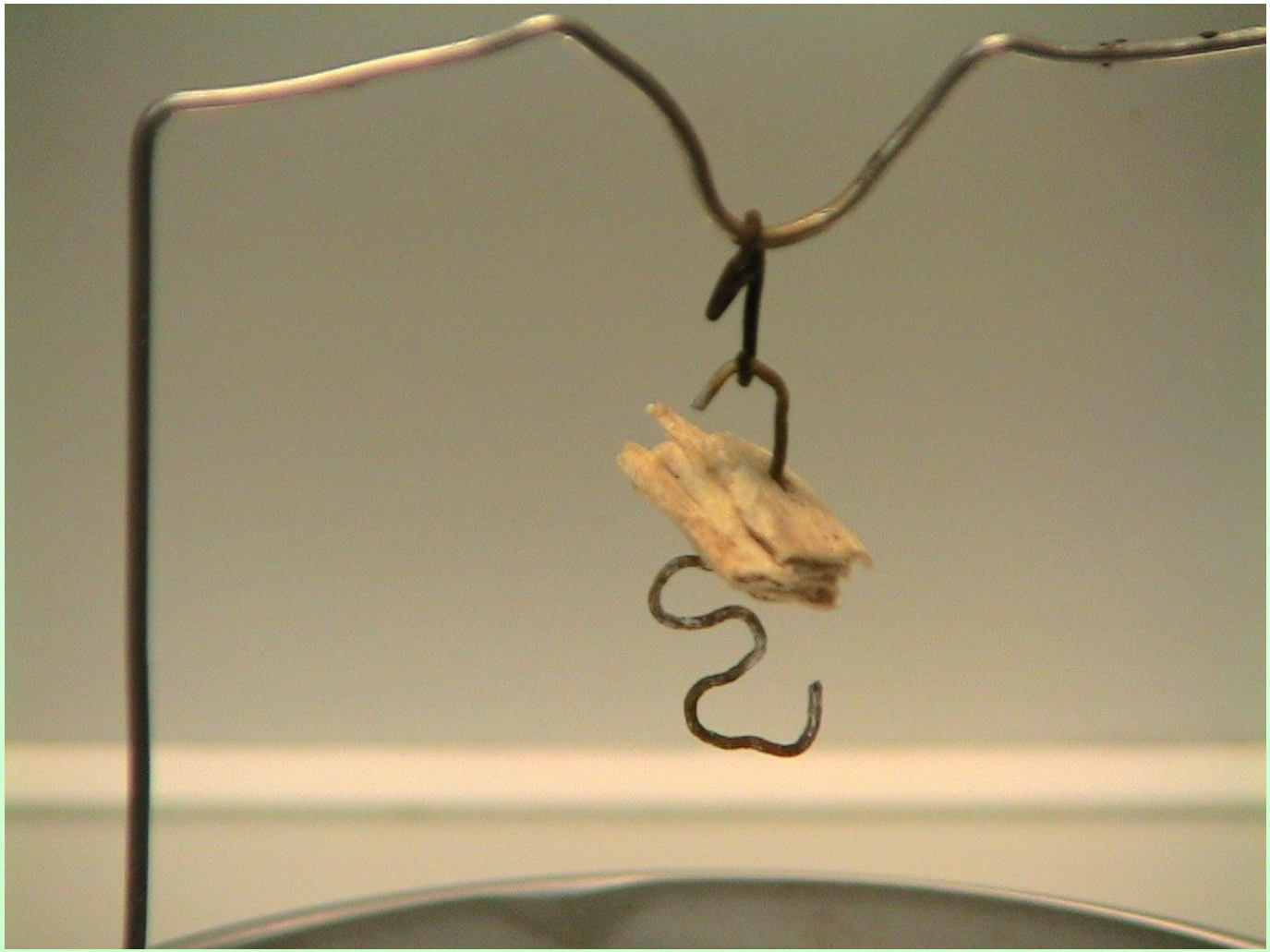
Resurscenter
för matematik, naturvetenskap och teknik i skolan
Vasa

