Decision Making under Uncertainty

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Michael Schilmoeller

Northwest Power and Conservation Council

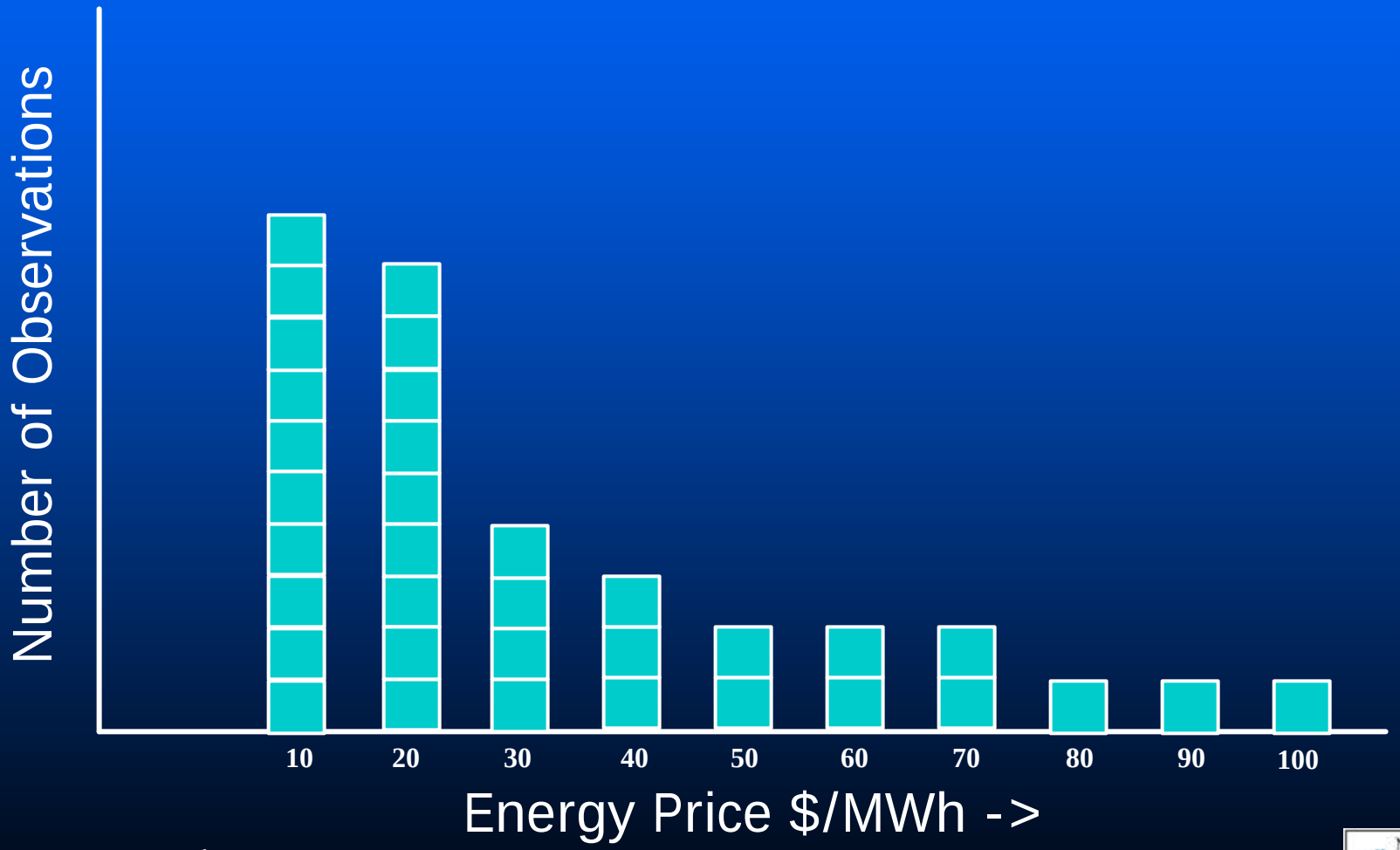
Overview

- Review of concepts from last presentation
  - Distributions
  - Variation and uncertainty
  - Risk measures and conditional value at risk
  - Risk-constrained least-cost planning
- Cost-risk trade-off
  - Efficient frontier
- Fixed cost risk
- Electric power industry risk, a 30-year perspective

Review

- Recall from last time that we considered the cost of energy produced by a combustion turbine
- To illustrate the construction of a distribution for the cost, we considered energy costs due to predictable variation of natural gas prices over the course of a month ….

Distribution of Energy Prices



Review

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Review

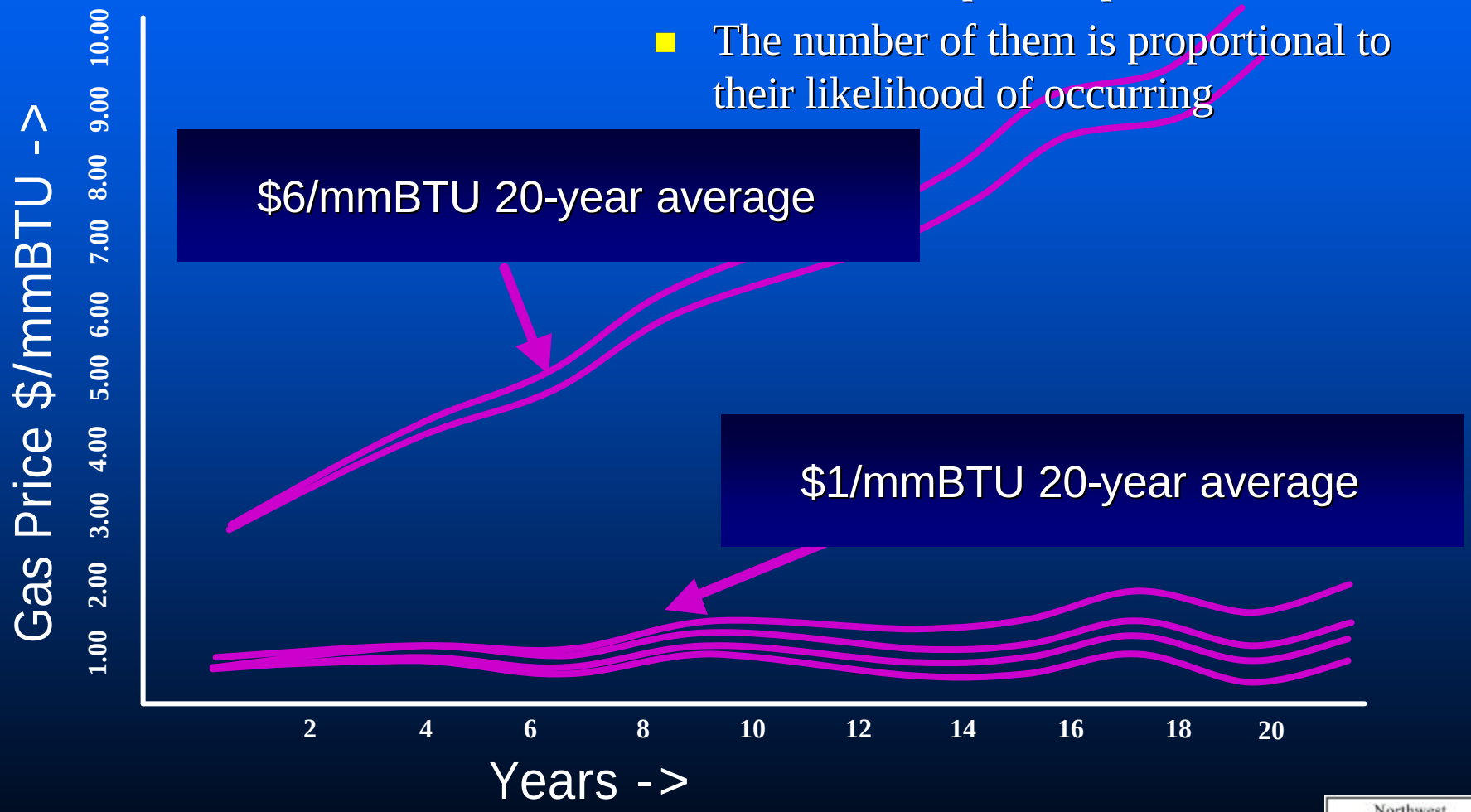
- … Where there is high certainty, average prices are probably fine for decision making, even where we have a lot of variation.
- We then contrast this with the situation where we consider possible “futures” and the uncertainty associated with these …

Decision Making Terms

- Plans
  - Future actions we can control
    - » Example: install conservation instead of a wind turbine
- Futures
  - Future situations we can not control
    - » Example: Natural gas price excursion
- Scenarios
  - Combinations of Plans and Futures
    - » Example: Scenario 1: Natural gas prices increase and we own a wind turbine; Scenario 2: High carbon taxes arise and we have built conservation

Uncertainty of Gas Price Futures

- Each of these paths represent a Future
- The number of them is proportional to their likelihood of occurring



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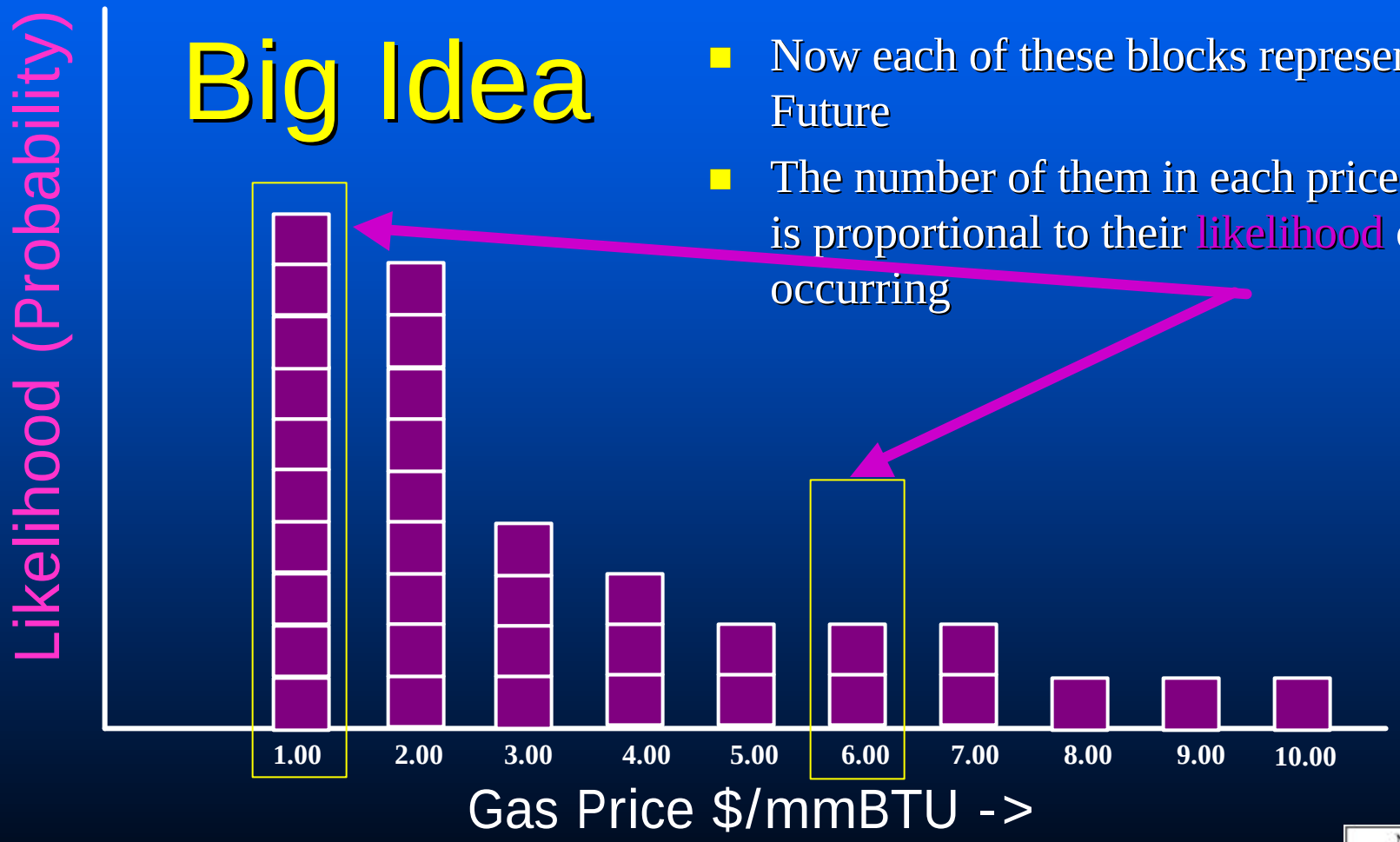
Review

- … Because we may be committed to a single outcome over the study period, the tails of the distribution may assume more importance than the average …

Review

Big Idea

- Now each of these blocks represent a Future
- The number of them in each price bin is proportional to their likelihood of occurring



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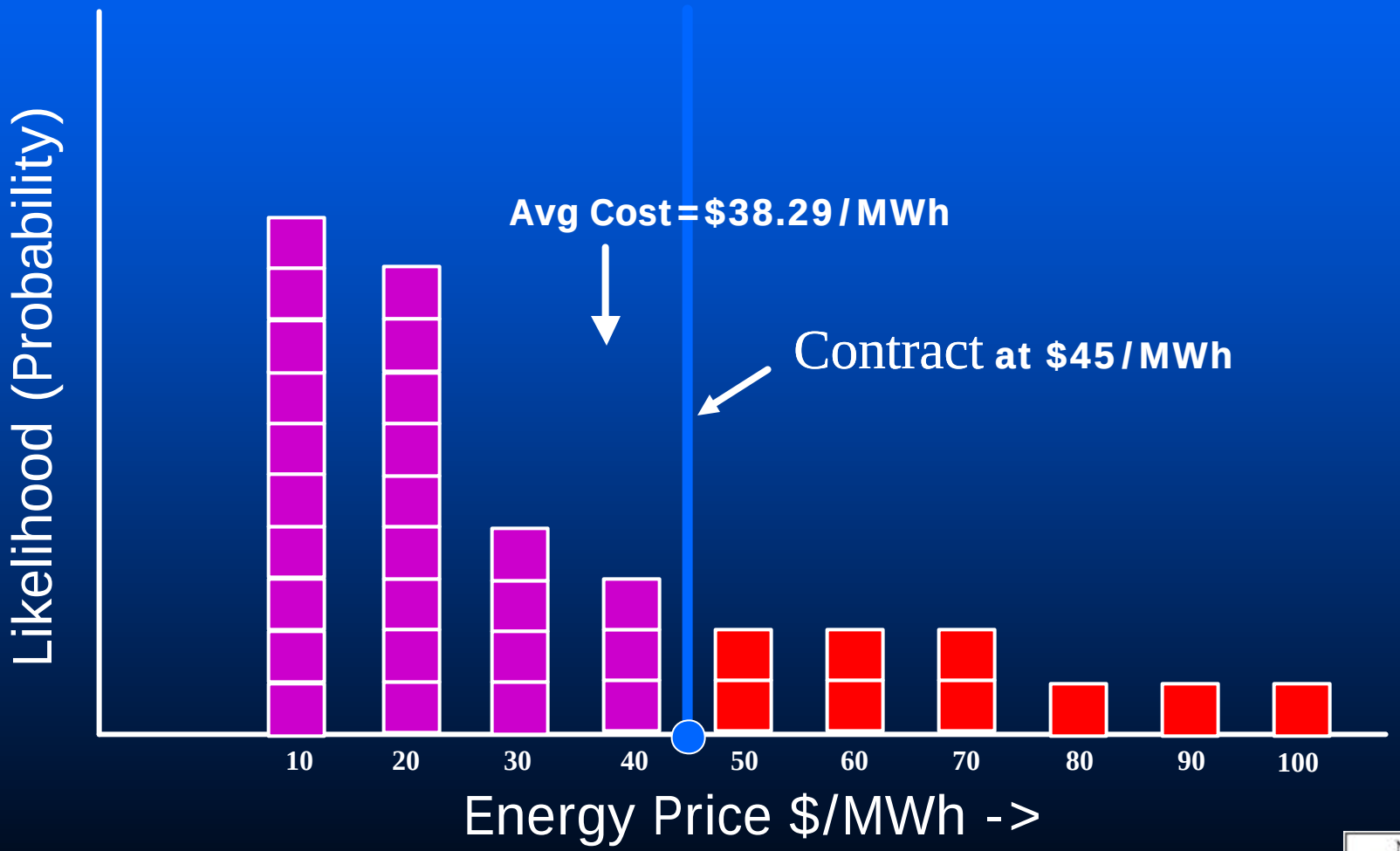
Review

