



Gasification

Presentation at LSU 2008 Energy Summit, Oct 22, 2008

Michael Roberts

Manager

Gasification and Gas Processing

GAS TECHNOLOGY INSTITUTE

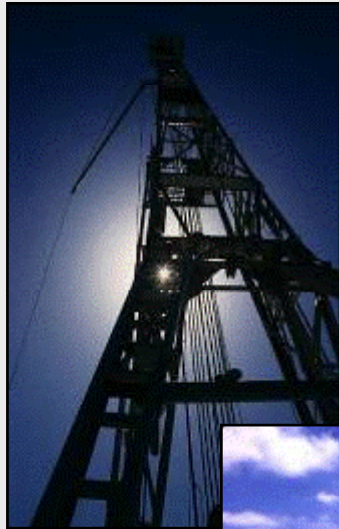
1700 S. Mount Prospect Road

Des Plaines, IL 60018

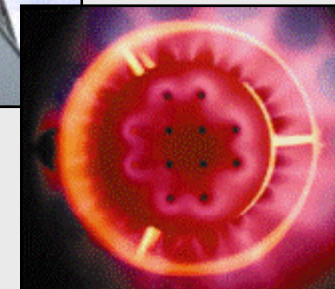
mike.roberts@gastechnology.org

Gas Technology Institute

Addressing Key Issues for the Natural Gas Industry

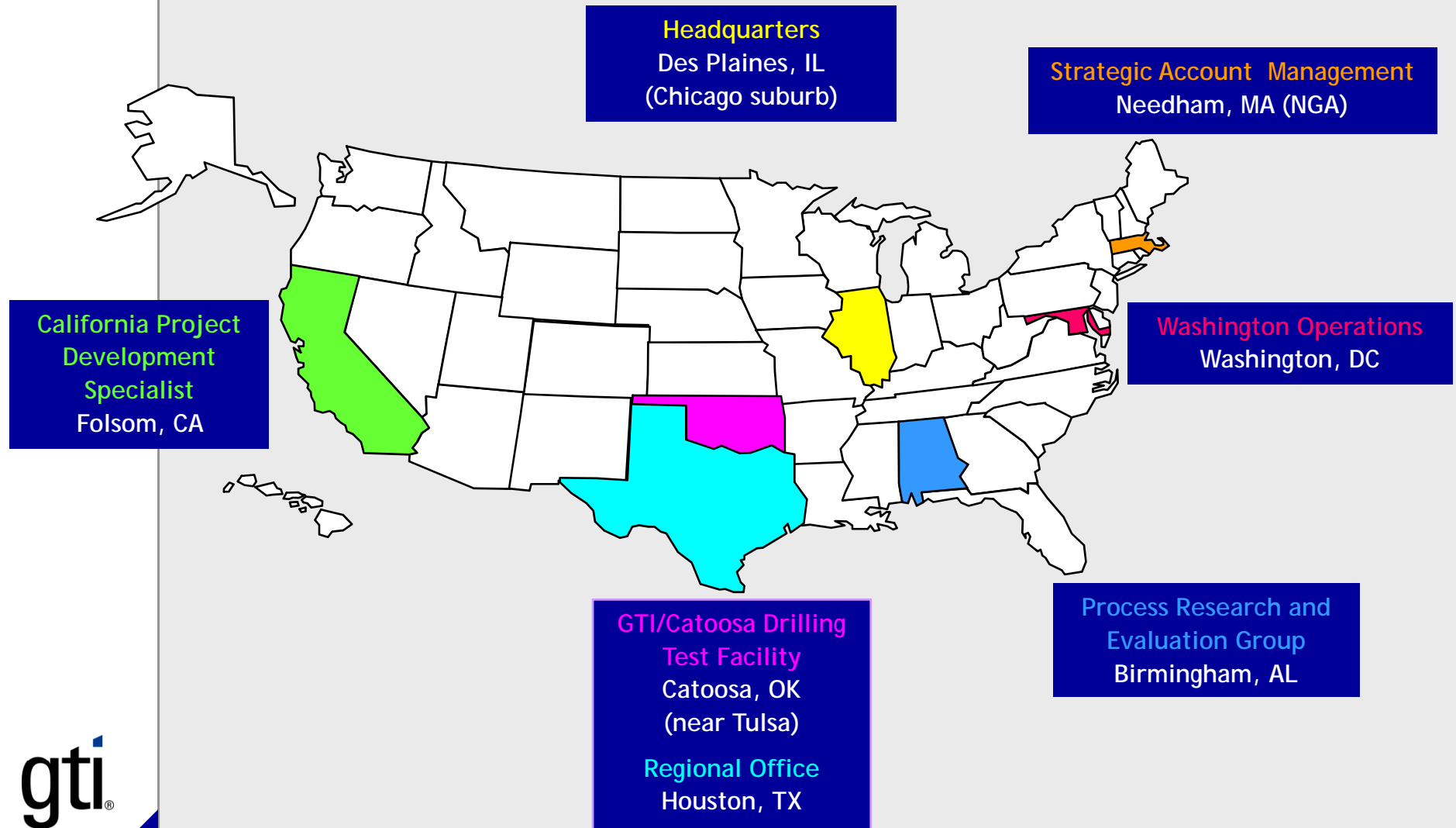


- > Contract Research
- > Program Management
- > Technical Services
- > Education and Training



- > Over 1,000 patents
- > Nearly 500 products commercialized

GTI Locations



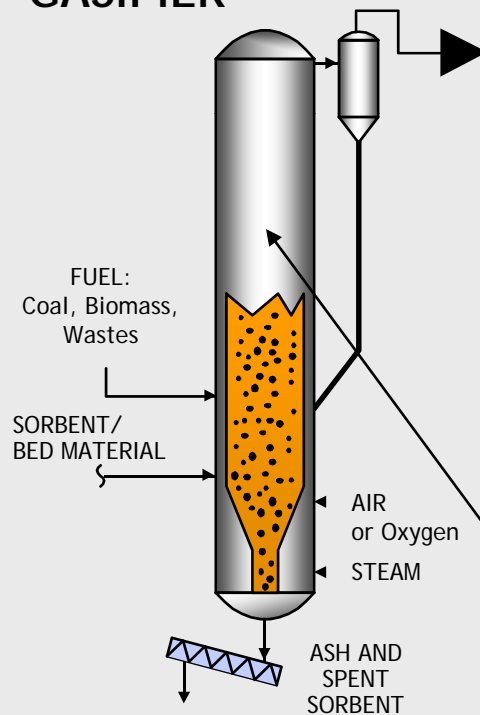
Facilities & Staff

- > Main Facility:
 - 7.3-ha Campus in Des Plaines
 - Over 18,500 m² of laboratory space
 - 28 specialized laboratories and facilities
- > Staff of 240
 - 70% scientists and engineers
 - 38 PhD's
 - 15 Professional Engineer licenses



What is Gasification?

