Black Liquor Gasification — Transforming the Pulp and Paper Industry

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Biomass Interest Group Meeting
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Outline

- Introduction
  - The pulp and paper industry
  - The pulp mill
  - Black liquor
- Black liquor gasification technology
  - Integration into a mill
  - Current BLG technologies
- Black liquor gasification R&D
  - Current research programs worldwide
  - Research in Utah
- Conclusions

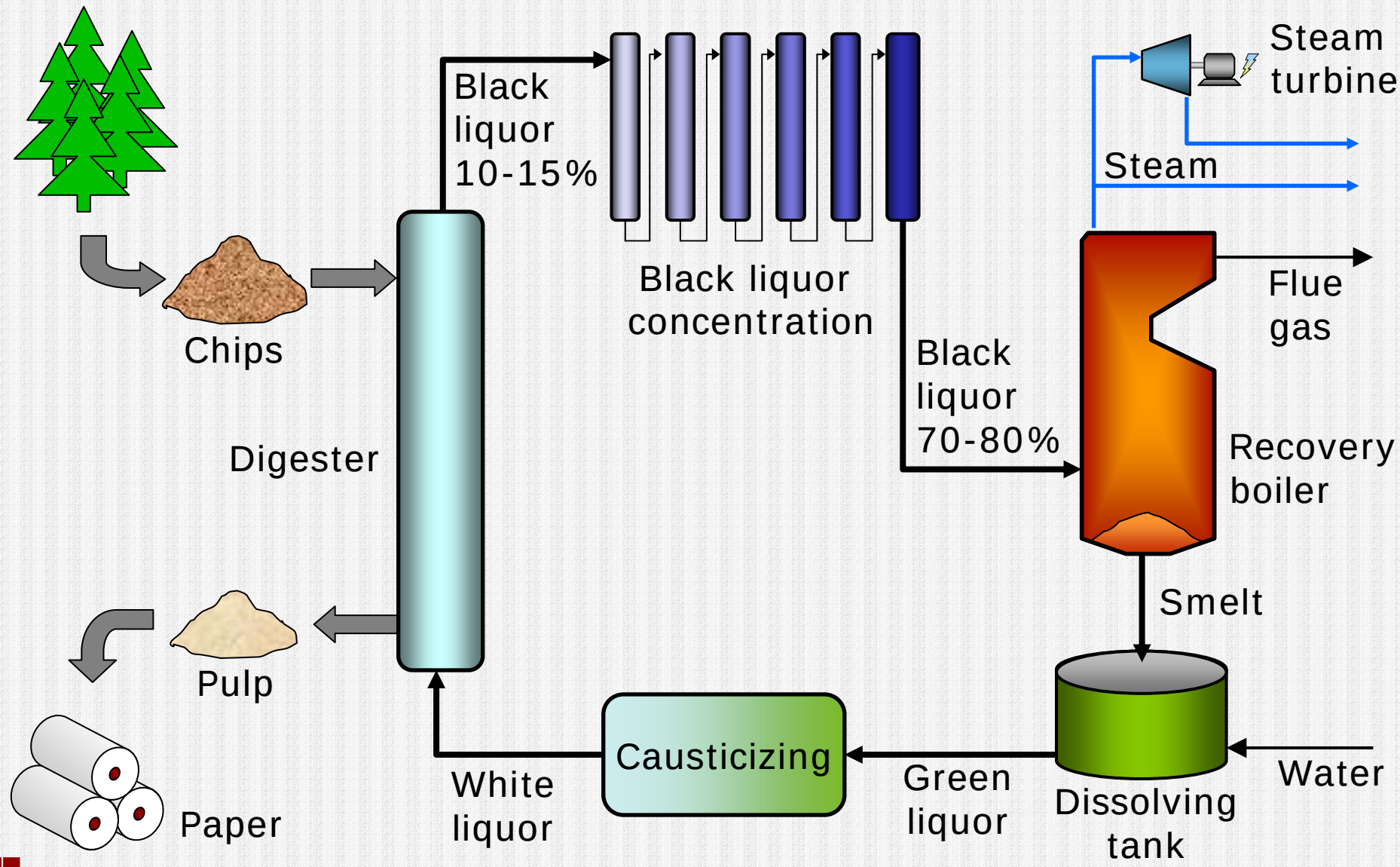
Pulp and Paper Industry Statistics

Approximate values, 2003

	U.S.	World
Paper production (million tons/y)	100	340
Paper production (per capita, kg/y)	344	54
Chemical pulp mills	175	500
Recovery boilers	250	700
Black liquor production (million tons ds/y)	80	200
Biomass-based fuel consumption (GW_{th})	55	192
On-site fossil fuel consumption (GW_{th})	30	94
Electricity production* (GW_{el})	7.7	24.2
Utility grid power consumption (GW_{el})	6.0	19.0

* Typically consumed on-site

Pulp Mill Chemical Cycle



Black Liquor (Kraft)

Approximate Composition	
1/3	Water
1/3	Organics
1/3	Inorganics

Heating Value (dry basis)	
HHV	14 MJ/kg
NHV	12 MJ/kg

Composition (moisture-free)	
Carbon	34 %
Hydrogen	3 %
Oxygen	34 %
Sulfur	5 %
Sodium	22 %
Potassium	1 %
Chlorine	0.5 %

	U.S.	World
Black liquor production (10^6 tds/y)	80	200
Black liquor energy flow (GW_{th})	32	80

Black liquor is a *renewable* energy source!