- … As a specific example, if we compare energy prices from a turbine, with uncertain natural gas price futures with energy from a higher-cost, risk-free contract …

Decision under Uncertainty



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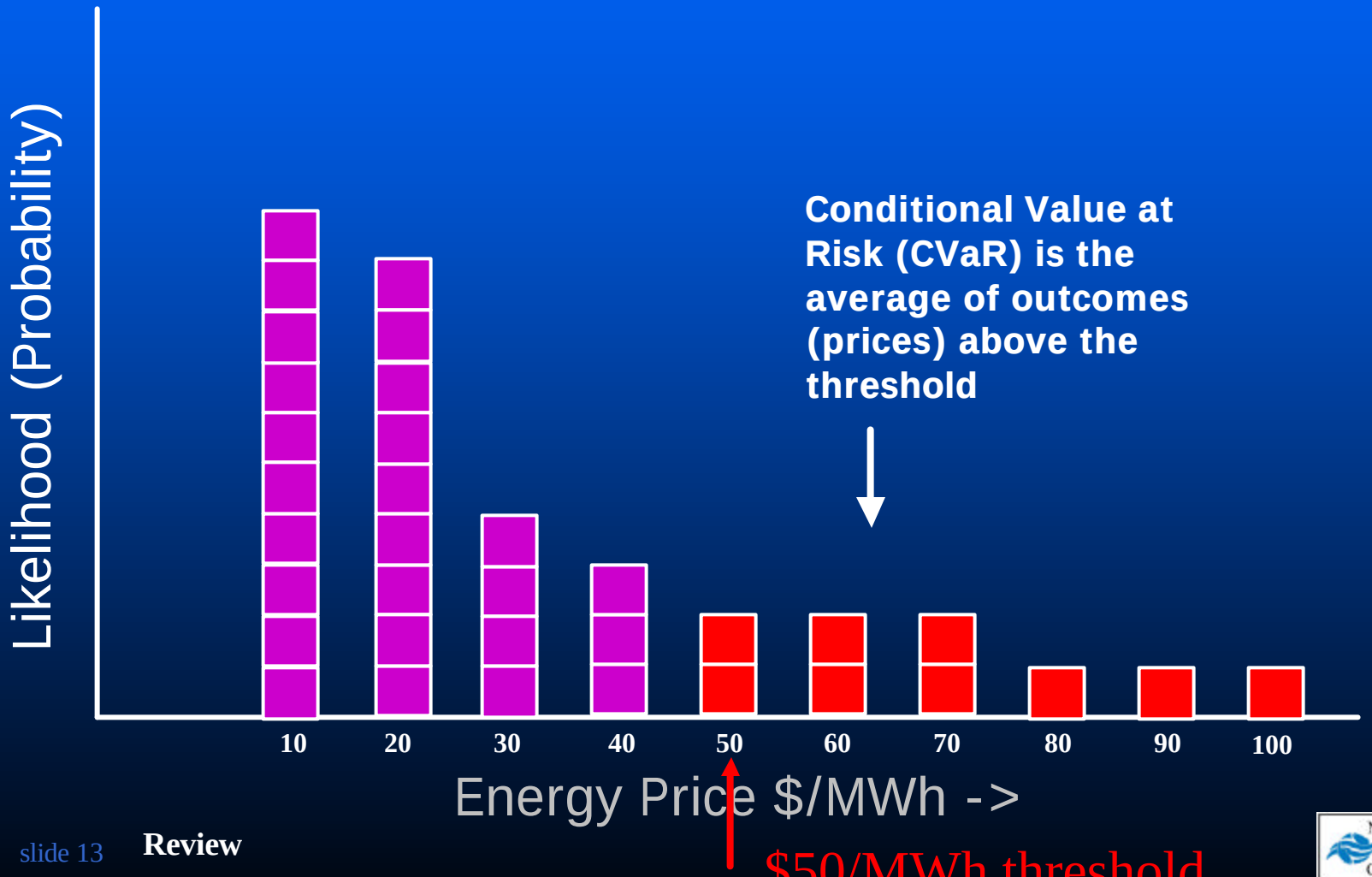
Review

- … We recognize the decision about which one to pursue looks more like one regarding the amount to pay for an *insurance policy*.
- To discuss and think about risk with precision, it is helpful to have a measure …

Risk Threshold and CVaR



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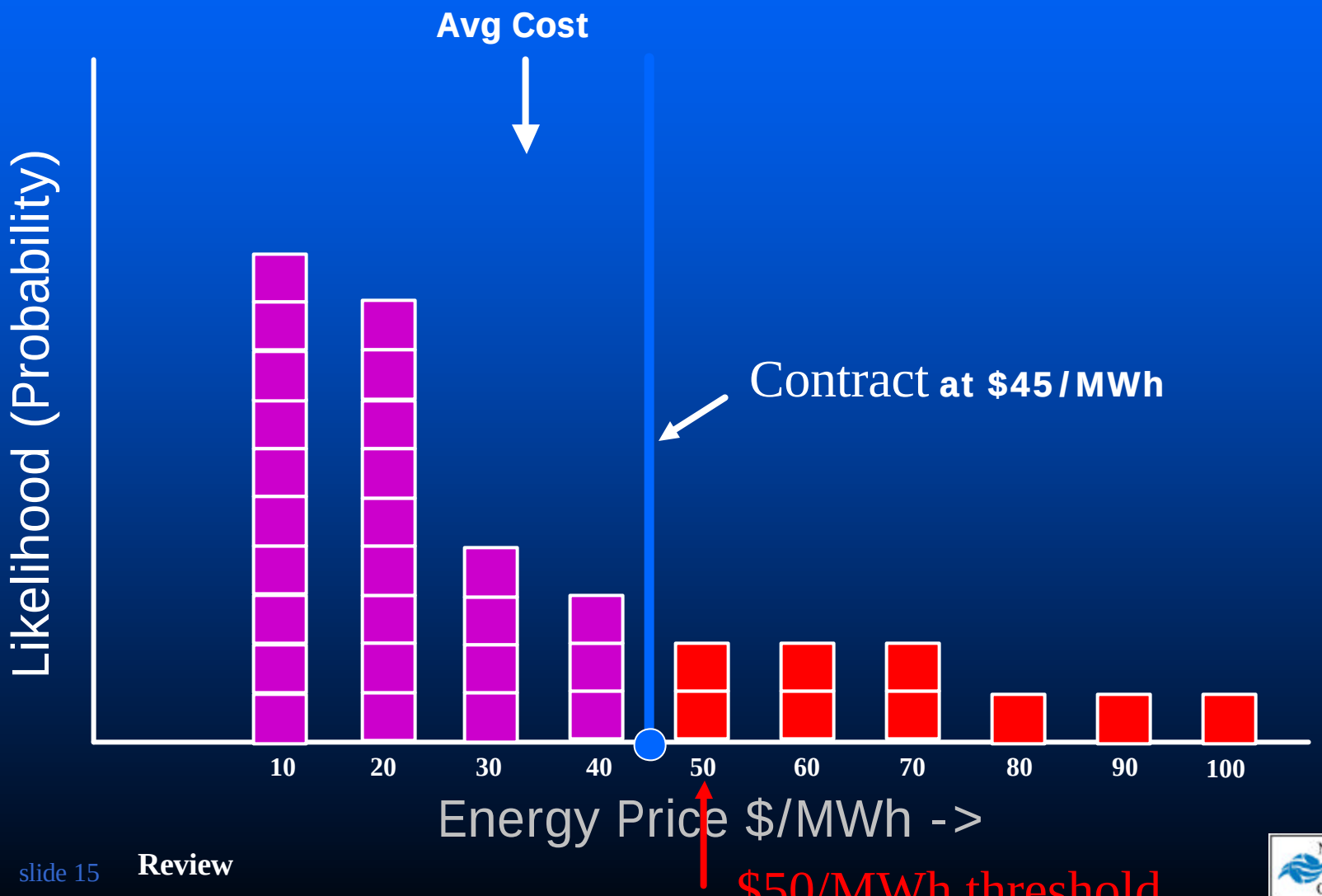
Review

- Finally, we looked at the situation where we could take a mix of combustion turbine energy and fixed contract, instead of one or the other.
- The combustion turbine provided lower expected cost and higher risk; the contract gave us no risk, but at substantially higher cost…

The Trade-Off



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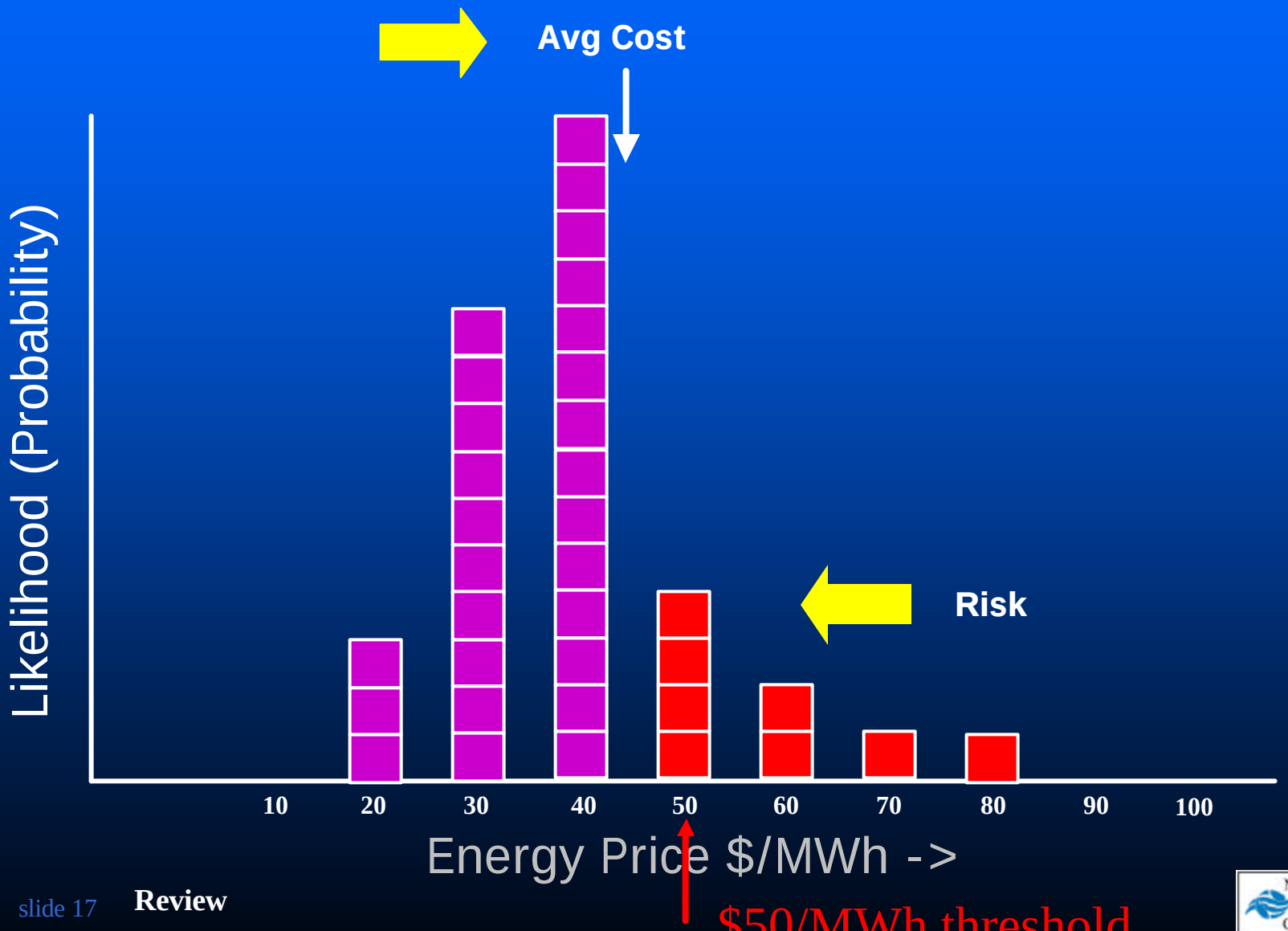
Review

- … and we saw that a mix of the two usually gave us lower risk than the turbine, but cost between the turbine and the contract …

The Trade-Off



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Conclusions From the September 9 Presentation

- Reducing risk costs something
  - Insurance
- For every level of risk, there is a least-cost means to obtaining it
- We want to choose the least-cost solution that satisfies our risk requirement
- Our model tell us which resources to pursue to do this

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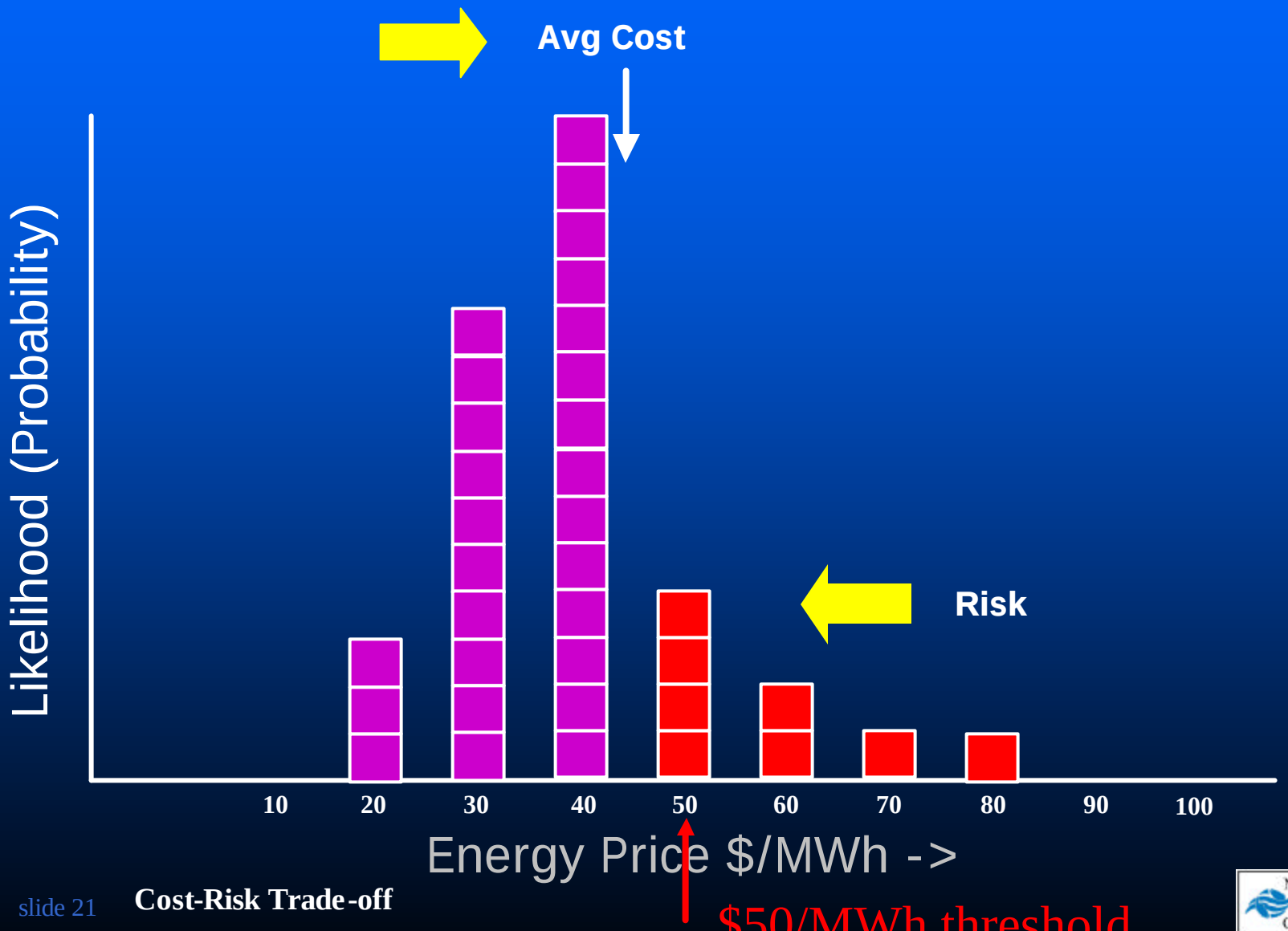
  - Efficient frontier
- Fixed cost risk
- Electric power industry risk, a 30-year perspective

