Vision 21
Advanced Power Plants for the 21st Century

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Vision 21

Advanced Power Plants

for the 21st Century

U.S. Department of Energy
Office of Fossil Energy

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A Pathway to Clean Affordable Energy

Vision

To realize sustained domestic economic robustness, enhanced industrial competitiveness, and high value jobs creation, while maintaining respect for our environment, including global climate, and ensuring secure, stable, affordable energy supplies through the creation of clean, efficient, low-cost energy from fossil resources.

Vision-21 Program

A government/industry cost-shared partnership supported by the States, national labs and universities, to develop enabling and competitive fossil energy and environmental technologies which will generate enhanced technology modules that can be integrated and configured into flexible, high efficiency, near-zero emission energyplexes which are competitive in the energy market of the 21st century

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Vision 21 Goals

- **Development of advanced technology modules for a new, enhanced fleet of 21st century energy plants tailored to market demand:**
  - efficiencies (to electricity)
    > 60 % on coal; > 75% on gas
  - overall thermal efficiency of 85 - 90%
  - near zero pollutant emissions
  - lower cost of electricity and fuels than today
  - cost effective management of carbon emissions
- **Establishing mechanisms for deploying these advanced technologies, including industry and government partnerships**

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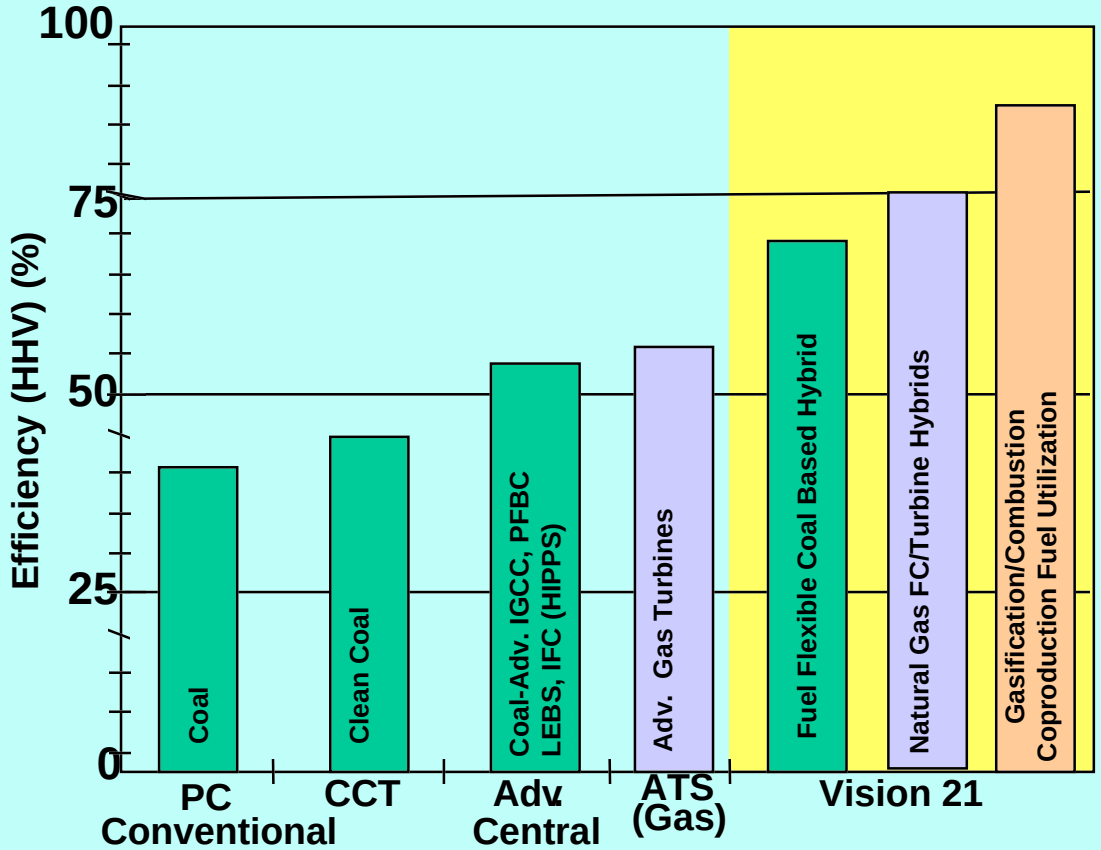
Rationale for Vision 21