"Energi"
Sommarkurs för kemi- och fysiklärare
5.6.2013 Vasa

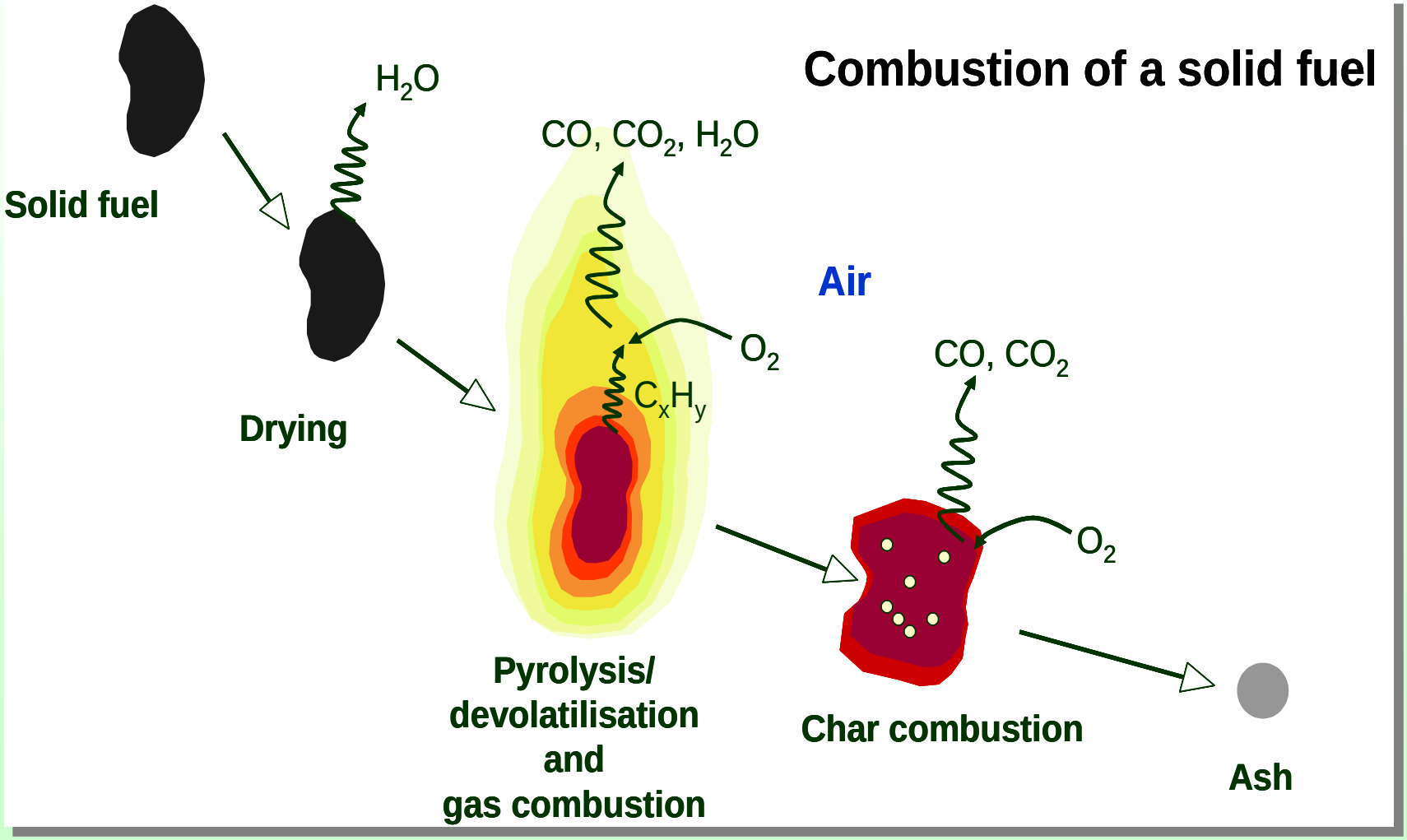
Bioenergi idag och i framtiden

Mikko Hupa
Åbo Akademi
Turku, Finland

Förbränning av en träpartikel 800 C, luft



Fuel Particle Burning Stages

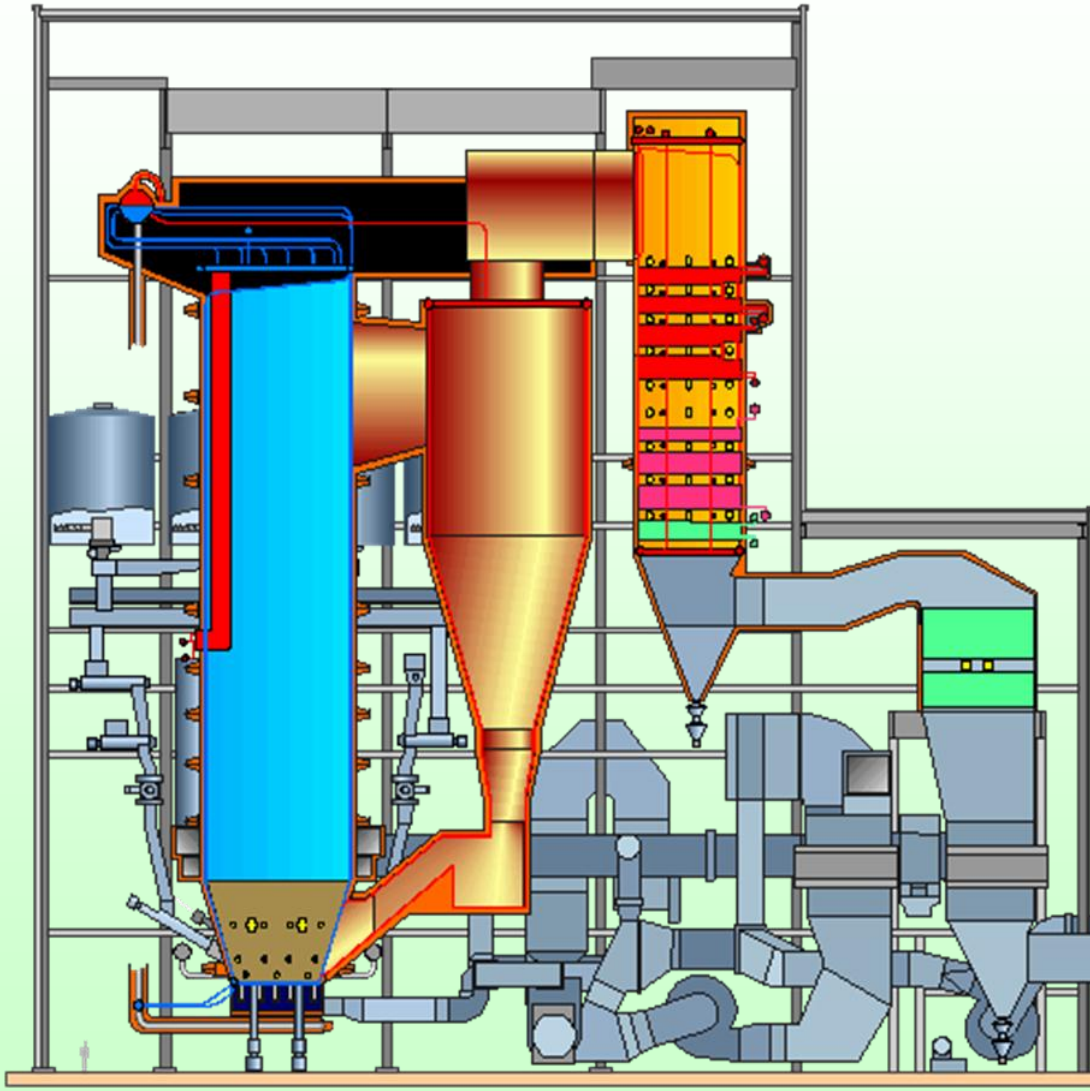


Fray Bentos, Uruguay (Andritz)

Alholmens Kraft – fluidicerad bädd panna

590 MW (545 C 165 bar)

Torv, bark, REF, skogsavfall, sågspån, kol, olja

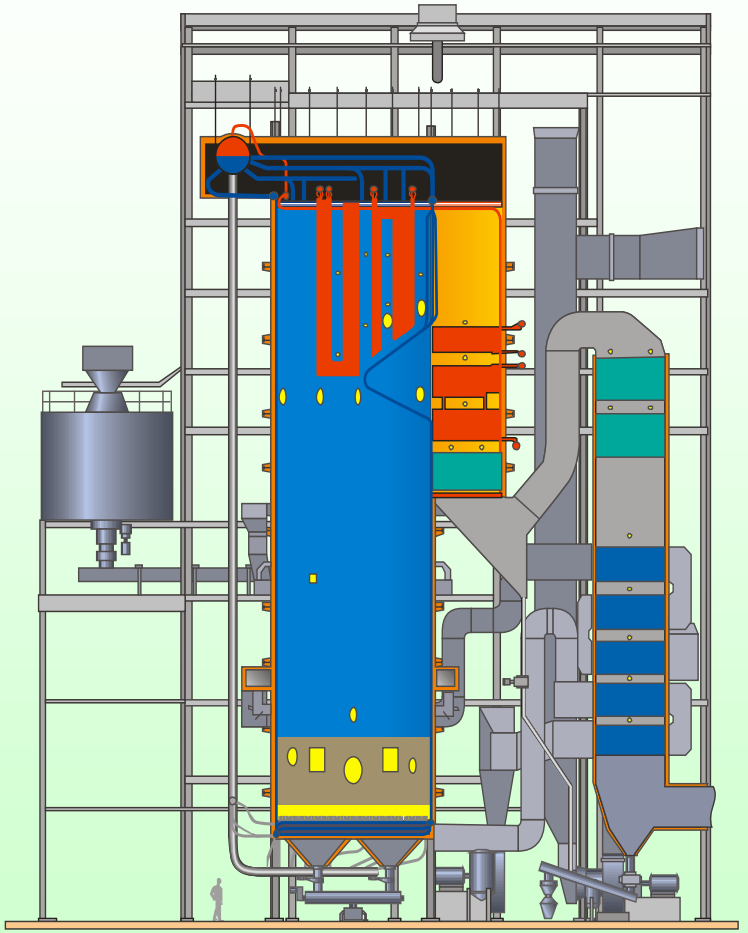


Metso Power

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



Bioenergiteknologi – Finlands styrkor

- Storskalig biomassaförbränning – fluidicerade bäddar
- Svartlut – sodapannor
- Dieselmotorer – biobränslen

- Nya tekniker: förgasning, pyrolys...

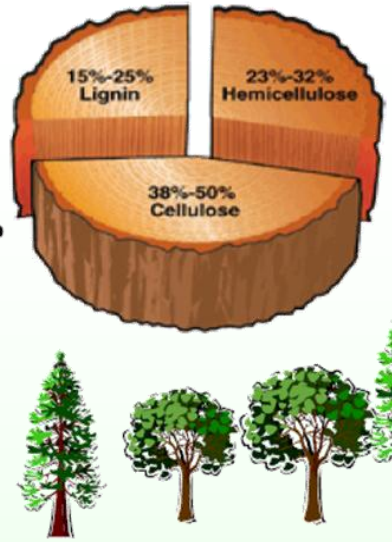
FBC video

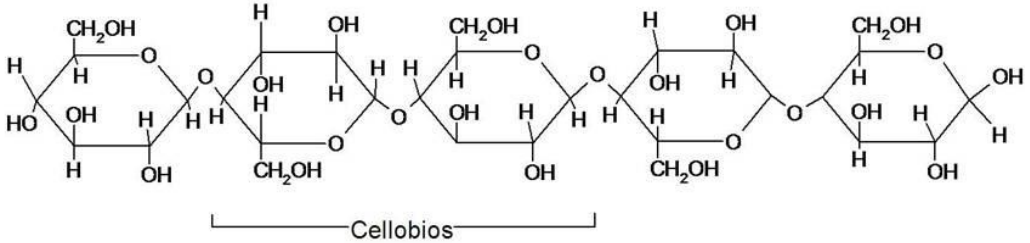
Solid Fuel Characteristics

Fuel	Typical Water content (Wt %)	Heating Value (MJ/kg)	Density (kg/m^3)
Straw	15	14 – 15	100
Straw + grains	15	14 – 15	200
Grains	15	15	700
Straw pellets	8	16	600
Wood chips	40	10 – 11	200 – 300
Saw dust	20	15	160
Wood pellets	6	17 – 18	660
Coal	10	25 - 28	800 - 1000

The energy specific volume of straw (vol/MJ) is approx. 20 times coals!

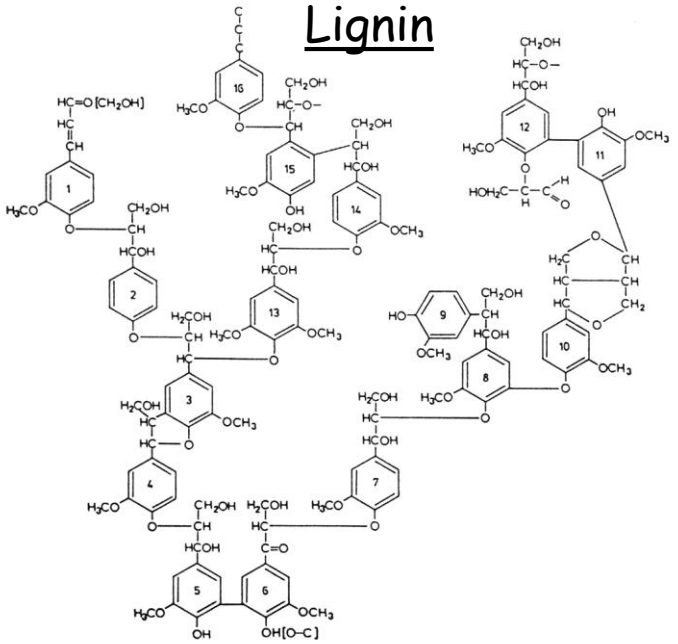
Träbiomassan består av...

