Case Study:
Electric Energy Resource Planning – *Which Technology is the Lowest Cost and How can we be certain?*

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Some terms I'm going to use

- **Life cycle economics**
- **NPV – Net Present Value**
- **Enterprise risk management**
- **Uncertainty**
- **Risk**
- **Risk tolerance**
- **Risk mitigation**

Why I use @Risk

- **Monte Carlo modeling engages a risk process consistent with the ERM process adopted by COSO and Sarbanes Oxley**
- **The process includes (besides running @Risk):**
  - **Thinking through the problem at hand**
  - **Deciding which input drivers will affect the outcome**
  - **Defining the degree of certainty associated with each key driver**
  - **Evaluating the likelihood of success or failure**
  - **Establishing the level of risk tolerance you are willing take**
  - **Determining which input drivers affect the outcome the most and how to control them.**

Defining an input probability is a challenge - but not as hard as you think

- You need to ask the right questions
- Be able to translate non-parametric information into a probability distribution
- Use historical data complemented by expert forecast

Scope: To prepare an independent and objective assessment of alternative base load generation

- **Energy Strategies, Inc. was retained to perform an independent assessment of the comparative life cycle economics of alternative base load generation.**
- **Key input drivers are defined by a unique set of probability distributions based on forecast uncertainty.**
- **Outcomes, as measured by Net Present Value (NPV) and levelized costs, are also expressed as a probability distribution representing the range of possible outcomes.**
- **The likelihood that a selected source of generation is more costly than one of the other alternatives is a measure of risk.**

Terminology used in Defining Risk:

- **Uncertainty** exposes us to a range of outcomes – which may be neither good or bad. We can define input uncertainty by assigning a probability distribution for each key driver.

- **Risk exposure** on the other hand is the relative cost of a given outcome. We use both levelized costs and Net Present Value of future expenses to compare one form of generation with another. For each, a probability distribution which defines the range of possible outcomes is also defined by a probability distribution.

- **Risk tolerance** is the balance between the level risk, its likelihood and competitive demands for our capital resources.

Monte Carlo Analysis:
The method used to model uncertainty and calculate risk. Both uncertainty and risk are defined in terms of probabilities, likelihood and confidence bands.

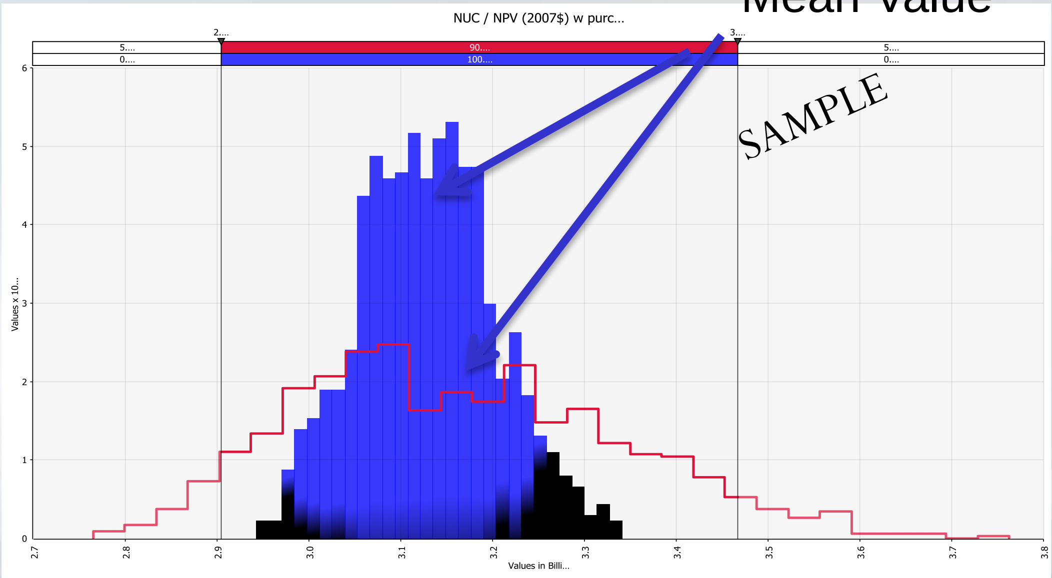
- **For this study we used probability distributions to define both input uncertainty as well as output risk exposure.**
- **A cumulative probability distribution is also used to assess the likelihood or percent of time that one form of generation is more or less expensive than another.**

Evaluating Relative Risks and Benefits:

A Probability Distribution tells us three things:

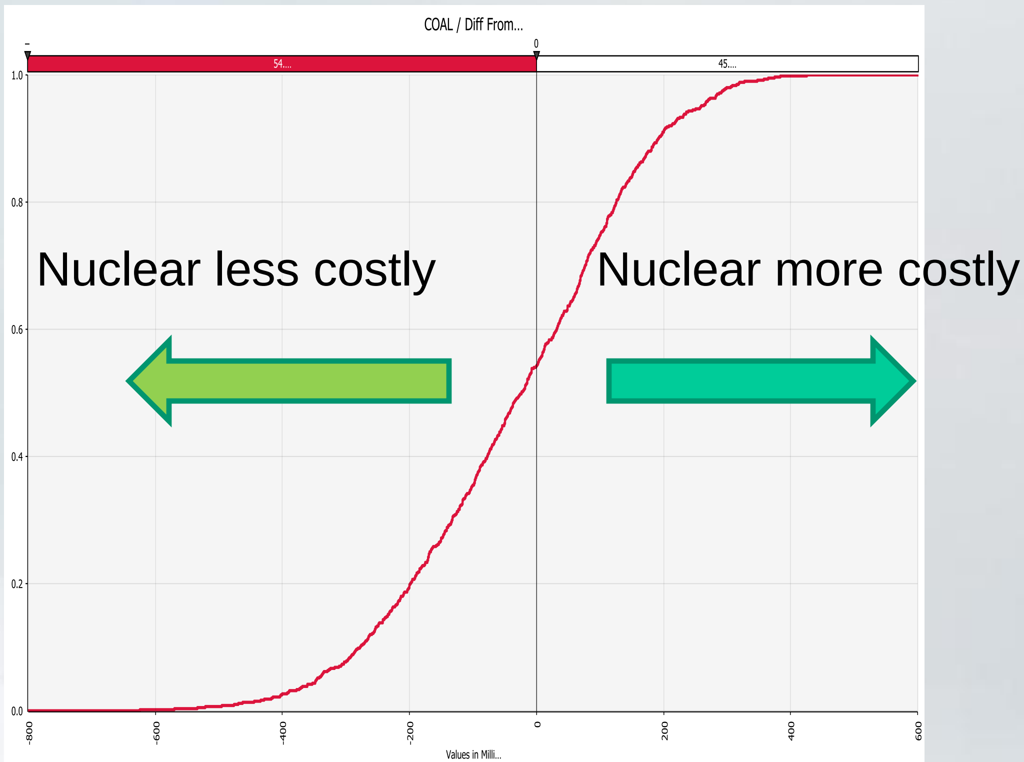
1. **The comparative mean values – in the sample below, both are about the same**
2. **The spread of possible outcomes – the blue curve has a narrow band which means its results have greater certainty while the red curve has a greater likelihood of being more or less expensive**
3. **The level of risk tolerance is a matter of preference: By choosing the blue curve one has a lower risk tolerance by giving up greater potential gains for greater potential losses.**