Risk-Constrained, Least-Cost

- We return to where we left off at the last meeting
- Ask whether there is a least-expensive way to meet our objective
- Consider some cases
- In all of the following examples, we will be talking about future uncertainty, not variation

The Trade-Off



Cost-Risk Trade-off

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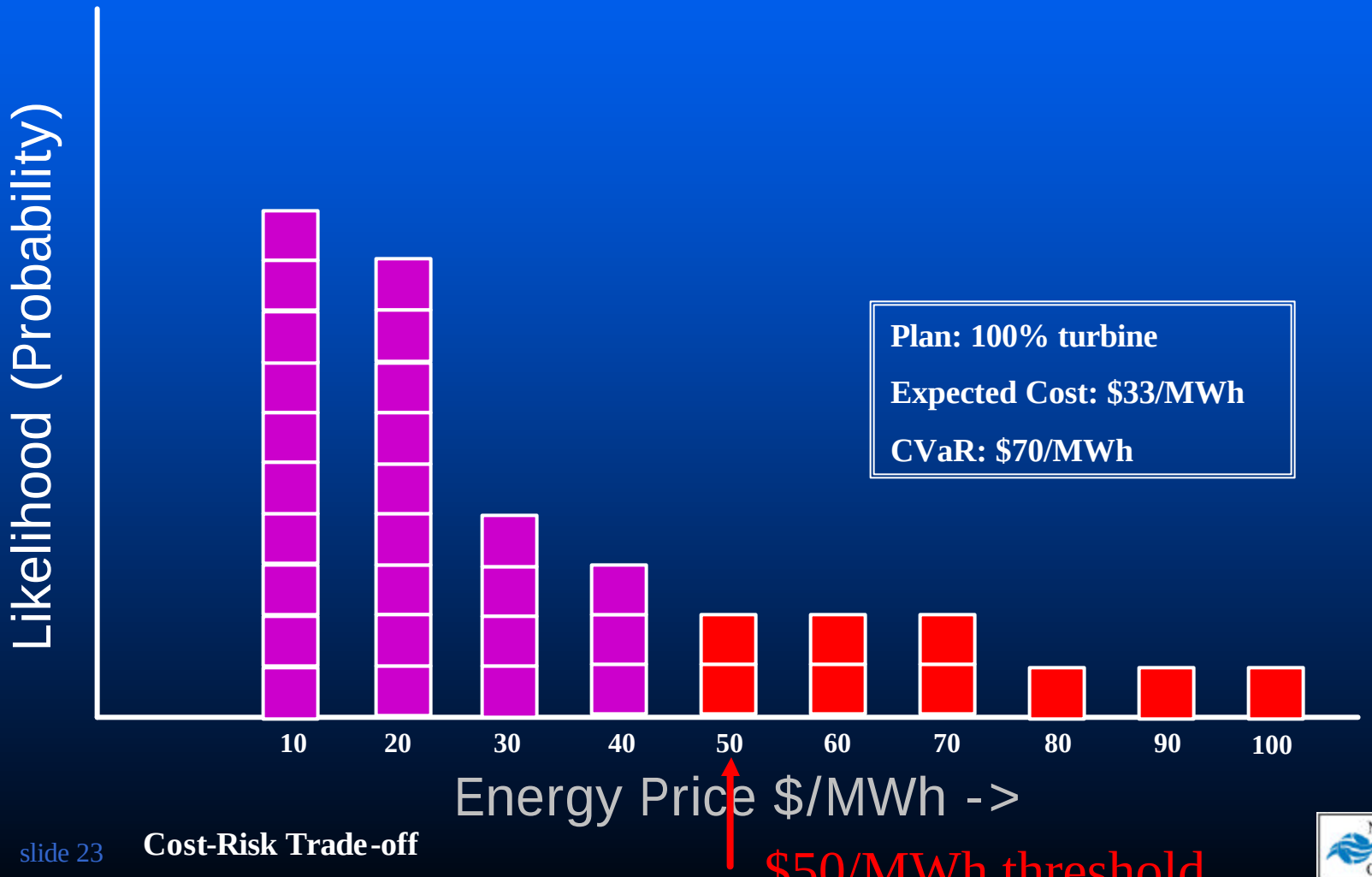
Our Objective

- Our plans consist of mixtures of contract energy and combustion turbine energies
- The risk threshold is $50/MWh
- We do not want CVaR to exceed $60/MWh
- We want to meet our risk requirement at minimum cost

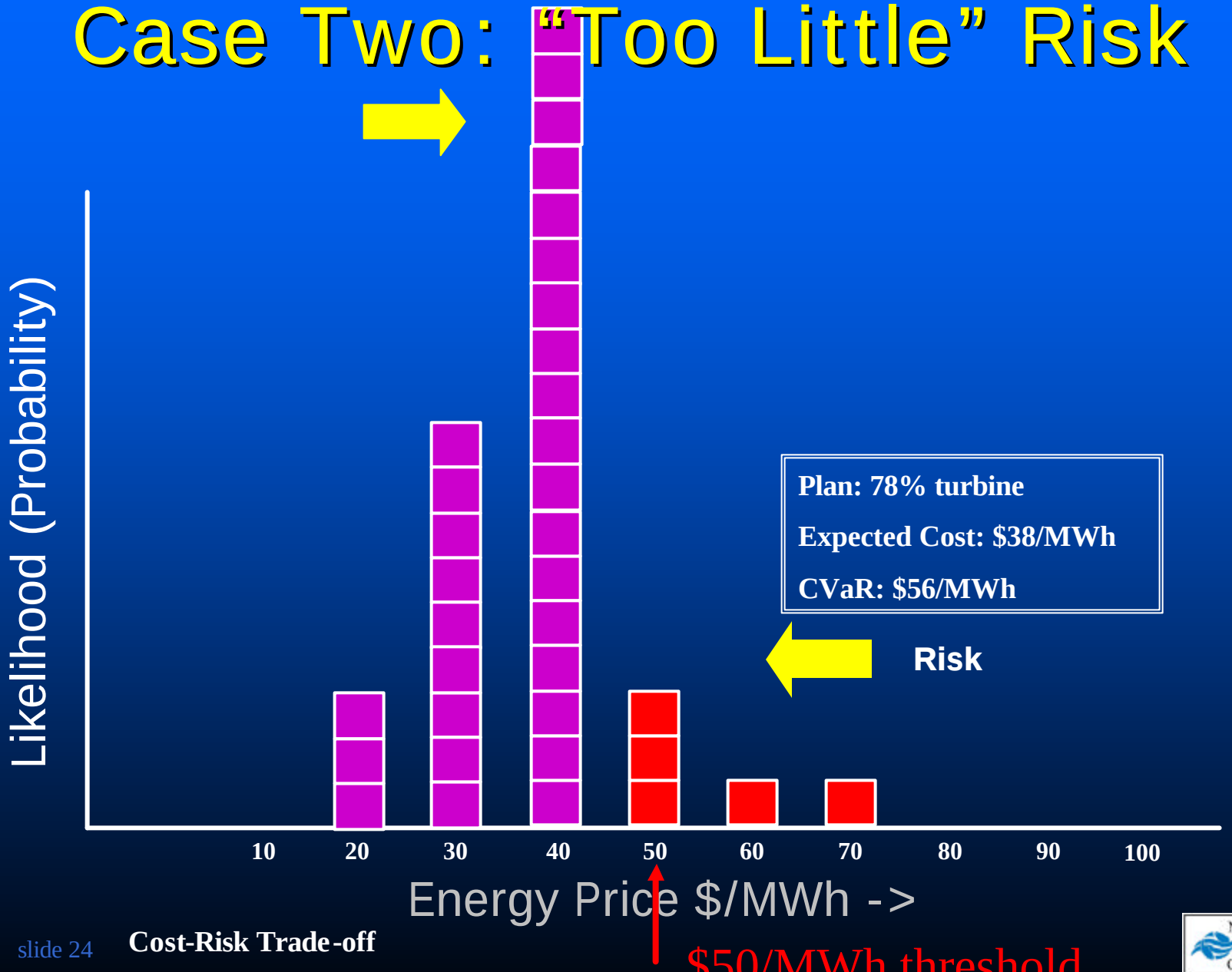
The threshold and CVaR values are arbitrary and hypothetical. As we will see in a minute, the values are not important to our understanding of the efficient frontier.

Case One: Too high



Cost-Risk Trade-off

Case Two: "Too Little" Risk



Cost-Risk Trade-off

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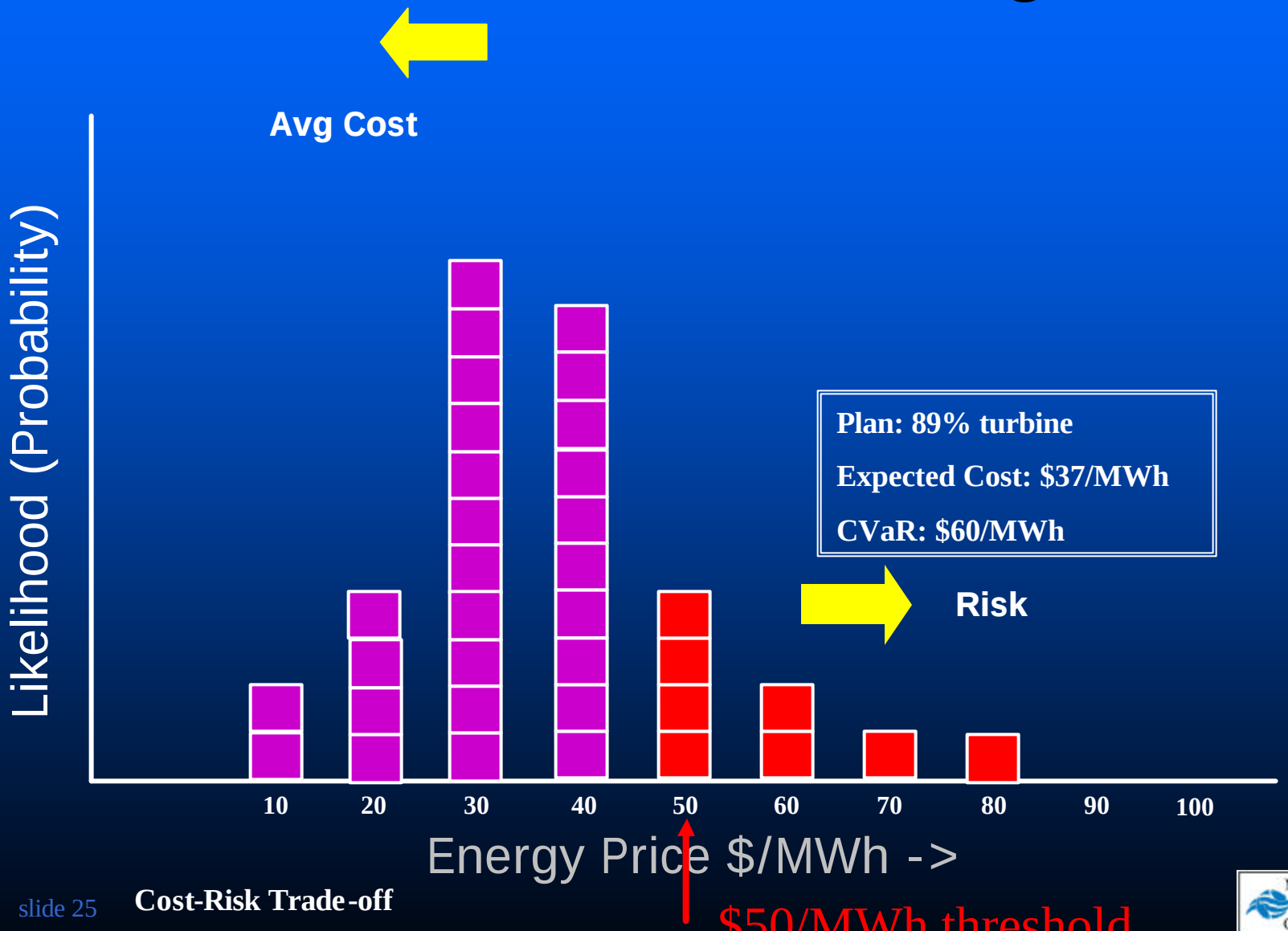
Case Three: Just right