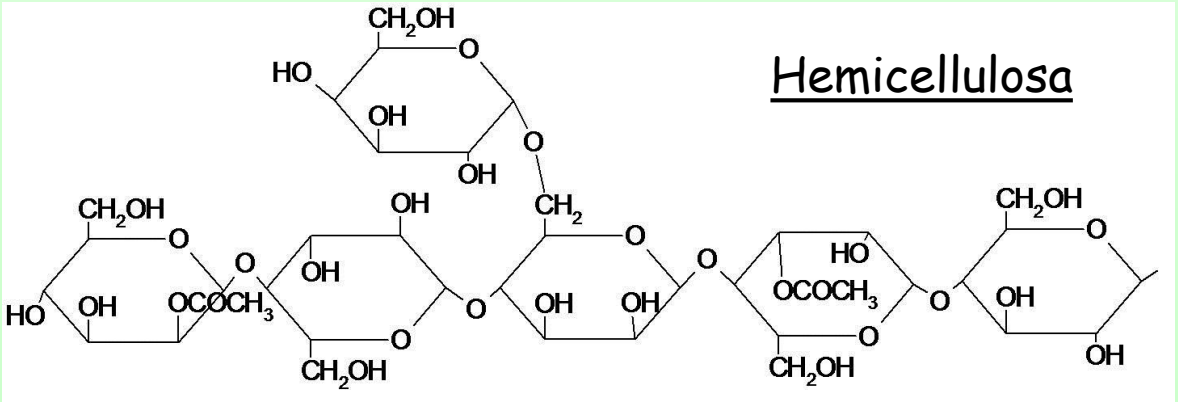




Cellulosa

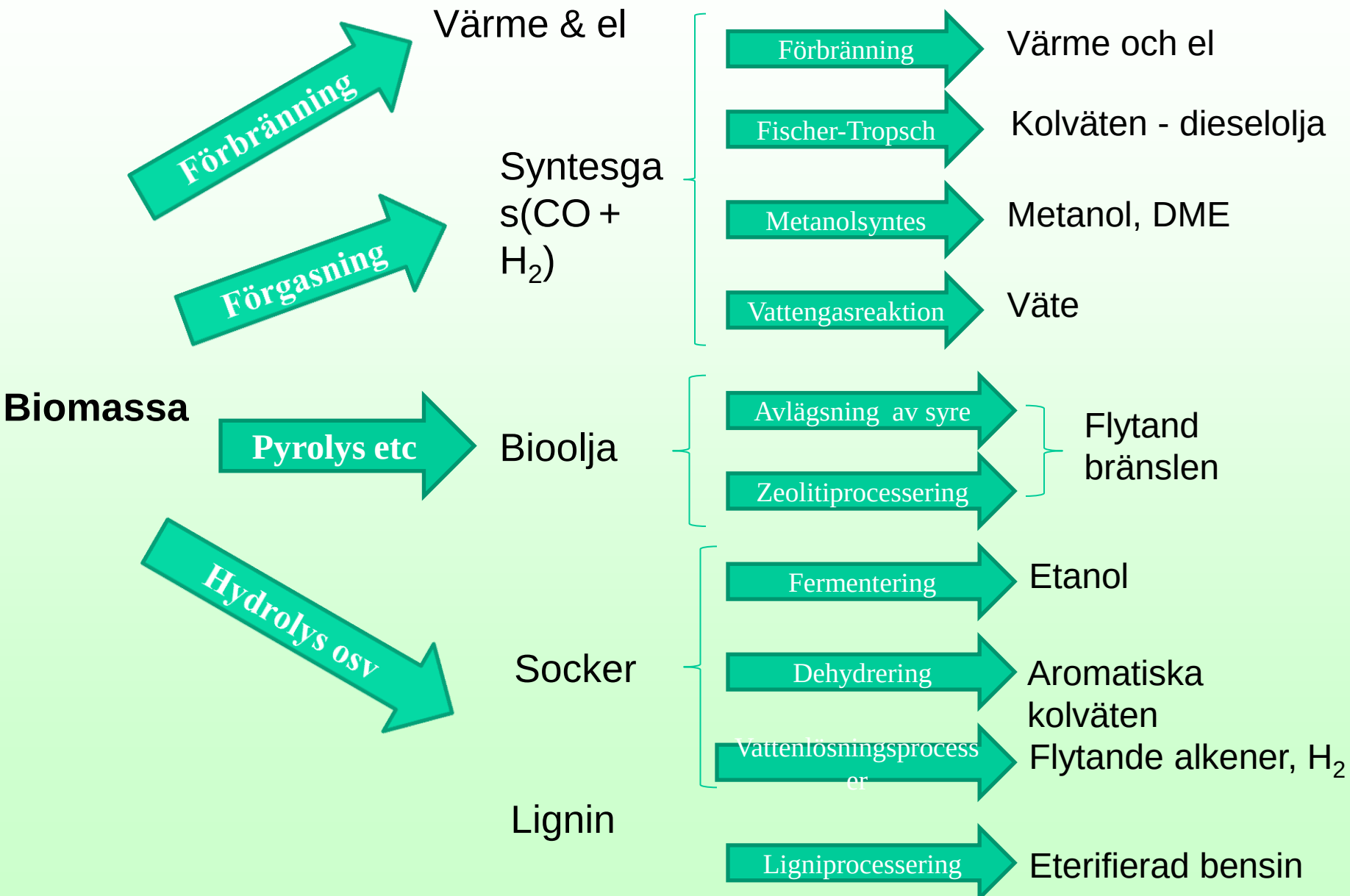
Lignin





Hemicellulosa

Bioenergialternativ

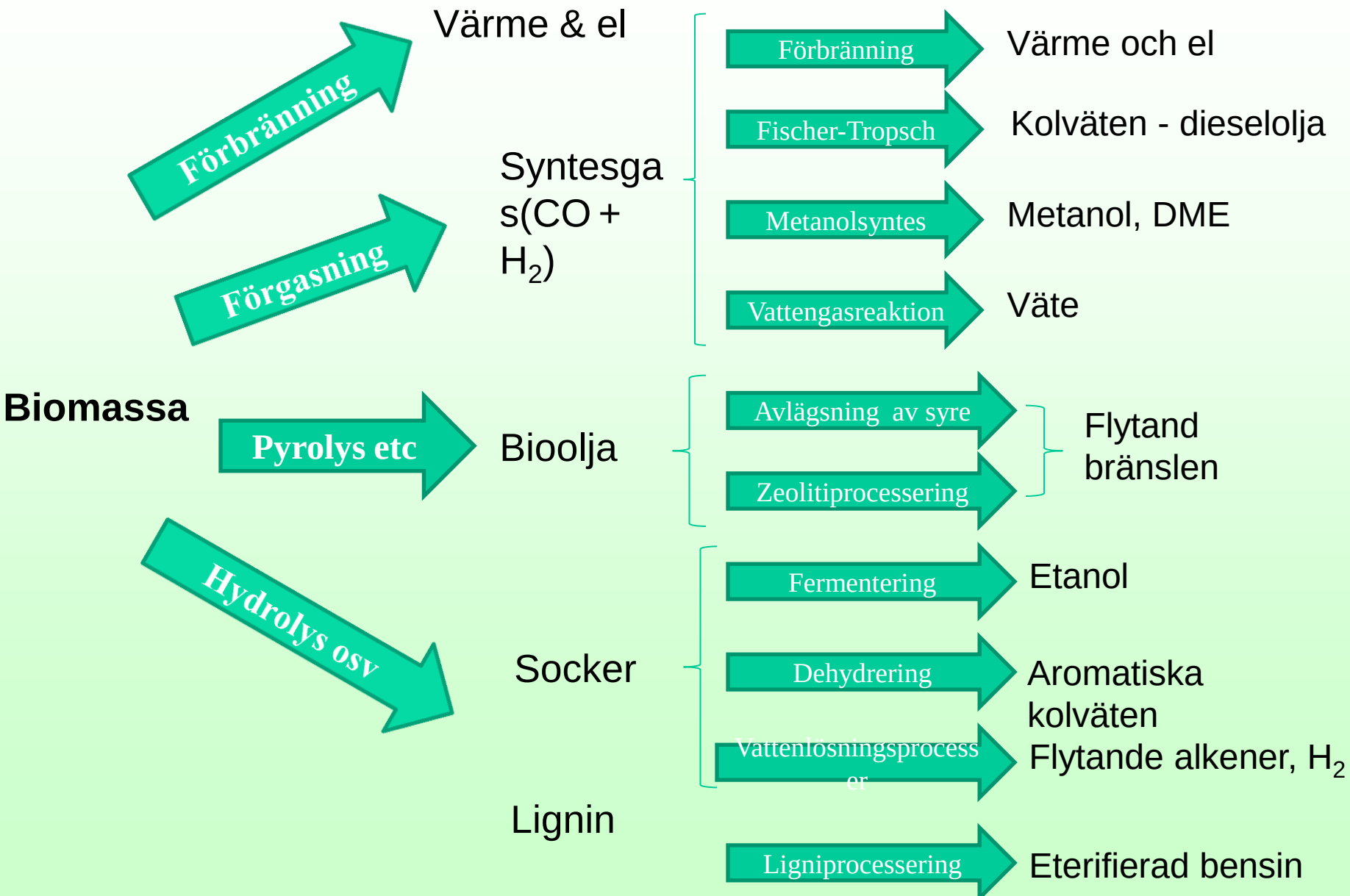


Termisk omvandling av biomassor

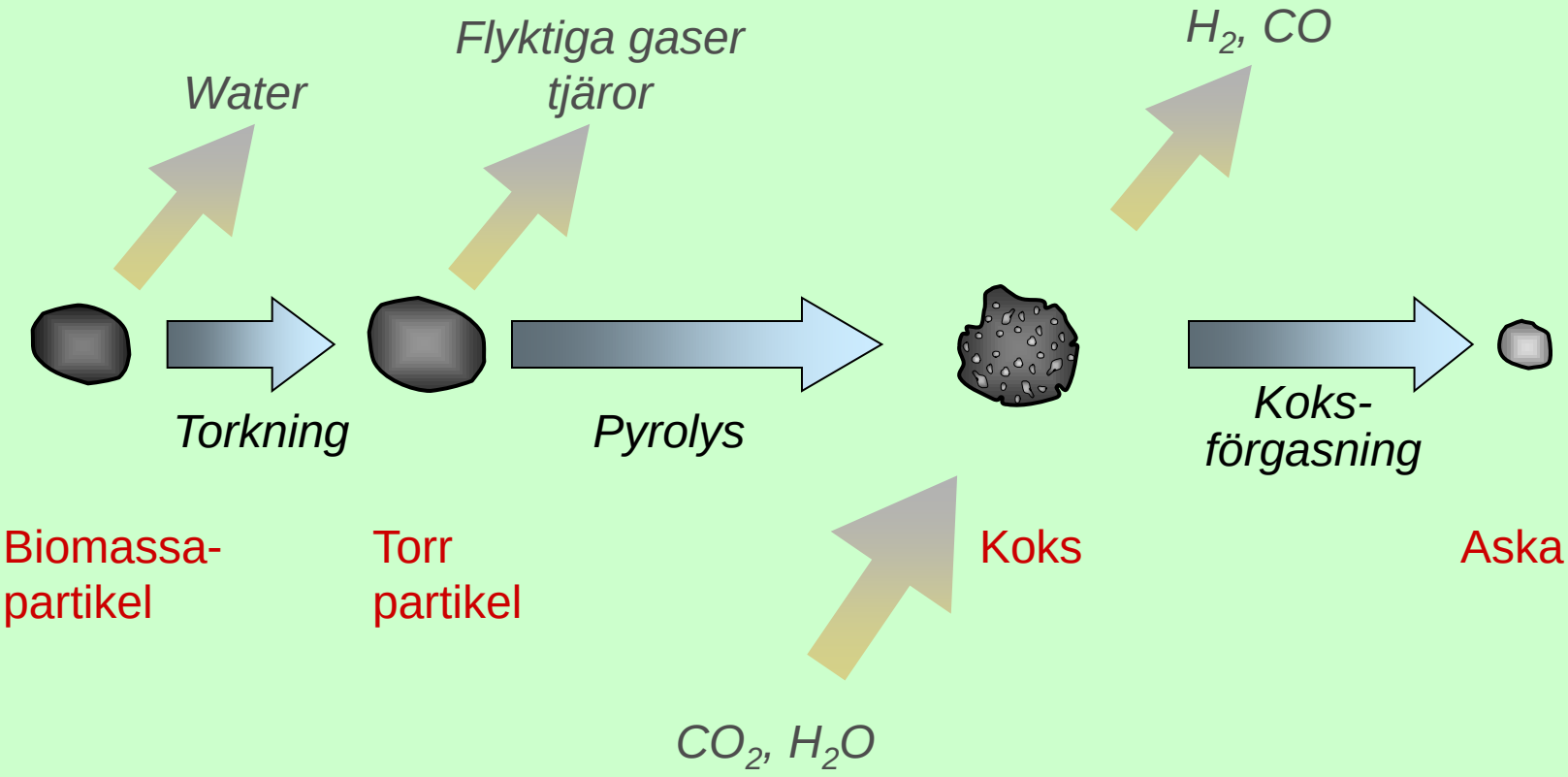
Värme genom förbränning (ca 1000 *C*):