Mean Value



The Cumulative Probability Curve: This graph tells us the likelihood that one form of generation is more or less expensive than another.

Diff in NPV = Zero



The Probability Distributions were developed using the following ranges in capital costs as expressed in 2007 dollars

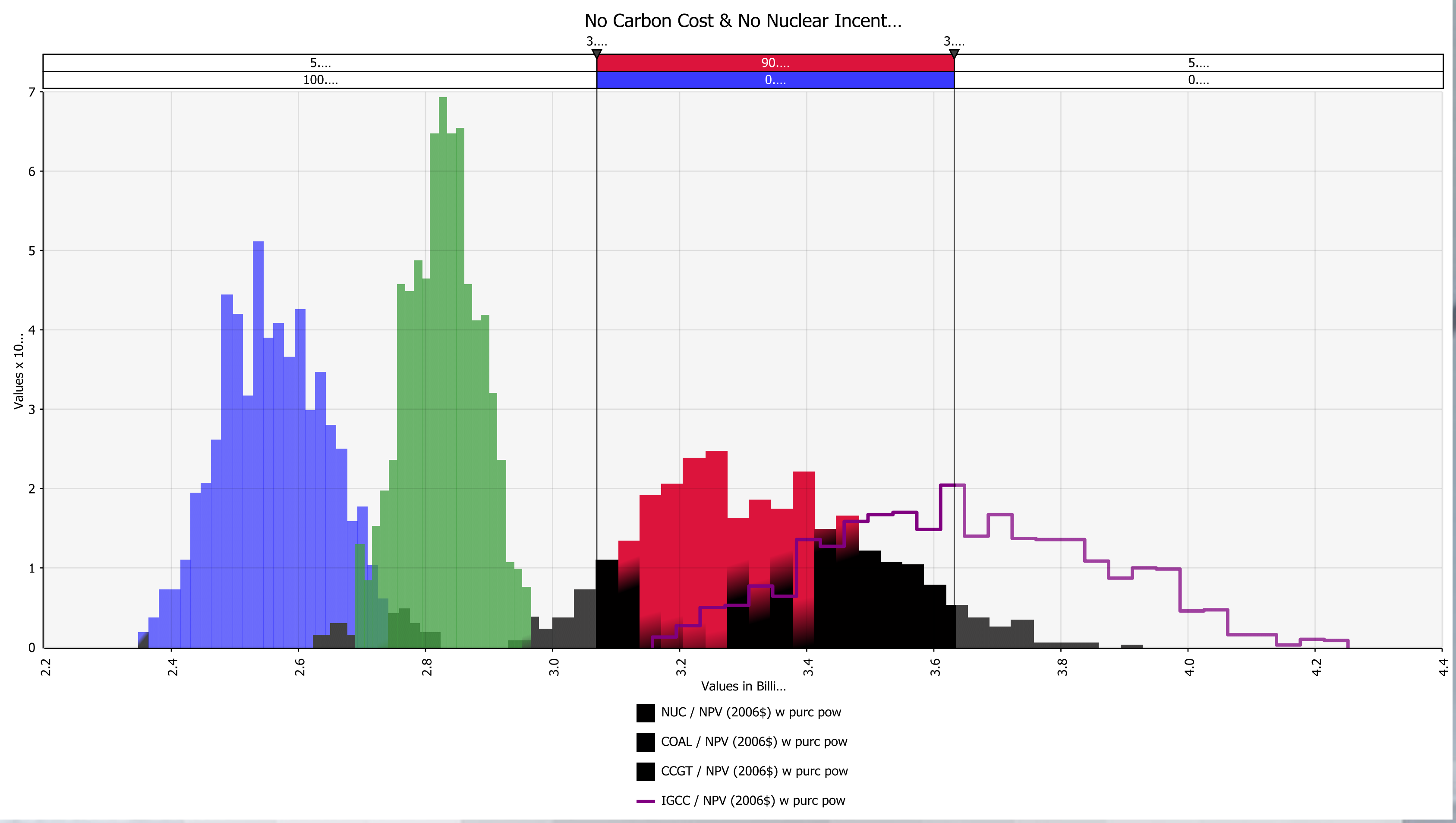
Construction Costs

$/kw

	Low	Mid	High
Nuclear	4,000	4,600	6,000
Coal	1,400	1,700	2,300
CCGT	600	700	1,000
IGCC	2,600	3,600	5,000

