The Integrated Environmental Control Model (IECM)

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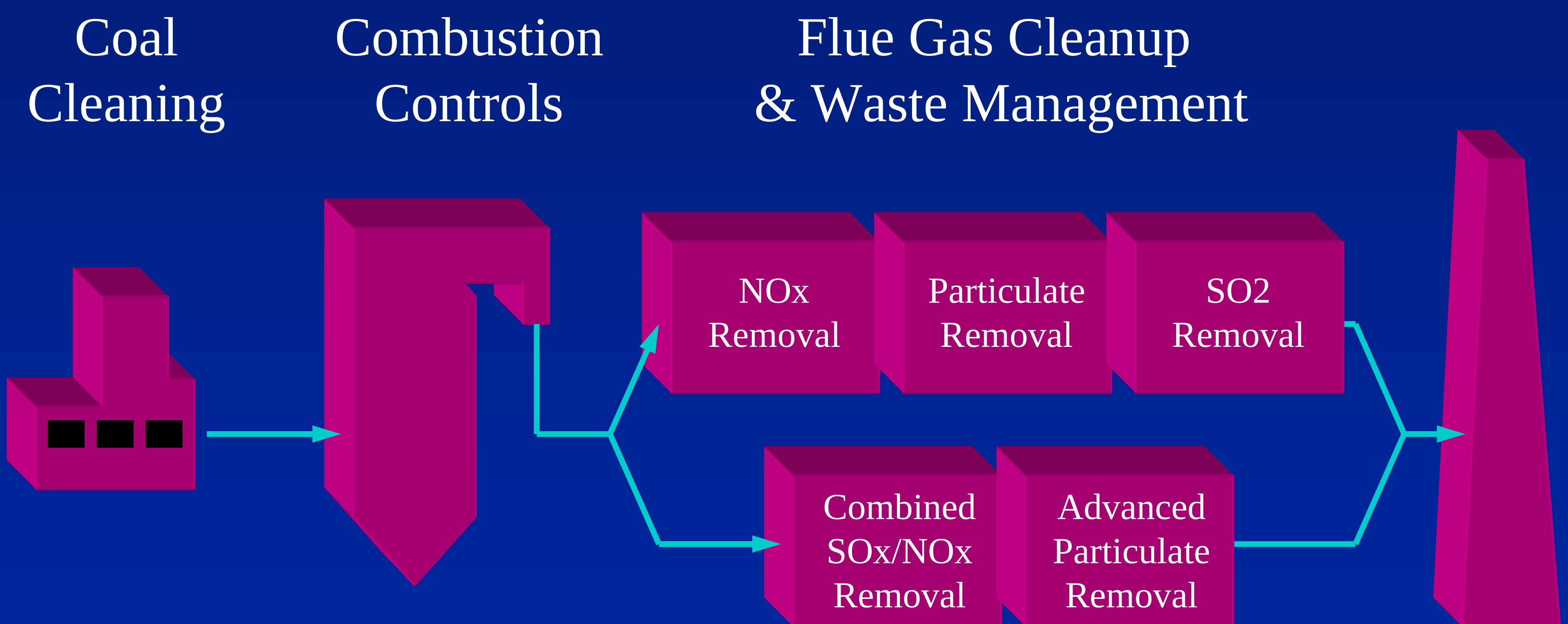
Objectives

- 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, including the effects of uncertainty

Approach

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

Integrated Environmental Control Model (IECM)



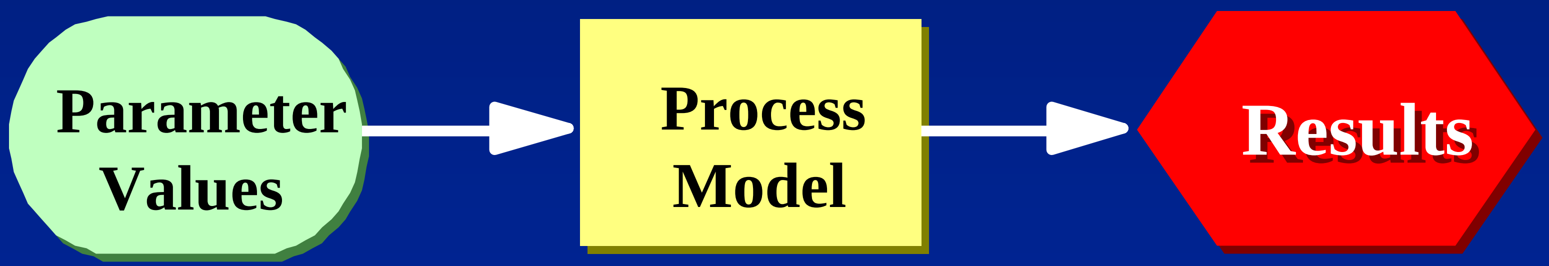
Process Performance Models

- Employ detailed mass and energy balances
- Empirical relationships and models used for complex process chemistry
- Calculate component and system mass flows, energy flows, and efficiency
- Calculate multi-media environmental emissions
- Approximately 10-20 performance parameters for each process technology

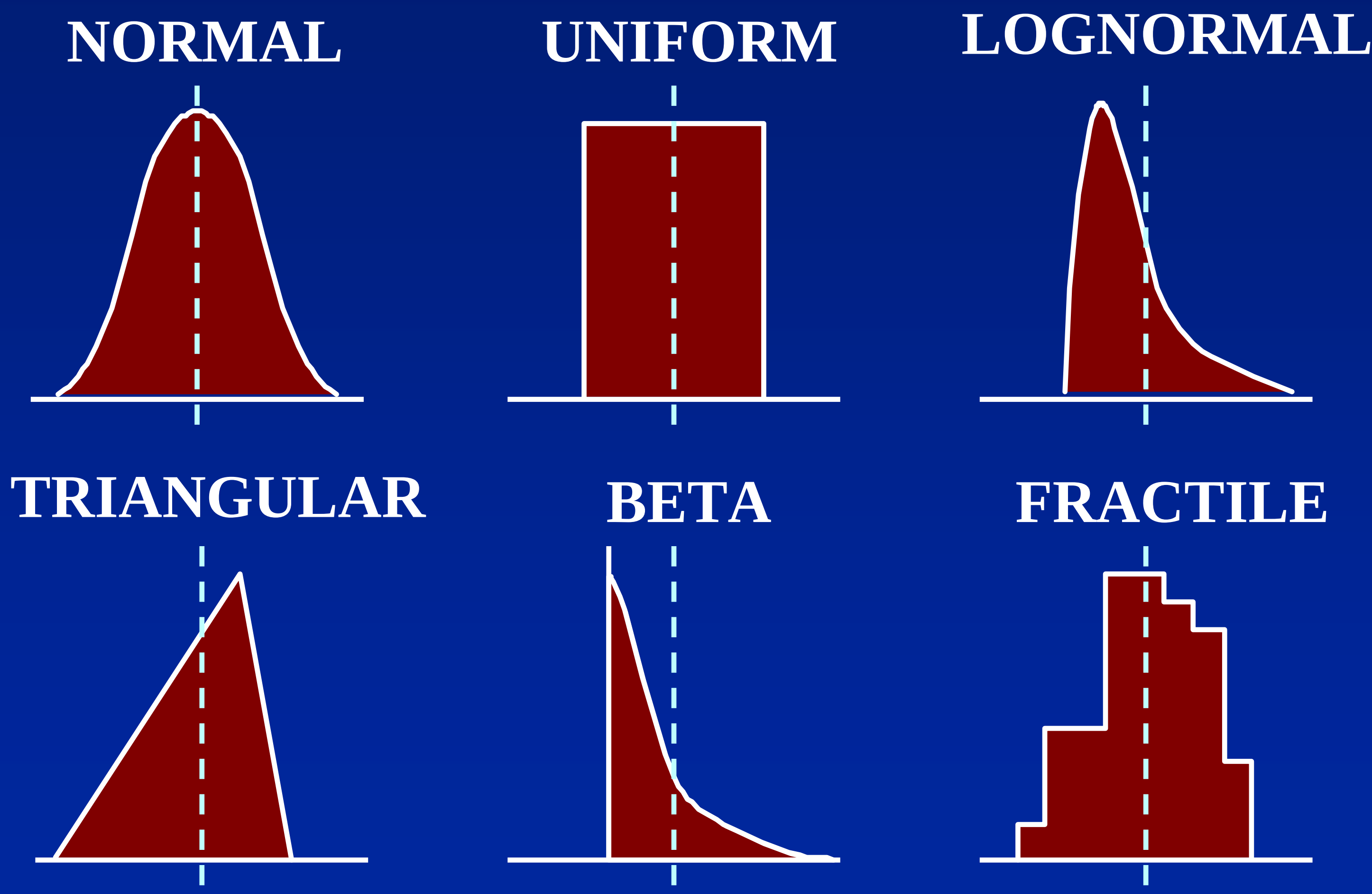
Process Cost Models

- Direct cost models for each major process area (typically 5-10 areas per technology)
- Explicit links to process performance models
- Calculate total capital cost
- Calculate variable operating costs
- Calculate fixed operating costs
- Calculate annualized cost of electricity
- Approximately 20-30 cost parameters for each process technology

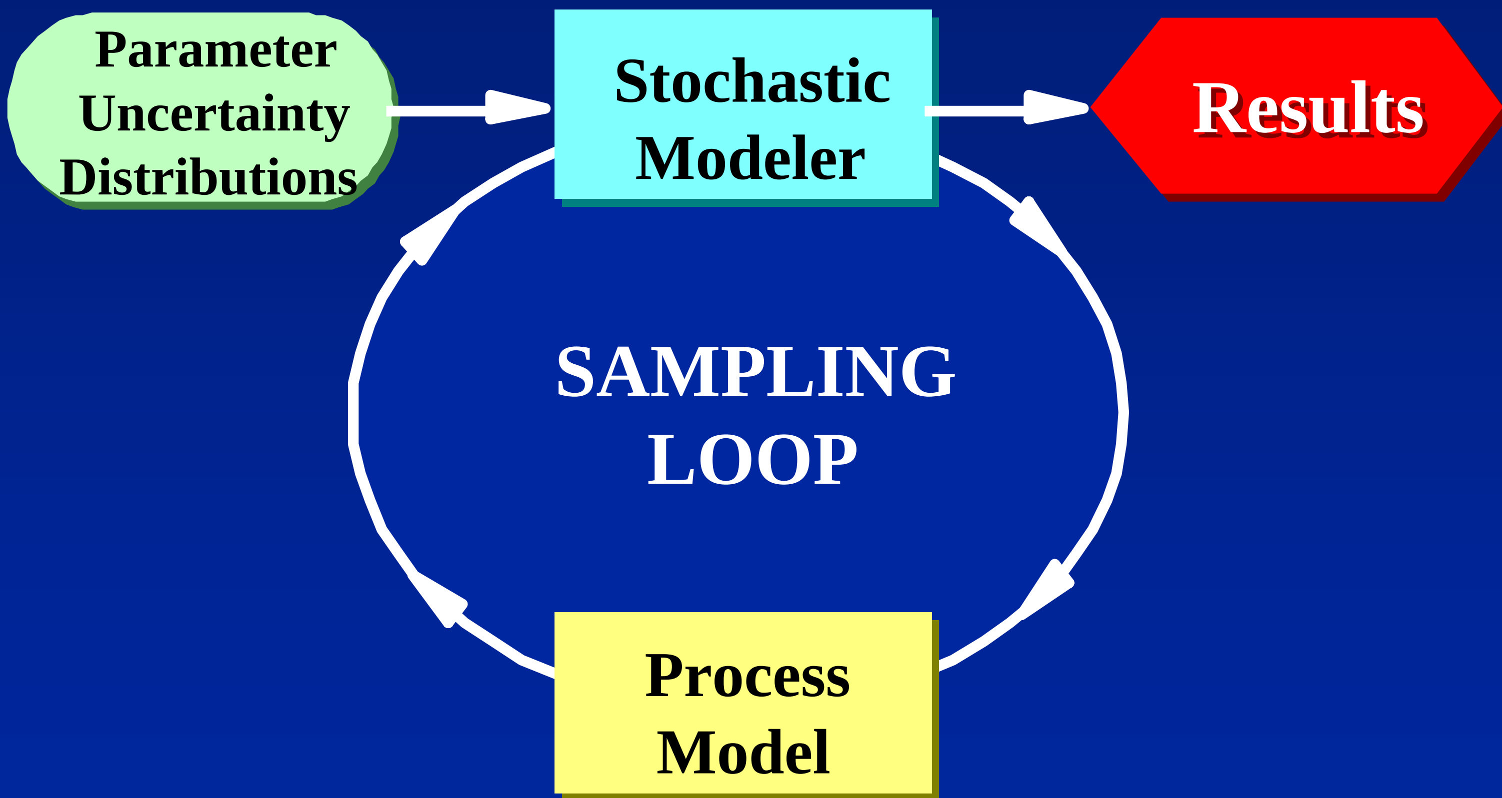
Conventional Process Modeling (Deterministic Simulation)



