Åbo Akademi Chemical Engineering Department Course
"The Forest based Biorefinery –
Chemical and Engineering Challenges and Opportunities"
May 3-7, 2010

Thermal conversion of biomass

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Åbo Akademi
Turku, Finland

Thermal conversion of biomass - Outline

1. Introduction
2. Combustion and biomass fuel properties
3. Gasification to produce combustible gas
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5. Pyrolysis to produce bio-oil
6. Black liquor: recovery boiler or gasifier?
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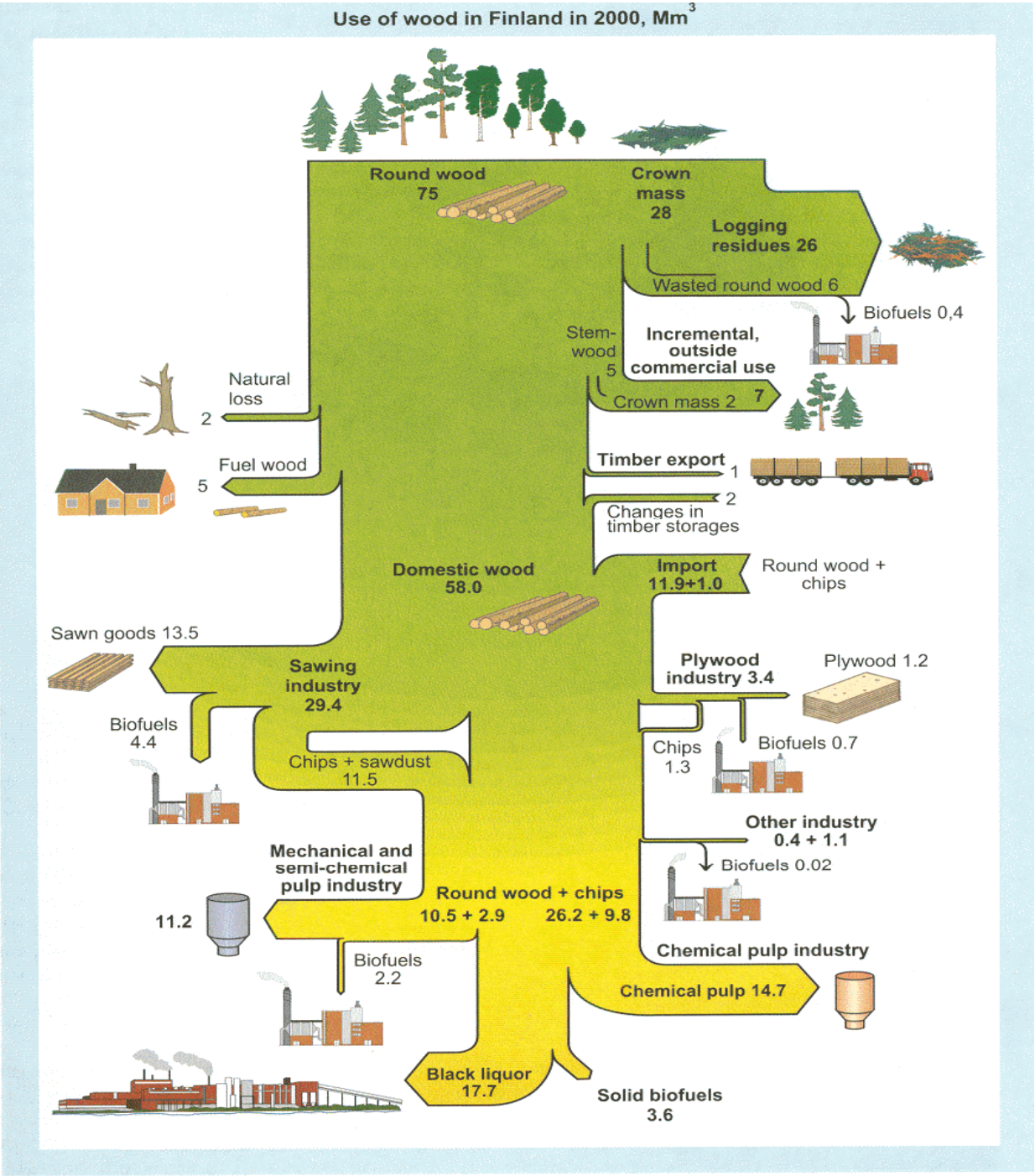
Use of Wood in Finland

(VTT 2000)



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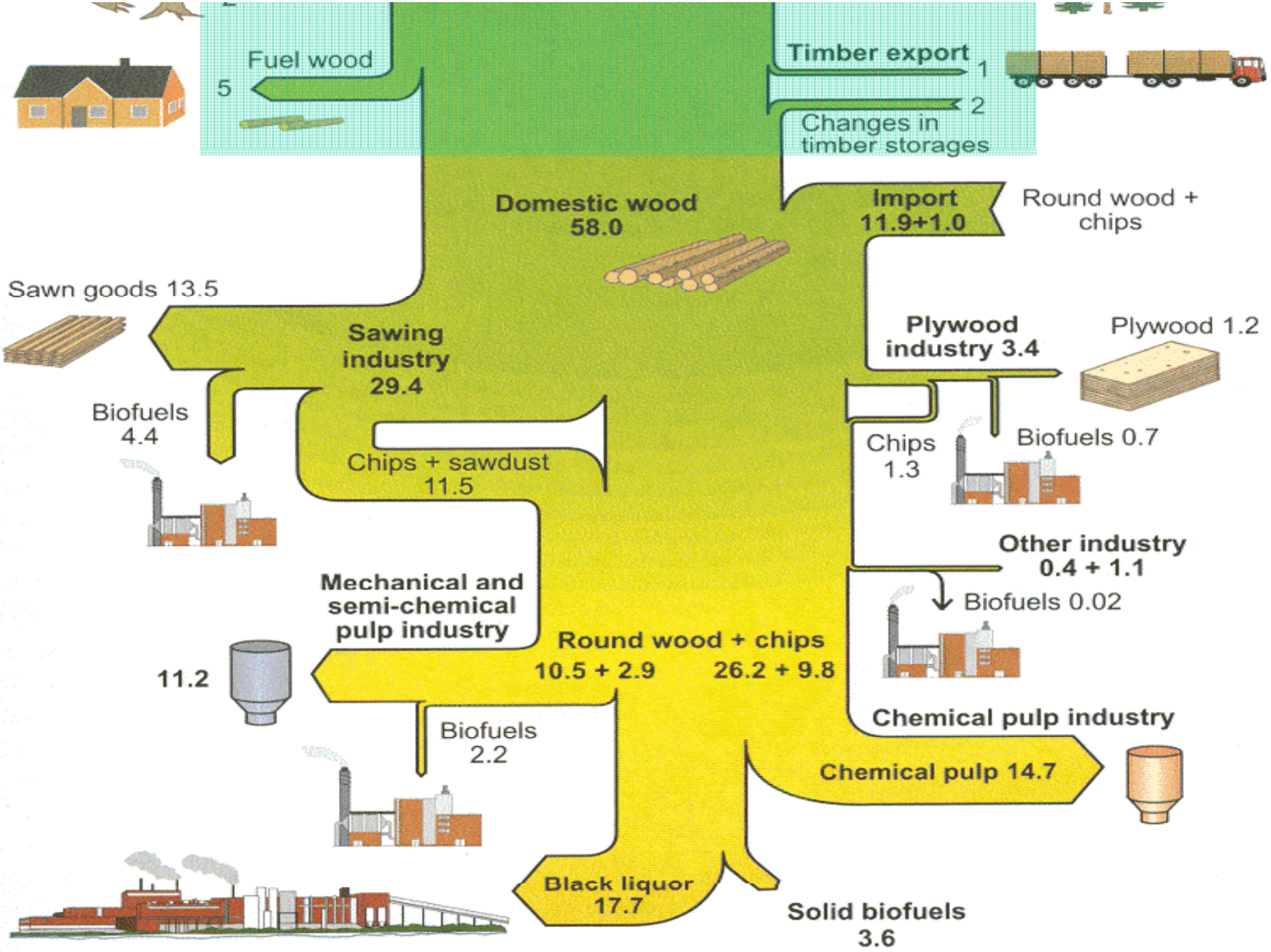
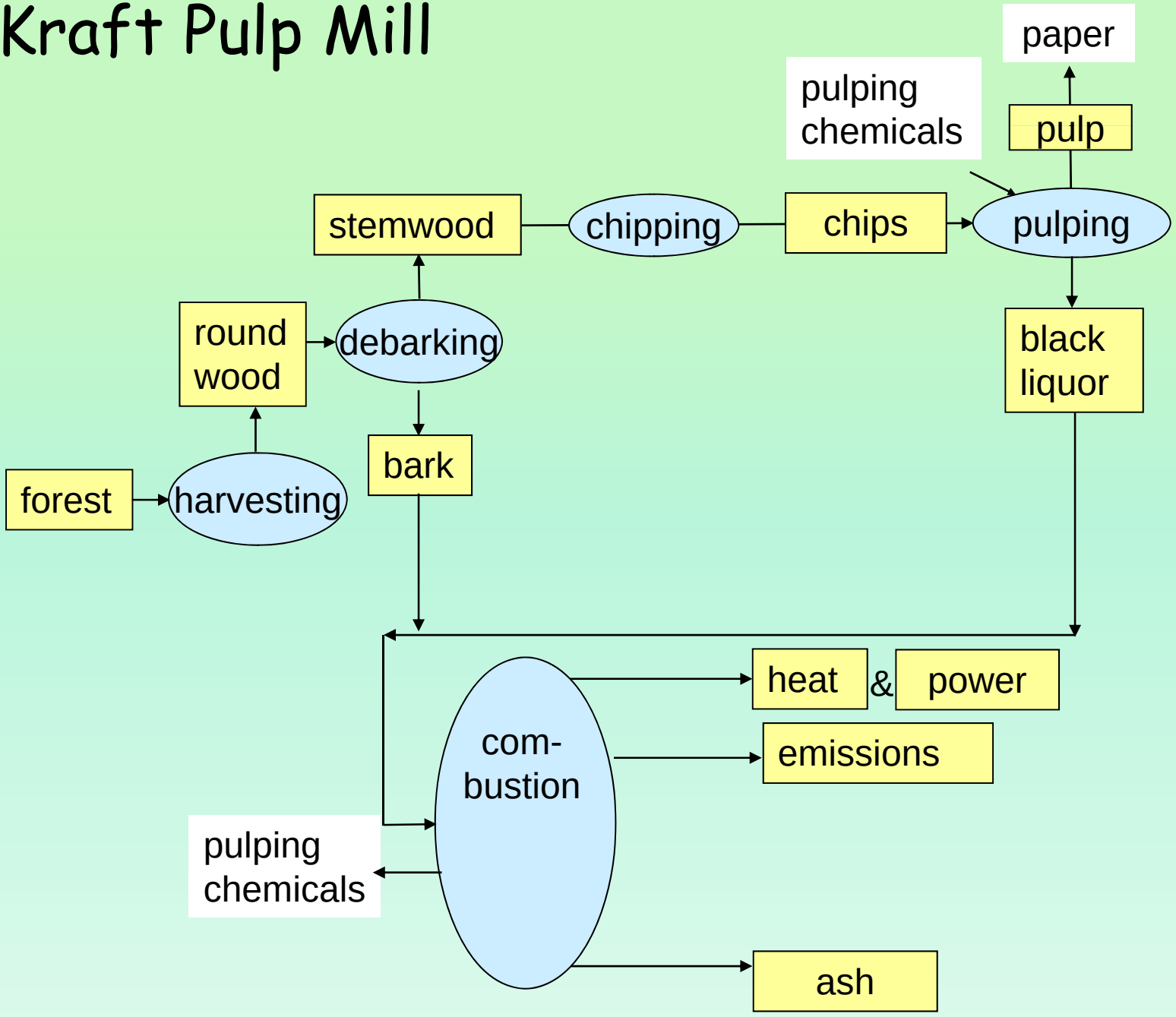
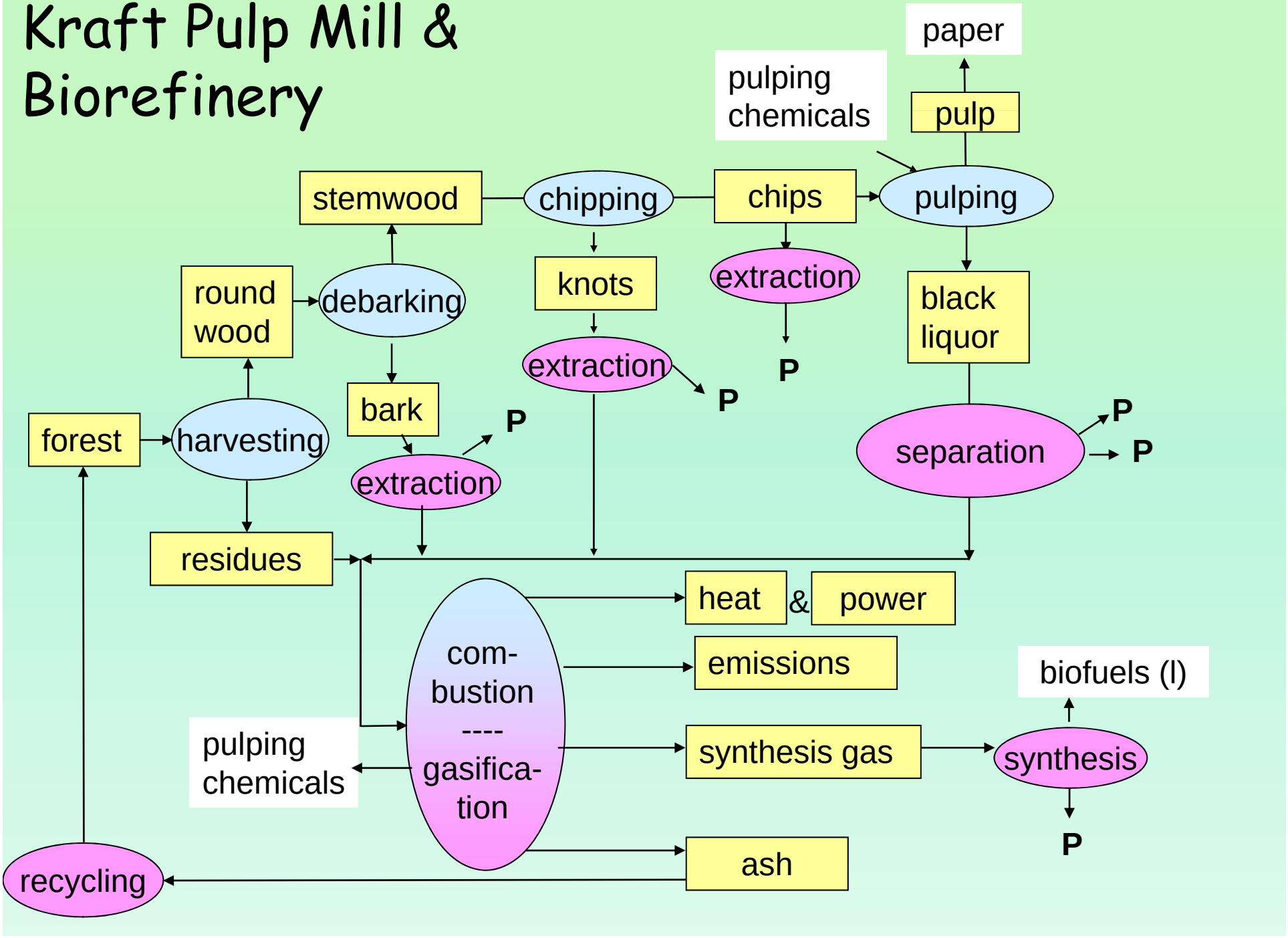