Cost-Risk Trade-off

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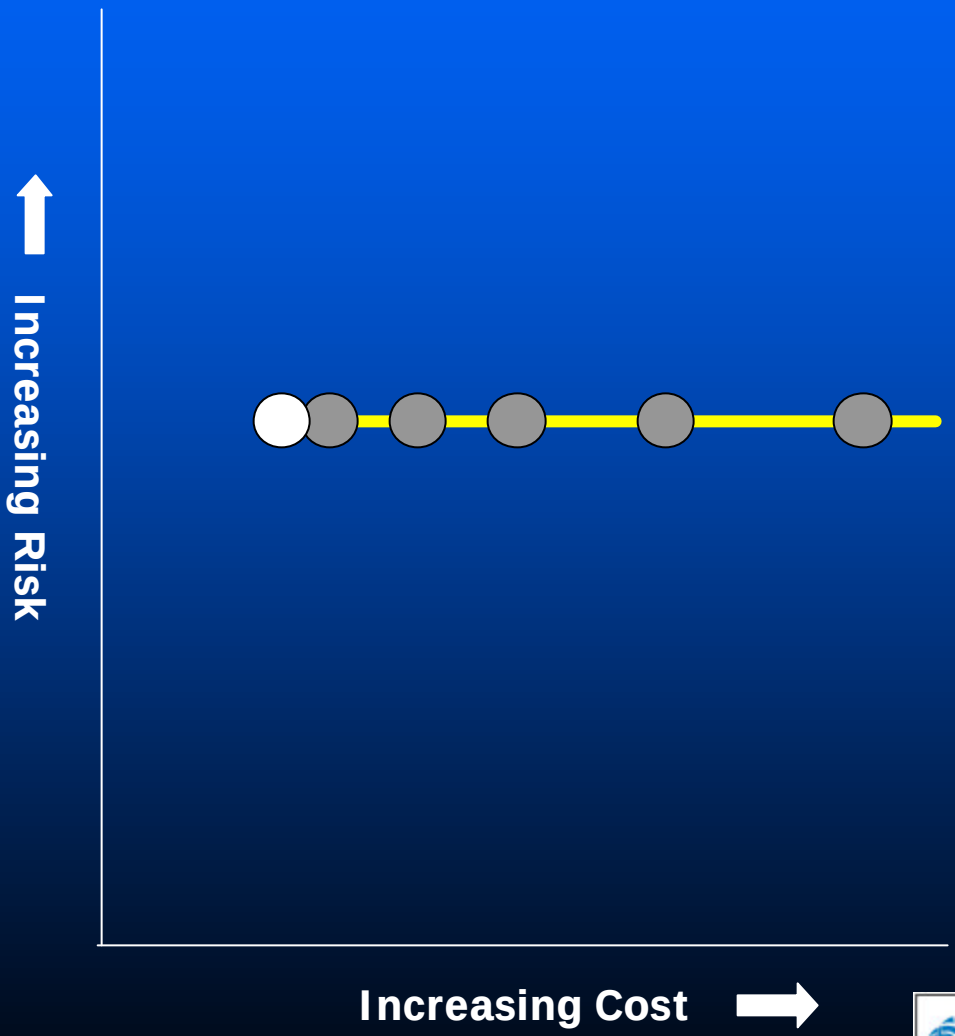
Efficient Frontier

- Consider those plans that carry a fixed amount of risk
- Each plan is illustrated here by a dot which represents its associated cost and risk
- There are many plans with the same risk level and they generally have different costs
- One (or several) will be “least cost”



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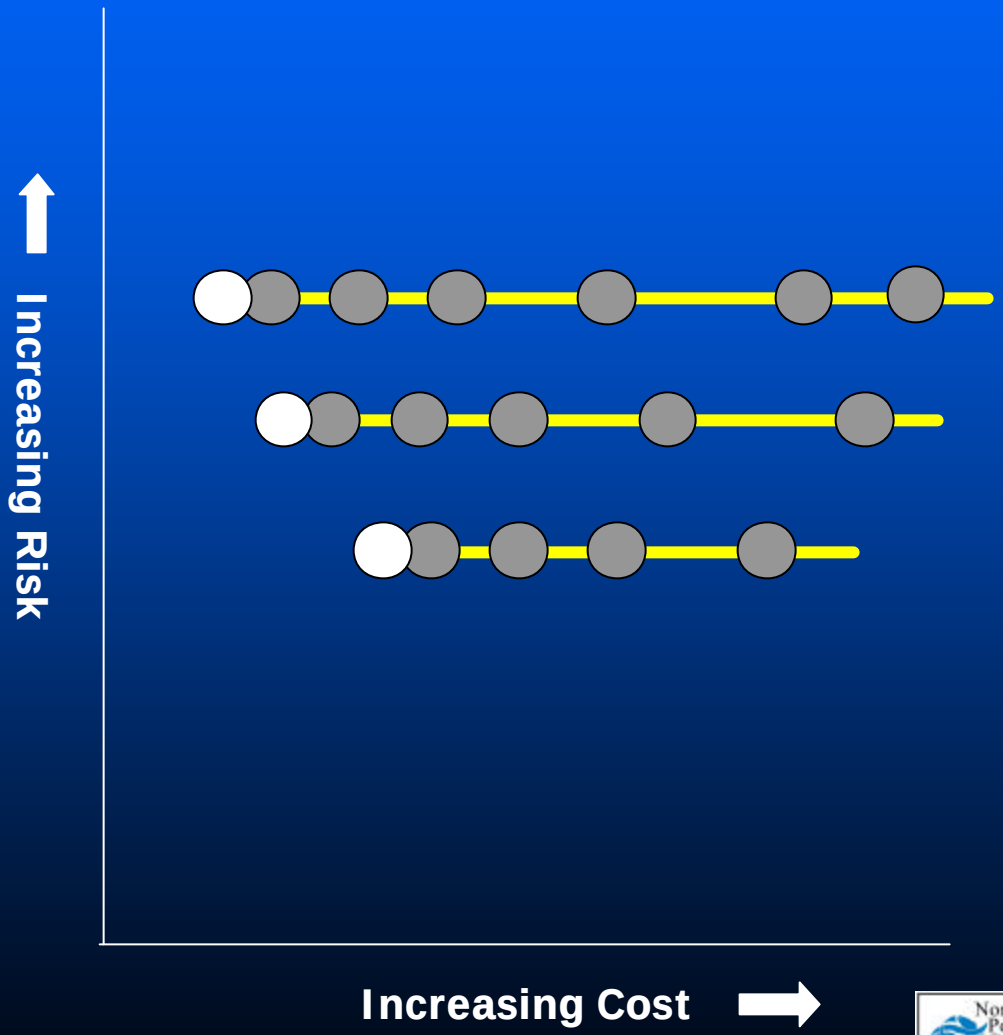
Efficient Frontier

- We could do the same thing for several levels of risk, examining the costs of different plans that have the same risk



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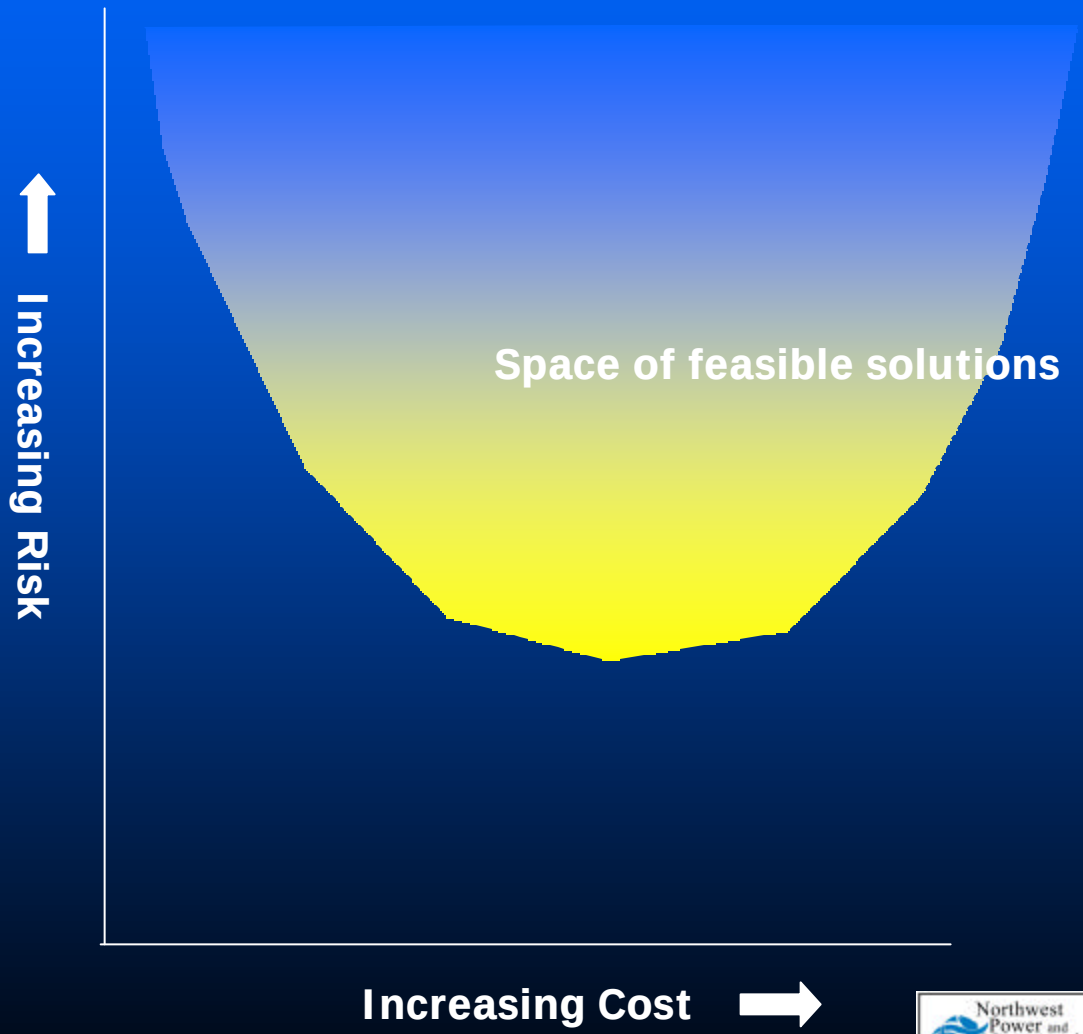
Efficient Frontier

- If we were to trace out such lines for all risk levels, we would obtain a "space" of feasible plans



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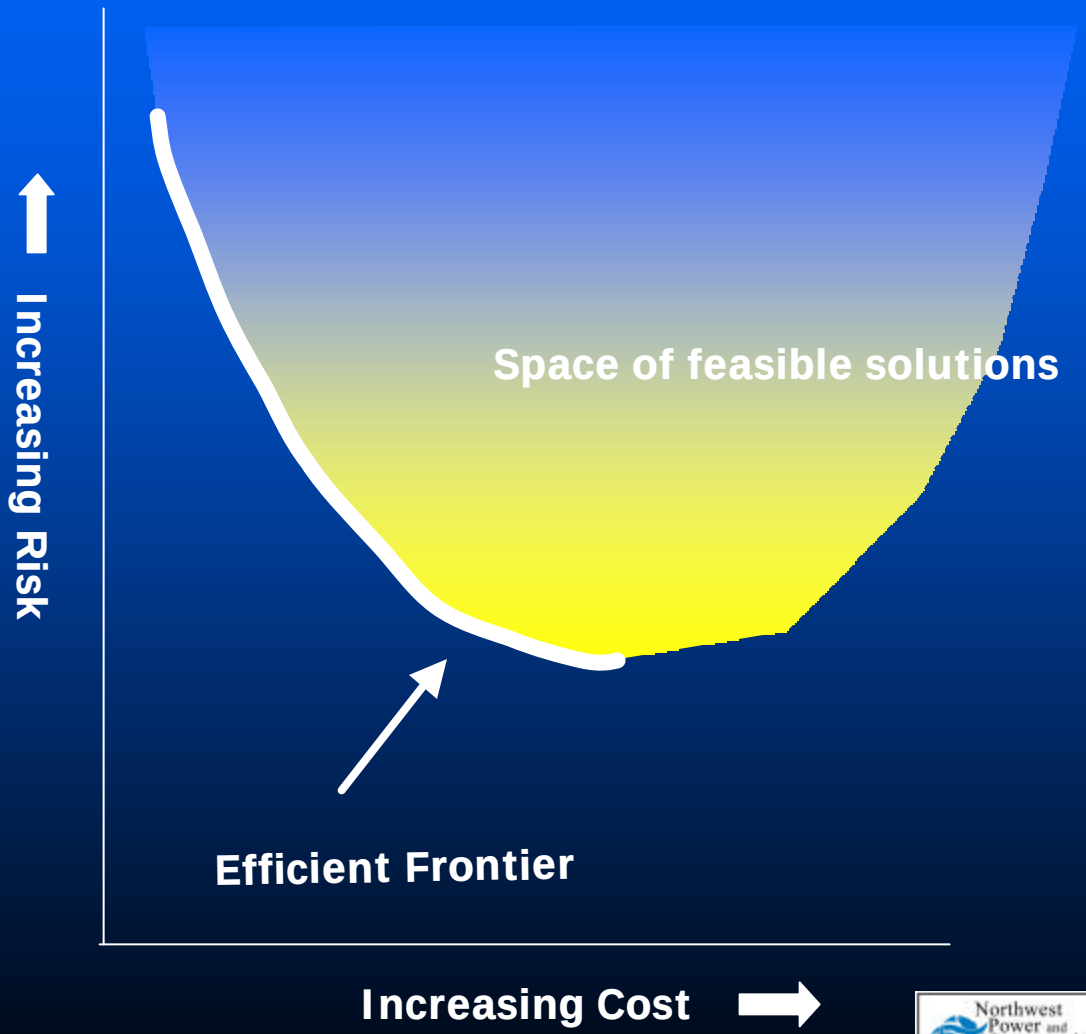
Efficient Frontier

- We want to stay on the efficient frontier of this space
- These are the "least-cost" plans



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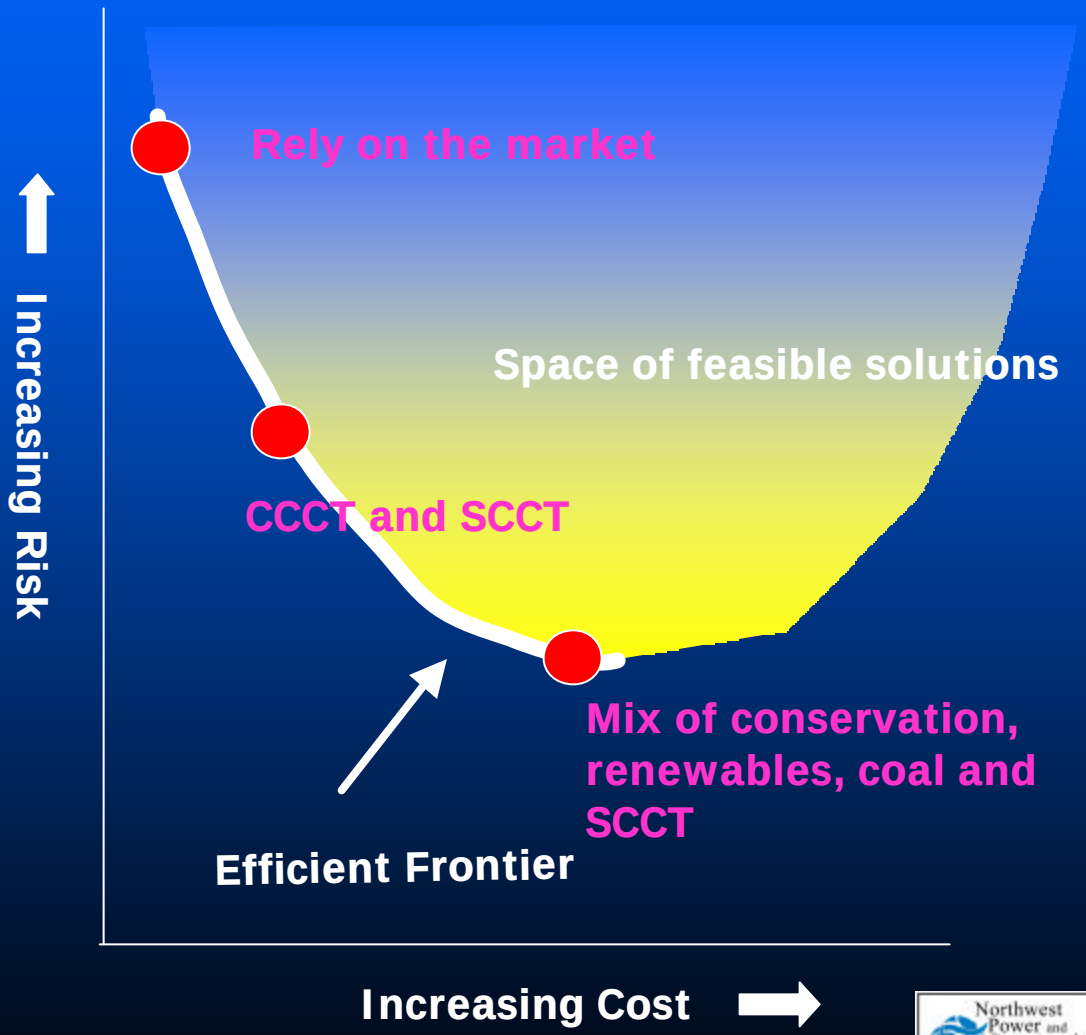
Preliminary Studies

- Fixed cost, low fuel risk resources tend to minimize risk, at increased cost



Cost-Risk Trade-off

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Background

- One of the issues we are addressing in the Plan is "Incentives for Generation Capacity"
- The reserve margin criteria suggested in the early drafts of the FERC SMD and the California MD-02 also called for load-serving entities to obtain capacity sufficient to cover their load and a prescribed load margin
- But are capacity reserves necessary for and sufficient to guarantee improvement in reliability and cost-effectiveness?

