

Gasification Technologies Program

Overview of Program Focus on Hydrogen Production

Gary J. Stiegel

Product Manager

National Energy Technology Laboratory

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Gasification Technologies Program

Mission and Vision

- **Mission**

- Foster the commercialization of gasification-based processes that convert low-cost carbonaceous feedstocks to some combination of electricity, steam, fuels, chemicals, or hydrogen

- **Vision**

- Compared to competing technologies, gasification-based systems are technology-of-choice
 - More economical
 - Higher thermal efficiency
 - Superior environmental performance
 - Fuel and product flexible



The Hydrogen Connection

- **Natural sources of hydrogen**

- Hydrocarbon (-C-H-) resources
 - Coal, oil, natural gas
- Water (H₂O)

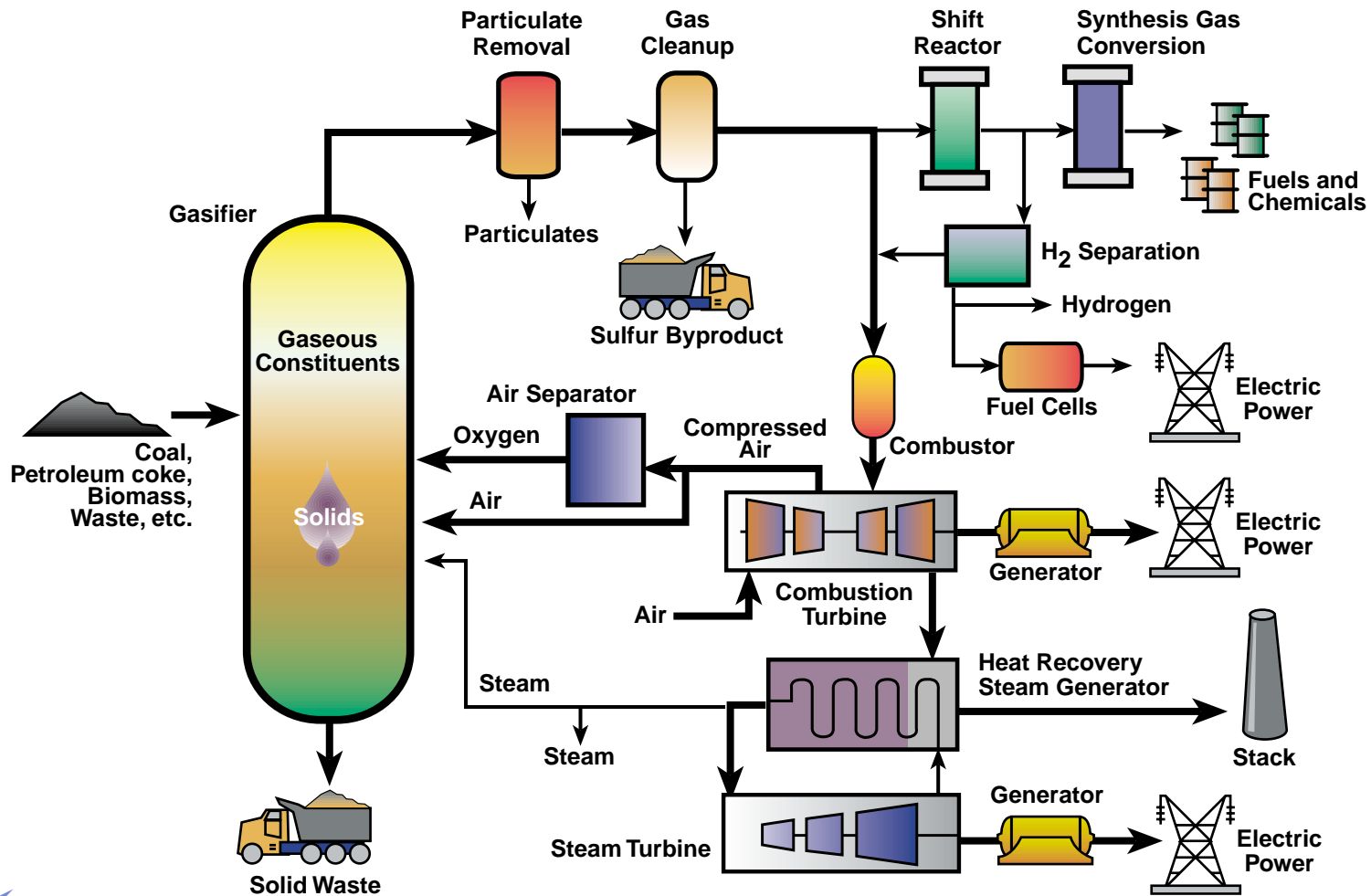
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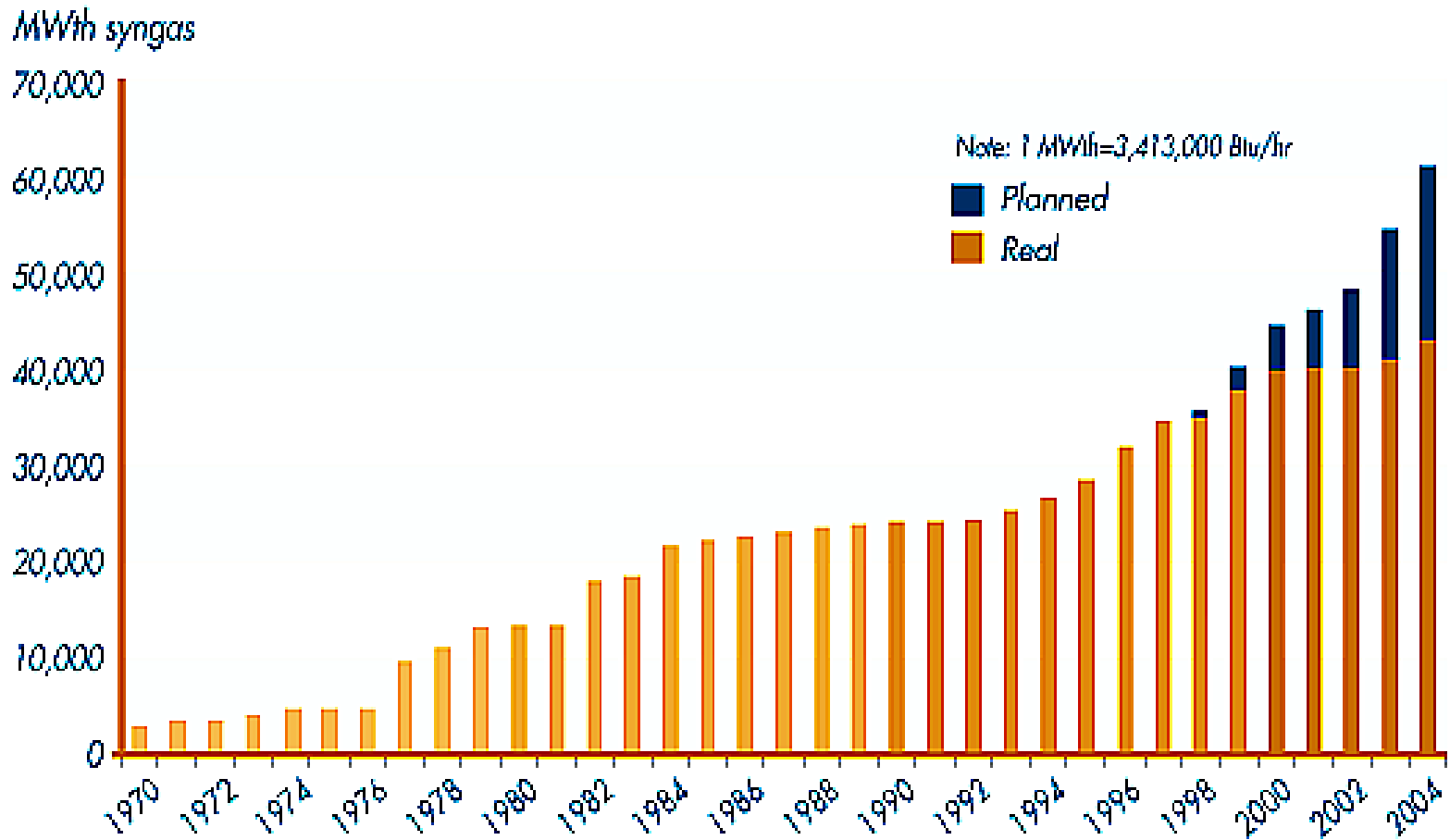
- **Uses of hydrogen**