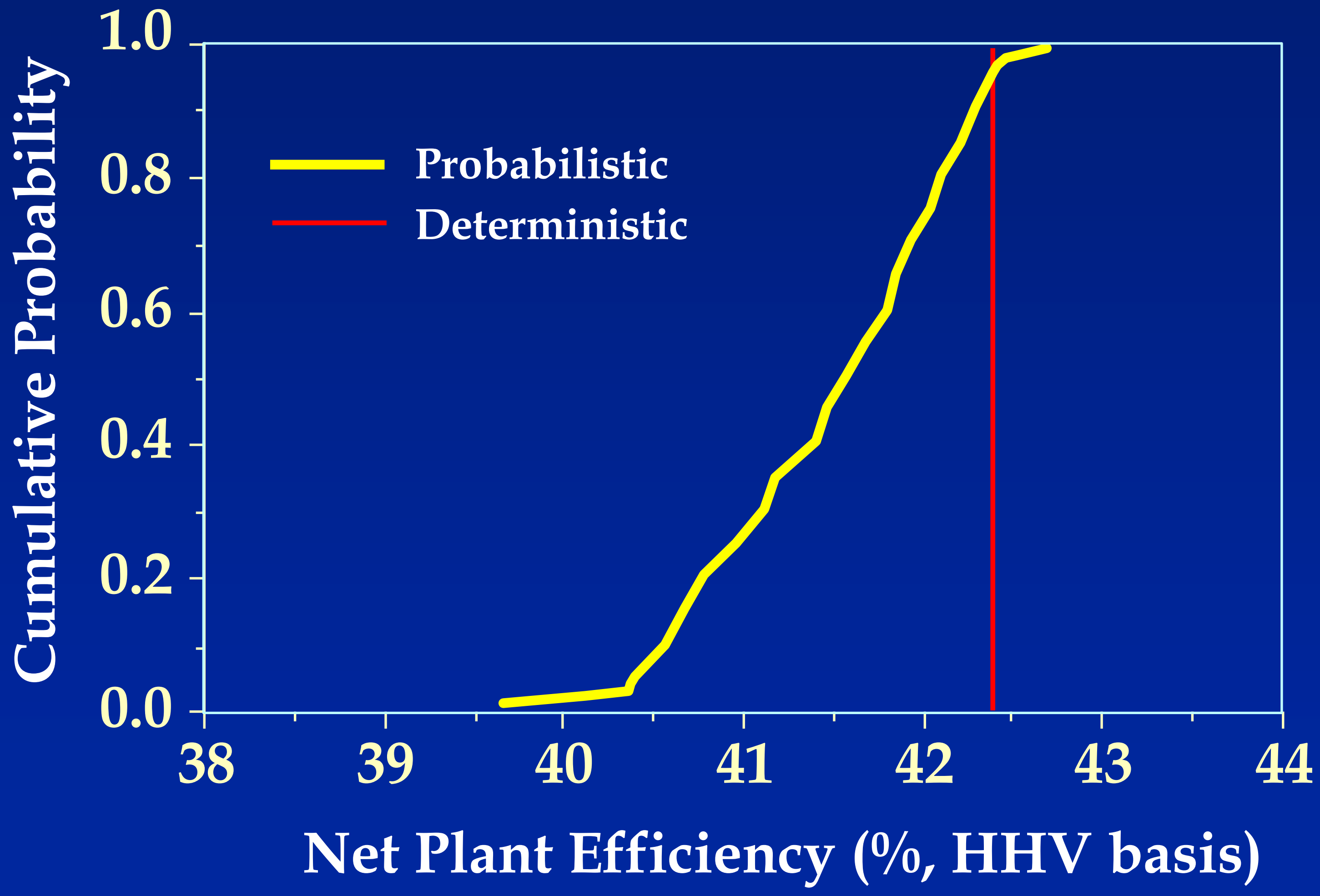
Parameter Uncertainty Distributions



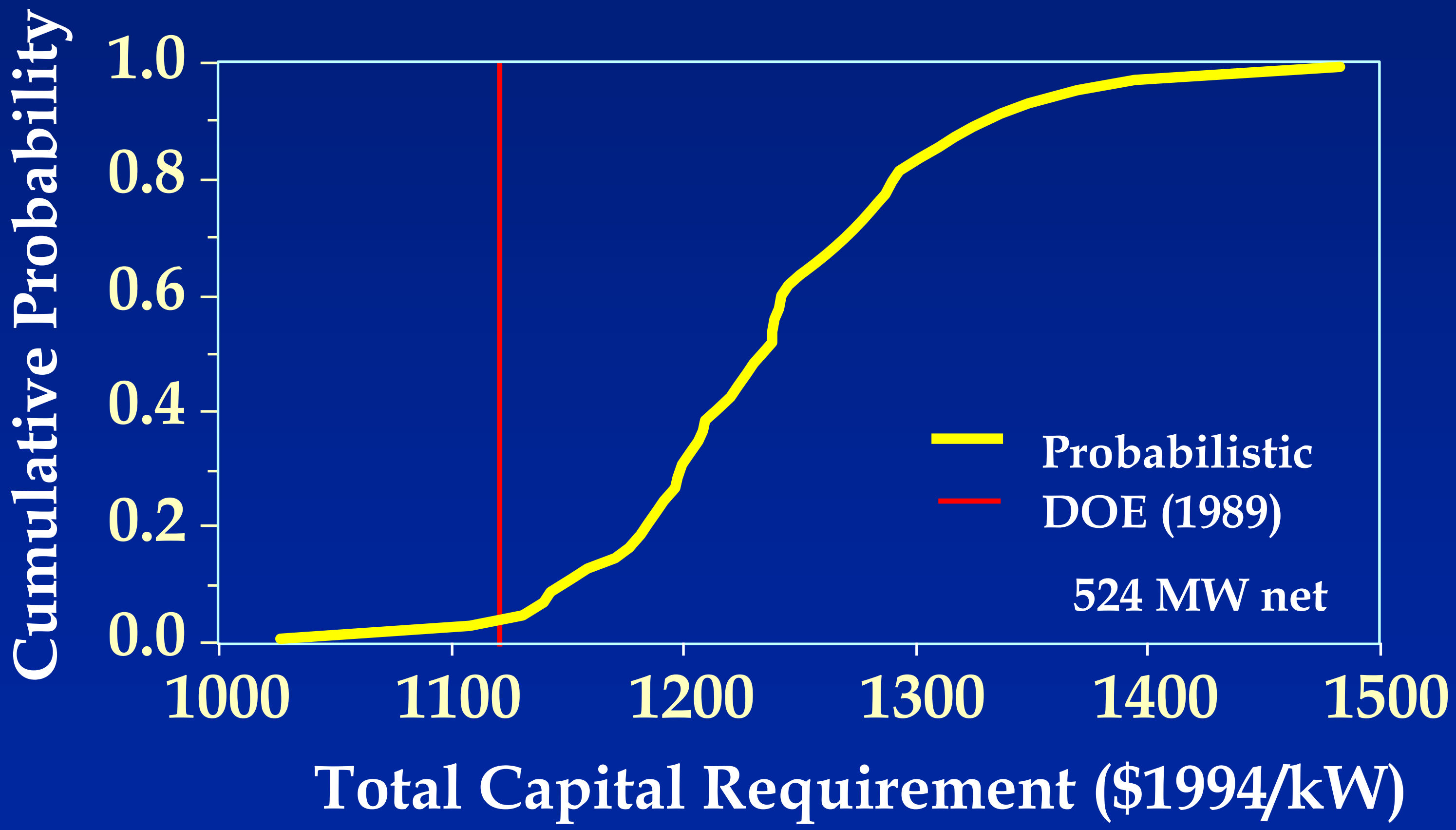
Stochastic Simulation

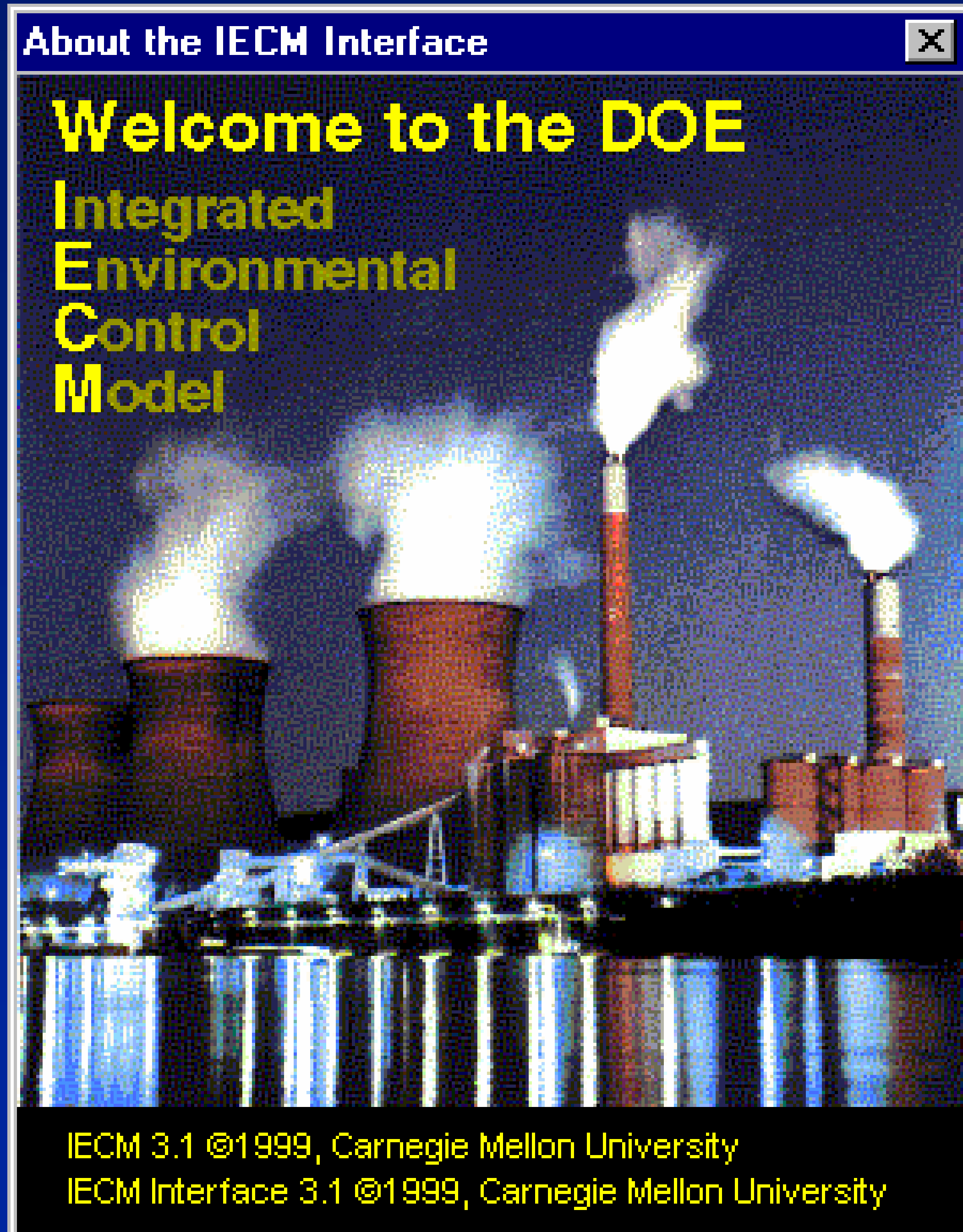


Calculated Plant Efficiency



Total Plant Capital Cost




About the IECM Interface
Welcome to the DOE
Integrated
Environmental
Control
Model
IECM 3.1 ©1999, Carnegie Mellon University
IECM Interface 3.1 ©1999, Carnegie Mellon University

(live demo of the IECM)

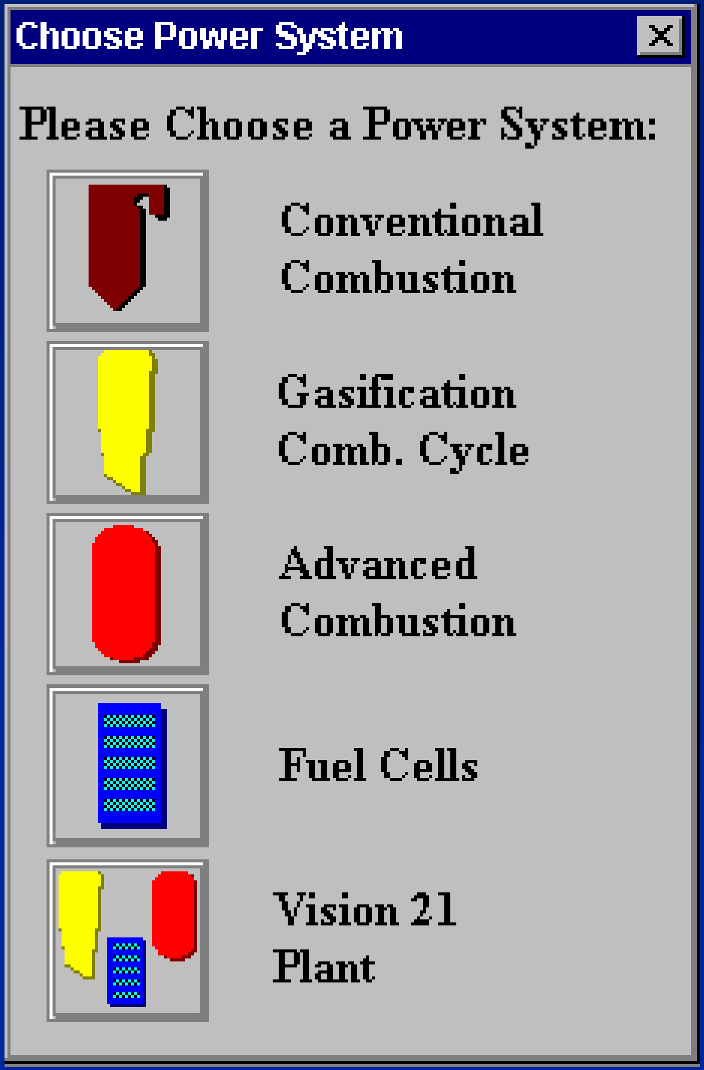
The IECM is Now Available for Downloading by the Public

- **Web Access:**
  - ftp://ftp.fetc.doe.gov/pub/IECM
- **FTP Access:**
  - ftp.fetc.doe.gov/pub/IECM
    - anonymous login
    - any password

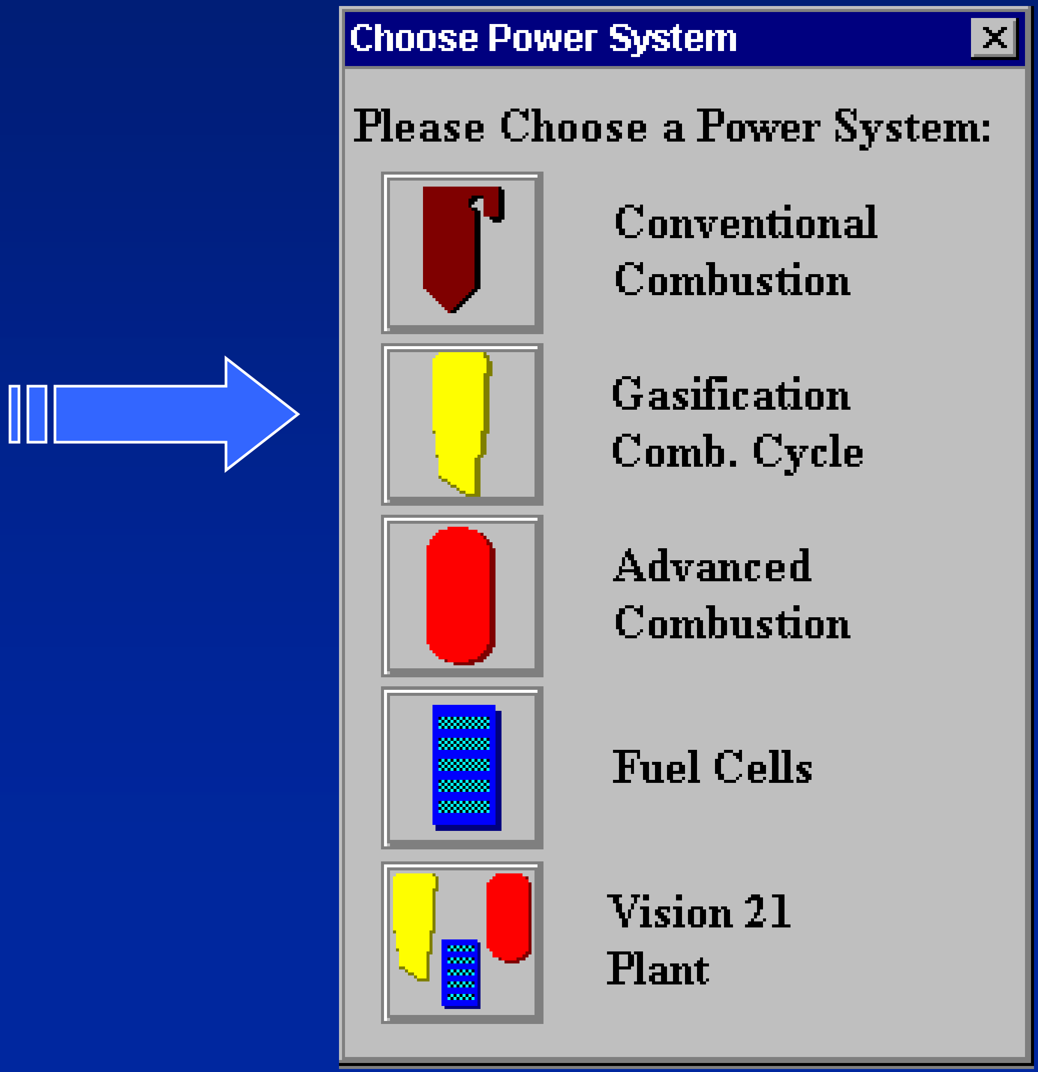
Additional Technology Options

- *Planned*
  - Combustion NO_x Controls
    - – Selective Non-Catalytic Reduction (SNCR)
    - – Low NOx Burners
    - – Overfire air
    - – Low Excess Air
    - – Lean Gas Reburn
    - – Burners Out of Service
    - – Selected combinations of the above
- *Proposed*
  - Post-Combustion Controls
    - – Air Toxics (mercury)
  - Other Fuels
    - – Natural Gas
    - – Petroleum
    - – Fuel Blending
  - Alternative Power Generation Systems