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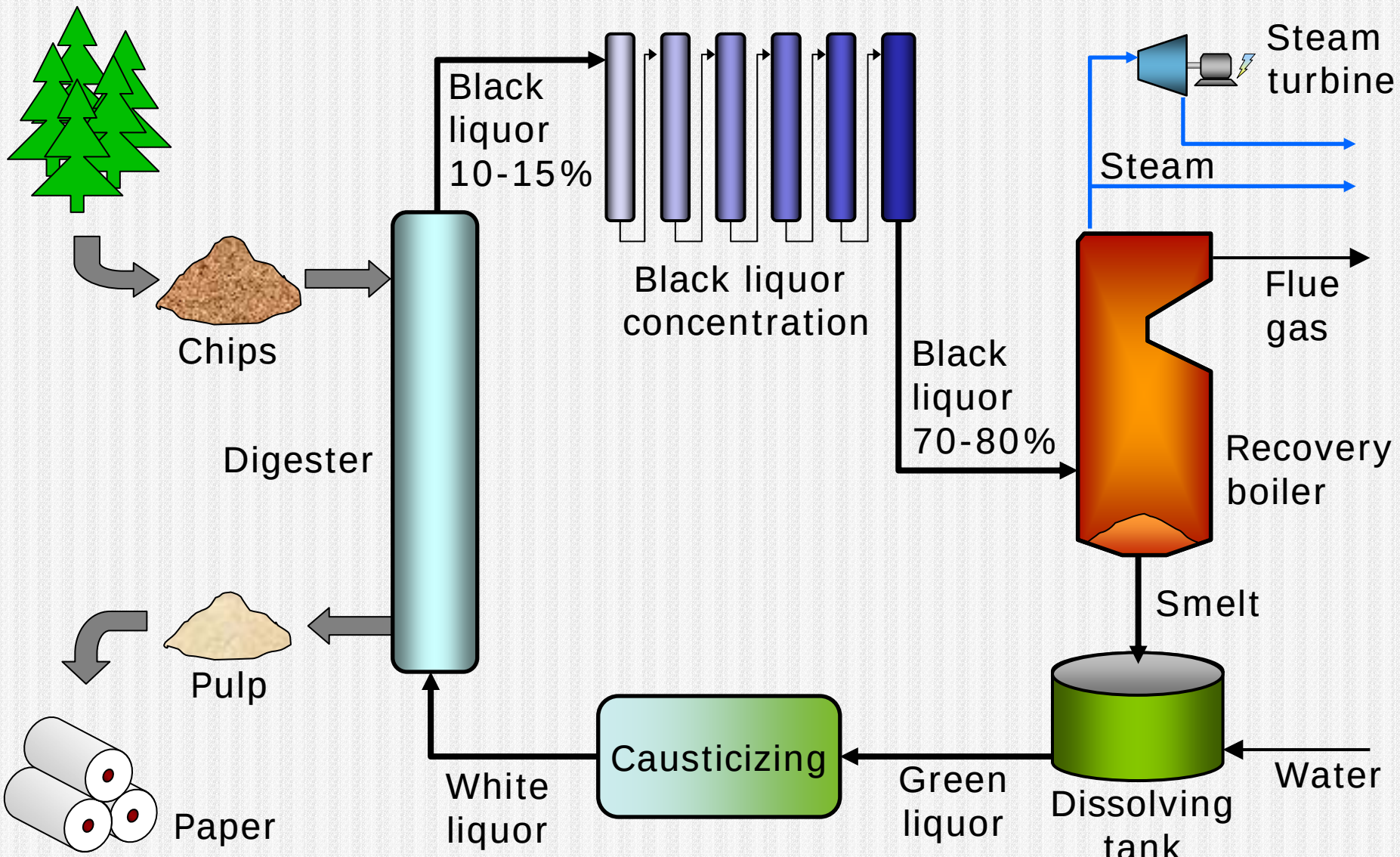
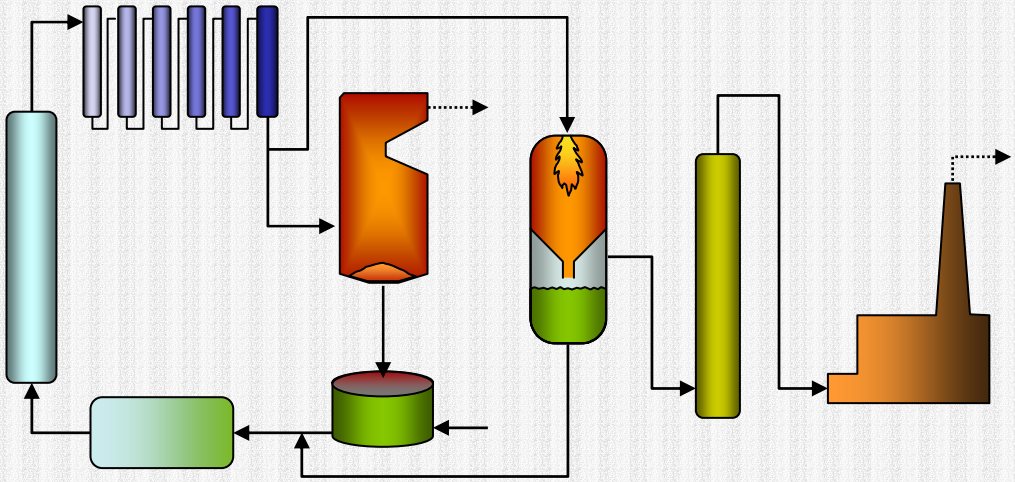
Pulp Mill Chemical Cycle