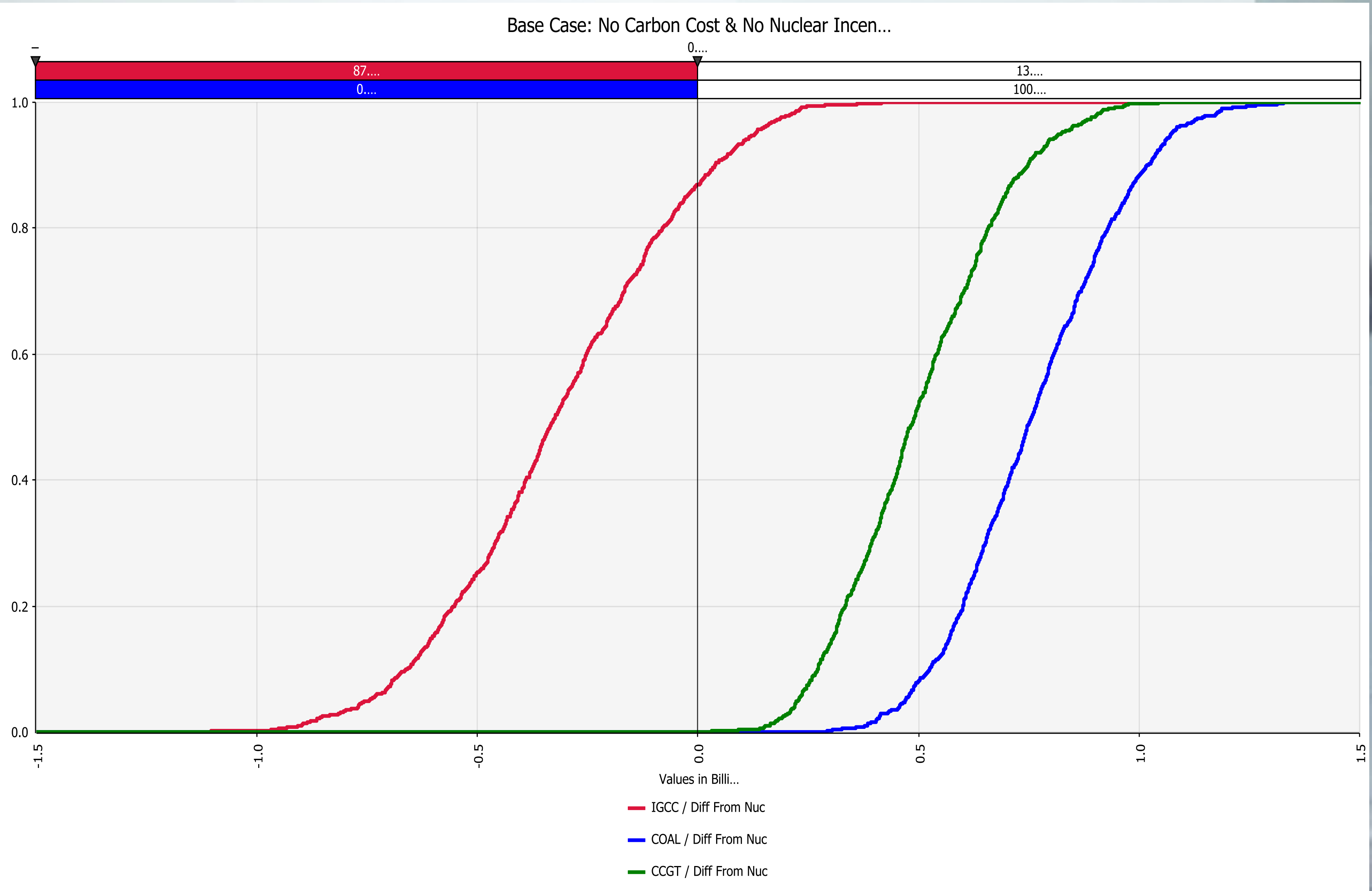
Base Case Scenario: No Carbon Tax & No Nuclear Incentives

Findings: W/O Carbon cost, Coal is least expensive given a wide range of uncertainties; CCGTs which burn natural gas are slightly more expensive



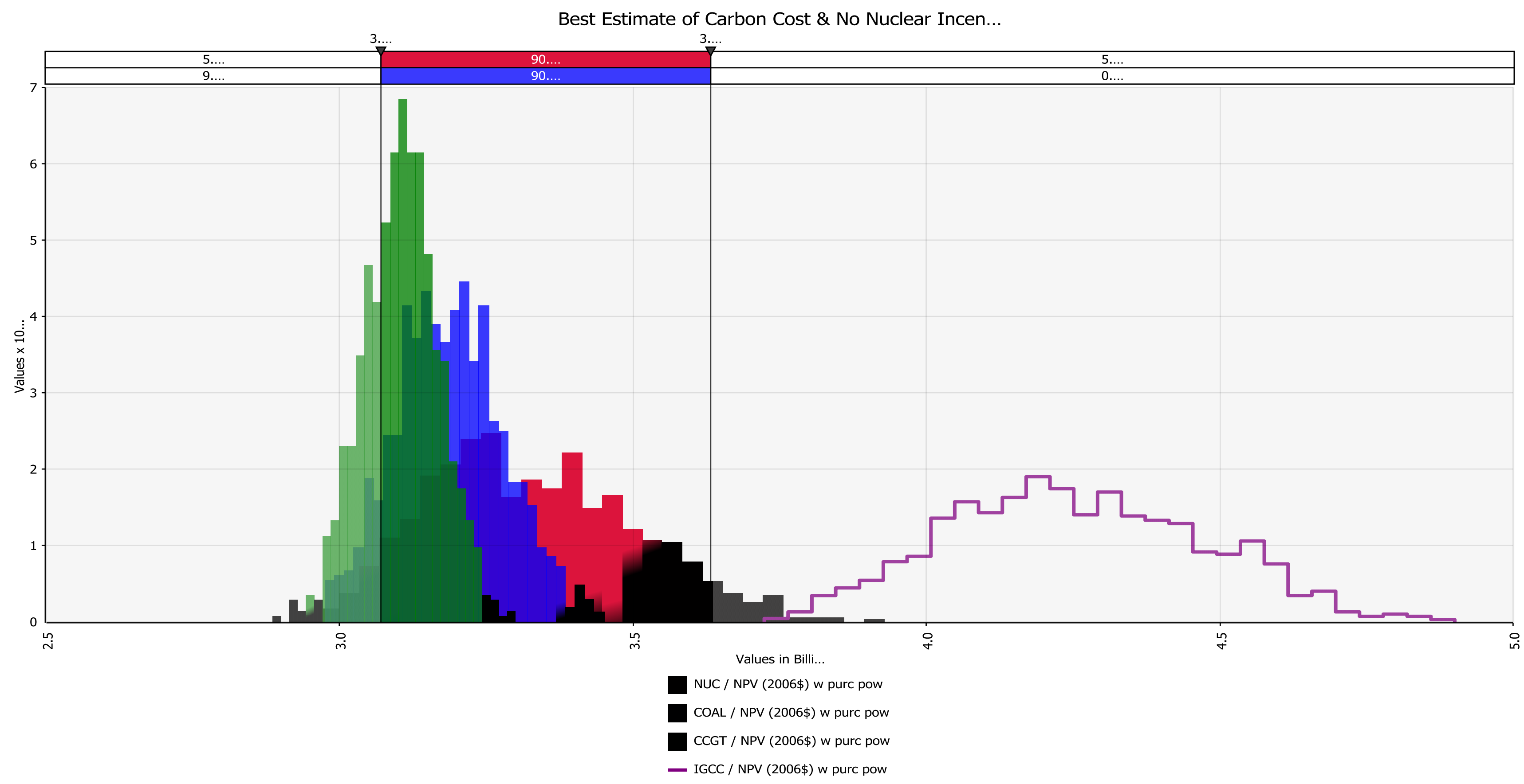
Base Case: No Carbon Cost & No Nuclear Incentives