GASIFIER



Products (syngas):

CO (carbon monoxide)

H₂ (hydrogen)

(CO/H₂ ratio can be adjusted)

By-products:

H₂S (hydrogen sulfide)

CO₂ (carbon dioxide)

Solids (minerals from fuel)

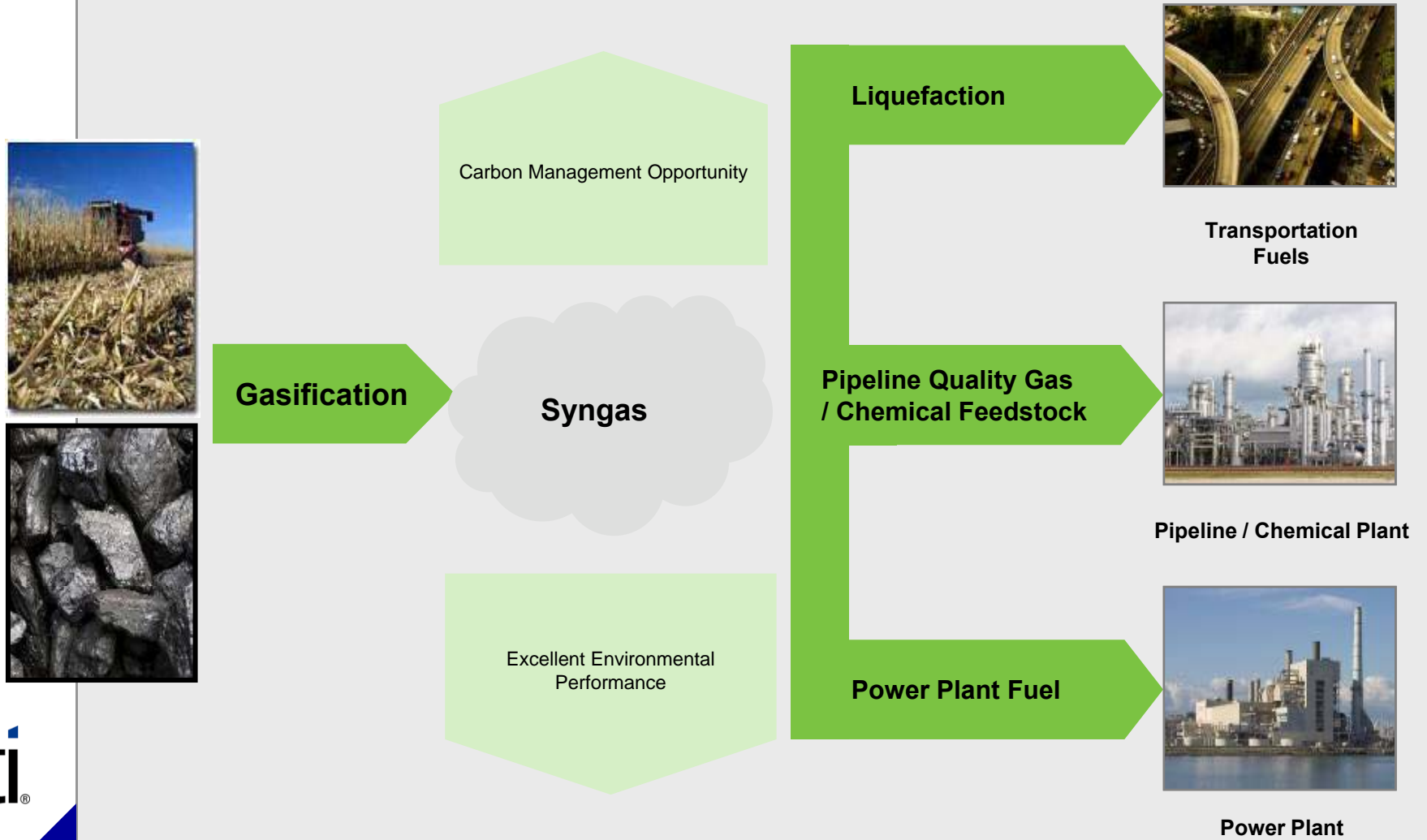
Process Conditions:

Pressure = 1 to 30 atm or more

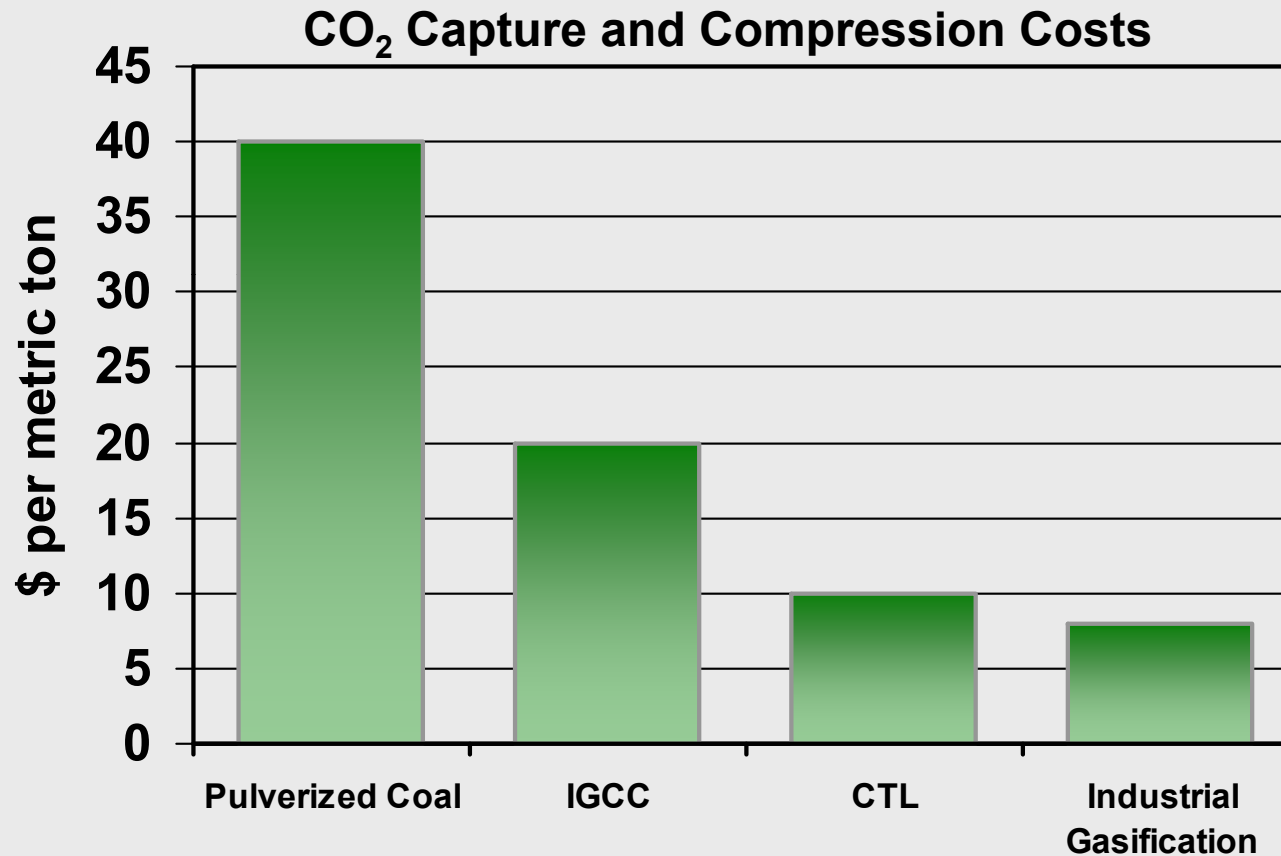
Temperature = 870 °C - 1425 °C

Gas
Cleanup
Before
Product
Use

Gasification - A Means to a Secure, Clean Energy Supply



Carbon Management Advantage for Coal Applications

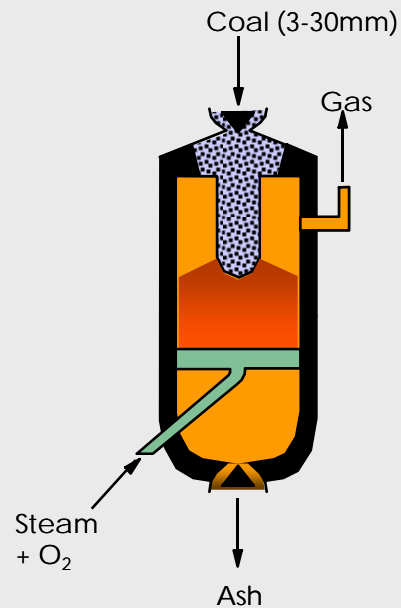


Source: MIT's *The Future of Coal*, 2007



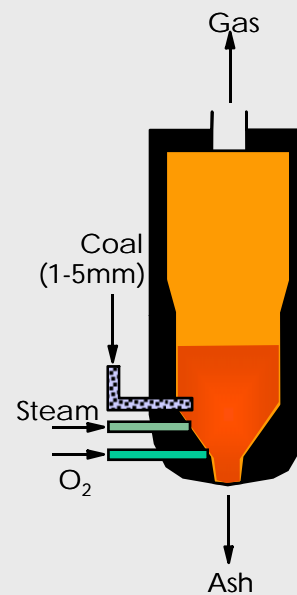
Gasification allows lower cost capture of carbon dioxide

Generic Coal Gasification Reactors



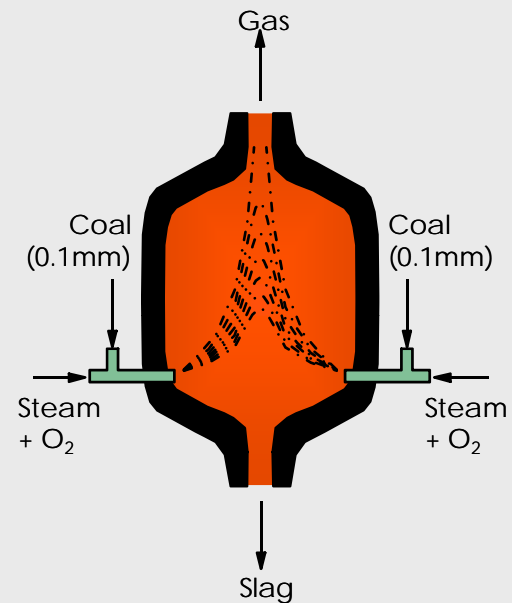
FIXED-BED
PROCESS

Lurgi
British Gas Lurgi



FLUIDIZED-BED
PROCESS

GTI
KRW
HTW



ENTRAINED-FLOW
PROCESS

ConocoPhillips E-Gas
GE (Texaco)
Shell
Siemens (GSP)

Changes in Market Position for Gasifier Technologies

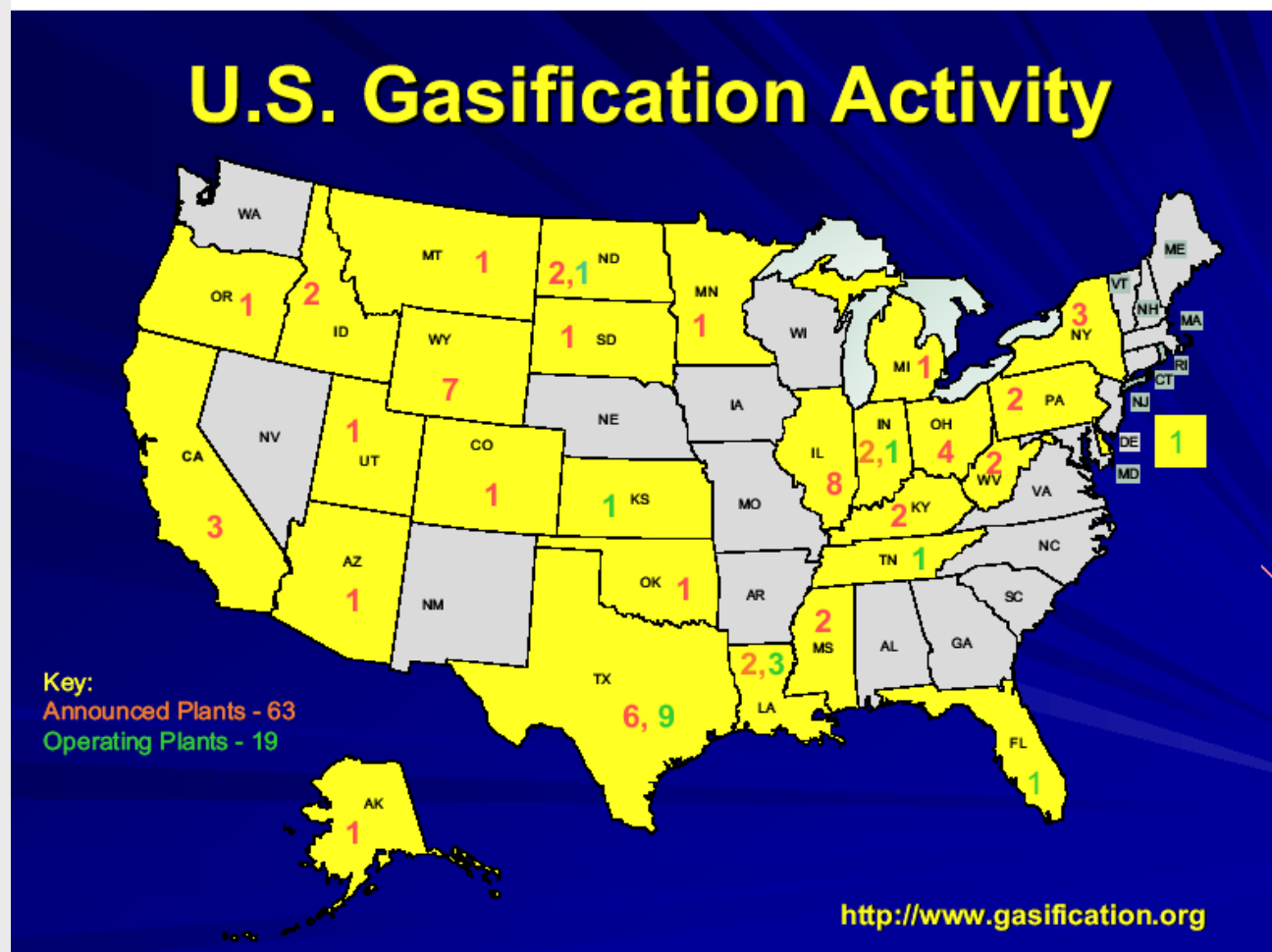
Gasifier Technology	1999	2004	2007	2010
Shell	21%	19%	28%	45%
Sasol Lurgi	28%	41%	34%	26%
GE Energy	39%	34%	31%	24%
Other	12%	6%	7%	5%