- Transportation fuel of future
- Fuels cells
- Fuels and chemicals

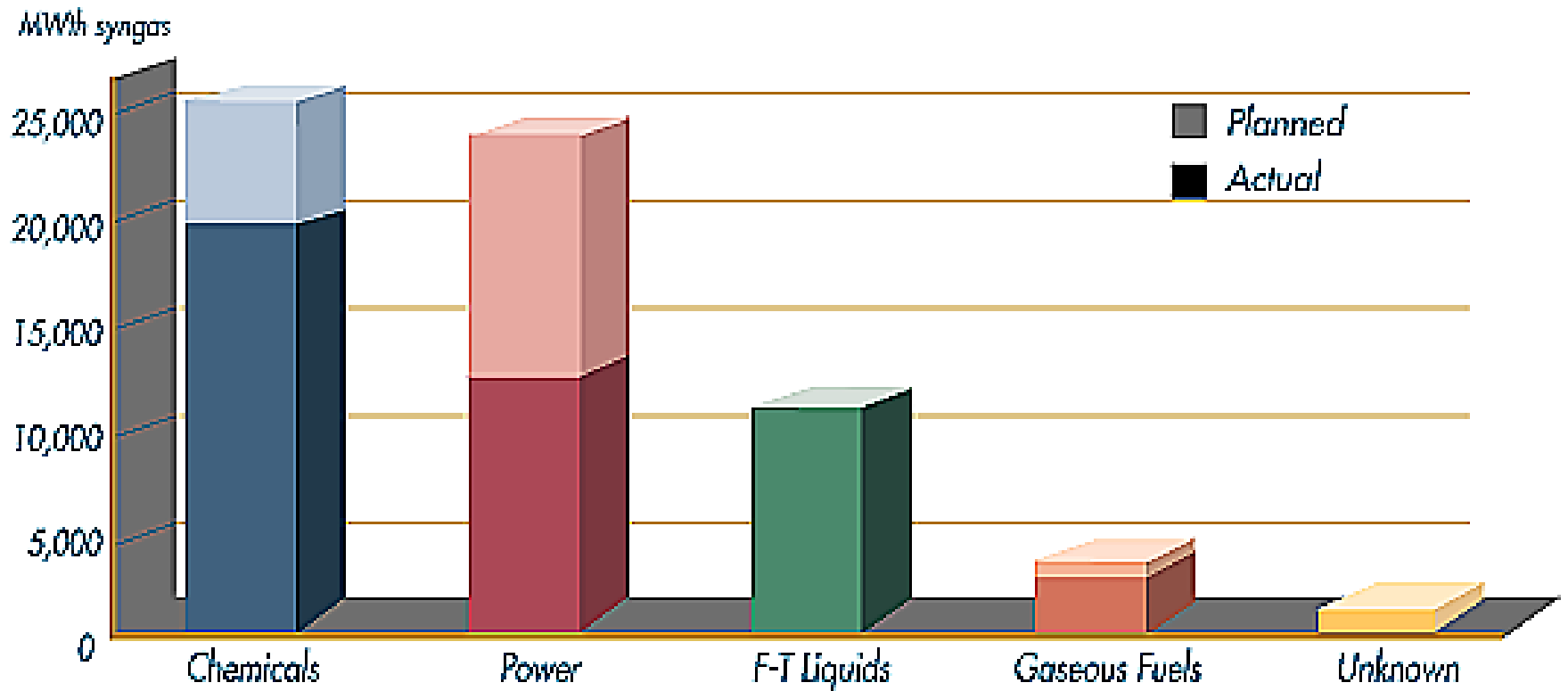
Gasification Technology Options



Cumulative Worldwide Gasification Capacity and Growth

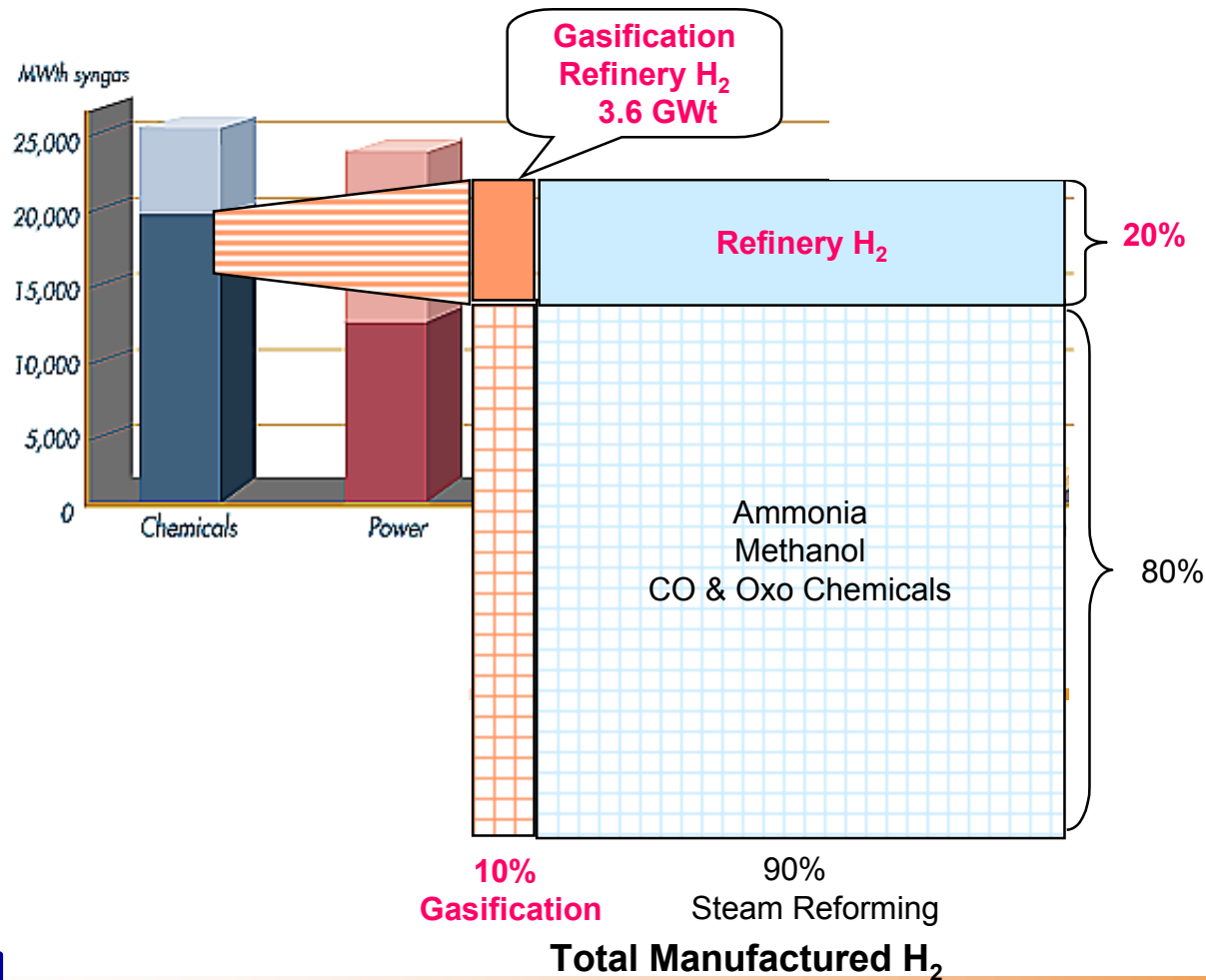


Gasification by Application



