OVERVIEW OF PROCESS MODELING ACTIVITIES & CAPABILITIES

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OBJECTIVES

- **Develop reliable and easy-to-use models to estimate the environmental performance and cost of conventional and advanced technologies to produce electricity from coal**
- **Develop a framework for comparing alternative options on a systematic basis**

Objectives- 2

- Develop a flexible and easy-to-use modeling system to estimate the performance, environmental emissions and cost of a preliminary Vision 21 plant design

- Develop a framework for comparing alternative options and on a systematic basis, including effects of uncertainty

ADVANCED DESIGN AND ANALYSIS METHODS ARE NEEDED

- Increasing complexity of advanced processes
- Multiple options for component design & selection
- Strong interactions among system components
- Significant performance and cost uncertainties

APPROACH

- Process Technology Models
- Engineering Economic Models
- Advanced Software Capabilities
- Systems Analysis Framework

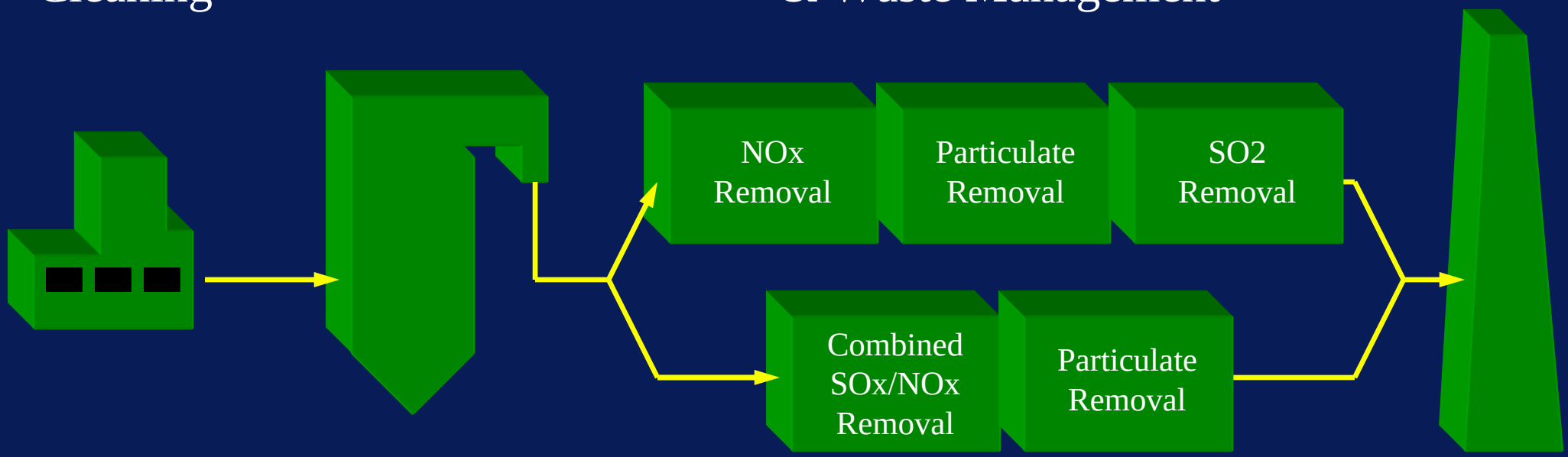
TECHNOLOGIES MODELED AND EVALUATED

- Integrated Gasification Combined Cycles (IGCC)
  - Air and oxygen blown gasifiers
  - Fixed bed and fluidized bed gasifiers
  - Hot gas and cold gas cleanup systems
  - Byproduct recovery options (e.g., sulfuric acid, Claus plant, direct sulfur reduction process)
  - Other environmental controls (e.g., SCR)
- Pressurized Fluidized Bed Combustion (PFBC)
- Externally-Fired Combined Cycle (EFCC)

TECHNOLOGIES MODELED (con't)

- Pulverized Coal Combustion Plants
  - Selective catalytic reduction (SCR)
  - Wet lime/limestone FGD
  - Lime spray dryer
  - Electrostatic precipitators
  - Fabric filters
- Advanced Environmental Control Systems
  - Combined SO_2/NO_x removal
- Coal Beneficiation Processes

INTEGRATED ENVIRONMENTAL CONTROL MODEL (IECM)



PROCESS PERFORMANCE MODELS

- Calculate detailed mass and energy flows
- Employ empirical relationships and models based on available data
- Predict component or system efficiency
- Predict multi-media environmental emissions

PROCESS COST MODELS

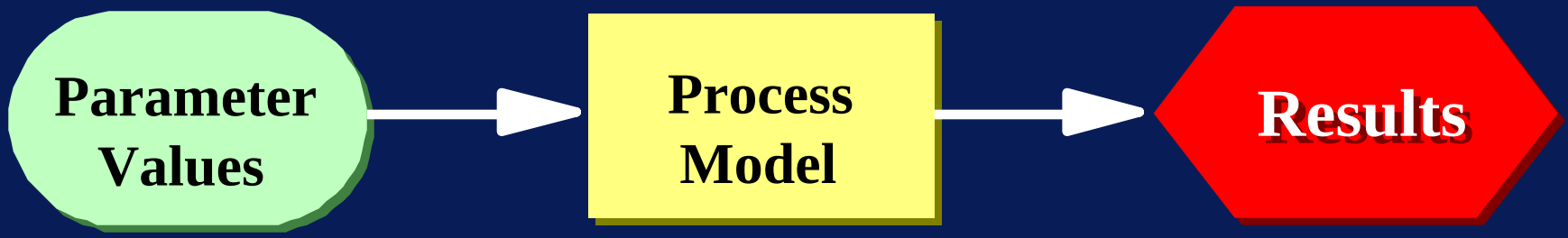
- Direct capital cost of major process areas
- Total capital cost of system
- Variable operating costs
- Fixed operating costs
- Total cost of electricity
- Explicitly linked to process performance model