2007 World Summary of the Gasification Industry

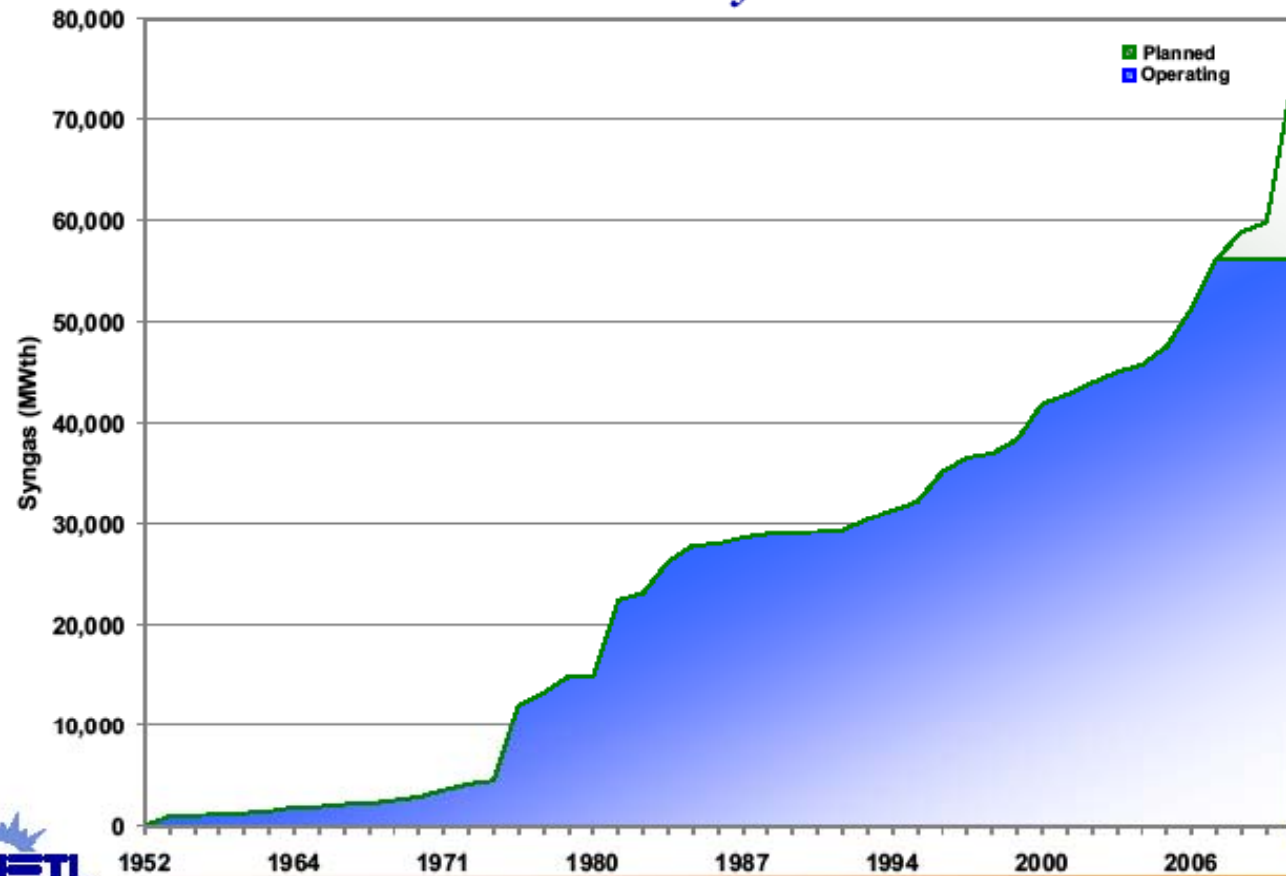
Feedstock		Operating 2007	Planned 2008-2010	Totals
Coal	MW _{th}	30,825	4,690	35,515
	Gasifiers	212	10	222
	Operating Plants	45	7	52
Petroleum	MW _{th}	18,454	620	19,074
	Gasifiers	145	3	148
	Operating Plants	59	1	60
Gas	MW _{th}	4,345	10,936	15,281
	Gasifiers	41	18	59
	Operating Plants	22	1	23
Petcoke	MW _{th}	1,441	889	2,330
	Gasifiers	8	3	11
	Operating Plants	5	1	6
Biomass/Waste	MW _{th}	1,174		1,174
	Gasifiers	21		21
	Operating Plants	13		13
Total MW_{th}		56,238	17,135	73,373
Total gasifiers (Operating plus spares)		427	34	461
Total Operating Plants		144	10	154



