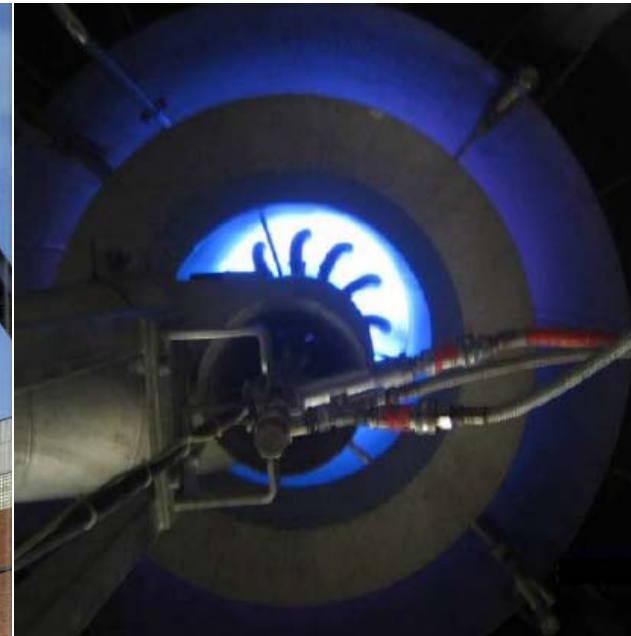


Biomass gasification in P&P industry

IEA Task 33 Meeting, Piteå 19.10.2011

Kari Salo, Carbona Inc.



Andritz Bioenergy Systems

- Gasifiers and Power boilers are handled by the Bioenergy Systems Unit (established 2006) as part of

ANDRITZ RECOVERY AND POWER DIVISION

- Power boiler completes the Andritz package for pulp and paper applications
- Bioenergy Systems is also introducing gasifiers to produce lime kiln fuel, gas to boilers and turbines and bio liquids/chemicals production

**PRODUCTS HAVE
COMMON PROJECT
EXECUTION
ORGANIZATION**



EVAPORATORS

**BIOENERGY SYSTEMS
= POWER BOILERS AND
CARBONA GASIFIERS**

RECOVERY BOILERS

ANDRITZ portfolio for biomass gasification

Equipment for Biomass Preparation and Handling



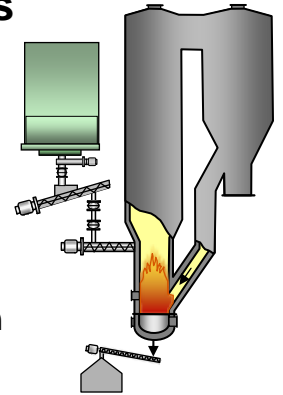
Belt and Drum Dryers



CFB Gasifiers - atmospheric

- air blown
- for boilers and kilns

10 – 150 MWth



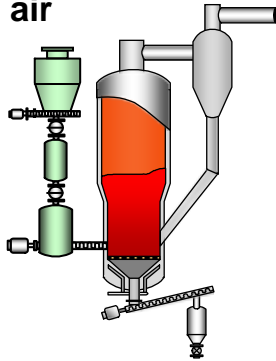
BFB Gasifiers

- low pressure, air

Clean gas to

- engines
- boilers

10 – 50 MWth



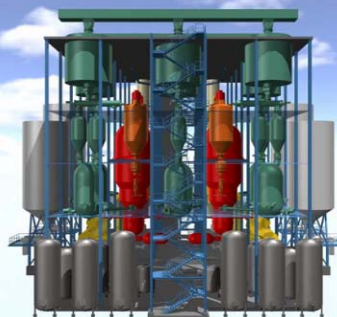
BFB Gasifiers

- high pressure, air/oxygen

- diesel
- ethanol
- gasoline
- SNG

• IGCC

>150 MWth

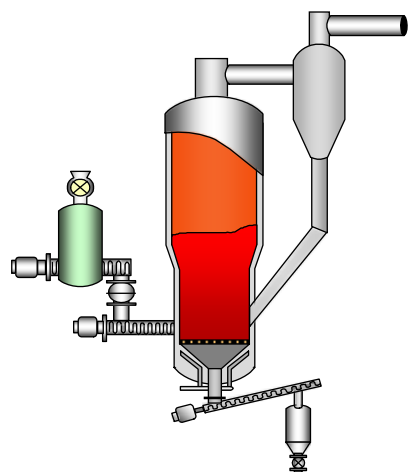


Gasification related equipment

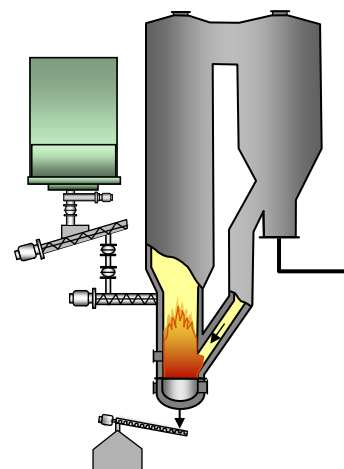
- Gas cooling, filtering
- Tar reforming (HTAS)
- Scrubbing
- Gas burners

Two gasifier product lines

Bubbling fluidized bed	Circulating fluidized bed
<ul style="list-style-type: none">▪ Atmospheric 10-50 MWth▪ Pressurized 30-?00 MWth	<ul style="list-style-type: none">▪ Atmospheric 10 -150 MWth