NEW MODELING CAPABILITIES

Process or System	Deterministic	Stochastic
Simulation	√	√
Optimization	√	√
Synthesis	√	√

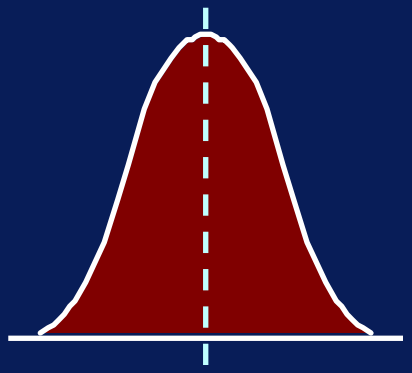
SIMULATION

CONVENTIONAL PROCESS MODELING
(Deterministic Simulation)

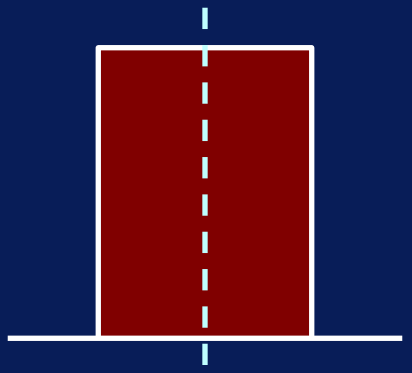


PARAMETER UNCERTAINTY DISTRIBUTIONS

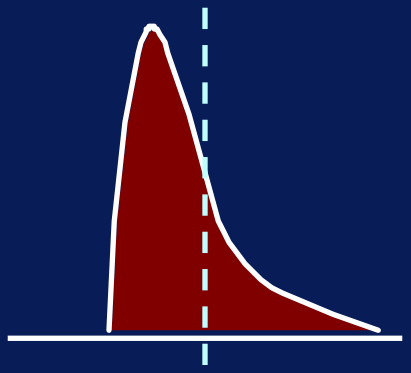
NORMAL



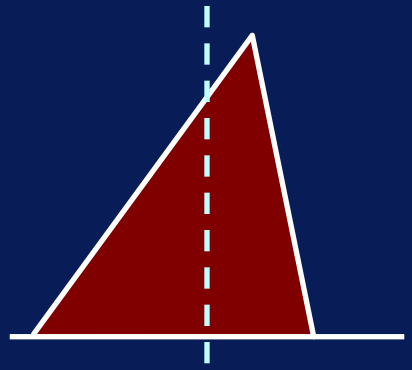