U.S. Gasification Activity Early 2007



Worldwide Gasification Capacity and Planned Growth *Cumulative by Year*



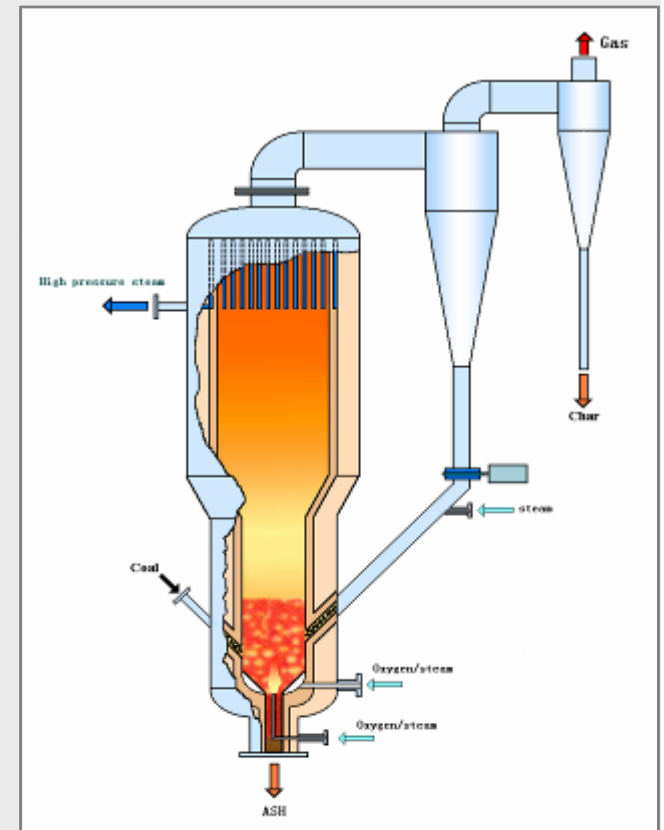
Overview Summary / September 2007

Cost Comparison of New Plants

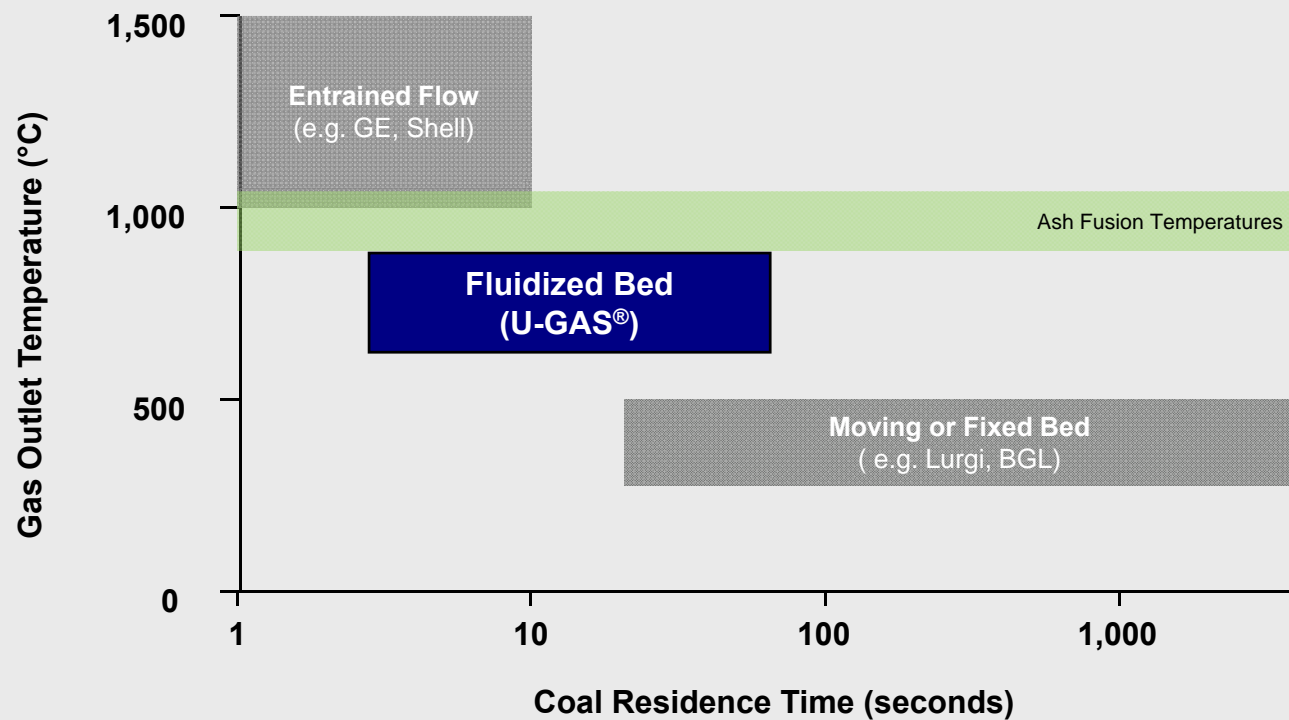
	Total Plant Cost, (\$/kW)		Levelized Cost of Electricity, (cents/kWhr)	
Study Year	1998	2007	1998	2007
IGCC	1,186	1,841	3.7	7.8
PC Supercritical	1,173	1,575	3.9	6.3
NGCC	524	554	3.6	6.8

GTI Fluidized Bed Gasifier

- > High carbon conversion, 95-98%+
- > Capability to gasify a wide variety of fuels, including coal/biomass combinations
- > Simple design with safe, reliable operation
 - Air-blown, enriched-air or oxygen-blown operation
 - Atmospheric to high pressure
- > Operates at lower temperature than slagging gasifier
 - Longer metal component and refractory life
- > Good turndown capability, 30 - 50%



U-GAS[®] Flexibility - Incorporating the Intrinsic Benefits of Fluidized Beds



U-GAS[®] Technology is highly efficient and able to gasify a wide range of fuels

Feedstocks Gasified by GTI

Bituminous Coals

Western Kentucky No. 9, washed & ROM
Western Kentucky No. 9 and 11, Camp
Illinois No. 6, Peabody No. 10 and Crown III
Pittsburgh No. 8, Champion and Ireland
Australian, Bayswater No. 2, Sydney Basin
Polish, Silesia
French, Merlebach - ROM
Utah , - ROM
Colombian
Chinese, Shen Fu
Indian, North Karanpura, washed and ROM

Low Rank Coals

Montana Rosebud, Colstrip
Wyoming, Big Horn

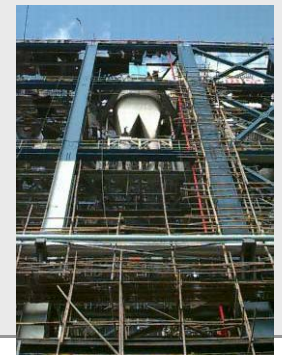
North Dakota, Freedom
Saskatchewan Lignite, Shand

Coke Char, Peat, Wastes

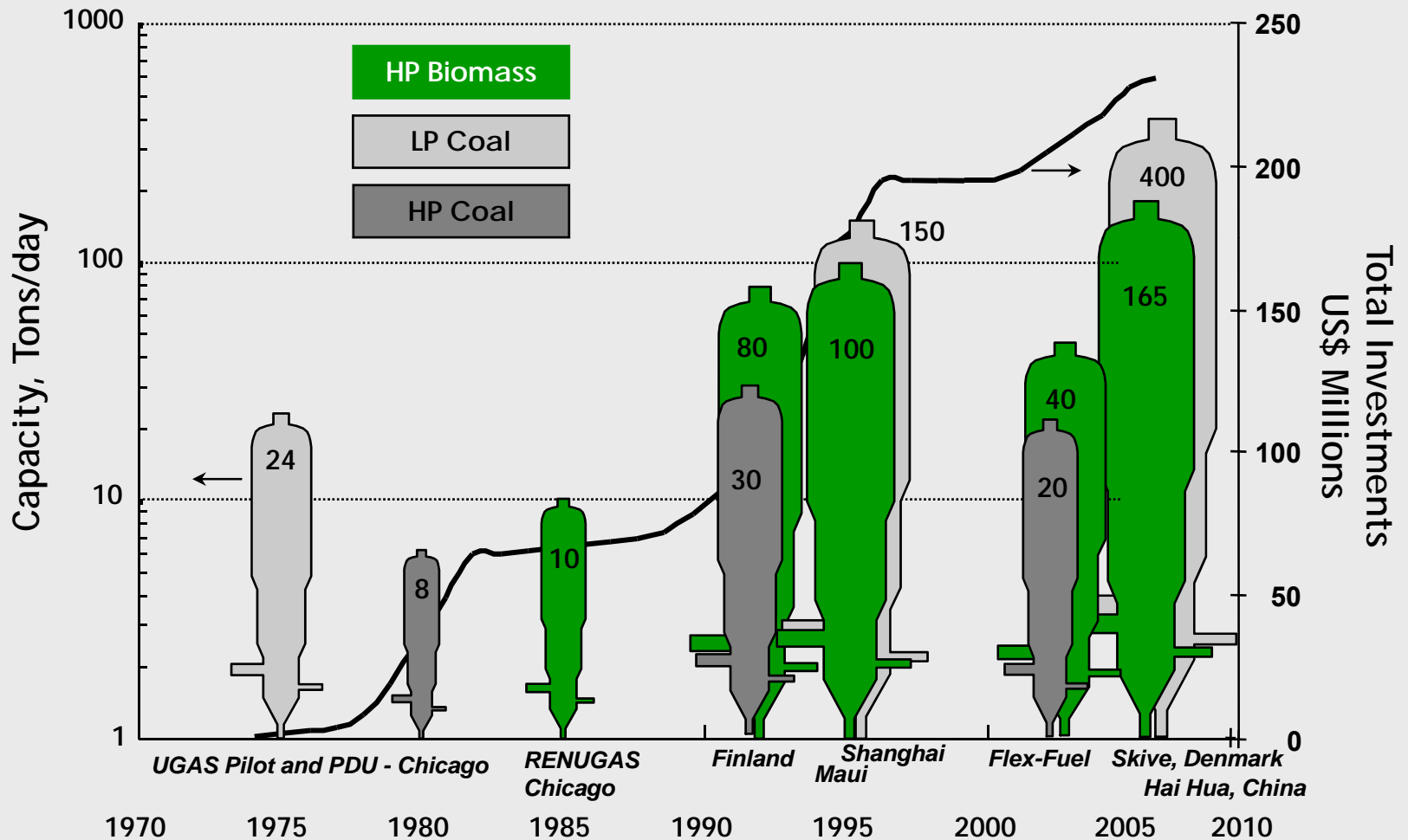
Metallurgical Coke, U.S., China, Poland
Western Kentucky No. 9 coal char
Illinois No. 6 coal char
Finnish Peat, Viidansuo and Savaloneva
Automobile Shredder Residue