Reserve Margin

- Define reserve margin to be the resource capacity in excess of loads

$$MW_{resources} - MW_{loads}$$

- This is often expressed as a percentage

$$(MW_{resources} - MW_{loads}) / MW_{loads}$$

- Exact definitions are slippery and the user must ask questions to get a clear idea of what is represented
  - time period? load conditions? resource conditions? hydro situation?
  - one can speak of an energy reserve margin, where the above definition is restated in terms of MWh

Fixed Cost Risk

- We can come to some insights by considering a simple model
- We have a load-serving entity (LSE) with
  - a fixed load of 1000 MW
  - the option to buy a risk-free, but expensive firm contract to cover from 600MW to 1400MW of load at a fixed cost
  - a risky market from which the LSE purchases to cover any remaining net load or into which the LSE would sell any surplus power

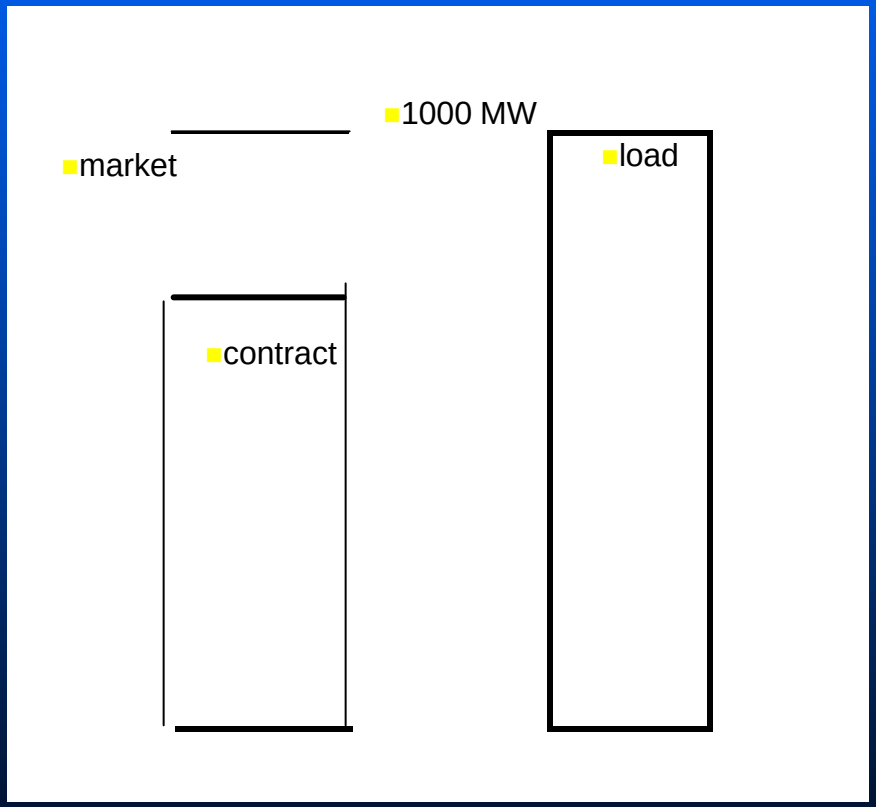
Market Risk

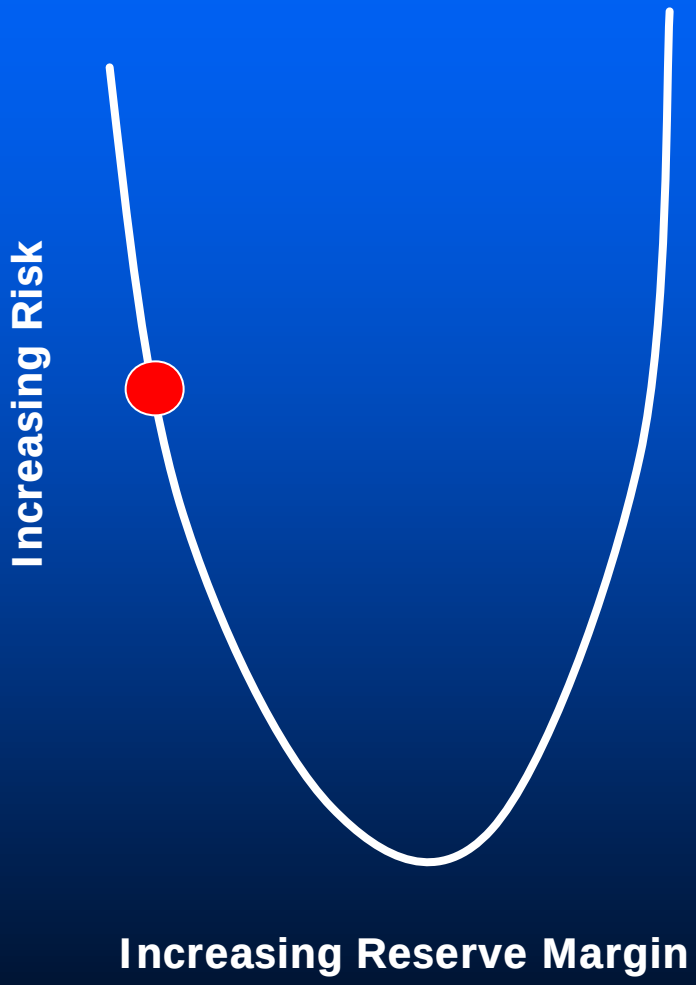
- Although we use the term “market” and the examples assume a wholesale energy market that provides efficient transactions, the concepts are the same even if there is no such market.
- The is always a value for wholesale energy, usually defined by the costs of alternative sources of energy or by the willingness of users to change their behavior for compensation.

Example

- If we start with the situation where the LSE is purchasing 600 MW of contract and the remaining portion from the market, we see that there is risk due to power market price exposure …

A Mix of Resources





Fixed cost risk

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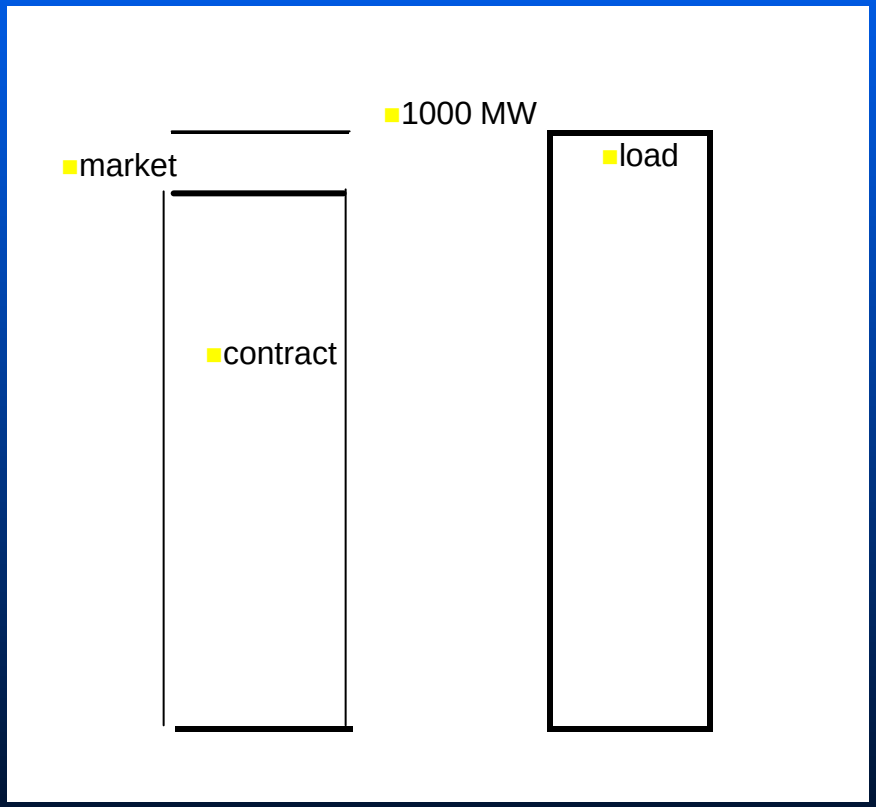
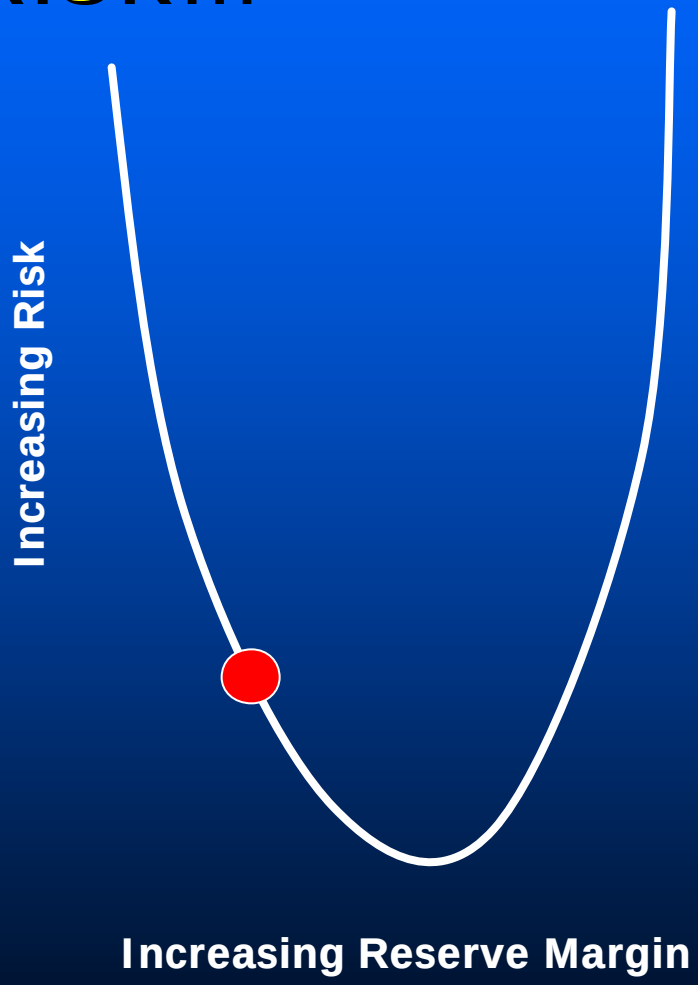
Start Out With a “Deficit”

- … and as we reduce our deficit and our reliance on the market, we reduce the risk …

Increasing Firm Contract Decreases Risk...





Fixed cost risk

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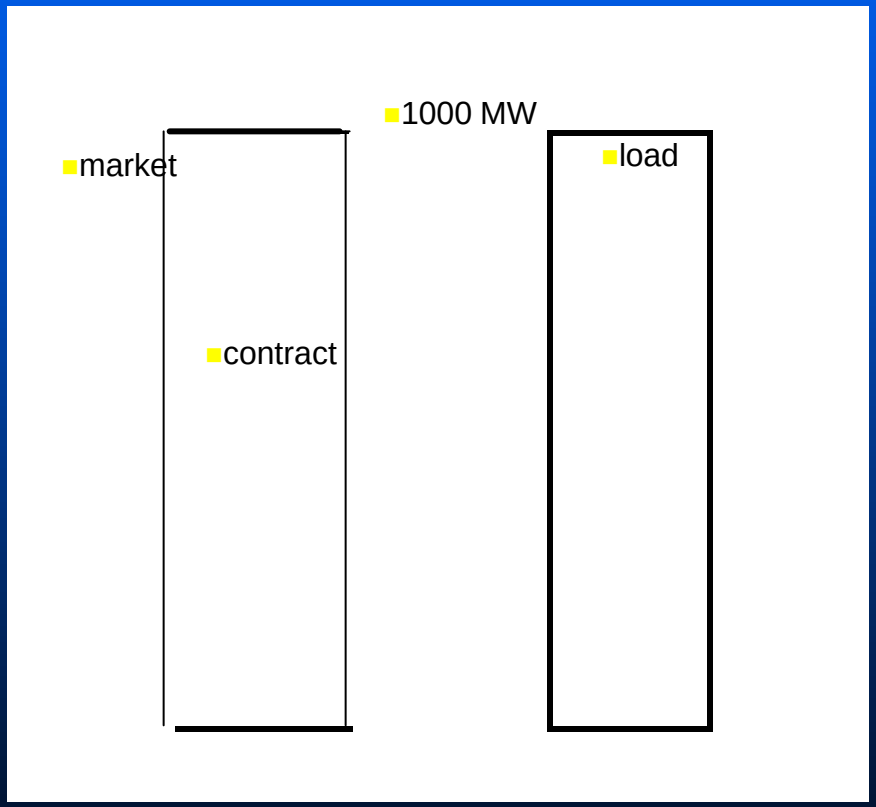
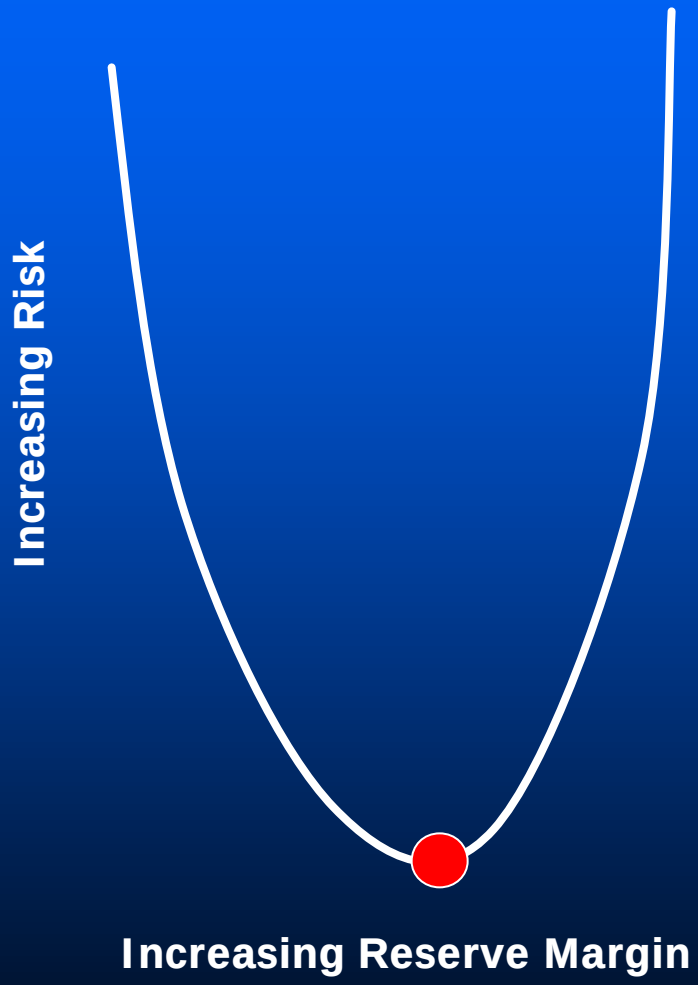
...Up to a Point