Fuel wood
5
Timber export
1
2
Changes in timber storages
Domestic wood
58.0
Import
11.9+1.0
Round wood + chips
Sawn goods 13.5
Sawing industry
29.4
Biofuels
4.4
Chips + sawdust
11.5
Plywood industry 3.4
Plywood 1.2
Chips
1.3
Biofuels 0.7
Other industry
0.4 + 1.1
Biofuels 0.02
Mechanical and semi-chemical pulp industry
11.2
Round wood + chips
10.5 + 2.9
26.2 + 9.8
Biofuels
2.2
Chemical pulp industry
Chemical pulp 14.7
Black liquor
17.7
Solid biofuels
3.6

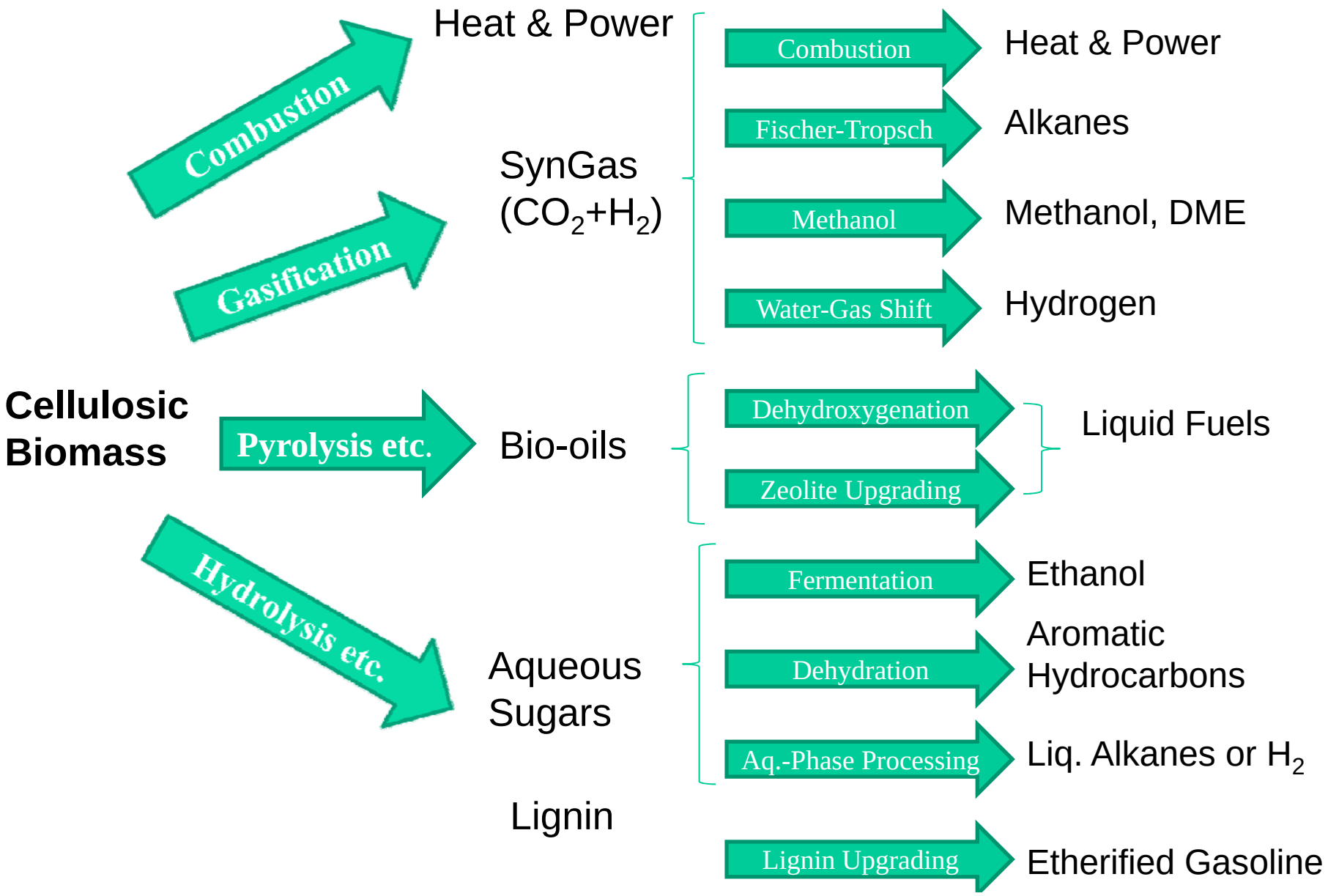
Kraft Pulp Mill



Kraft Pulp Mill & Biorefinery



Conversion Routes for Cellulosic Biomasses



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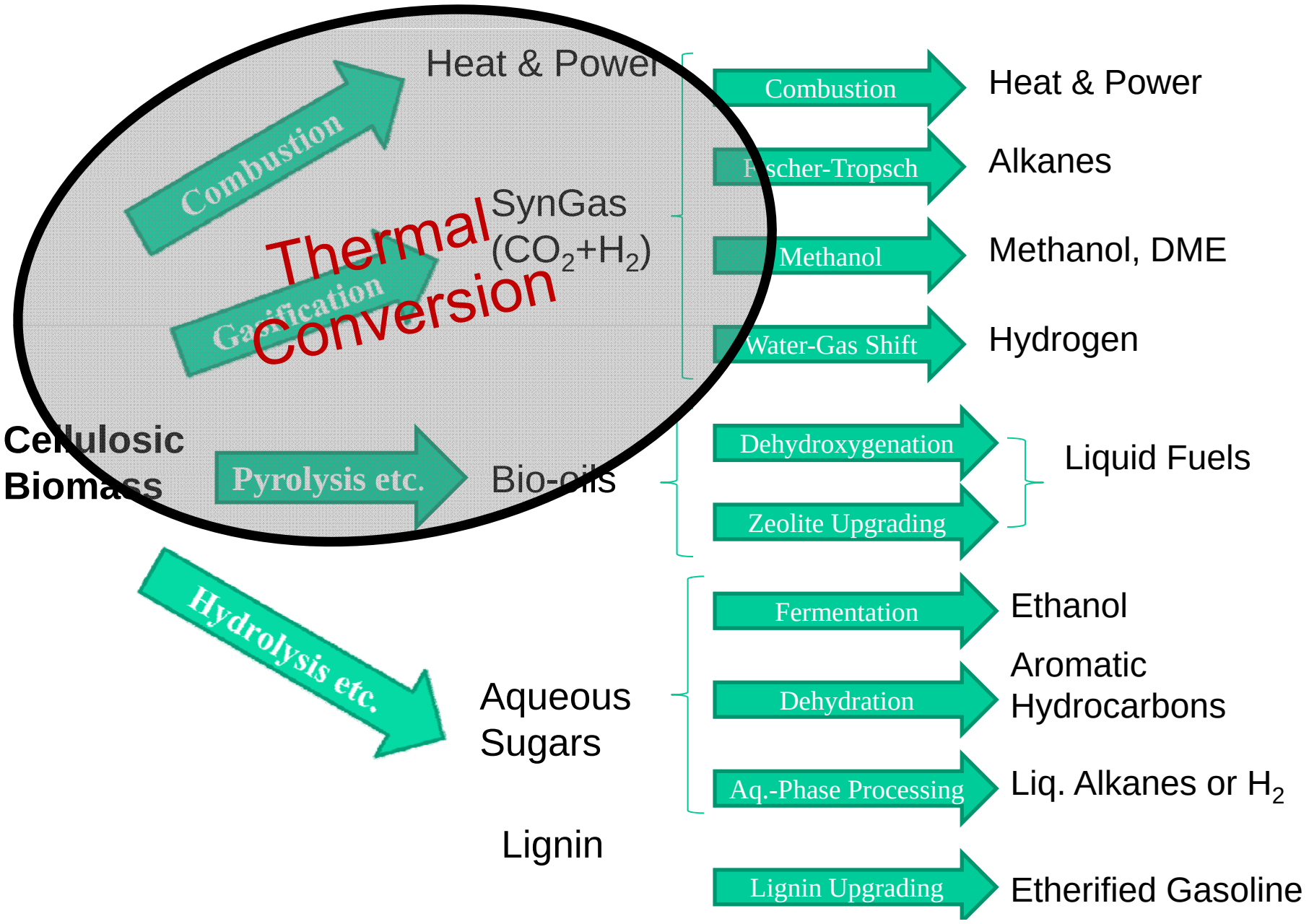

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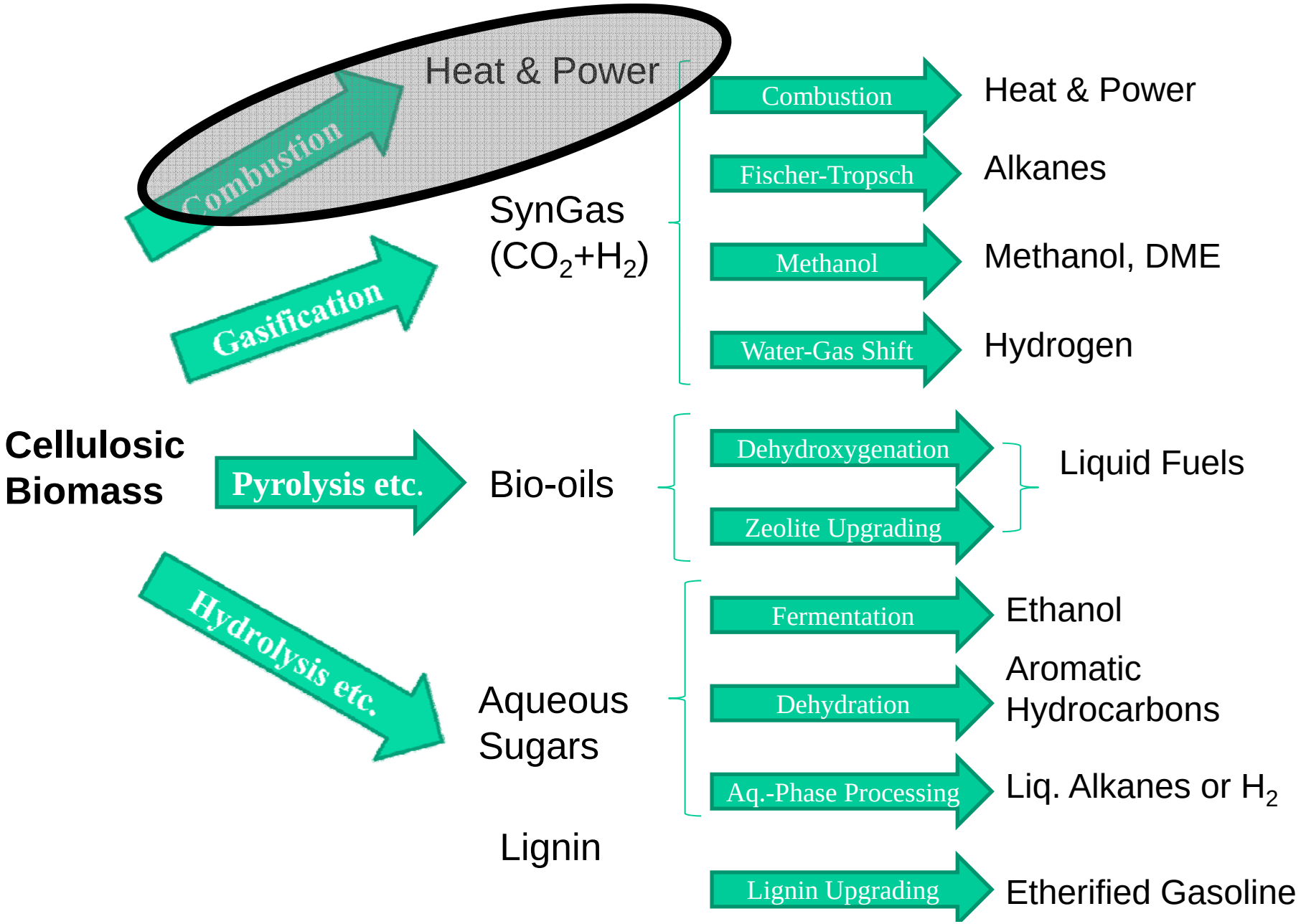
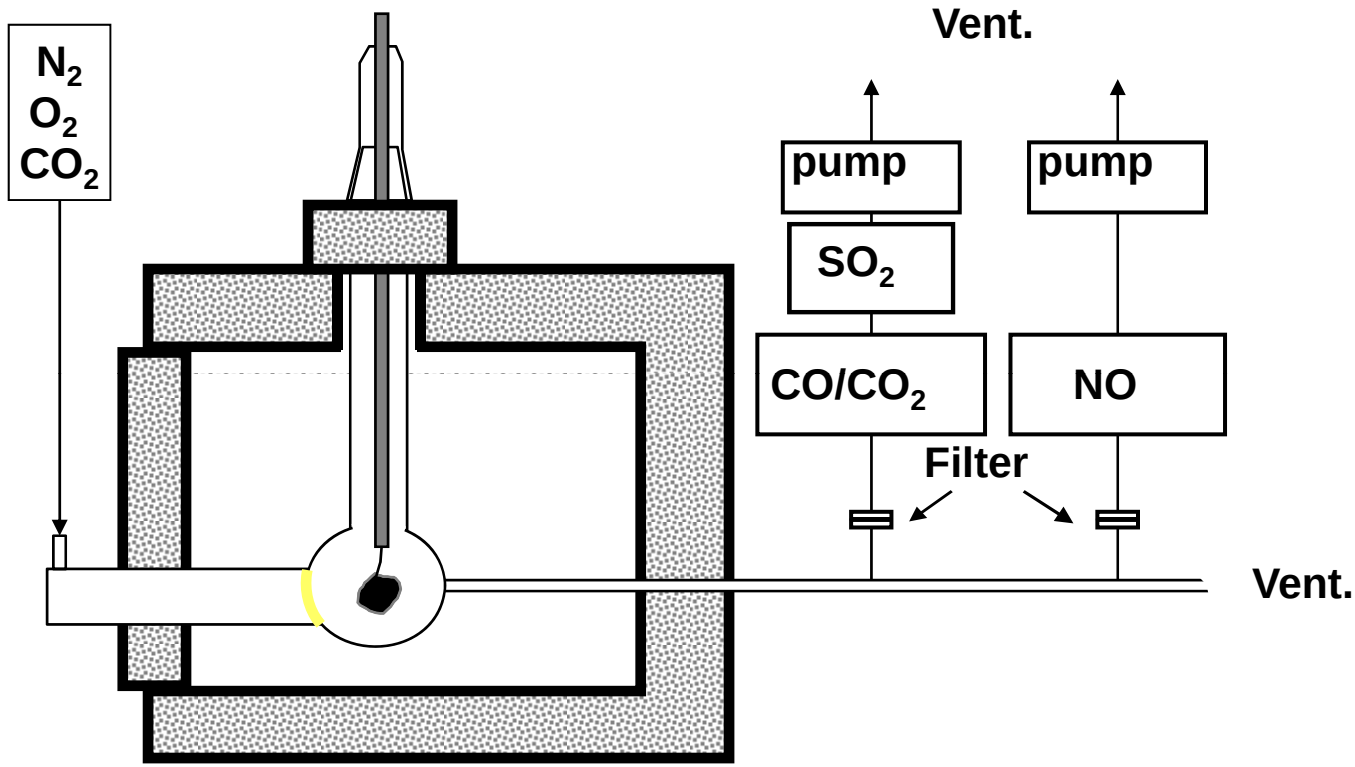