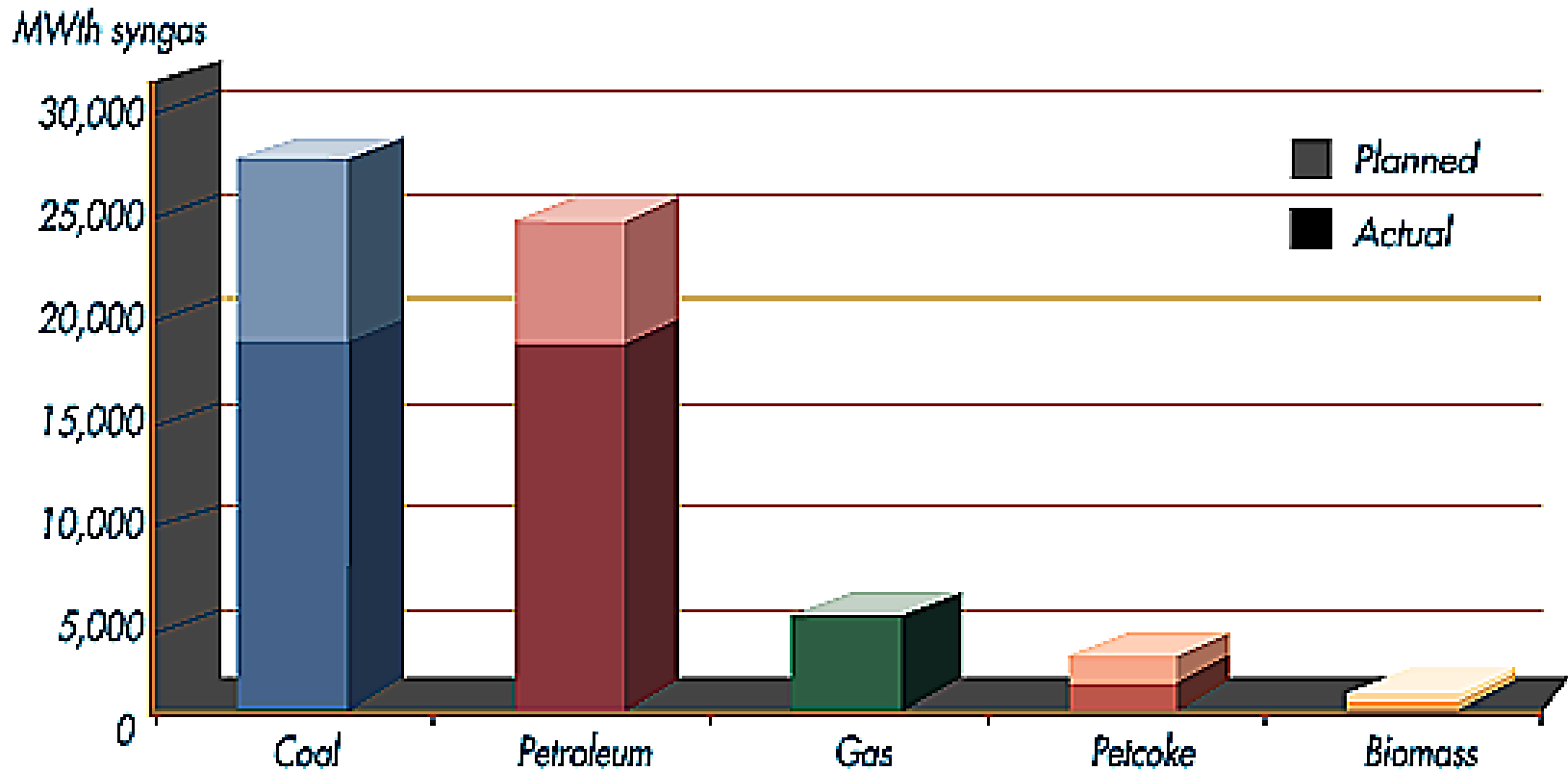
Breakout of Worldwide Hydrogen Production from Synthesis Gas

Gasification by Application



In Red
Growing Rapidly

Gasification by Primary Feedstock



Gasification Technologies Program Goals

- **Cost and Efficiency Targets**

Year	Capital Costs (\$/kW)	Efficiency (%HHV)
2000	1250	42
2008	1000	52
2015	850	>60

- **Environmental Performance Targets**

- Near-zero pollutants
- Combustion applications --- ppm levels
- Fuel cells, fuels/chemicals --- ppb levels

