

# Report on Recent Accomplishments and Future Directions

Ed Rubin, Mike Berkenpas,  
Urmila Diwekar, and Karen Kietzke  
Carnegie Mellon University  
and  
Chris Frey  
North Carolina State University

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# FY99 Projects and Funding

## **Enhancements to the Integrated Environmental Control Model (IECM)**

Sponsor: Process Analysis Division  
Amount: \$50 k  
COR: Gerst Gibbon

## **Development of a Framework for the Preliminary Design and Analysis of Vision 21 Plants**

Sponsor: Advanced Research & Technology Development  
Amount: \$150 k  
COR: Gerst Gibbon (Bob Romanosky)

# Highlights of Activities to Date

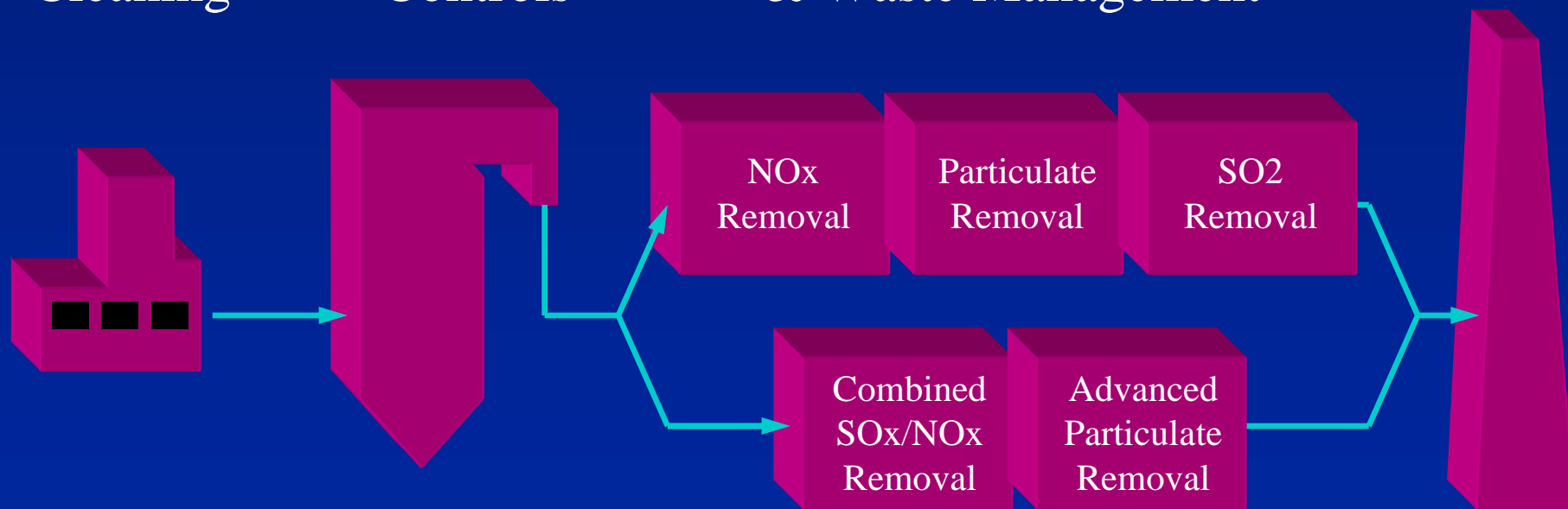
- Completed IECM Version 3.1 plus associated technical documentation and user manuals
- Developed new performance and cost models of selected process technologies for the IECM
- Began implementing new models in the IECM code and graphical interface
- Developed a plan to add process optimization options
- Developed a conceptual framework for a Vision 21 preliminary planning model

# Integrated Environmental Control Model (IECM)

Coal  
Cleaning

Combustion  
Controls

Flue Gas Cleanup  
& Waste Management



# IECM Performance and Cost Models

- Detailed mass and energy balances, plus empirical relationships for complex process chemistry
- Calculates mass flows, energy flows, efficiency, and multi-media environmental emissions
- Component cost models (5-10 process areas per technology) explicitly linked to flowsheet performance parameters
- Calculates total capital cost, O&M costs, and COE
- Approximately 10-20 performance parameters and 10-20 cost parameters for each technology

# 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

# Preliminary IECM User Group

- ABB Power Plant Control
- American Electric Power
- Consol, Inc.
- Energy & Env. Research Corp.
- Exportech Company, Inc.
- FirstEnergy Corp.
- FLS Miljo A/S
- Foster Wheeler Development Corp.
- Lehigh University
- Lower Colorado River Authority
- McDermott Technology, Inc.
- Mitsui Babcock Energy Ltd.
- National Power Plc.
- Niksa Energy Associates
- Pacific Corp.
- Pennsylvania Electric Association
- Potomac Electric Power Co.
- Private Consultants
- Savvy Engineering
- Sierra Pacific Power Co.
- Southern Company Services, Inc.
- Stone & Webster Engineering Corp.
- Tampa Electric Co.
- University of California, Berkeley

# New Performance and Cost Models Under Development

- In-Furnace NO<sub>x</sub> Controls
  - Low NO<sub>x</sub> Burners (LNB)
  - LNB + Overfire air
  - Gas Reburn
  - Selective Non-Catalytic Reduction (SNCR)
  - LNB + SNCR
  - Tangential, Wall, and Cyclone Firing
- Gasification Combined Cycle Systems
  - KRW Gasifier with Hot Gas Cleanup
  - Texaco Gasifier with Cold Gas Cleanup






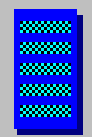

(live demo of the new in-furnace  
NO<sub>x</sub> control options)