Single Particle Burning System

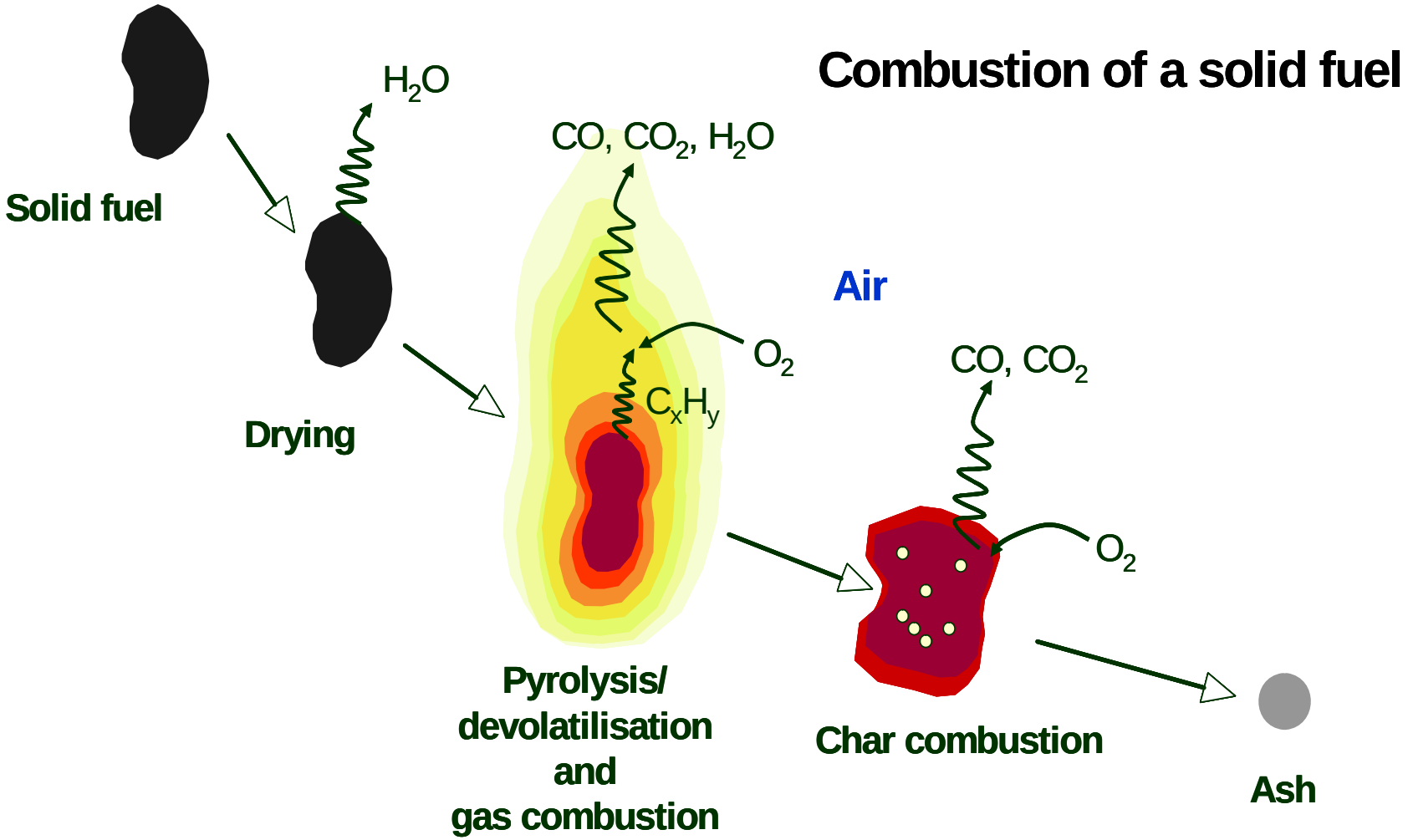
(Source: Åbo Akademi)

Single Particle Burning of Wood – 92.6 mg

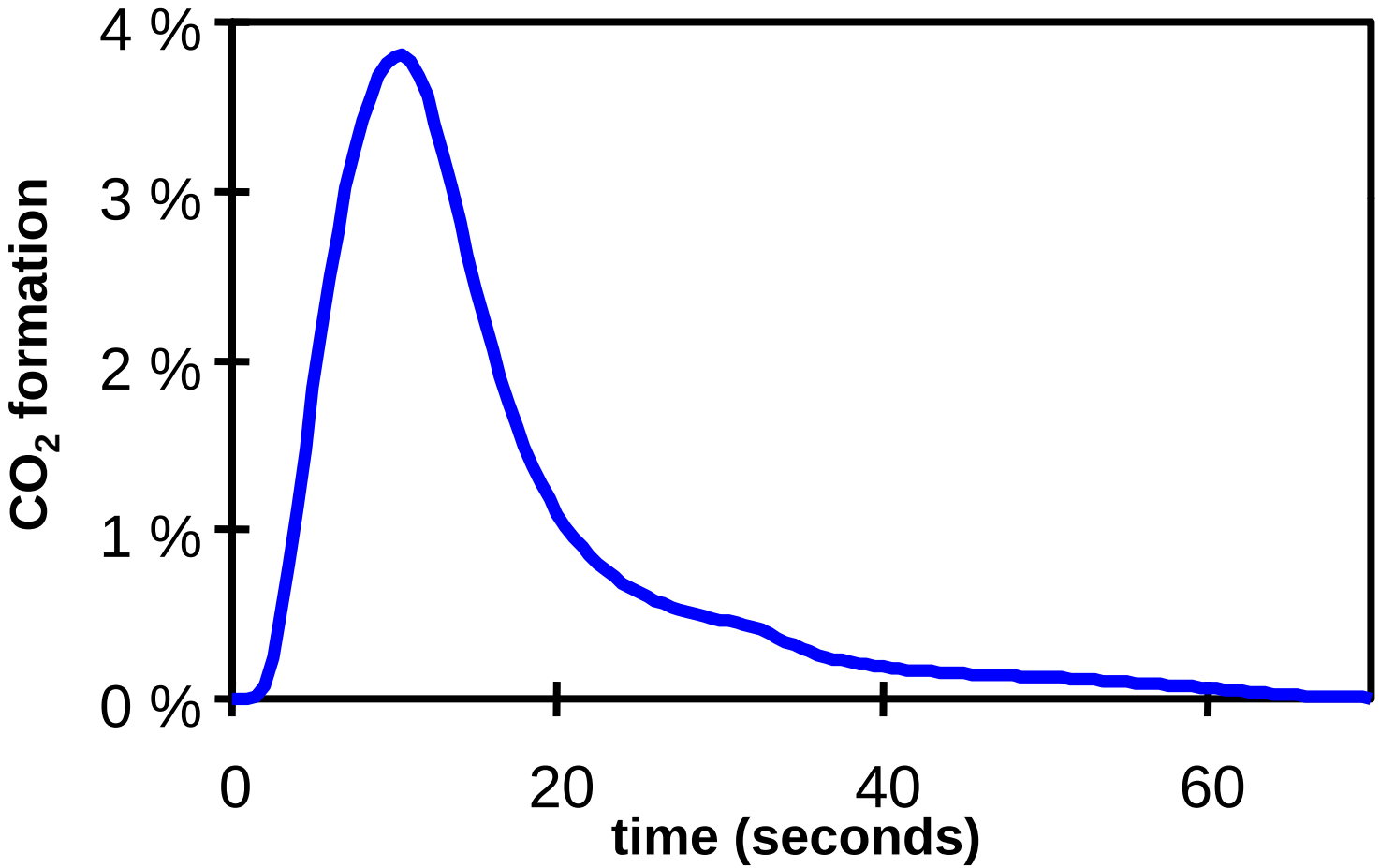
800 ºC

21 % O_2 (air)

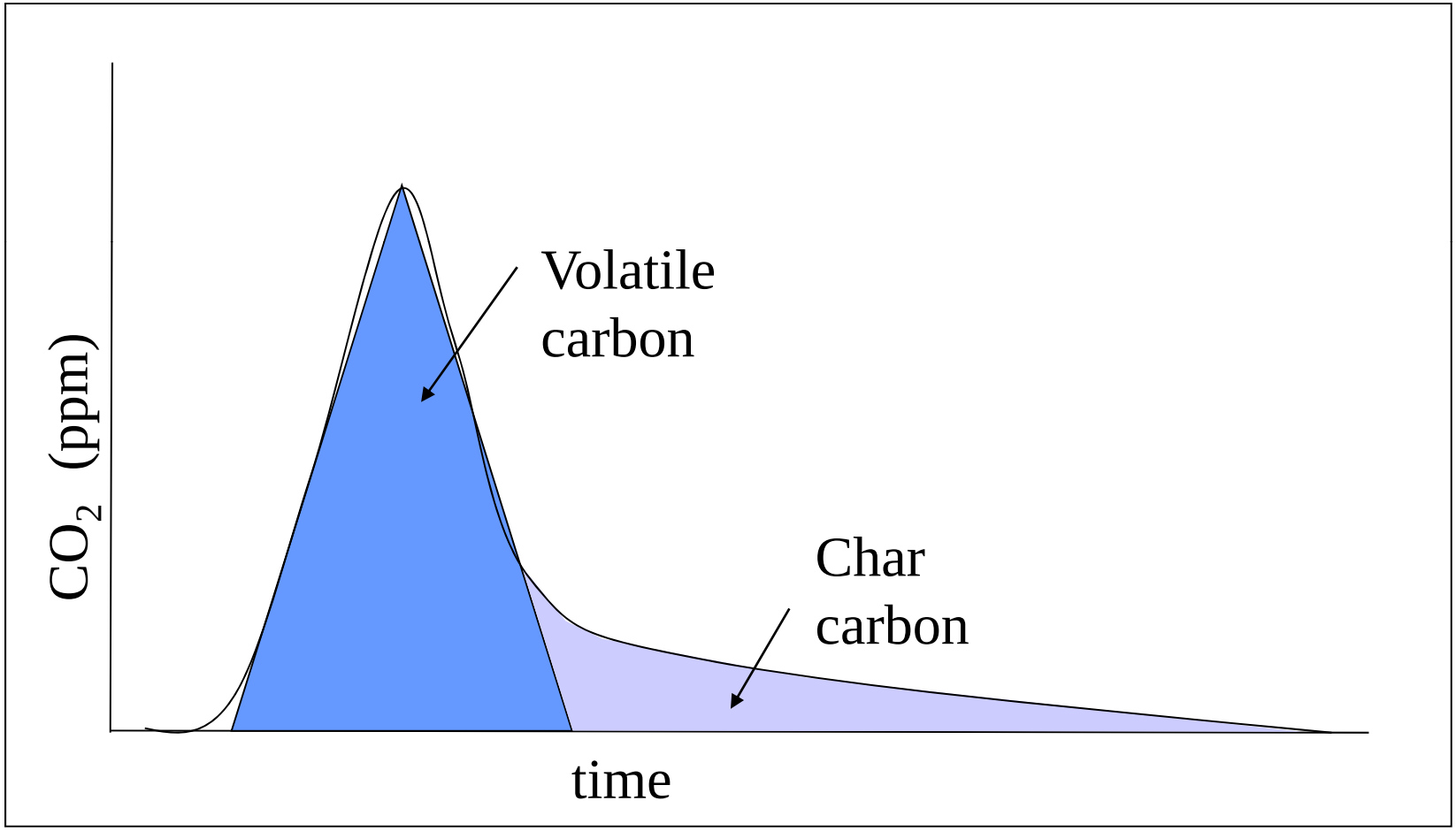
Fuel Particle Burning Stages



Single Particle Burning – On-line CO_2 Analysis



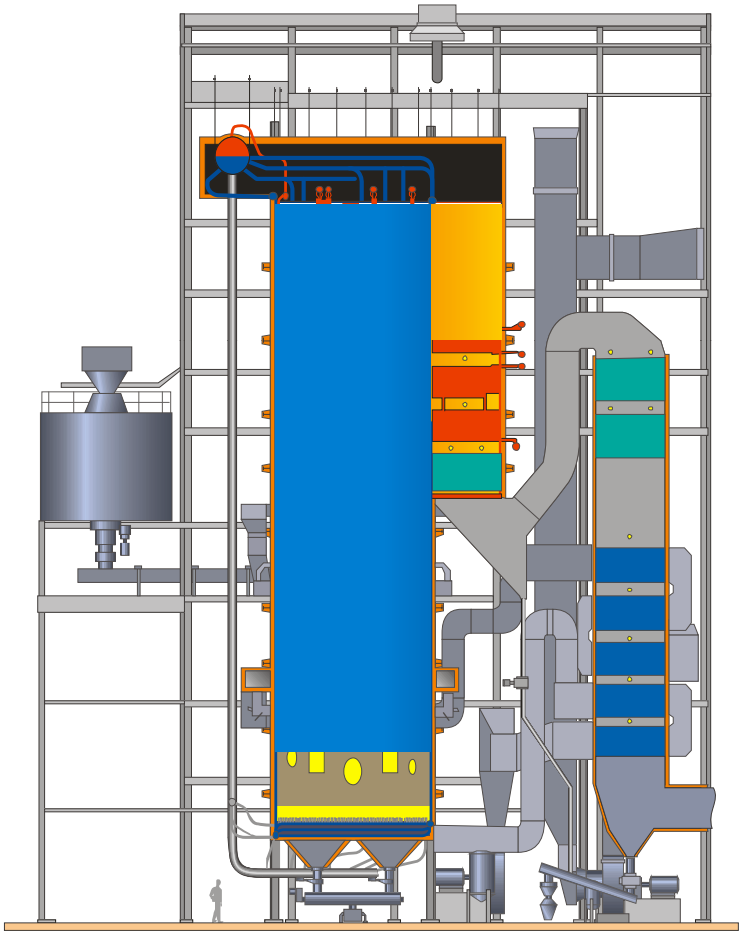
Single Particle Burning – Volatile Carbon vs. Char Carbon