Two Applications of BLG

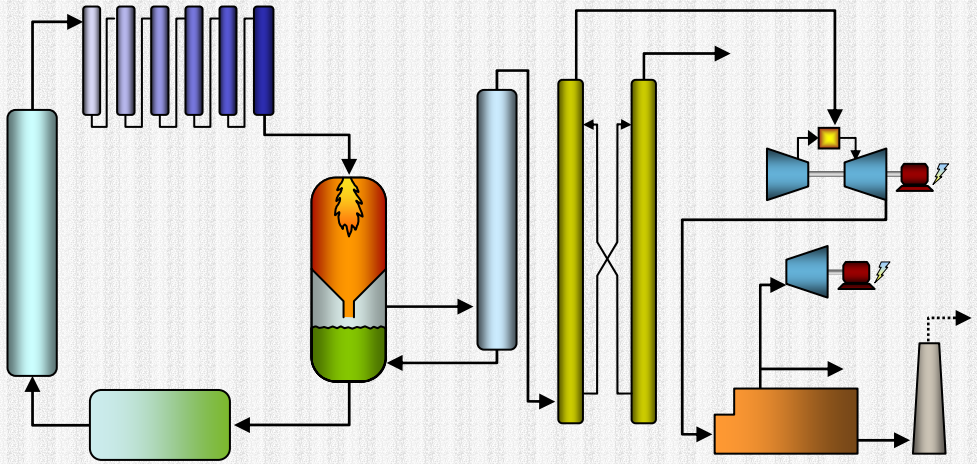
"Booster" System

- In parallel with recovery boiler
- Incremental capacity
- Typically atmospheric
- Simple fuel gas handling
- Low thermal efficiency



Recovery Boiler Replacement

- Replace recovery boiler
- Typically pressurized/O2 blown
- Improved efficiency
- Use syngas for power production via turbine, or for chemicals/fuels production