Fixed cost risk

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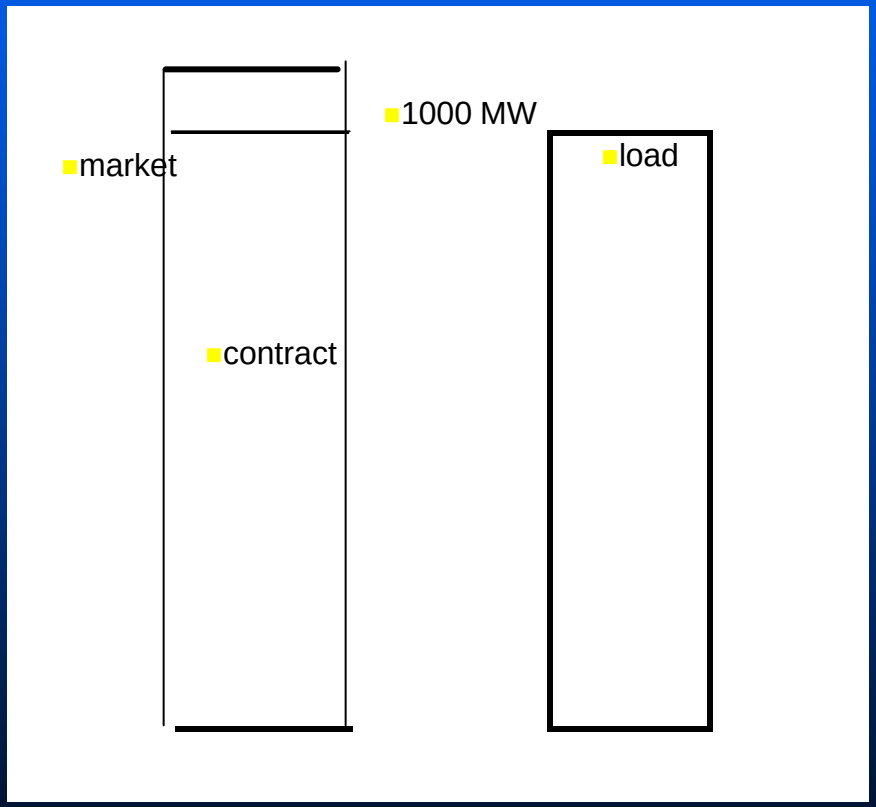
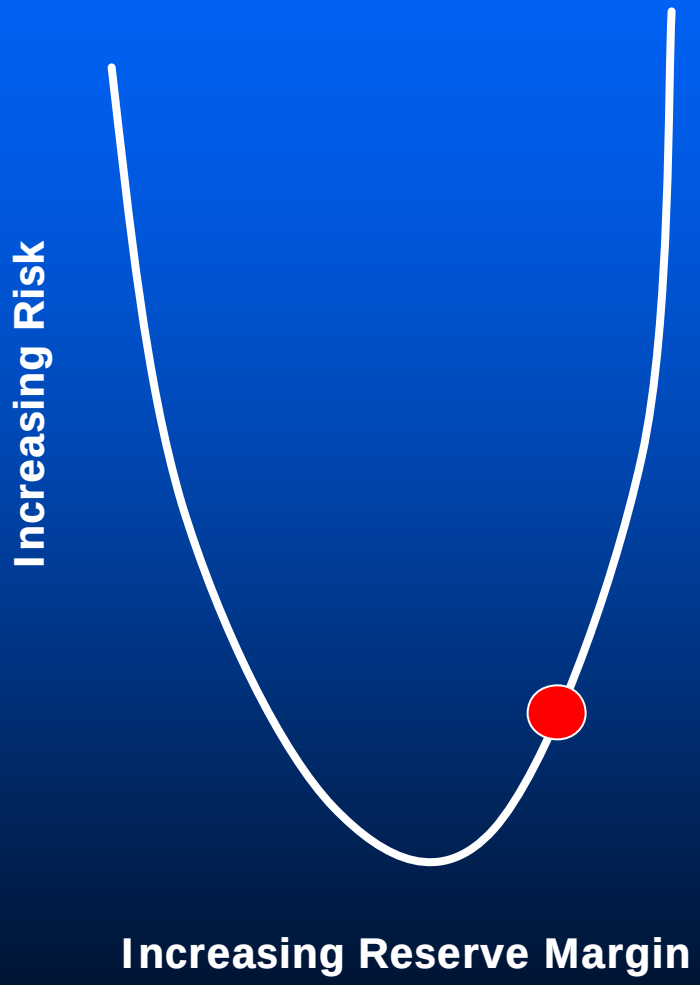
Surplus Firm Capacity

- … However, once we have covered our obligation, additional capacity exposes us to *more* risk …

Surplus Firm Capacity





Fixed cost risk

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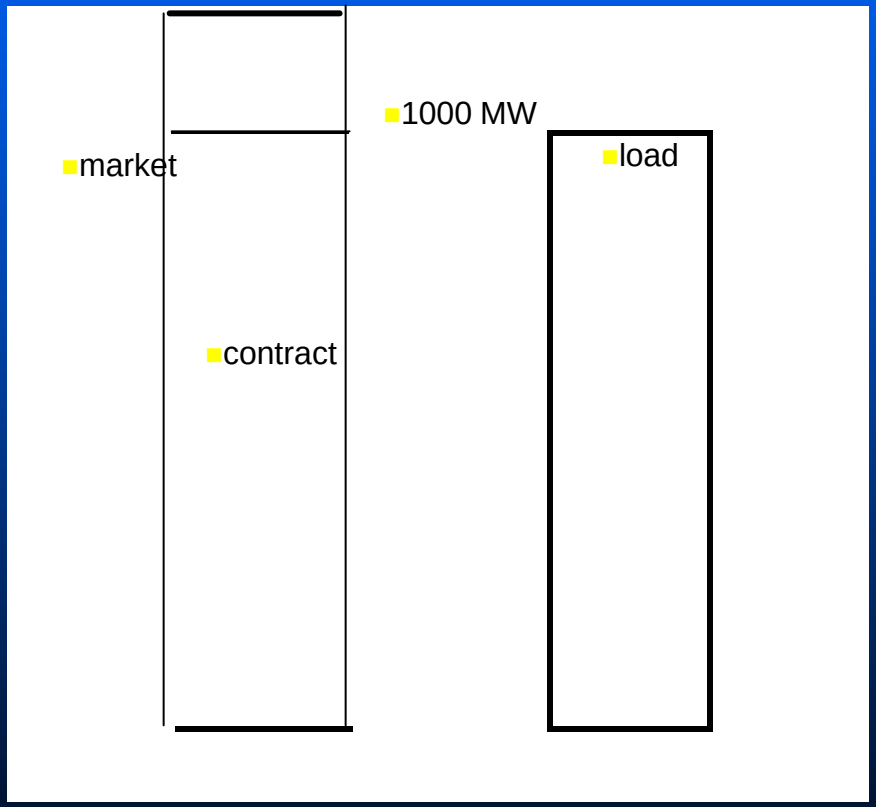
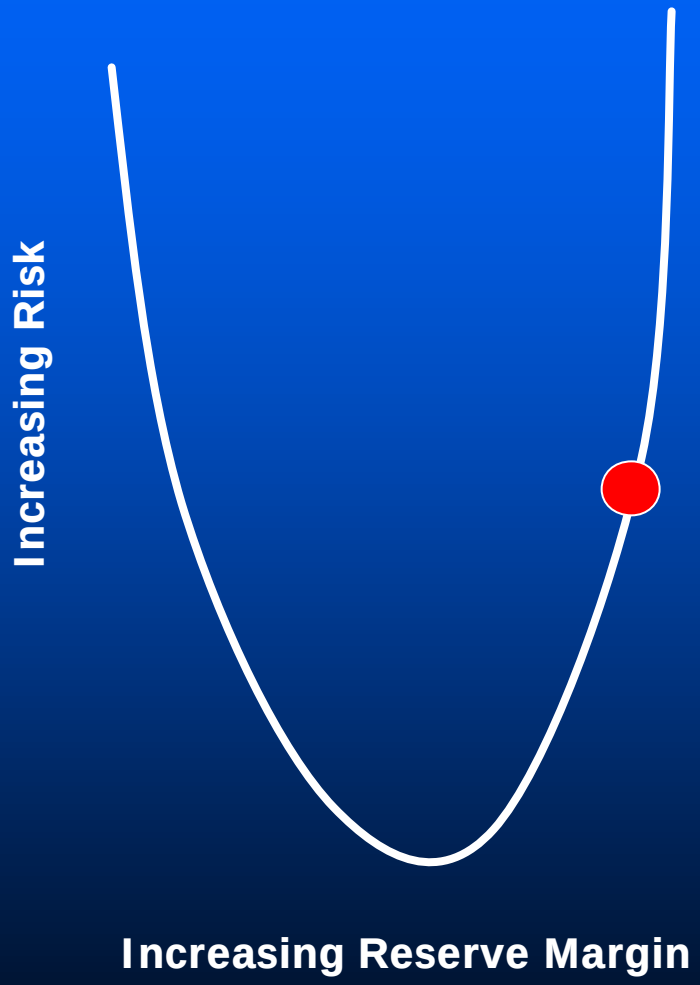
Surplus Firm Capacity





Fixed cost risk

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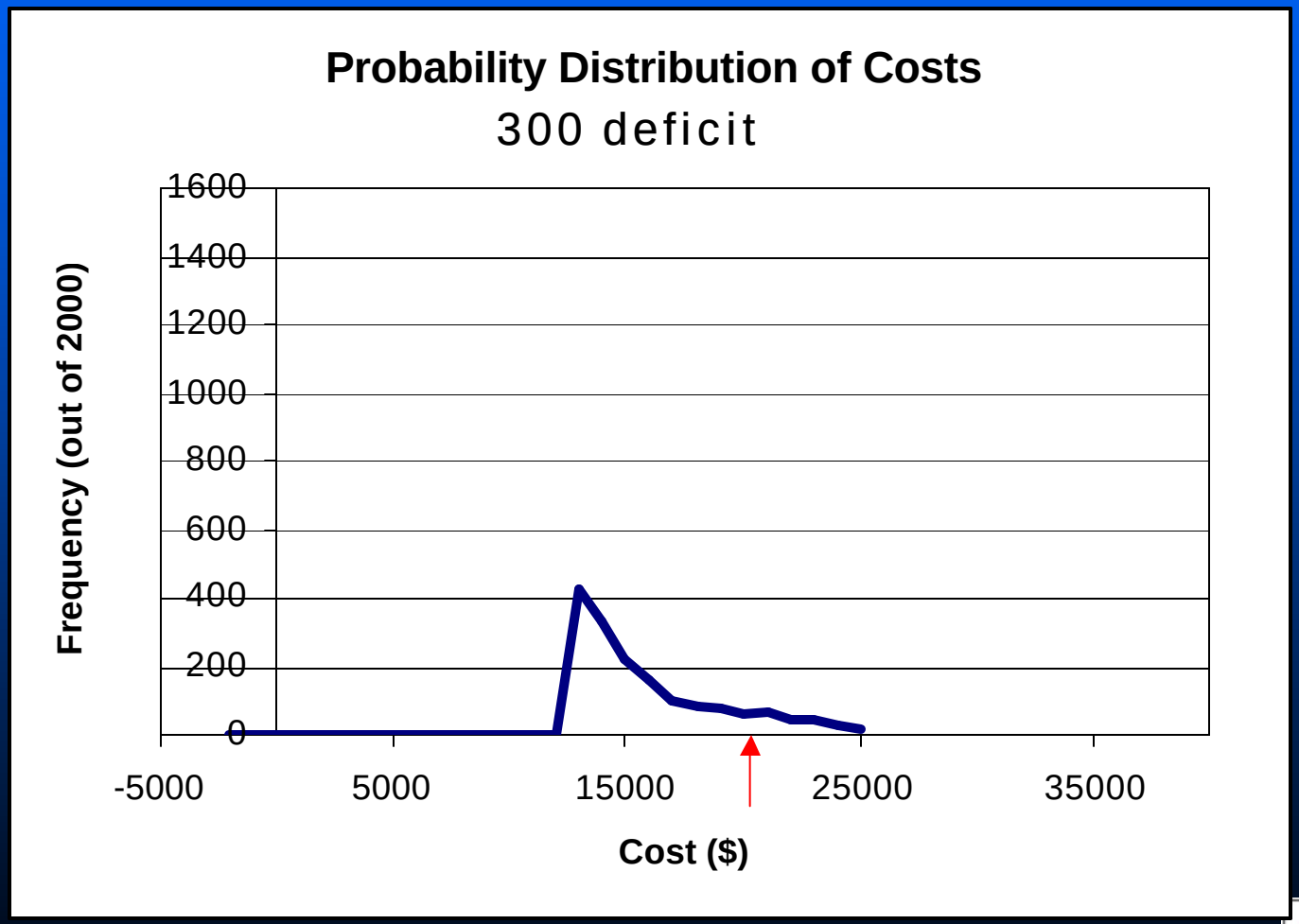
Surplus Firm Capacity Can Increase Risk

- … Why?
  - We still have market risk. Selling our surplus power into a market with *low* prices increases our costs.
  - As we purchase more of the expensive contract, we push more of our cost distribution over the risk threshold.