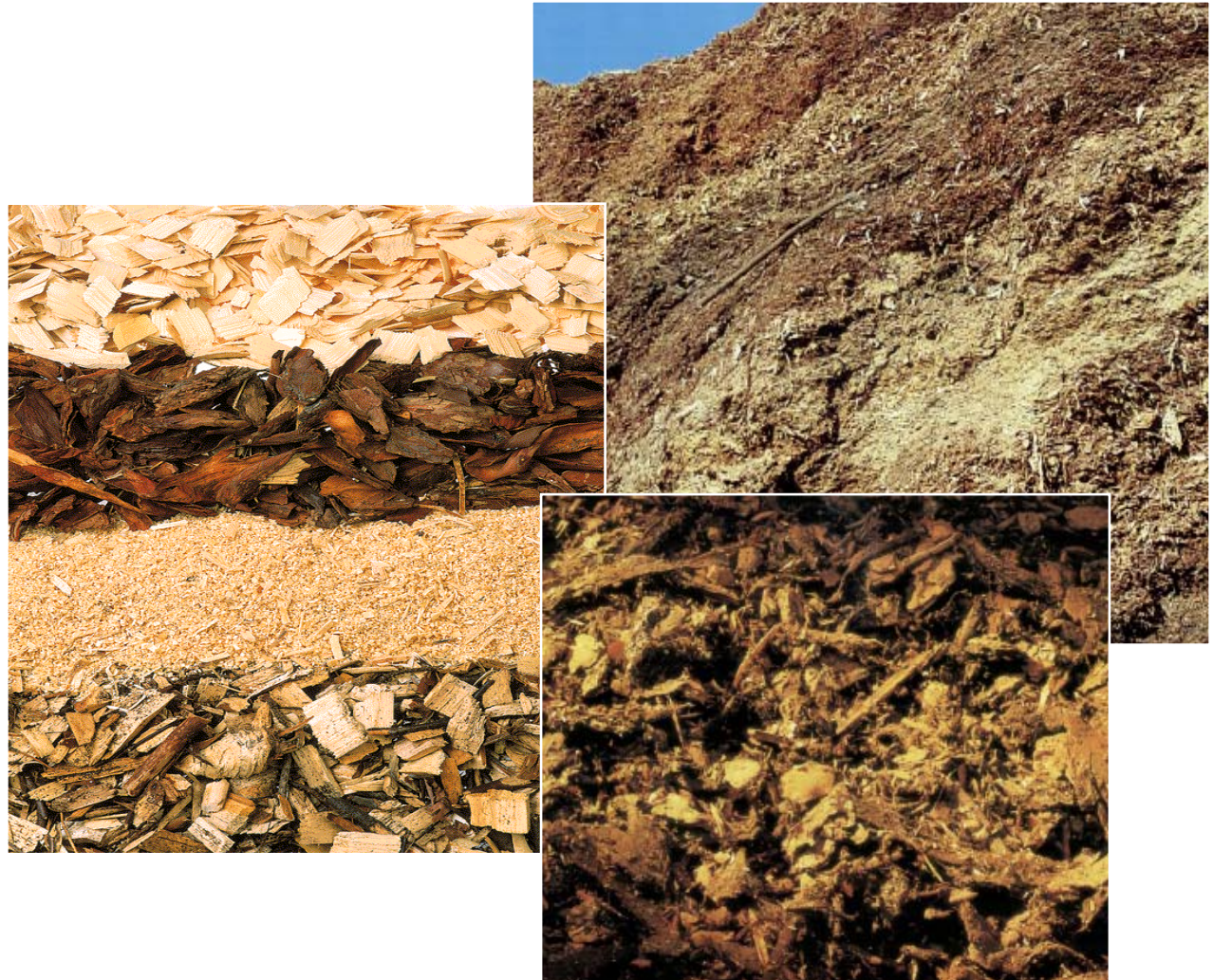
BFB

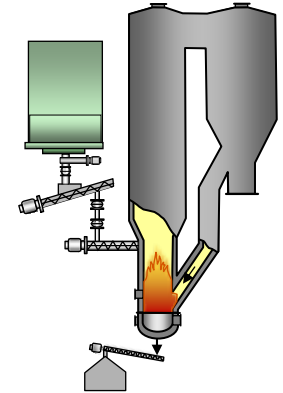


CFB

Wood-fuels

- Bark
- Forest residue
- Stumps
- Wood chip
- Saw dust
- Pellets





CIRCULATING FLUIDIZED BED GASIFIERS (CFB)

Former Ahlstrom Pyroflow CFB Gasifiers

Lime kiln gasification

1. To replace lime kiln oil/natural gas consumption with biomass based gasification gas
2. To utilize mill biomass side products for gas generation
3. To utilize low temperature waste heat in fuel drying available at the mill
4. Integrate expertise and experience of ANDRITZ units

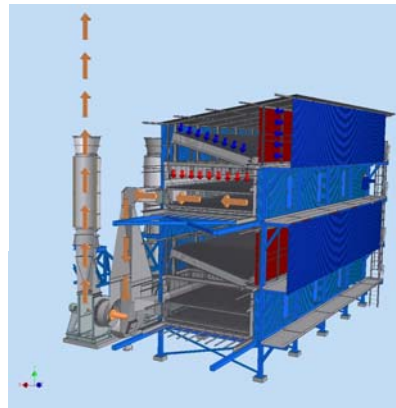
LIME KILN GASIFICATION PLANT:

Fuel handling – Dryer – Gasifier – Lime kiln burner & kiln modifications

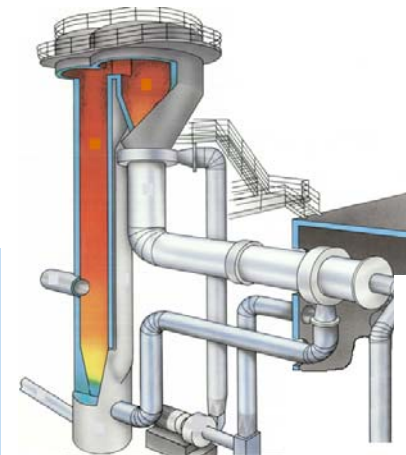
WHOLE CHAIN OF ANDRITZ PRODUCTS



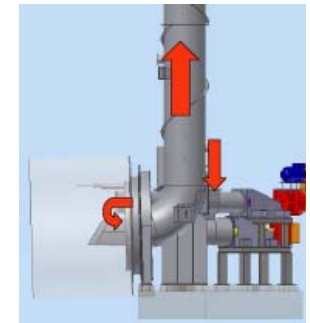
Fuel handling



Fuel drying



Circulating Fluidized Bed Gasifier

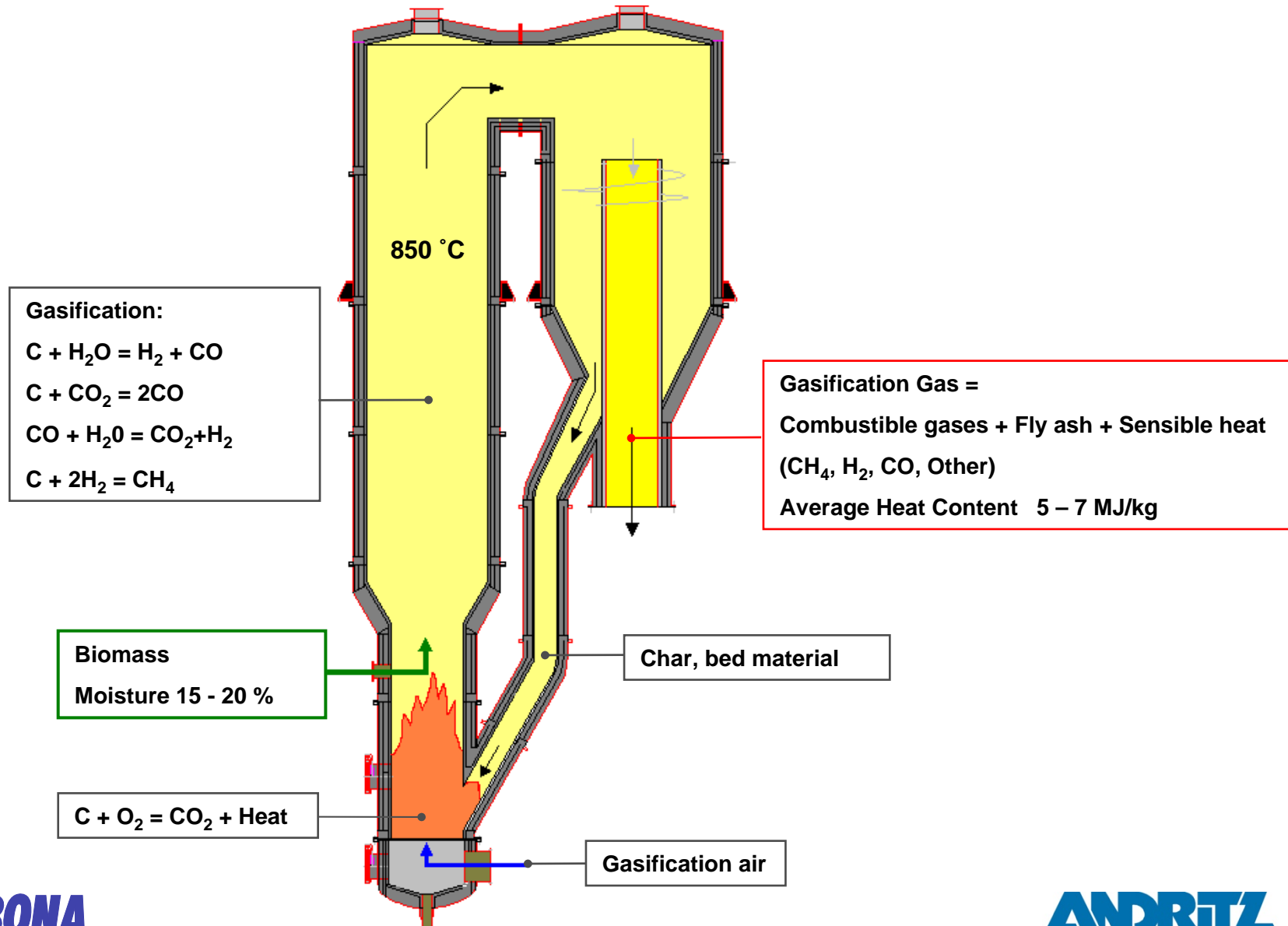


Lime Flash



Gas Combustion

Principle of circulating fluidized bed gasifier



Metsä-Botnia, Joutseno gasification project



48 MWth gasification plant

Metsä-Botnia Joutseno, gasification plant

Plant start in summer 2012

▪ Target

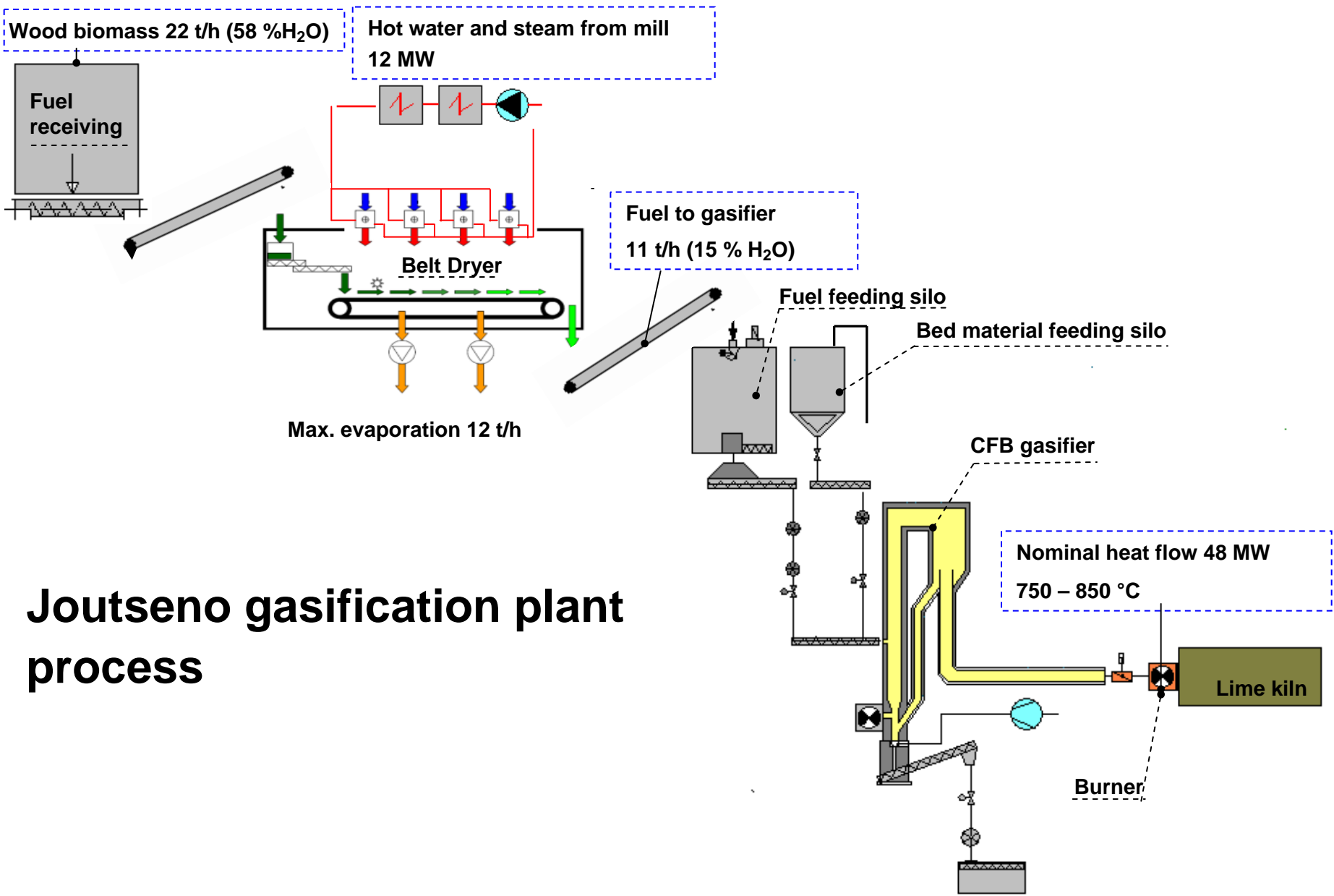
1. To replace 100% NG at lime kiln with gasification gas
2. To utilize biomass side products from mill
3. To utilize waste heat available from mill for biomass drying
4. To deliver whole line of Andritz products from fuel handling to lime kiln burner

▪ Andritz deliveries

1. Fuel handling – Andritz Wood Processing
2. Fuel drying – Andritz Environmental & Process
3. Gasifier – ANDRITZ Carbona
4. Lime kiln burner – Andritz Chemical & Fiber