UNIFORM



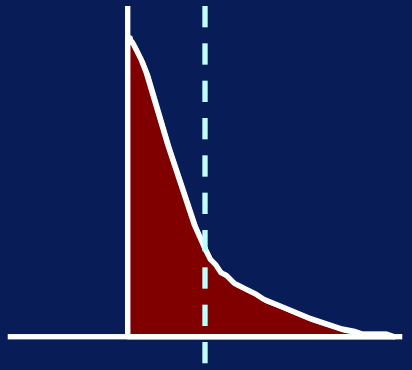
LOGNORMAL



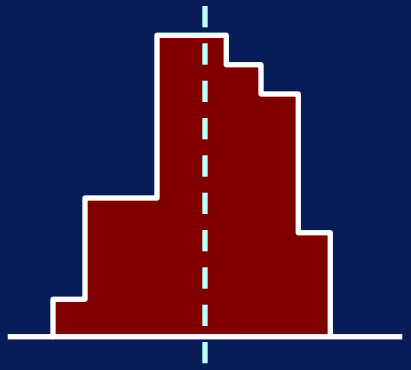
TRIANGULAR



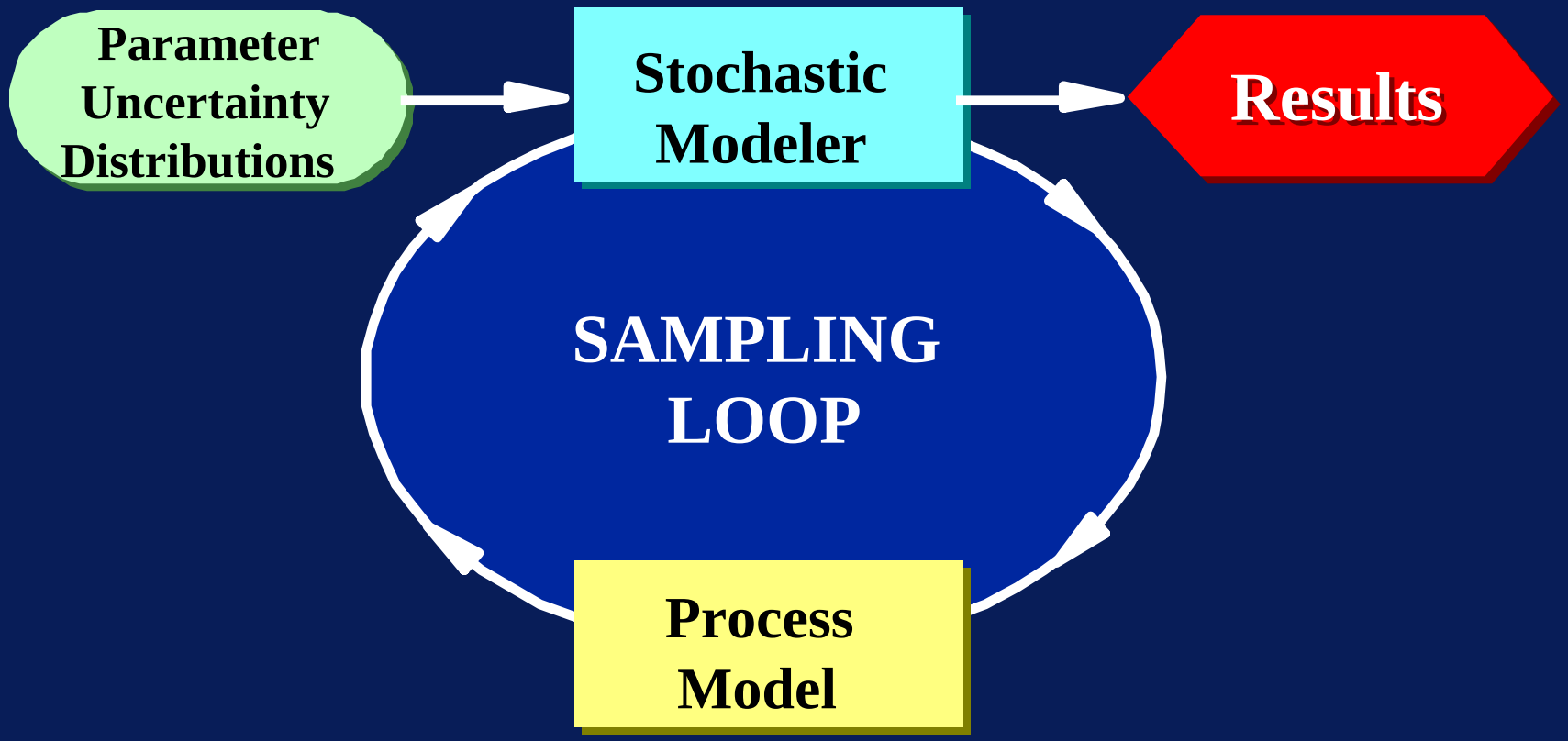
BETA



FRACTILE



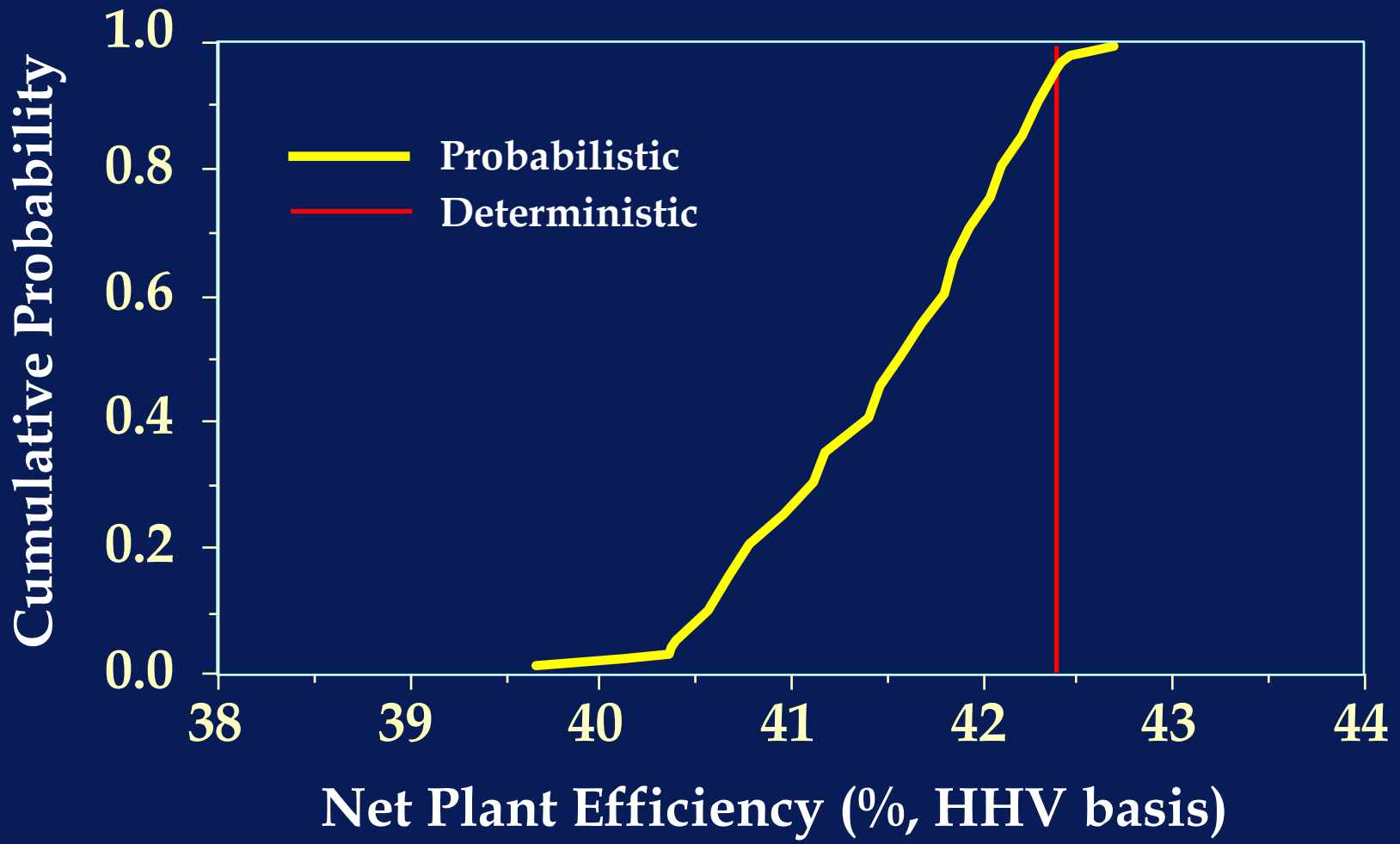
STOCHASTIC SIMULATION



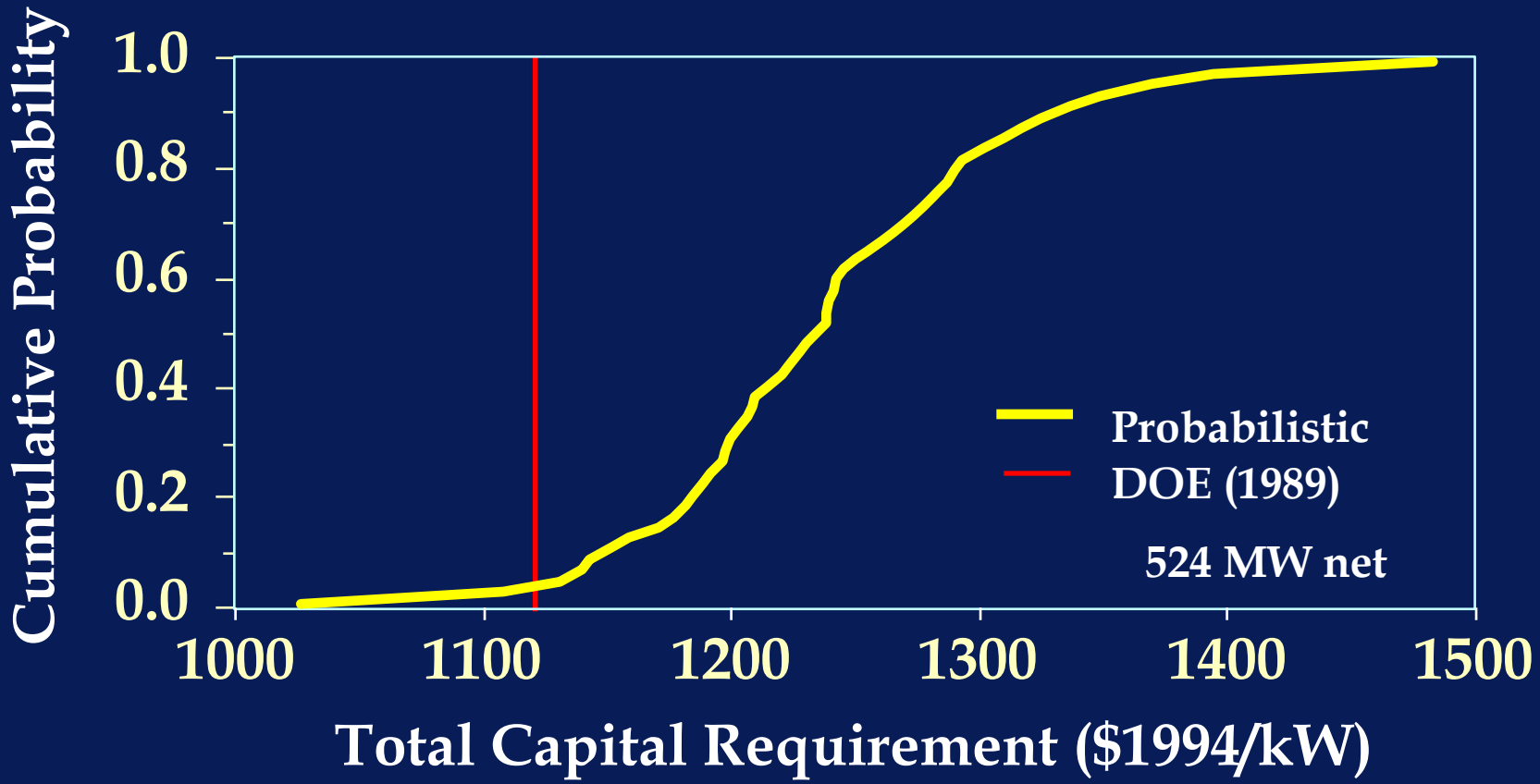
SOME QUESTIONS ADDRESSED BY STOCHASTIC SIMULATION

- What performance can we expect from this technology (e.g., efficiency, emissions)? What is its expected cost, given current uncertainties?
- What is the likelihood of performance shortfalls? Of cost overruns?
- What factors or process parameters contribute most to overall uncertainty in performance and cost?
- What is the potential payoff of R&D to reduce these key uncertainties and risks?
- How does this technology compare to other competing technologies?