$$C,H,O(biom.) + O_2 \rightarrow CO_2 + H_2O + Q$$

Bioenergialternativ



Vad händer vid förgasningen?



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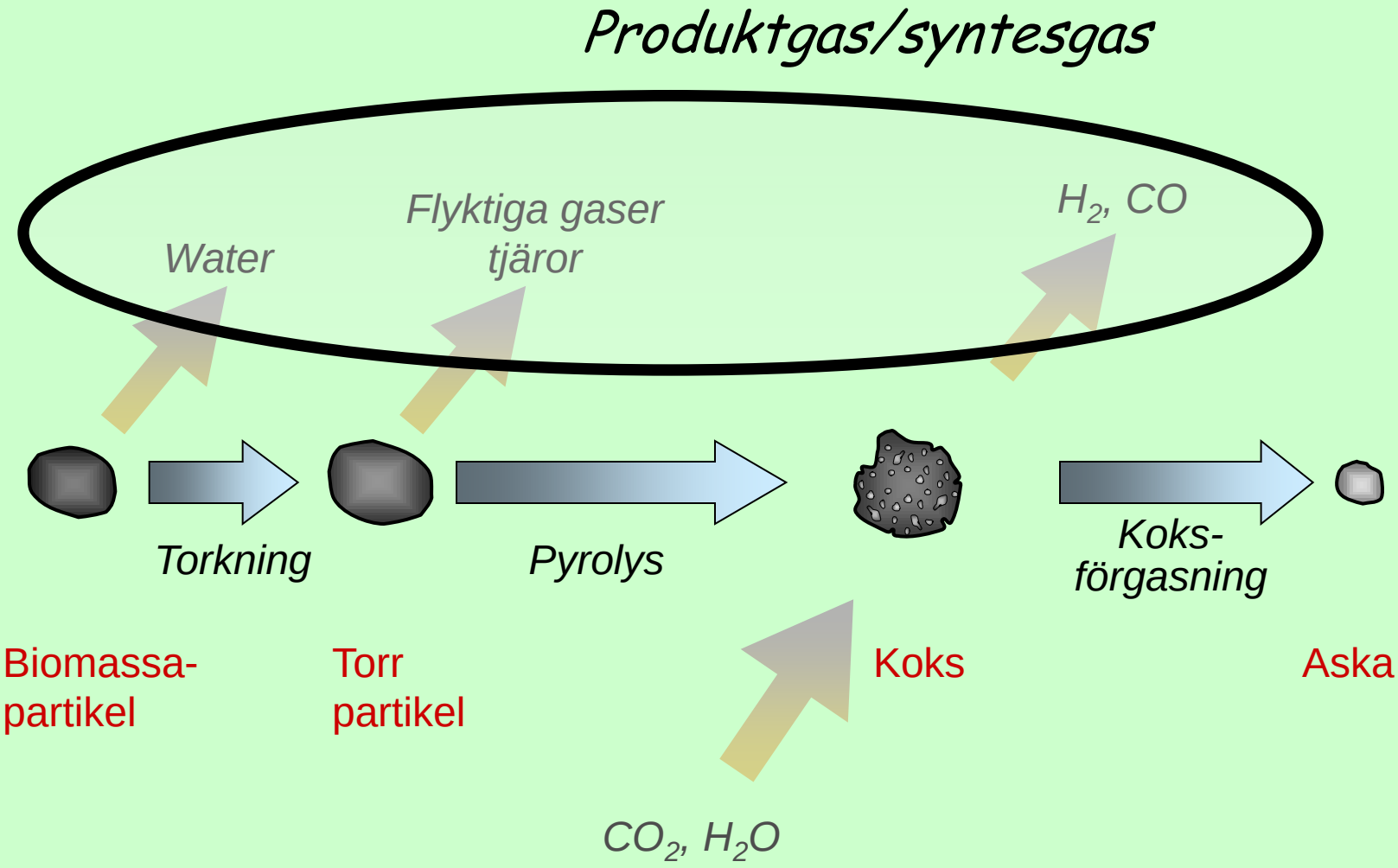
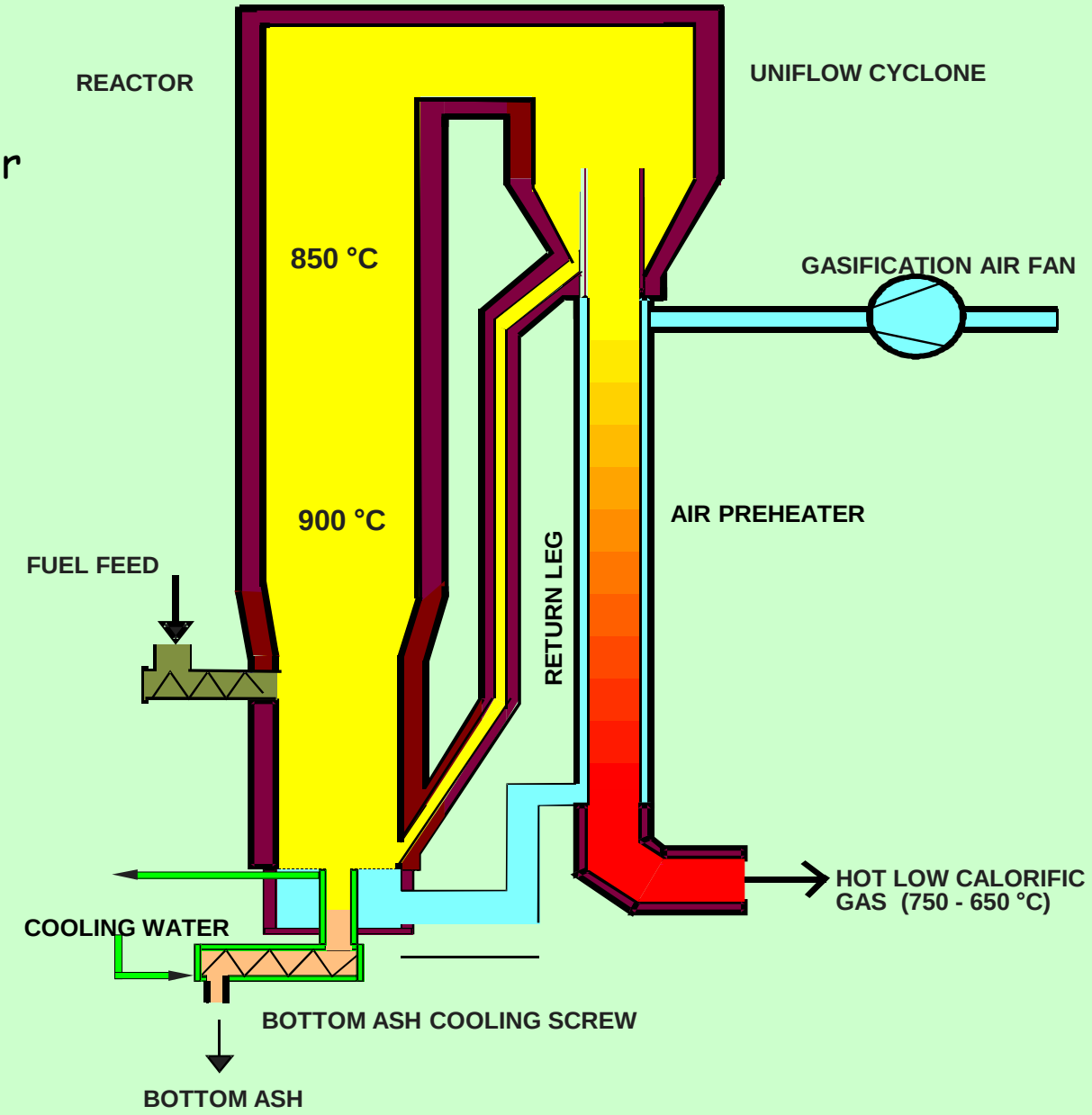