Nuclear NPV compared to Coal, CCGT and IGCC

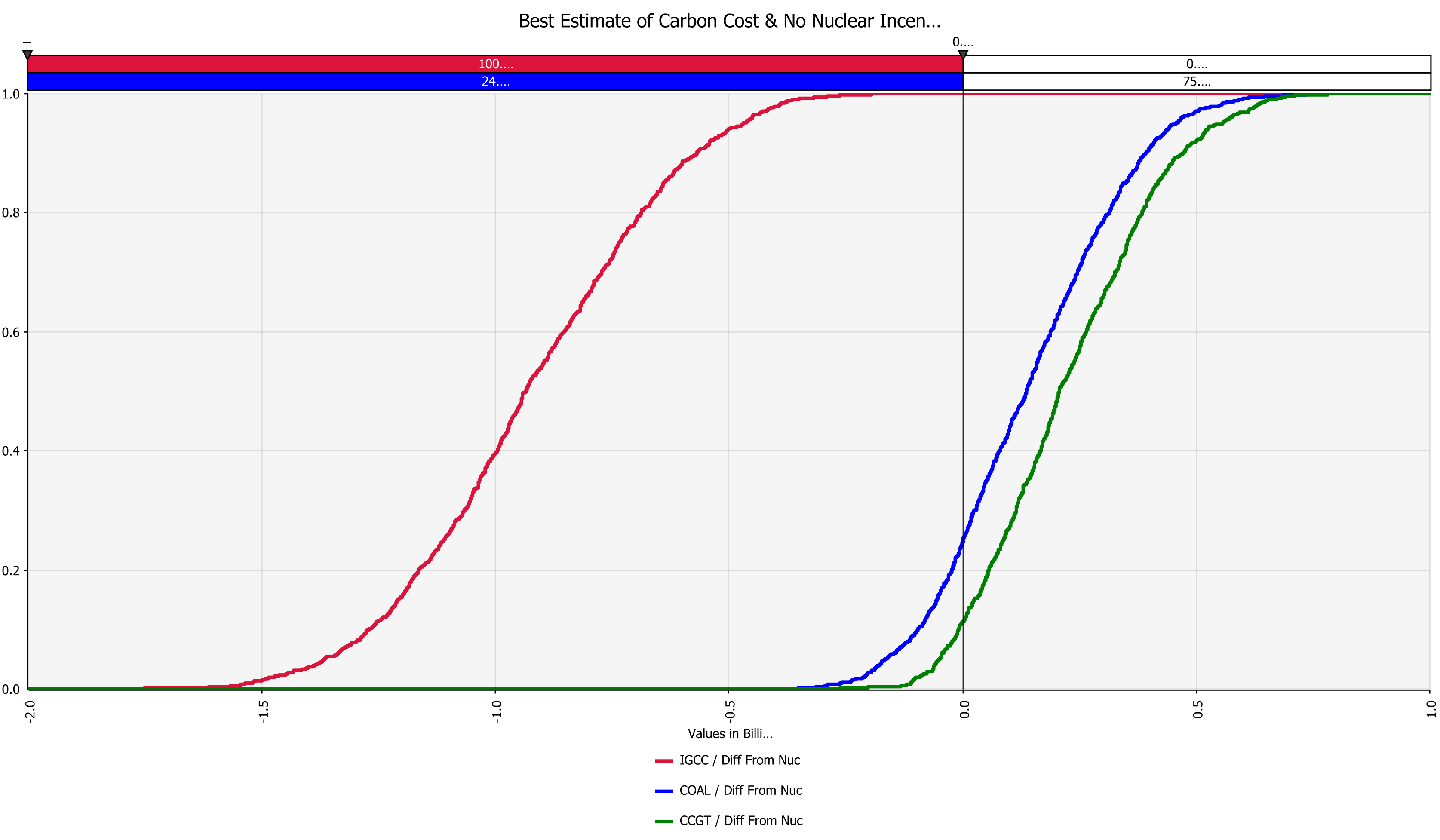


Carbon Scenario: Best Estimate of Carbon cost with no Nuclear Incentives

Finding: Between a $10 - $20 carbon cost Coal & CCGT are nearly the same and are less expensive than nuclear a majority of the time.