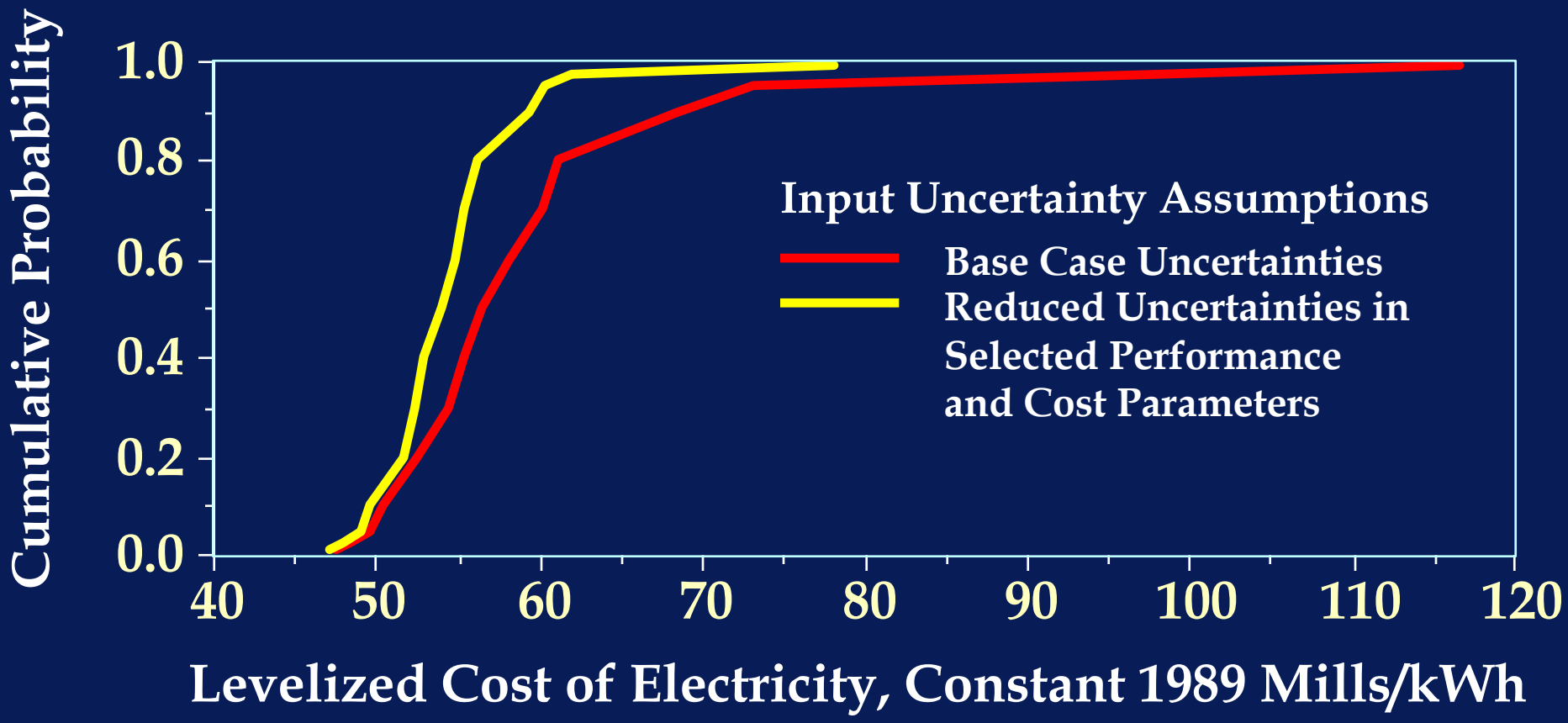
EFCC PLANT EFFICIENCY



SECOND GENERATION PFBC SYSTEM TOTAL CAPITAL COST



VALUE OF TARGETED RESEARCH

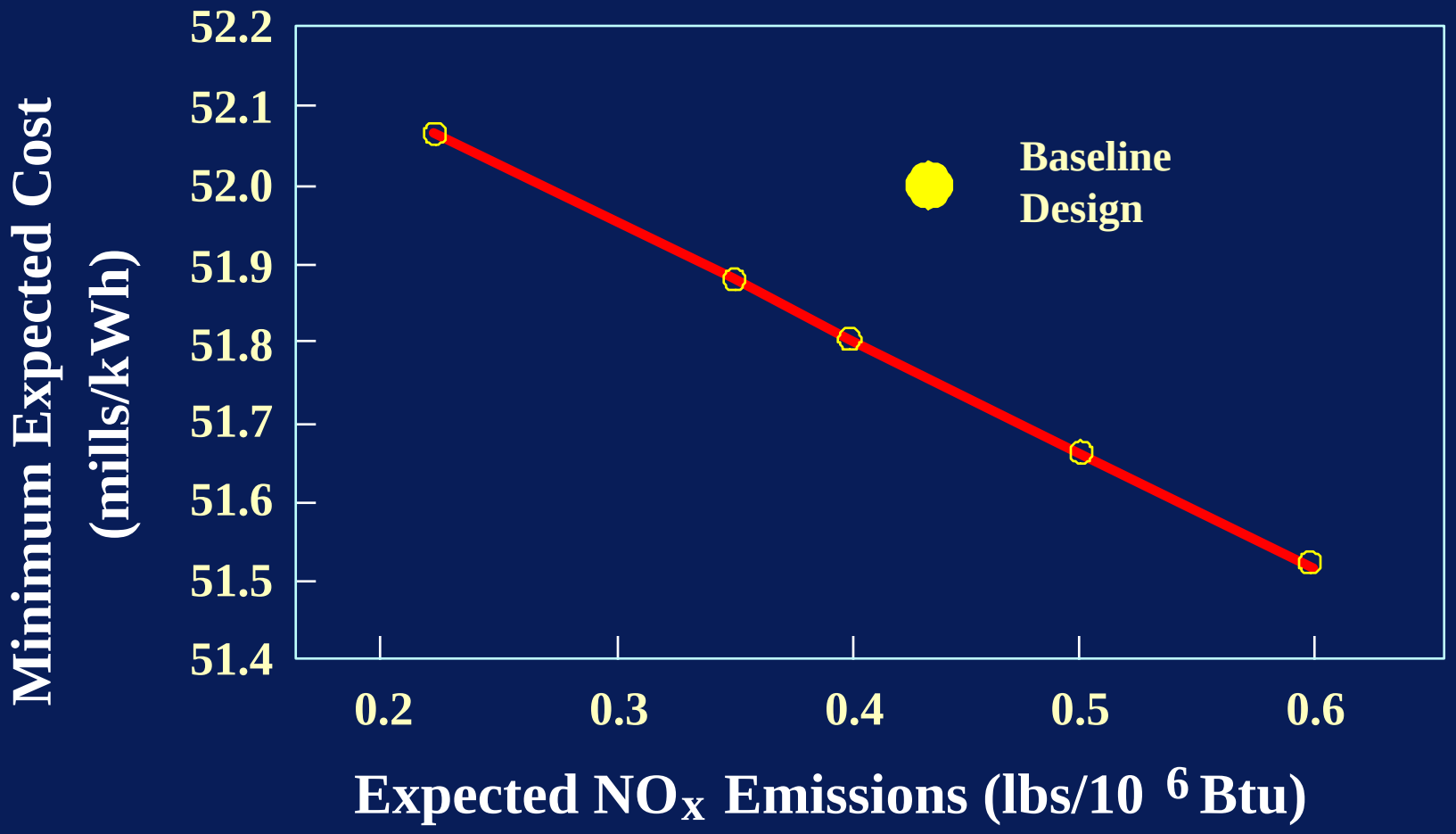


OPTIMIZATION

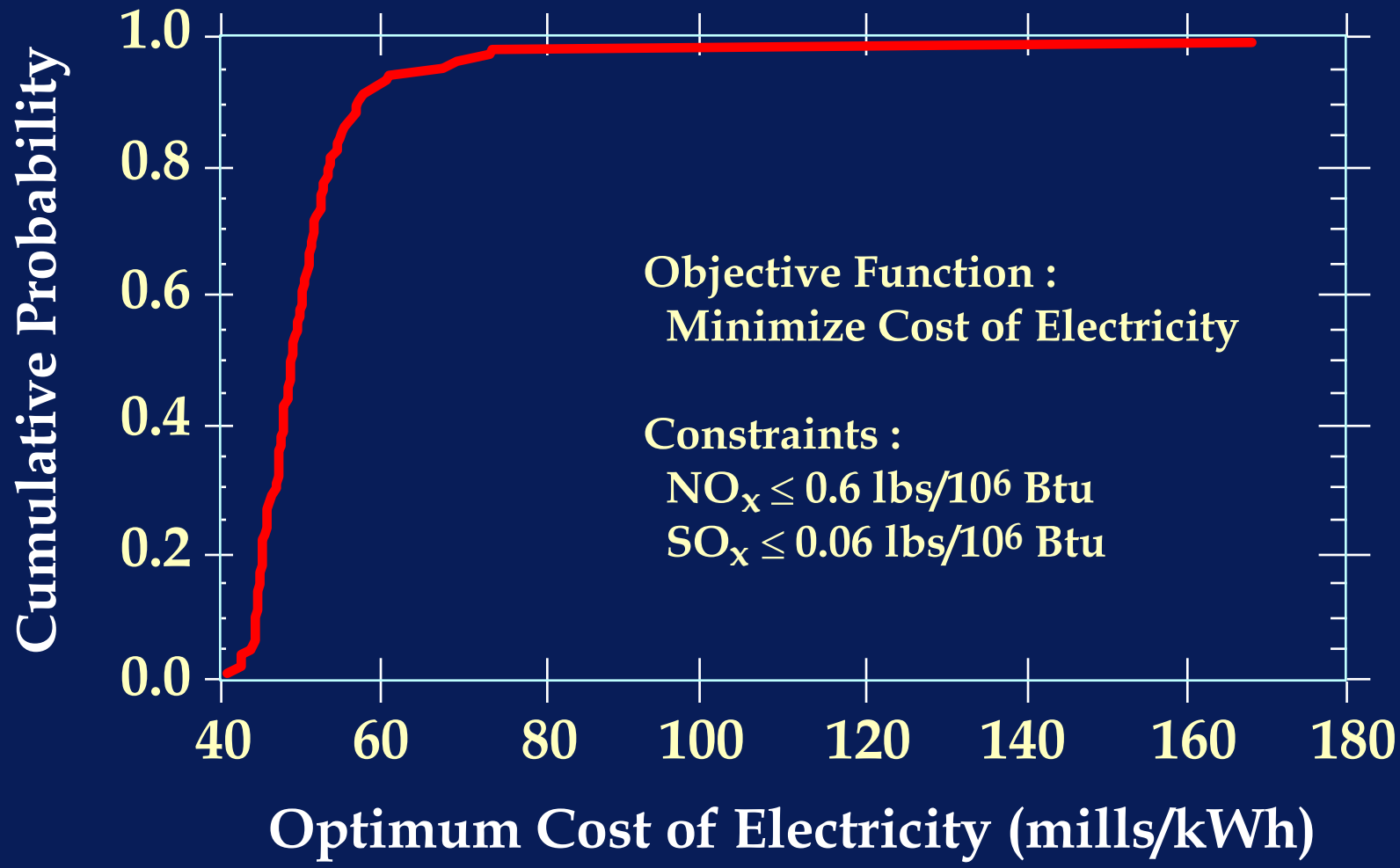
SOME QUESTIONS ADDRESSED BY OPTIMIZATION CAPABILITIES

- **Is there a better choice of parameter values for this process to improve its performance? To lower its cost?**
- **What levels of performance and cost can we expect from an optimized design?**
- **How do uncertainties in process performance and cost variables affect the optimal design?**
- **What design choices will minimize the risk of a performance shortfall? Or the risk of a cost overrun?**