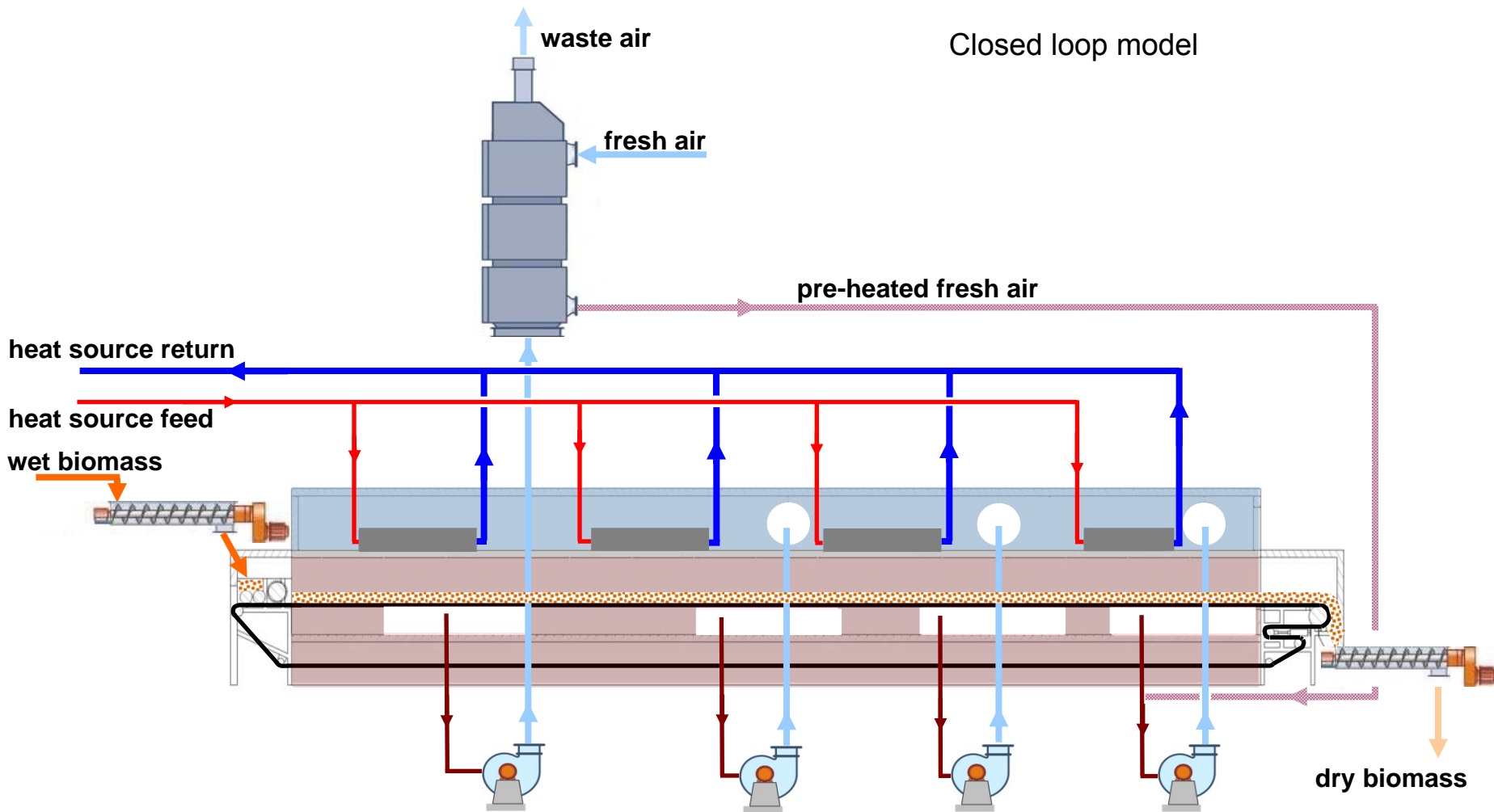
▪ Capacity numbers

- heat flow to lime kiln 48 MW (lime kiln burner capacity)
- dryer evaporation capacity 12 t/h, max.
- fuel handling 150 m³/h (loose m³)