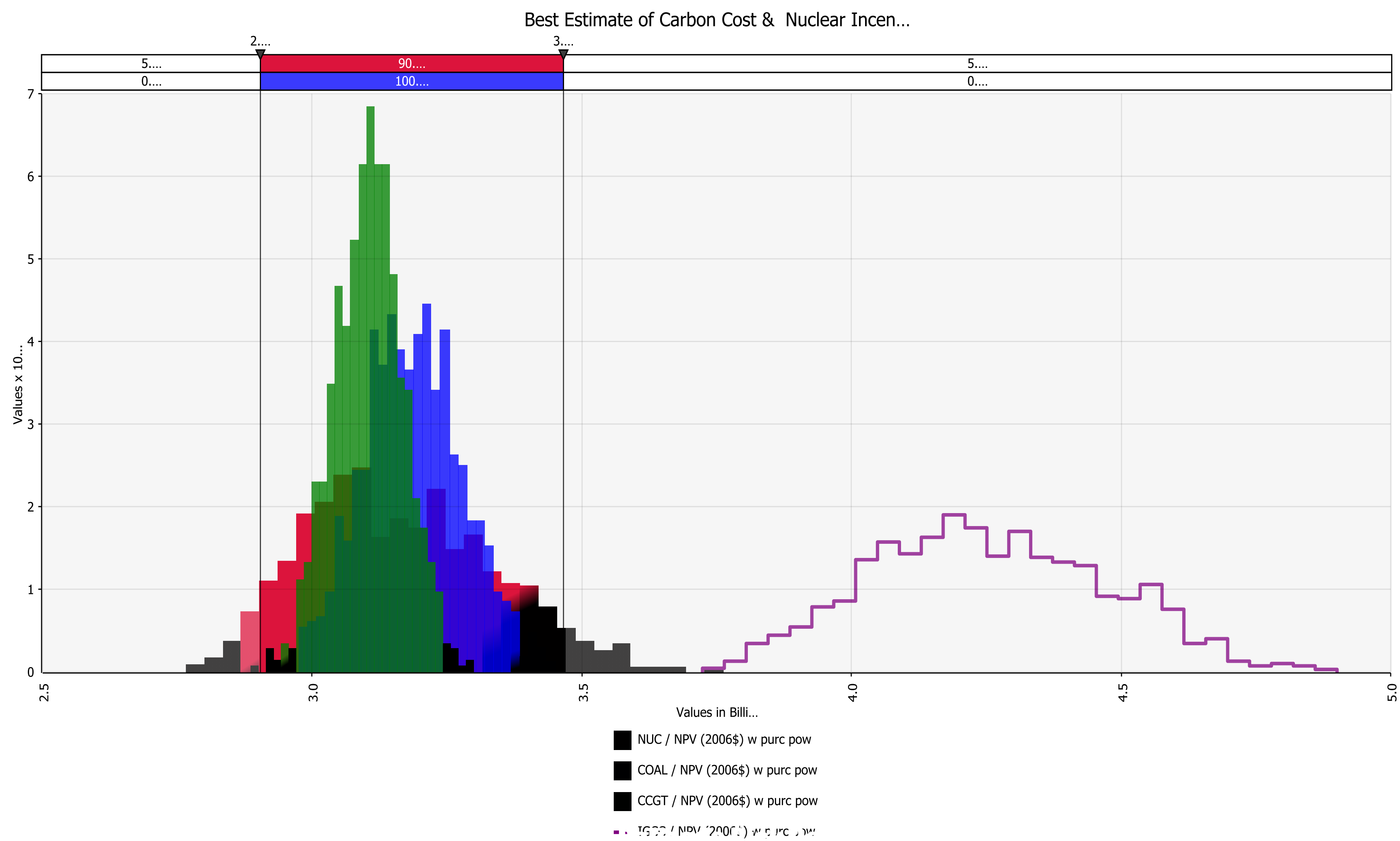


RESULTS:
Best Estimate of Carbon Cost & No Nuclear Incentives

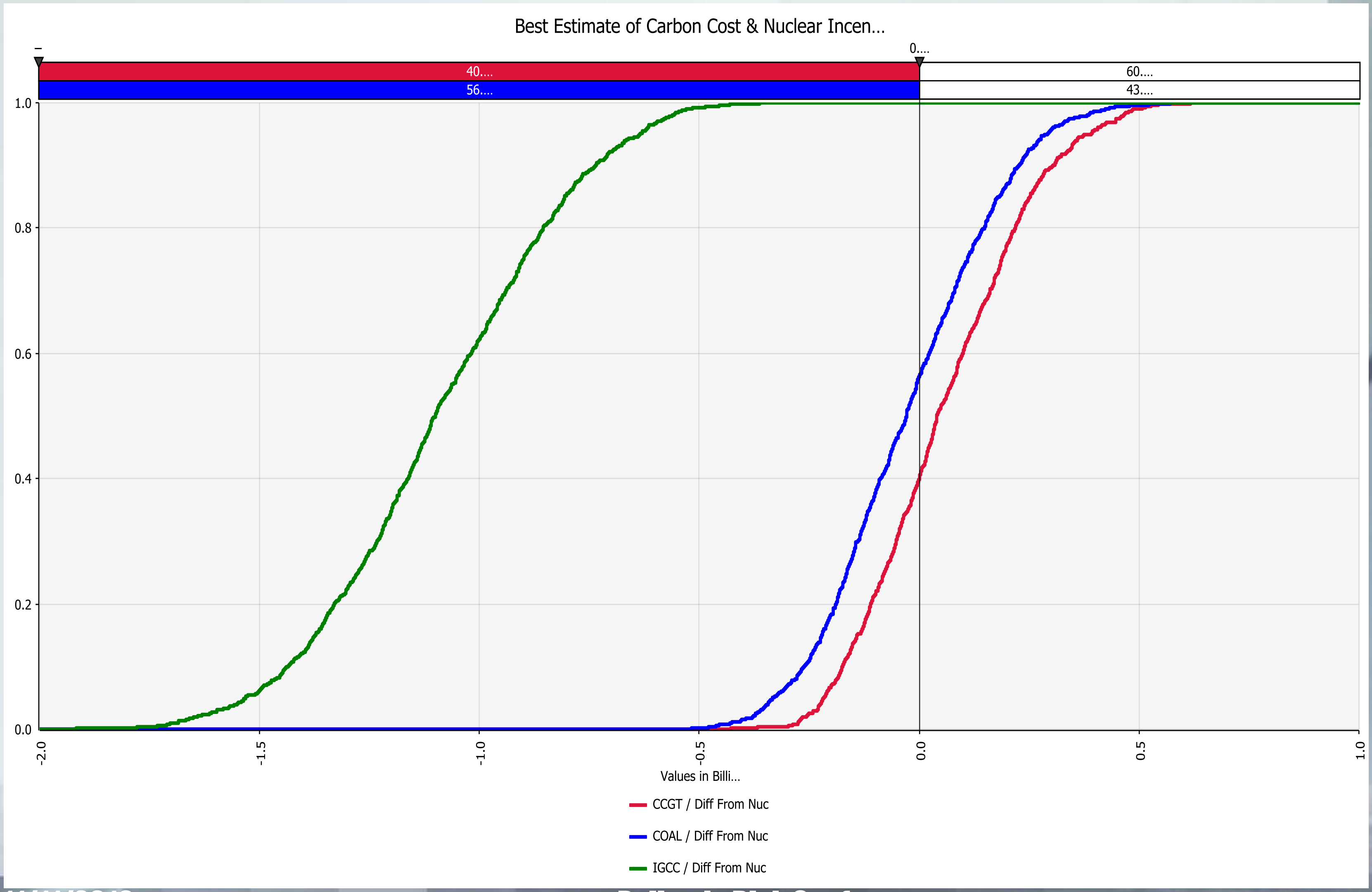


Best Estimate Carbon Cost & Revenue Tax Credits

Findings: Between a $10 - $20 Carbon cost with the Revenue Tax Credit; nuclear