- Removes environmental barriers to fossil fuel use
- Keeps energy costs affordable
- Assures the availability of affordable transportation fuels
- Continues U.S. leadership role in clean energy technology
- Provides the most certain route to achieving our energy/environmental/economic objectives

Fossil-Based Power and Energy Utilization Systems Efficiencies



- Conventional new power plants operate at 35 - 37% efficiency
- The Clean Coal Technology program has already demonstrated plants with 38 - 40% efficiency.
- "Nth" of a kind CCT units will improve to 45 - 50% efficiency.
- Vision 21 Power Plants capable of 60 - 65% efficiency on coal; 75% on gas; and 85% fuel utilization in coproduction

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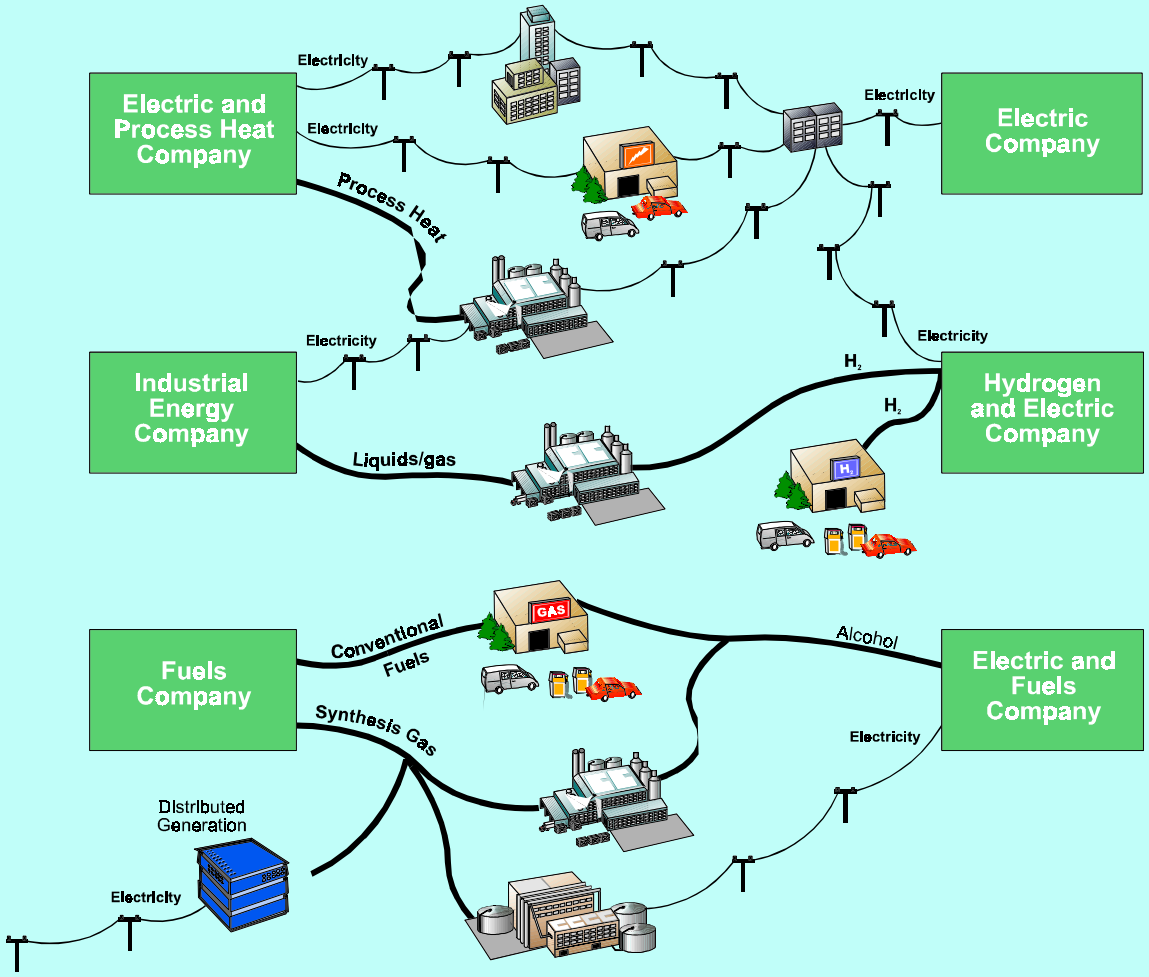
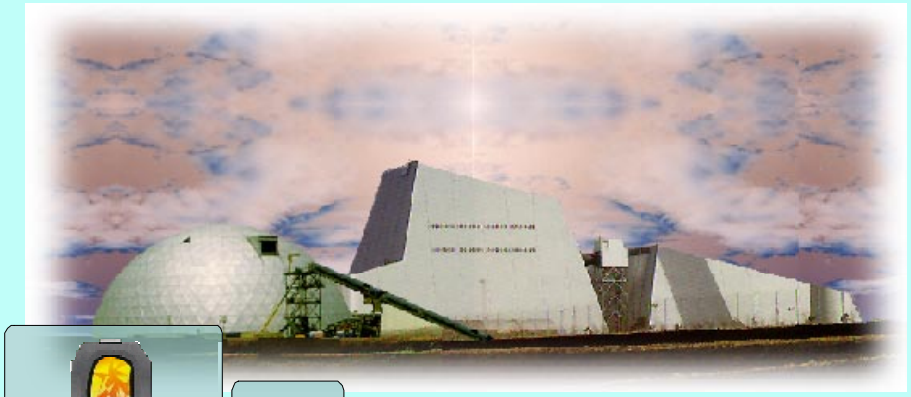
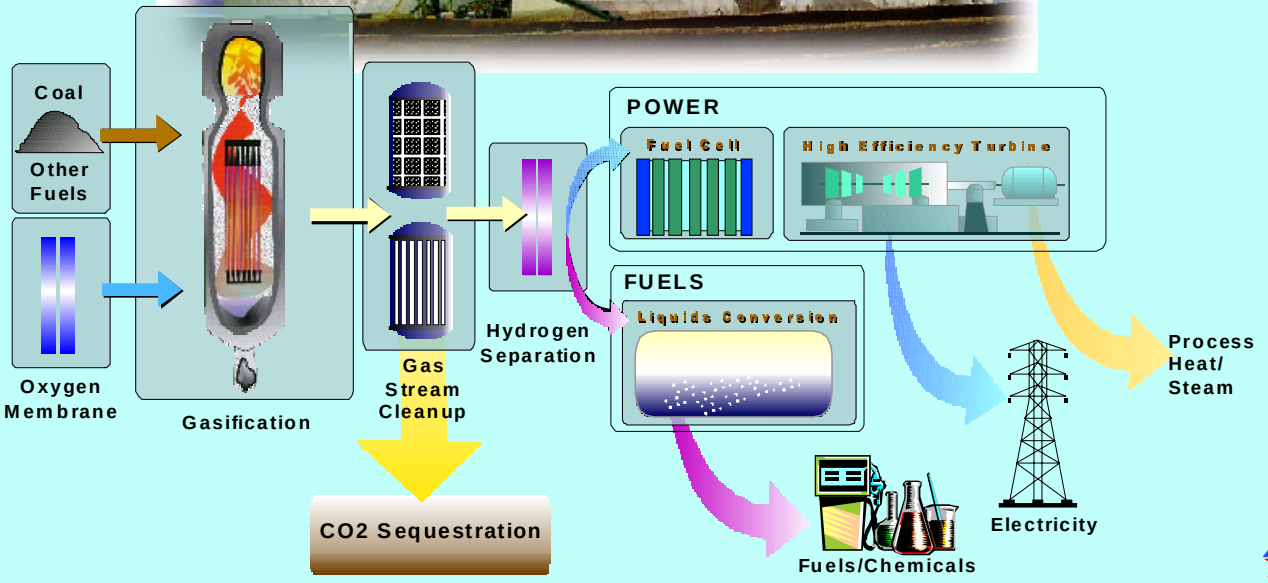
A Vision 21 Fleet for the 21st Century