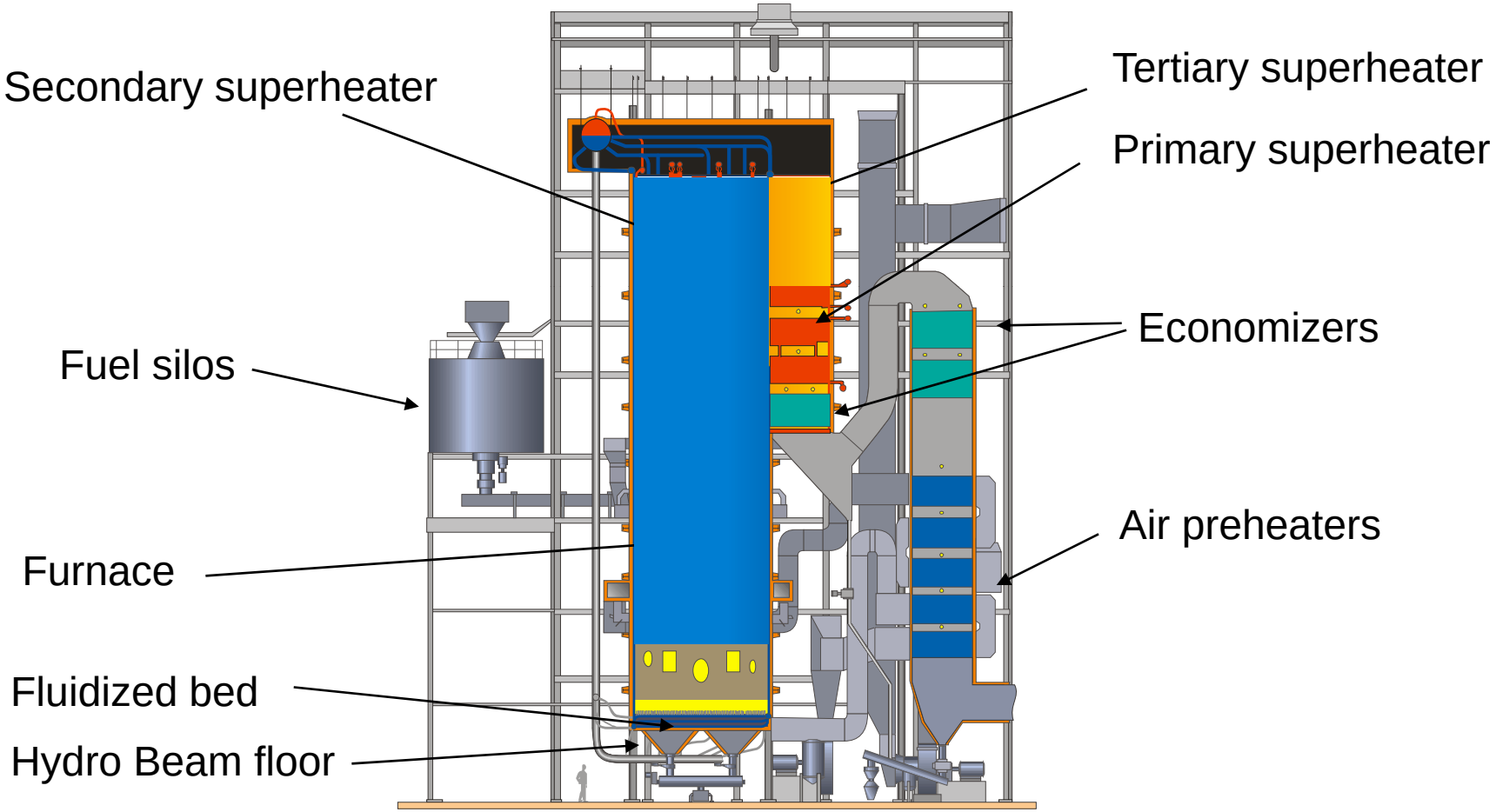
Bubbling Fluidized Bed Boiler (Metso Power)

E.ON UK
Steven's Croft Power Station
Lockerbie
UK

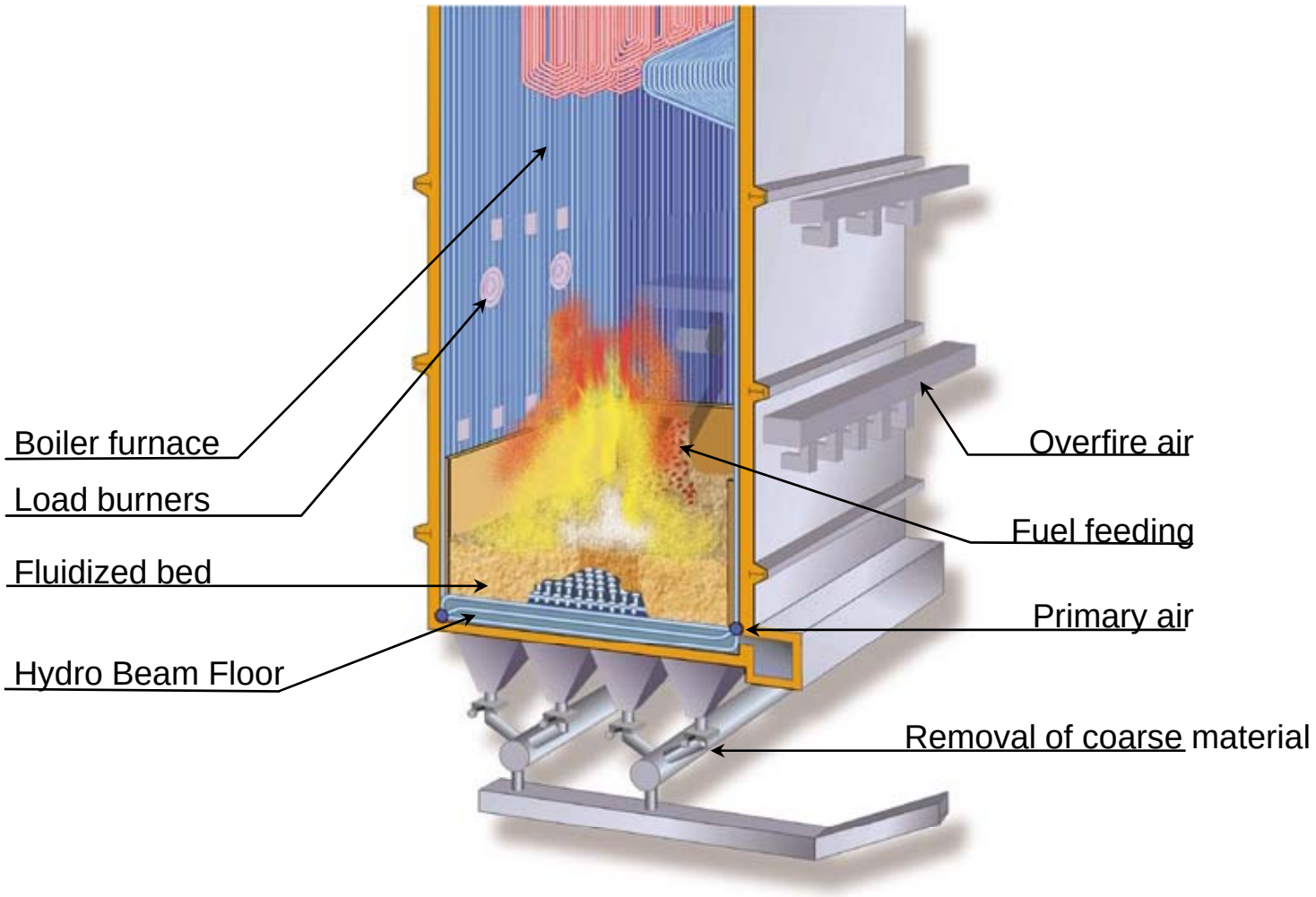
Steam	126 MW_{th} 48 kg/s 137 bar 537 °C
Fuels	Wood chips, sawdust, bark, recycled wood
Start-up	2007



Bubbling Fuidzed Bed Boiler (Metso Power)

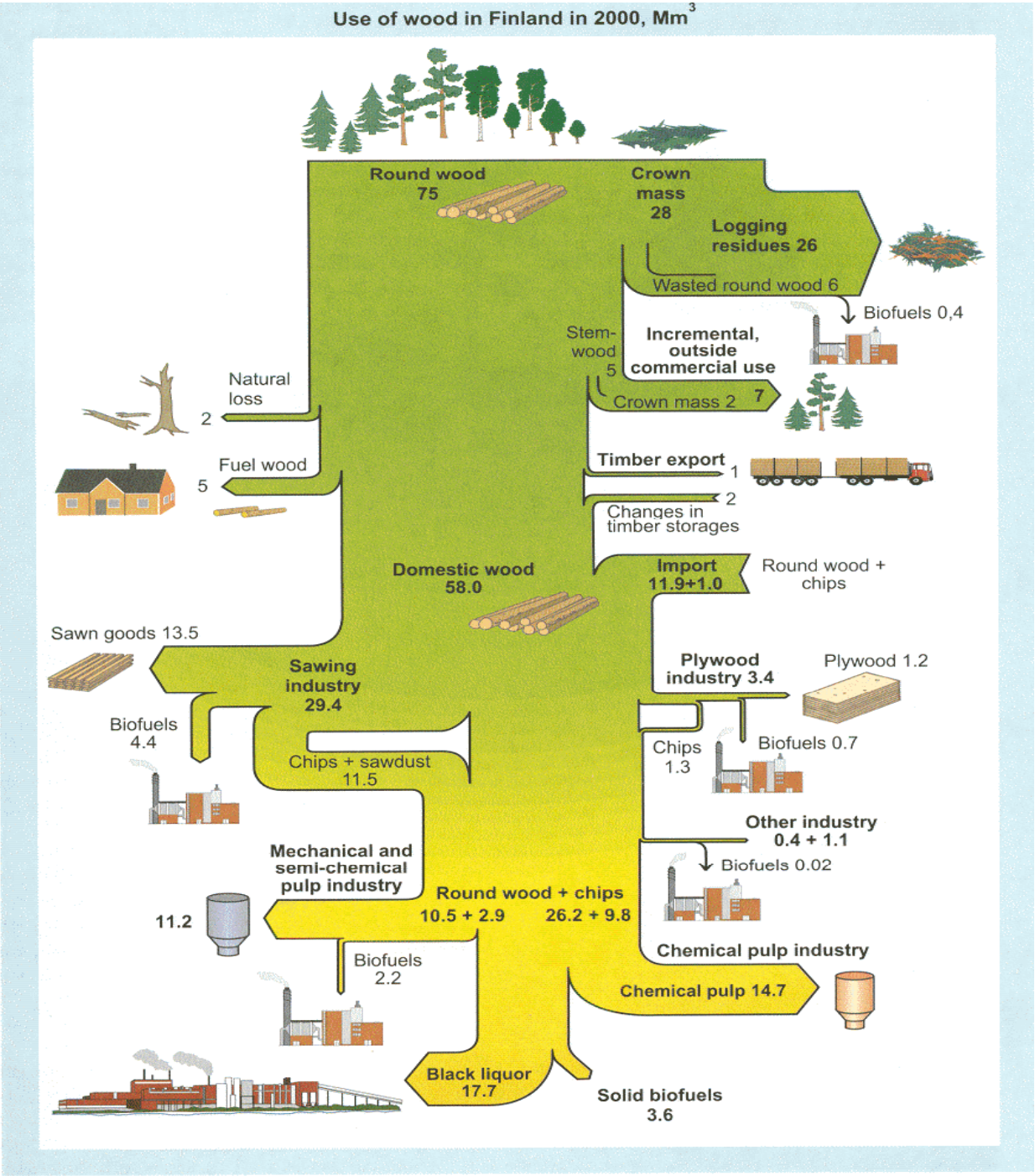


Bubbling Fluidized Bed Furnace



Use of Wood in Finland

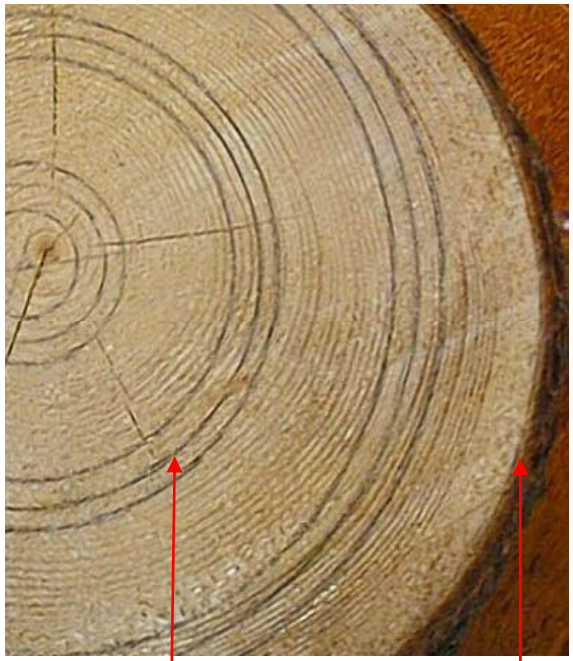
(VTT 2000)



The use of wood in Finland.