Changing Firm Commitment



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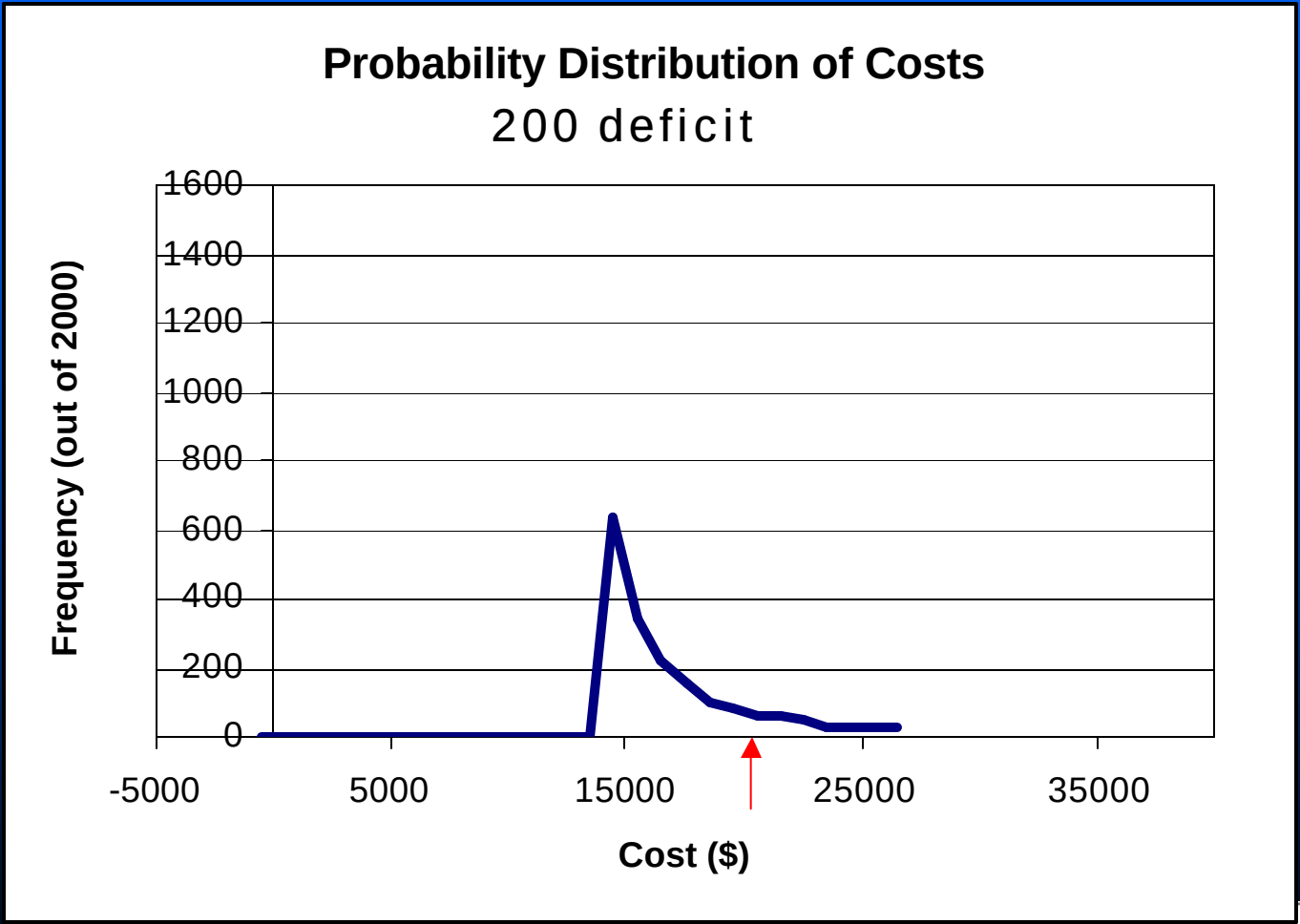
Changing Firm Commitment



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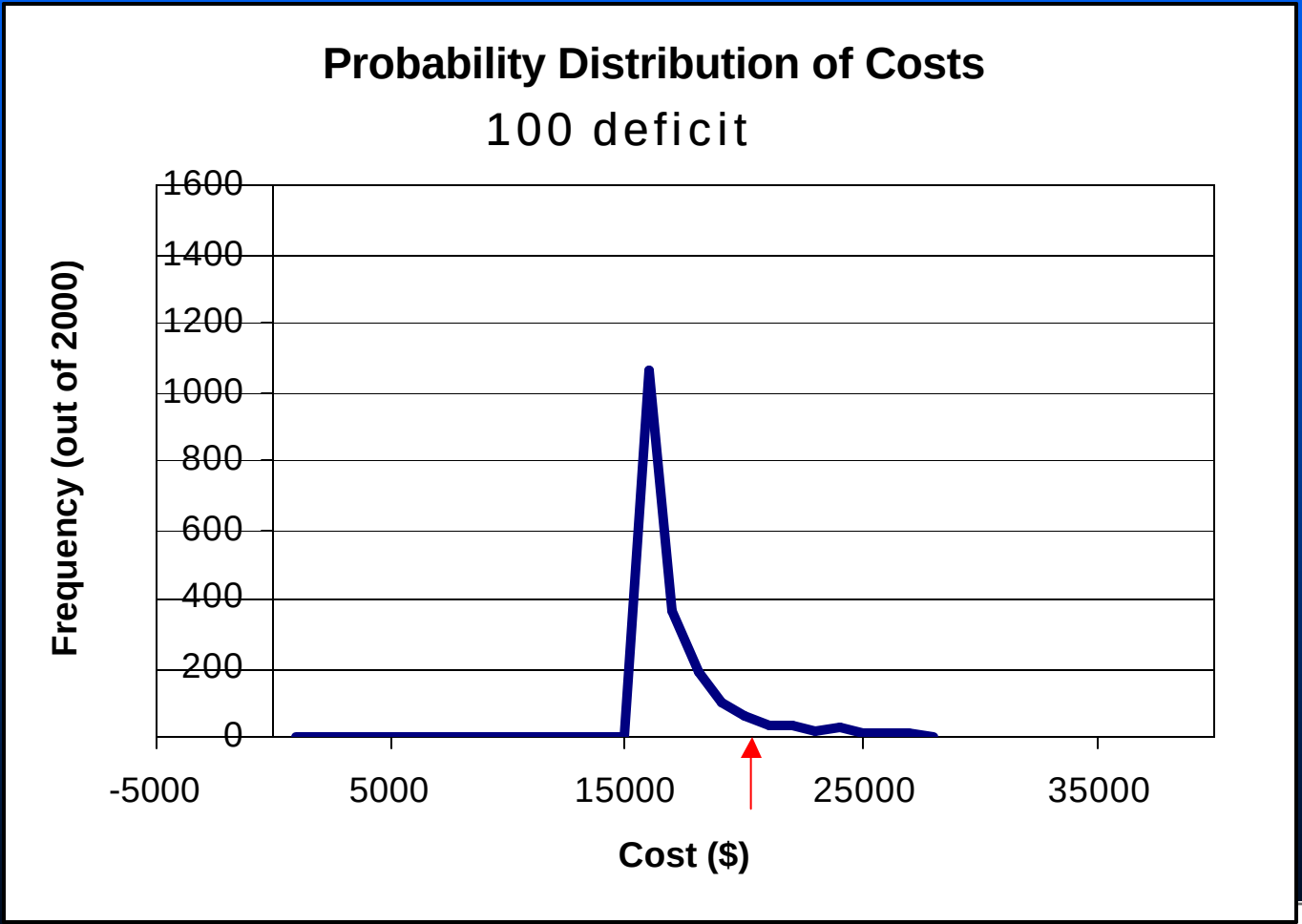
Changing Firm Commitment



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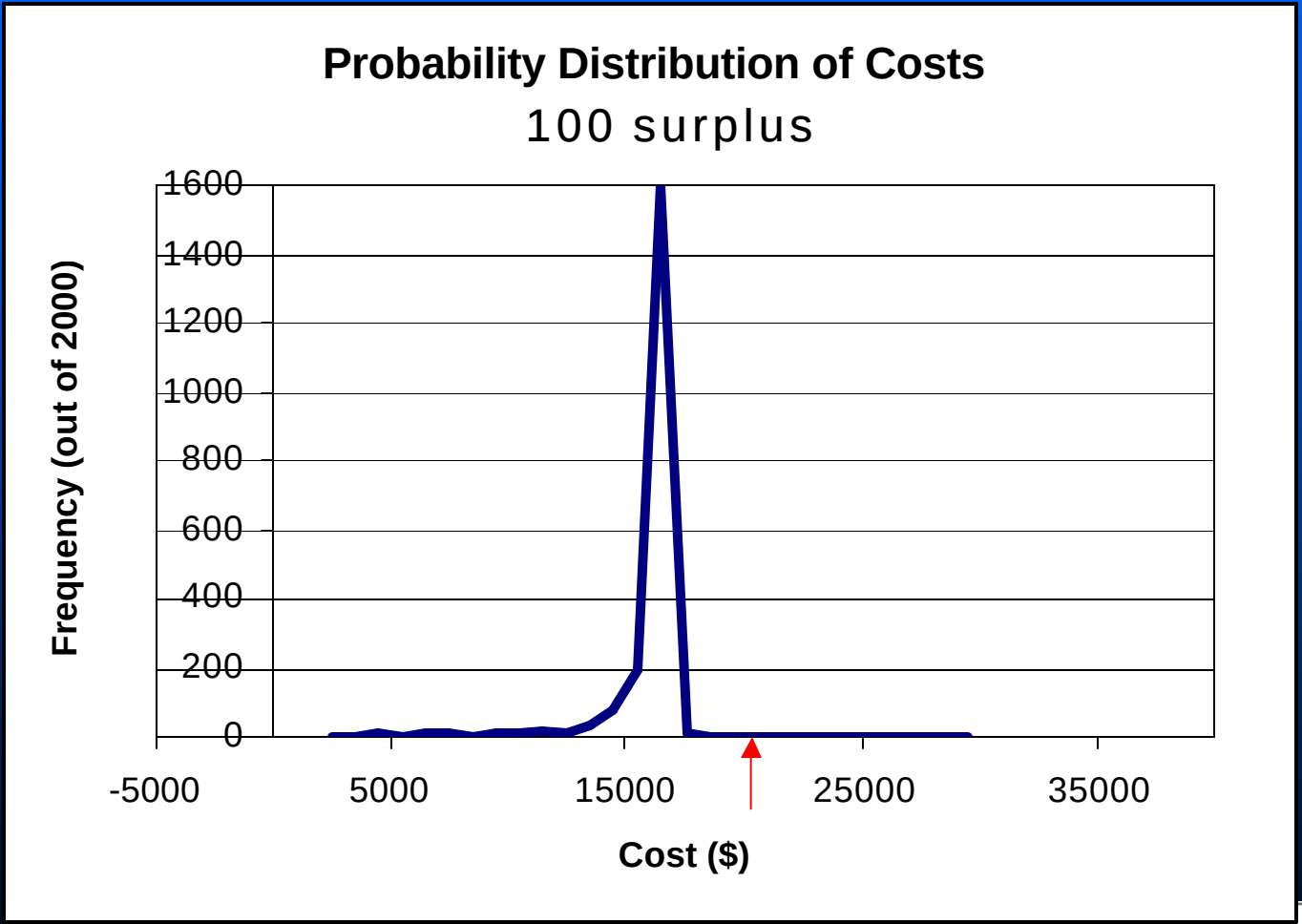
Changing Firm Commitment



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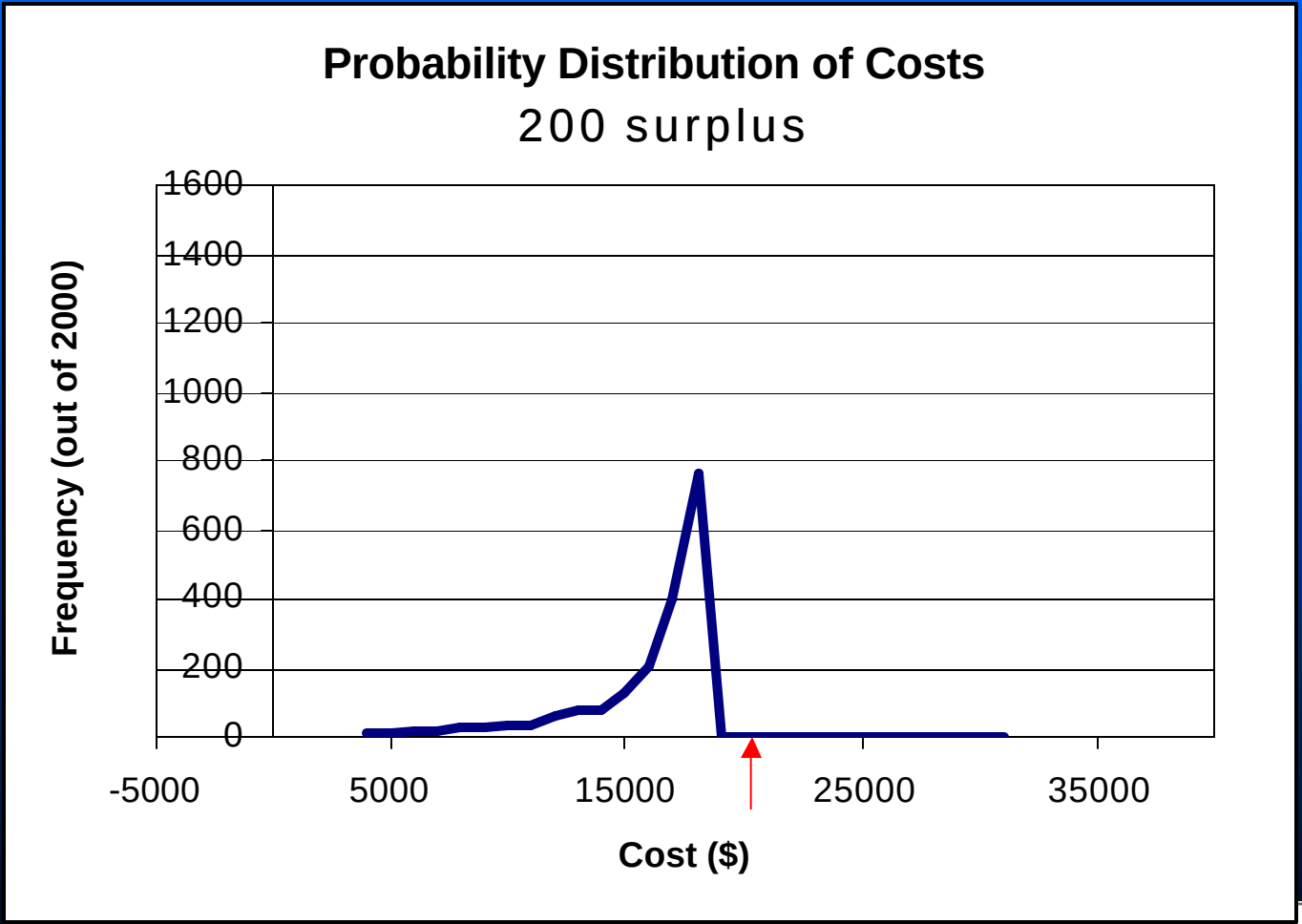

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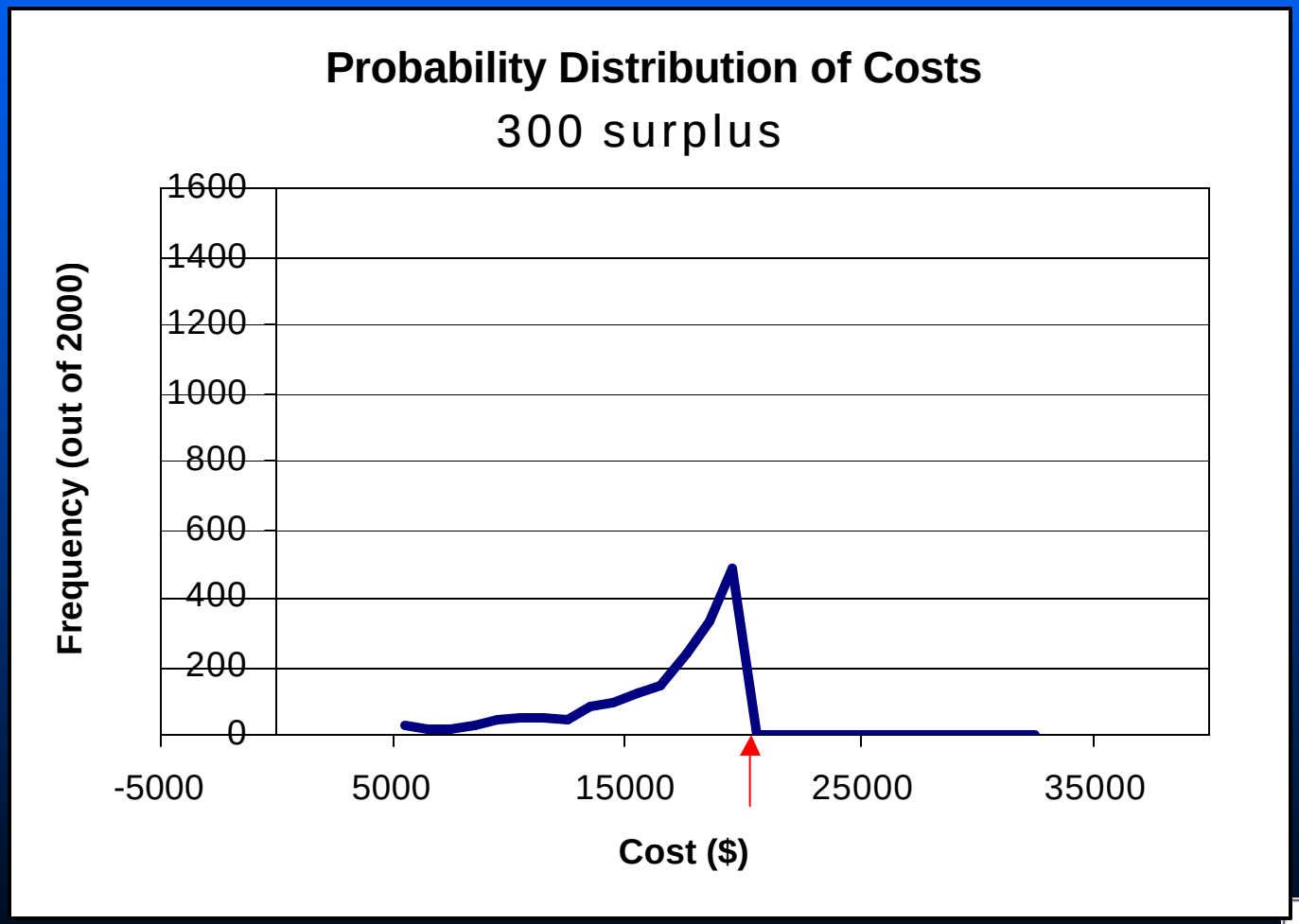