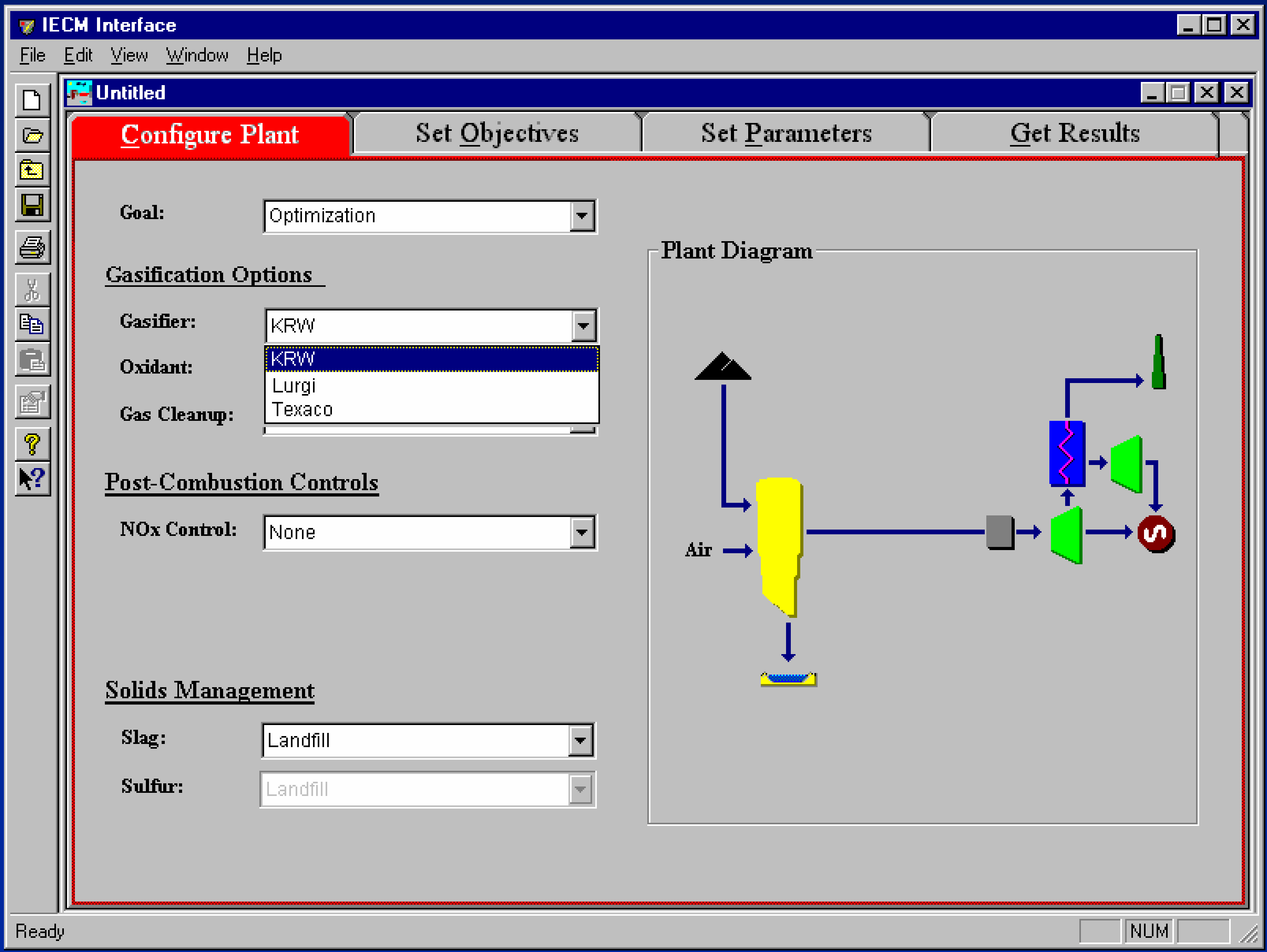
Future Development:
A Menu of Technology Options



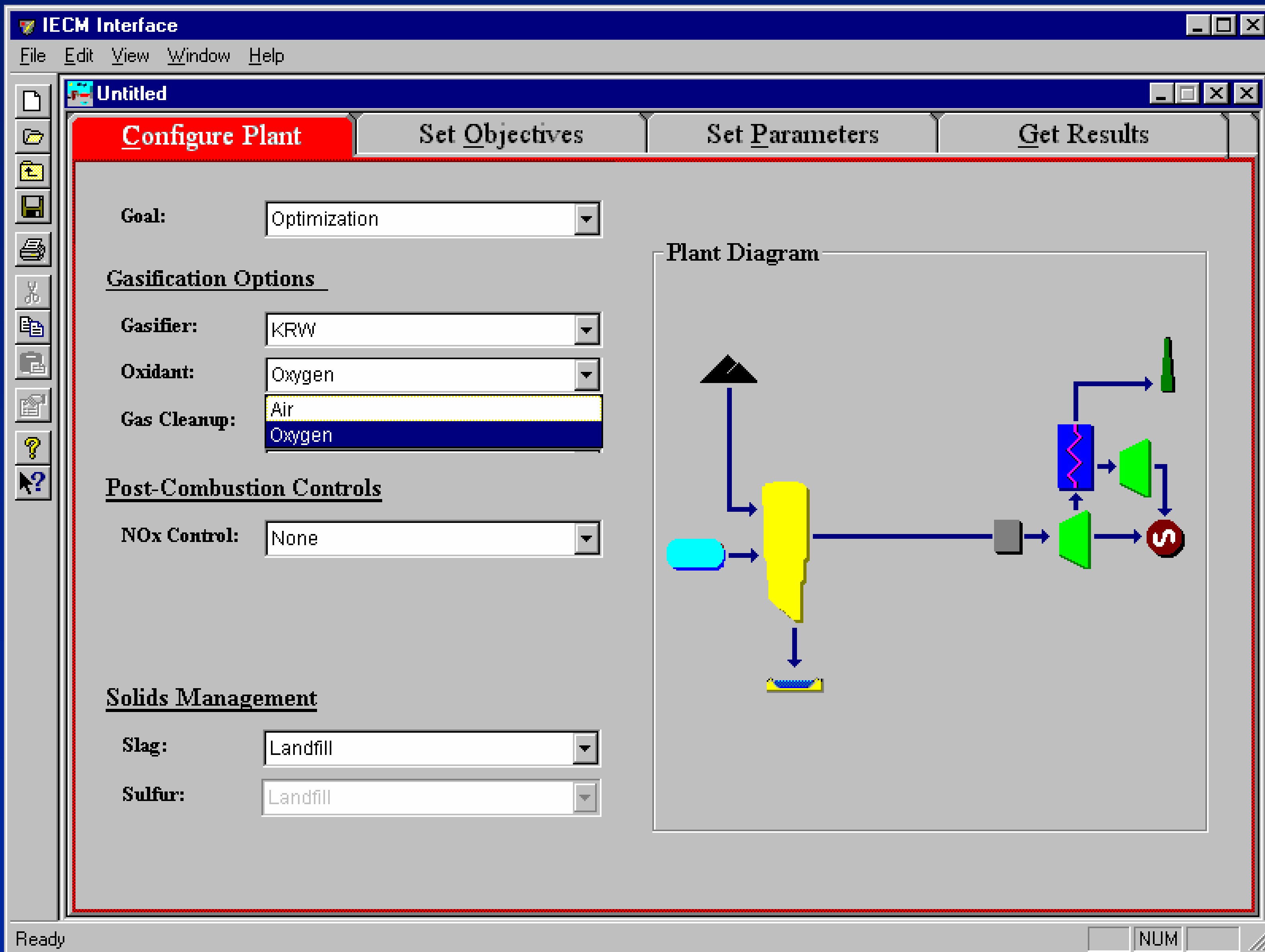
Select Gasification Combined Cycle (IGCC) Options