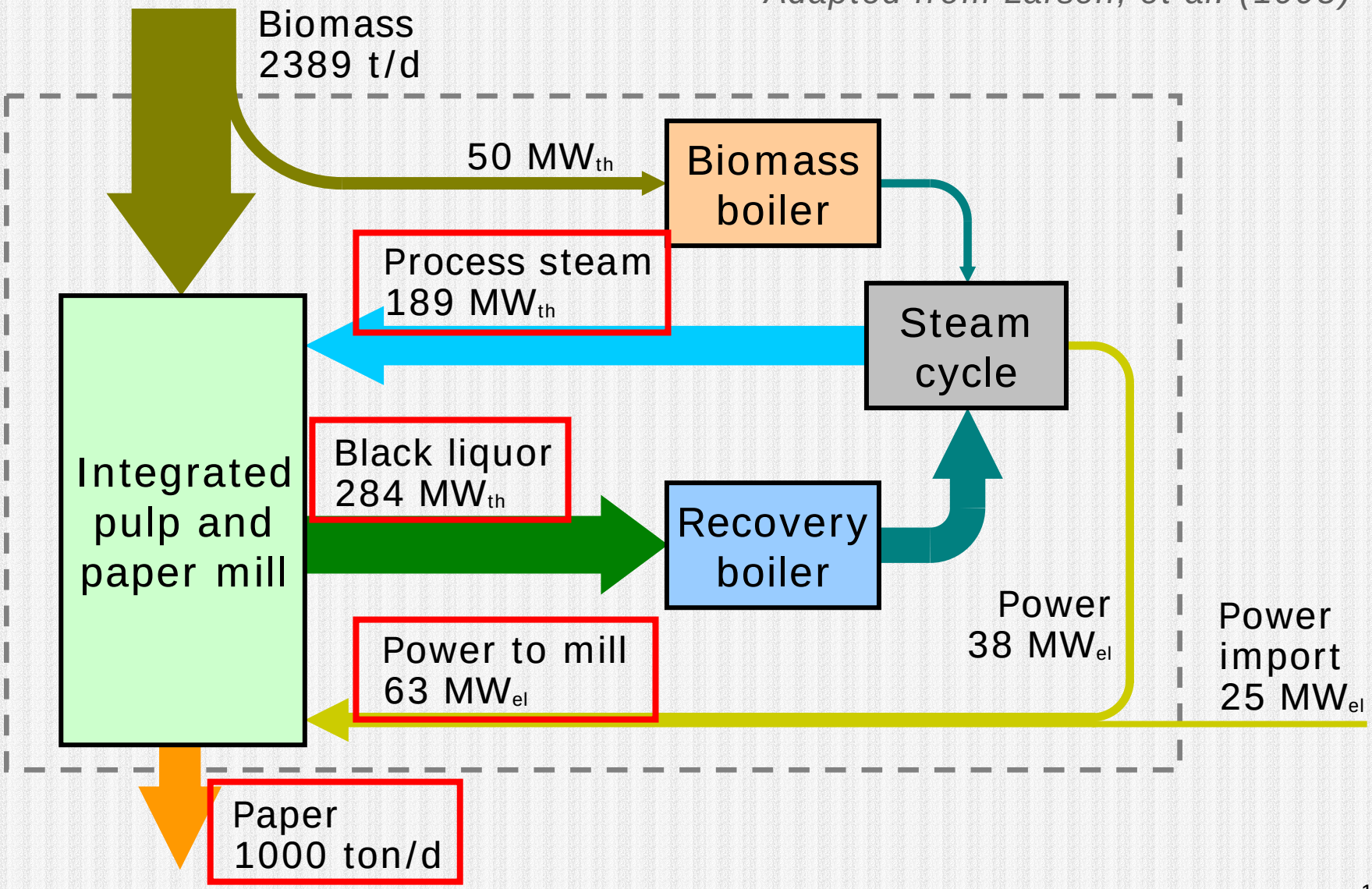


Integration of Gasification

- Power production
  - IGCC
  - Fuel cell
- Chemicals production
  - Hydrogen
  - Fine chemicals
  - Automotive fuels
    - Methanol
    - Ethanol
    - Biodiesel (Fischer-Tropsch)