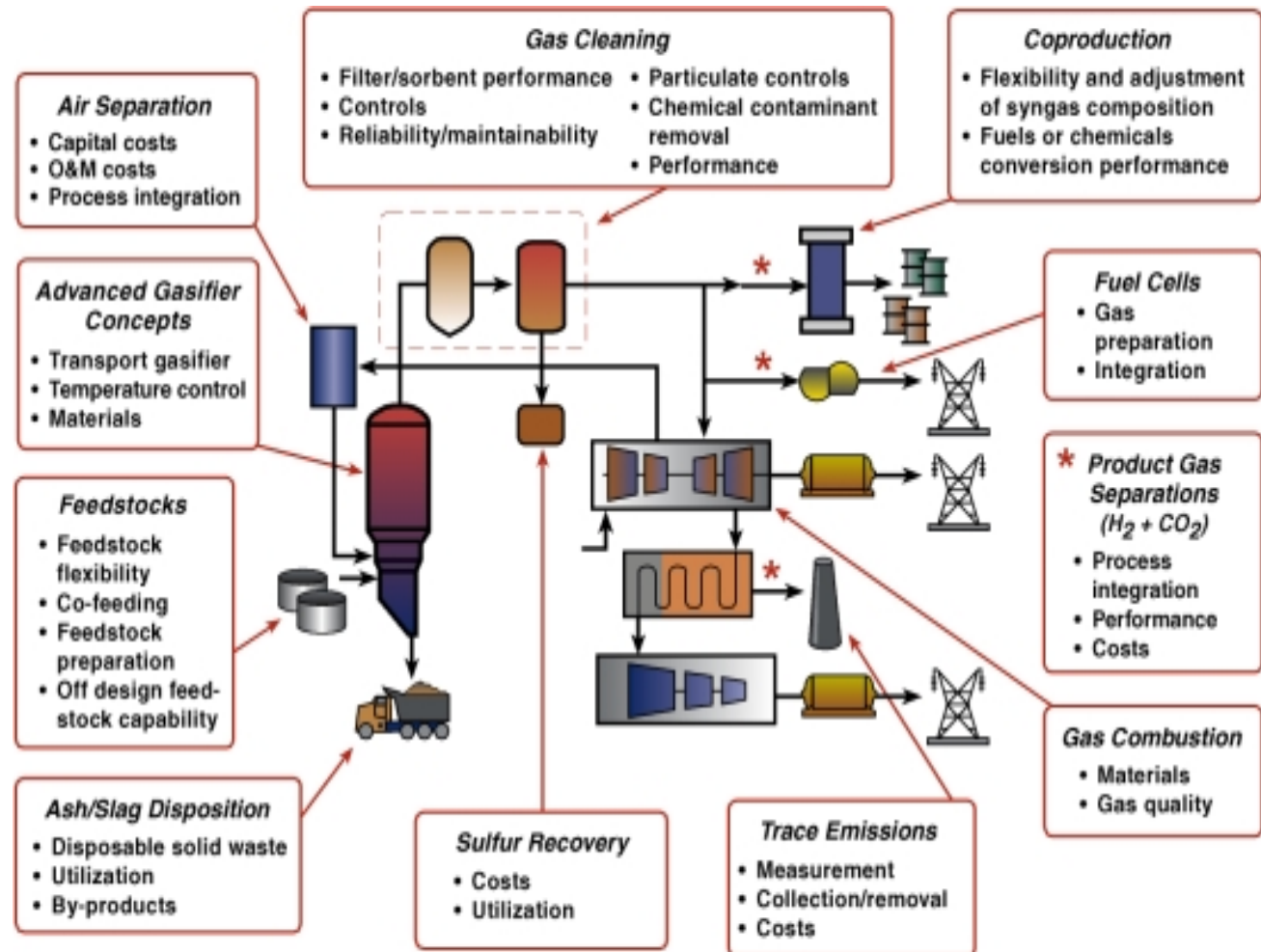
- **Feedstock and Product Flexibility Capabilities**



Gasification Technologies R&D Issues

Overall System:

- Instrumentation/control
- Capital/operating/product costs
- Process integration/optimization