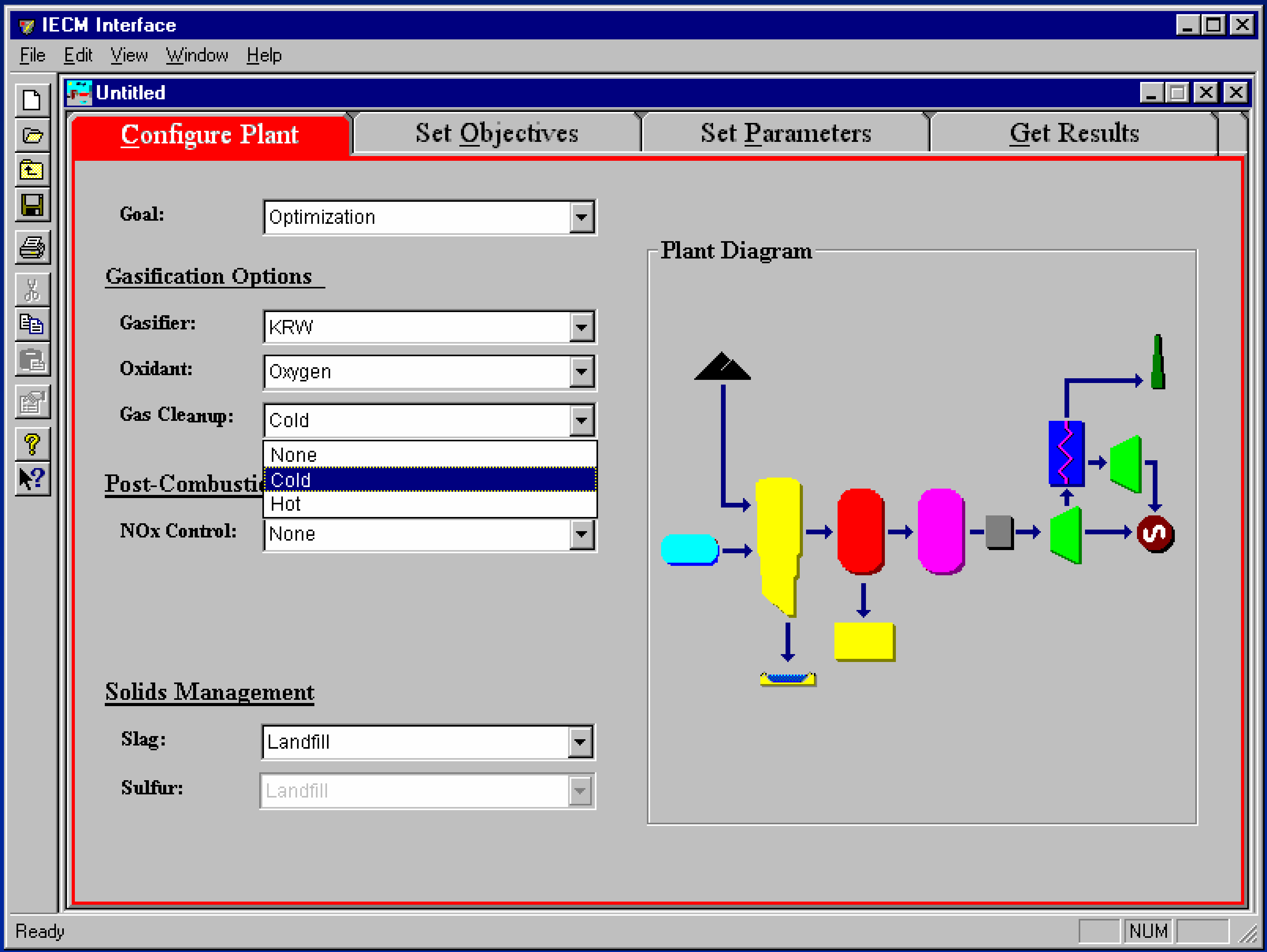
Select KRW Gasifier



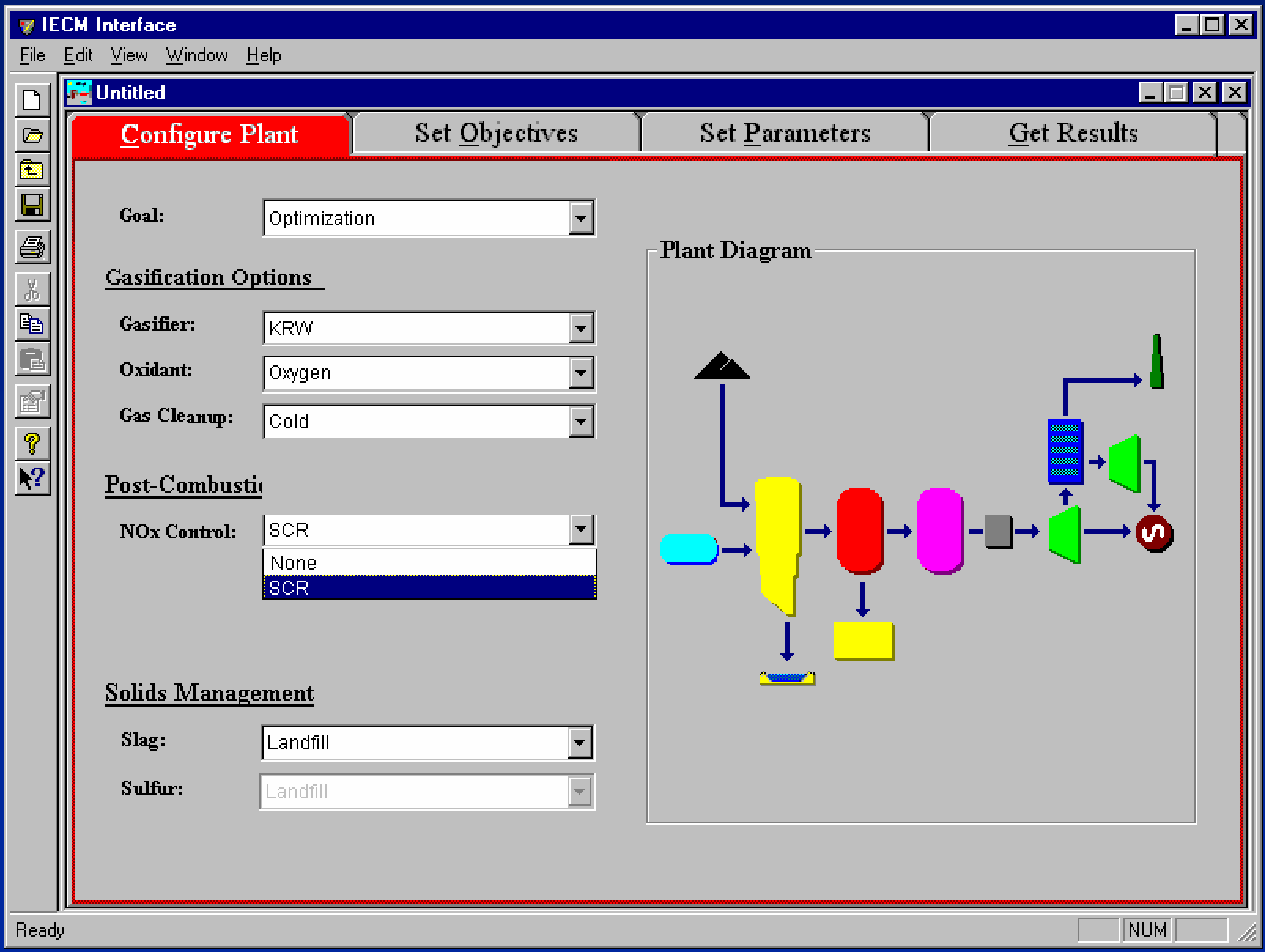
Select Oxygen Plant



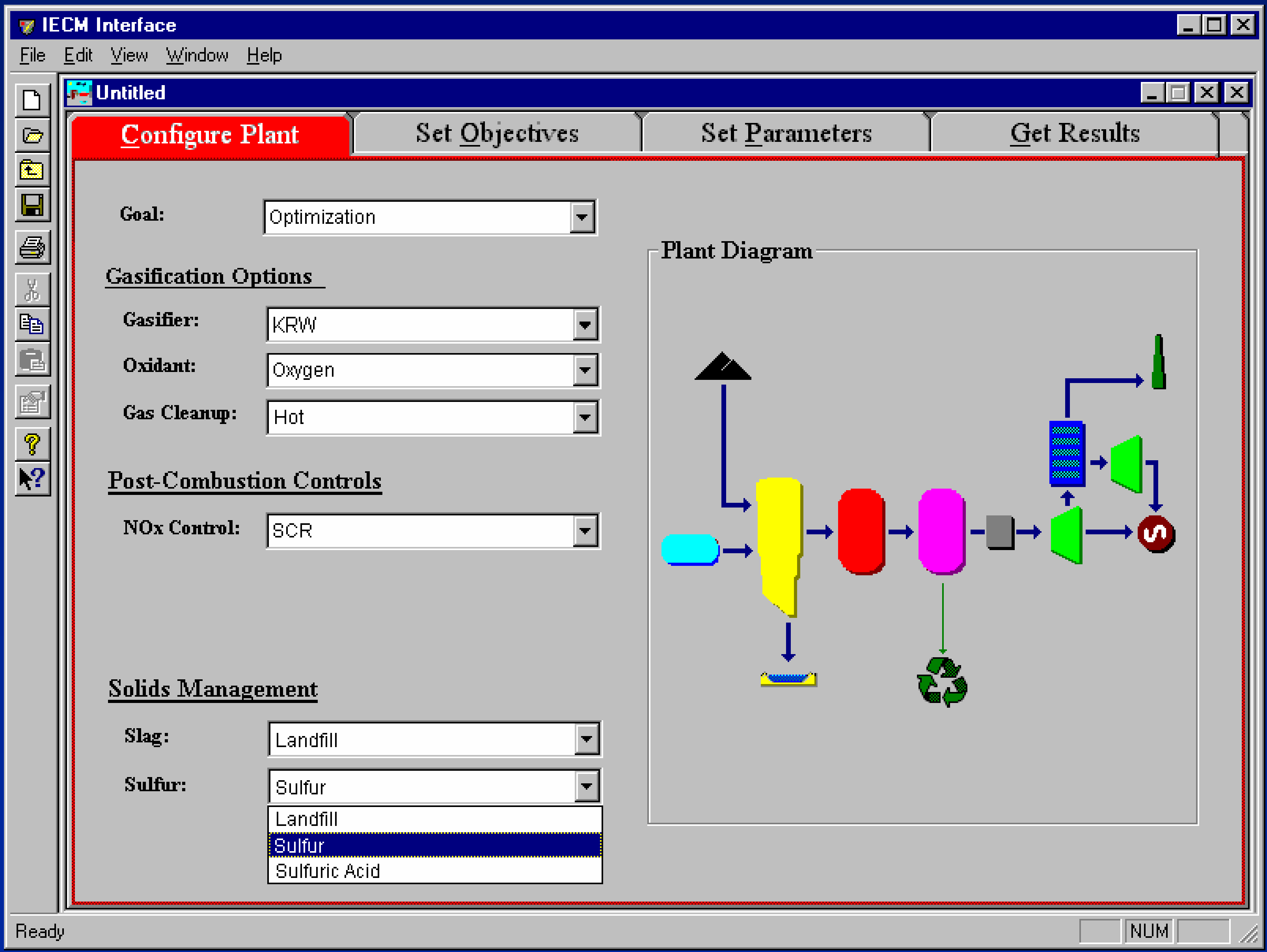
Select Cold Gas Cleanup



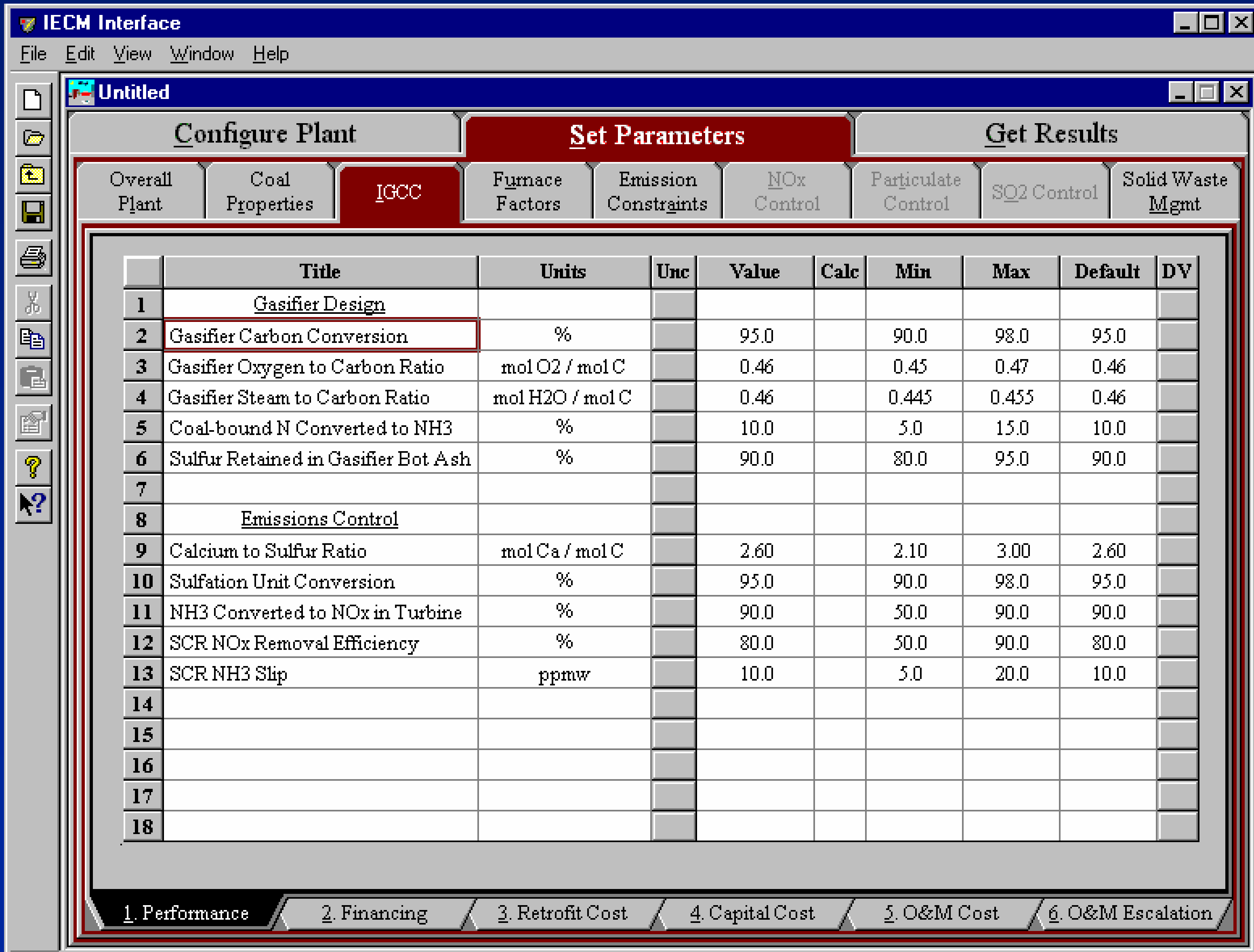
Select NO_x Control



Select Byproduct Recovery

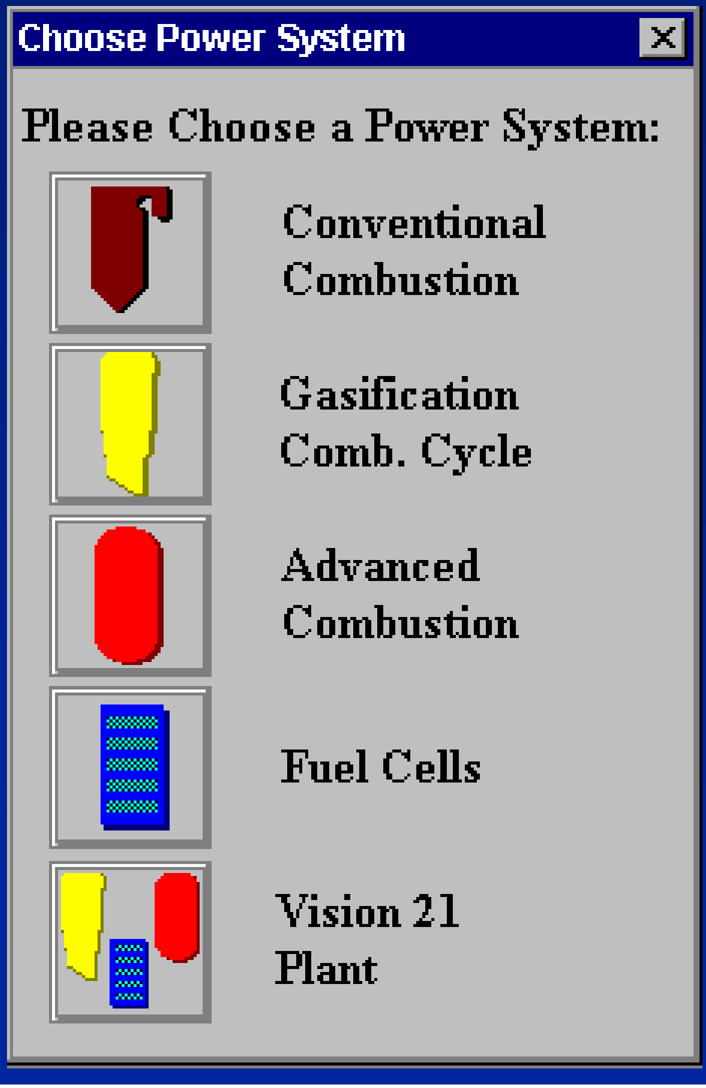


Set Process Parameters



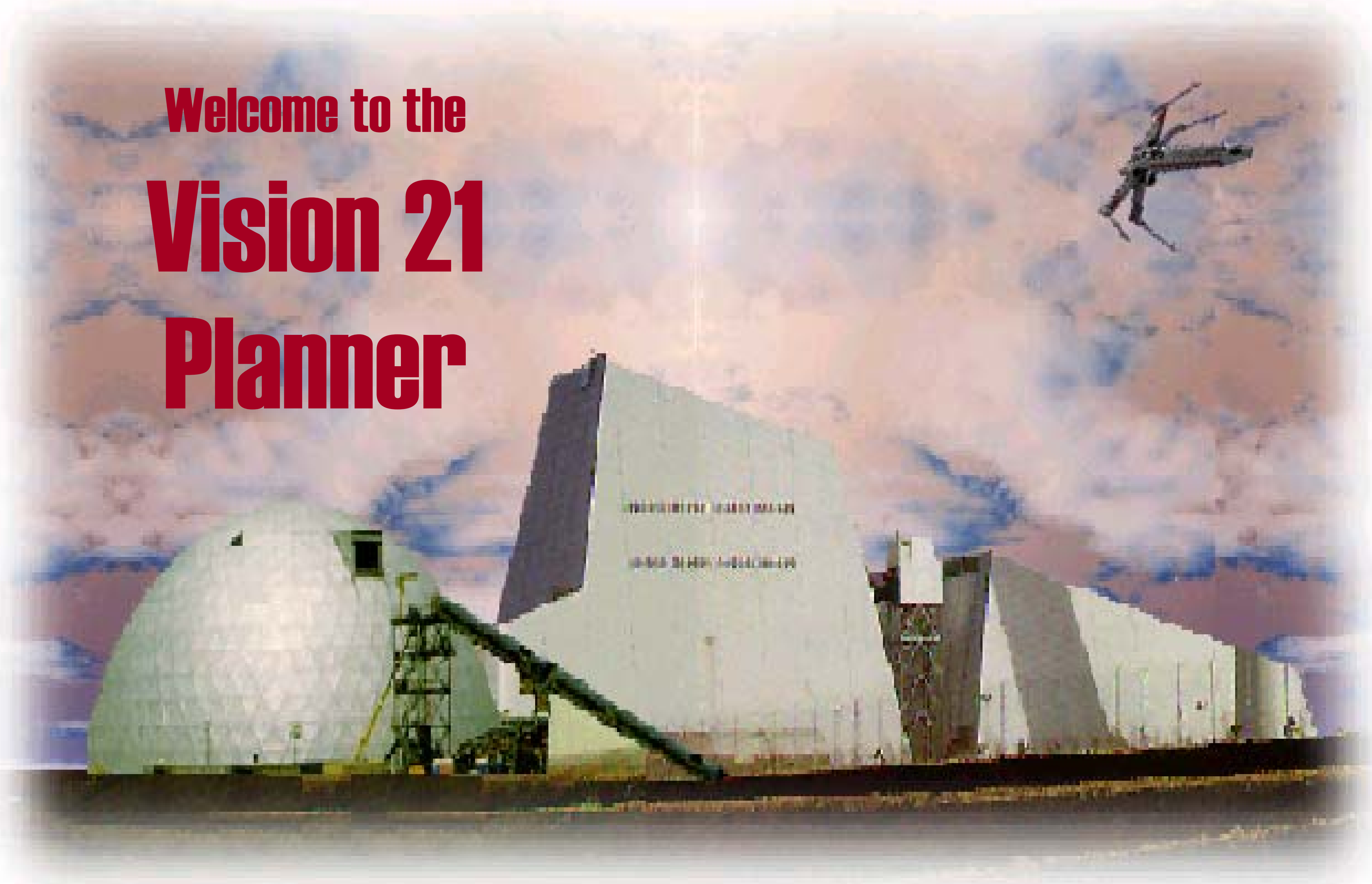
	Title	Units	Unc	Value	Calc	Min	Max	Default	DV
1	Gasifier Design								
2	Gasifier Carbon Conversion	%		95.0		90.0	98.0	95.0	
3	Gasifier Oxygen to Carbon Ratio	mol O2 / mol C		0.46		0.45	0.47	0.46	
4	Gasifier Steam to Carbon Ratio	mol H2O / mol C		0.46		0.445	0.455	0.46	
5	Coal-bound N Converted to NH3	%		10.0		5.0	15.0	10.0	
6	Sulfur Retained in Gasifier Bot Ash	%		90.0		80.0	95.0	90.0	
7									
8	Emissions Control								
9	Calcium to Sulfur Ratio	mol Ca / mol C		2.60		2.10	3.00	2.60	
10	Sulfation Unit Conversion	%		95.0		90.0	98.0	95.0	
11	NH3 Converted to NOx in Turbine	%		90.0		50.0	90.0	90.0	
12	SCR NOx Removal Efficiency	%		80.0		50.0	90.0	80.0	
13	SCR NH3 Slip	ppmw		10.0		5.0	20.0	10.0	
14									
15									
16									
17									
18									