# New Gasification Combined Cycle (IGCC) Options

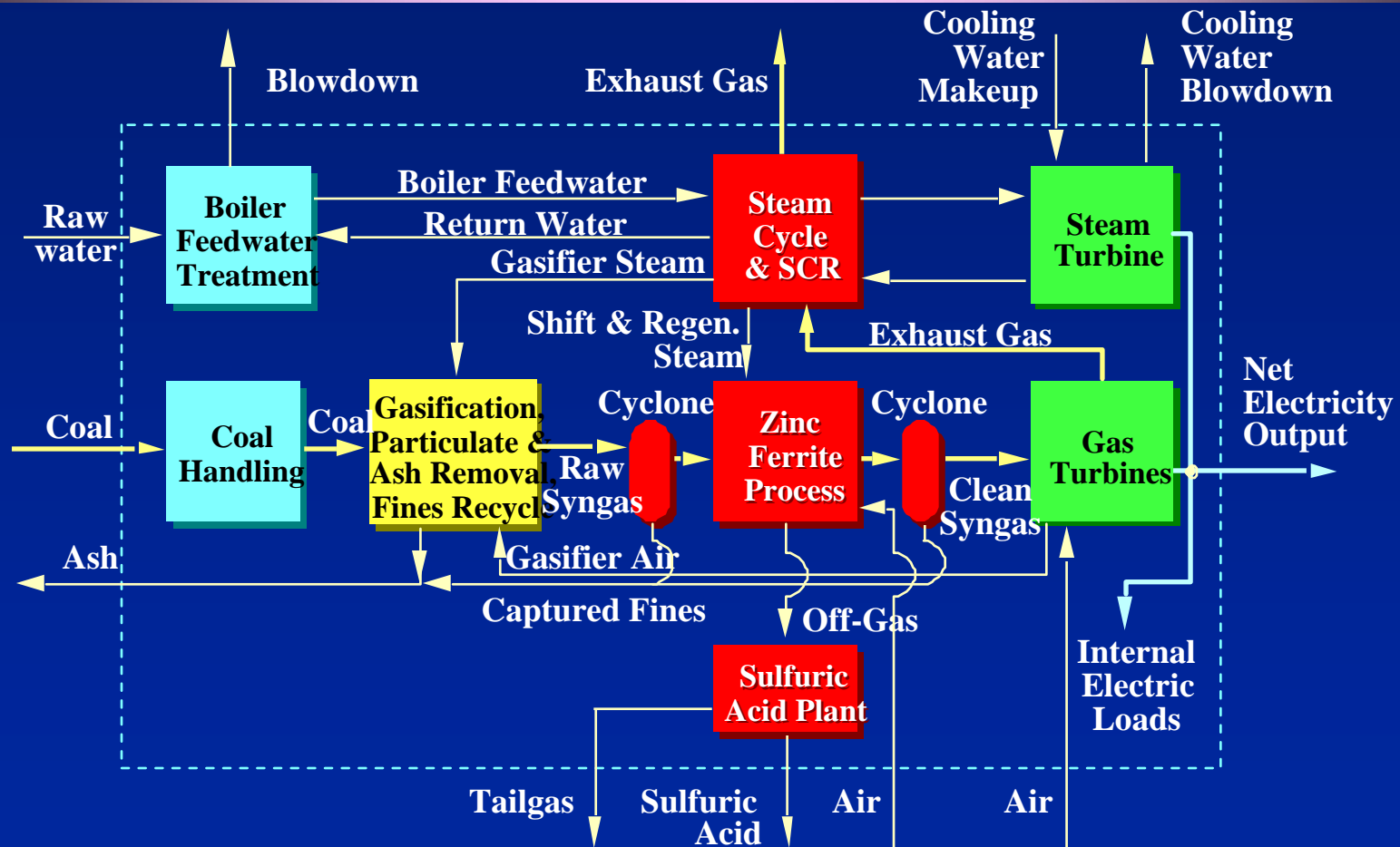


**Choose Power System** [X]

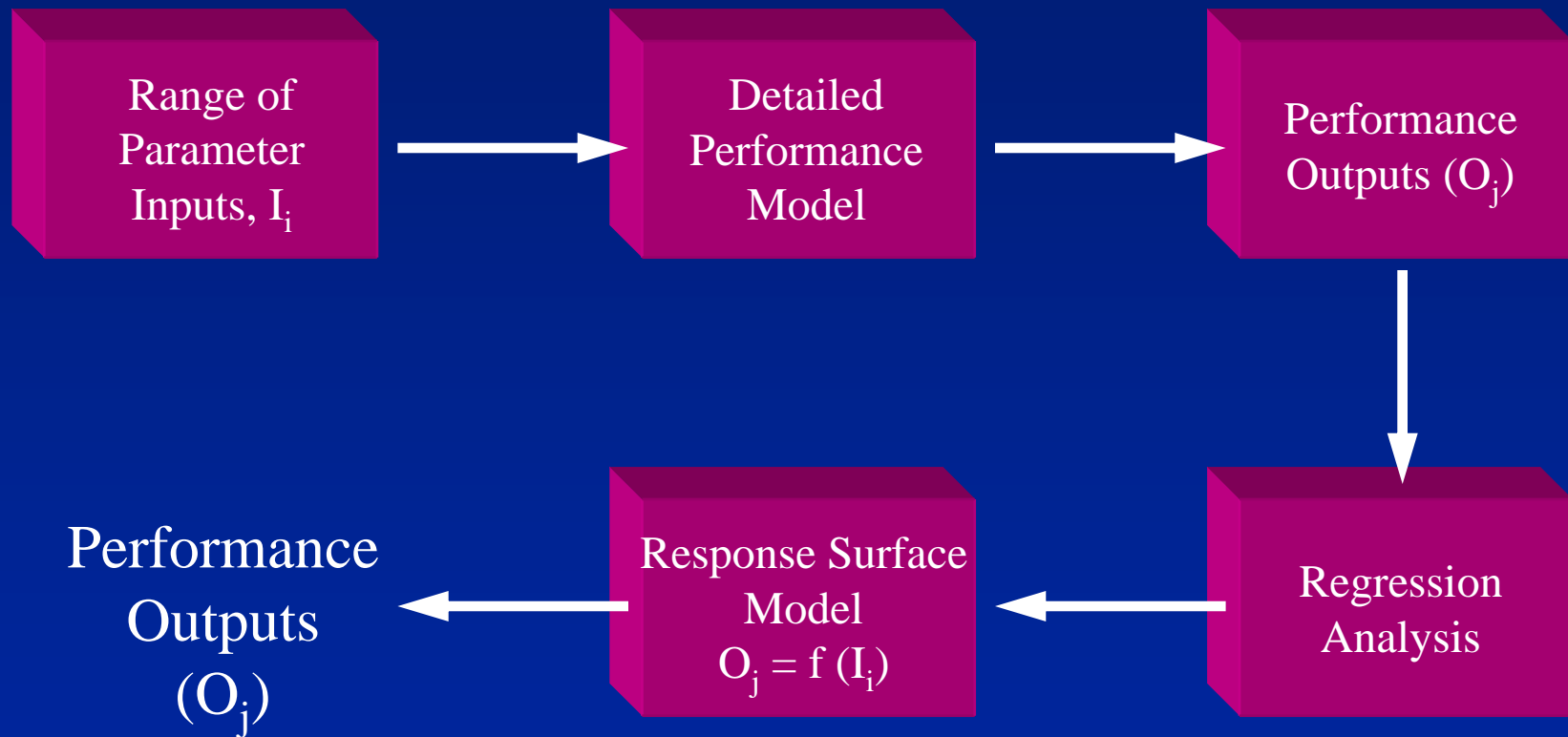
Please Choose a Power System:

	Conventional Combustion
	Gasification Comb. Cycle
	Advanced Combustion
	Fuel Cells
	Vision 21 Plant