becomes more competitive . Coal and gas are comparable with each other and less than nuclear about 50% of the time.



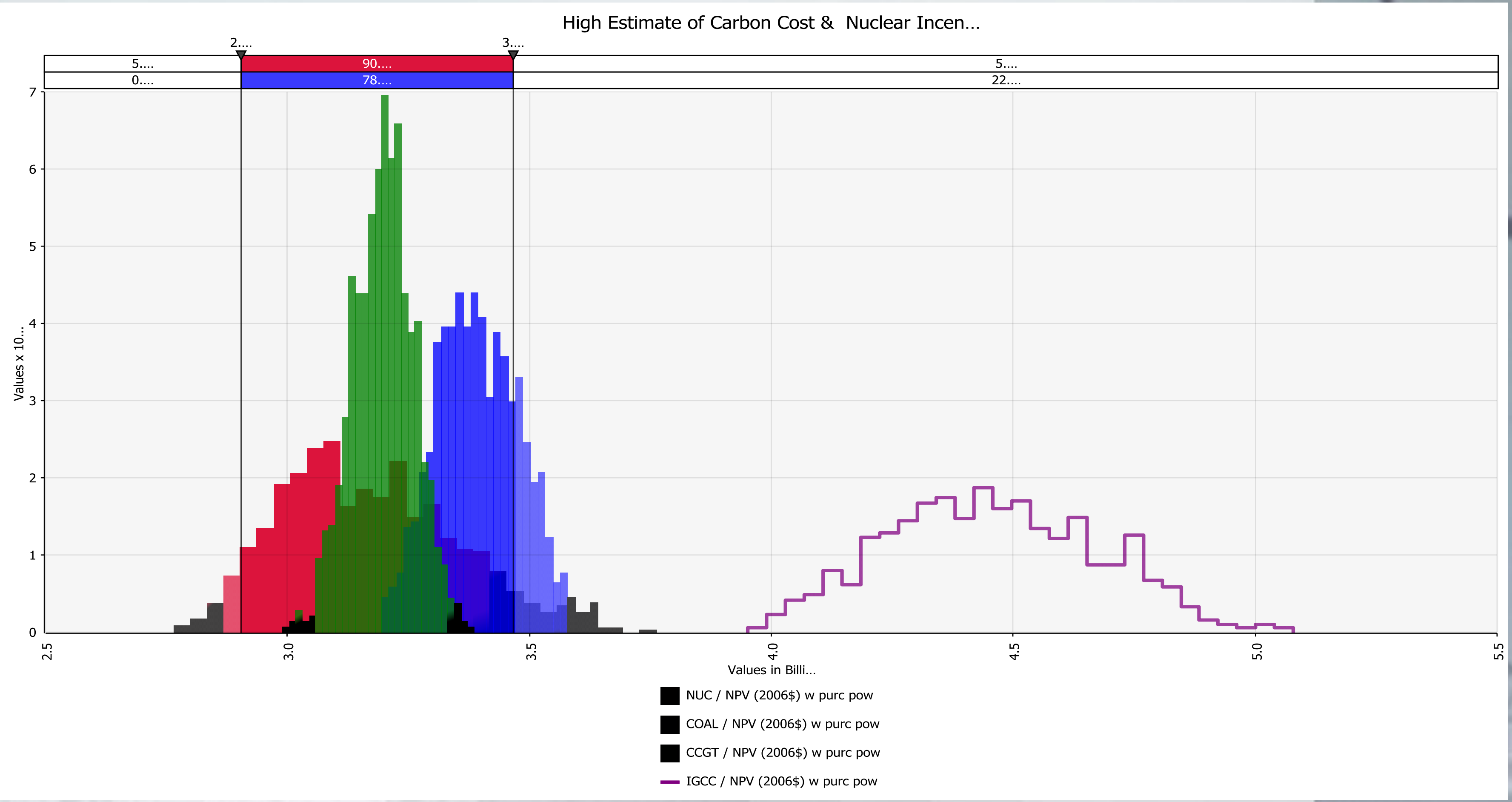
RESULTS:
Best Estimate Carbon Cost & Revenue Tax Credits
Nuclear is now competitive with both coal and CCGT.