Vision21 EnergyPlex



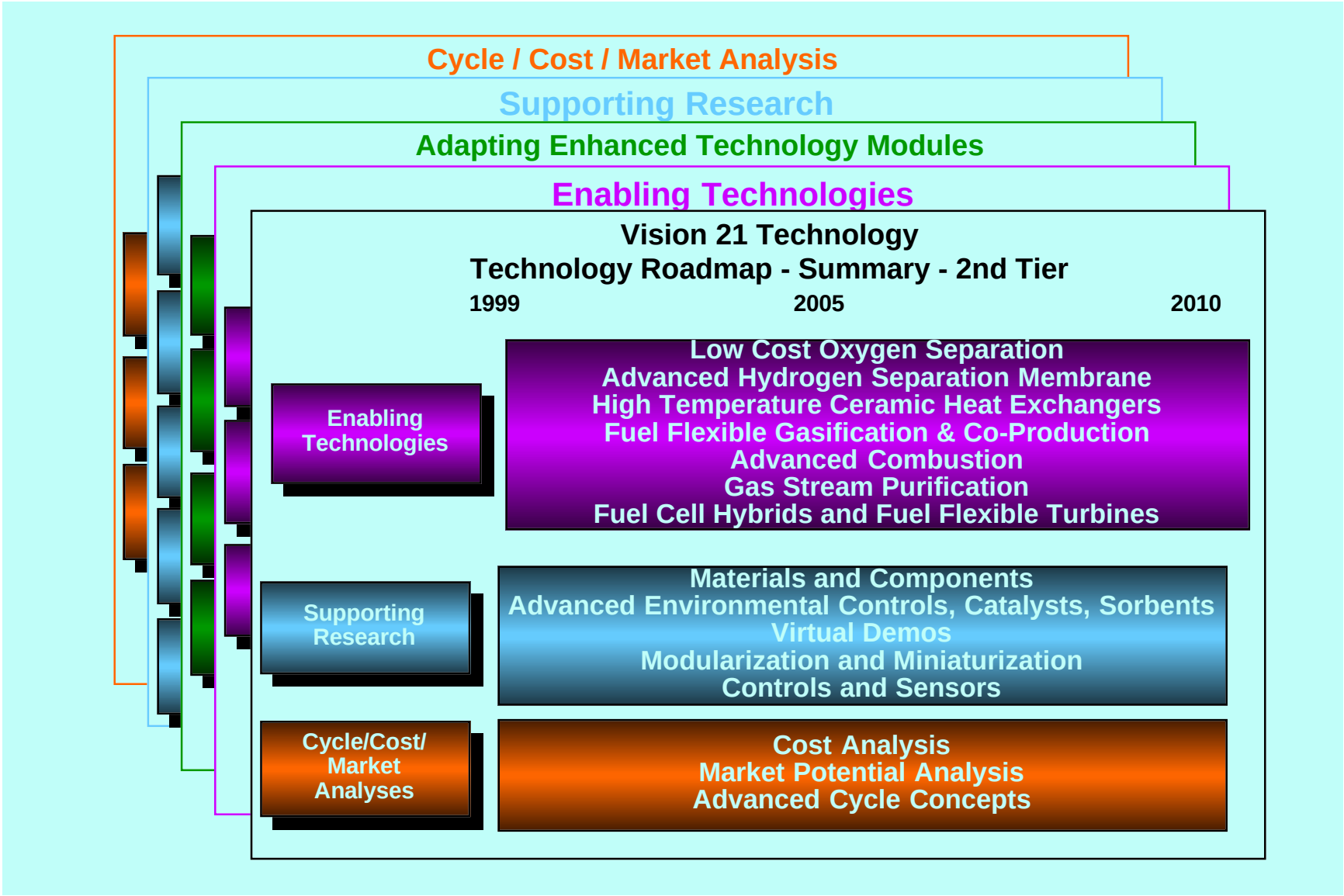


R&D Investment Portfolio

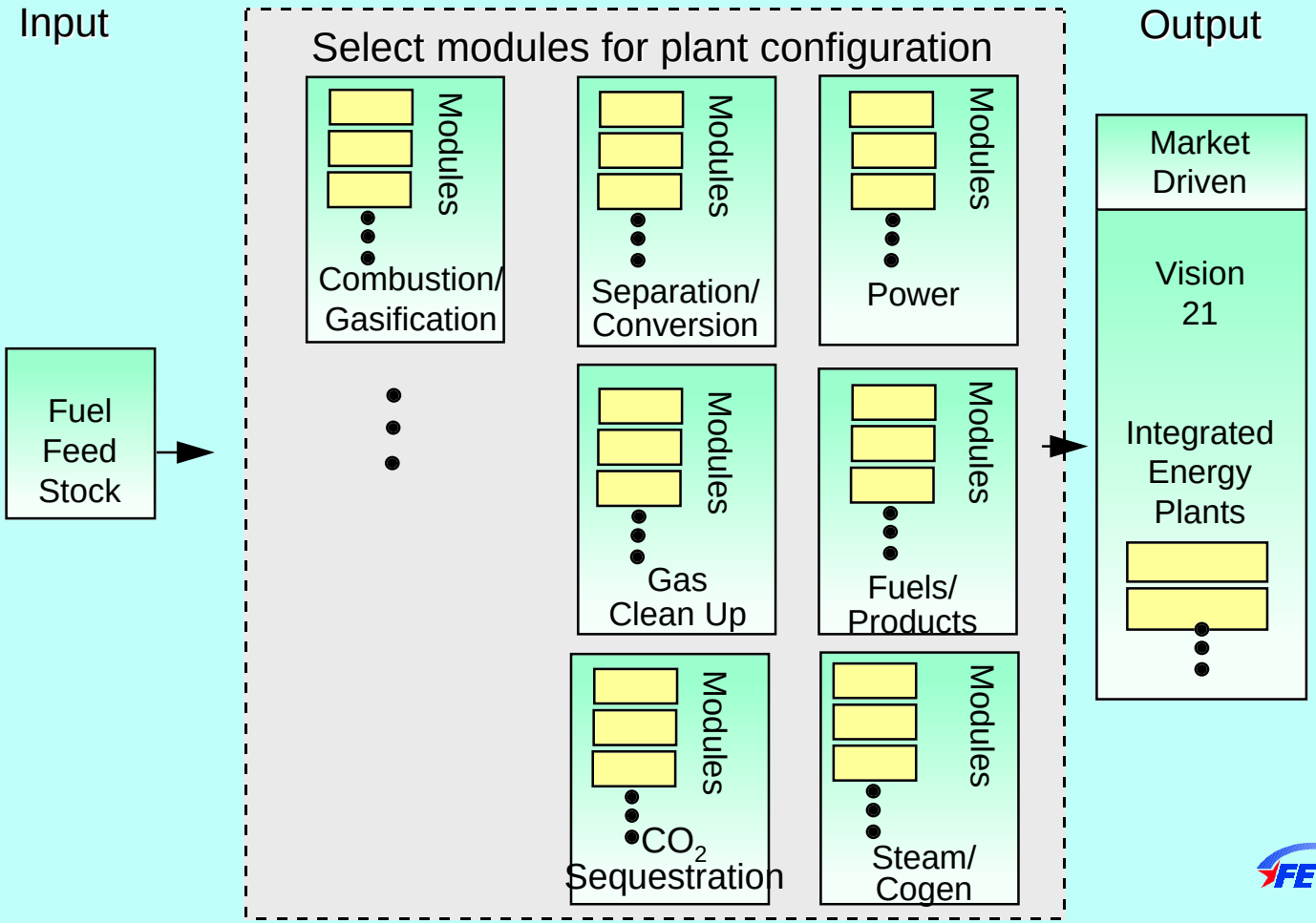
- **Enabling Technologies**
  - O_2 and H_2 separation membranes
  - High temperature heat exchangers
  - Fuel flexible gasification
  - Extended gas stream purification
  - Advanced combustion systems
  - Fuel cell / hybrids
  - Fuel flexible turbines
  - Coproduction

R&D Investment Portfolio (continued)