Gasification Technologies R&D Program

- **Gasification**
 - Improvements to Existing Technologies
 - Alternative Feedstocks
 - Advanced Designs
 - Hybrid Systems
- **Gas Cleaning/Conditioning**
 - High-Temperature Contaminant Removal
 - Ultra-Clean Synthesis Gas
 - Novel Technologies
- **Gas Separations**
 - H₂ and Air Separation
 - CO₂ Separation and Recovery
- **Products/By-Products Utilization**
 - Value-Added Products
 - Slag/Ash Quality Improvement
 - Sulfur Recovery
 - Synthesis Gas for Fuel Cells and Turbine Hybrid Systems
- **Systems Analysis / Technology Integration**
 - Systems Engineering and Optimization
 - Advanced Computational Models
 - Technology Integration and Demonstration
 - Market Analysis / Outreach



Gas Separation R&D

- **Air and Hydrogen Separations**
 - Advanced membranes
 - reduce the cost of oxygen supply for gasification
 - low cost separation of H₂ for use in refineries, as fuel for fuel cells, and for H₂ product gas
- **CO₂ Separation and Recovery**
 - Novel, low-temperature H₂ and CO₂ separation
 - Reduced energy requirement and cost
 - Separate and concentrate CO₂
 - Low-cost, concentrated synthesis gas for fuel cells or chemical/energy conversions