Joutseno gasification plant process

Andritz belt dryer, functional principle

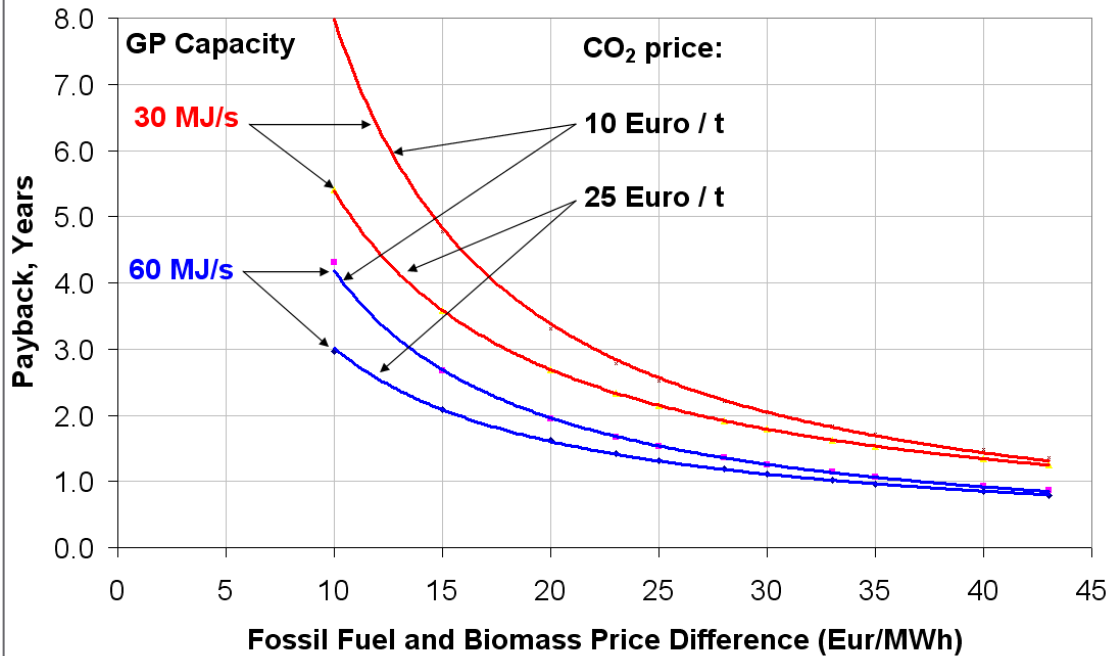


Andritz belt dryer

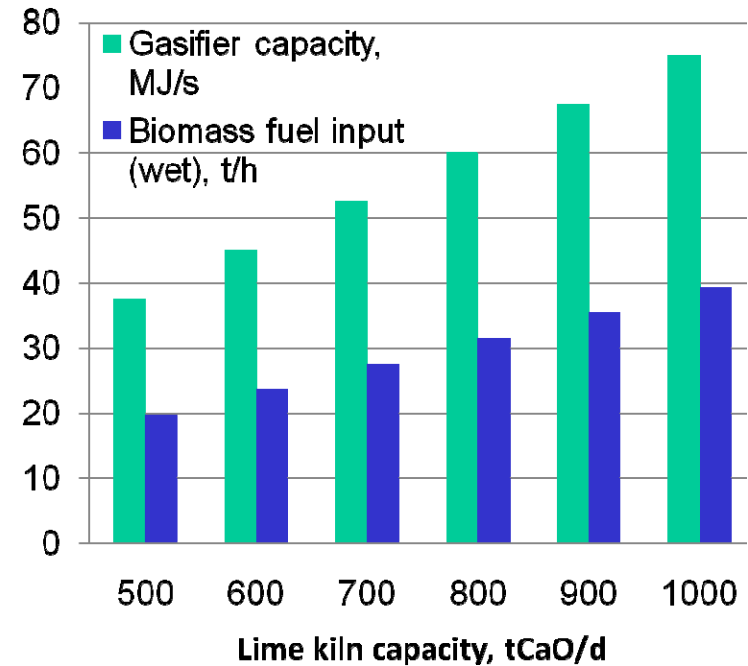


Lime kiln gasifier simple payback time

Simple payback time of the gasification plant



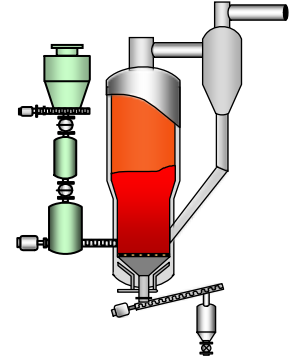
Fuel Demand & Gasifier Capacity vs. LK Capacity



Summary of lime kiln gasifier features

- Can utilize cheapest fuel residues with high ash content
- Degree of fuel drying moderate, can be adjusted according to kiln properties
- Low temperature heat to be used in belt drying
- Harmful fuel ash/soil in gas can be minimized
- Lime quality not to be affected
- Total replacement of fossil fuels
- Lime kiln capacity stays as before because:
 - fuel heating value controlled by degree of drying
 - small excess air in gas combustion
 - flue gas amount remains close to fossil fuel combustion
 - lime flash to deal with elevated kiln exhaust temperature (if needed)
- Excellent gasifier operation history during decades
- CO₂ benefits and short pay-back time for the investment

Product line 2

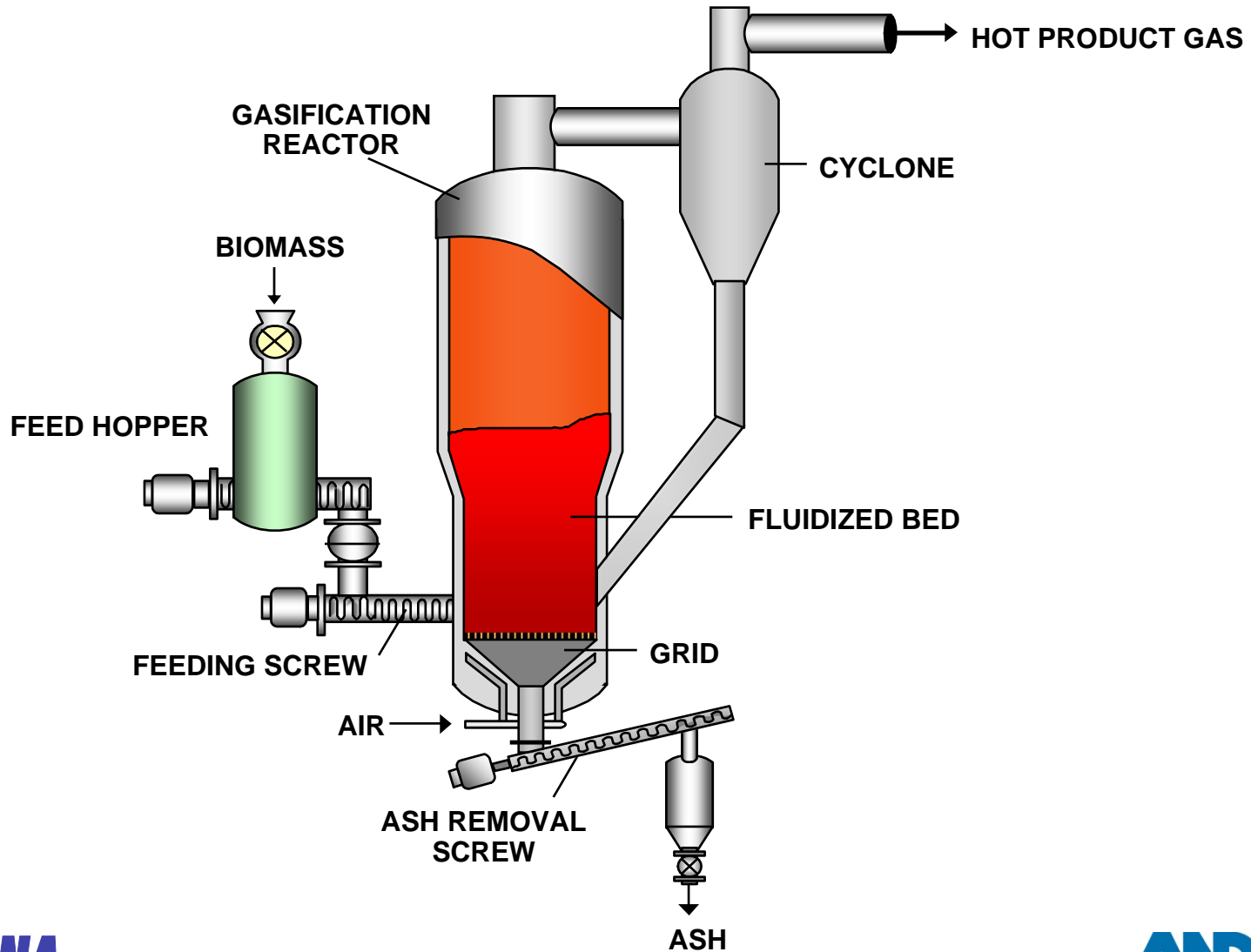


BUBBLING FLUIDIZED BED GASIFIERS (BFB)

Original license from the Gas Technology Institute (GTI),
Chicago USA

Principle of Bubbling Fluidized Bed Gasifier

High or low pressure



ANDRITZ Carbona gasification development platforms for BTL/SNG

Skive Gasification Plant in Denmark and Pilot Plant at the Gas Technology Institute, USA

CHP-Plant, Denmark



Biodiesel with UPM-Kymmene
Bio2G, SNG with EON Sweden
Gasoline, Tigas with Haldor Topsoe