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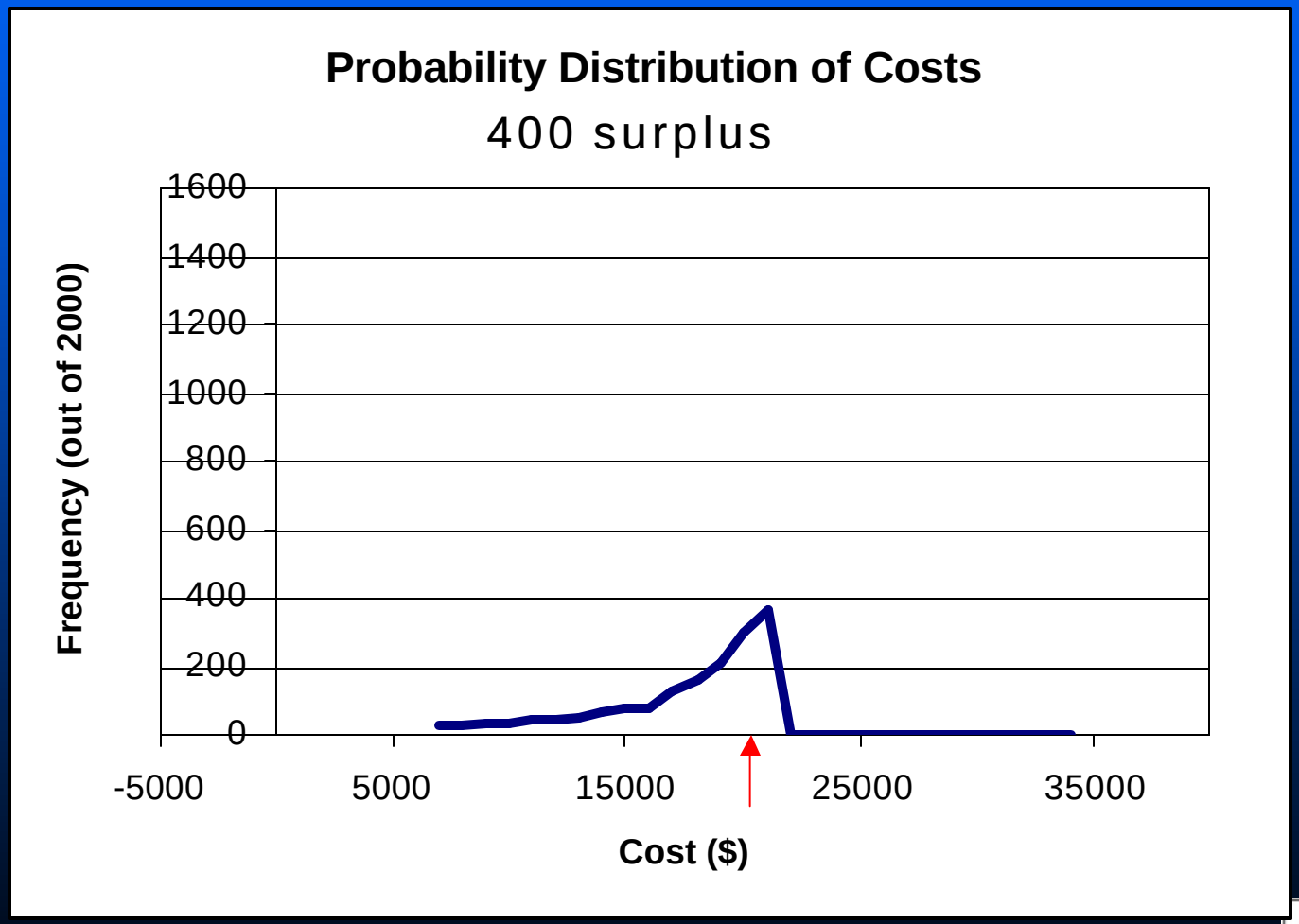

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Conclusions

- Firm commitments (fixed cost obligations to resources) can reduce *or increase* risk.
- This is relevant to the discussion or reserve margins.
- While higher reserve margins and greater capacity often do make our costs more predictable, they are at best a “rule of thumb”

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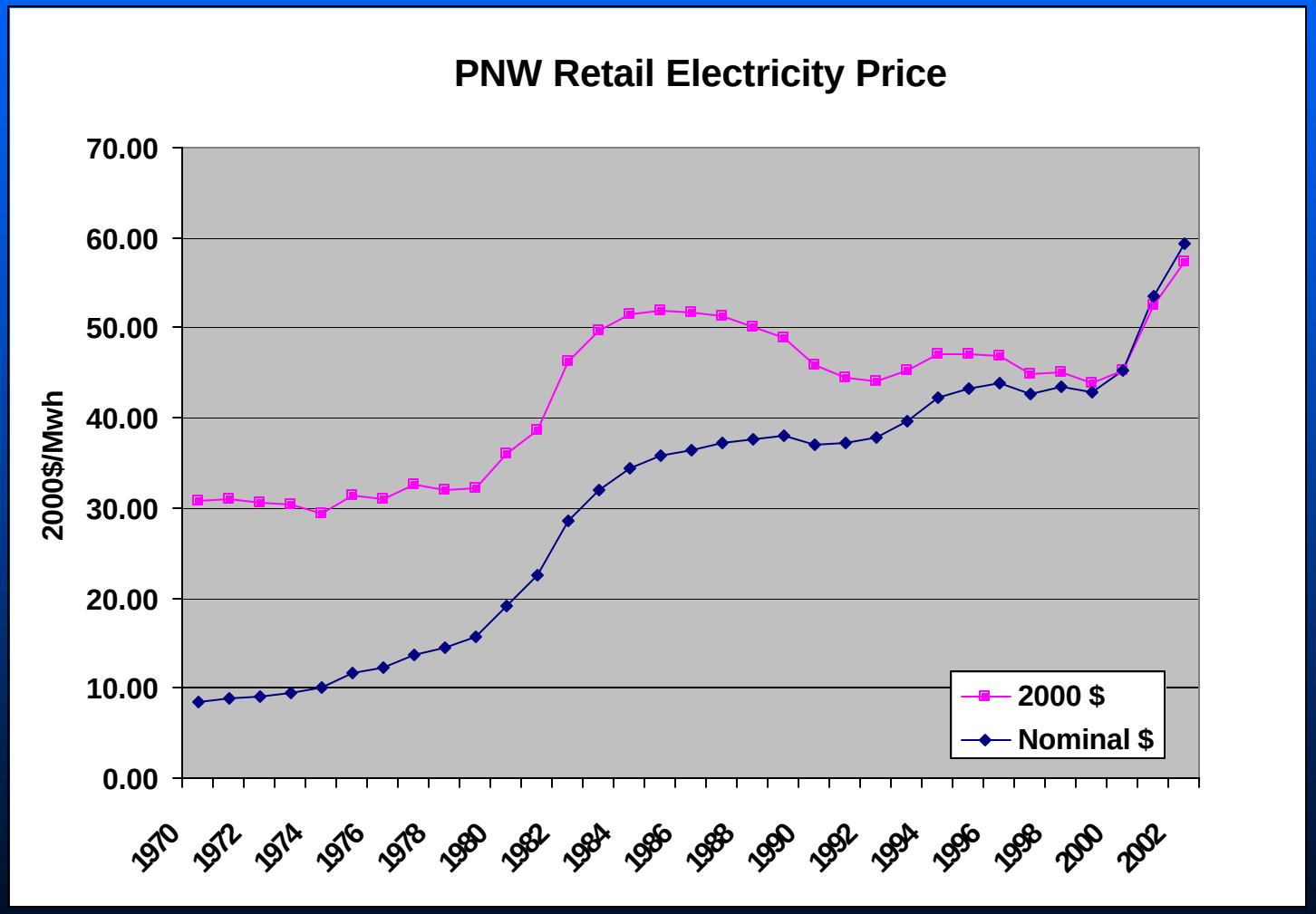
History

- … The preceding observations about excess fixed cost are much more than intellectual exercises.
- The history of the power industry over the last 30 years provides examples where injudicious or untimely construction of capacity netted rate-payers shocks that rival or surpass those of the 2000-2001 energy crisis …

30-Year Overview of Risk



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History

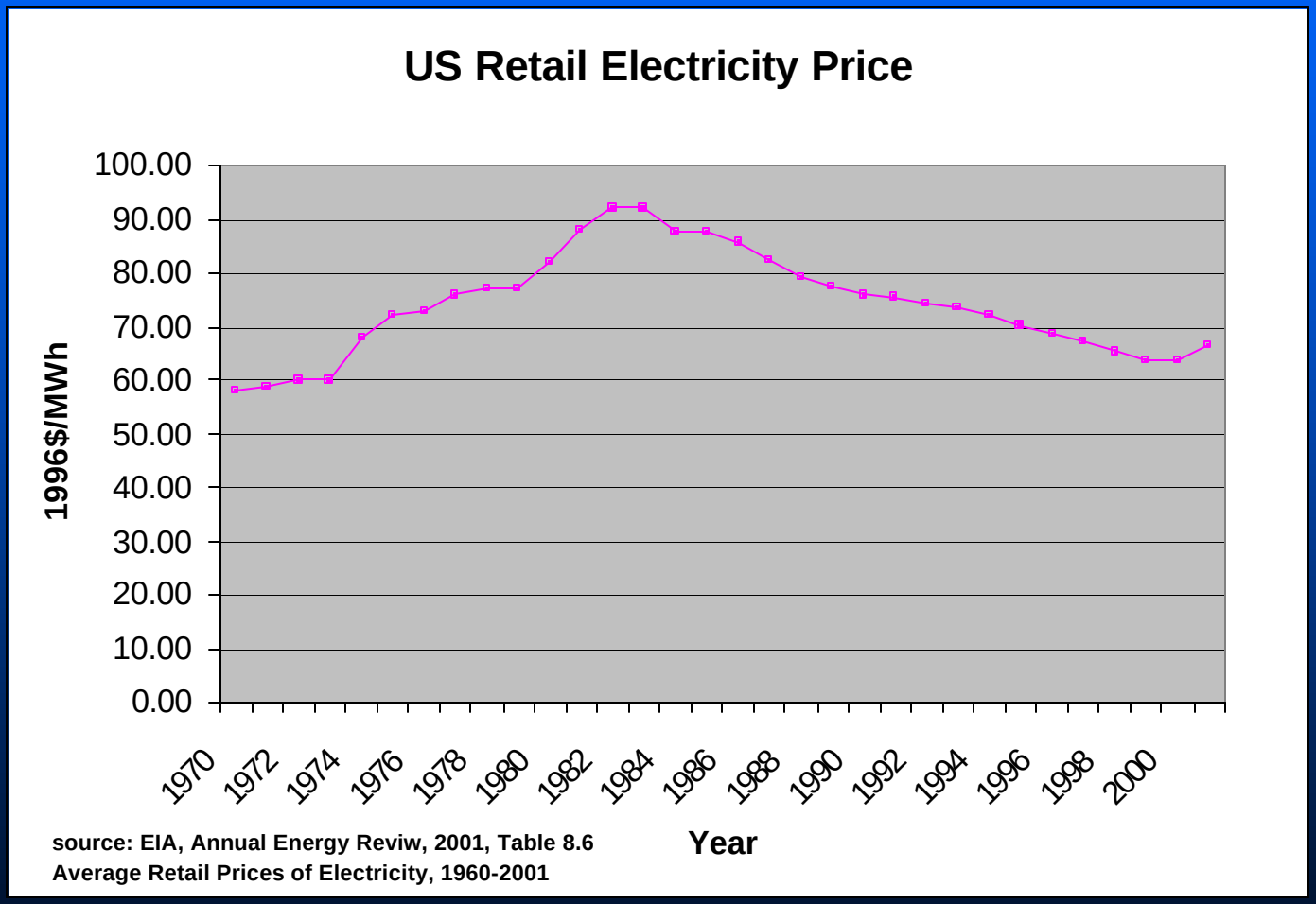
- … In the late 1970s and early 1980s, utilities built to meet their own reserve margins and assumed that the costs would be recovered from rate base.
- Oil price increases in 1973 and 1978 convinced utilities to build capital-intensive coal and nuclear plants; environmental restrictions were placed on the use of natural gas for power generation; PURPA provided additional incentive to purchase relatively long-term contracts at fixed rates.
- Shortly thereafter, loads began to fall…

History

- Loads fell off due to the interest rates and related economic downturn, high petroleum prices, and increasing electricity prices
- This led to an overabundance of fixed capacity …
- … which caused the value of plants to decline, eliminating the opportunity to resale surplus capacity…
- At the same time, inflation and interest rates ballooned, increasing the cost of capital for constructing such plants, which made any surpluses more expensive for a shrinking customer base.
- As the previous slide illustrates, nominal rates in the PNW almost quadrupled.
- And the PNW was not alone …

30-Year Overview of Risk

The National Perspective



source: EIA, Annual Energy Reviw, 2001, Table 8.6
Average Retail Prices of Electricity, 1960-2001

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History

- PURPA was showing the industry that power could be efficiently produced by non-utilities.
- Transmission access issues raised by non-utility generators uncovered the greater efficiencies that were available when transmission owners were compelled to offer access in a non-discriminatory fashion.
- This led many regulators and policy makers to conclude that much of the existing regulation did a poor job of allocating risk, costs, and rewards.
- Building on the momentum of deregulation that started in the 1960s and fueled by these power industry disasters of the 1970s and 1980s, the 1990s gave rise to the power industry's first experiments in deregulation in England and Wales.

History-Conclusions

- Like many other industries, the electric power industry has a history of over-reacting to the most recent history
- Fundamentals of physics and economics conspire to make this industry inherently unpredictable and risky. There probably is no “silver bullet.”
- We need to learn from the mistakes of the past, and to choose a path that balances our requirements for cost and certainty, given all the various sources of risk.

Conclusions

- We are interested in plans that lie on the "efficient frontier" of all feasible plans. When we speak of "risk-constrained, least cost plans," we will be referring to plans along this frontier.
- Firm commitments (fixed cost obligations, such as construction of power plants) can reduce *or increase* risk.
- Recent history (2000-2001) has made us aware of the risk in not having sufficient resources. A longer-term perspective reminds us that commitment to too much fixed cost or to the wrong mix of resources is also risky. It is important to consider diverse sources of risk.

End

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