Biomass

Finnish waste wood and pulp mill waste
Danish Willow
Danish Straw
Alfalfa stems
Waste wood
Bagasse



Scale-up and Investment History of GTI Gasification Technology



Gasifier Projects



80 ton per day Gasification Pilot Plant in Tampere, Finland using biomass & coal



100 ton per day Bioenergy Demo Plant in Hawaii using bagasse



1000 ton per day U-GAS[®] Industrial fuel gas in Shanghai, China using coal



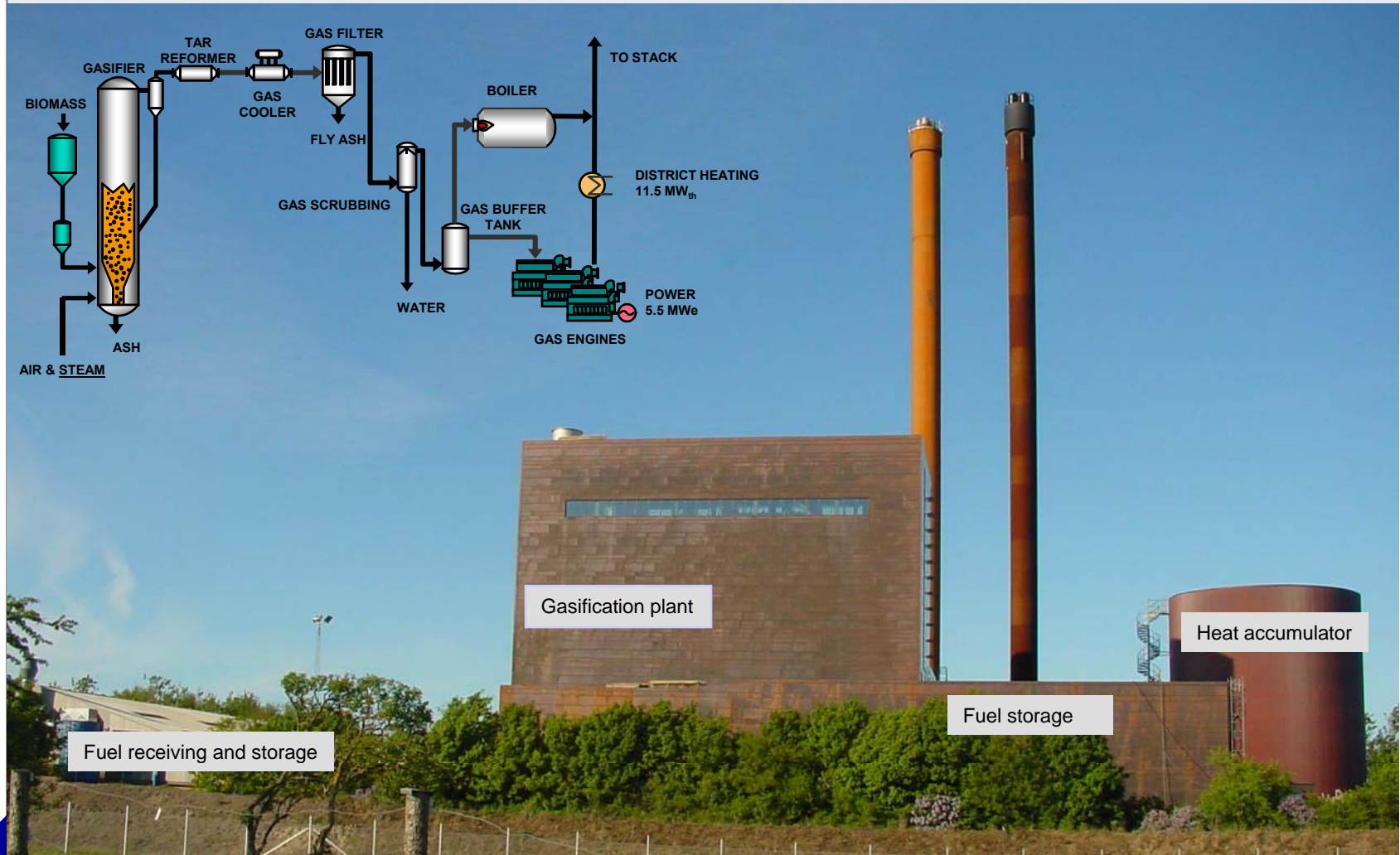
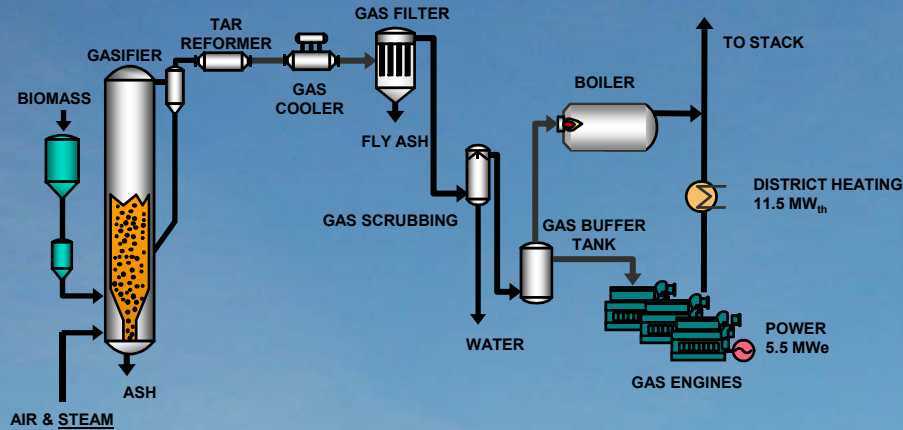
165 ton per day CHP Plant in Skive, Denmark using wood

Projects at GTI

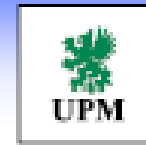
We are responding to the interest in gasification & gas processing by

1. supporting GTI commercialized technologies
2. developing and evaluating technologies for industry
3. developing new solutions