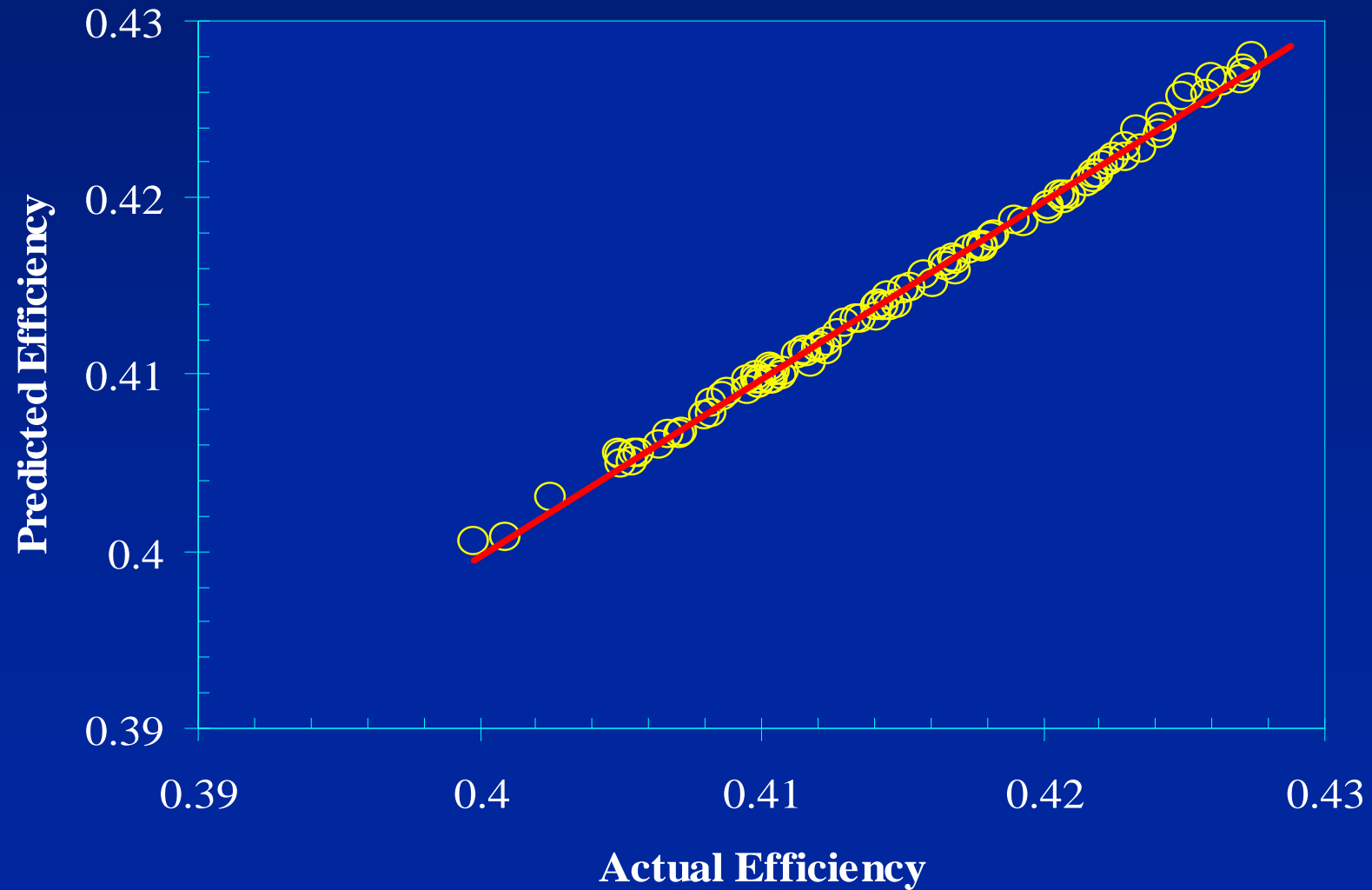
# ASPEN Model of an IGCC System



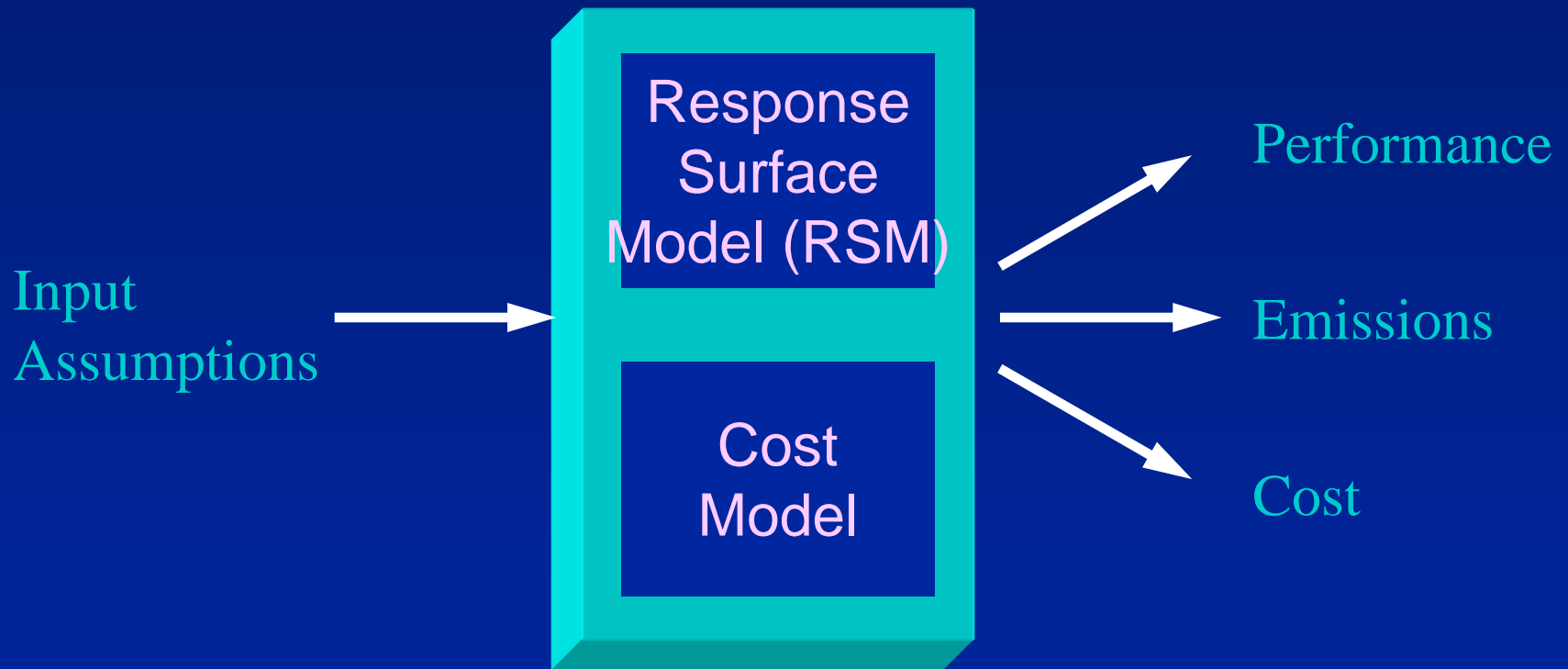
# Response Surface Model Development



# Evaluation of Desktop Model: IGCC Plant Efficiency



# Desktop Model of a Process



# Select KRW Gasifier

IECM Interface

File Edit View Window Help

Untitled

**Configure Plant** Set Objectives Set Parameters Get Results

Goal: Optimization

**Gasification Options**

Gasifier: KRW

Oxidant: KRW

Gas Cleanup: Lurgi  
Texaco

**Post-Combustion Controls**

NOx Control: None

**Solids Management**

Slag: Landfill

Sulfur: Landfill

Plant Diagram

Ready NUM

# Select Oxygen Plant

IECM Interface

File Edit View Window Help

Untitled

**Configure Plant** Set Objectives Set Parameters Get Results

Goal: Optimization

Gasification Options

Gasifier: KRW

Oxidant: Oxygen

Gas Cleanup: Air  
Oxygen

Post-Combustion Controls

NOx Control: None

Solids Management

Slag: Landfill

Sulfur: Landfill

Plant Diagram

Ready NUM

The screenshot shows the 'Configure Plant' window of the IECM software. The window is titled 'Untitled' and has a menu bar with 'File', 'Edit', 'View', 'Window', and 'Help'. Below the menu bar is a toolbar with various icons. The main area is divided into four tabs: 'Configure Plant' (highlighted in red), 'Set Objectives', 'Set Parameters', and 'Get Results'. The 'Configure Plant' tab contains several sections of configuration options: 'Goal' (set to 'Optimization'), 'Gasification Options' (Gasifier: 'KRW', Oxidant: 'Oxygen', Gas Cleanup: 'Air' and 'Oxygen'), 'Post-Combustion Controls' (NOx Control: 'None'), and 'Solids Management' (Slag: 'Landfill', Sulfur: 'Landfill'). To the right of these options is a 'Plant Diagram' showing a process flow. The diagram includes a gasifier (yellow cylinder), a gas cleanup unit (blue box with a zigzag line), a combustion engine (green box), and a power generator (red circle with a 'S'). Arrows indicate the flow of materials between these components.



# Select Cold Gas Cleanup

IECM Interface

File Edit View Window Help

Untitled

**Configure Plant** Set Objectives Set Parameters Get Results

Goal: Optimization

Gasification Options

Gasifier: KRW

Oxidant: Oxygen

Gas Cleanup: Cold

Post-Combustion: Cold

NOx Control: None

Solids Management

Slag: Landfill

Sulfur: Landfill

Plant Diagram

The plant diagram illustrates a sequential process flow. It begins with a blue cylindrical input on the left. The flow proceeds through a yellow vertical gasifier, a red horizontal reactor, and a pink horizontal reactor. From the pink reactor, the flow goes to a grey square component, then to a green trapezoidal separator. The separator has two outputs: one goes to a blue zigzag heat exchanger, and the other goes to a green trapezoidal separator. The blue zigzag heat exchanger has an output to a green trapezoidal separator. The final output is a green trapezoidal separator with a red 'S' symbol, representing sulfur recovery. There are also arrows pointing to a black triangle at the top and a green bottle on the right.

Ready NUM

# Select NO<sub>x</sub> Control

IECM Interface

File Edit View Window Help

Untitled

**Configure Plant** Set Objectives Set Parameters Get Results

Goal: Optimization

Gasification Options

Gasifier: KRW

Oxidant: Oxygen

Gas Cleanup: Cold

Post-Combustion

NO<sub>x</sub> Control: SCR  
None  
SCR

Solids Management

Slag: Landfill

Sulfur: Landfill

Plant Diagram

The plant diagram illustrates a gasification process. It starts with a feed stream entering a yellow gasifier. From the gasifier, a stream goes to a red gas cleanup unit, which has a yellow solid handling unit below it. The cleaned gas then passes through a pink combustion chamber. The combustion chamber is connected to a blue heat exchanger, which in turn feeds into a green turbine. The turbine's exhaust goes to a green condenser, which has a green solid handling unit below it. The final gas stream goes to a red sulfur recovery unit. The diagram also shows a black triangle representing a stack at the top left, and a blue stream entering the gasifier from the left.

Ready NUM

# Select Byproduct Recovery

IECM Interface

File Edit View Window Help

Untitled

**Configure Plant** Set Objectives Set Parameters Get Results

Goal: Optimization

**Gasification Options**

Gasifier: KRW

Oxidant: Oxygen

Gas Cleanup: Hot

**Post-Combustion Controls**

NOx Control: SCR

**Solids Management**

Slag: Landfill

Sulfur: Sulfur  
Landfill  
Sulfur  
Sulfuric Acid

Plant Diagram

The plant diagram illustrates a gasification process. It starts with a blue gasifier on the left, which feeds into a yellow gas cleanup unit. From there, the gas flows to a red combustion chamber, then to a pink sulfur recovery unit. The sulfur recovery unit has a green recycling symbol below it, indicating a closed-loop process. The gas then passes through a grey scrubber, a green condenser, and a blue separator. The final product is shown as a green bottle, and a sulfur stream is collected in a red circle with a white 'S'.

Ready NUM

# Set Process Parameters

IECM Interface

File Edit View Window Help

Untitled

Configure Plant **Set Parameters** Get Results

Overall Plant Coal Properties **IGCC** Furnace Factors Emission Constraints NOx Control Particulate Control SO2 Control Solid Waste Mgmt

	Title	Units	Unc	Value	Calc	Min	Max	Default	DV
1	<u>Gasifier Design</u>								
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	<u>Emissions Control</u>								
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									

1. Performance 2. Financing 3. Retrofit Cost 4. Capital Cost 5. O&M Cost 6. O&M Escalation

# Potential New Models for the IECM (FY 2000)

- Mercury Control Technologies
  - In-Furnace
  - Post-Combustion
- Alternative Fuel Selections
  - Natural Gas
  - Petroleum
  - Fuel Blending
- Advanced Plant Designs
  - Additional Model Parameters
  - Additional Process Technologies

# Conceptual Design of a Vision 21 Planner

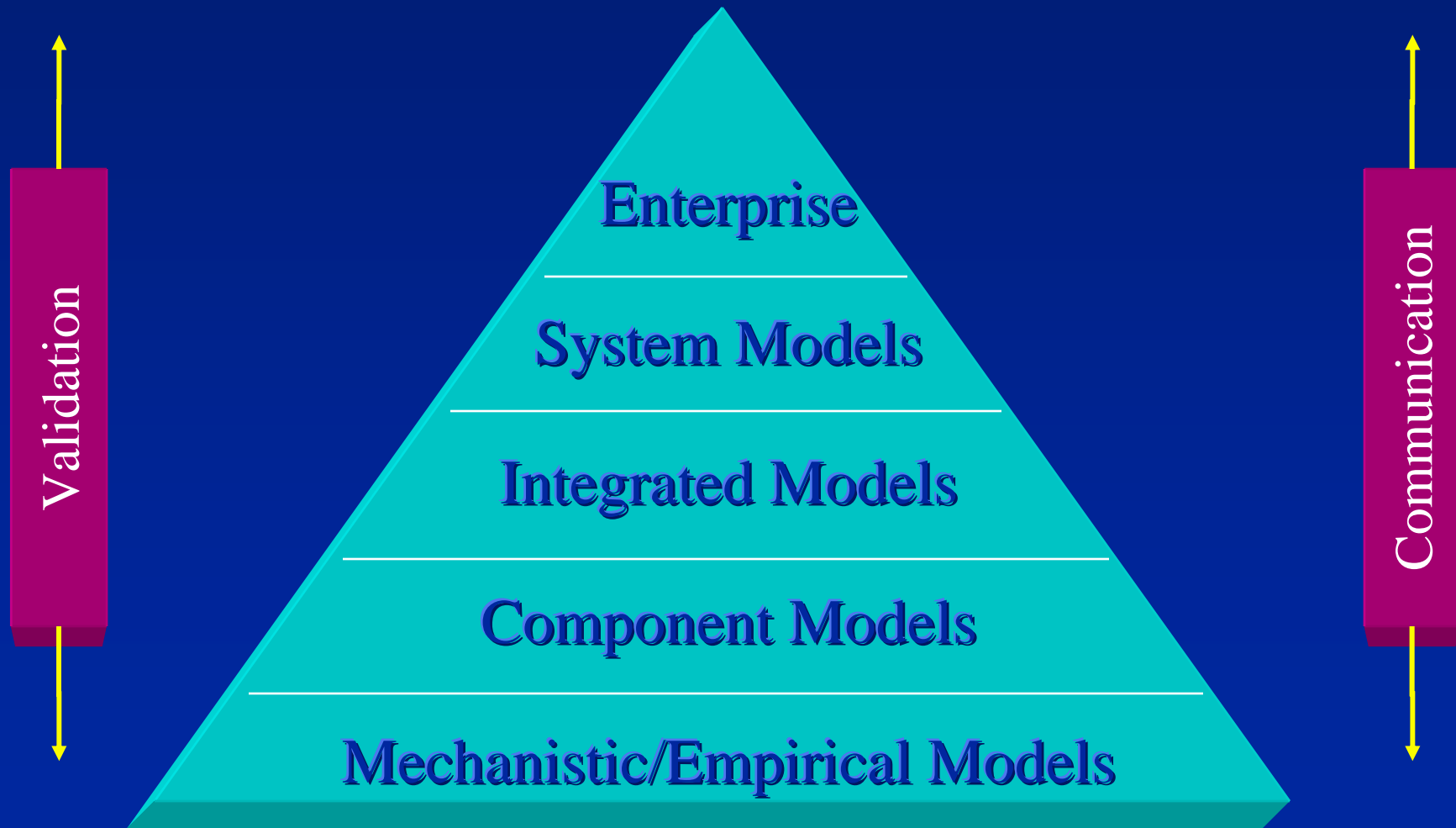
- *A preliminary design model to analyze:*
  - Process Components
  - Systems Integration
  - Performance and Cost
  - Process Optimization
  - Current Uncertainties