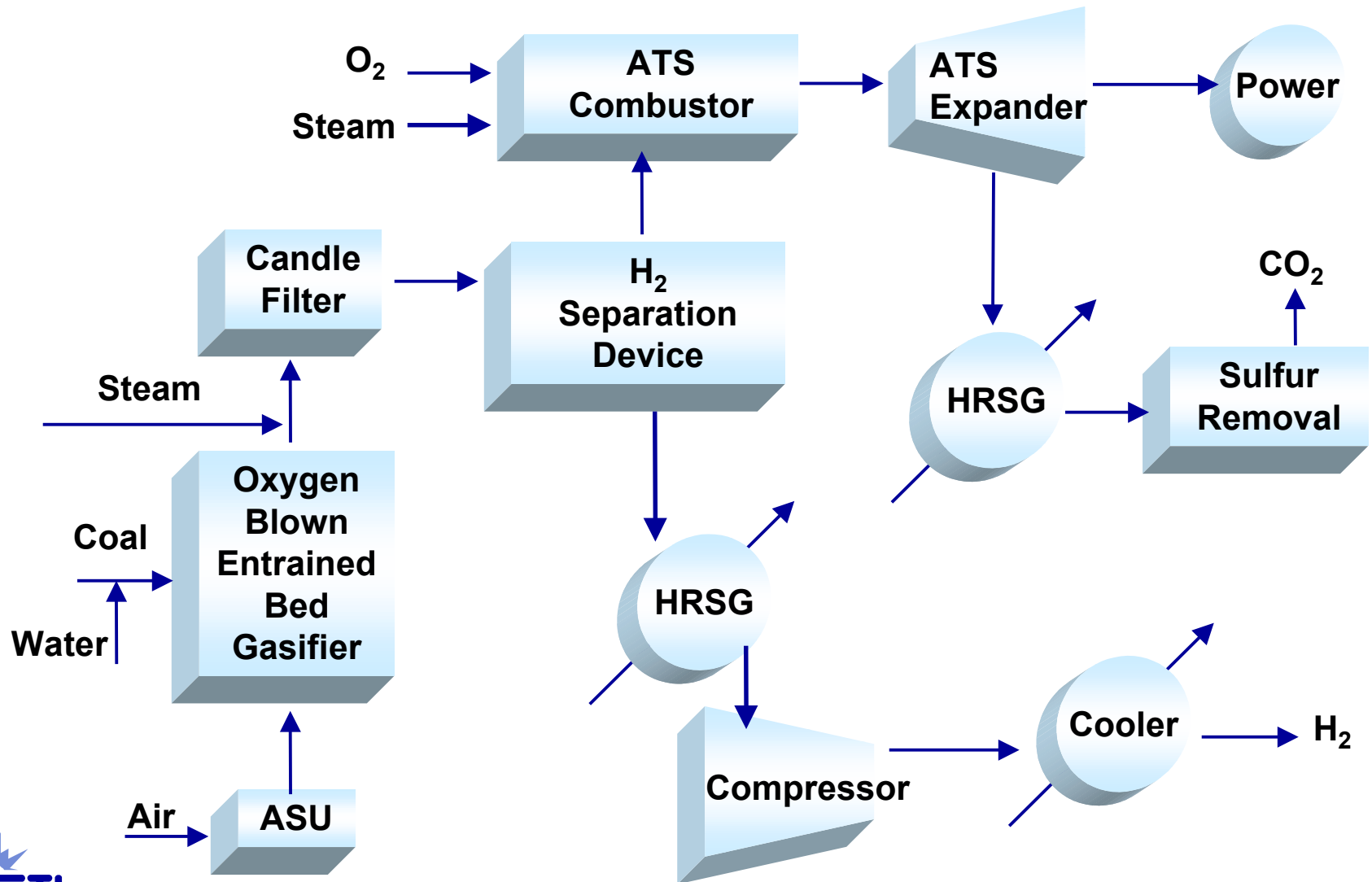


Comparison of Hydrogen Cost from Conventional and Advanced Plant Designs

	Steam Reforming Natural Gas		Cleaned Synthesis Gas by Coal Gasification		
	No	1 Stage Amine	No	2 Stage Amine	Inorganic Membrane
CO ₂ Capture					
Plant Size (Tons H ₂ /day)	417.8	417.8	312.6	317.8	430.8
Coal Feed (Dry TPD)	N/A	N/A	2,500	2,500	2,500
Natural Gas Feed (MMSCFD)	65.5	60.3	N/A	N/A	N/A
Equivalent Thermal Efficiency, HHV, %	83.9	78.6	62.3	60.1	80.4
CO ₂ Recovered (TPD)	N/A	2,609	N/A	6,233	6,362
% CO ₂ Recovered	N/A	71	N/A	92	94
Net Power (MWe)	-6	-15	38	12	7
Total Plant Cost (million \$, yr 2000)	131	142	322	375	360
Cost of Hydrogen					
(\$/MMBtu)	5.54	5.93	5.71	6.91	5.06
(\$/MSCF)	1.8	1.92	1.86	2.25	1.65



Membrane-Based H₂ from Gasification



Early Entrance Coproduction Plants (EECP)

- **Early Entrance Plants:**
 - Develop design and cost/risk reduction information
 - Enable the co-producing of high value, revenue enhancing product streams
 - Accelerate commercialization and acceptance of industry and financial stakeholders
- **Gasification Technologies Goals**
 - High quality, clean feed gas
 - Synthesis gas adjusted to tight specifications of application
 - Integration of gasification with downstream process
 - Risk reduction and cost improvement



EECP Projects

- **Waste Management and Processors, Inc., Frackville, PA**
 - Convert coal residue into premium transportation fuels and electricity
 - Texaco gasifier with SASOL Fischer-Tropsch technology
 - Additional Team Members: Bechtel National; Texaco Global Gas & Power; SASOL Technology Ltd.
- **Dynegy Power Corporation, Houston, TX**
 - Power and chemicals at Wabash site in Indiana
 - Dynegy gasification technology with Liquid Phase Methanol (LPMEOH™) to produce methanol
 - Additional Team Members: Air Products & Chemicals; Dow Chemical; Dow Corning; Methanex; Siemens Westinghouse
- **Texaco Natural Gas, Inc. (TGNI), Houston, TX**
 - Texaco gasification with Rentech's Fischer-Tropsch technology to produce high-quality transportation fuels and electricity from coal and petroleum coke.
 - Additional Team Members: Brown & Root Services; GE Power Systems; Praxair, Inc.; Texaco Development Corporation



Summary

- **Gasification can be an effective way to produce hydrogen from hydrocarbon resources and water (steam)**
- **Hydrogen can be separated and purified from synthesis gas prepared by gasification using currently available technologies.**
- **Contaminants must be removed prior to these applications**
- **Technology development is in progress**
- **Advanced H₂ separation technologies offer potential for substantial reduction in H₂ cost**