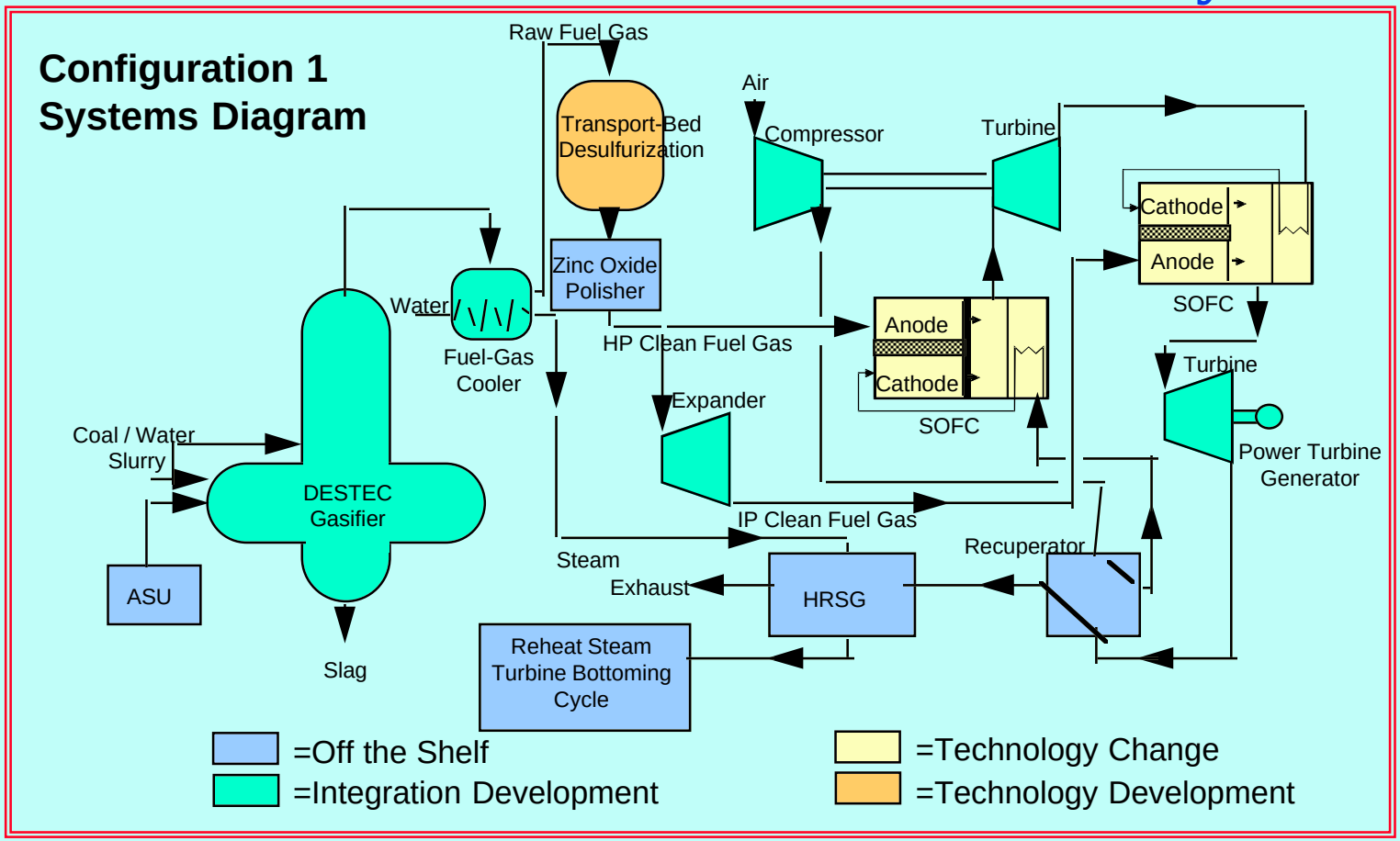
- **Supporting Research**
  - Materials and components
  - Virtual demonstration plant
  - Advanced control and sensors
  - Modularization
- **Cost / Advanced Conversion Cycles / Market Analysis**
- **Linkages to Carbon Sequestration**


Cycle / Cost / Market Analysis
Supporting Research
Adapting Enhanced Technology Modules
Enabling Technologies
Vision 21 Technology
Technology Roadmap - Summary - 2nd Tier
1999
2005
2010
Enabling Technologies
Low Cost Oxygen Separation
Advanced Hydrogen Separation Membrane
High Temperature Ceramic Heat Exchangers
Fuel Flexible Gasification & Co-Production
Advanced Combustion
Gas Stream Purification
Fuel Cell Hybrids and Fuel Flexible Turbines
Supporting Research
Materials and Components
Advanced Environmental Controls, Catalysts, Sorbents
Virtual Demos
Modularization and Miniaturization
Controls and Sensors
Cycle/Cost/ Market Analyses
Cost Analysis
Market Potential Analysis
Advanced Cycle Concepts