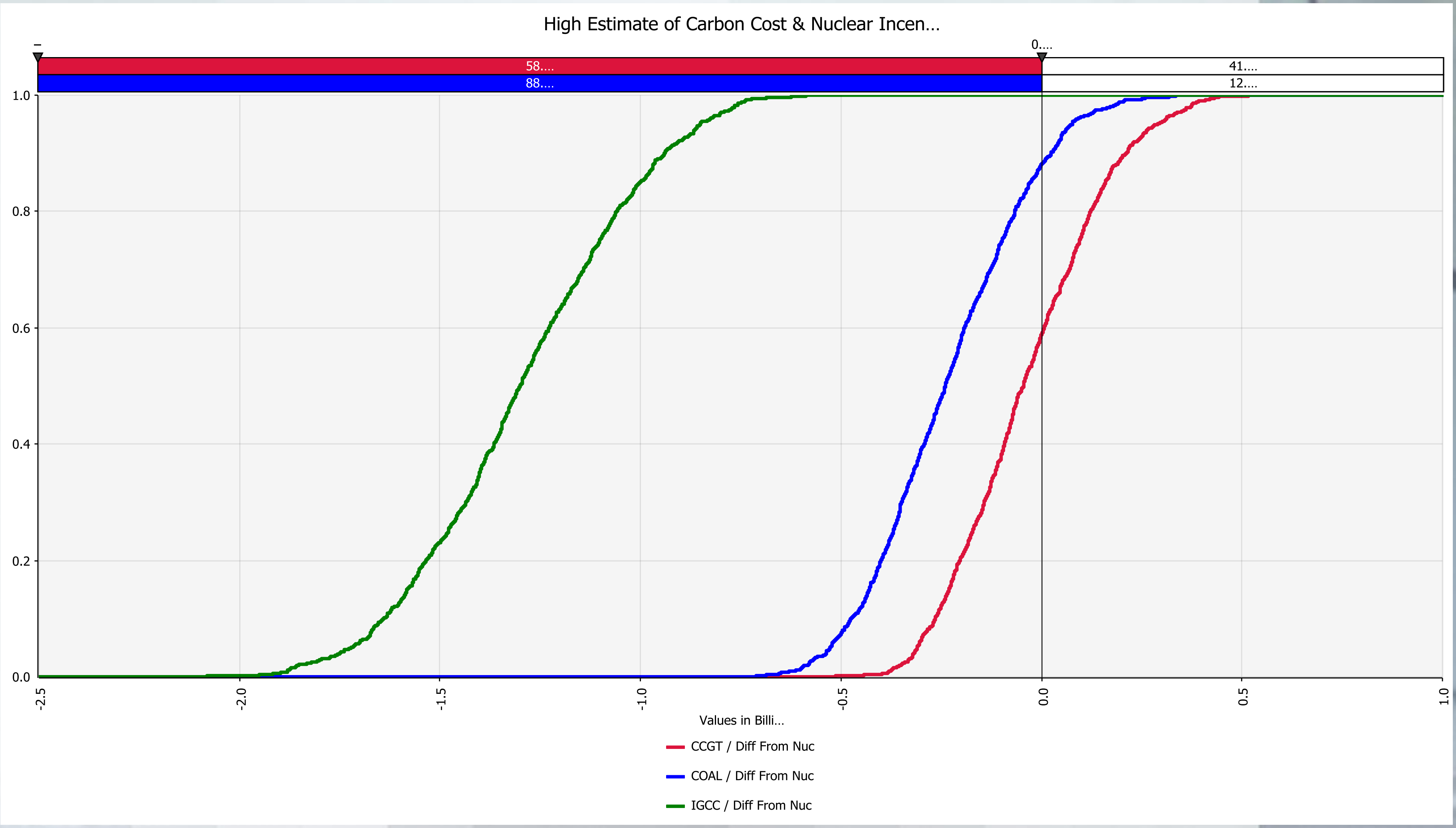
RESULTS:

Higher Carbon Cost & Revenue Tax Credit

Findings: At a higher carbon cost estimate of $20 per ton and adjusted for inflation, nuclear and CCGT become much more competitive. As carbon cost increases, nuclear becomes more competitive.