# Objectives

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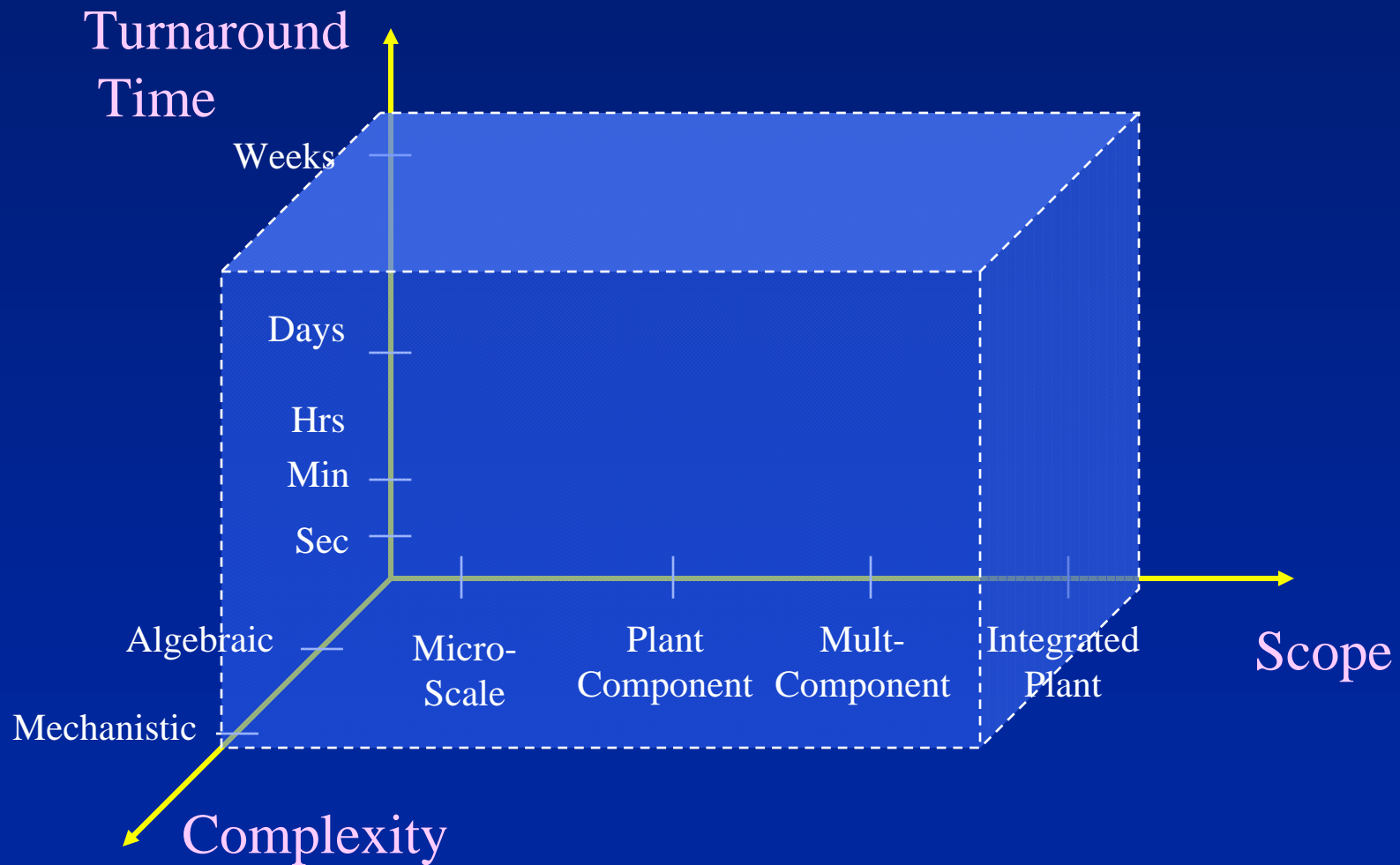
- Develop a flexible and easy-to-use modeling system to estimate the performance, environmental emissions and cost of a preliminary Vision 21 plant design
- Develop a framework for comparing alternative options and on a systematic basis, including effects of uncertainty

