transportation Cost + **EA Price** + Other Variable O&M

Then, the plant should dispatch.

However, the likelihood and extent to which the plant is dispatched depends on power price, fuel price and EA price, all of which are uncertain market variables, i.e., they each have a range of possible values.

4. Model Uncertainty Variables Used In Dispatch Decision

For each uncertainty variables in the dispatch decision (power price, fuel price and EA price), the range of possible prices must be defined using expected prices and price volatilities to create probability distributions for each variable.

For example,

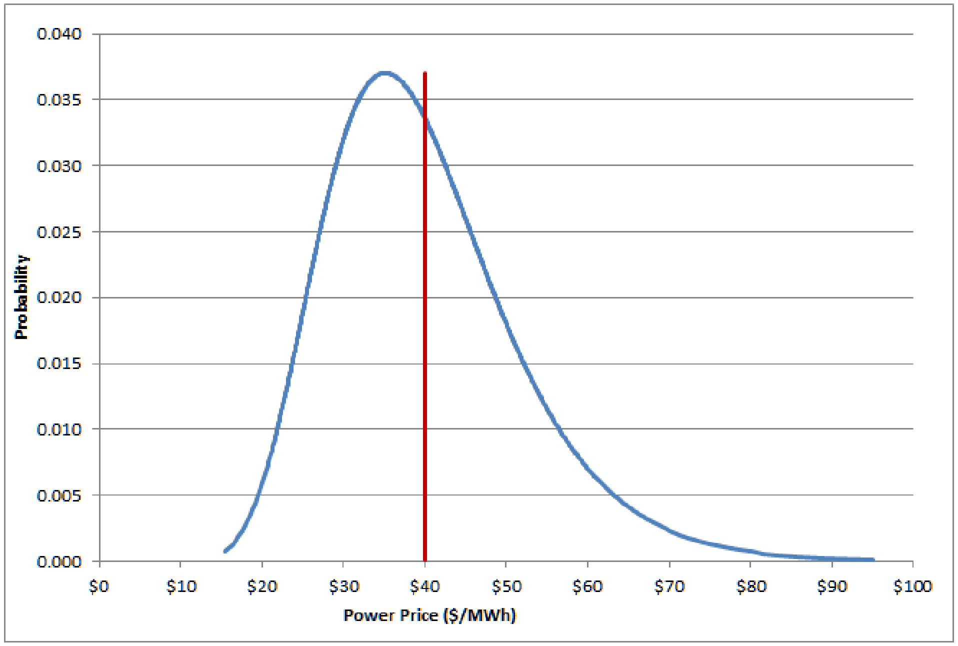
With **Expected Power Price =**

$40/MWh and **Price Volatility = 30%**,

the range of possible power prices can

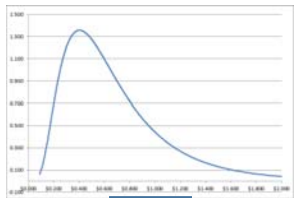
be defined by this probability

distribution



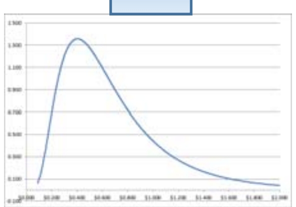
5. Add Uncertainty Variables to Modeled Dispatch Decision

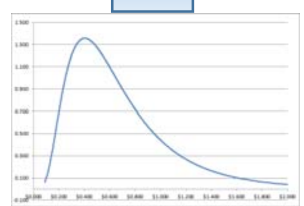
Probability distributions for uncertain market variables are inserted into the dispatch decision.



In the modeling, when market prices indicate the plant should dispatch for a certain period, market prices are applied to volumes to calculate revenues, fuel costs and EA costs.