Förgasning

Fluidicerad bädd -reaktor

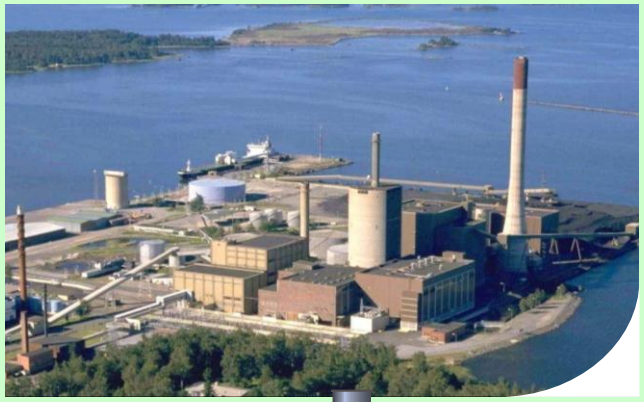


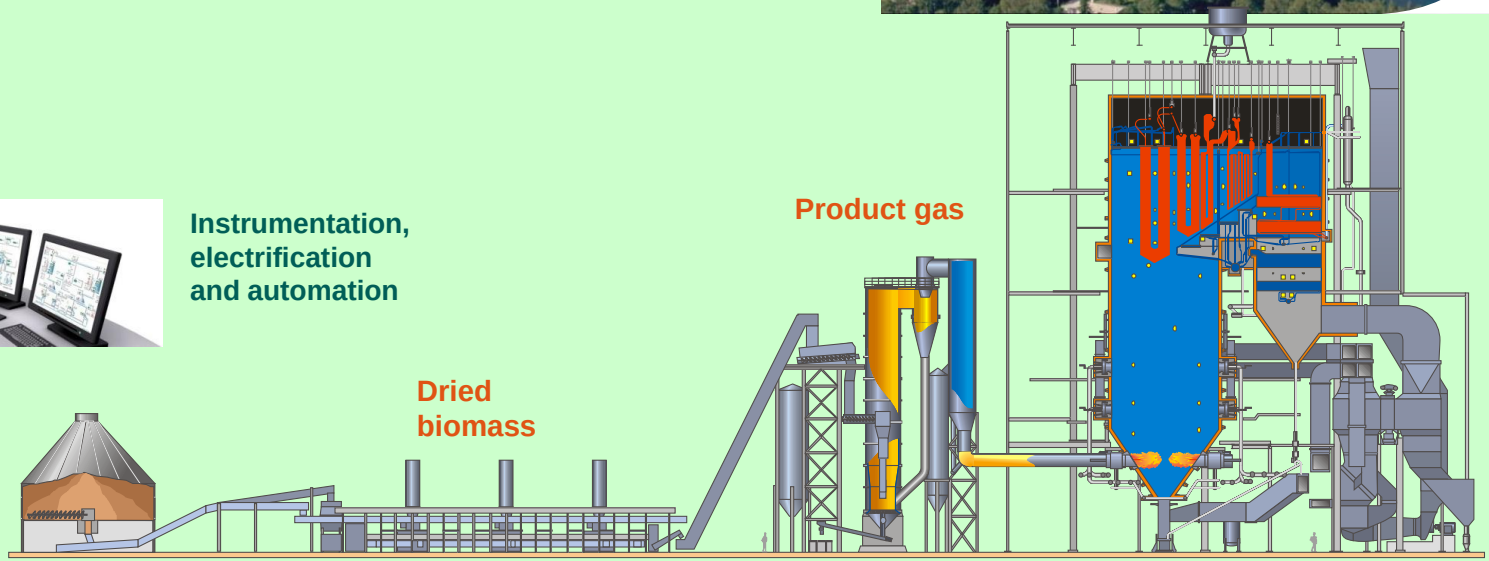
Foster Wheeler

Product Gas for power boilers

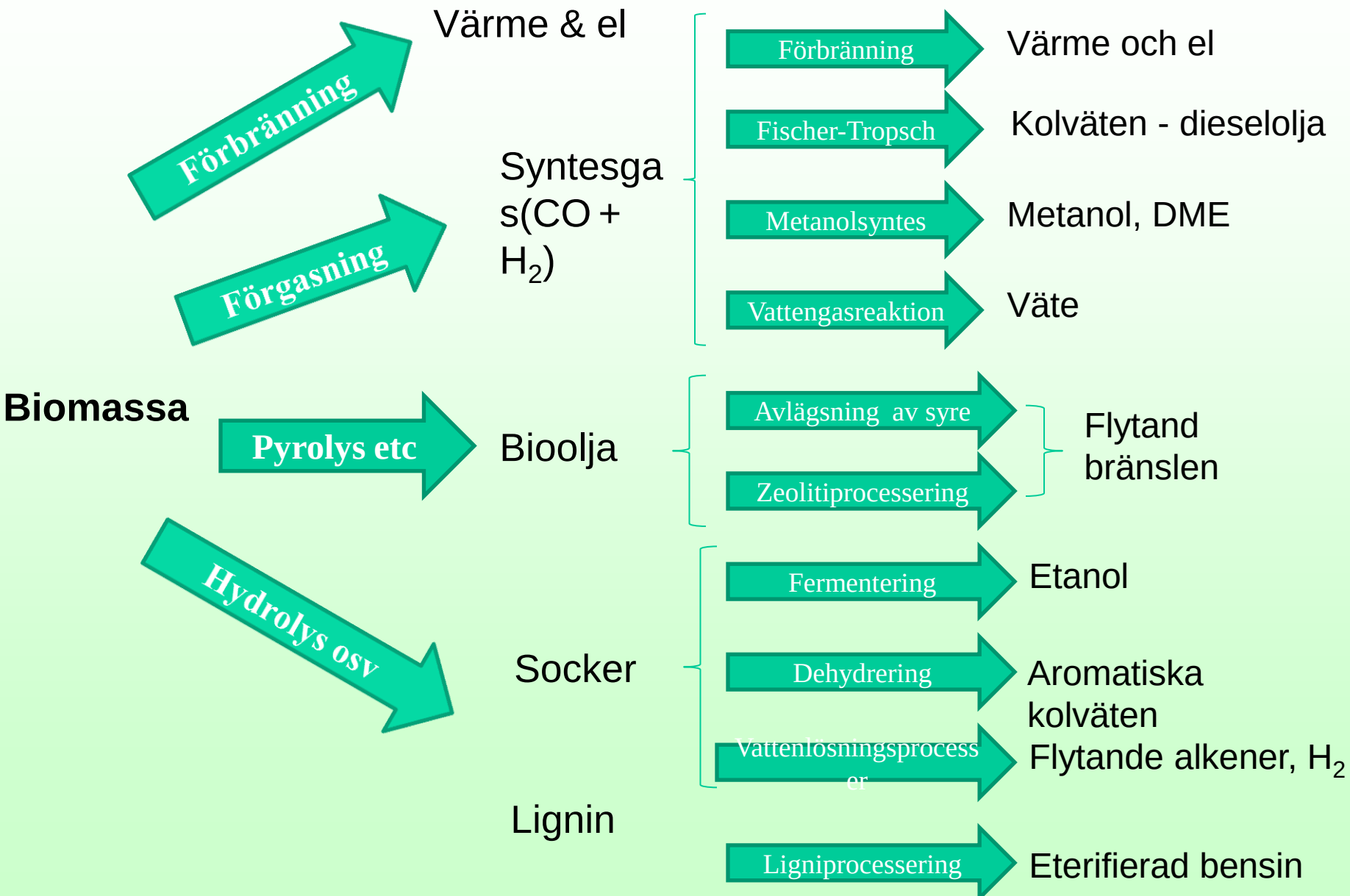
Vaskiluodon Voima Oy, City of Vaasa, Finland

- Substituting **coal for biomass**
- 140 MW_{th} biomass gasifier
- Gasifier adjoined to an existing coal-fired boiler (560 MW_{th})
- Gasification plant operational 12/2012