# A Hierarchy of Process Models





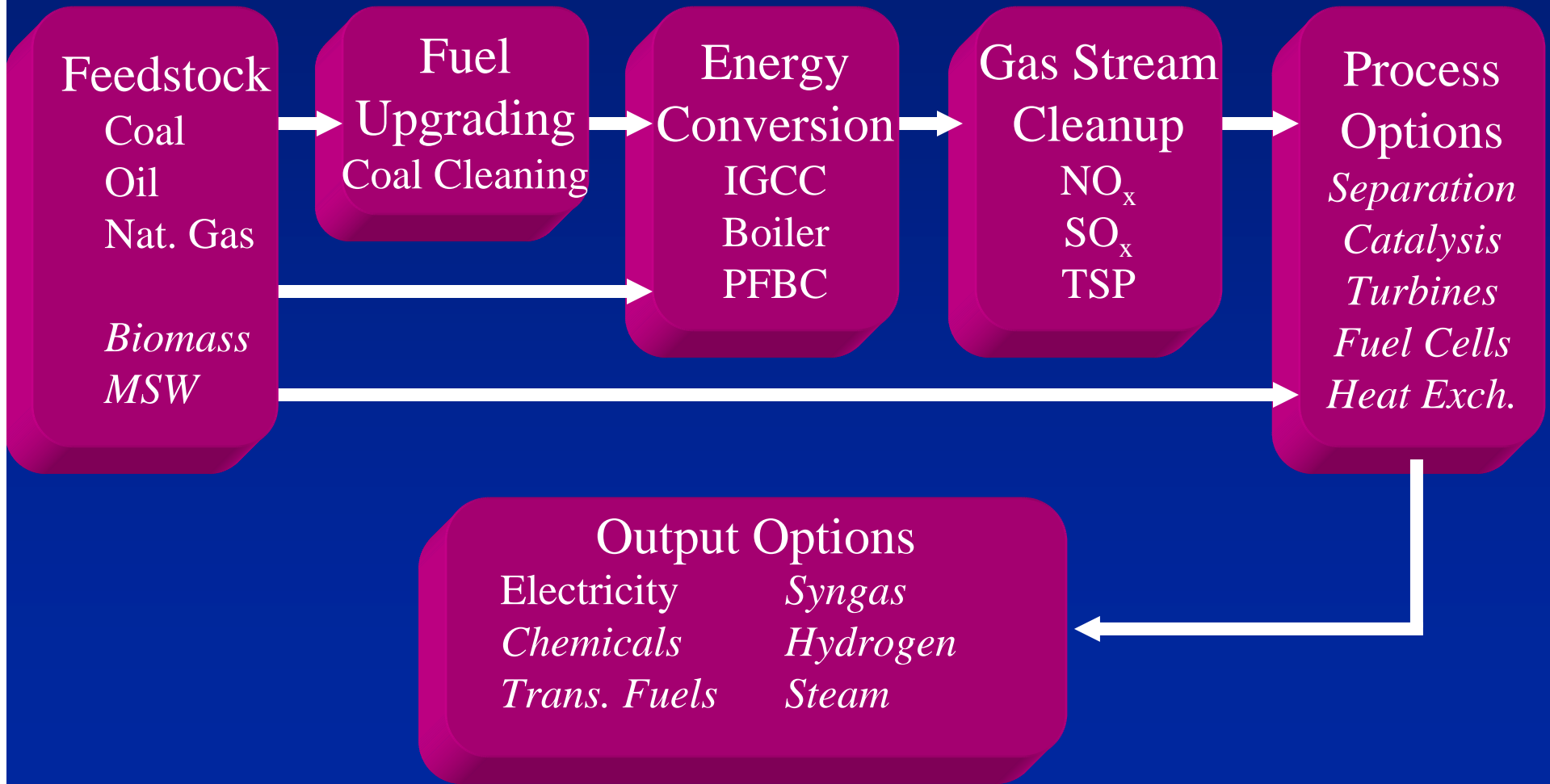
# Attributes of Process Models



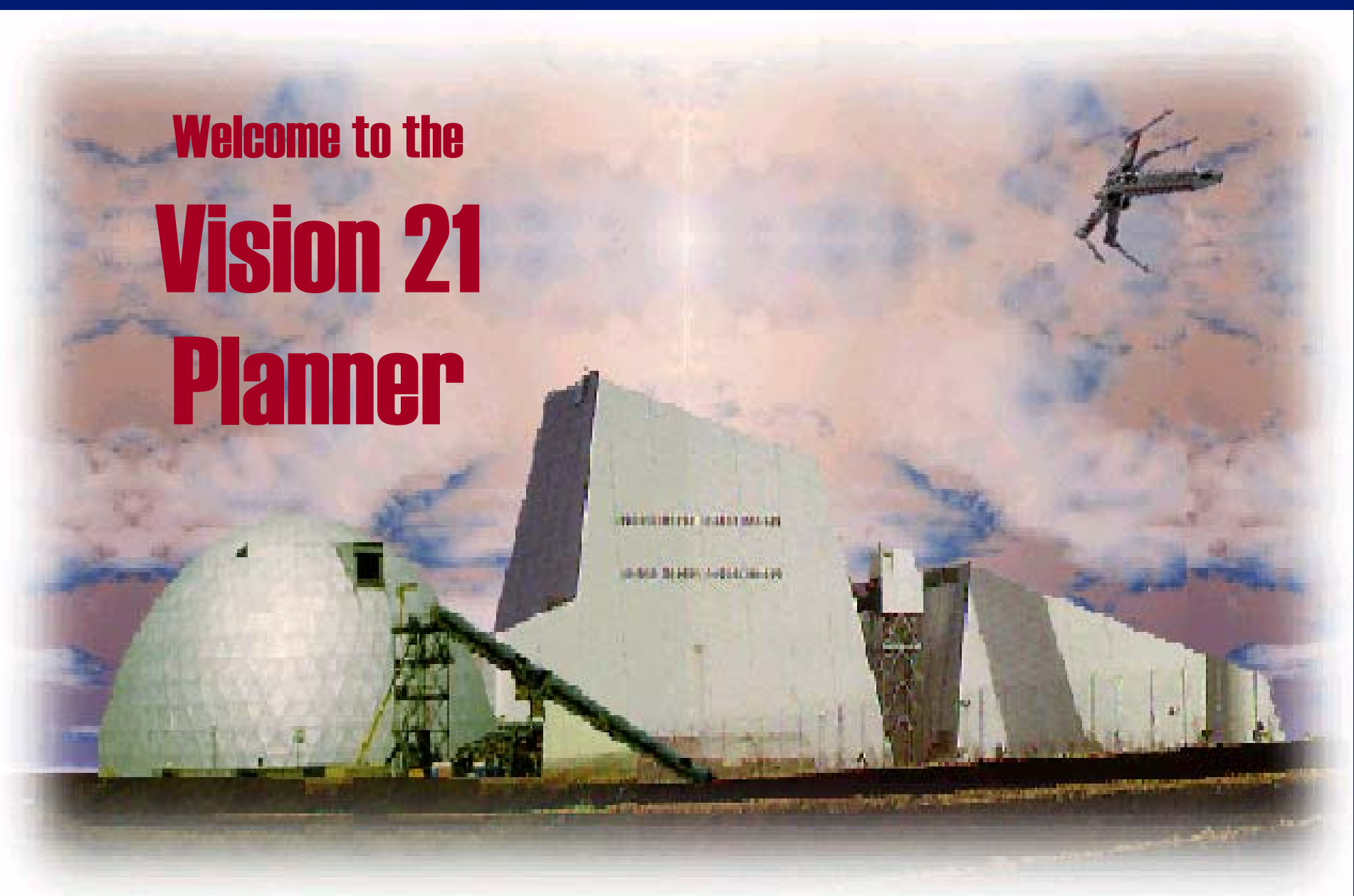
# Benefits of Desktop Models

- Precise and accurate representation of detailed models
- Execution takes seconds, not hours
- Can run on any desktop PC
- Amenable to “what if” analyses
- Incorporates process performance, emissions, and cost models in one package
- Useful by analysts and decision makers who have no time, ability or resources (staff, software, hardware, funds) to run complex models

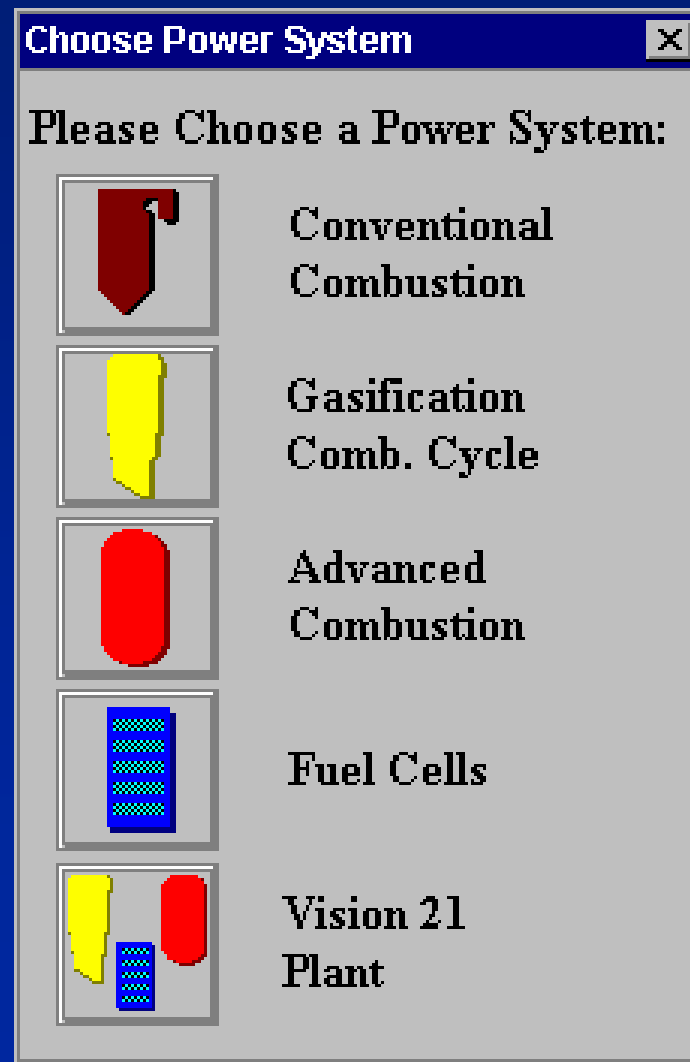
# Schematic of the Proposed Vision 21 Planner



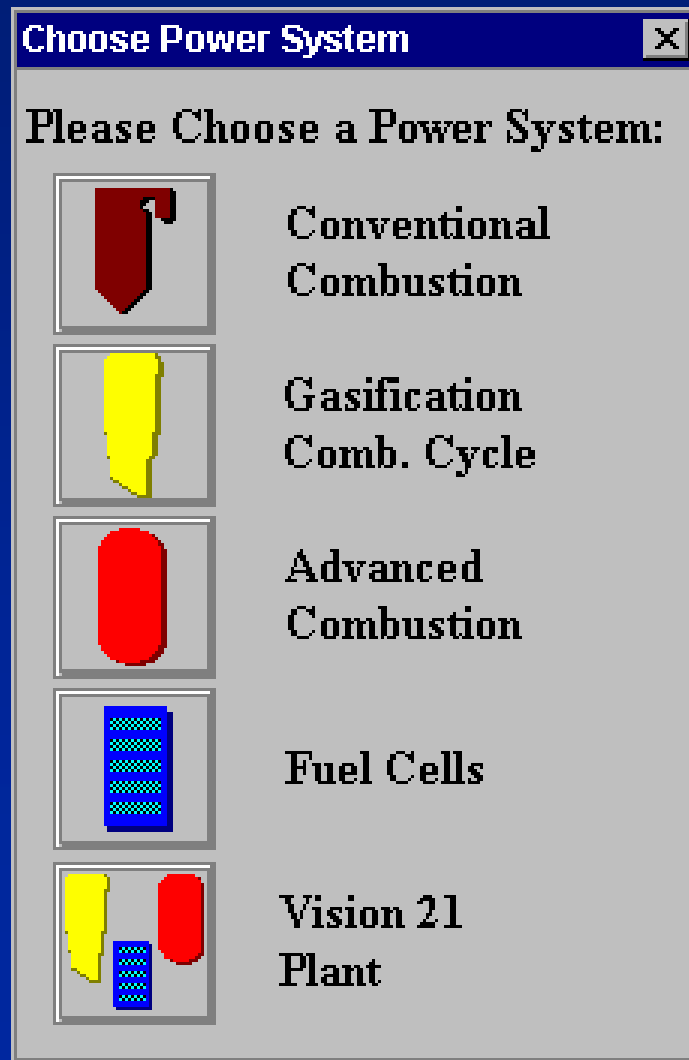
Welcome to the  
**Vision 21  
Planner**



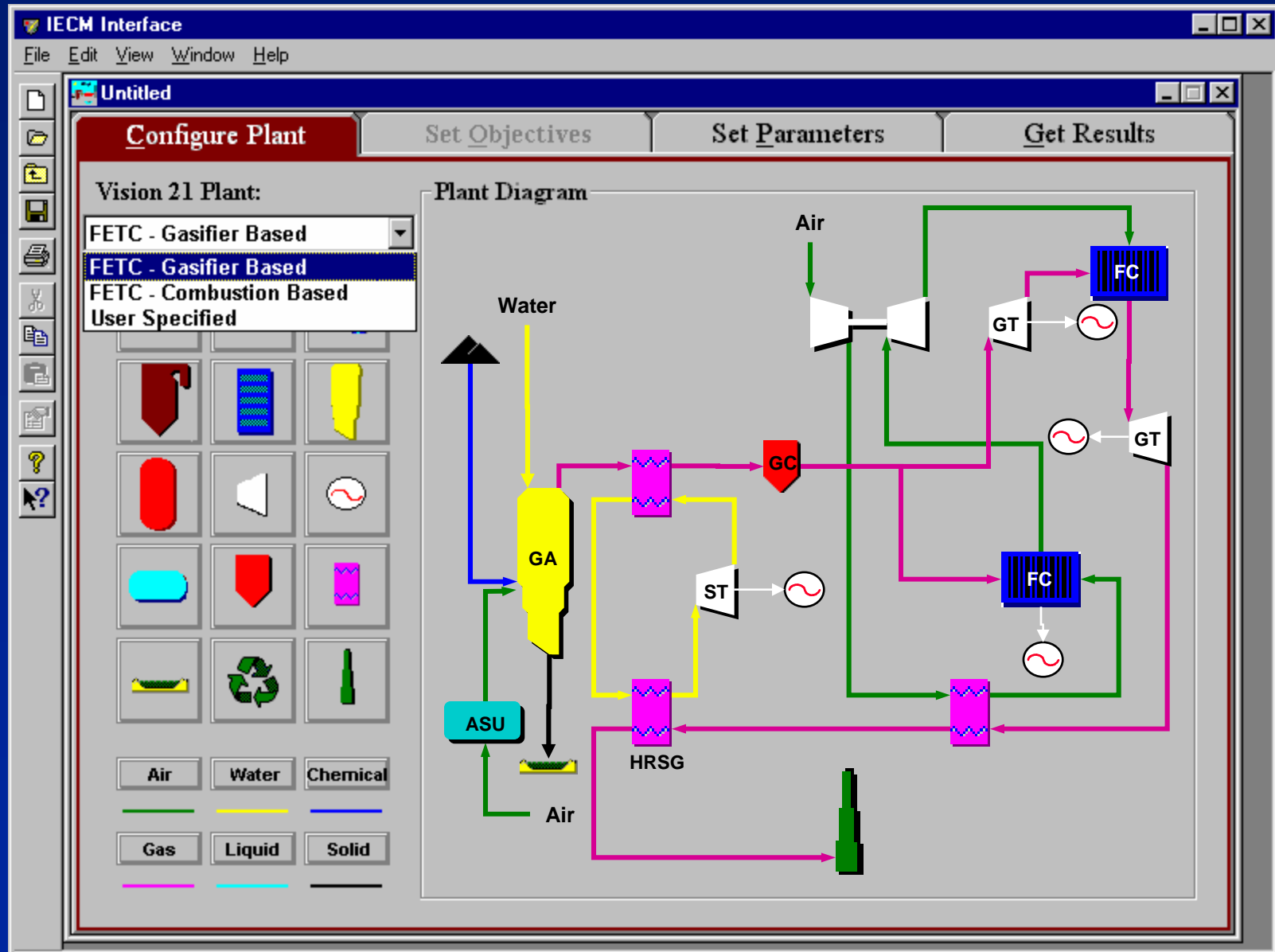
# Opening Screen: A Menu of Technology Options