Vision 21 Concept Technology Modules



Vision 21 Fuel Cell / Gas Turbine Cycle

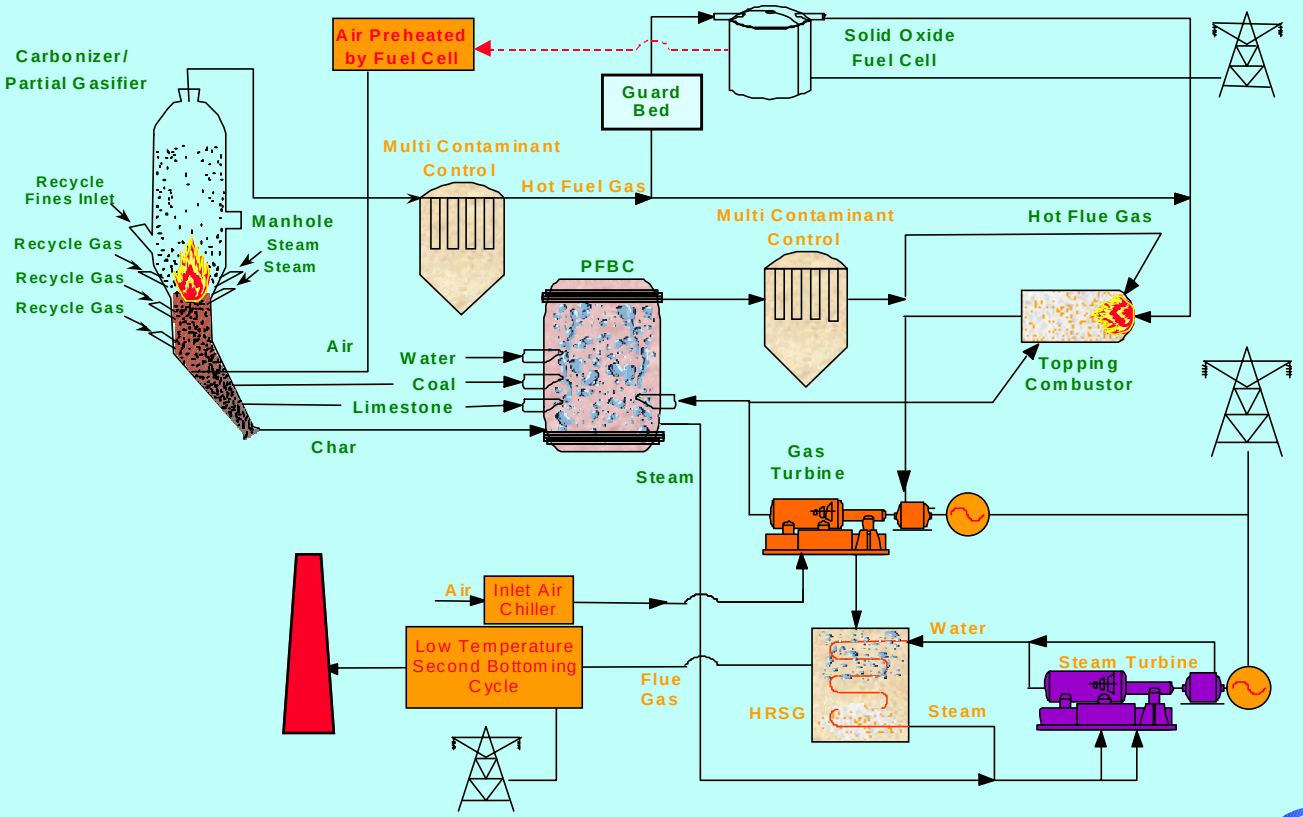


Vision 21 Fuel Cell/GT Cycle

Configuration 1
Plant Performance Summary

Gasifier	Destec
Coal Input to Gasifier, lb/hr	256,142
Thermal Input, MW_t	875.8
HP SOFC Module, MW, dc/ac	189.4/182.8
LP SOFC Module, MW, dc/ac	121.4/117.2
Gas Turbine, MW	133.7
Steam Turbine, MW	118.0
Fuel Expander, MW	9.6
Gross Power, MW	561.3
Auxiliary Power MW	40.4
Net Power, MW	520.9
Efficiency, % HHV	59.5

Vision 21 PFBC System Description



Vision 21 PFBC Configuration

Plant Performance Summary

Gas Turbine	141
Steam Turbine	185
SOFC, MW	27
Low Temp Bottom, MW	19
Gross Power, MW	358
Auxiliary Power, MW	14
Net Power, MW	344
Efficiency, % HHV	62