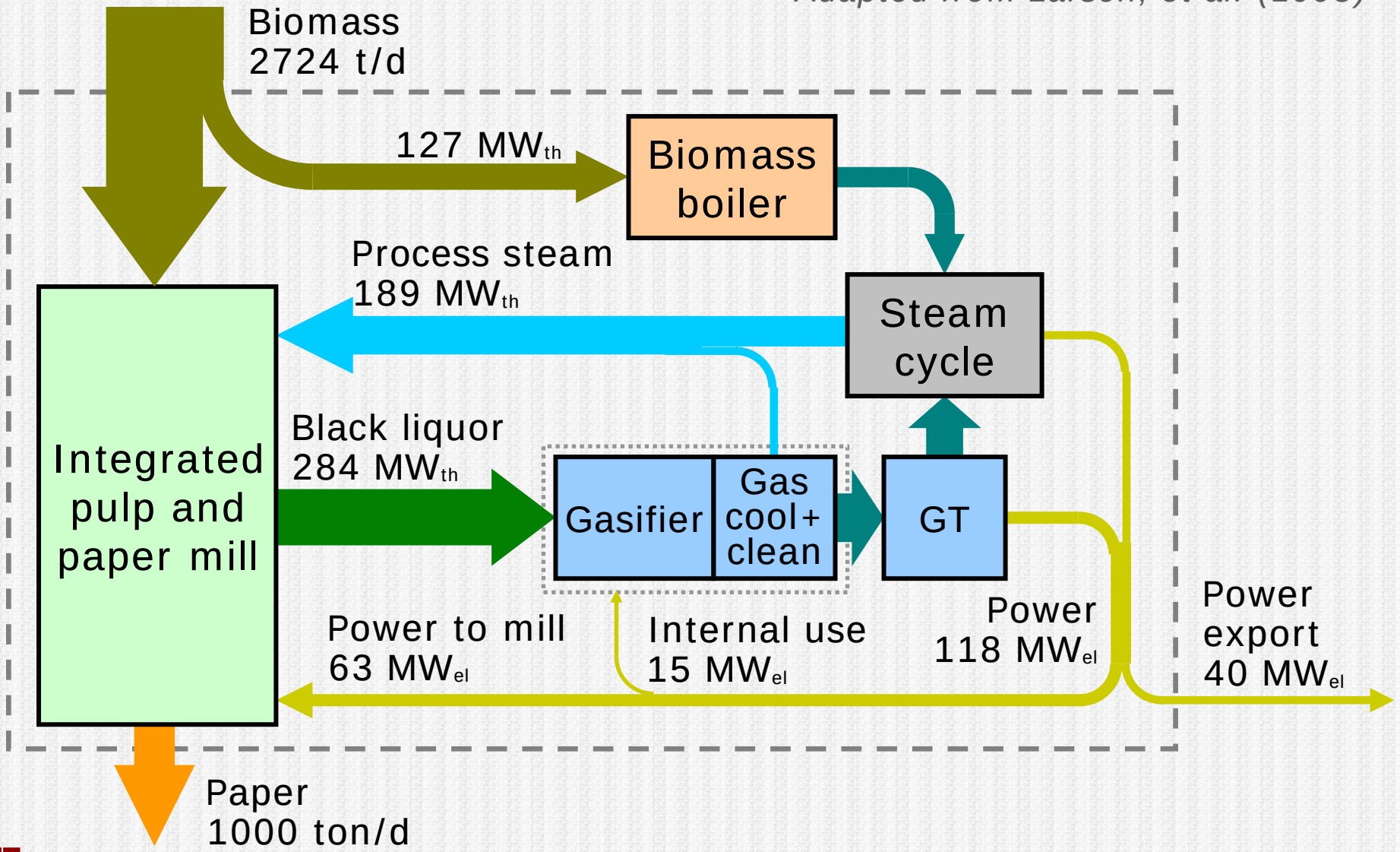
Power Production – Recovery Boiler

Adapted from Larson, et al. (1998)



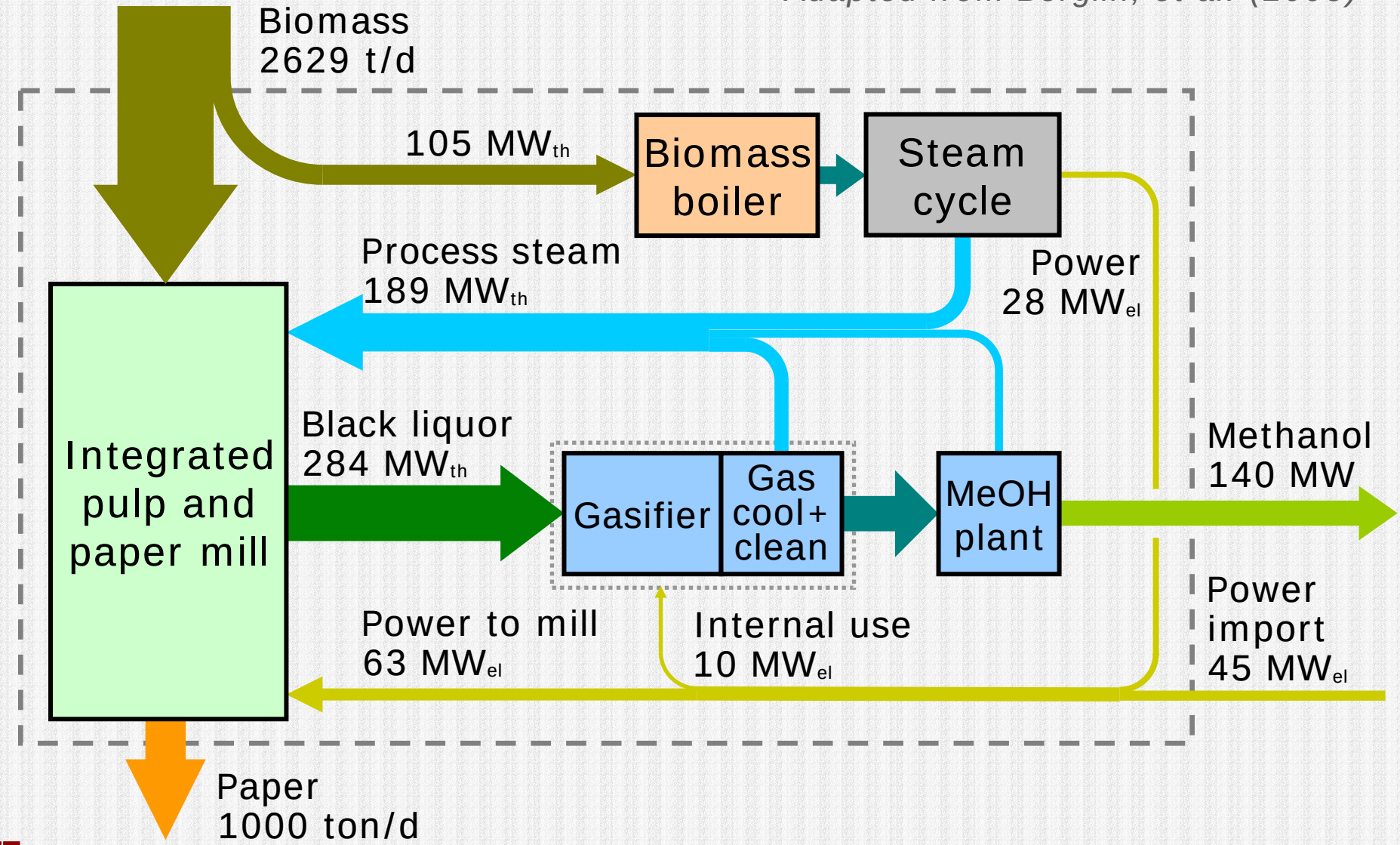
Power Production – IGCC (BLGCC)