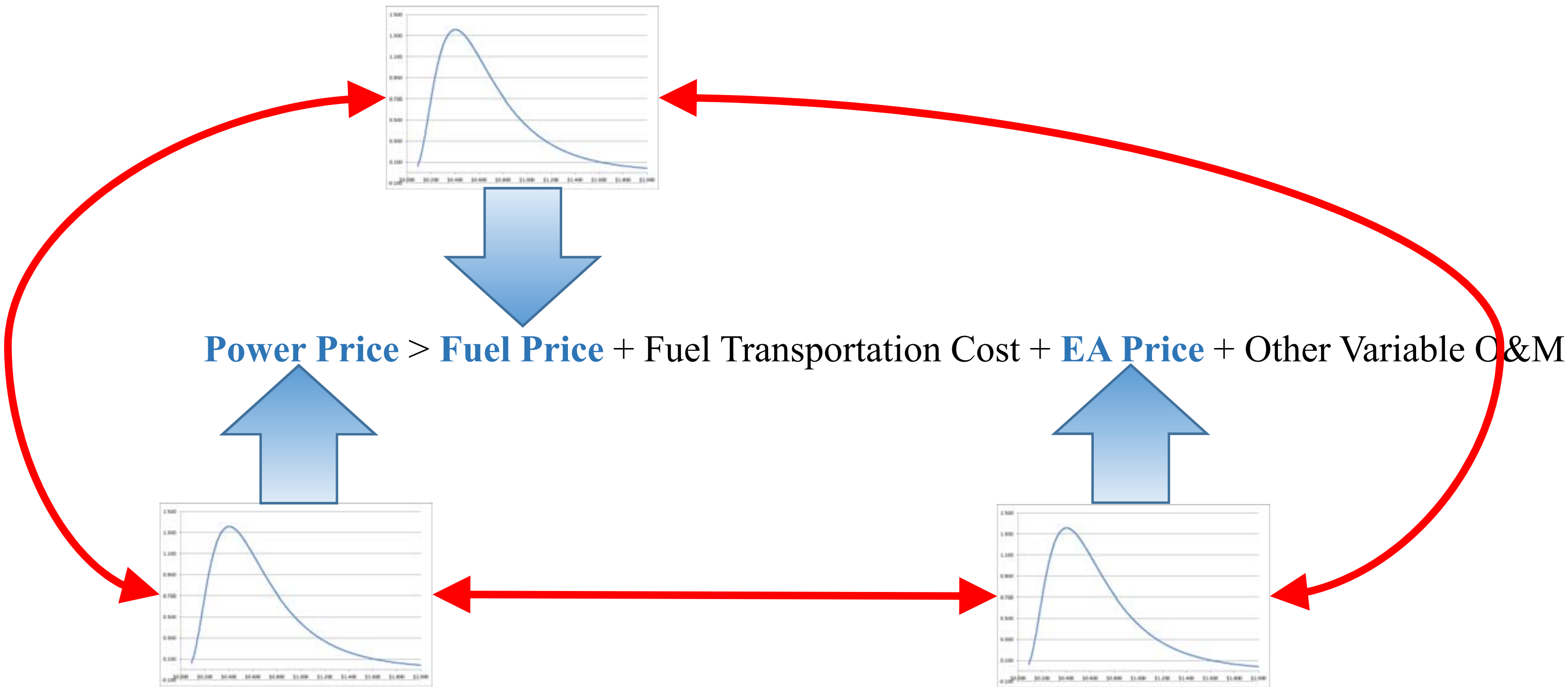
Power Price > **Fuel Price** + Fuel Transportation Cost + **EA Price** + Other Variable O&M