Business Strategy

- **Cost-shared, Industry Driven Program that Generates Public Benefits :**
  - Solicit Vision-21 concepts and Evaluate ideas
  - Identify R&D Needs and Investment Priorities
  - Establish Industry/Government Partnerships and Consortia
  - Phased R&D Approach using Cooperative Agreements
  - Establish Resource and Cost Sharing Requirements
  - Develop Continuous Products
    - designs for commercial and prototype plants
    - designs for subsystems and components
    - simulation tools

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Vision 21 Program Elements

- Management Plan
- Systems Analysis
- Enabling Technologies
- Supporting Technologies
- Vision 21 Plant Design

Vision 21 Program Elements

- **Management Plan**
  - R&D roadmap
  - Coordination with other organizations
  - Acquisition
  - Program and project management
- **Systems Analysis**
  - Development of computer software
  - Definition of Vision 21 system configurations
  - System evaluations
  - Economic analysis
  - Virtual demonstration

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Vision 21 Program Elements (continued)

- **Enabling Technologies**
  - Advanced combustion
  - Gasification
  - Fuel Cells
  - Advanced turbine systems
  - O_2 and H_2 separation membranes
  - High-T heat exchangers
  - Gas stream purification
  - Coproduction

Vision 21 Program Elements (continued)

- **Supporting Technologies**
  - Advanced materials
  - Advanced environmental controls
  - Virtual demonstration
  - Advanced controls and sensors
  - Advanced manufacturing / modularization
- **Vision 21 Plant Design**
  - Component / subsystem designs
  - Prototype plant designs
  - Commercial plant designs

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Next Steps

- **Establish process forum for stakeholder and customer participation:**
  - Feedback on the Vision and Goals
  - Vision 21 road mapping in context of overall planning
  - Formulating new ideas and concepts for Vision 21
- **Examining possible configurations for their potential attributes against Vision 21 goals**

Coal & Power Systems Budget - FY2000

- **Central Systems**
  - Existing Plants (formerly AR&ET)
  - Advanced Systems (next fleet)
    - LEBS
    - IFC (HIPPS)
    - IGCC
    - PFB
  - Turbines (ATS)
  - Vision 21
    - Adv. Gasification/Combustion
    - Fuel Cell/Turbine Hybrid
- **Distributed Generation**
  - Fuel Cells
  -
-
- **Sequestration R&D**
- **Fuels**
  - Tx. Fuels & Chemicals
  - Solid Fuels & Feedstocks
  - Advanced Fuels Research
  - Vision 21 Fuels
- **Advanced Research**
  - Coal Utilization Science
  - Materials
  - Technology Crosscut
  - UCR
  - HBCU
  - Vision 21 - Advanced Research

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Summary

- Vision 21 endorsed by Presidents Committee of Advisors on Science and Technology
- Supported by DOE's 11-Lab Study on climate change and by industry stakeholder groups
- Market oriented approach -- configurations for Vision 21 dictated by market forces
- Requires key enabling technologies and enhancements and integrates advanced technologies currently under development
- Linkage to Carbon Sequestration options

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Back up Information

Color Coding for Technology Status
Vision 21 Diagrams

BLUE Off-the-Shelf - Tested and in conformance to National Standards by a national organization, e.g., ASTM, ASME, etc. Operation and performance warranted. Supported by multiple vendors. Procurement entails writing a specification and receiving bids from several qualified vendors. Examples include coal handling, ASU, HRSG, steam turbine generator, zinc oxide polisher, BOP equipment.

GREEN Integration Development - Commercially available but at a different size, capacity, performance, aggressive operation, or application than proposed. Demonstrated, but not at the conditions of this particular cycle. Differs from Off-the-Shelf components in that design verification or demonstration needed. More than single vendor. Examples include gasifier, fuel gas coolers, high efficiency gas turbomachinery, expanders.

YELLOW Technology Change - Existing technology demonstrated, at the pilot-scale level. Change in design, operation on different fuel, or other important parametric change must be addressed. Multiple vendors may be available. Example is SOFC at large scale and different fuel.

RED Technology Development - Pilot plant, PDU or demonstrations still required. Multiple vendors not available. Examples are transport reactor for sulfur removal or O_2 separation membrane.

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