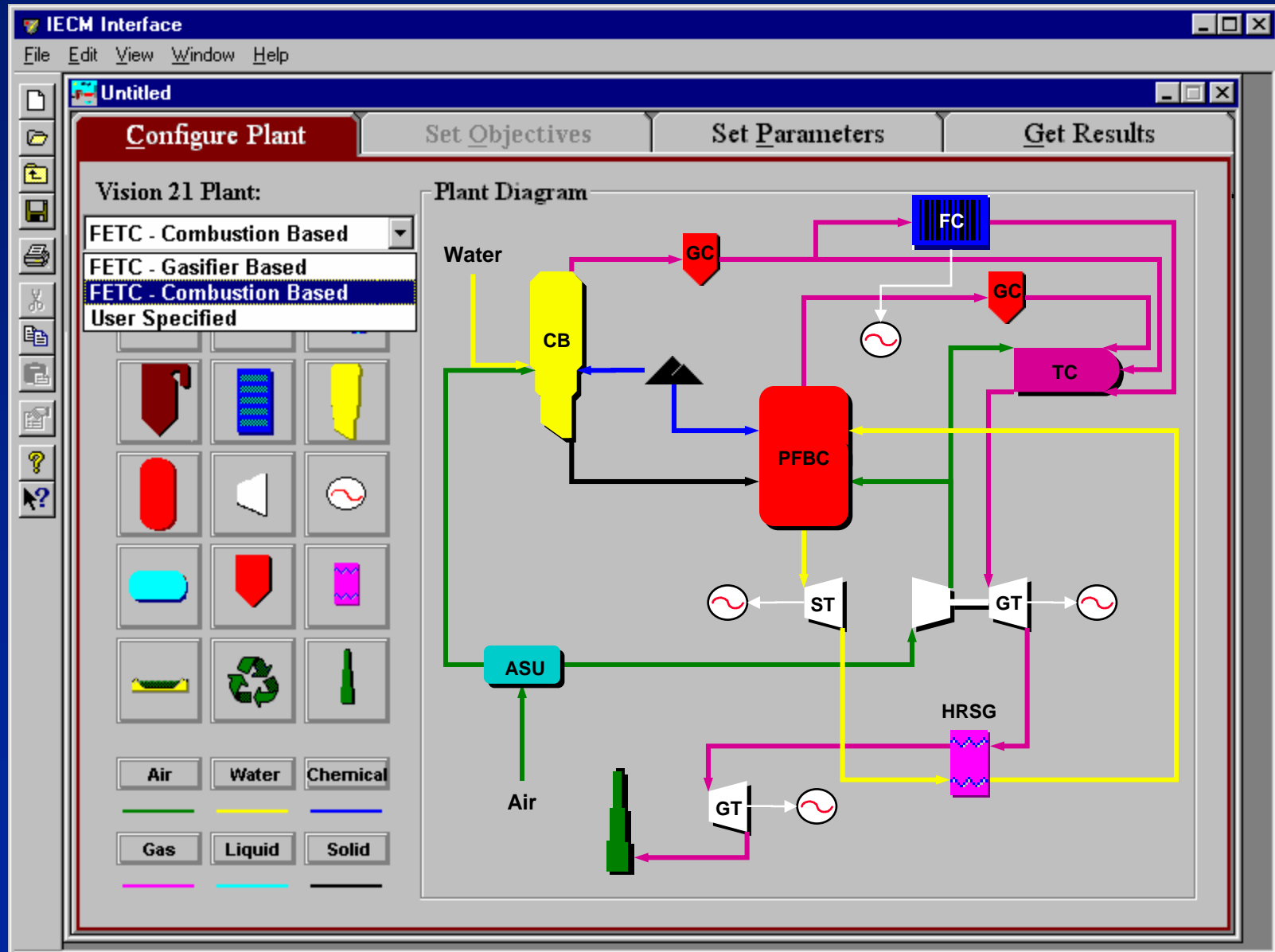
# Open Vision 21 Plant Options



# Select Existing Flowsheet - 1

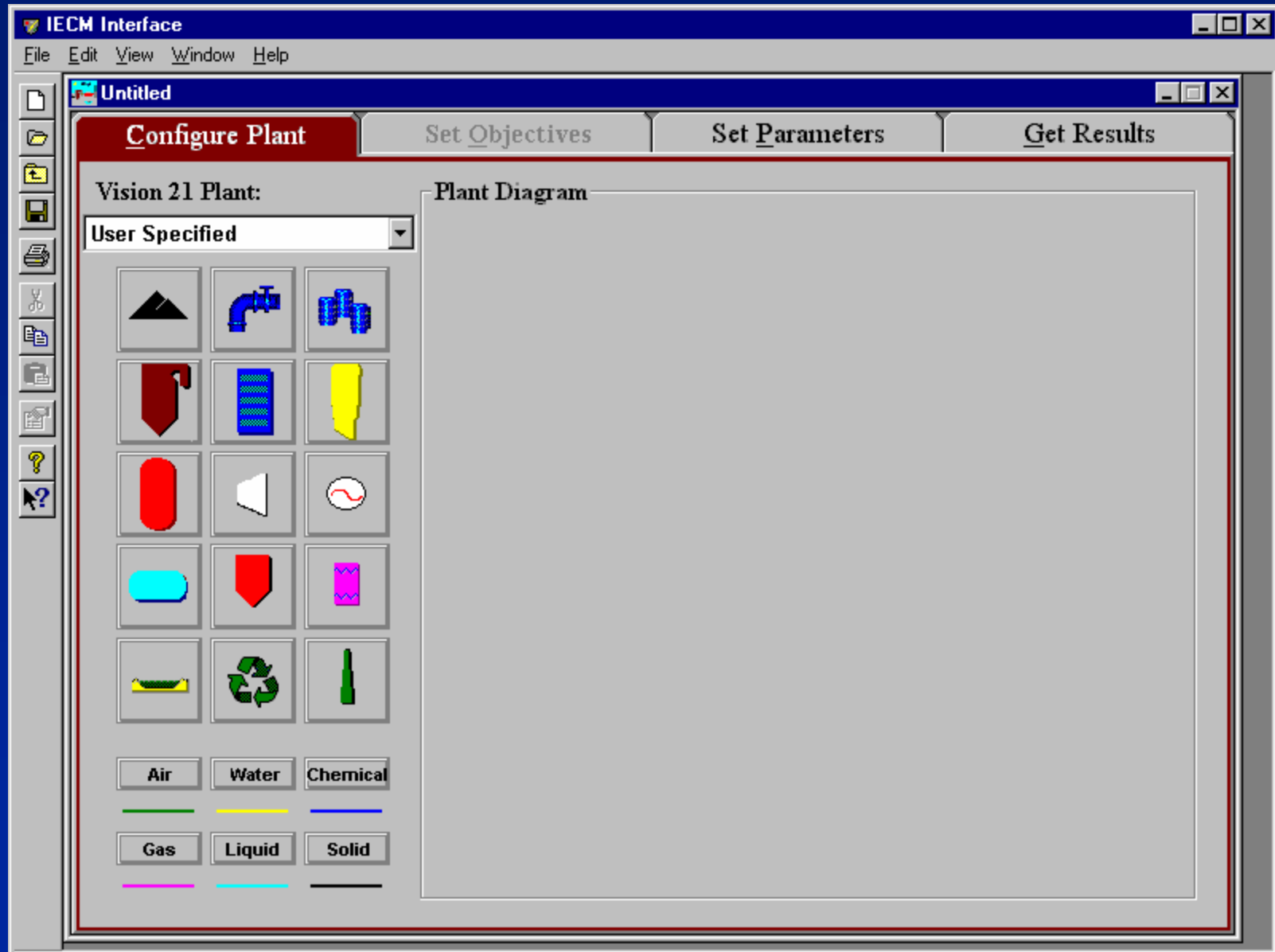


# Select Existing Flowsheet - 2





# Vision 21 Workbench





# The Vision 21 Planner Would . . .

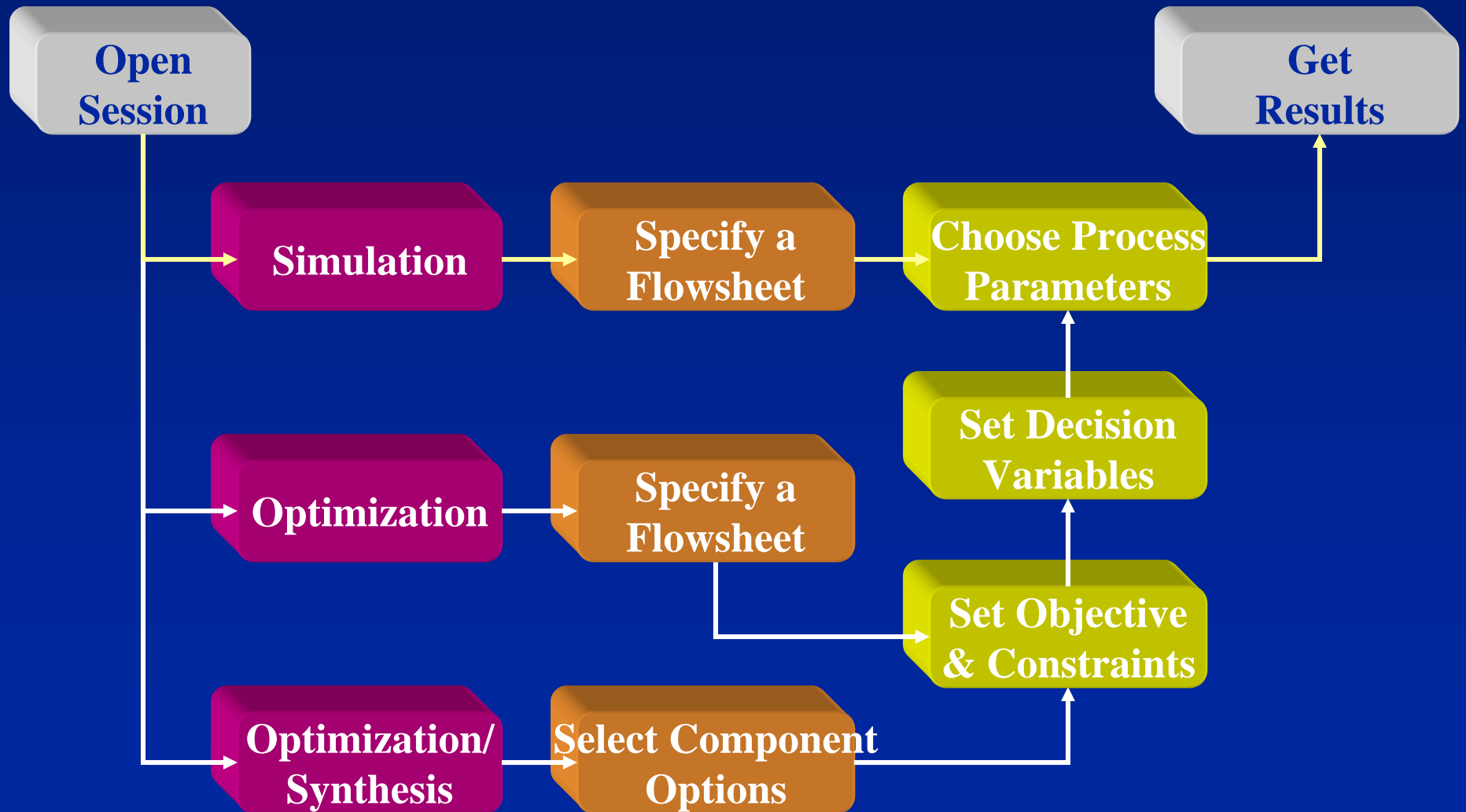
- Bring together a spectrum of performance and cost models for plant components and integrated systems, suitable for preliminary design and analysis
- Run quickly and easily on a desktop or laptop computer
- Allow new process concepts to be easily modeled
- Allow uncertainties to be characterized explicitly
- Facilitate selection of optimal (most promising) designs
- Be public domain software available to all

# Potential New Software Options

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- Process Optimization  
(of a given flowsheet)
  
- Process Synthesis  
(to define an optimal flowsheet)

# Advanced Design Capabilities: Operation Overview



# Select Optimization Mode

IECM Interface

File Edit View Window Help

Untitled

**Configure Plant** Set Objectives Set Parameters Get Results

Goal: Simulation  
Simulation  
**Optimization**  
Synthesis

**Combustion Controls**

Furnace Type: Tangential  
NOx Control: Low NOx Burners

**Post-Combustion Controls**

NOx Control: Hot-Side SCR  
Particulates: Cold-Side ESP  
SO2 Control: Wet FGD  
SO2/NOx: None

**Solids Management**

Recovery: None  
Fly Ash Disposal: mixed w/ Landfill

Plant Diagram

The plant diagram illustrates a complex industrial process flow. It begins with a furnace (red trapezoid) on the left, which feeds into a series of control units: a yellow trapezoid, a pink zigzag filter, a blue vertical scrubber, and another red trapezoid. The flow continues to a final stack (green vertical cylinder) on the right. Arrows indicate the direction of material flow between these components. Additionally, there are two yellow trapezoidal units at the bottom, one under the first furnace and one under the second furnace, likely representing ash recovery or disposal points.

# Set Objective and Constraints

IECM Interface

File Edit View Window Help

Untitled

Configure Plant **Set Objectives** Set Parameters Get Results

Objective: Minimize Capital Cost

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

# Set Parameter Values

IECM Interface

File Edit View Window Help

Untitled

Configure Plant Set Objectives **Set Parameters** Get Results

Overall Plant Coal Properties Base Plant Furnace Factors Emission Constraints NOx Control Particulate Control SO2 Control Solid Waste Mgmt

Goal: Optimization

**Combustion Controls**

Furnace Type: Tangential

NOx Control: Low NOx Burners

**Post-Combustion Controls**

NOx Control: Hot-Side SCR

Particulates: Cold-Side ESP

SO2 Control: Wet FGD

SO2/NOx: None

**Solids Management**

Recovery: None

Fly Ash Disposal: mixed w/ Landfill

Plant Diagram

The Plant Diagram illustrates the process flow. It starts with a furnace (red trapezoid) on the left, which feeds into a Hot-Side SCR (green trapezoid), then a Cold-Side ESP (pink trapezoid), and finally a Wet FGD (blue trapezoid). From the FGD, the flow goes to a stack (green vertical cylinder) on the right. Below the furnace, there is a fly ash handling unit (yellow and blue trapezoid). Below the FGD, there is another fly ash handling unit (yellow and blue trapezoid). Arrows indicate the direction of flow between these components.



# Select Decision Variables

IECM Interface

File Edit View Window Help

Untitled

Configure Plant Set Objectives **Set Parameters** Get Results

Overall Plant Feedstocks Fuel Upgrade **Energy Conversion** Gas Stream Cleanup Process Options Co-Products