Skive, Denmark Combined Heat & Power Project



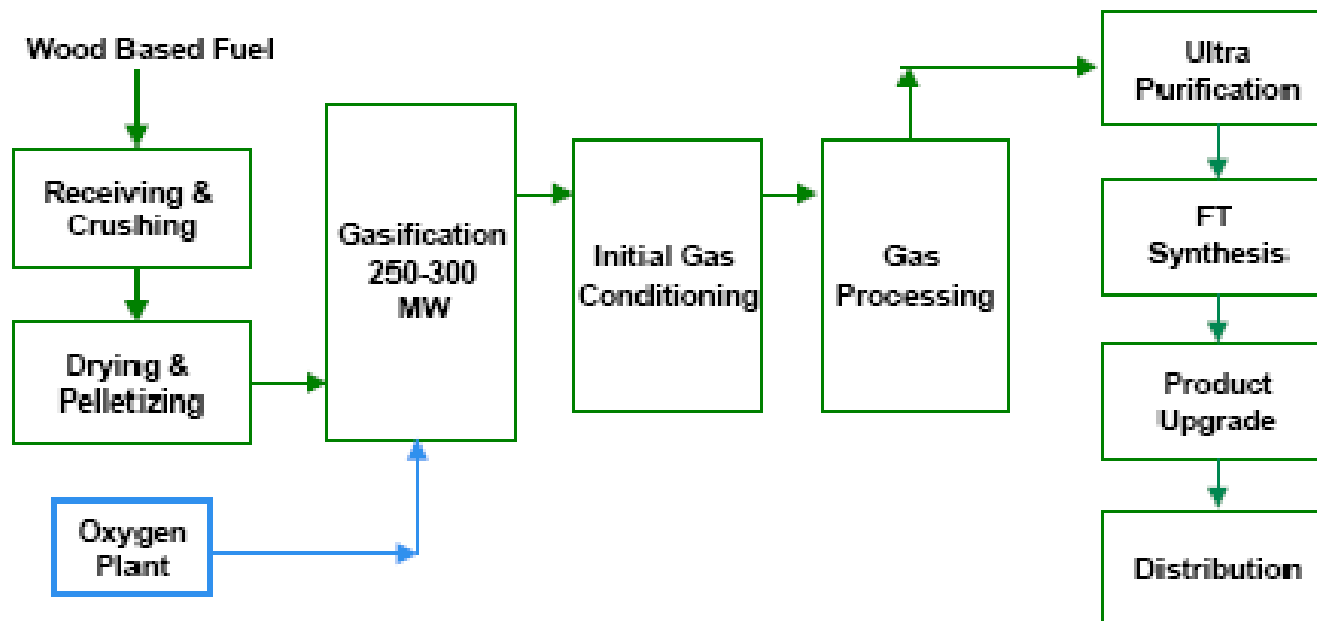
UPM-KYMMENE BIODIESEL PROCESS



Fuel Pre-treatment

Syngas Process

FT & Refining
& Distribution



- > GTI - Pilot Flex-Fuel Test Facility Modification, 2007
- > GTI - Pilot Testing Program 2008
- > Development of fuel supply and handling, ongoing
- > Process development and BTL Plant Design, 2008
- > Plant operation, 2011

U-GAS[®] Technology Support to Synthesis Energy Systems Projects



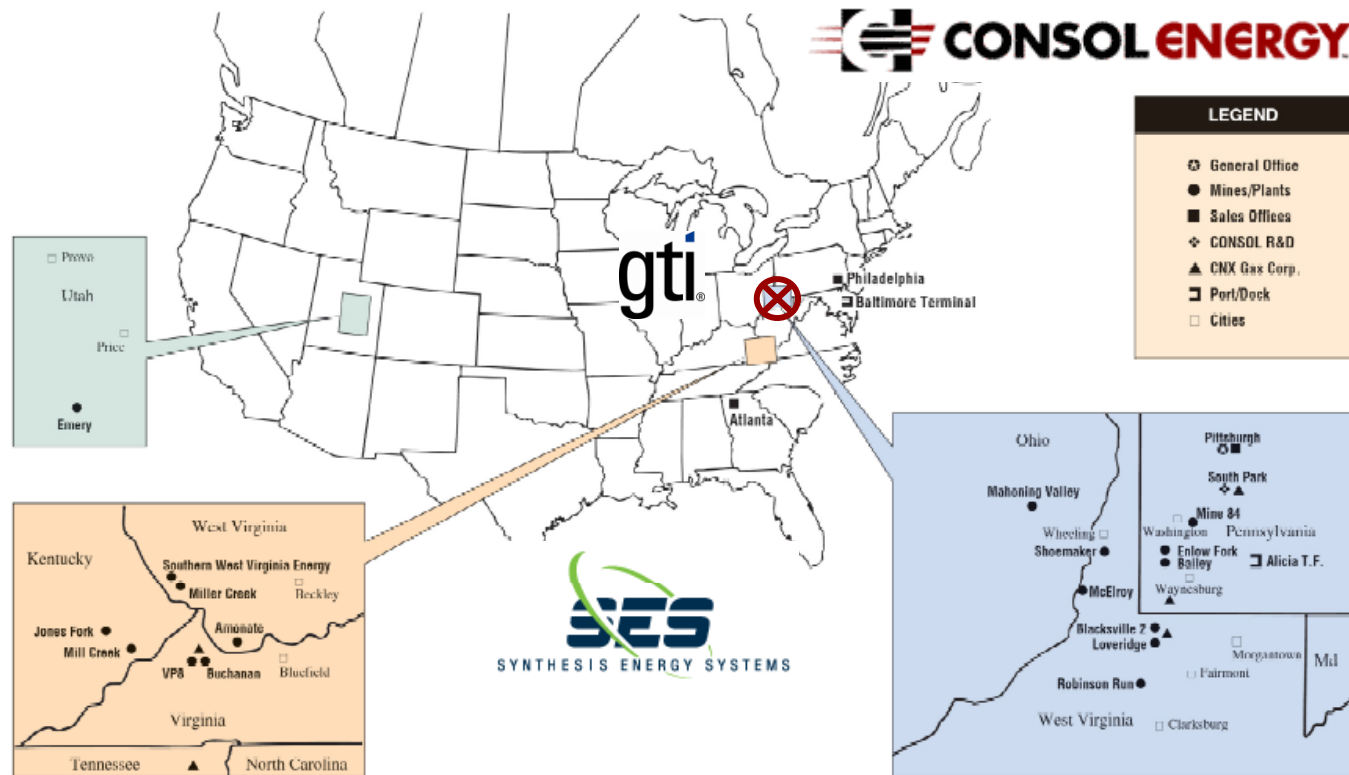
Two U-GAS[®] gasifiers at the Hai Hua project (19 November 2007).



SES Project Queue

- > Hai Hua: 28k m³/h syngas for MeOH (400 tpd coal)
- > Golden Concord: 150k tpa MeOH / 225k tpa DME (~4x Hai Hua)
- > YIMA: 1,000,000 tpa MeOH / DME (~13x Hai Hua)
- > CONSOL Energy: MeOH, SNG, NH₃
- > Chemical company: China coal-to-MeOH feasibility

SES - CONSOL Energy Project



"CONSOL Energy and SES will perform engineering, environmental, and marketing assessments... of projects that would use coal gasification technology to convert coal... located in the eastern United States into higher-value products including: methanol, ethanol, mixed alcohols, ammonia and SNG." 9/06/07 news release

GTI's Flex-Fuel Test Facility: A Technology Development and Systems Integration Platform



- > Flexible fuel capability
- > Operational flexibility
- > Plug and play systems integration and testing

Flex-Fuel Test Facility Overview

Features

- Coal - 10 tpd w/air; 20 tpd w/oxygen
- Biomass - 24 tpd w/air; 40 tpd w/oxygen
- Gasification Pressure to 27 bara
- Multi-contaminant Syngas Cleanup
- On-line Syngas Analysis Systems

Process Evaluations

- Hydrogen Production
- SNG Production
- CO₂ Capture Technologies
- Syngas-to-Liquids Production
- Advanced Power Conversion Systems
- Industrial Syngas End-Use