Bioenergialternativ



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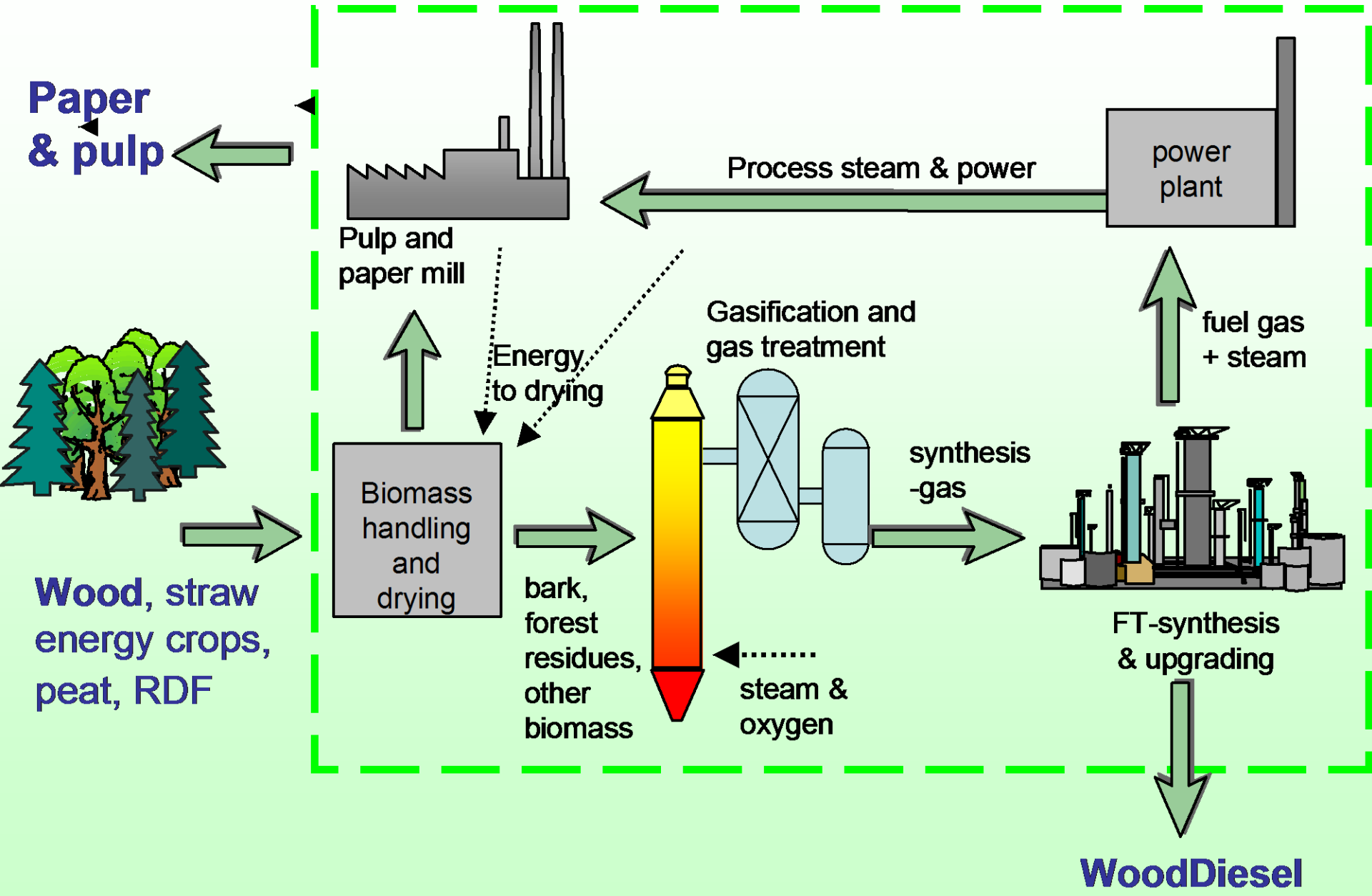
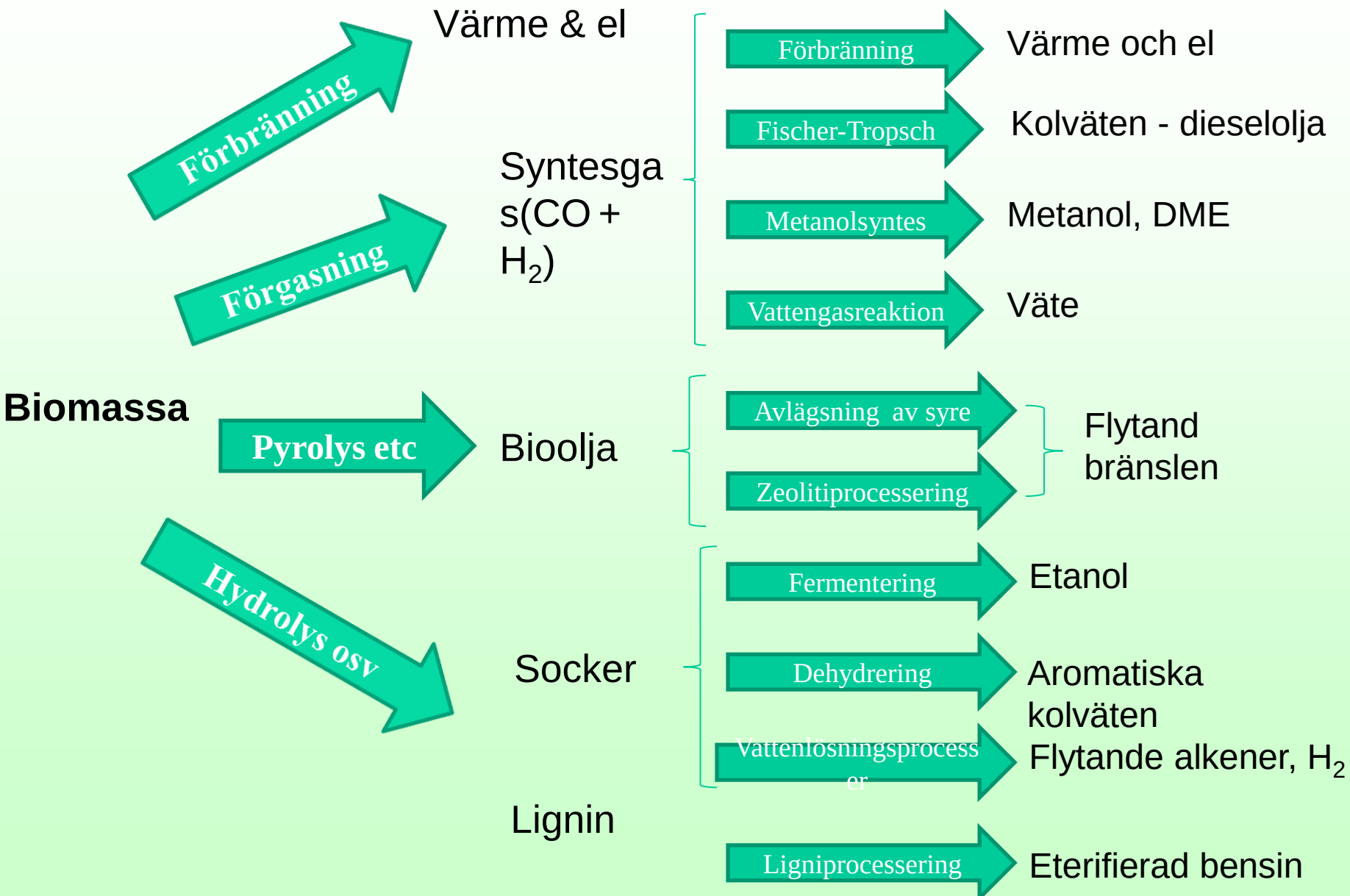
$(2n+1)\ H_2 + n\ CO \rightarrow C_nH_{(2n+2)} + n\ H_2O$