Adapted from Larson, et al. (1998)



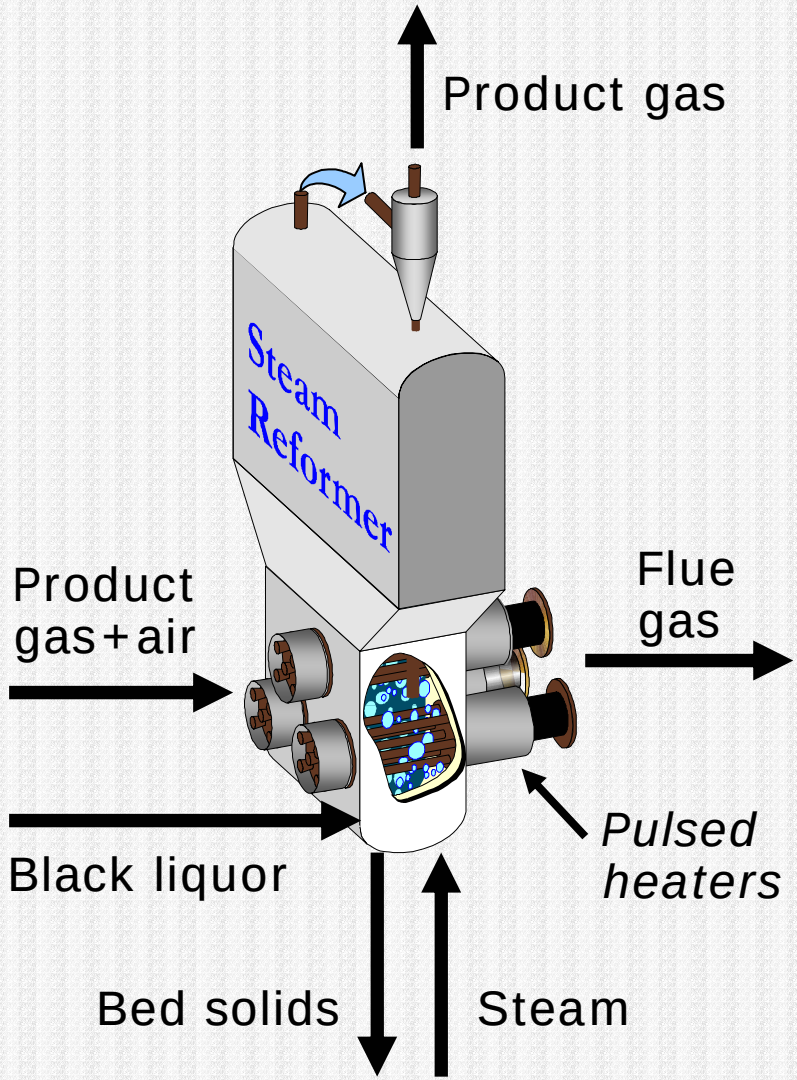
Chemicals Production – Methanol

Adapted from Berglin, et al. (2003)