Gasifier, Denmark



GTI Gasifier



GTI Pilot-Plant



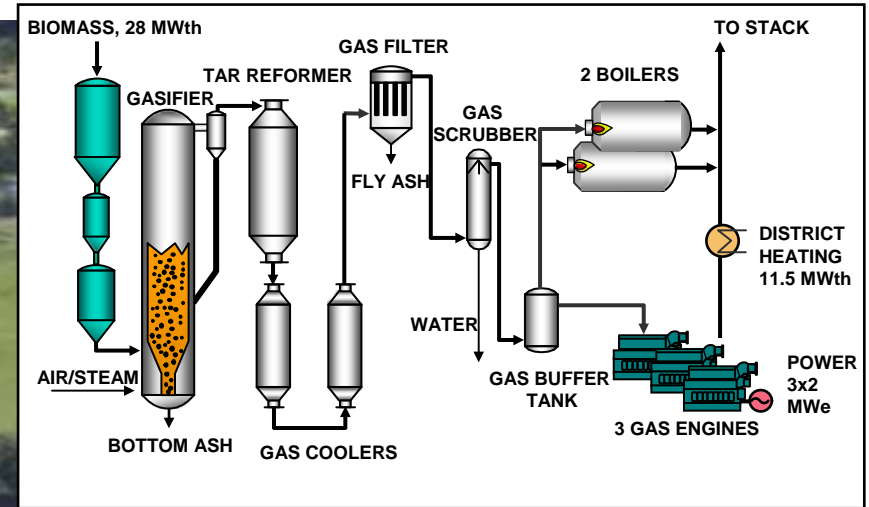
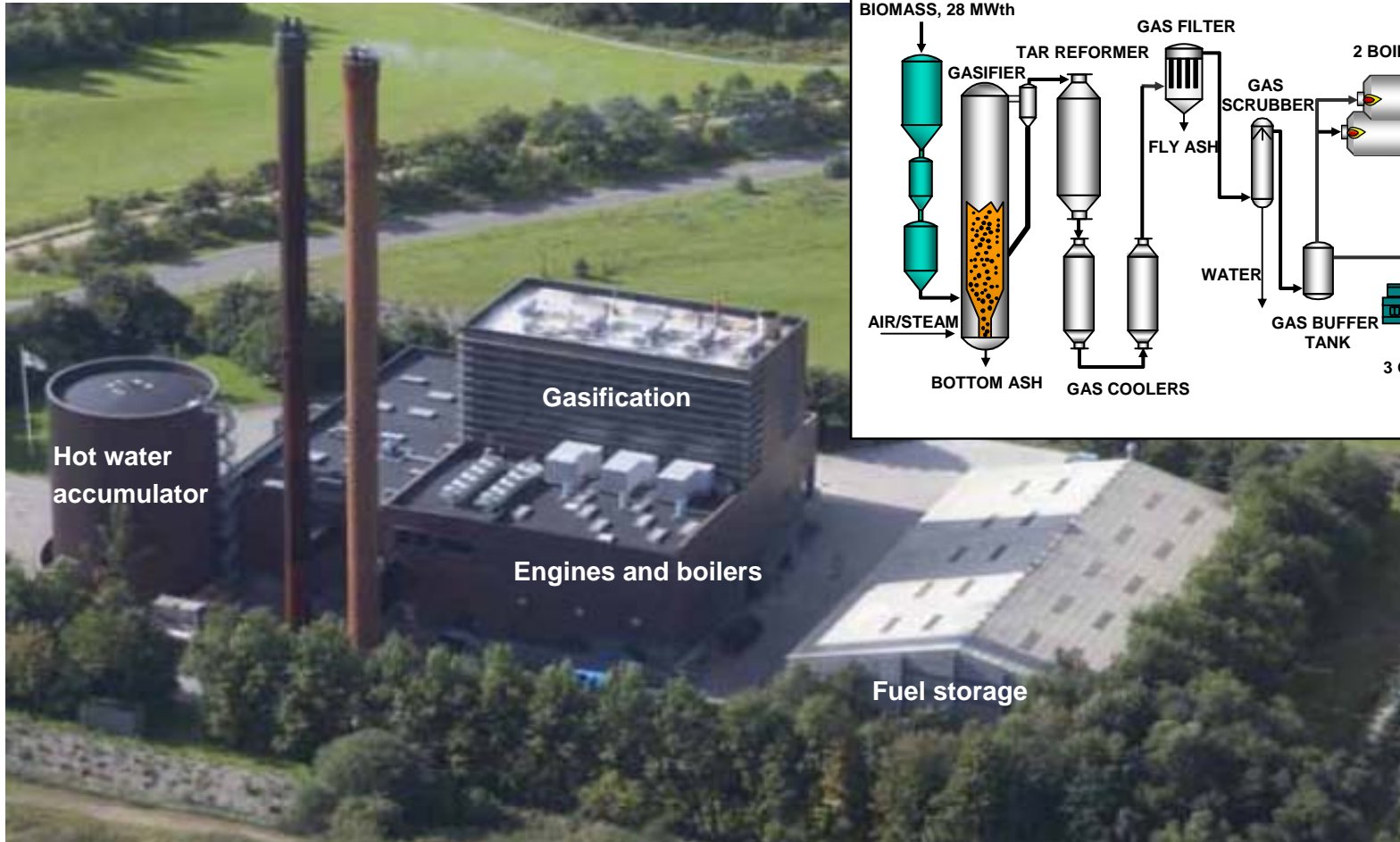
CARBONA