IGCC **Conventional Boiler** Fuel Cell PFBC

	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	<input checked="" type="checkbox"/>	0	100	calc	
4	Capacity Factor	%		75		0	100	75	
5	Excess Air For Furnace	% stoich.		20.00	<input checked="" type="checkbox"/>	0	40	calc	
6	Leakage Air at Preheater	% stoich.		19.00	<input checked="" type="checkbox"/>	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	<input checked="" type="checkbox"/>	0	100	calc	
13	<u>Base Plant Energy Requirements</u>								
14	Coal Pulverizer	% MWg		0.6000	<input checked="" type="checkbox"/>	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	

1. Performance 2. Financing 3. Retrofit Cost 4. Capital Cost 5. O&M Cost 6. O&M Escalation

# Get Results (Run Model)

**IECM Interface**

File Edit View Window Help

Untitled

**Configure Plant** | **Set Objectives** | **Set Parameters** | **Get Results**

Overall Plant | Fuel (Coal)

Goal: Optim

**Combustion Controls**

Furnace Type: Tanger

NOx Control: Low NO

**Post-Combustion Control**

NOx Control: Hot-Sid

Particulates: Cold-S

SO2 Control: Wet FG

SO2/NOx: None

**Solids Management**

Recovery: None

Fly Ash Disposal: mixed w/ Landfill

**IECM Analysis Progress**

Iteration	Obj. Function Value	Optimizer Error Value
6	90.345 %	1.4e-01
7	90.462 %	2.4e-02
8	90.523 %	9.5e-04
9	90.549 %	5.4e-05
10	90.563 %	4.0e-07
11	90.568 %	1.7e-07
12	90.570 %	3.3e-09
13	90.570 %	6.2e-11

Calculating New Decision Variables

Pause Stop

Landfill Stack

1. Diagram | 2. Perf. Summary | 3. Flow Summary | 4. Cost Summary

# View Results

IECM Interface

File Edit View Window Help

Untitled

**Configure Plant** | **Set Objectives** | **Set Parameters** | **Get Results**

**Overall Plant** | Fuel (Coal) | Boiler | Air Preheater | NOx Control | Particulate Control | SO2 Control | Pond | Landfill | Stack

**Goal:** Optimization

**Combustion Controls**

Furnace Type: Tangential  
NOx Control: Low NOx Burners

**Post-Combustion Controls**

NOx Control: Hot-Side SCR  
Particulates: Cold-Side ESP  
SO2 Control: Wet FGD  
SO2/NOx: None

**Solids Management**

Recovery: None  
Fly Ash Disposal: mixed w/ Landfill

**Plant Diagram**

The Plant Diagram illustrates the process flow. It starts with a furnace (represented by a black triangle) on the left. The flow goes through a red furnace, then a green ESP, a pink SCR, a blue FGD, and finally a red stack. Below the main flow, there are two disposal units (represented by yellow and green shapes) that receive ash from the process.

1. Diagram | 2. Perf. Summary | 3. Flow Summary | 4. Cost Summary

# Select Synthesis Mode

IECM Interface

File Edit View Window Help

Untitled

**Configure Plant** Set Objectives Set Parameters Get Results

Goal: Simulation  
Simulation  
Optimization  
**Synthesis**

**Combustion Controls**

Furnace Type: Tangential  
NOx Control: Low NOx Burners

**Post-Combustion Controls**

NOx Control: Hot-Side SCR  
Particulates: Reverse Gas Fabric Filter  
SO2 Control: Lime Spray Dryer  
SO2/NOx: None

**Solids Management**

Recovery: None  
Fly Ash Disposal: mixed w/ Landfill

Plant Diagram

The Plant Diagram illustrates a complex industrial process flow. It begins with a red furnace on the left, which feeds into a yellow-green heat exchanger. This is followed by a pink zig-zag heat exchanger, then a purple heat exchanger, and finally a blue scrubber. The process concludes with a green stack on the right. Arrows indicate the flow of materials between these components. Additionally, there are two yellow and blue storage bins at the bottom, one connected to the furnace and another to the scrubber. A black triangle at the top left represents an input or output point.