VALMET ALLIE 20m
Timberjack

Five Spruce Tissues

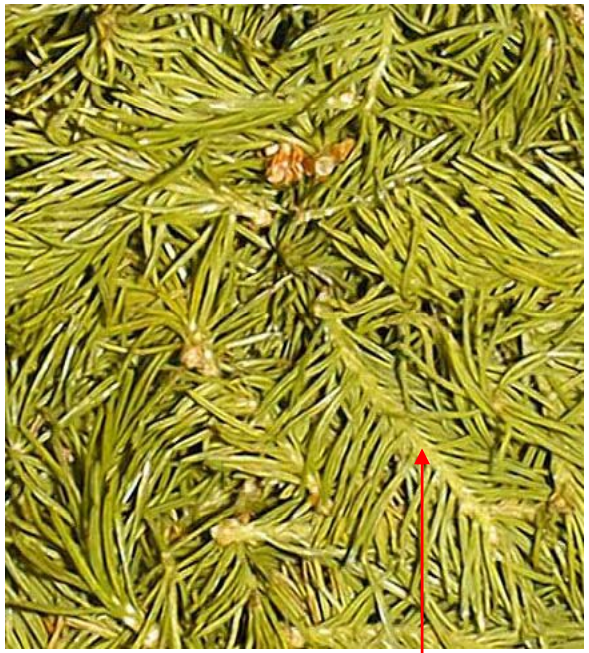


Wood

Bark

Twigs

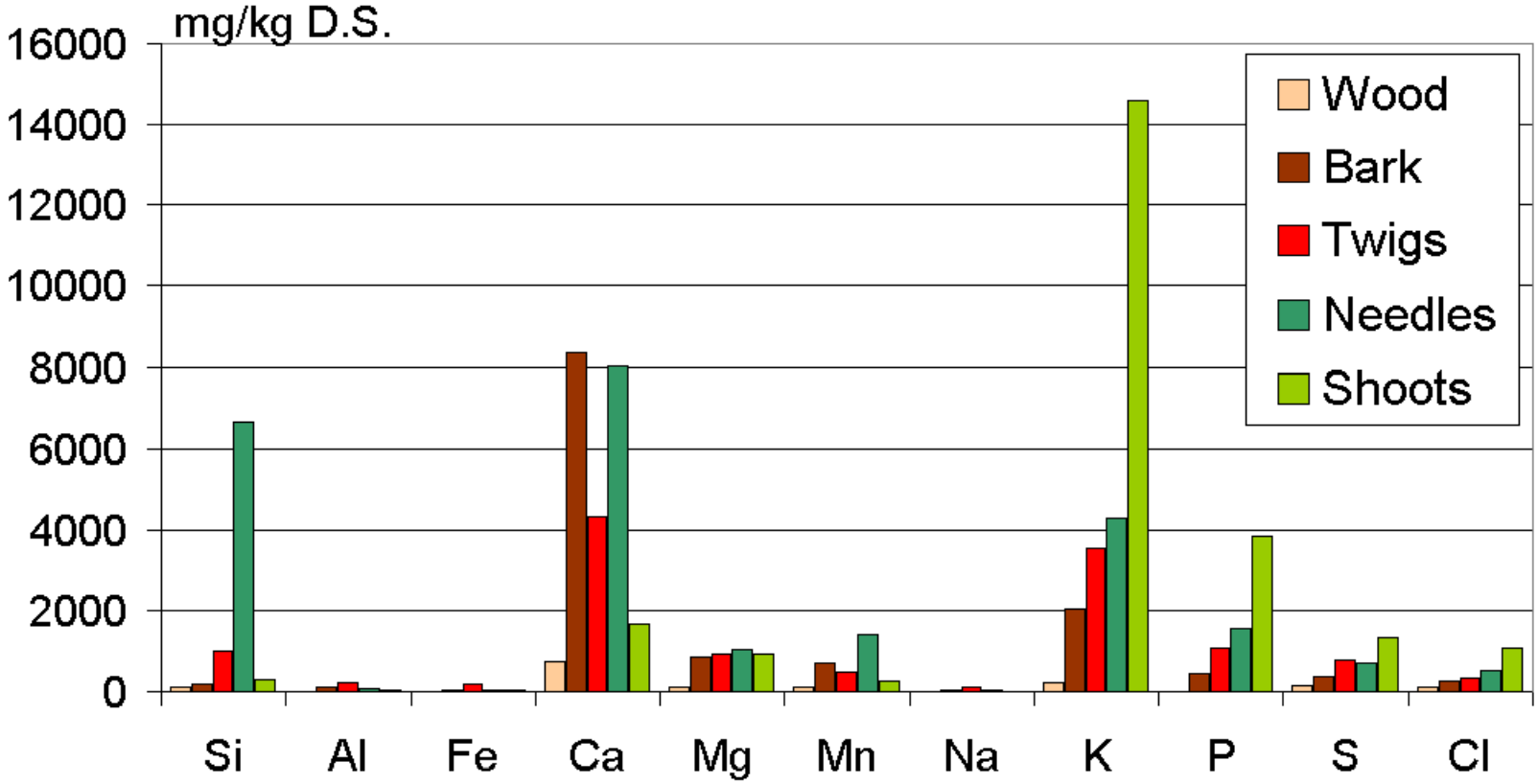
Needles



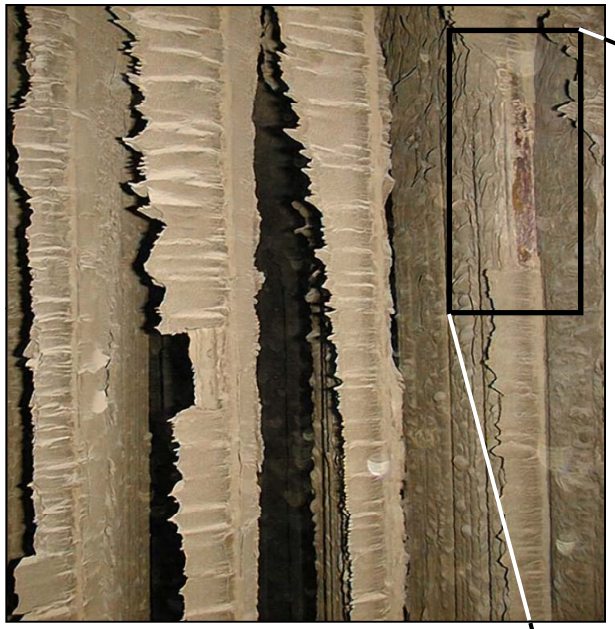
Shoots

Ash Elements in Spruce Tissues

(J. Werkelin 2005)



Fouling and Corrosion
due to Unsuitable Fuel Mixture



Summary 1: Biomass Combustion for Heat & Power

- Dominating biomass-to-energy technology
- Finland strong with FBC technology
- Research on demanding feedstocks: moisture, heating value, ash, emissions
- Research on improved power production – controlling superheater corrosion

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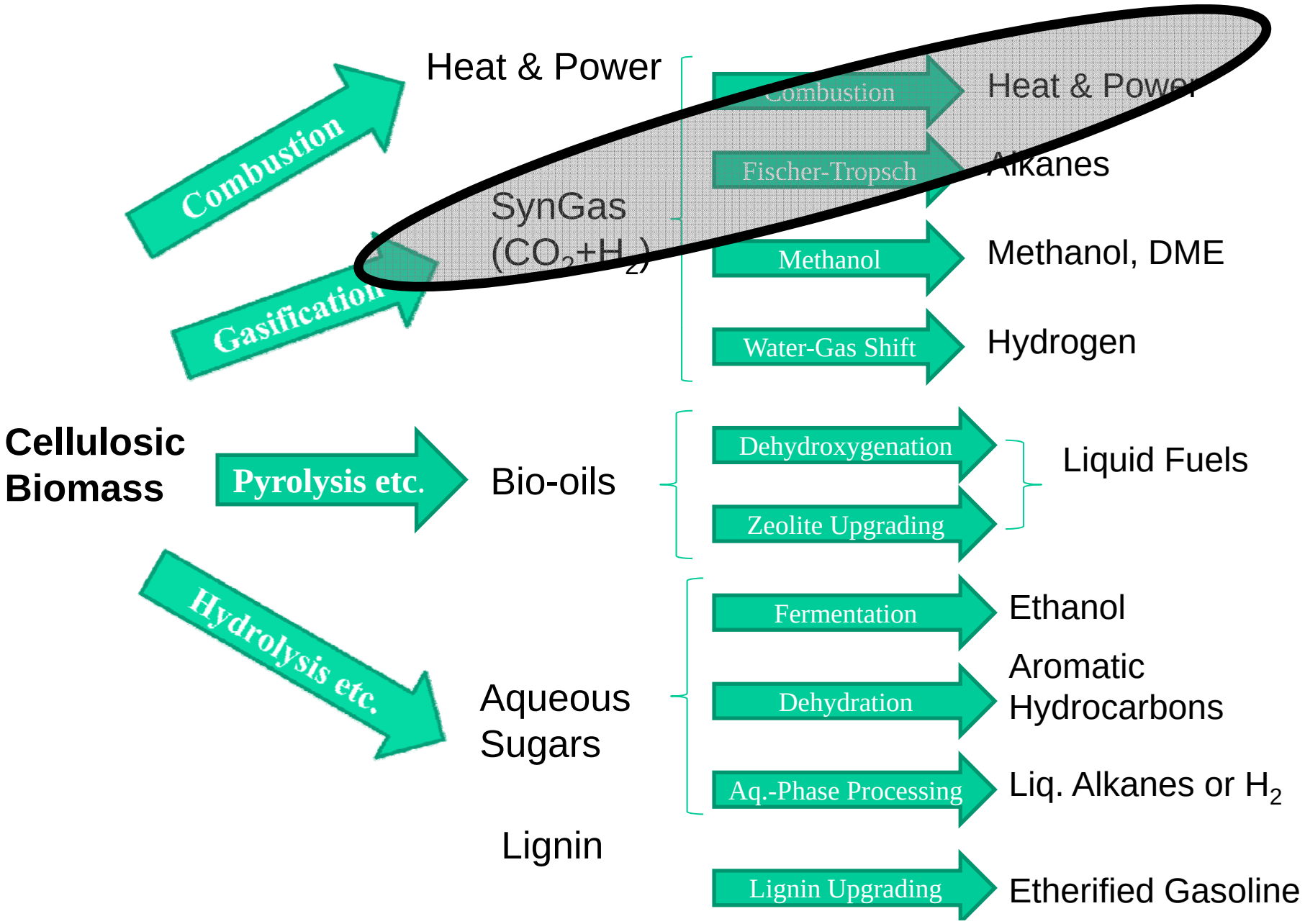
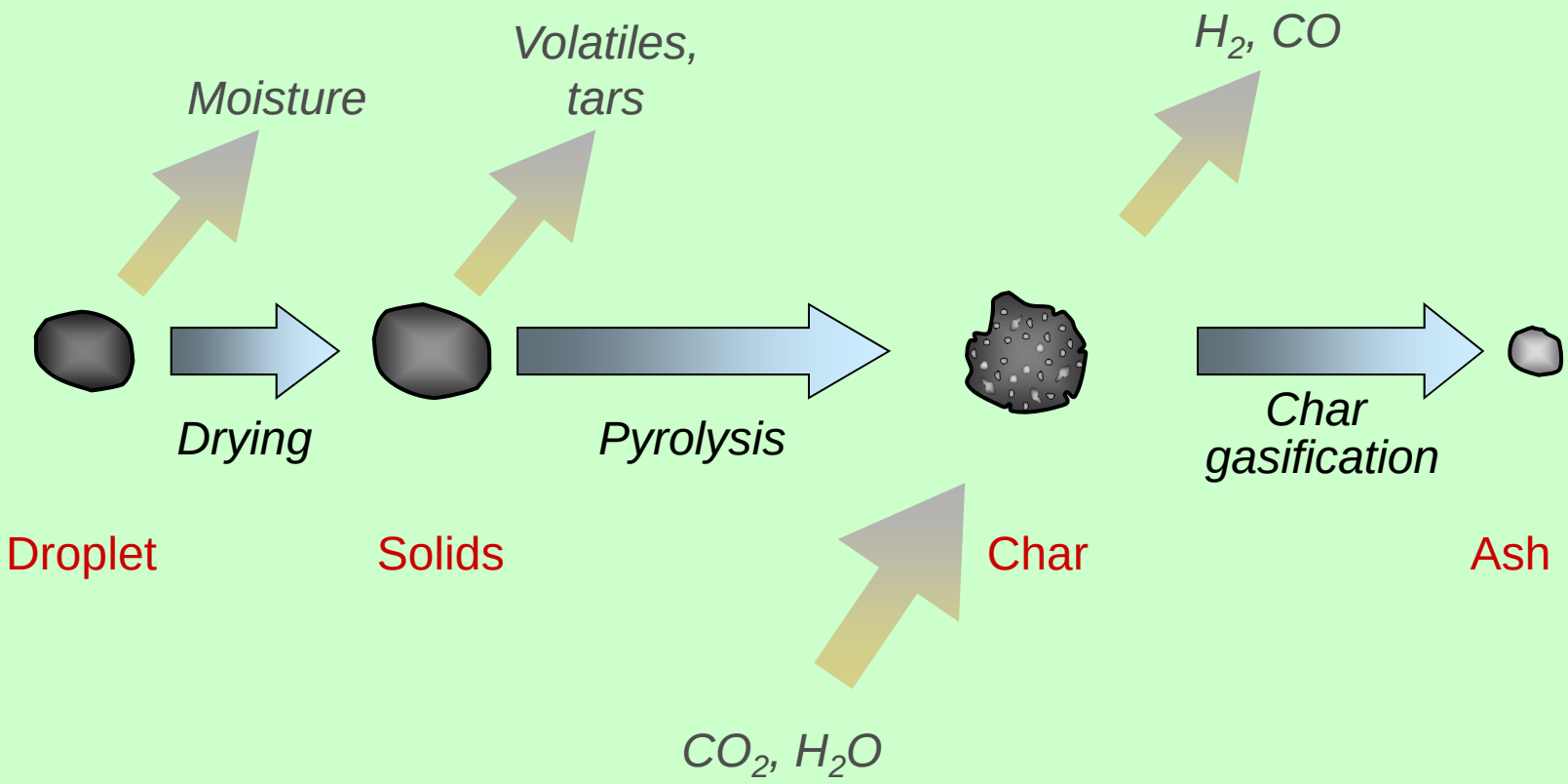
Conversion Routes for Cellulosic Biomasses



What Happens in a Gasifier?