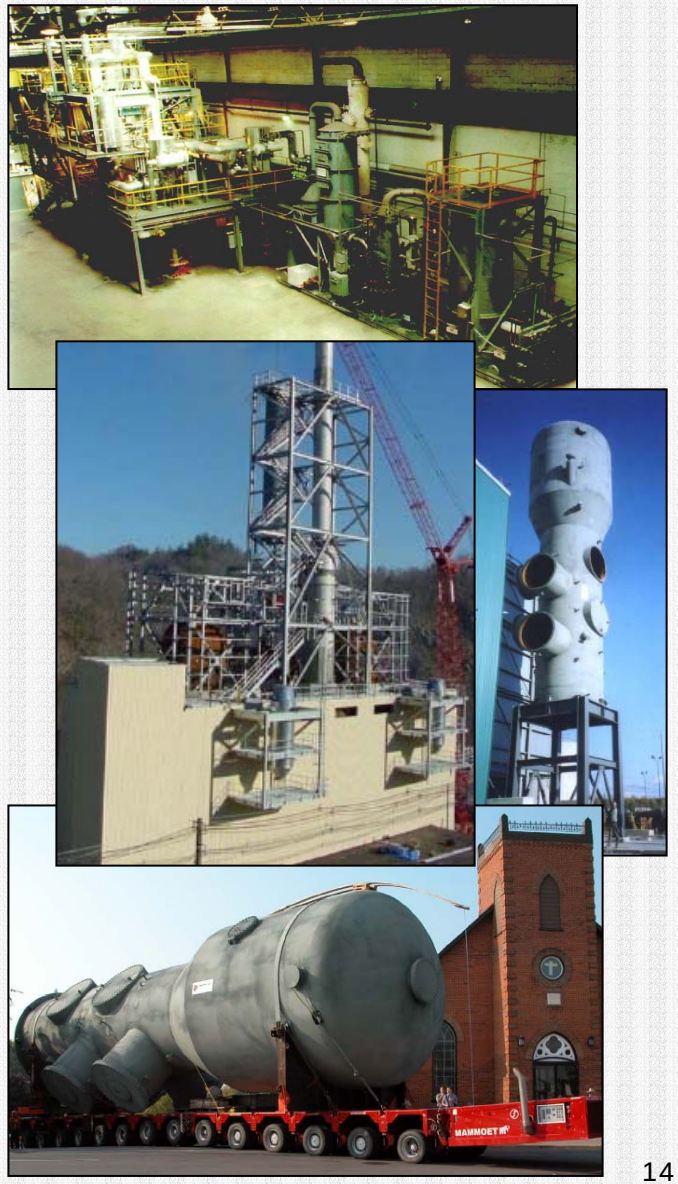
MTCI Steam Reformer

- Low temp (600°C)
- Steam fluidized
- Indirectly heated by pulsed combustion heaters
- Medium HV syngas
  - 10-12 MJ/m^3
  - 60-75% H_2
- Incremental capacity or replacement technology



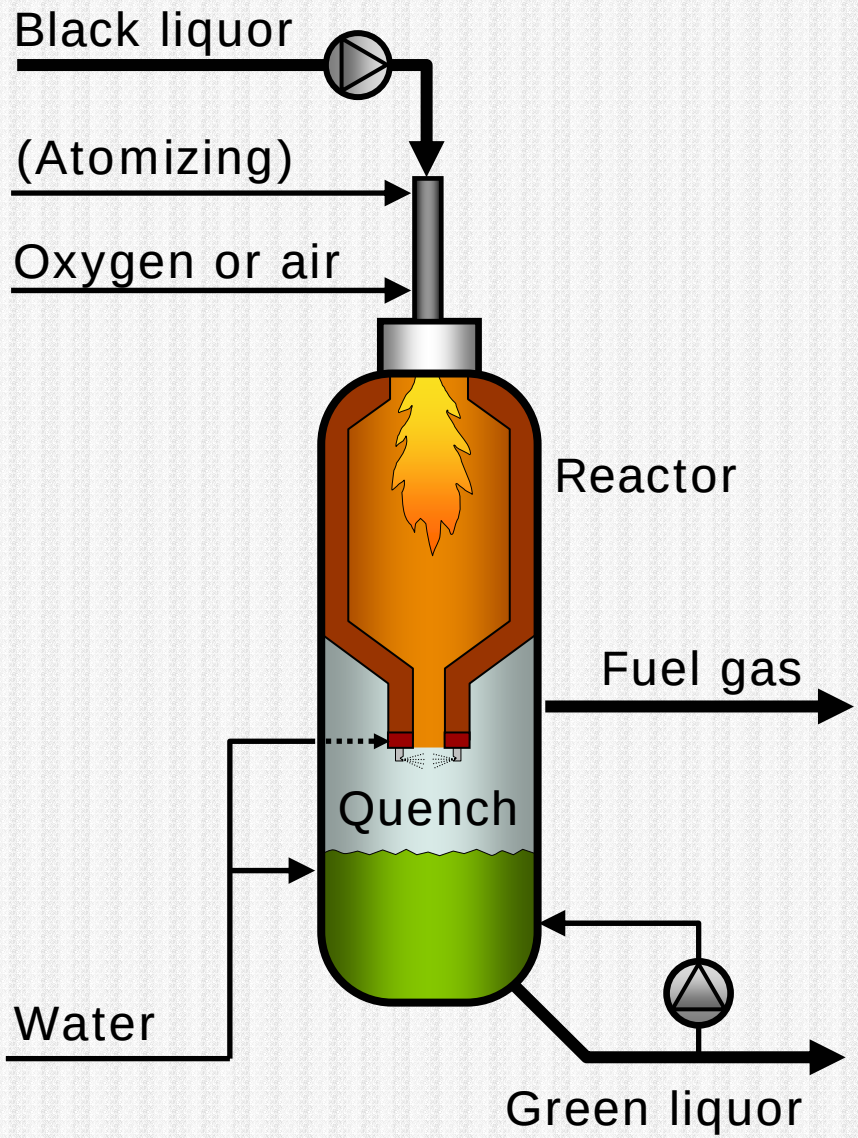
Development Status – MTCI

- PDU testing since 1990
- Two installations in progress
  - Georgia-Pacific demonstration in Big Island, Virginia
    - 200 tds/d
    - Startup early 2004
  - Norampac commercial plant in Trenton, ON
    - 100 tds/d
    - Startup fall 2003
- Several other projects in discussion phase
- Yet to be proven on kraft liquor