# Select Possible Technologies

IECM Interface

File Edit View Window Help

Untitled

**Configure Plant** Set Objectives Set Parameters Get Results

Goal: Optimization

**Combustion Controls**

**Furnace Type:**  Tangential  
 Wall  
 Cyclone

**NOx Control:**  Low Excess Air  
 Burners out of Service  
 Low NOx Burners (LNB)  
 LNB + Overfire Air (OFA)  
 Lean Gas Reburn  
 Gas Reburn + OFA  
 Coal Reburn  
 None

**Solids Management**

**Recovery:**  Gypsum  
 Sulfur  
 Sulfuric Acid  
 None

**Fly Ash Disposal:**  mixed w/ Bottom Ash  
 mixed w/ Landfill  
 None

**Post-Combustion Controls**

**NOx Control:**  Hot-Side SCR  
 None

**Particulates:**  Cold-Side ESP  
 Reverse Gas Fabric Filter  
 Reverse Gas Sonic Fabric Filter  
 Shake & Deflate Fabric Filter  
 None

**SO2 Control:**  Wet Lime FGD  
 Wet Limestone FGD  
 Wet Limestone w/ Additives FGD  
 Spray Dryer  
 None

**SO2/NOx:**  Copper Oxide  
 NOXSO  
 None

# Set Parameters

IECM Interface

File Edit View Window Help

Untitled

Configure Plant Set Objectives **Set Parameters** Get Results

Overall Plant Feedstocks Fuel Upgrade **Energy Conversion** Gas Stream Cleanup Process Options Co-Products

IGCC **Conventional Boiler** Fuel Cell PFBC

	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	<input checked="" type="checkbox"/>	0	100	calc	
4	Capacity Factor	%		75		0	100	75	
5	Excess Air For Furnace	% stoich.		20.00	<input checked="" type="checkbox"/>	0	40	calc	
6	Leakage Air at Preheater	% stoich.		19.00	<input checked="" type="checkbox"/>	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	<input checked="" type="checkbox"/>	0	100	calc	
13	<u>Base Plant Energy Requirements</u>								
14	Coal Pulverizer	% MWg		0.6000	<input checked="" type="checkbox"/>	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	

1. Performance 2. Financing 3. Retrofit Cost 4. Capital Cost 5. O&M Cost 6. O&M Escalation

# Get Results (Run Model)

The screenshot displays the IECM Interface software. The main window has a menu bar (File, Edit, View, Window, Help) and a toolbar on the left. The main area is divided into several tabs: 'Configure Plant', 'Set Objectives', 'Set Parameters', and 'Get Results' (which is highlighted in red). Below these are sub-tabs for 'Overall Plant', 'Fuel (Coal)', 'Boiler', 'Air Preheater', 'NOx Control', 'Particulate Control', 'SO2 Control', 'Pond', 'Landfill', and 'Stack'. The 'Overall Plant' sub-tab is active, showing various control settings for 'Combustion Controls' and 'Post-Combustion Control'. A central dialog box titled 'IECM Analysis Progress' is open, displaying a table of optimization results. The table has three columns: 'Iteration', 'Obj. Function Value', and 'Optimizer Error Value'. The data shows a decreasing trend in both the objective function and optimizer error over 13 iterations. Below the table are 'Pause' and 'Stop' buttons. To the right of the dialog box is a process flow diagram showing a boiler, a red heat exchanger, a stack, and a pond. At the bottom of the interface, there are four tabs: '1. Diagram', '2. Perf. Summary', '3. Flow Summary', and '4. Cost Summary'.

**IECM Analysis Progress**

Iteration	Obj. Function Value	Optimizer Error Value
6	787.3	1.4e-01
7	702.0	2.4e-02
8	669.8	9.5e-04
9	619.3	5.4e-05
10	627.5	4.0e-07
11	580.5	1.7e-07
12	526.2	3.3e-09
13	526.2	6.2e-11

Calculating New Decision Variables

Pause Stop

1. Diagram 2. Perf. Summary 3. Flow Summary 4. Cost Summary

# View Optimal Flowsheet

IECM Interface

File Edit View Window Help

Untitled

Configure Plant Set Objectives Set Parameters **Get Results**

Overall Plant Fuel (Coal) Boiler Air Preheater NOx Control Particulate Control SO2 Control Pond Landfill Stack

Goal: Optimization

**Combustion Controls**

Furnace Type: Tangential  
NOx Control: Low NOx Burners

**Post-Combustion Controls**

NOx Control: Hot-Side SCR  
Particulates: Cold-Side ESP  
SO2 Control: Wet FGD  
SO2/NOx: None

**Solids Management**

Recovery: None  
Fly Ash Disposal: mixed w/ Landfill

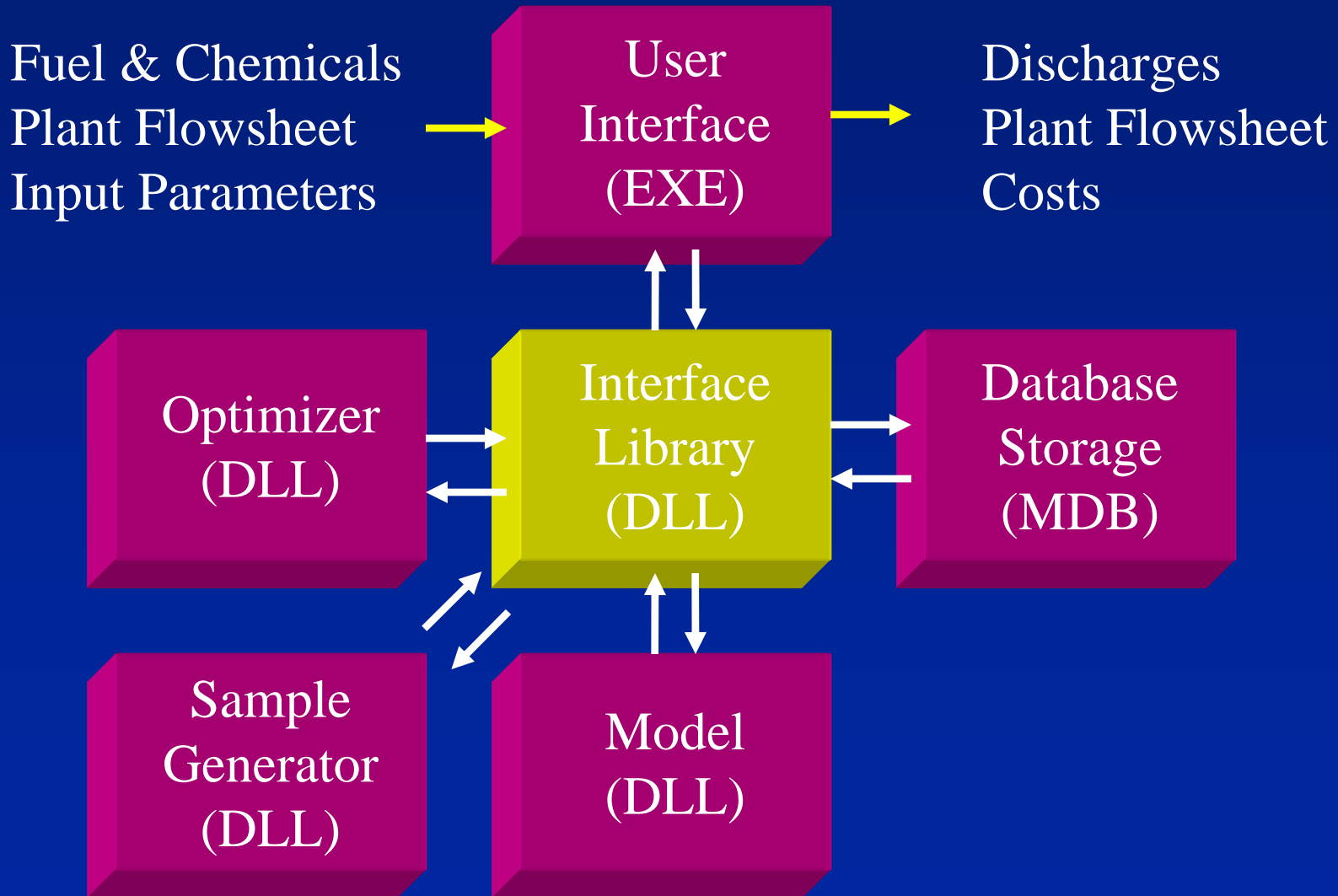
Plant Diagram

The Plant Diagram illustrates the process flow. It starts with a furnace (red) that feeds into a series of control units: a particulate control unit (green), a cold-side ESP (pink), a hot-side SCR (blue), and a wet FGD (red). The flow then goes to a stack (green). There are also two ash handling units (yellow) at the bottom, one for each FGD unit.

1. Diagram 2. Perf. Summary 3. Flow Summary 4. Cost Summary



# Details of the Programming Module Structure



# Where Do We Go from Here?

- To enhance the use of the IECM we could:
  - Add new models of environmental control systems and advanced technology options of interest to DOE (both performance and cost)
  - Add new output reports and software features
  - Conduct case studies of specific issues
  - Add process synthesis and optimization capabilities
  - Offer user training programs and user support

# Where Do We Go from Here?

- To develop the Vision 21 Planner we would:
  - Implement preliminary versions of enabling technology models (both performance and cost)
  - Use the Vision 21 Planner as a testbed for systems integration development
  - Add process synthesis and optimization capabilities
  - Incorporate dynamics modeling of integrated systems
  - Develop linkages to more detailed models of process components and systems (modeling hierarchy)