Open Vision 21 Plant Options

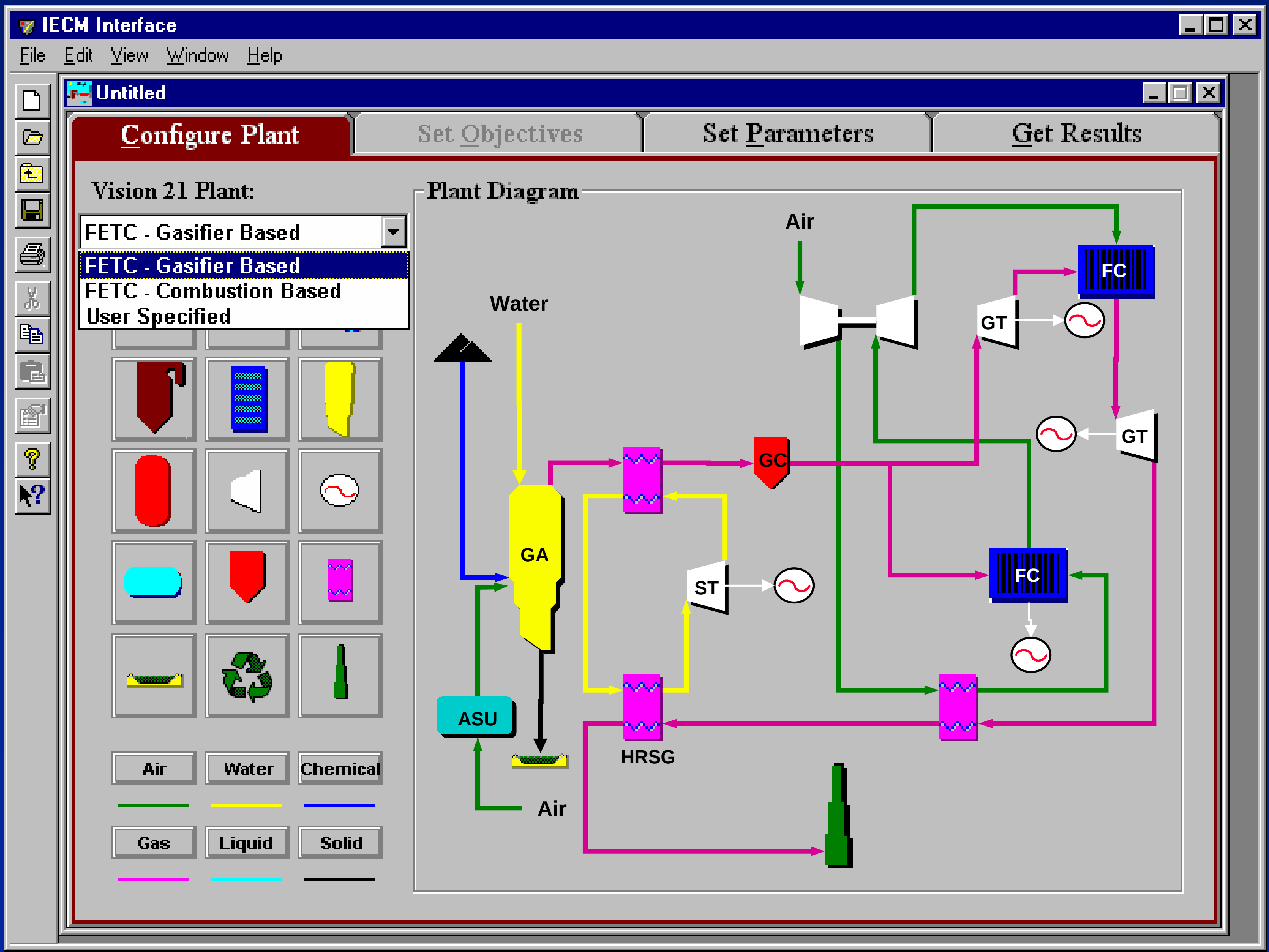


Welcome to the

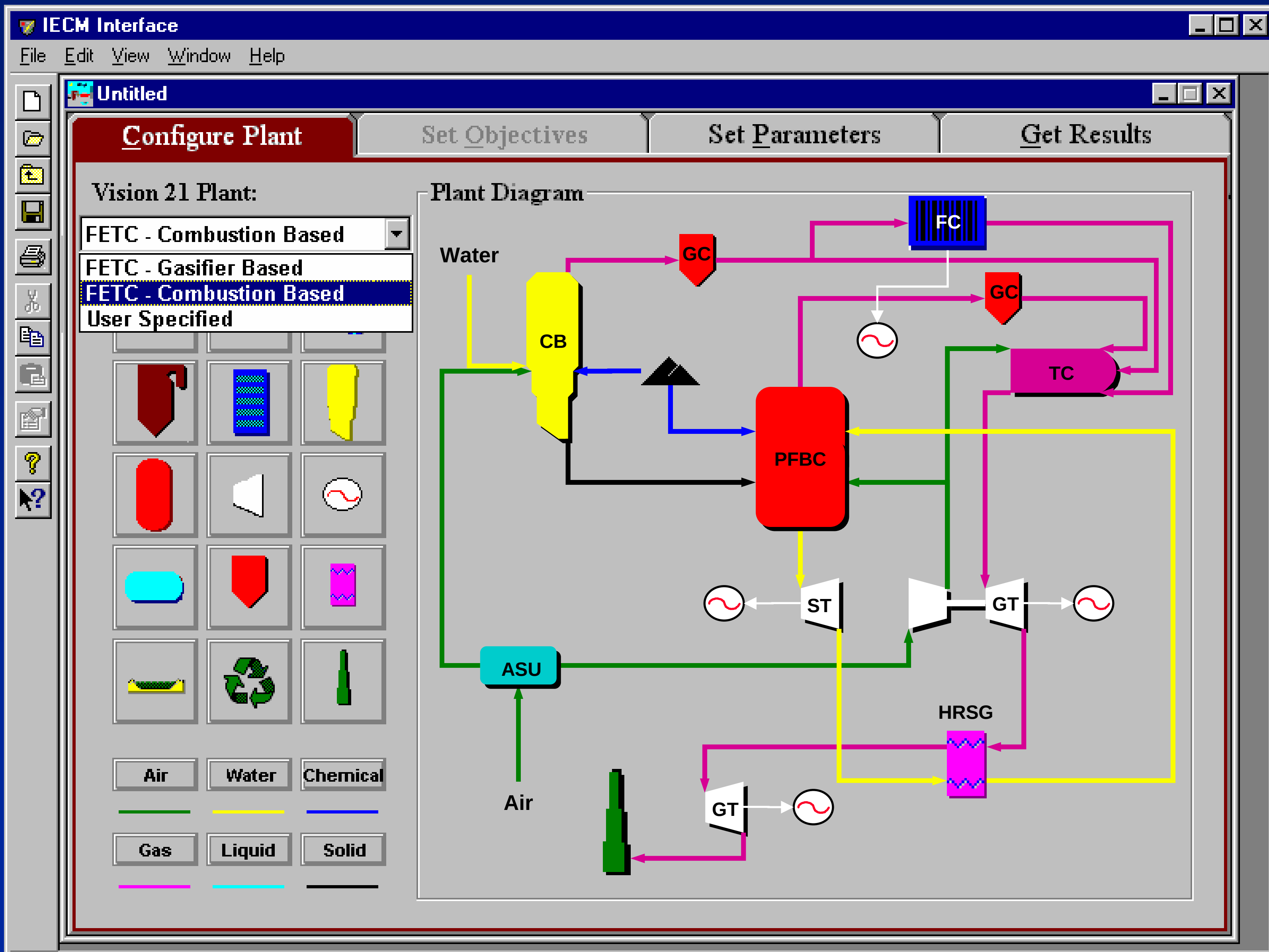
Vision 21 Planner



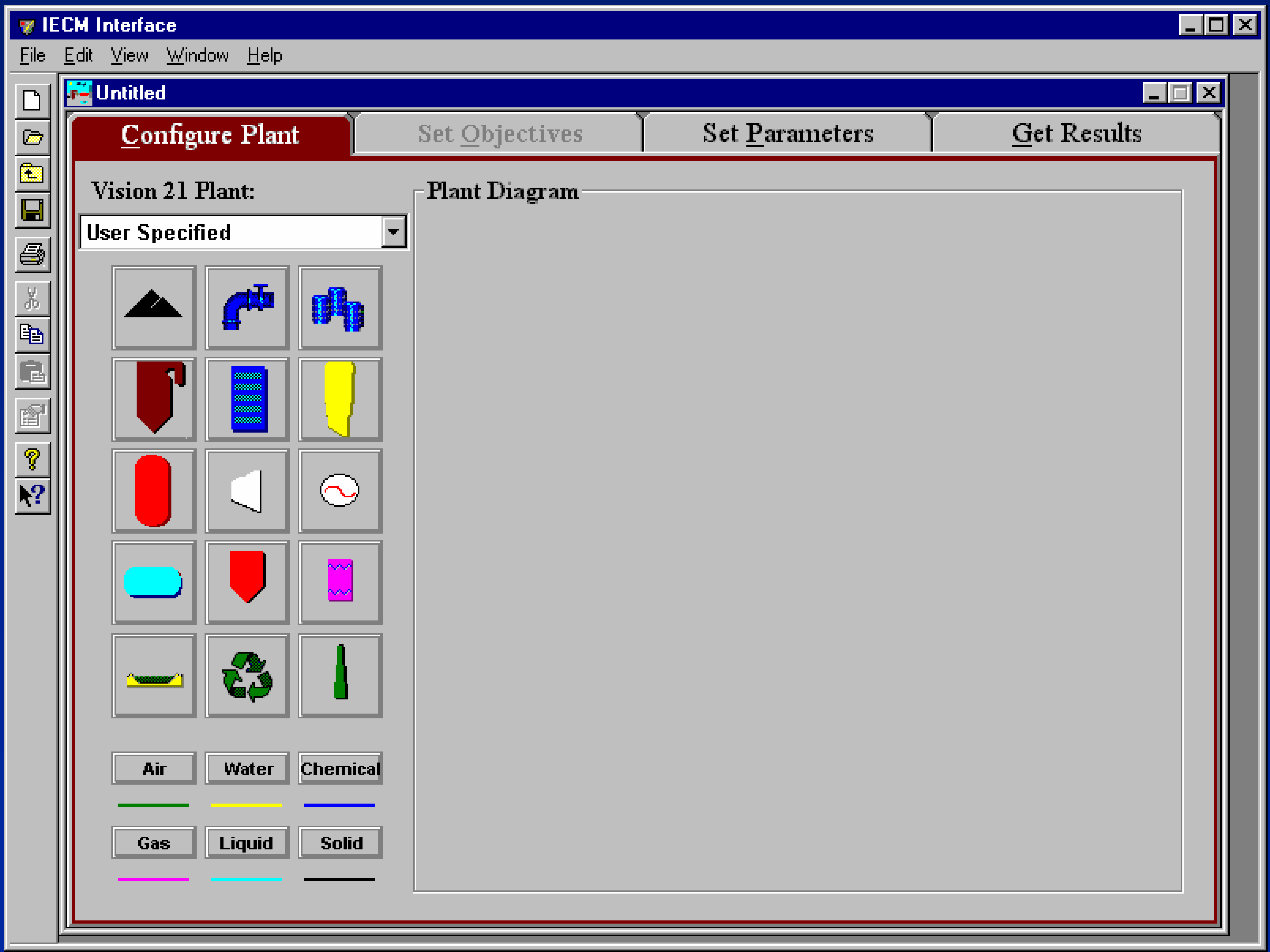
Select Existing Flowsheet - 1



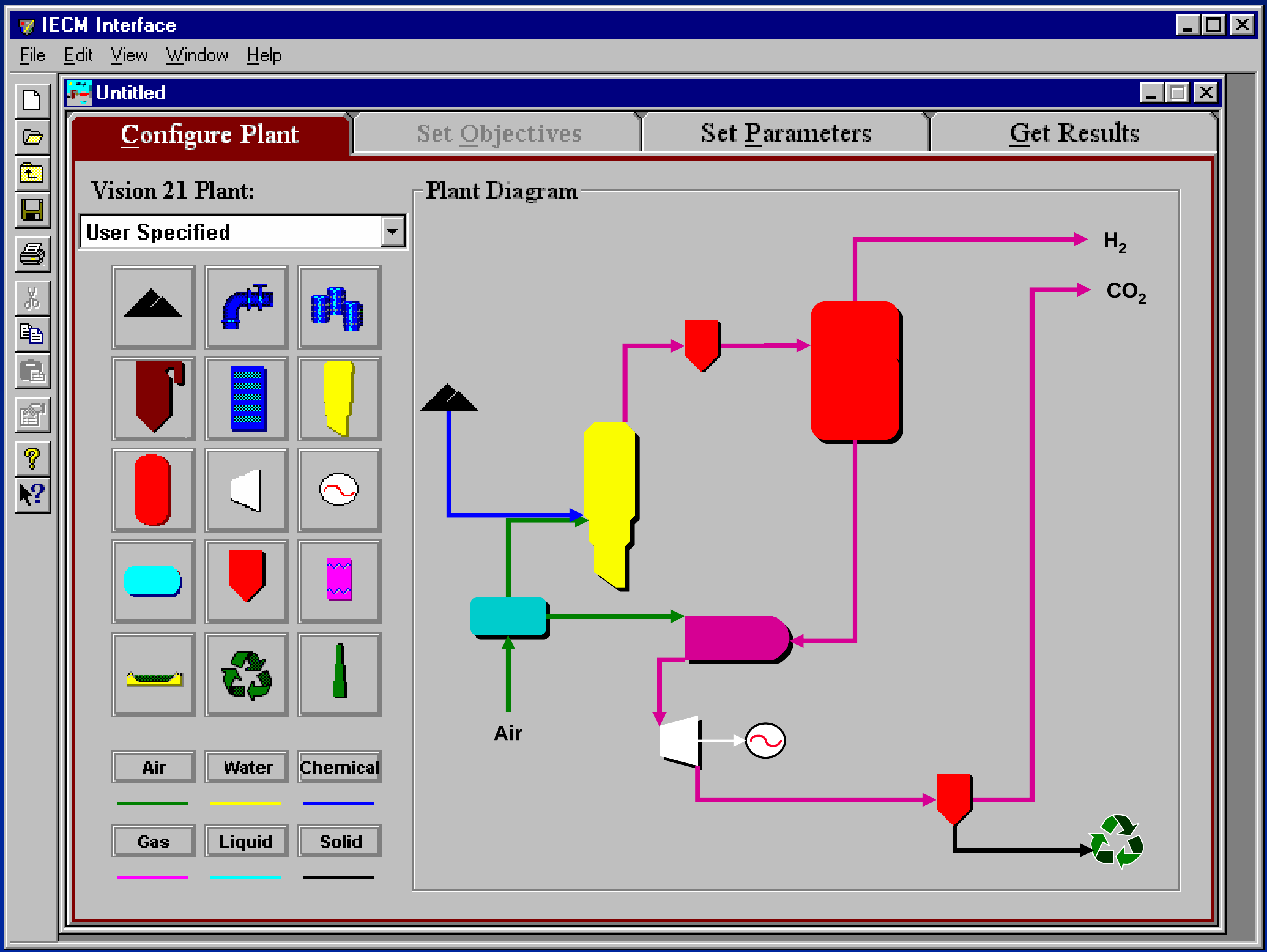
Select Existing Flowsheet - 2



Vision 21 Workbench



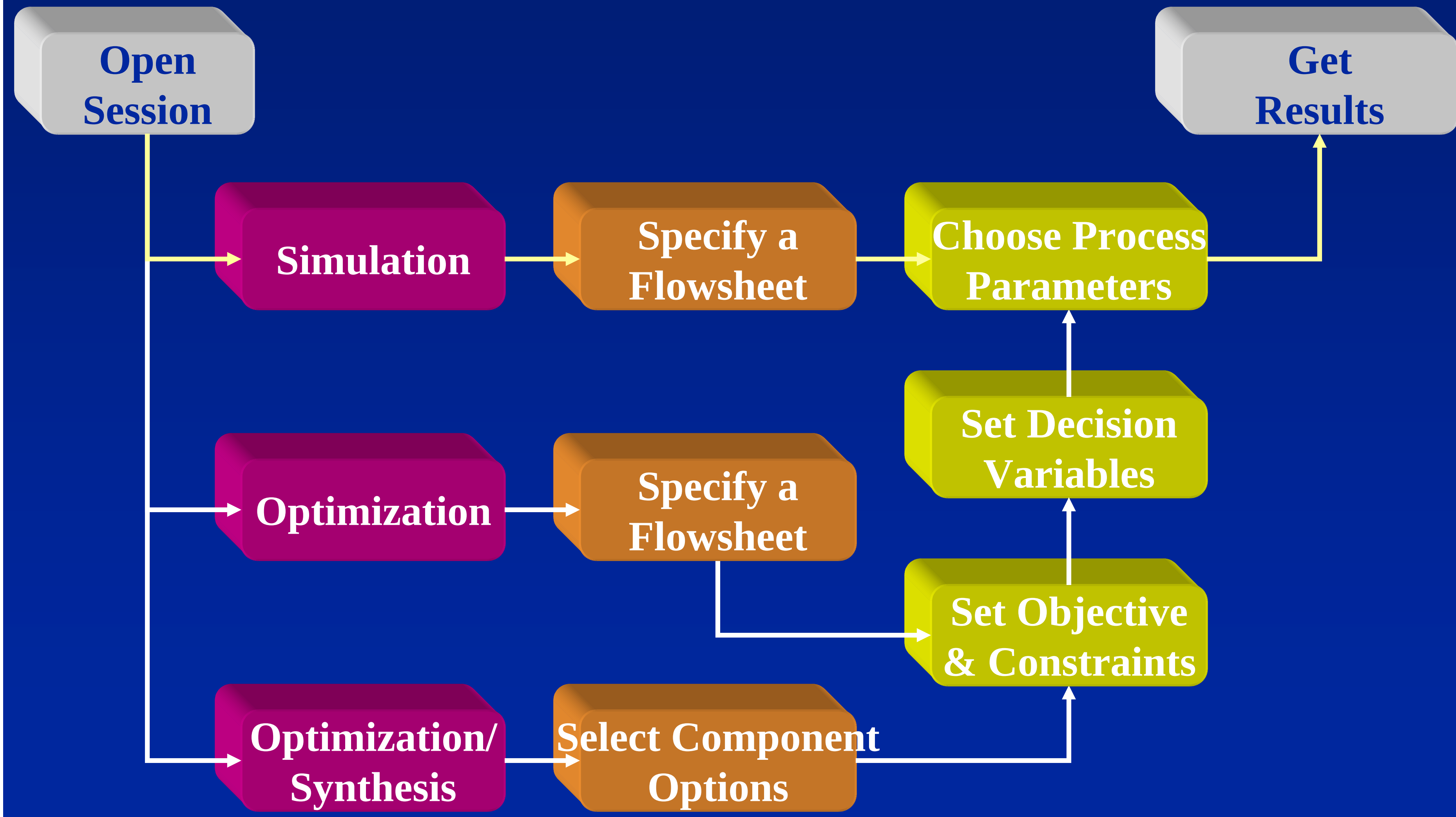
Configure a New System



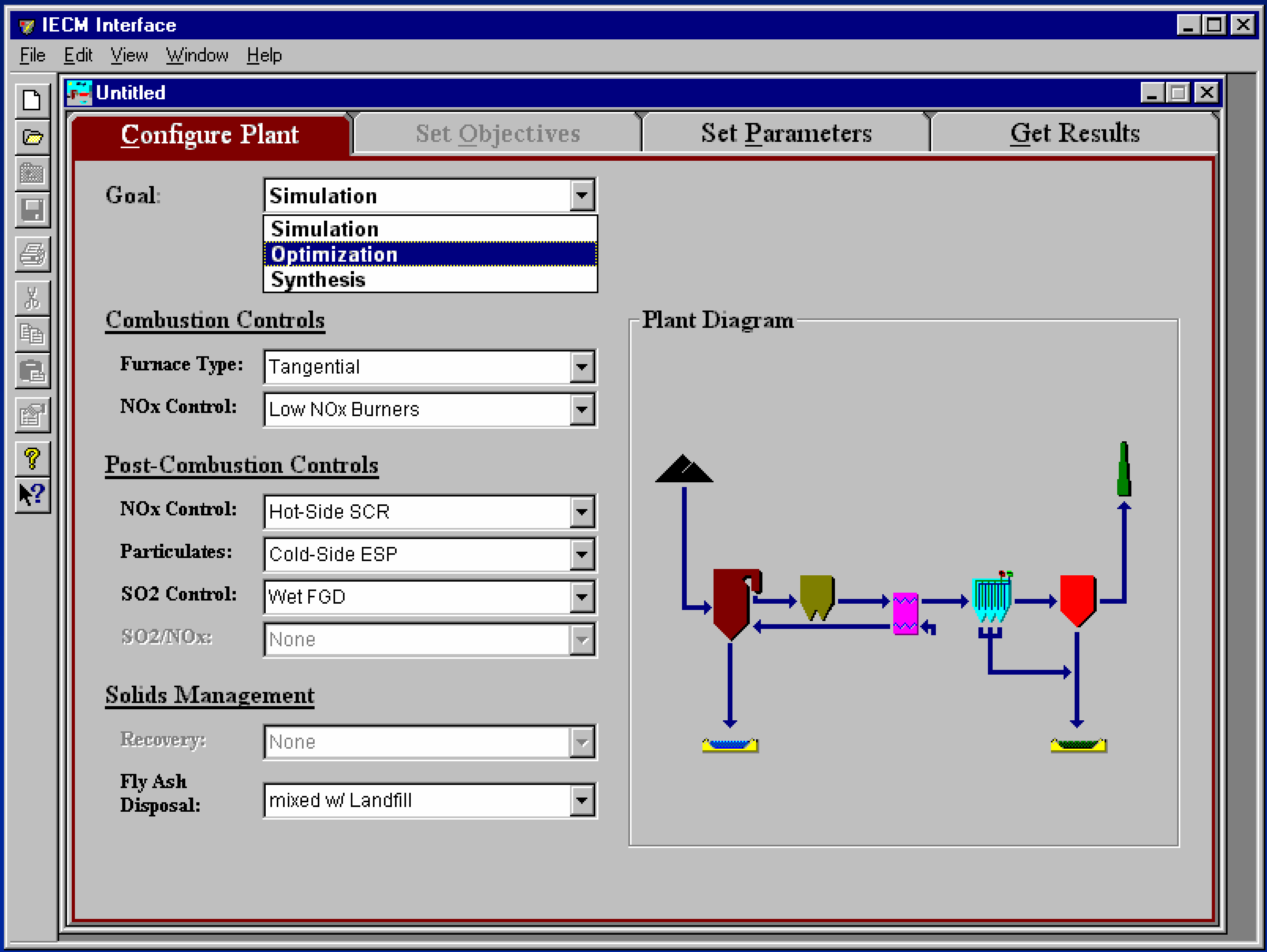
Potential New Software Options

- Process Optimization
- Process (Flowsheet) Synthesis

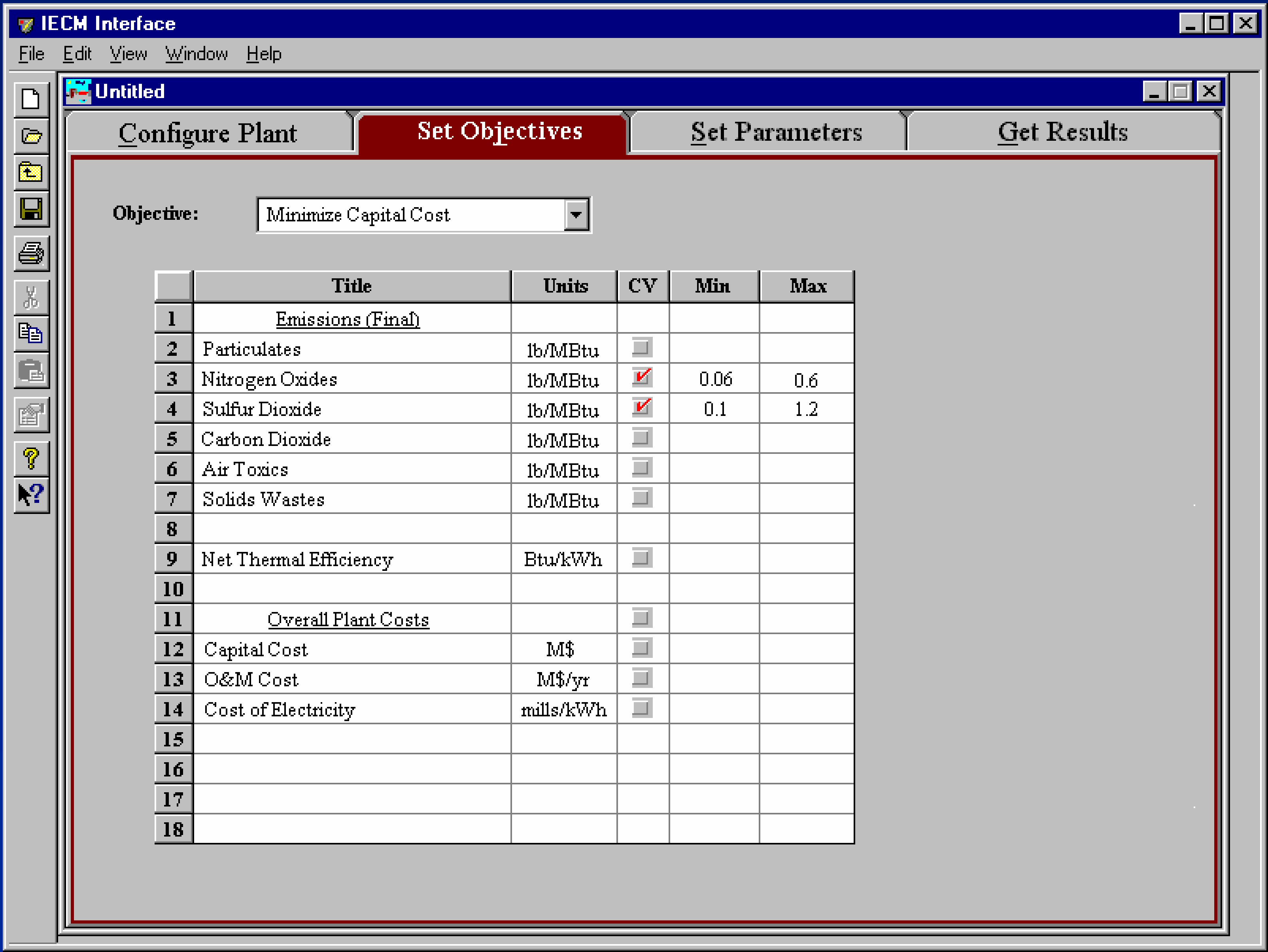
Advanced Design Capabilities: Operation Overview