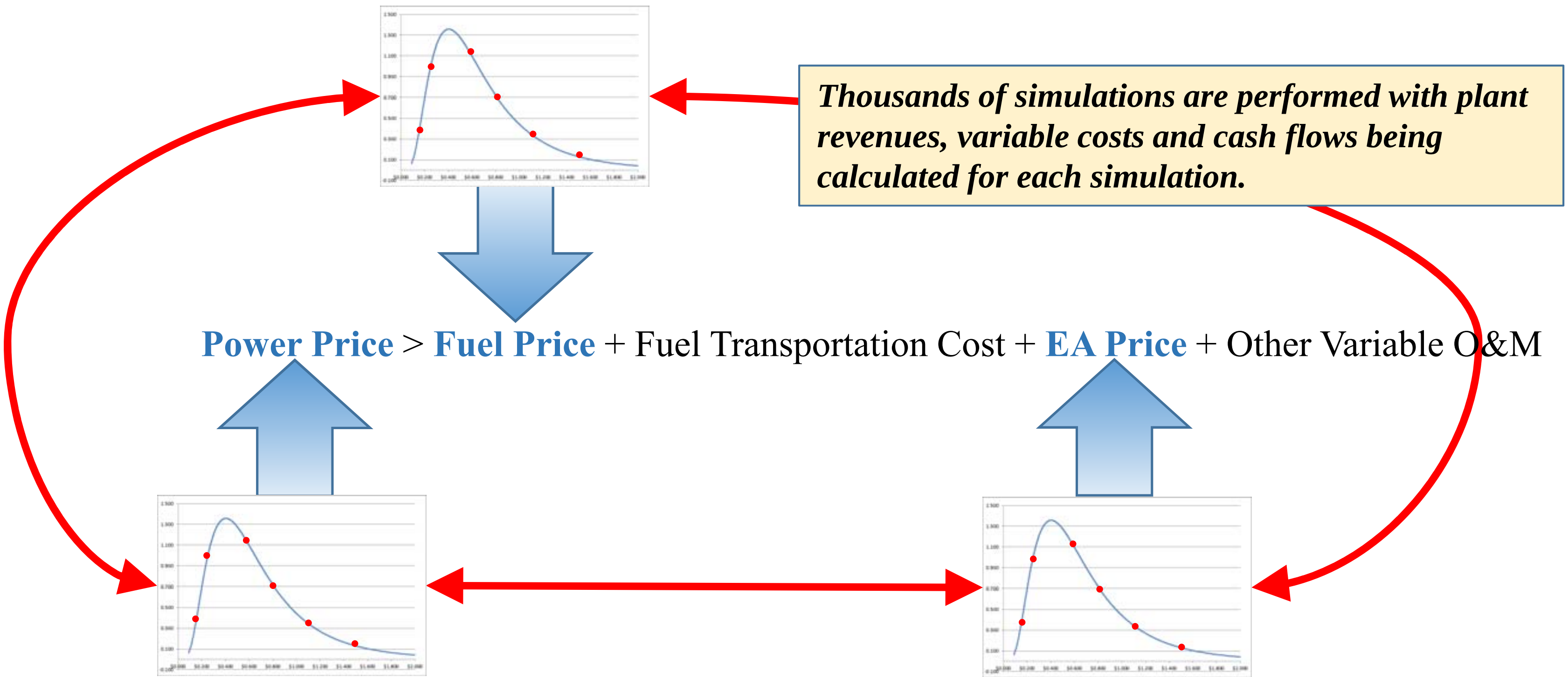
6. Correlate Uncertainty Variables in Modeled Dispatch Calculation

Correlation between variables, which measures likelihood of variables moving in the same or different directions, are assigned to each possible combination of variables.



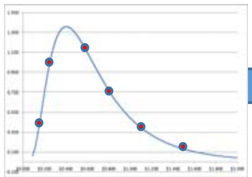
7. Simulate Dispatch Decision with Correlated Uncertainty Variables

Each simulation samples (picks) points on each distribution using Monte Carlo sampling techniques and considers how the variables are correlated. Solving the dispatch decision based on the sampled variables, which are estimated thousands of times, results in revenues and variable costs.

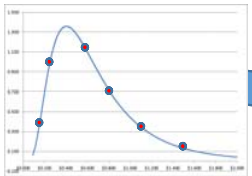


8. Flow Simulation of Dispatch Decision Through Cash Flow Model

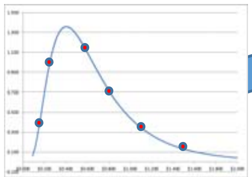
With each simulation, the plant model is run to calculate revenues, variable costs and cash flows based on the sampled uncertainty variables.