MINIMIZE TOTAL COST SUBJECT TO NO_x EMISSION CONSTRAINT



EFFECT OF UNCERTAINTIES ON OPTIMAL DESIGN COST

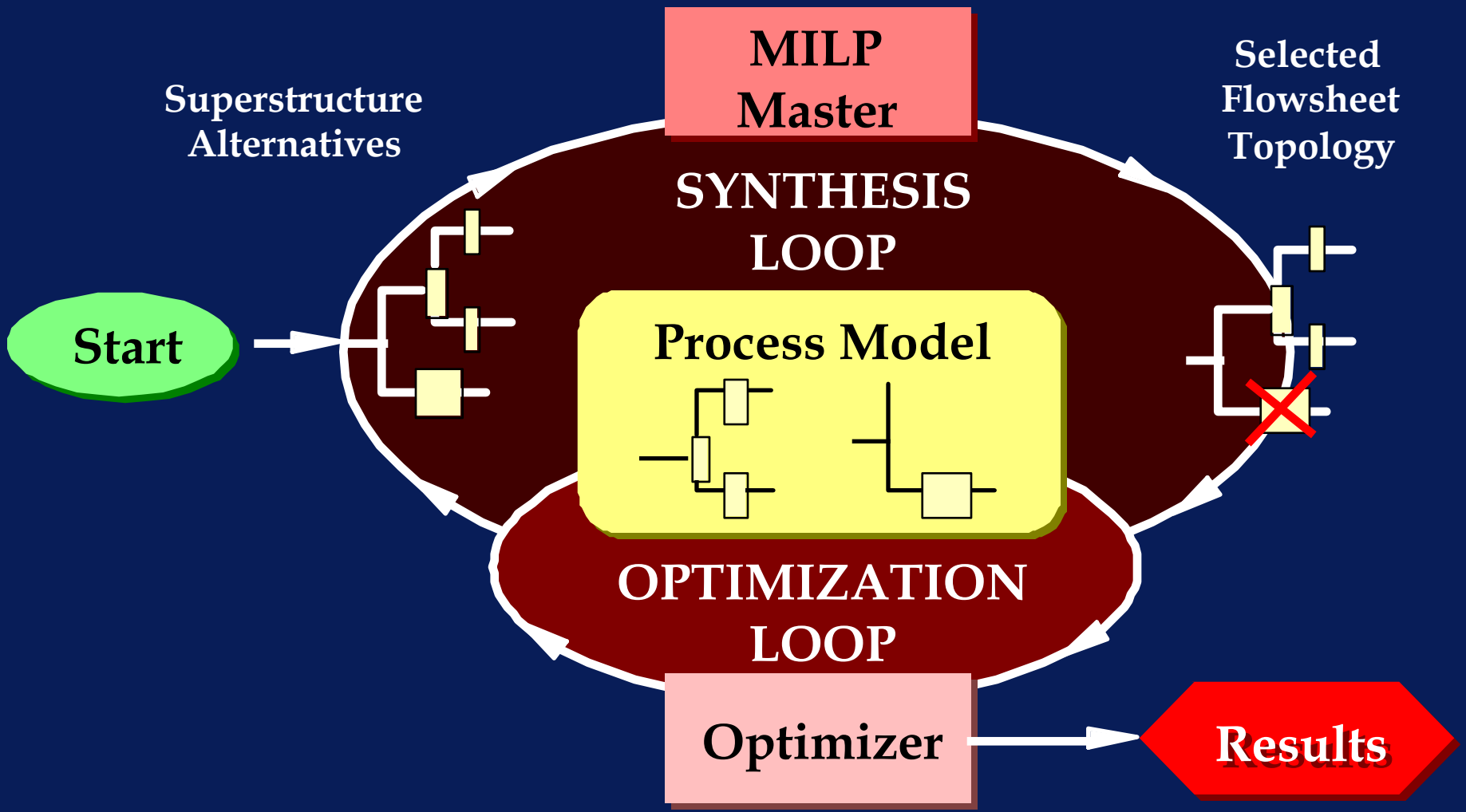


SYNTHESIS

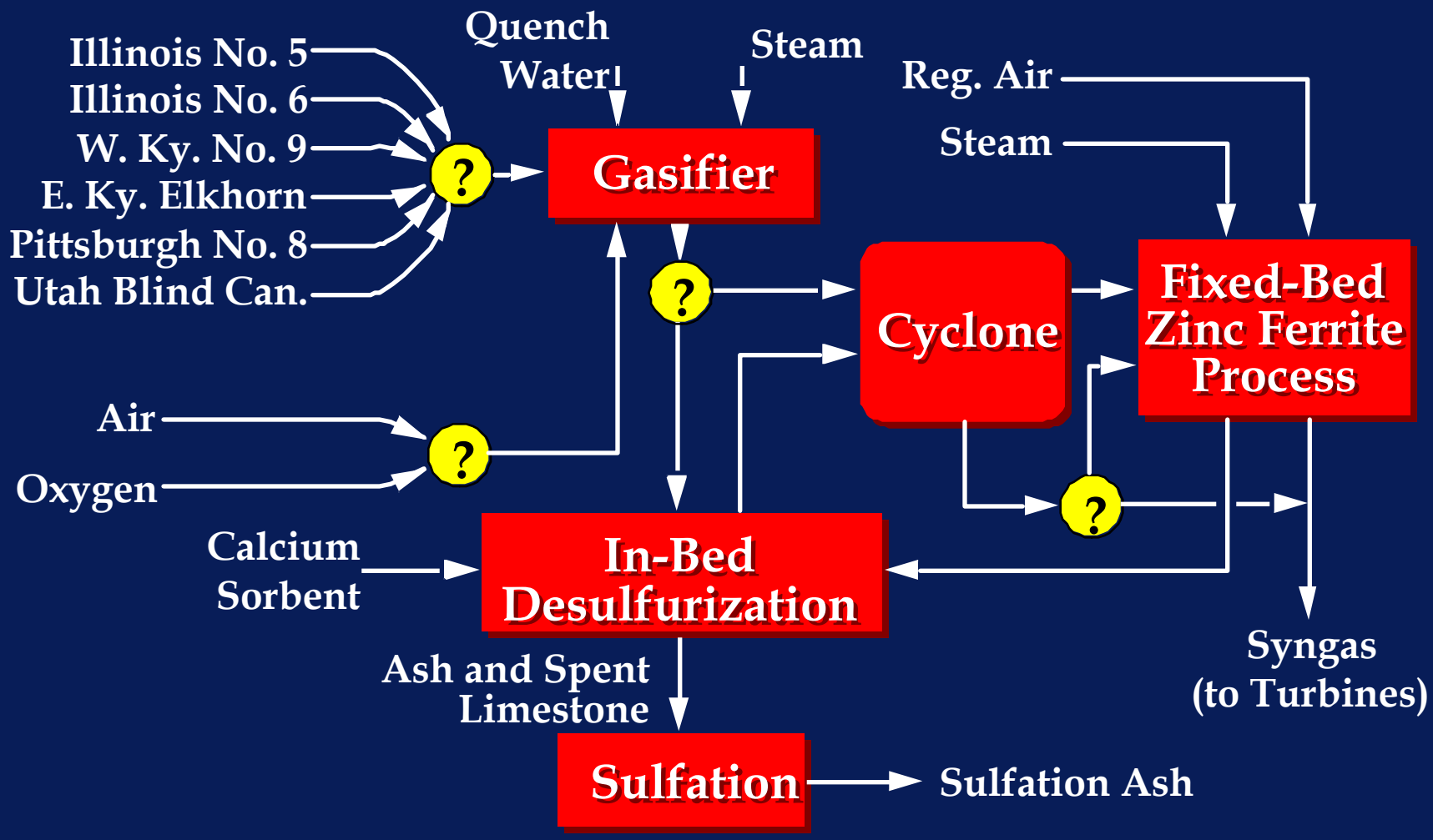
SOME QUESTIONS ADDRESSED BY PROCESS SYNTHESIS CAPABILITIES

- How should the flowsheet be configured to achieve performance goals at lowest cost?
- What are the feasible flowsheet options to meet specified goals and constraints? Which options are not feasible?
- What are the cost savings (or performance gains) from moving to a more optimal design?

PROCESS SYNTHESIS



SYNTHESIS OF IGCC SYSTEM



MODEL APPLICATIONS

- Process design
- Risk analysis
- Cost estimation
- R&D management
- Technology evaluation
- Environmental compliance
- Marketing studies
- Strategic planning