Select Optimization Mode

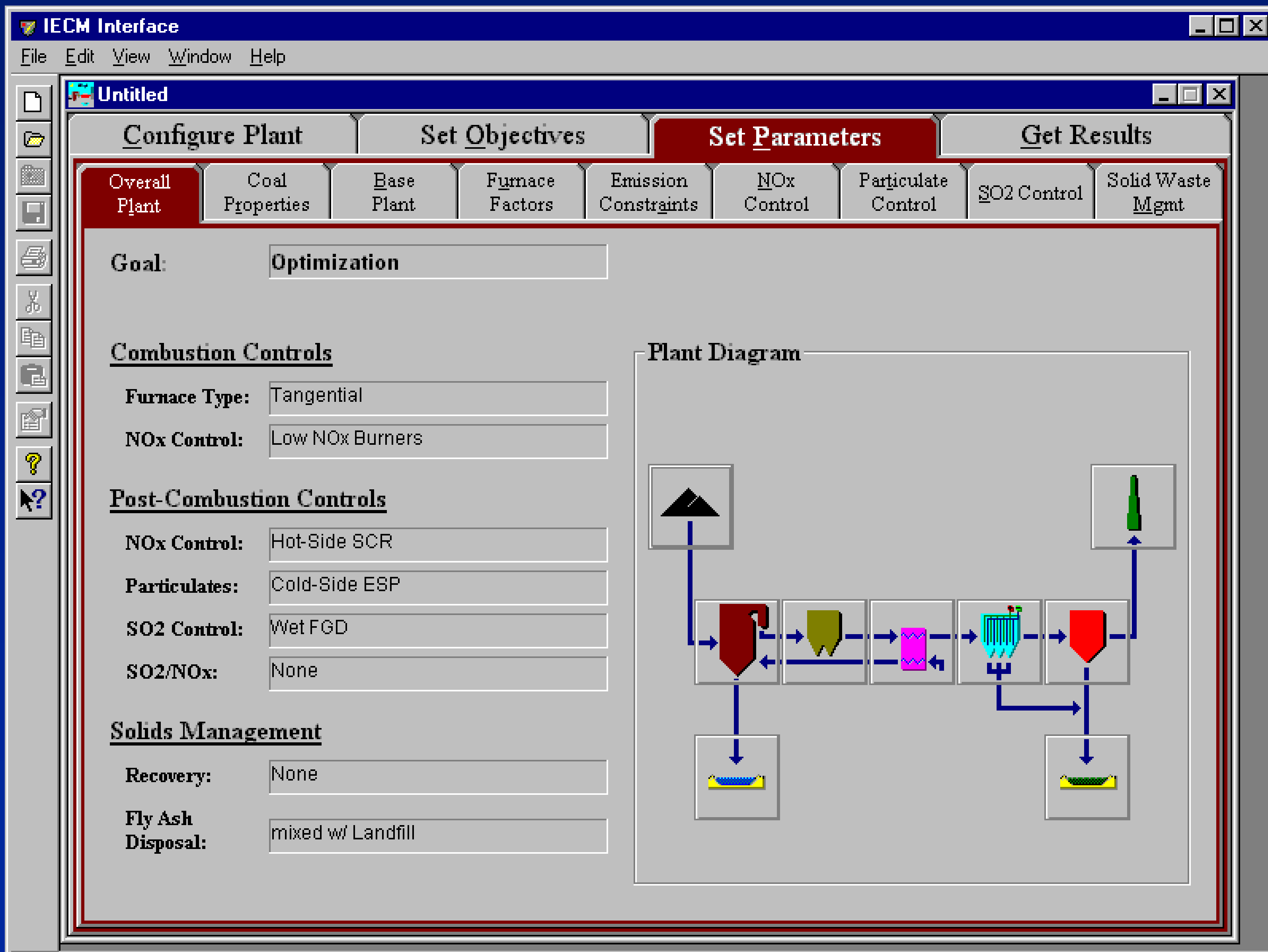


Set Objective and Constraints

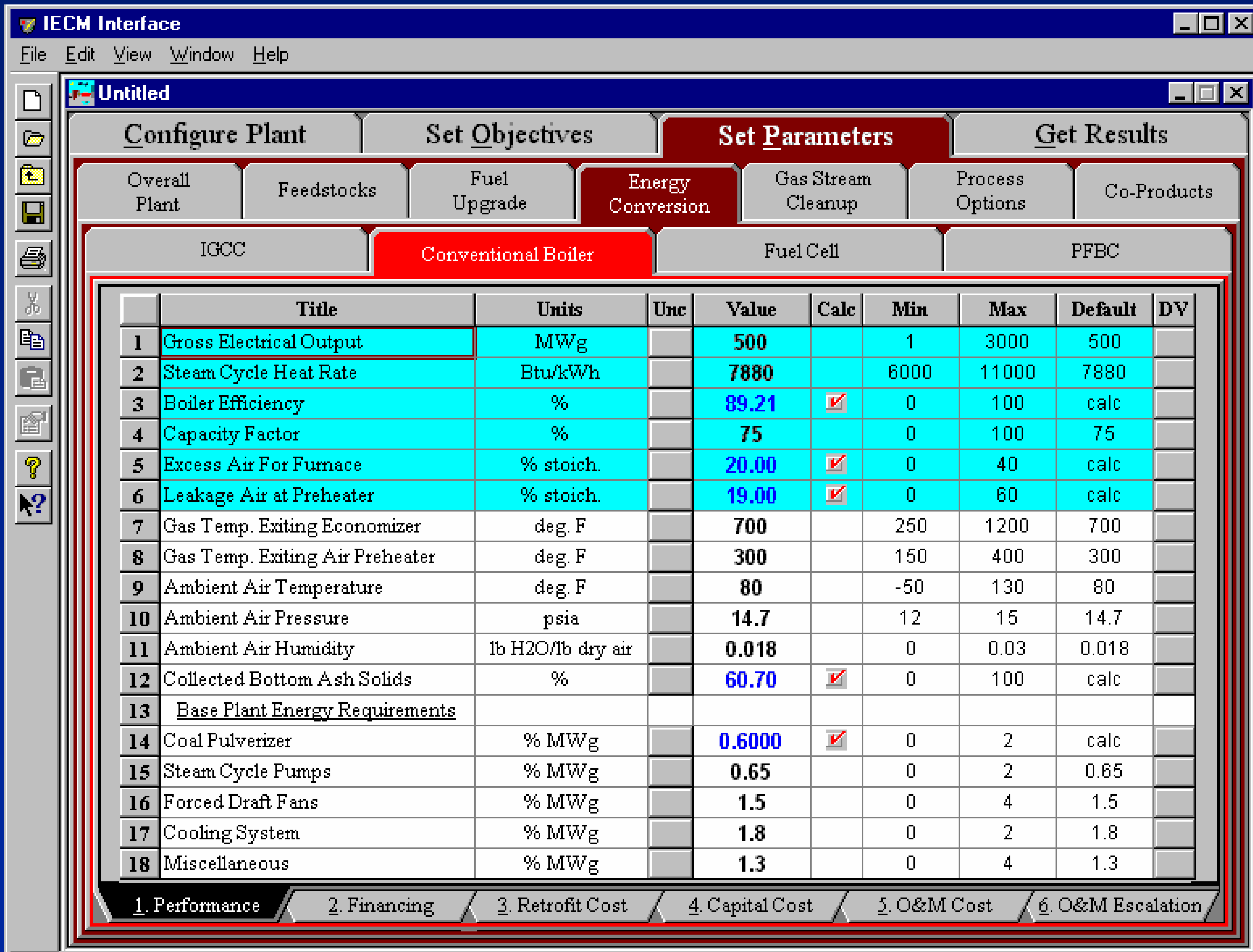


	Title	Units	CV	Min	Max
1	Emissions (Final)				
2	Particulates	lb/MBtu	☐		
3	Nitrogen Oxides	lb/MBtu	☑	0.06	0.6
4	Sulfur Dioxide	lb/MBtu	☑	0.1	1.2
5	Carbon Dioxide	lb/MBtu	☐		
6	Air Toxics	lb/MBtu	☐		
7	Solids Wastes	lb/MBtu	☐		
8					
9	Net Thermal Efficiency	Btu/kWh	☐		
10					
11	Overall Plant Costs		☐		
12	Capital Cost	M$	☐		
13	O&M Cost	M$/yr	☐		
14	Cost of Electricity	mills/kWh	☐		
15					
16					
17					
18					