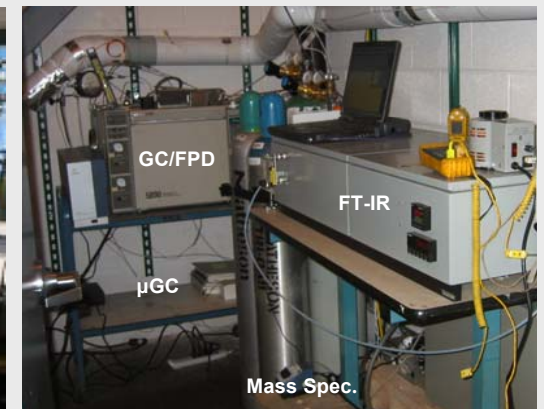
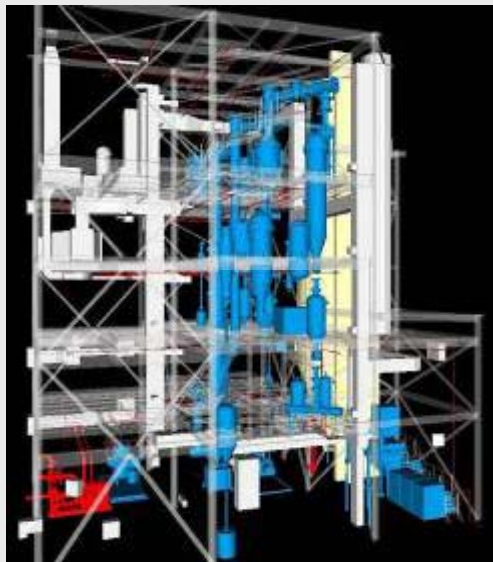
Commercial Operator Training



Industrial Combustion Lab

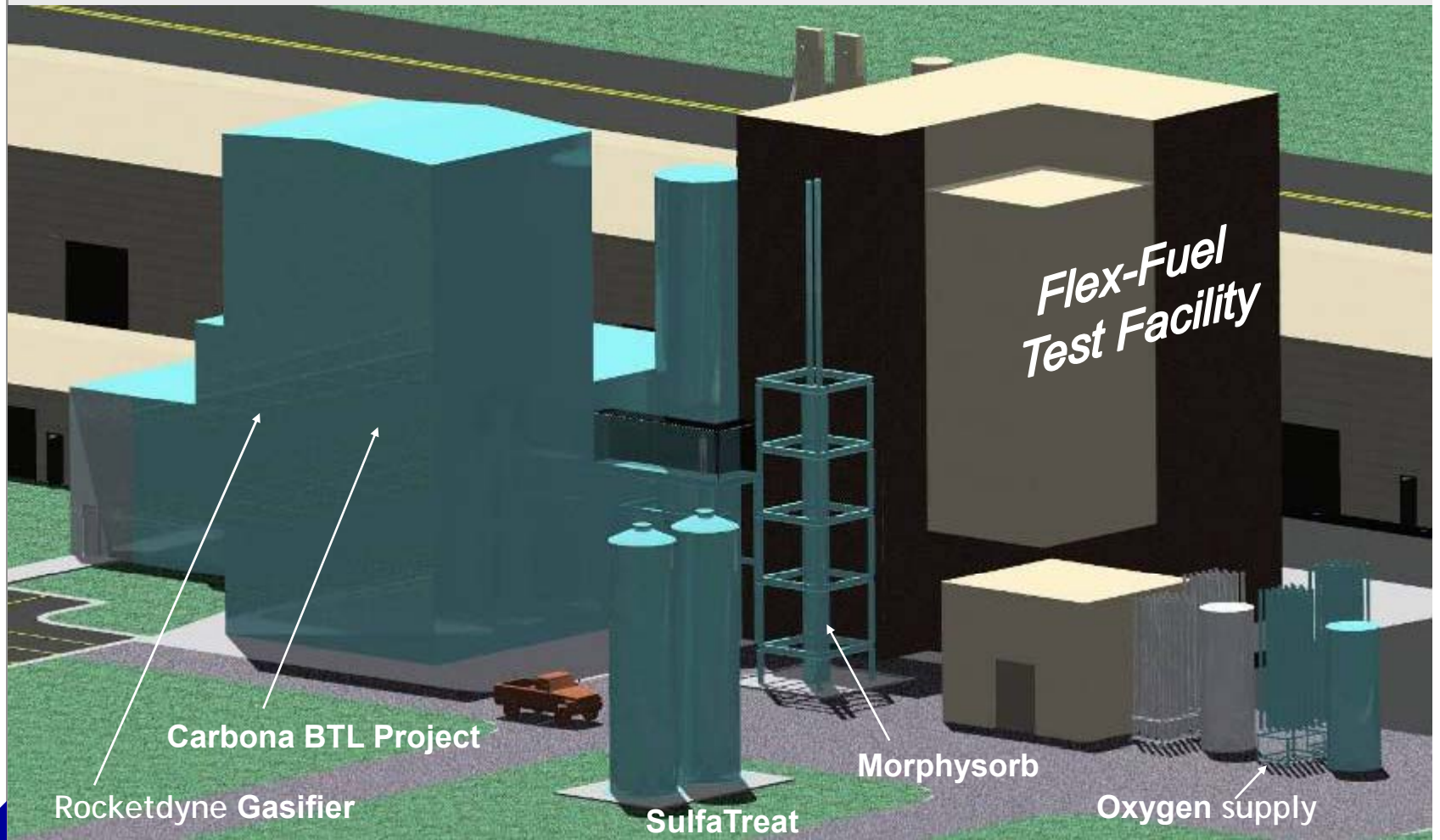
Configurable Systems Development Platform

- Specific test campaigns for each client
- Each process simulated with customized equipment and configuration
- Programs of 3 to 30 months
- Some campaigns with multiple missions



FLEX-FUEL TEST FACILITY—

The Core for Growth of New Projects and Capabilities



bluegas[®] Catalytic Gasification

Value: Produce low-cost substitute natural gas (SNG) from coal.

> Sponsor: GreatPoint Energy

> Scope

- Evaluate catalytic gasification for production of SNG from two potential fuels.
- Laboratory tests followed by pilot-scale tests in Flex-Fuel Test Facility.

> Schedule

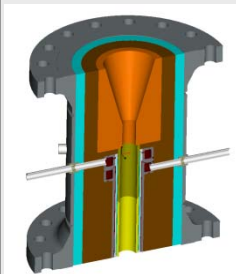
- 21 month program, started Jan 06

Pratt & Whitney Rocketdyne (PWR) Compact Gasification System

Value: Convert all coals to power and fuels at high efficiency and economy with advanced gasifier.

Component Development & Pilot Plant

2004 - 2009



Component Development



Pilot Plant Gasifier & Test Facility



Commercial Demonstrations (1500 & 3000 TPD Gasifiers)

2007 - 2012



Commercial Gasification Plant

15% to 20% Lower End Product Cost from Improved Efficiency, Cost and Availability

Advantages of GTI as Gasification Technology Development Partner

- > Easily accessible location, transportation hub
- > Existing, permitted facilities fast-tracks projects
 - Gasification from wide range of fuels
 - Flexibility to conduct air- or oxygen-blown gasification
 - Multiple gas cleaning and conditioning systems
 - Operation at high pressure for multiple applications
- > Experienced scientists, engineers, and operators
 - Pilot-scale, commercial plant, technology transfer
 - Record of innovation