ANDRITZ

LCV gas for power generation

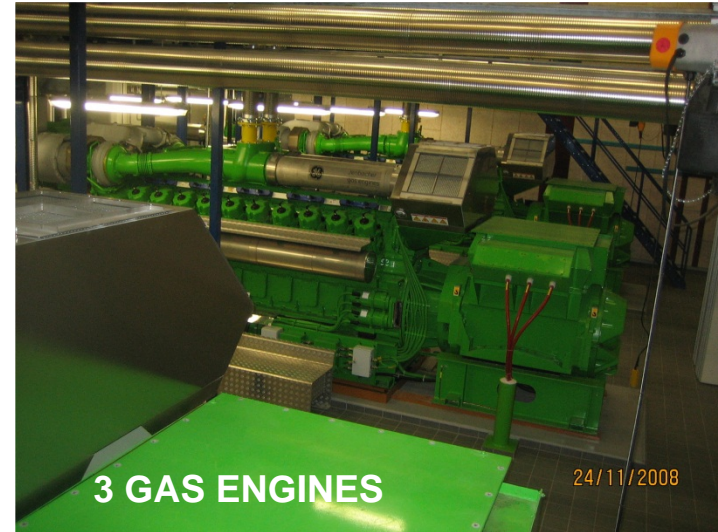
Air blown BFB gasification

Gasification / gas engine CHP plant in Skive, Denmark



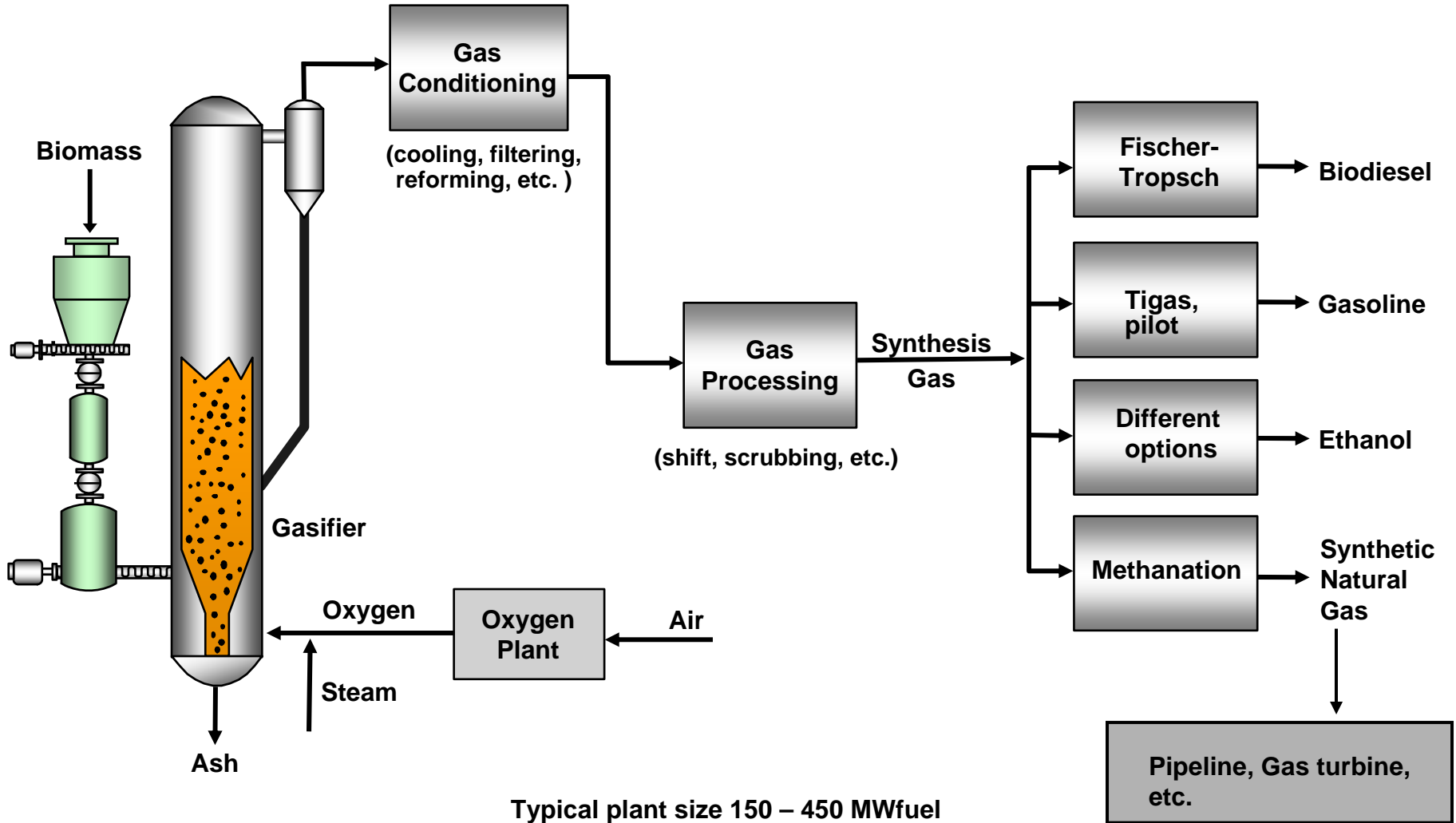
Skive Gasification CHP Plant

Main parameters & equipment



Pulp mill becomes a biorefinery

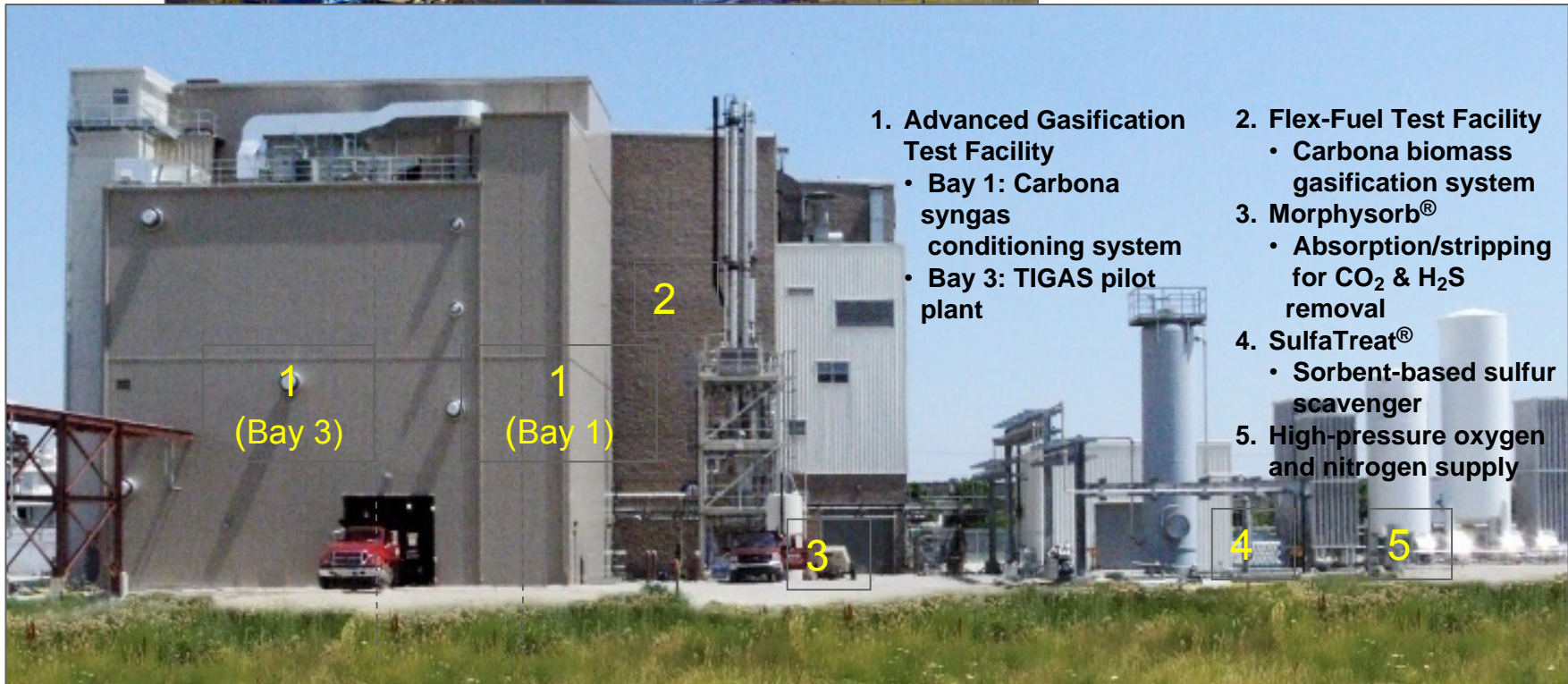
ANDRITZ Carbona active projects



Gas Technology Institute



**GTI Energy &
Environmental
Technology Campus**
Des Plaines, Illinois



**1. Advanced Gasification
Test Facility**

- Bay 1: Carbona syngas conditioning system
- Bay 3: TIGAS pilot plant

2. Flex-Fuel Test Facility

- Carbona biomass gasification system

3. Morphysorb®

- Absorption/stripping for CO₂ & H₂S removal

4. SulfaTreat®

- Sorbent-based sulfur scavenger

**5. High-pressure oxygen
and nitrogen supply**

UPM has two possible BTL-biorefinery locations: Rauma and Stracel mill sites

- Environmental impact assessment has been completed in UPM's Rauma mill site in Finland.
- Environmental impact assessment is ongoing at UPM's Stracel mill site in Strasbourg, France.