Set Parameter Values

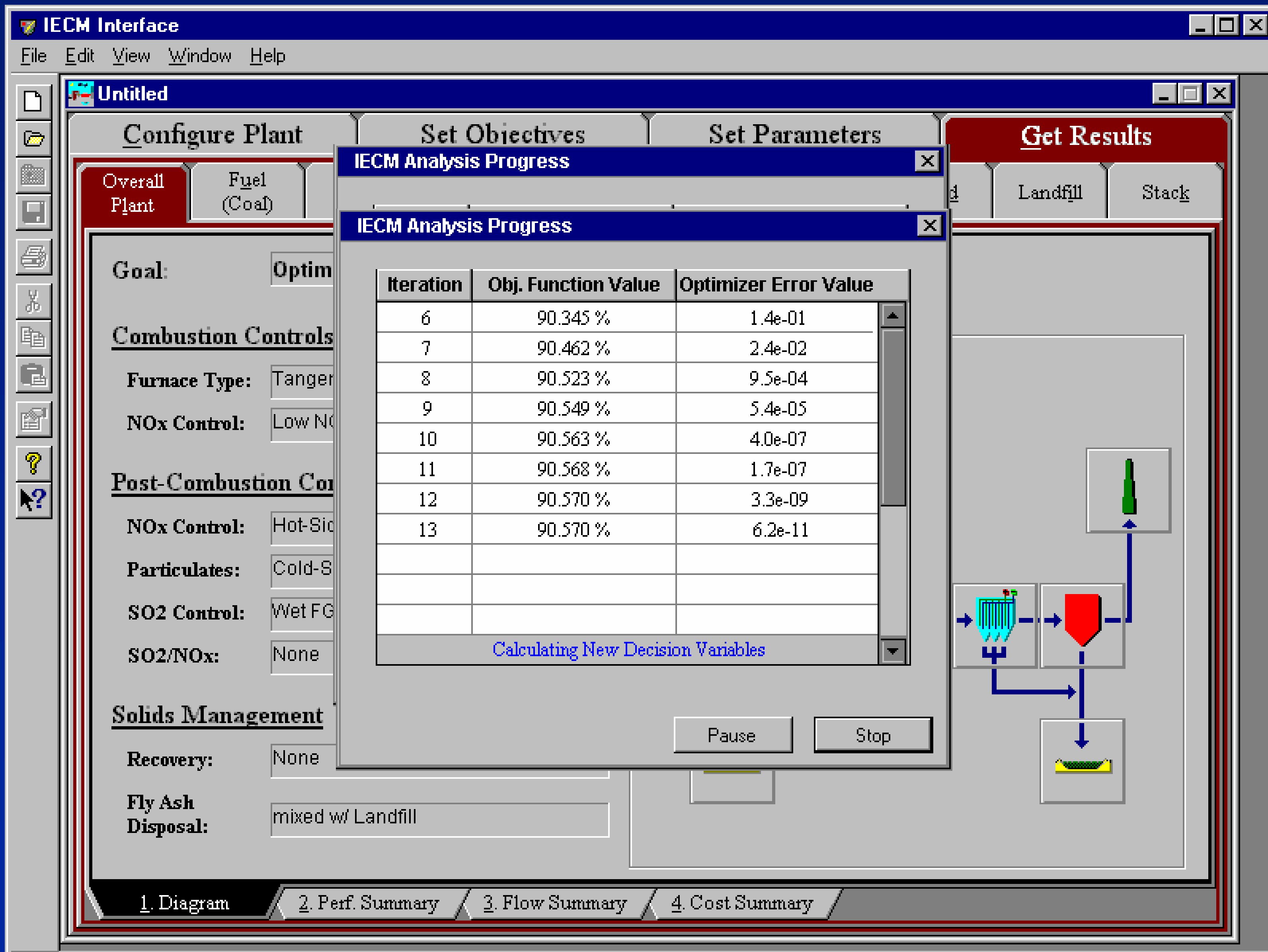


Select Decision Variables

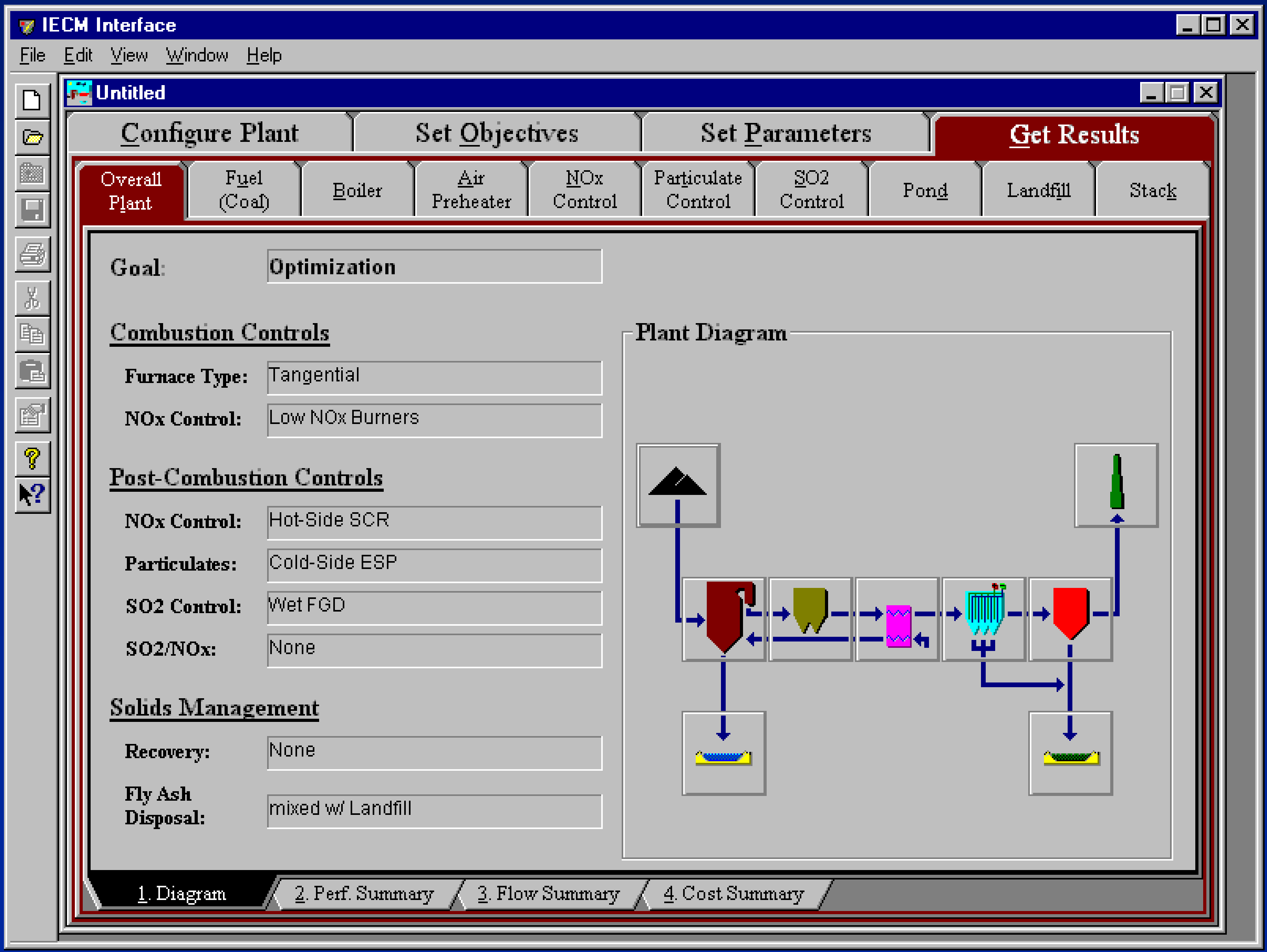


	Title	Units	Unc	Value	Calc	Min	Max	Default	DV
1	Gross Electrical Output	MWg		500		1	3000	500	
2	Steam Cycle Heat Rate	Btu/kWh		7880		6000	11000	7880	
3	Boiler Efficiency	%		89.21	✓	0	100	calc	
4	Capacity Factor	%		75		0	100	75	
5	Excess Air For Furnace	% stoich.		20.00	✓	0	40	calc	
6	Leakage Air at Preheater	% stoich.		19.00	✓	0	60	calc	
7	Gas Temp. Exiting Economizer	deg. F		700		250	1200	700	
8	Gas Temp. Exiting Air Preheater	deg. F		300		150	400	300	
9	Ambient Air Temperature	deg. F		80		-50	130	80	
10	Ambient Air Pressure	psia		14.7		12	15	14.7	
11	Ambient Air Humidity	lb H2O/lb dry air		0.018		0	0.03	0.018	
12	Collected Bottom Ash Solids	%		60.70	✓	0	100	calc	
13	Base Plant Energy Requirements								
14	Coal Pulverizer	% MWg		0.6000	✓	0	2	calc	
15	Steam Cycle Pumps	% MWg		0.65		0	2	0.65	
16	Forced Draft Fans	% MWg		1.5		0	4	1.5	
17	Cooling System	% MWg		1.8		0	2	1.8	
18	Miscellaneous	% MWg		1.3		0	4	1.3	

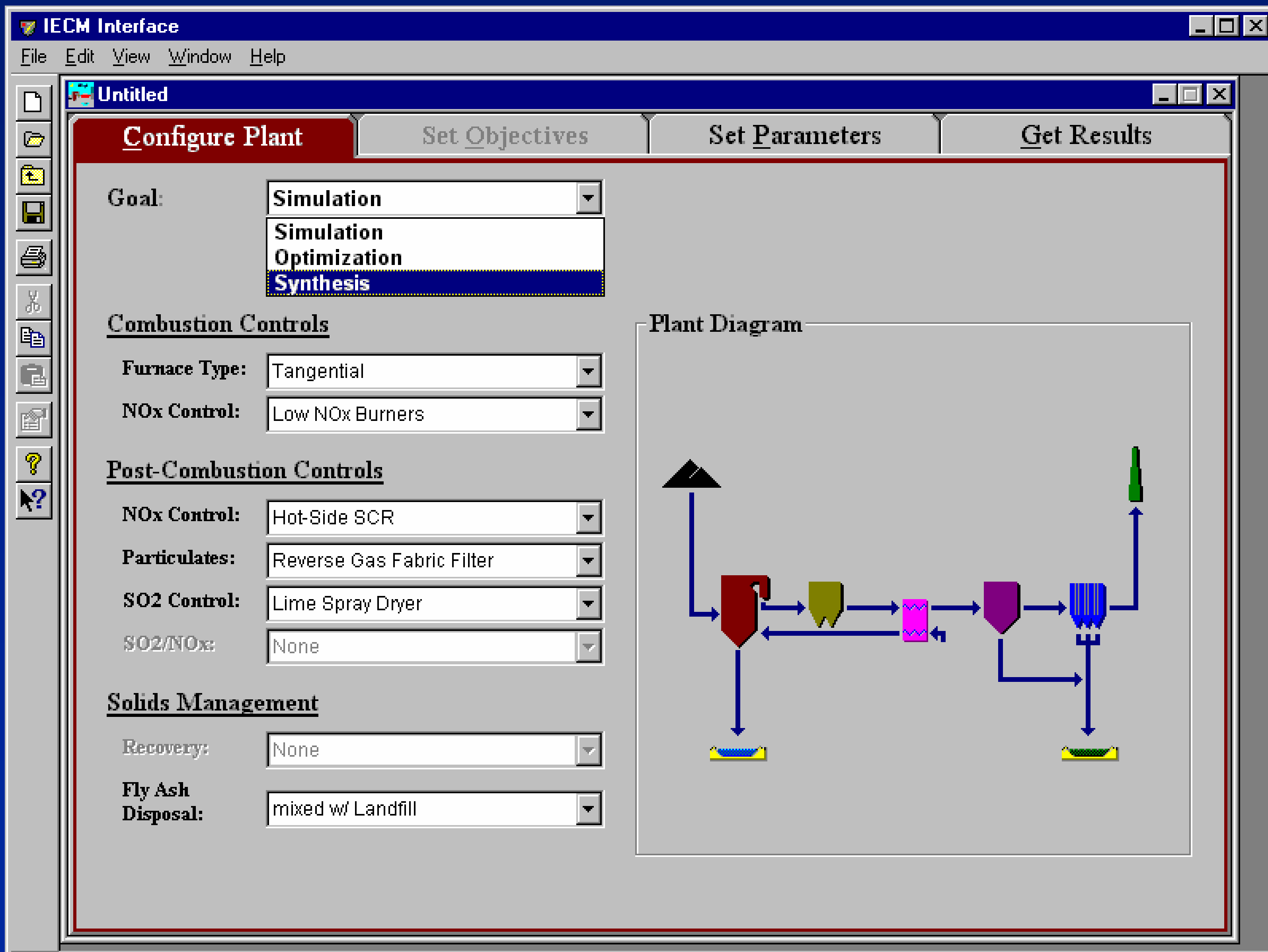
Get Results (Run Model)