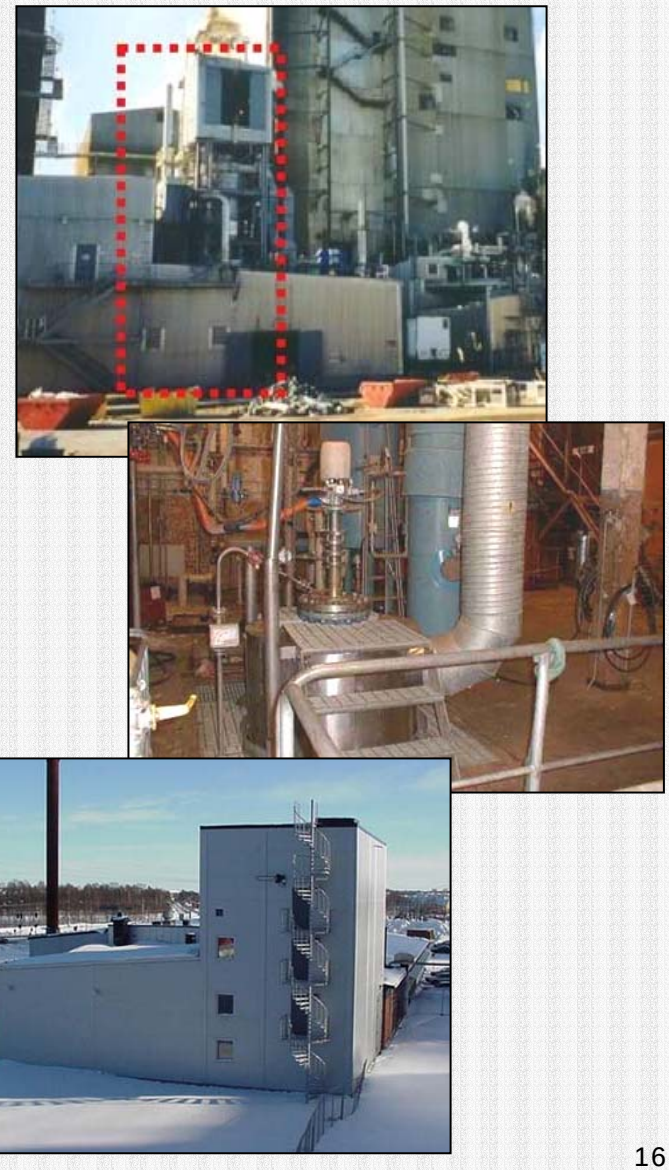
Chemrec Entrained Flow Gasifier

- High temp (950°C)
- "Booster" application
  - Incremental capacity
  - Low pressure
  - Air-blown
  - 2.5-3.5 MJ/m^3 syngas
  - 45% thermal efficiency
- "BLGCC" application
  - Replacement technology
  - High pressure
  - Oxygen-blown
  - 7.0-9.5 MJ/m^3 syngas
  - 80% thermal efficiency



Development Status – Chemrec

- Booster System
  - Pilot system early 1990s
  - One commercial installation at Weyerhaeuser's New Bern, North Carolina mill
- BLGCC System
  - Pressurized pilot 1994-2000
  - Larger development plant startup late 2004
  - Commercial demo targeted for 2007
- BLGMF System
  - Economic studies in progress



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Black Liquor Gasification Research

- Approximately 16 R&D projects worldwide
  - Chemistry (5 projects)
  - Materials (4 projects)
  - Integration (3 projects)
  - Modeling (4 projects)
- Research concentrated in North America and Scandinavia
  - Mostly government-funded
  - Corporate R&D spending currently low
- IEA Annex XV – Black liquor gasification
  - Foster international collaboration

BLG Research in Utah

- University of Utah
  - Small-scale fluidized bed steam reformer
  - Lab-scale single particle experiments
  - Cold flow reactor modeling
- Brigham Young University
  - Fluidized bed agglomeration studies
  - Lab-scale single droplet experiments
  - Thermochemical modeling
- Reaction Engineering International
  - Computational modeling
  - Optimization and troubleshooting assistance

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Conclusions

- BLG promising technology for P&P industry
  - Improved energy efficiency
  - Improved environmental performance
  - Potential to offset consumption of fossil fuels with biomass-based energy
- Currently on brink of commercialization
  - MTCI has several commercial projects in progress
  - Chemrec offering booster commercially
- Strong research effort worldwide
  - Focusing on all aspects of BLG
  - Utah plays significant role

Acknowledgements

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- Chemrec AB