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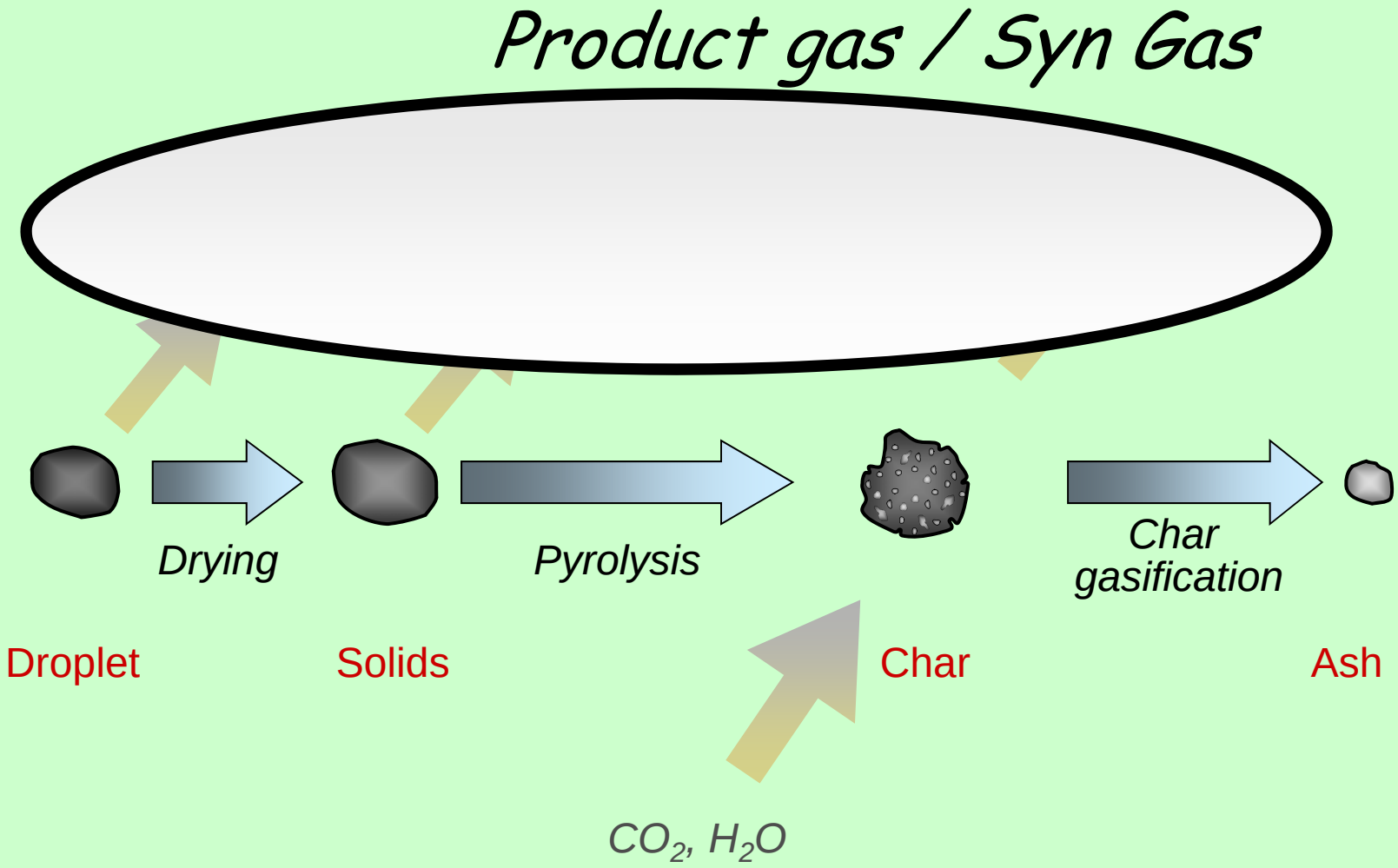
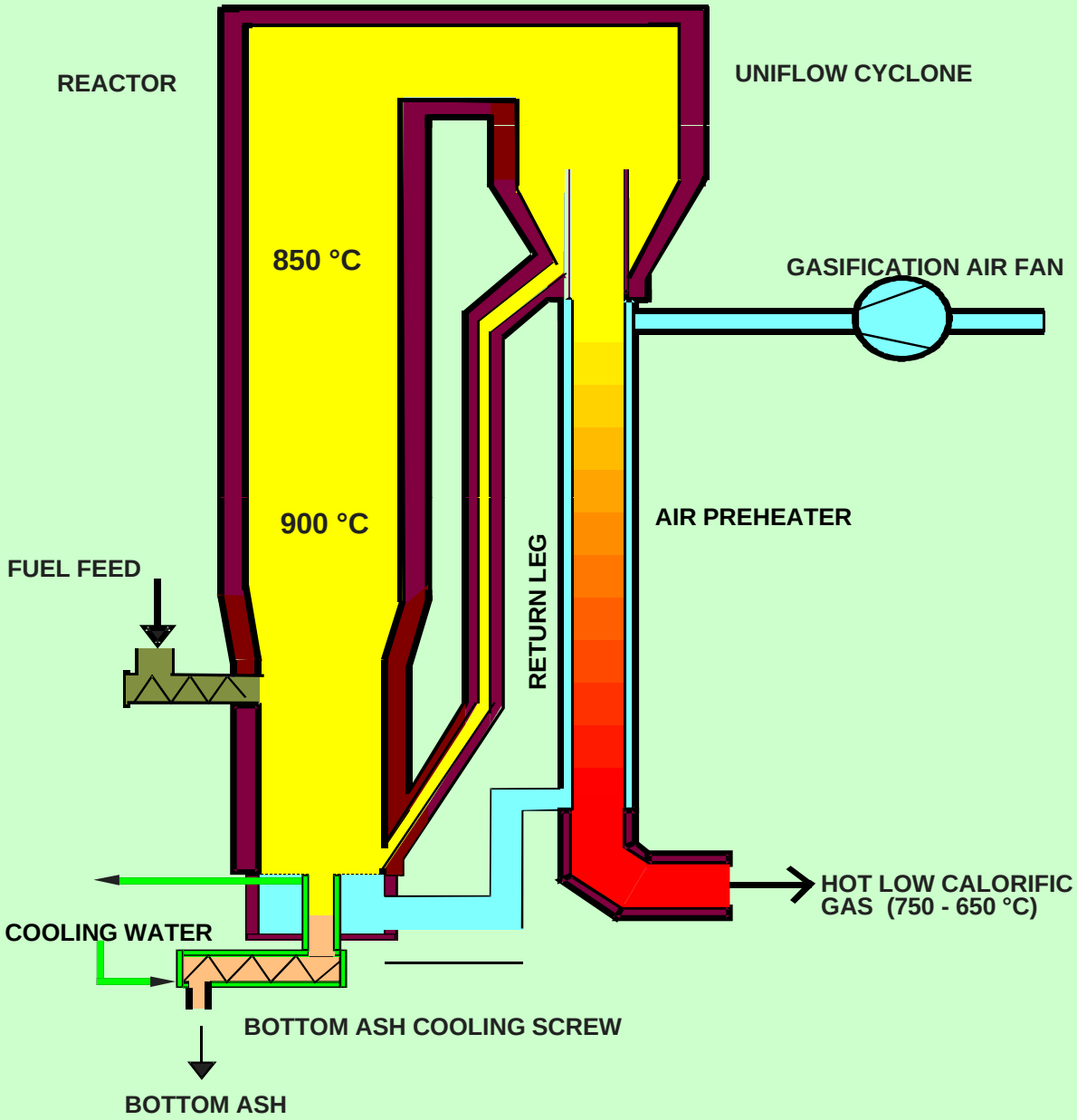
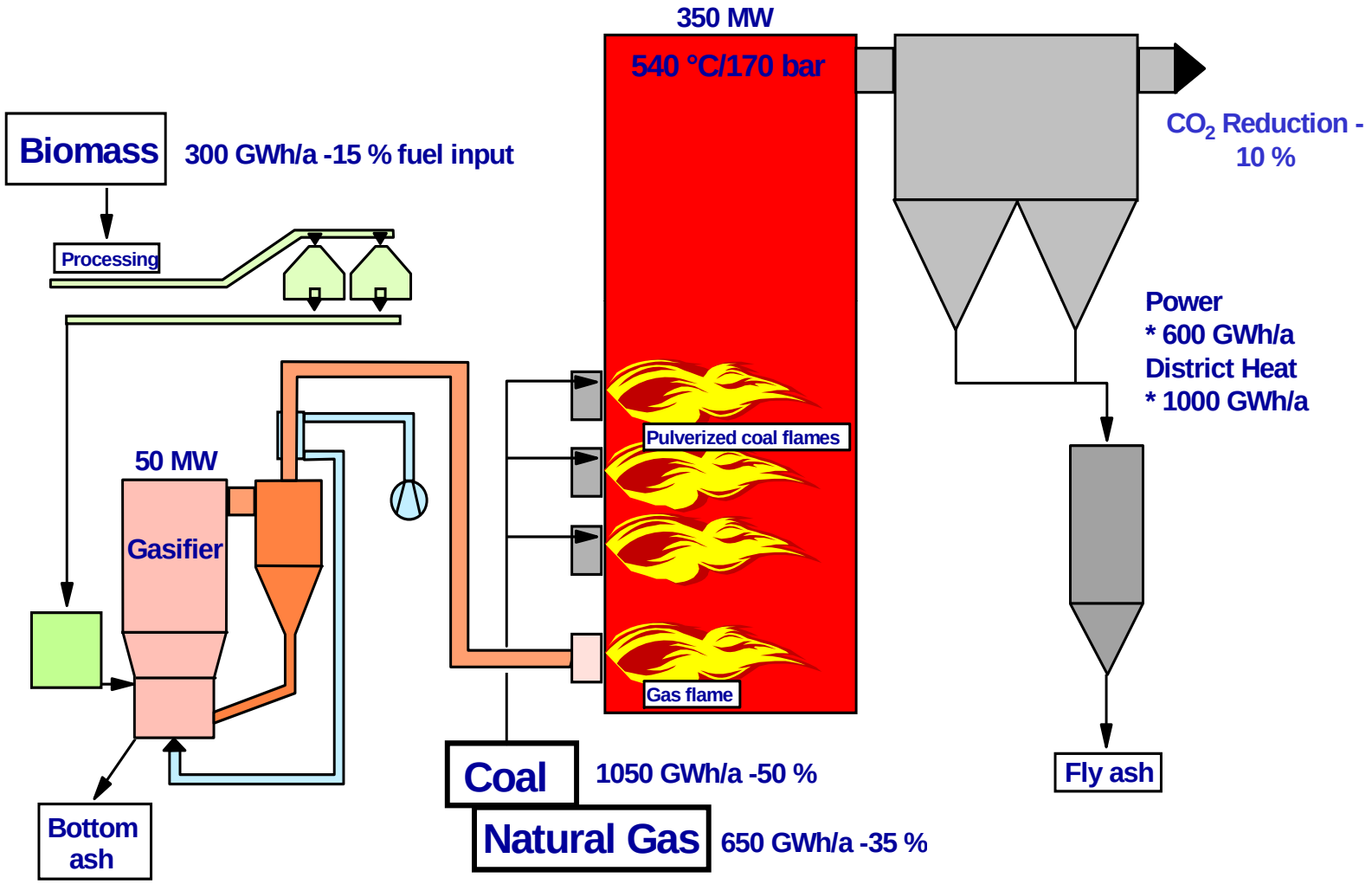


CFB Gasifier

Foster Wheeler



BIOMASS GASIFICATION - COAL BOILER - LAHTI PROJECT



Foster Wheeler

Summary 2: Biomass Gasification & Combustion of the Gas for Heat & Power

- Simple process – de facto partial oxidation of the fuel into a combustible gas mixture (air ratio 30-40 %)
- Used instead of direct combustion in special applications: lime kilns, co-firing with coal
- Challenges to achieve complete conversion of the biomass fuel