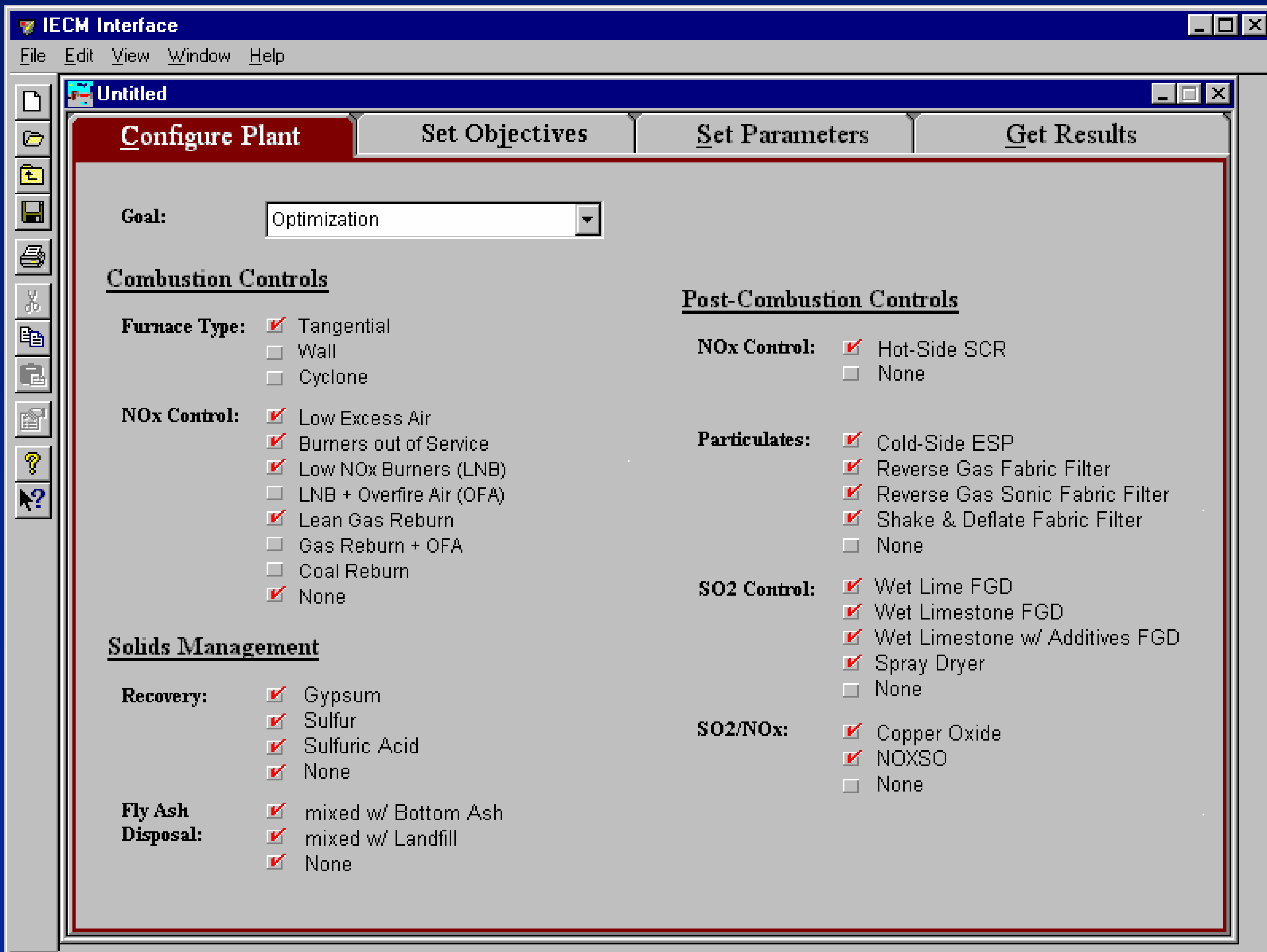
View Results



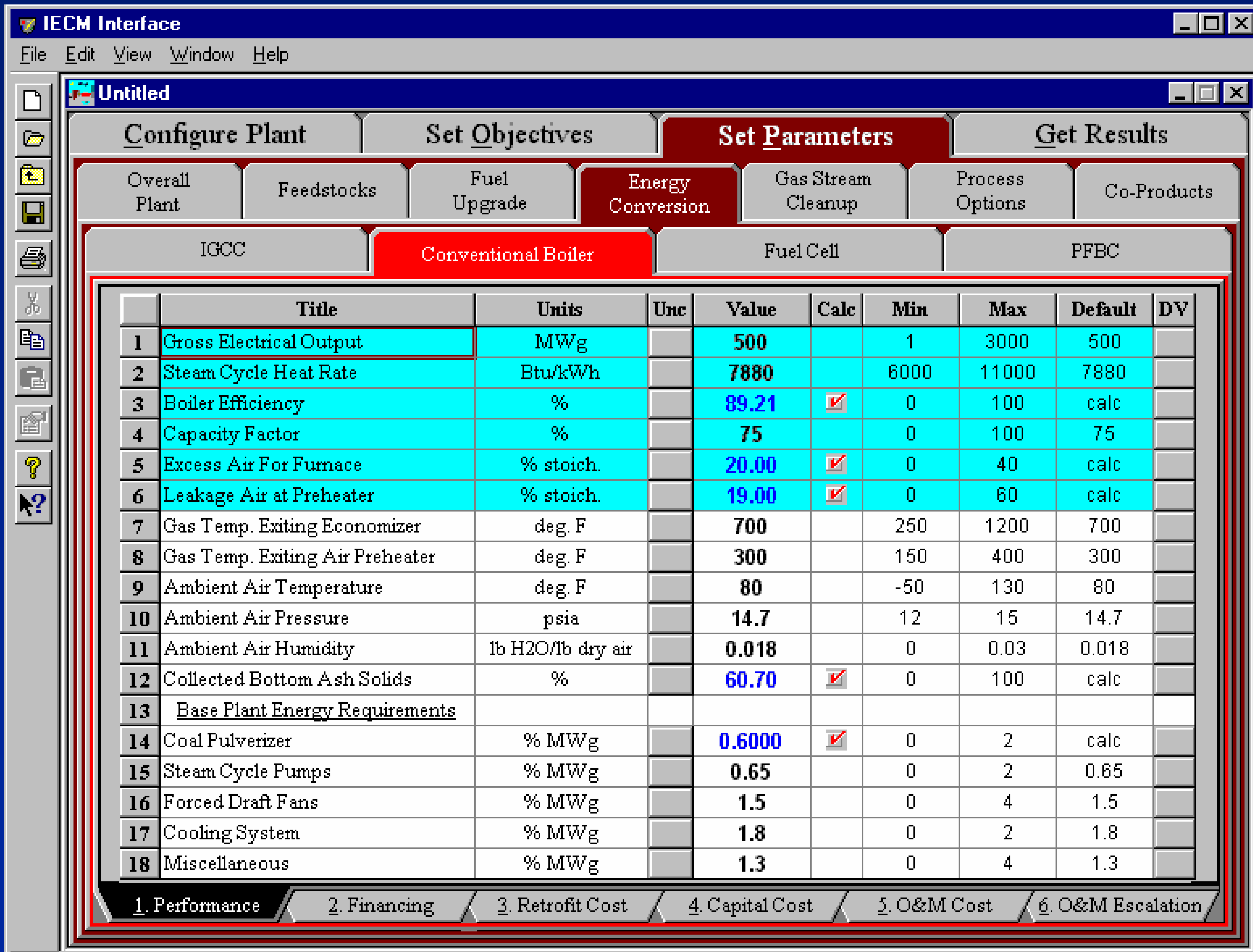
Select Synthesis Mode



Select Possible Technologies



Set Parameters



	Title	Units	Unc	Value	Calc	Min	Max	Default	DV
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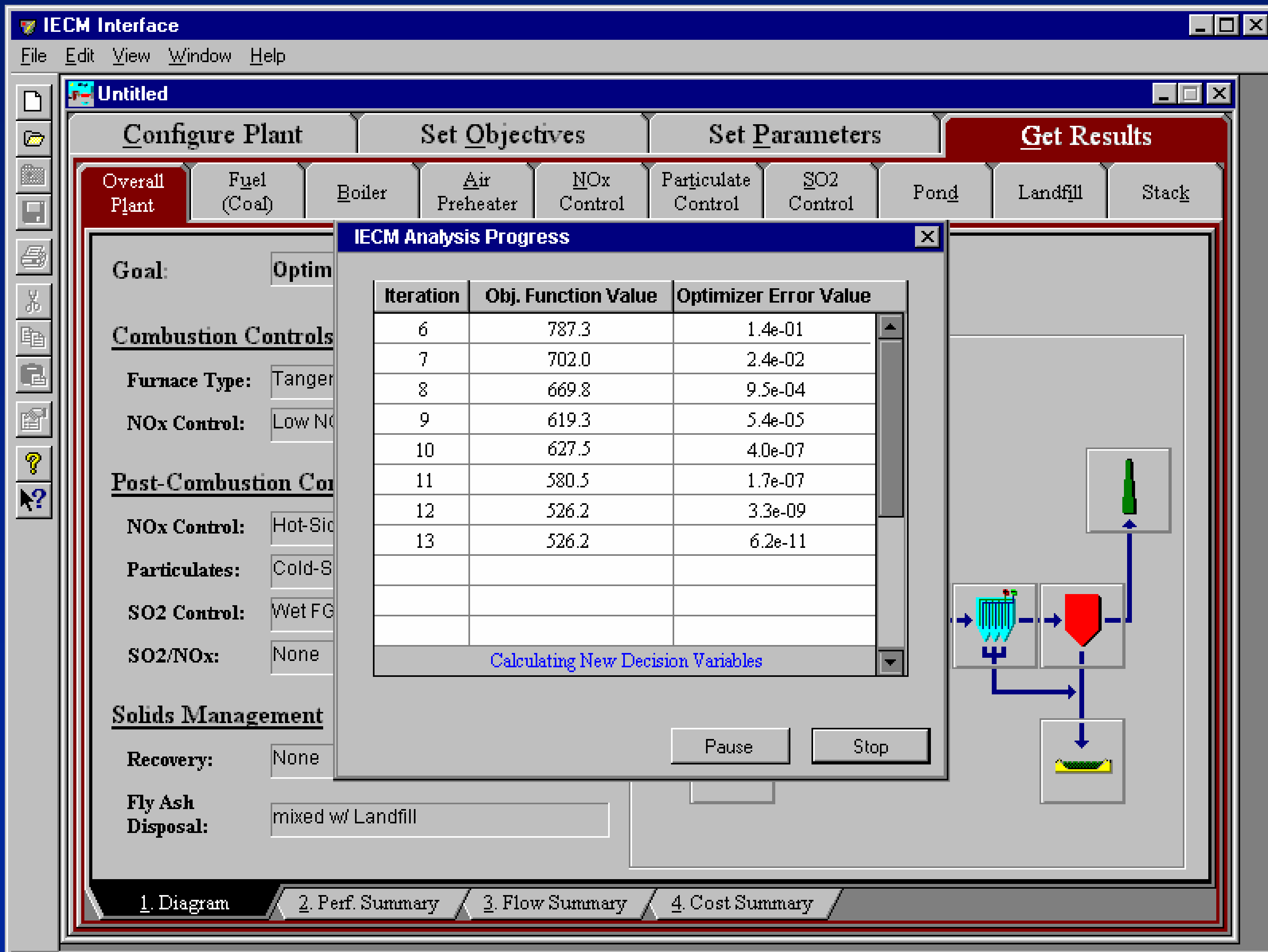
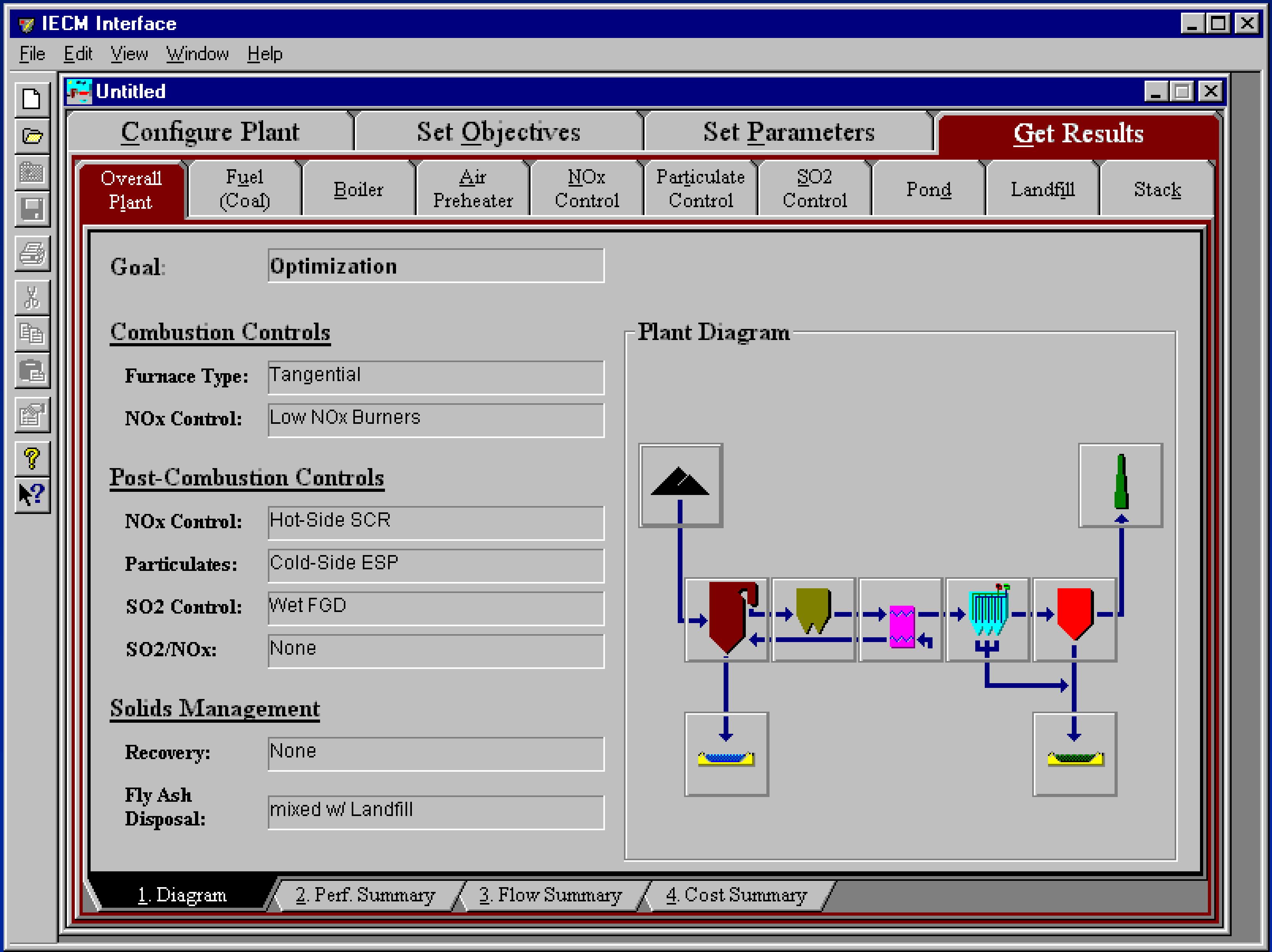
3	Boiler Efficiency	%		89.21	✓	0	100	calc	
4	Capacity Factor	%		75		0	100	75	
5	Excess Air For Furnace	% stoich.		20.00	✓	0	40	calc	
6	Leakage Air at Preheater	% stoich.		19.00	✓	0	60	calc	
7	Gas Temp. Exiting Economizer	deg. F		700		250	1200	700	
8	Gas Temp. Exiting Air Preheater	deg. F		300		150	400	300	
9	Ambient Air Temperature	deg. F		80		-50	130	80	
10	Ambient Air Pressure	psia		14.7		12	15	14.7	
11	Ambient Air Humidity	lb H2O/lb dry air		0.018		0	0.03	0.018	
12	Collected Bottom Ash Solids	%		60.70	✓	0	100	calc	
13	Base Plant Energy Requirements								
14	Coal Pulverizer	% MWg		0.6000	✓	0	2	calc	
15	Steam Cycle Pumps	% MWg		0.65		0	2	0.65	
16	Forced Draft Fans	% MWg		1.5		0	4	1.5	
17	Cooling System	% MWg		1.8		0	2	1.8	
18	Miscellaneous	% MWg		1.3		0	4	1.3	

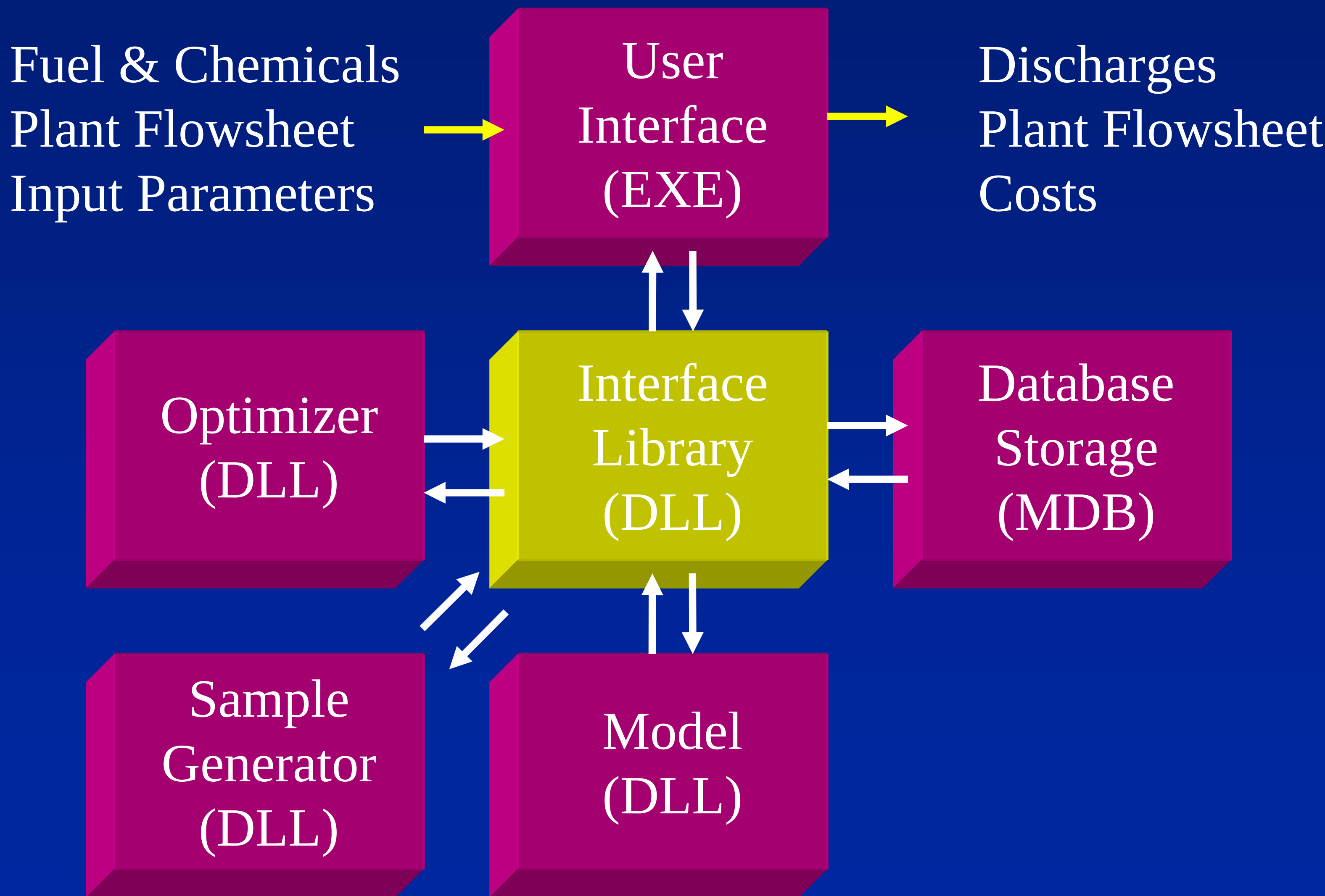
Get Results (Run Model)



View Optimal Flowsheet



IECM Programming Module Structure



Model Applications

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

Please let us know what you think

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