Power Prices



Fuel Prices



EA Prices

All dollars in millions

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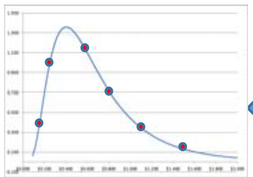
Cash Flows

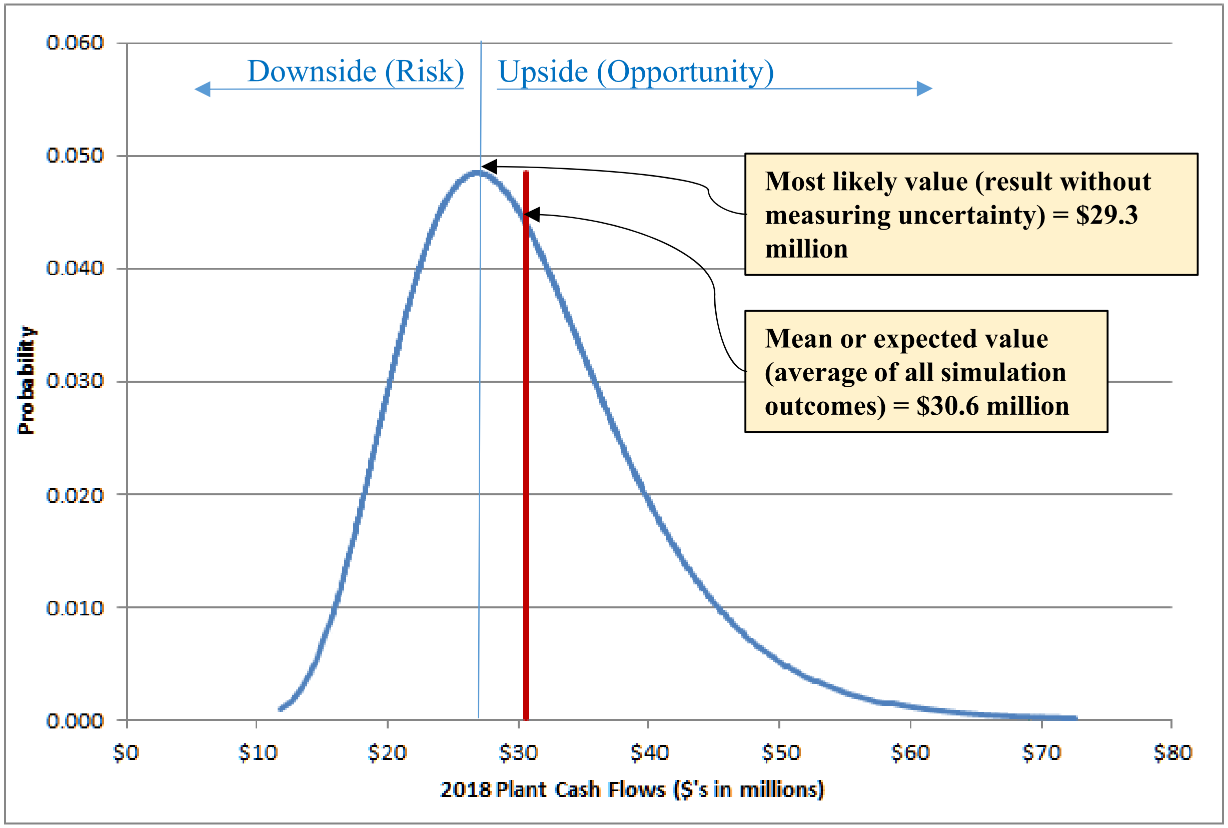


Range of possible Cash Flow outcomes becomes the output.

9. Generate Distribution of Cash Flows

The simulation output (2018 cash flows in the example below) shows the range of possible cash flows based on the correlated uncertainty variables, which can be referred to as a cash flow risk profile.

