Integrated Gasification Combined Cycles and other advanced concepts for Biomass Power Generation

Presented at

2nd Annual California Biomass Collaborative Forum

Sacramento, California
March 1, 2005

francis.lau@gastechnology.org
The Gas Technology Institute

> An Independent, Not-for-Profit Research, Development & Deployment Organization
  – Located on an 18-acre campus in Des Plaines, Illinois
  – 300 employees
GTI Serves the Energy Industry, from the Wellhead to Burnertip...

Performing:
> Contract Research
> Program Management
> Technical Services & Consulting
> Education and Training
Biomass Gasification for Power Generation

> Integrated Gasification
  - Power: IGCC
  - CHP: engine, micro-turbine, fuel cell
  - Boiler
Biomass Power Generation

Fluidized Bed Gasification - IGCC Process

HIGH PRESSURE

Figure 1
Biomass Power Generation

Fluidized Bed Gasification - Gas Engine
LOW PRESSURE

Figure 3
Biomass Power Generation

Fluidized Bed Gasification - Boiler Application

LOW PRESSURE

LARGE BOILER

TO STACK

COAL OIL

GASIFIER

BIOMASS

GAS COOLER

PRODUCT GAS FILTER

ASH

TO STACK

AIR

ASH

Biomass Power Generation
Biomass Power Generation

Fixed-Bed Gasifier in Power Generation

Figure 4
Generic Gasification Reactors

FIXED-BED PROCESS

FLUIDIZED-BED PROCESS

ENTRAINED-FLOW PROCESS
GTI Fluidized-Bed Gasifier

FUEL

HOT PRODUCT GAS

Air/Oxygen/Steam

ASH
**FORCED FUEL FEEDING**
- use of low density fuels possible

**FIXED BED OPERATION**
- tars decomposed above the fixed fuel bed by additional air feeding

**PRODUCT GAS**
- high temperature & low tars
IGCC Project in Andhra Pradesh, India

GASIFIER

CYCLONE

GAS COOLER

STEAM TO HRSG

WATER FROM HRSG

FLY ASH

PARTICULATE REMOVAL

CLEAN PRODUCT GAS

AIR

GAS TURBINE No. 1

GAS TURBINE No. 2

4.7 MW<sub>e</sub>

4.7 MW<sub>e</sub>

HEAT RECOVERY STEAM GENERATOR

STACK

BIOFILL Mass 210 tpd

BED MATERIAL

ASH AND BED MATERIAL

STEAM

BOOSTER COMPRESSOR

BOOSTER COMPRESSOR

FROM GAS COOLER

TO GAS COOLER

STEAM TURBINE

CONDENSER

4 MW<sub>e</sub>

Carbona
India IGCC Proces Design Basis

Fuel
- Wood chips and woody biomass from plantations
- Moisture content 20 wt %
- 9,000 Btu/lb (dry)
- Feed rate 210 tons per day

Power
- Gas turbines 9.5 MWe
- Steam turbine 4.0 MWe
- Net power 12.5 MWe

Net Electric Efficiency: 37%
Skive Project, Denmark

- **Biomass** → **Gasifier**
- **Gas Cooler** → **Gas Filter** → **Fly Ash**
- **Tar Reformer**
- **Air & Steam** → **Gas Scrubbing** → **Gas Buffer Tank** → **Gas Engines**
- **Boiler**
- **District Heating 11.5 MWth**
- **Power 5.5 MW**
- **Water** → **Stack**
Skive Project Design Basis

**Fuel:**
- Wood pellets
- Moisture content 9.5 wt%
- 10,000 Btu/lb (dry)
- Feed rate: 110 tpd

**Power and heat:**
- Power generation max. 5.4 MW
- District heat 11.5 MW

**Plant Efficiency:**
- Electrical efficiency 28 % (LHV)
- Overall efficiency 87 % (LHV)
Novel Power Plant: 1.8 MWe + 3.3 MWth

- Kokemäki, Finland
- electric efficiency 28 %
- supplied by Condens OY
The Kokemäki Novel CHP Plant

- Integrated to the existing Kokemäki district heating plant
- Fuel drying by waste heat from the plant
- Wood fuel

- Fuel capacity 7200 kW
- Power output 1800 kWₑ
- District heat output 4300 kW
- Heat output to the fuel dryer 430 kW

- Plant commissioning underway
CHP Forest Residue Project, under development
- 12 tons per day forest residue
- Produce 600 kWe, 1,800 kWth
- Electric Efficiency 28%, overall 85%
- Transportable unit
- Project team: GTI, Carbona, TSS

Gasification - Gas Engine

Gasifier - Gas cooler and Filter - Gas engine
Other Biomass Gasification Projects

- 2 ton per day Biomass Gasifier for H₂ in UM, Minnesota, Xcel Energy
- 60 ton per day Chicken Litter Gasifier in Georgia, ERI & USDA
- Biomass Gasification Tar and Oil Catalytic Reforming, USDOE EE
Gasification Feedstocks Tested

- **Biomass**: Bagasse, wood chips, whole tree chips, rice straw, alfalfa, highway clippings, bark and pulp, chicken litter
- **Waste**: RdF, autofluff
GTI Gasification R&D Facility

> GTI’s State-of-the-Art Gasification Pilot Plant Test Platform

> Flexible Fuel Capability
  – Coal: ~ 10-20 tons/day
  – Biomass: ~ 20-40 tons/day

> Operational Flexibility
  – Pressure ~ 400 psig
  – Air/Oxygen Operation

> Plug and play systems integration and testing (Feed, Gasifier, Cleanup, End-use)

> Commissioned in Dec 04
Flex Fuel Gasification R&D Facility

- Solids feed system
- Gasifier
- Cyclones
- Gas conditioning unit
- Emissions & Controls
Ultra-Clean Process for Control of Sulfur, Chloride, Mercury, and Particulates
Analytical Instruments
Comprehensive, continuous, sensitive and accurate measurements at key points in the process are essential

Sampling & Conditioning Systems
Additional Gas Purification and Clean-Up Systems

> Warm Gas Multi-Pollutant Clean Up
  - POM membrane

> Ambient-Temperature Gas Separation Membranes
  - Solvents & new polymer membranes
Fundamental Research Laboratories

High Pressure TGA

Bench-Scale Unit
GTI Gasification Test Facility at work
For contacts:

> Francis.lau@gastechnology.org