Biodiesel Production in Pulp Mill

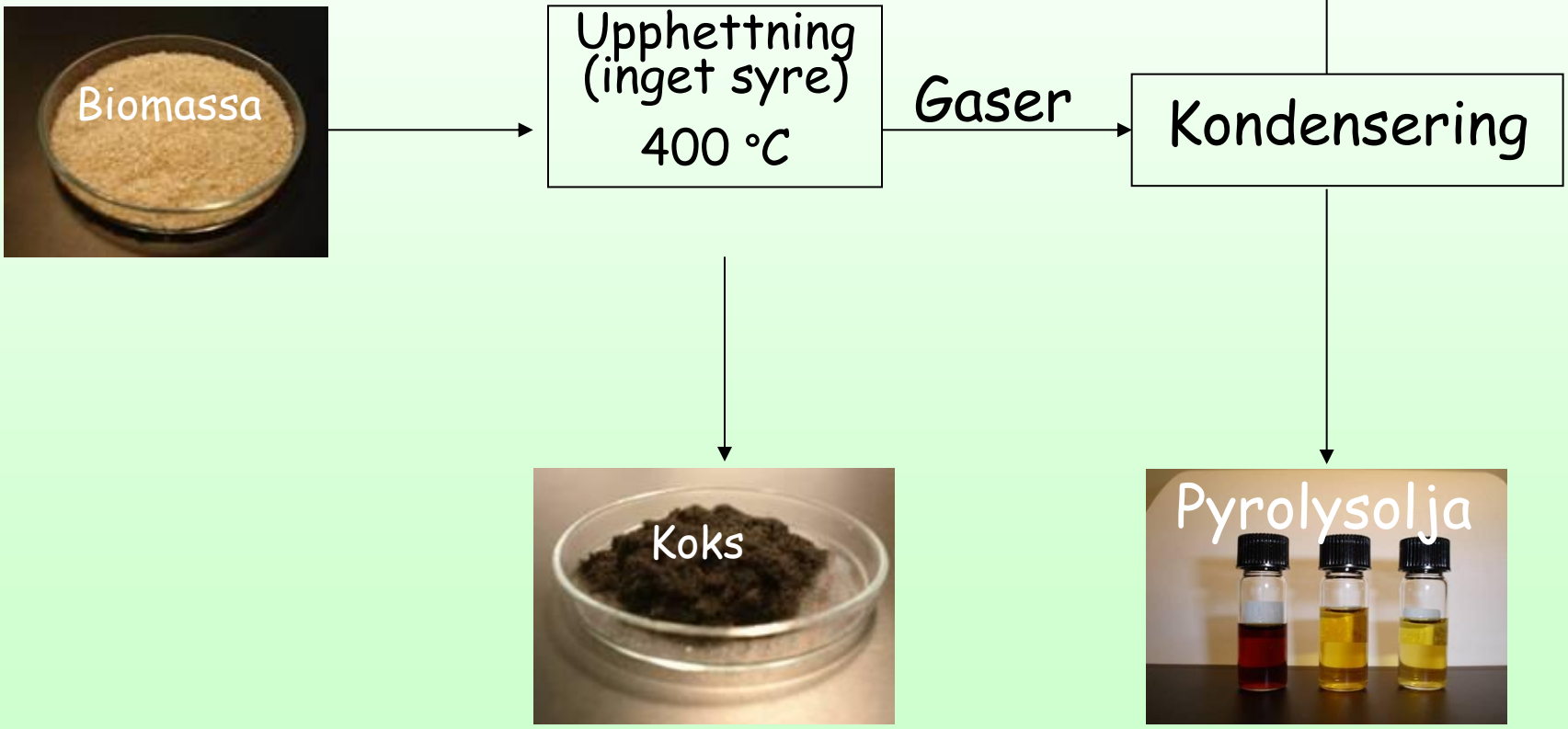


Biomass Gasifier for Biodiesel
Demo by Stora Enso – Neste in Varkaus, Finland

Bioenergialternativ

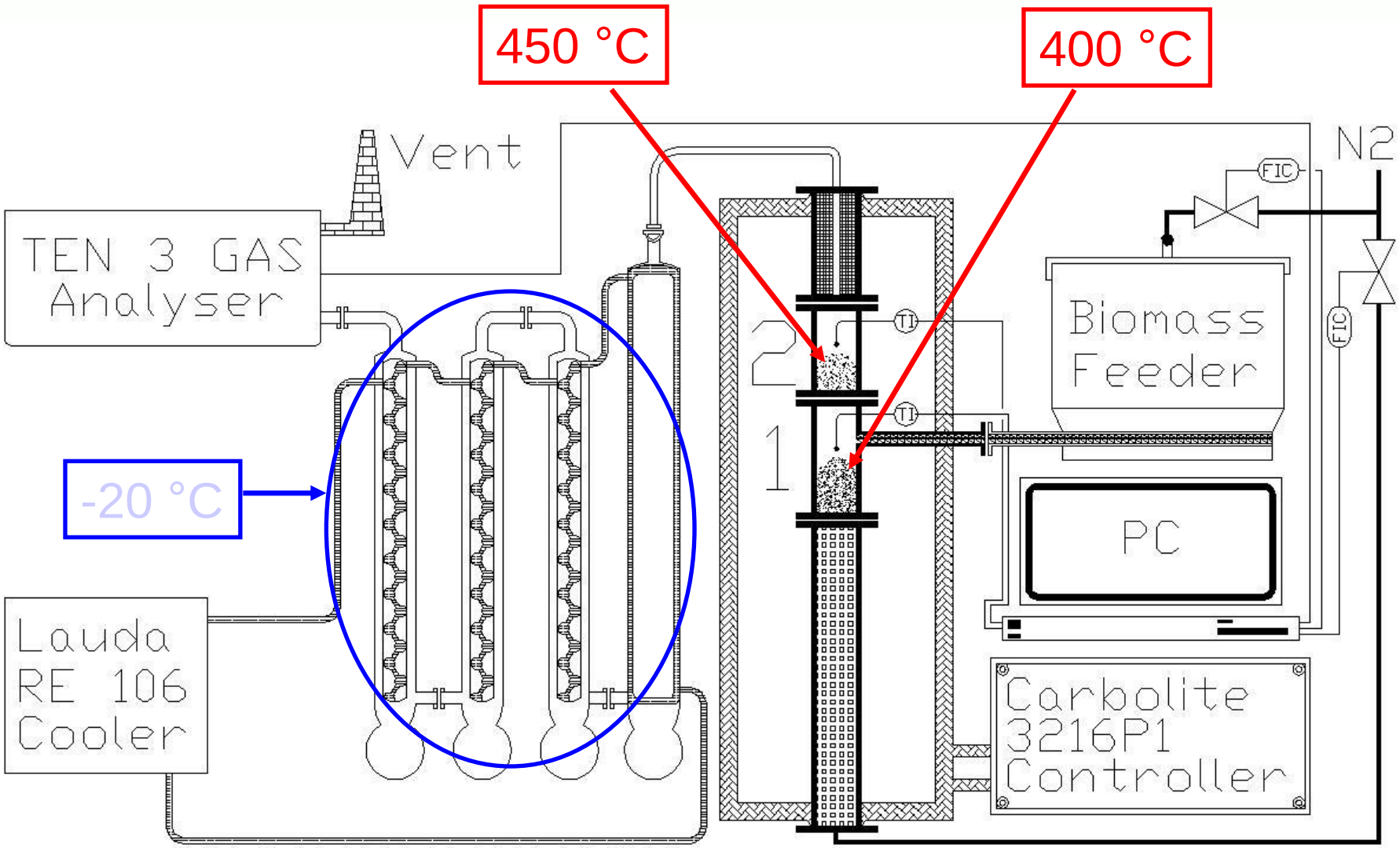


Biomassans pyrolys



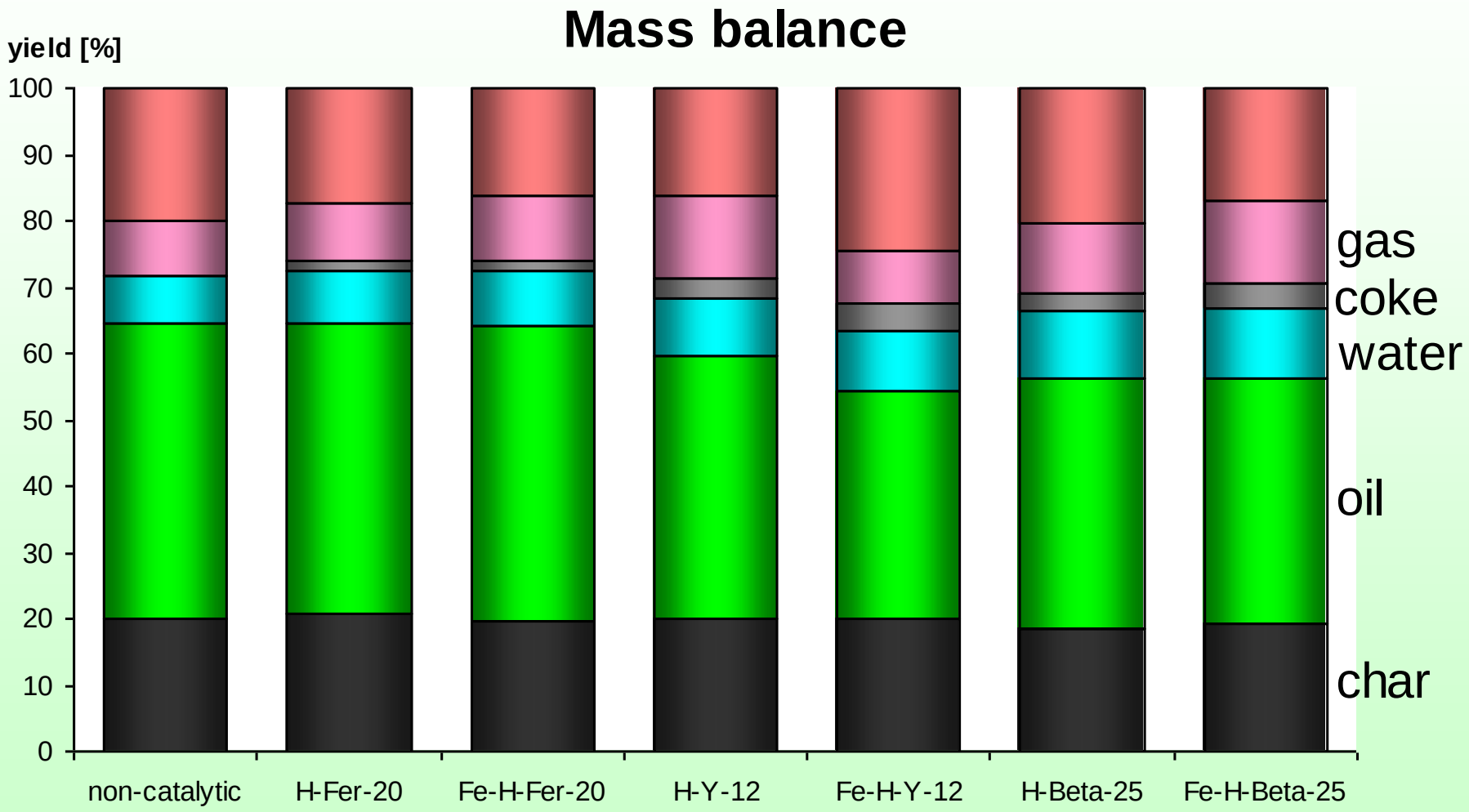
(Atte Aho et al. 2009)

Attes laboratoriepyrolysator




LAUDA
ECOLINE STAREDITION
RE 106
FEED RATE
OFF
ON

Product Distribution in Pyrolysis Oil Production



(Atte Aho et al. 2008)

Pyrolysolja

- Blanding av organiska vätskor och vatten
  - Aldehyder, syror, alkohol, ketoner, fenoler
- Över 200 föreningar
- Sammansättning beror av råvaran
- Sur - pH 2,5
- Förändras, åldras (viskositet!)

Bioöljyn valmistus ja käyttö on yksi reitti vähähiiliseen energiantuotantoon




Voimalaitoksen polttoaineet
= bioöljyn raaka-aineet

CHP-voimalaitos
- sähköntuotanto
- lämmöntuotanto
- **bioöljyn tuotanto**

Bioöljyn loppukäyttö
Vähähiilinen lämmön ja höyryn tuotanto

Bioöljyn valmistaminen sähkön- ja lämmöntuotannon yhteydessä on paitsi erittäin energiatehokasta, myös investointi- ja käyttökustannuksiltaan edistyksellinen vaihtoehto.

Fortum

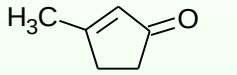
Mitä on pyrolyysimenetelmällä valmistettu bioöljy?

- Puusta tuotettua bioöljyä, jolla voidaan korvata fossiilisia polttoöljyjä
- Bioöljyn lämpöarvo on noin puolet fossiilisen lämmitysöljyn energiasisällöstä ja siten hyvin tiiviissä muodossa olevaa bioenergiaa
- Perinteisten polttoöljyjen tapaan bioöljy on helposti pumpattavissa ja siten käytettävissä nykyisissä kattiloissa kohtuullisin muutoksin
- Bioöljy on erilaisten orgaanisten yhdisteiden hapan seos (pH noin 3) eikä se sovellu sekoitettavaksi muihin lämmitysöljyihin
- Tulevaisuudessa bioöljy voi toimia raaka-aineena liikenteen polttoaineiden ja kemikaalien jalostamisessa

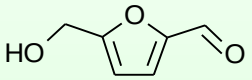
Fortum

Bio-oil

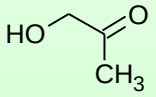
- Carbohydrates, cellulose and hemicellulose
  - Furans, cyclopentanones
  - Open chain acids, aldehydes, ketones and alcohols
- Lignin
  - Alkyl, methoxy, carbonyl and hydroxy substituted phenols