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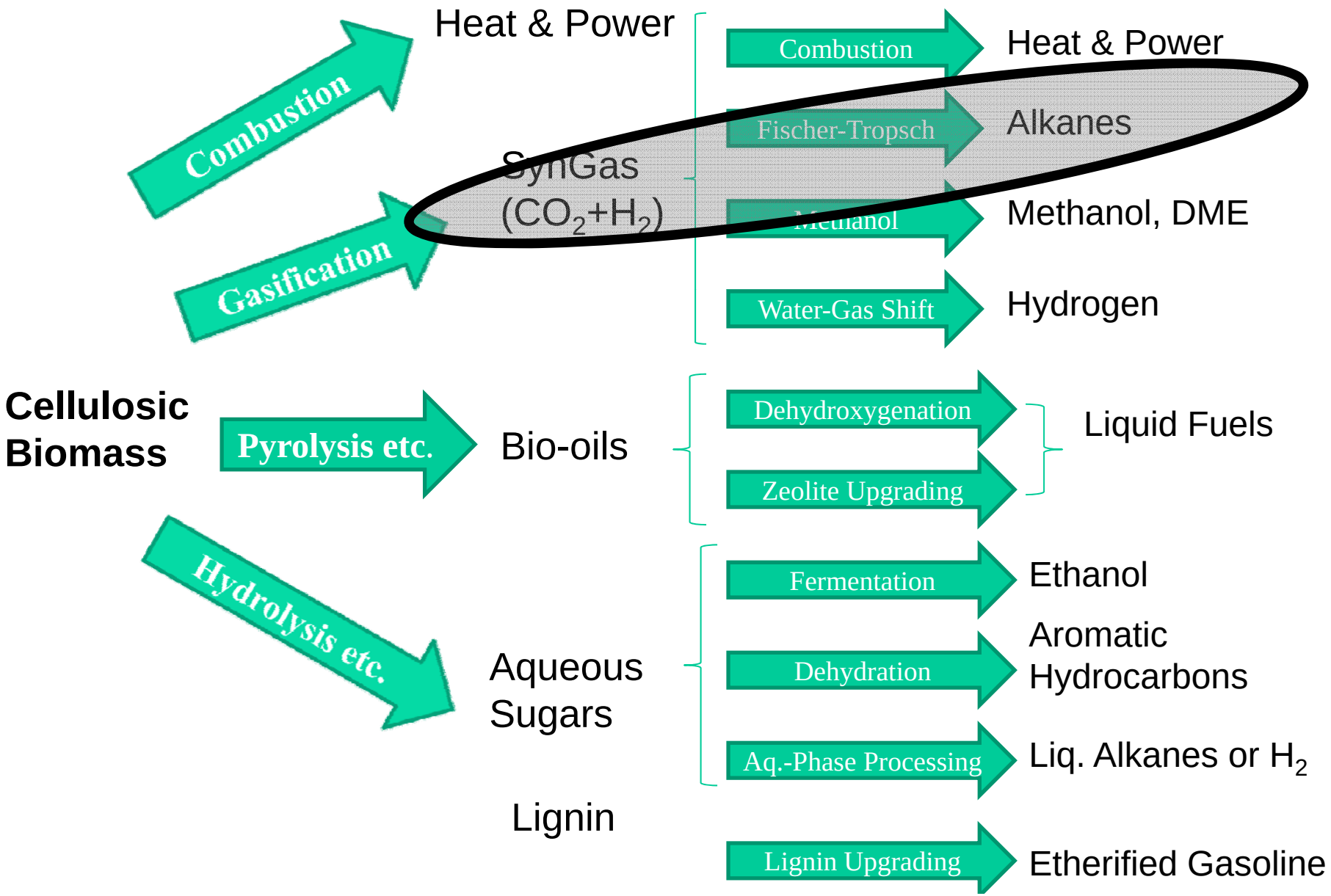
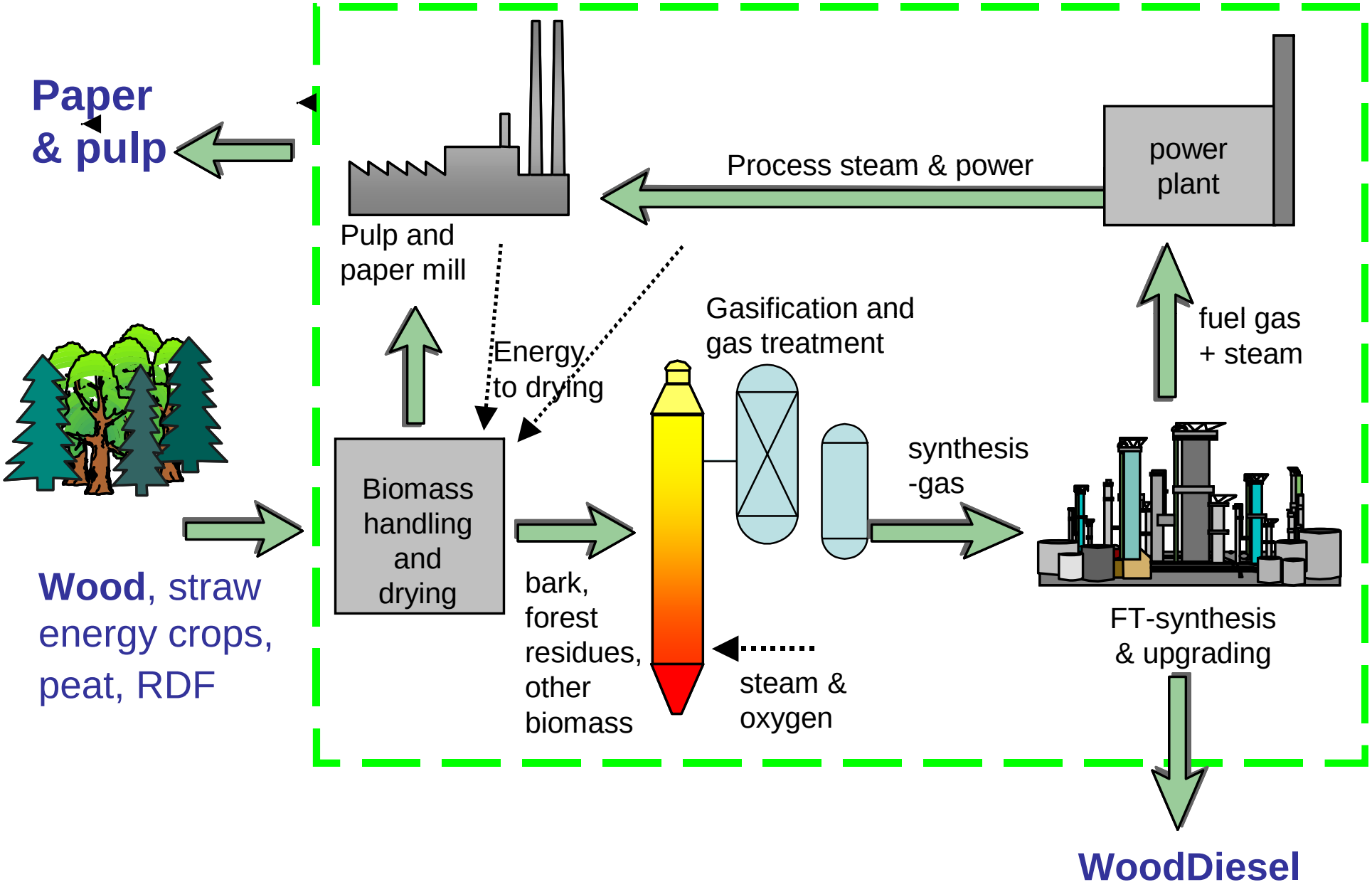
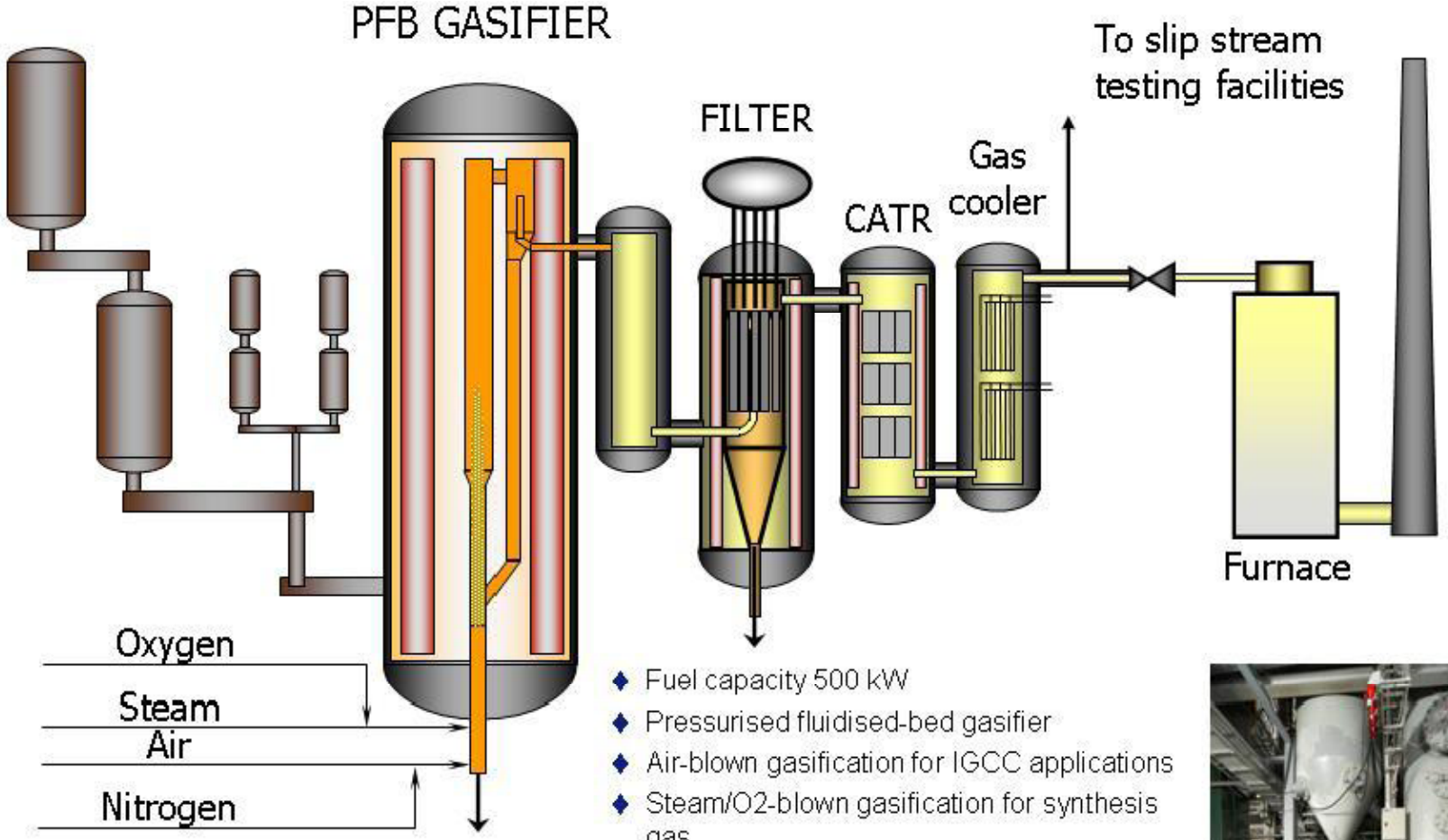


Biodiesel Production in Pulp Mill

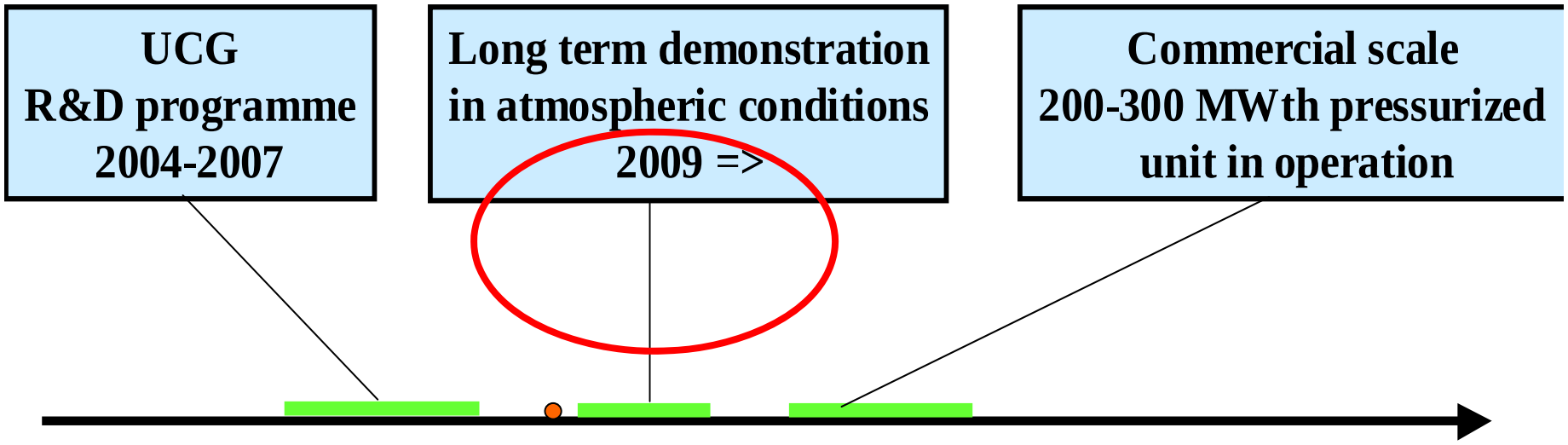


Pressurized Gasifier for Syngas Production (VTT)



- Fuel capacity 500 kW
- Pressurised fluidised-bed gasifier
- Air-blown gasification for IGCC applications
- Steam/O2-blown gasification for synthesis gas
- Advanced High-Temperature Filtration
- Catalytic reforming of tars and hydrocarbon gases
- Slip-stream gas purification, conditioning and synthesis testing

Stora Enso - Neste
BTL Gasification Projet



Biomass Gasifier for Biodiesel
Demo by Stora Enso – Neste in Varkaus, Finland

Summary 3: Biomass Gasification for Synthesis gas and Liquid Biofuels

- Under development – no plants in operation (applied for coal in South-Africa)
- Demanding technology: Pressurized, oxygen blown gasifier
- Advanced syngas cleaning
- Various options for synthesis: FT Diesel, Methanol, DME
- Very hot topic – political pressure

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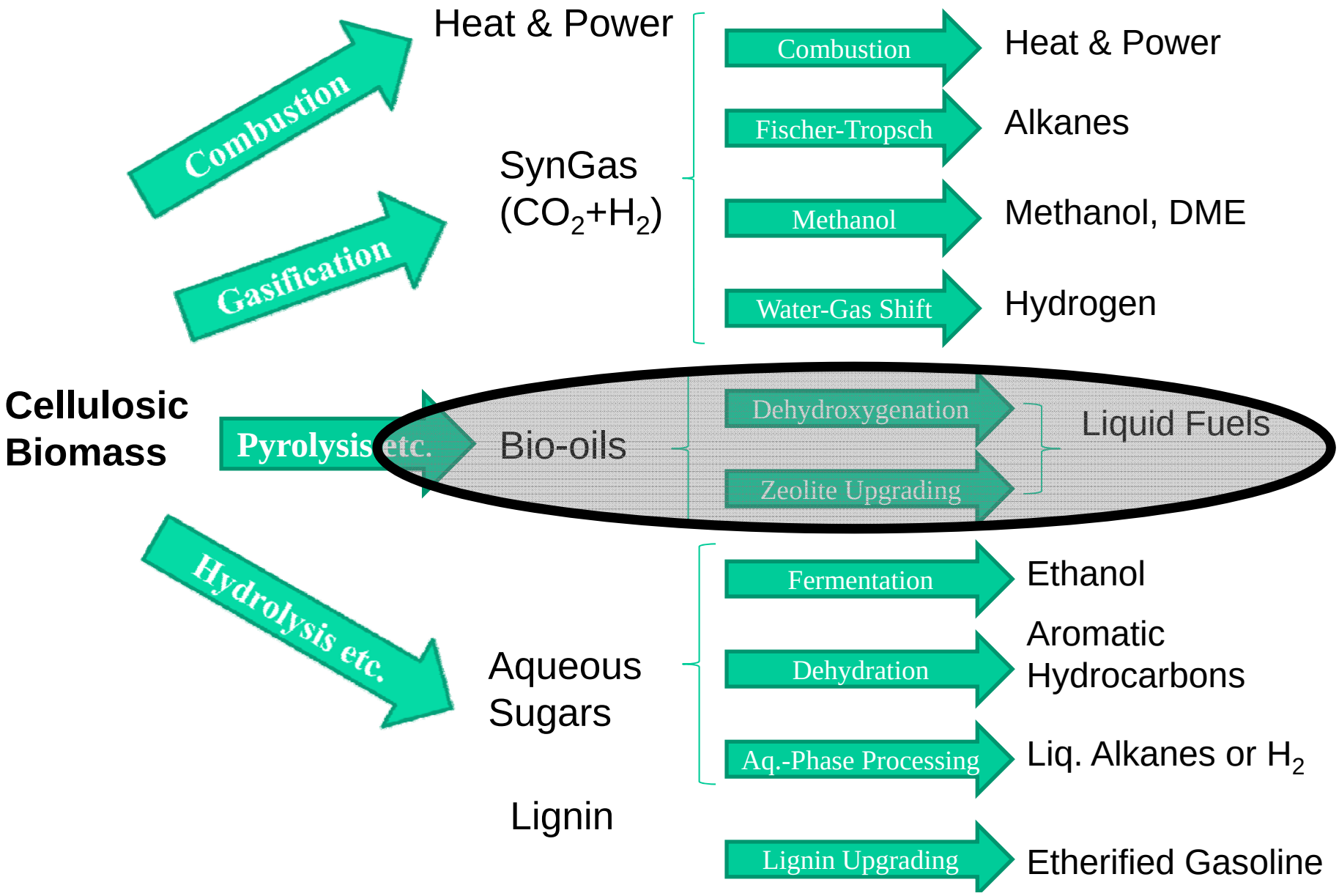