(Source: UPM-Kymmene)

Tigas: Wood to Gasoline

U.S. Department of Energy
Golden Field Office

DOE Award No. DE-EE0002874

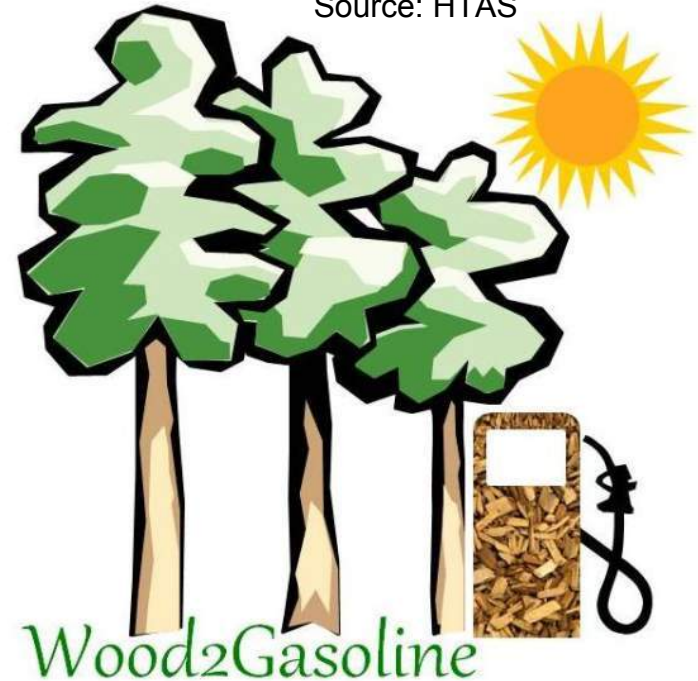
Government share:
\$ 25,000,000

Cost share:
\$ 9,771,643

Period of performance:
12/28/09 through 12/31/14

Final investment decision in place

Source: HTAS



Demonstration plant at GTI

- Gasification and TAR reforming (Carbona, existing)
- Morphysorb AGR unit (GTI, existing)
- Utility units & control system (GTI, existing)
- Syngas compression (new)
- TIGAS synthesis unit (new)
- Gasoline & waste water storage (new)

Tigas, Wood to Gasoline, project team



- UPM-Kymmene is one of the world's largest pulp and paper companies with more than 100 production facilities.
- Provides: gathering, handling and transporting of wood; 1st commercial plant site



- Haldor Topsoe is a leading worldwide supplier of catalysts and catalytic technology for fuel conversion and upgrading.
- Provides: TIGAS process, syngas cleanup including tar reforming and conversion; overall project management



- ConocoPhillips is a leading oil refiner & contributor to TIGAS
- Provides: Liquids fuels handling, transportation and marketing, sample characterization, pilot plant design, construction, operation and scale-up assistance



- Carbona is a supplier of biomass gasification and gas cleanup plants
- Provides: fluidized-bed gasification, tar reforming, commercialization support

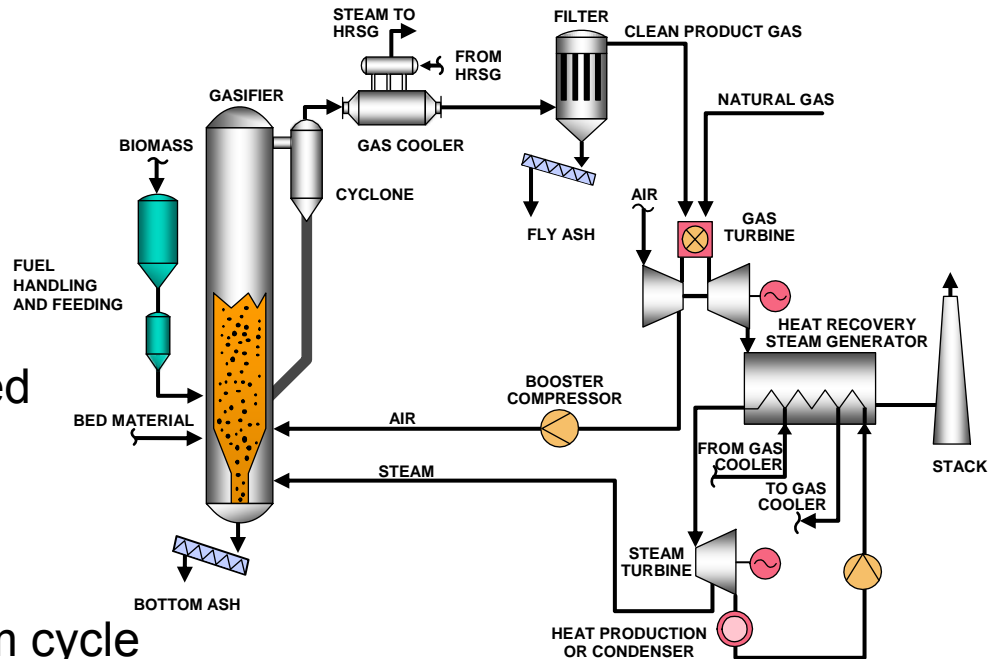


- GTI is the developer of gasification technology, licensor of acid gas removal process, and owner/operator of pilot plant test facility
- Provides: design, construction, and operation of pilot plant plus modeling, data analysis, commercialization support

High efficiency power generation

IGCC technology to be commercialized

- High-efficiency Biomass Based Power Generation, η_e 40-50%
- Basic concept:
 - Pressurized air-blown BFB gasifier (20 bar, demonstrated in Tampere/Finland)
 - Hot gas cleaning by filtration (300-500 °C)
 - gas cooling, integrated steam cycle
 - gas turbine with air extraction
 - burner for high temperature LCV gas (LHV 5 MJ/m³n)
 - new or existing steam cycle for integration, repowering
- Most plant components are of conventional technology
- IGCC process is demonstrated in smaller scale (Värnamo)





ANDRITZ Carbona

Any questions?

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CARBONA

www.andritz.com