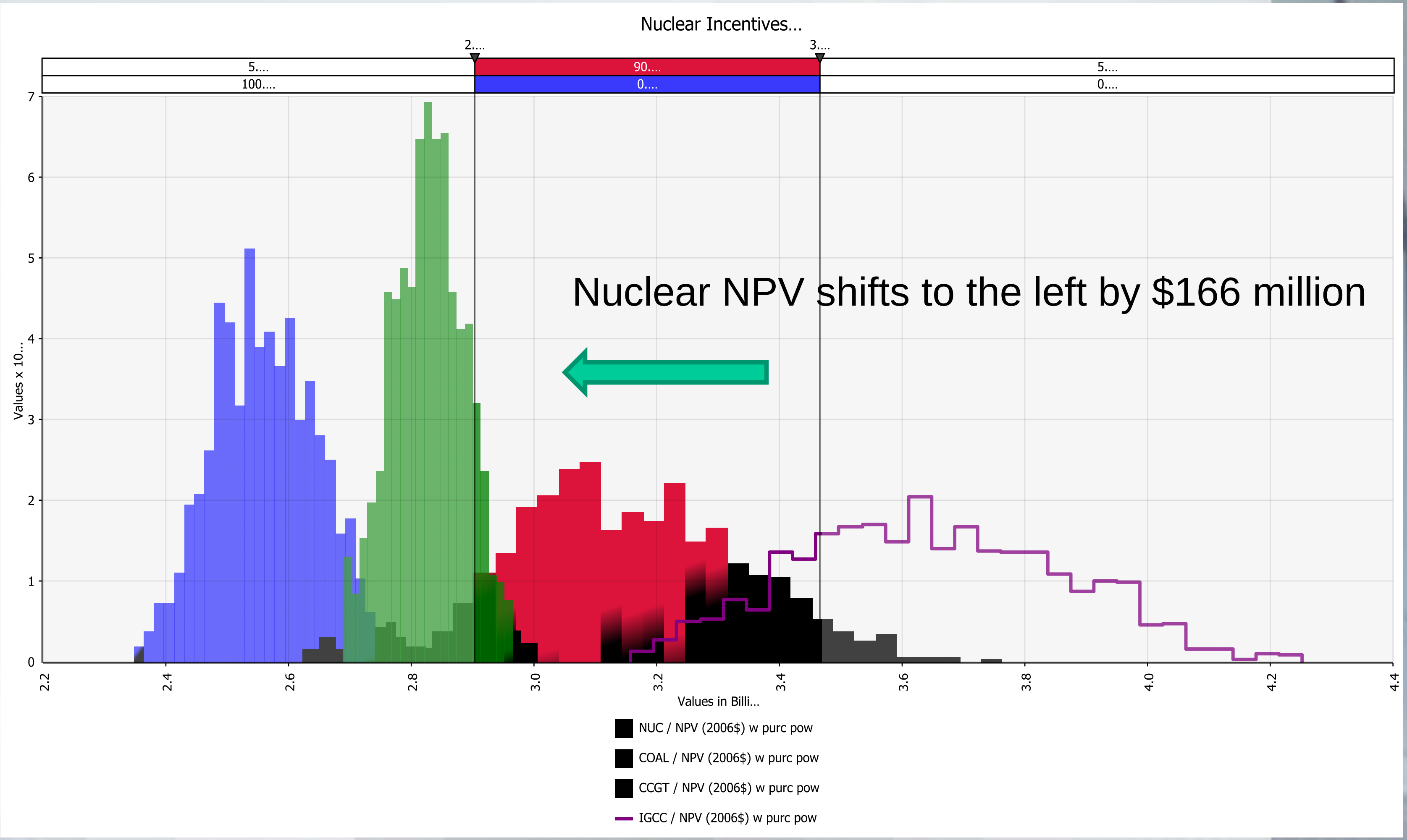


Scenario: Higher Carbon Cost & Revenue Tax Credit

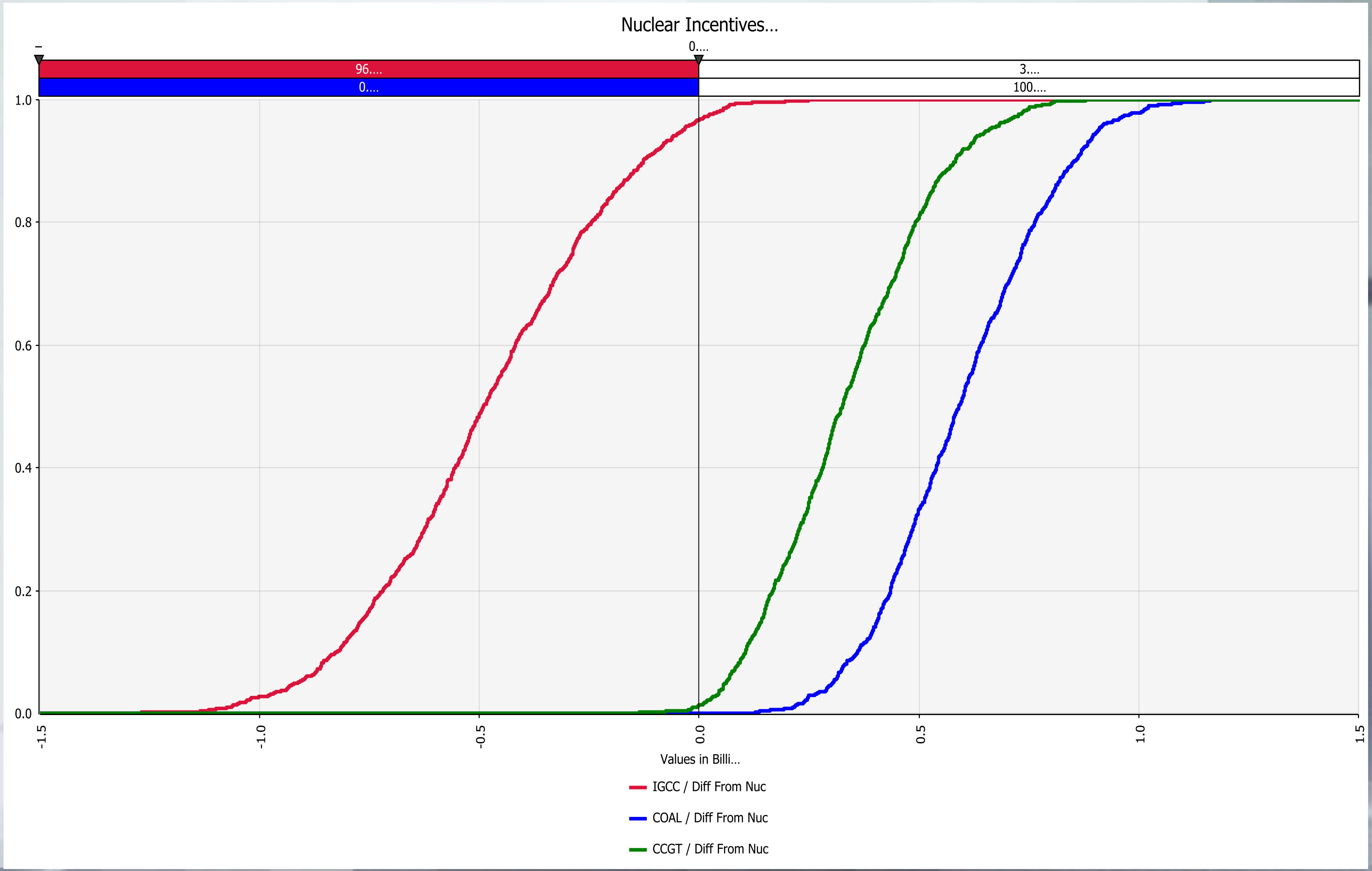


Scenario: Impact of the Nuclear Revenue Tax Credit with No Carbon Tax

Finding: the Revenue Tax Credit does reduce the Nuclear NPV by $166 million (2007$)



Scenario: Revenue Tax Credit Assessment



Some findings

- The risk model developed for this study considers the uncertainty of a wide range of cost and environmental inputs.
- With no Carbon cost, coal is the most viable choice. The higher the Carbon cost, the more likely a nuclear plant will be the lowest cost.
- With Carbon Cost at $20 per ton, nuclear, coal and CCGT's are all a close choice in terms of average NPV and risk exposure.
- If a utility could capture the benefits of the EPACT'05 Revenue Tax Credit, nuclear is competitive at $10 per ton Carbon cost; and as the Carbon cost exceeds $20, nuclear becomes the more viable or least cost option.

As the Carbon Cost rises, the relative economics shifts from coal to CCGT to nuclear.

The hard decisions

- If a Carbon Tax is imposed, it is then possible for all three types of base load power plants to have the same NPV
- The question becomes: what factors create the greatest risk and can they be controlled, mitigated or transferred?
- For Nuclear it is Capital Cost
- For Coal it is carbon tax
- For Natural Gas it is fuel prices