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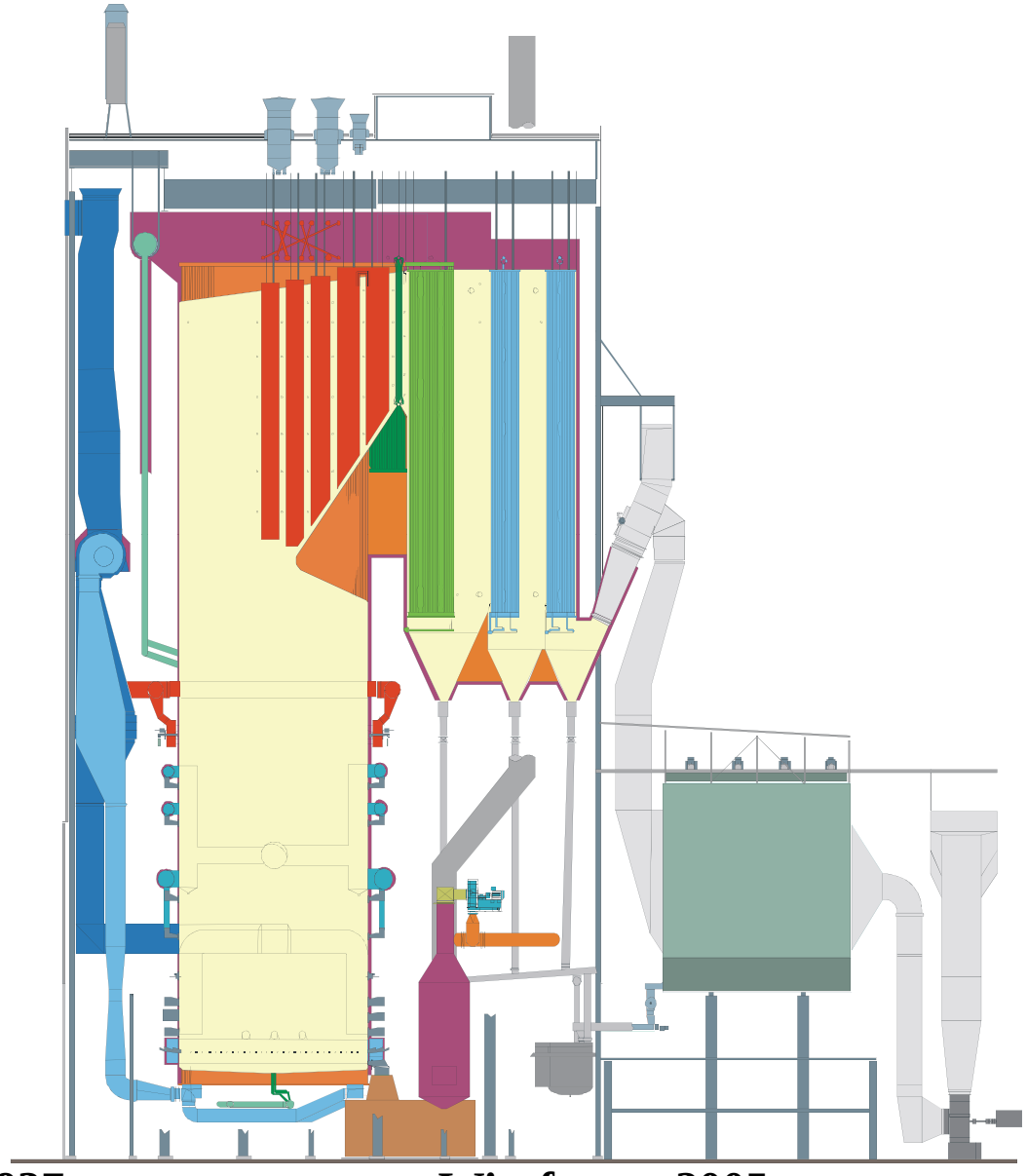
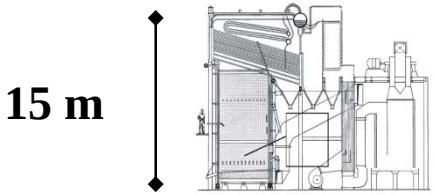




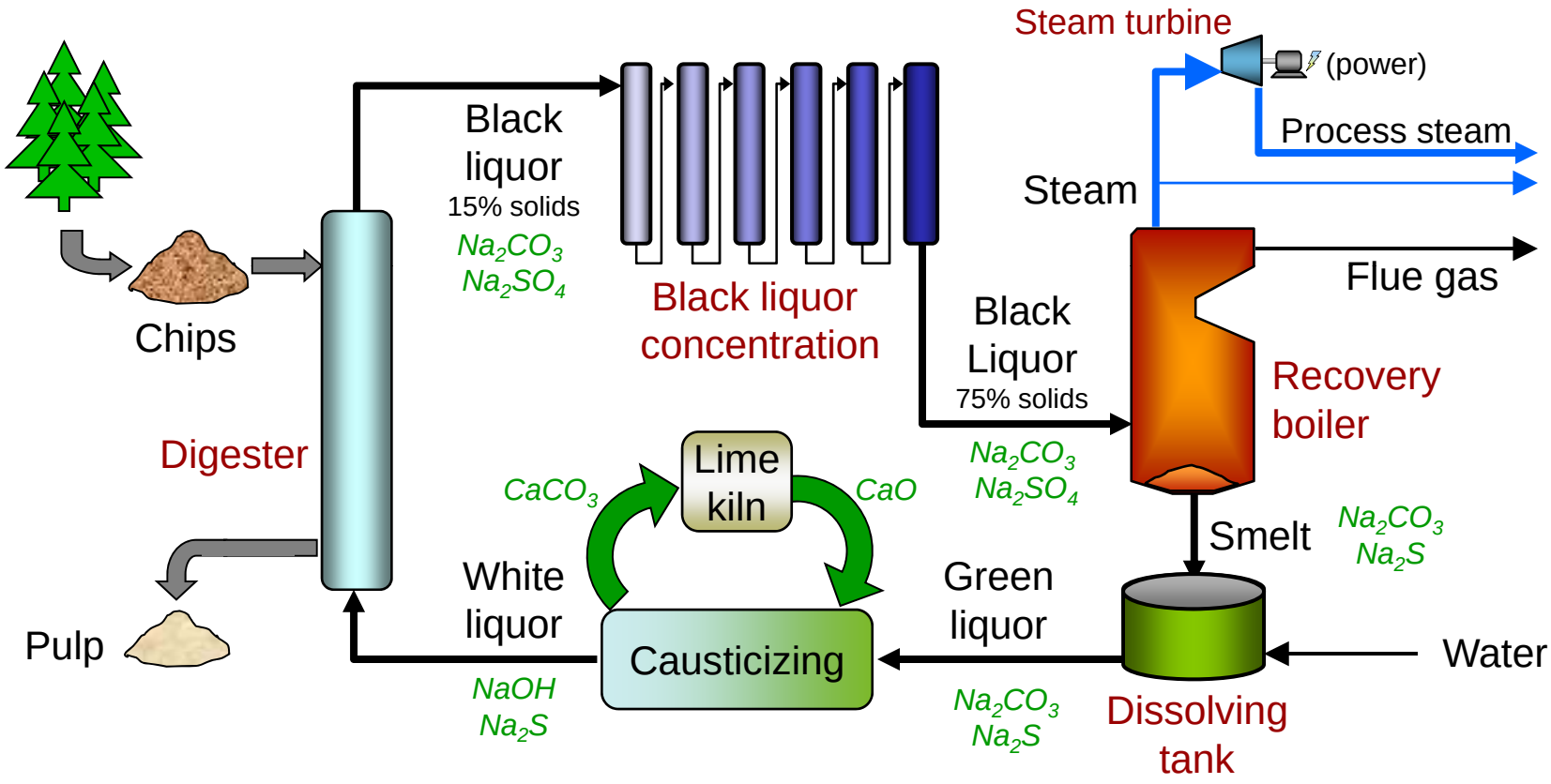
Tomlinson kattila, 1937

Wisaforest, 2005

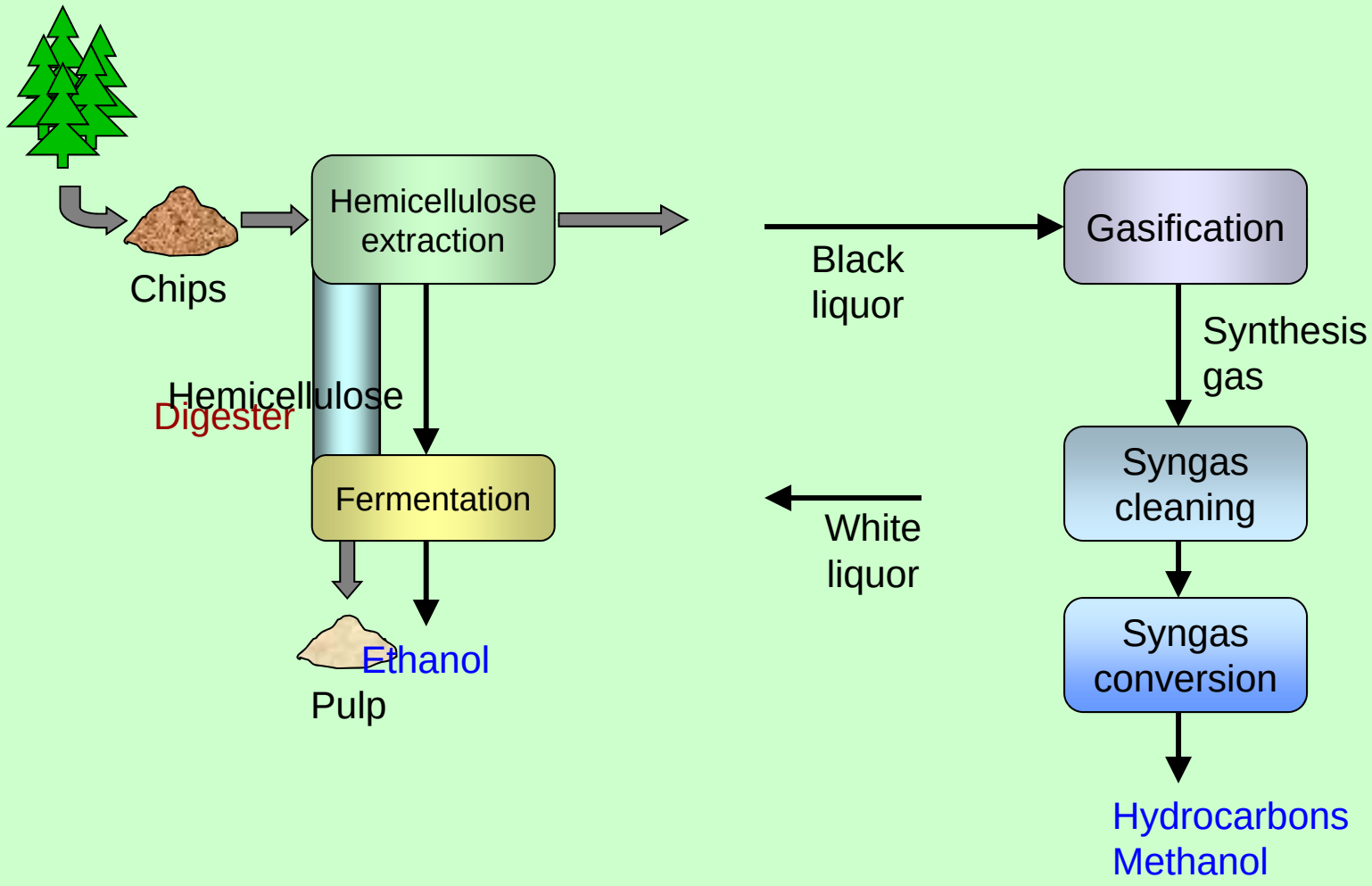
Fray Bentos, Uruguay (Andritz)

Hainan Jinhai, Kiina (Metso 2007)

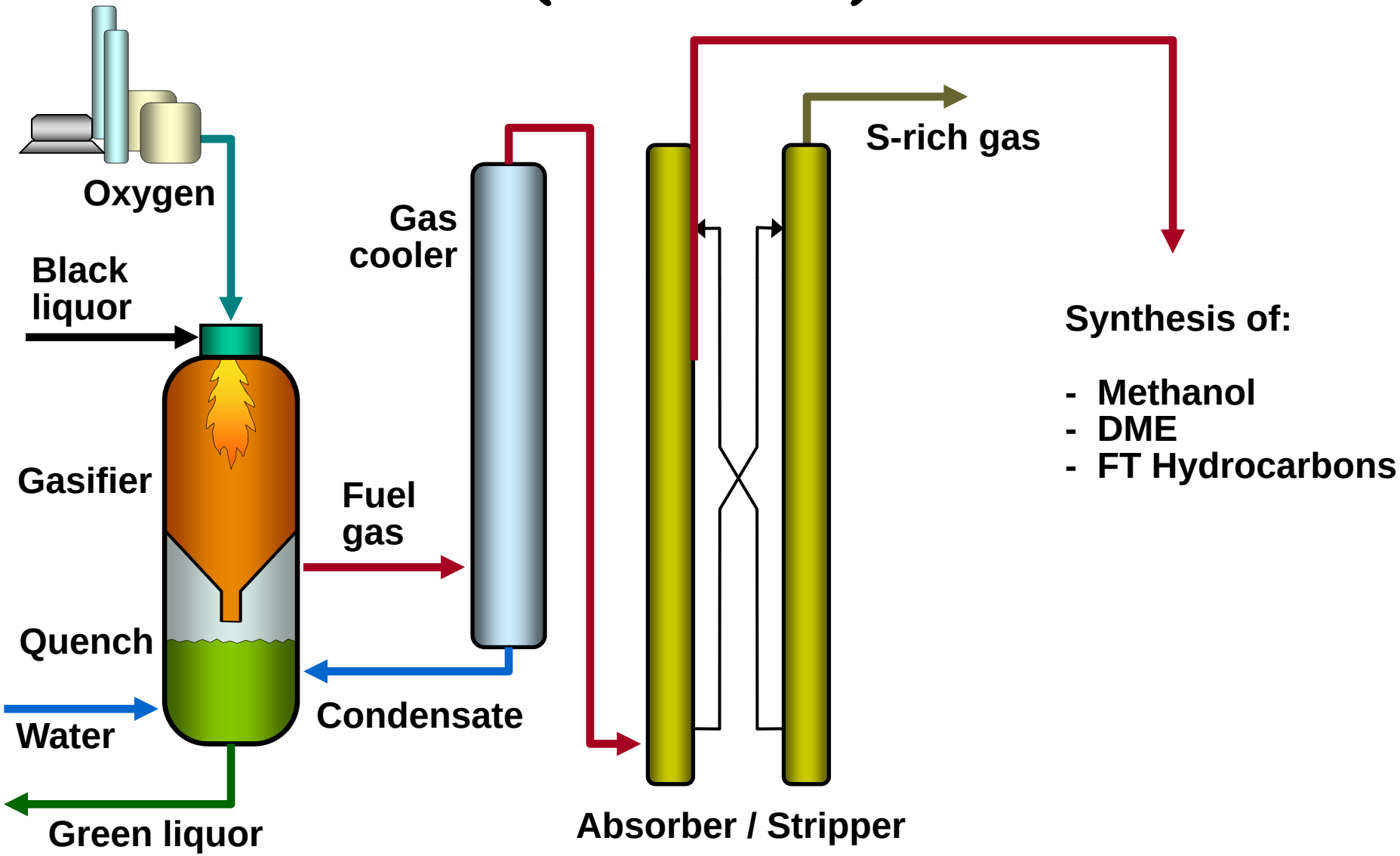
Kraft Pulp Mill



The Pulp Mill as a Biorefinery for Production of Transportation Fuels



Black Liquor Gasification for Syngas (Chemrec)



Summary 5: Biorefinery & Energy

1. Biomass molecules can be extracted as valuable chemicals (fractionation)
2. Biomass can be converted thermally to heat and/or power
   - combustion (commericial)
   - gasification for combustion (commercial)
3. Residues may also be used for production of liquid biofuels:
   - pyrolysis for bio-oil (under development)
   - gasification for synthesis (under development)
4. Need for intense research: The devil is in the (chemical) details