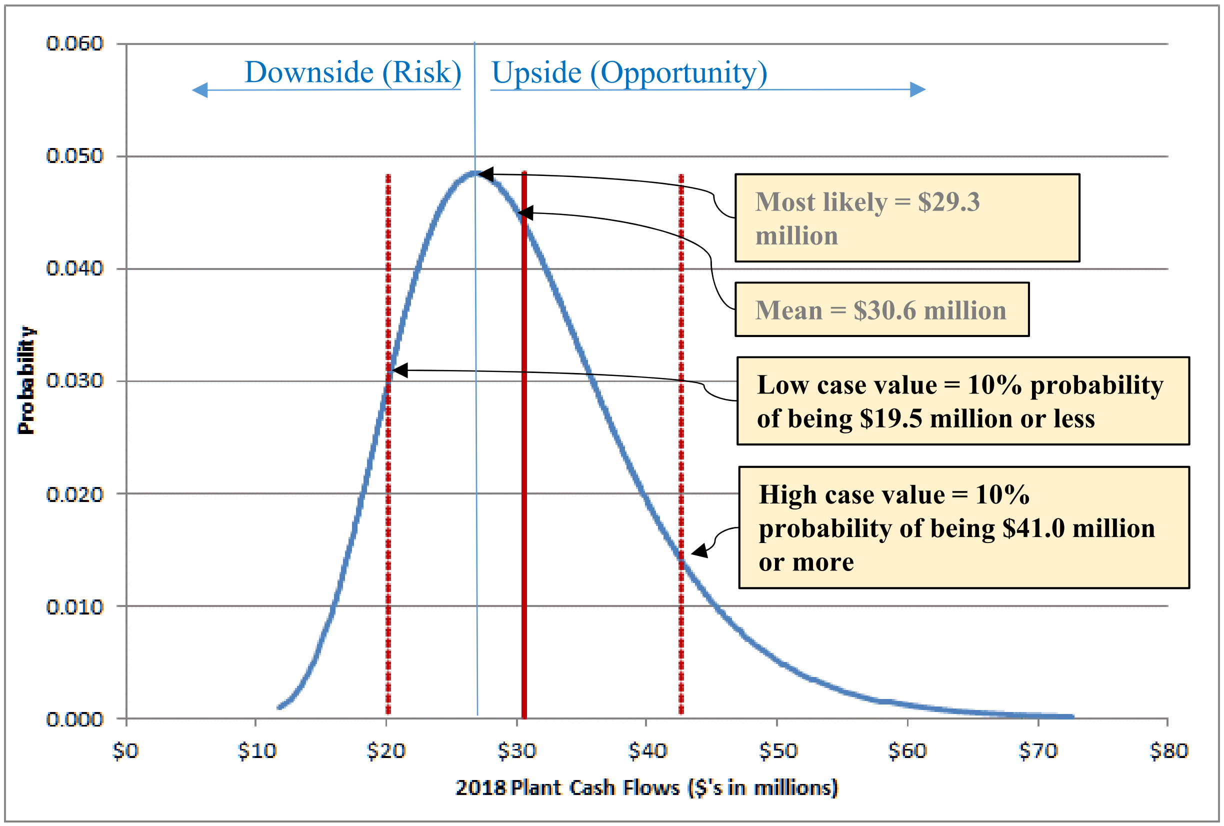
Range of possible cash flow options can be expressed as a probability distribution, showing cash flow risk and opportunity



10. Identify Range of Possible Cash Flows

The simulation output allows for the identification of representative "High Case" and "Low Case" cash flow values.

Power plant cash flows are skewed to the right (upside) because power prices are skewed to the right



Summary

By injection economic dispatch simulation into power plant planning models, a distribution of possible cash flows can be generated.

This approach to assessing financial risk of power plants can be a highly effective tool for the following decision support activities:

- ✓ **Development of power plant hedging strategies** for power and fuel by starting with a desired cash flow risk profile and adding price hedging instruments, such as fixed price contracts or financial derivatives to meet the desired profile;
- ✓ **Support for power plant acquisition, sales and retirement decisions** by developing the real option value of an asset through the discounting of cash flows over the remaining life of an asset;
- ✓ **Proper valuation of power contracts with dispatch optionality** by modeling the contract like an actual power plant;
- ✓ **Analysis of portfolio effects for a fleet of power plants** by allowing for the revelation of natural hedges and correlations between assets in a portfolio; and
- ✓ **Evaluation of capital expenditures** by calculating the return on capital based on a distribution of discounted cash flow results.

For more information or to discuss specific needs, please contact Tom Crowley or Brian Despard at (703) 836-0100.