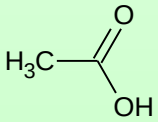
3-methylcyclopent-2-en-1-one



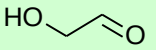
5-(hydroxymethyl)furan-2-carbaldehyde



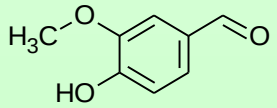
1-hydroxypropan-2-one



acetic acid

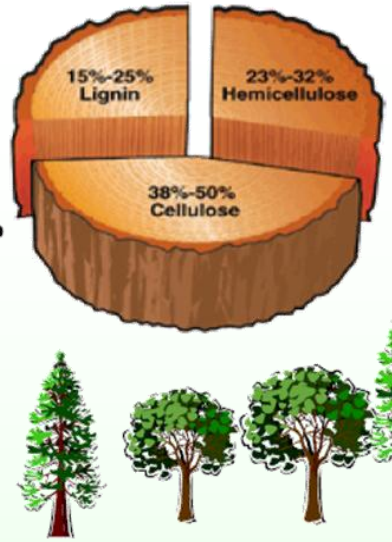


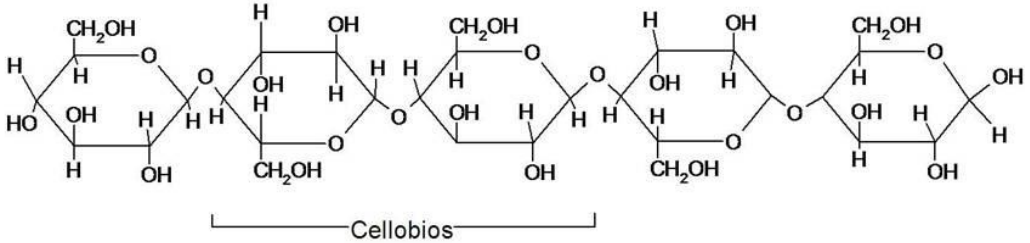
hydroxyacetaldehyde



4-hydroxy-3-methoxybenzaldehyde

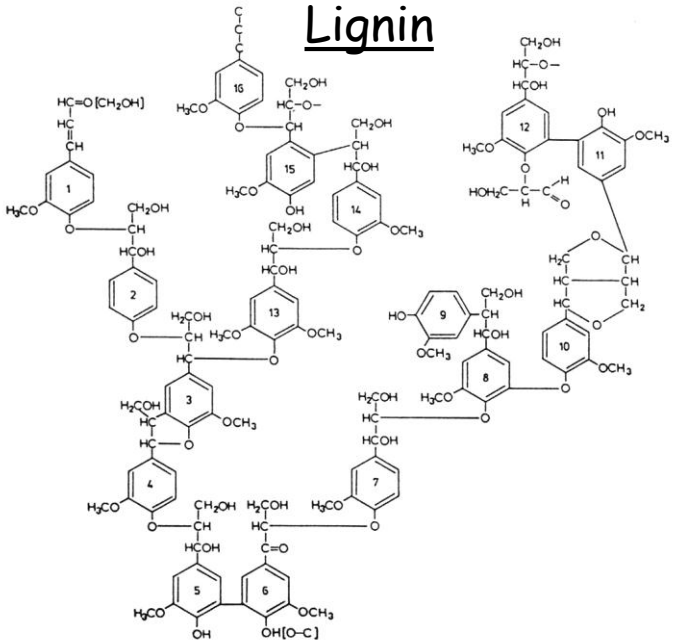
Träbiomassan består av...

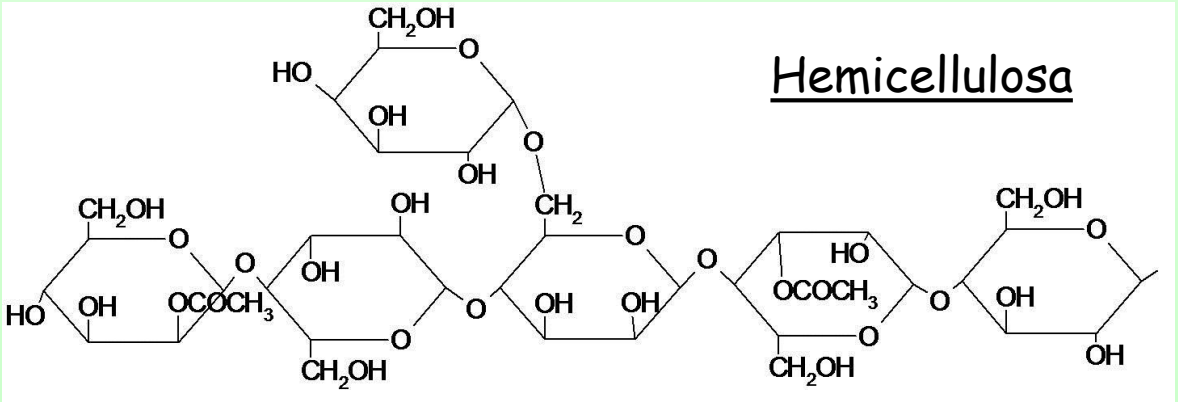




Cellulosa

Lignin





Hemicellulosa

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$(2n+1)\ H_2 + n\ CO \rightarrow C_nH_{(2n+2)} + n\ H_2O$

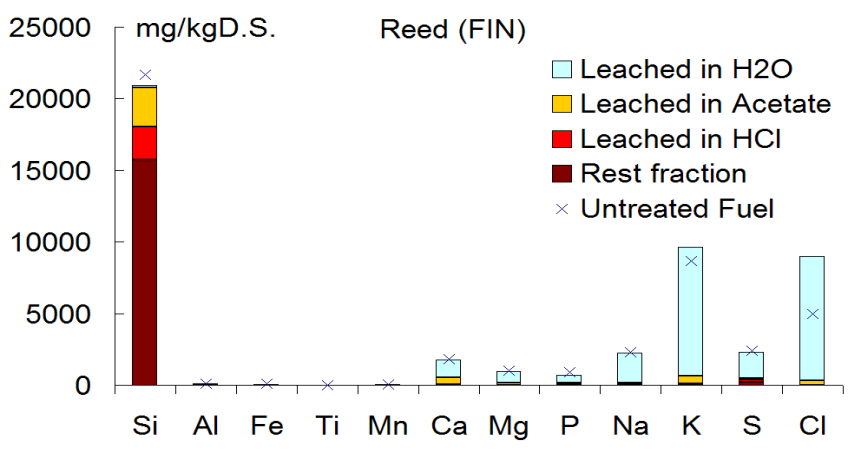
Bio-olja genom pyrolys (400-500 C):

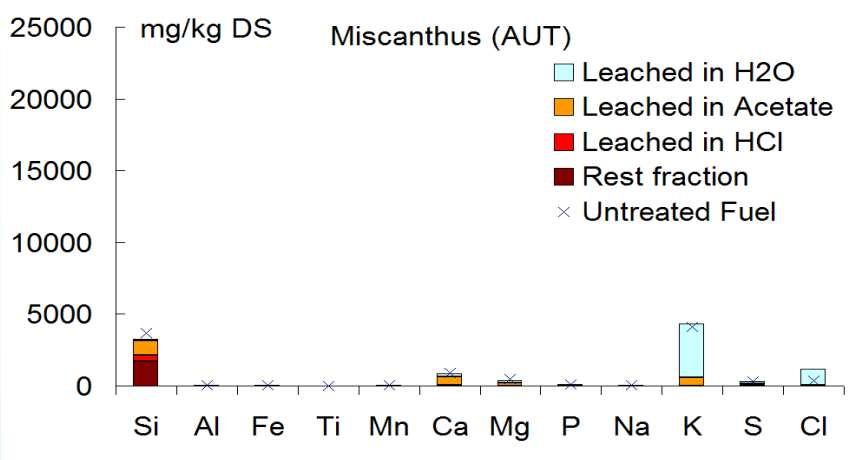
$C,H,O(biom.) + Q \rightarrow$ Tjäror, oljor, vatten + CO, CO_2...

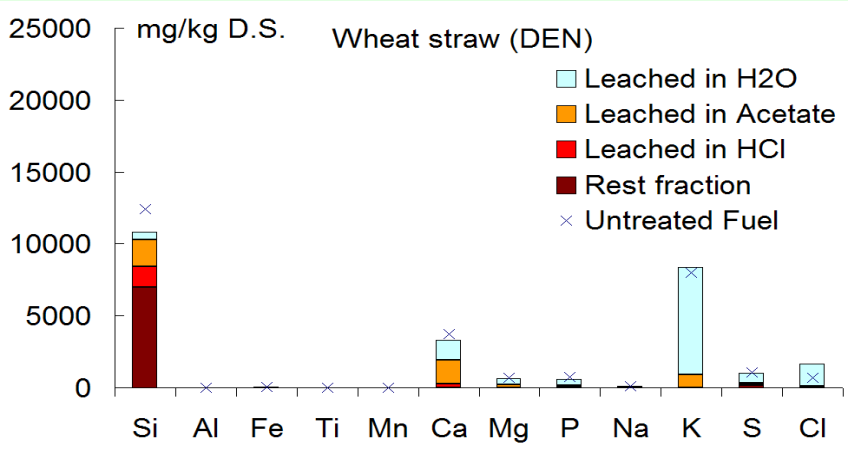
Utmanande biomassor

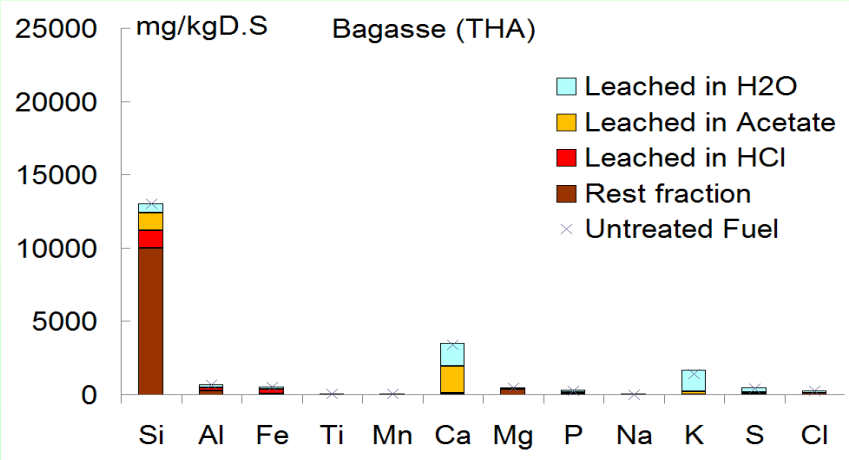
- Miscanthus (AUT)
- Reed (FIN)
- Wheat straw (DEN)
- Suger cane bagasse (THA)

Fuel analysis









Wire Mesh – Grid Heater

- Electrically heated wire mesh in a reactor purged with N_2
- Small and well-defined samples
- Close temperature control

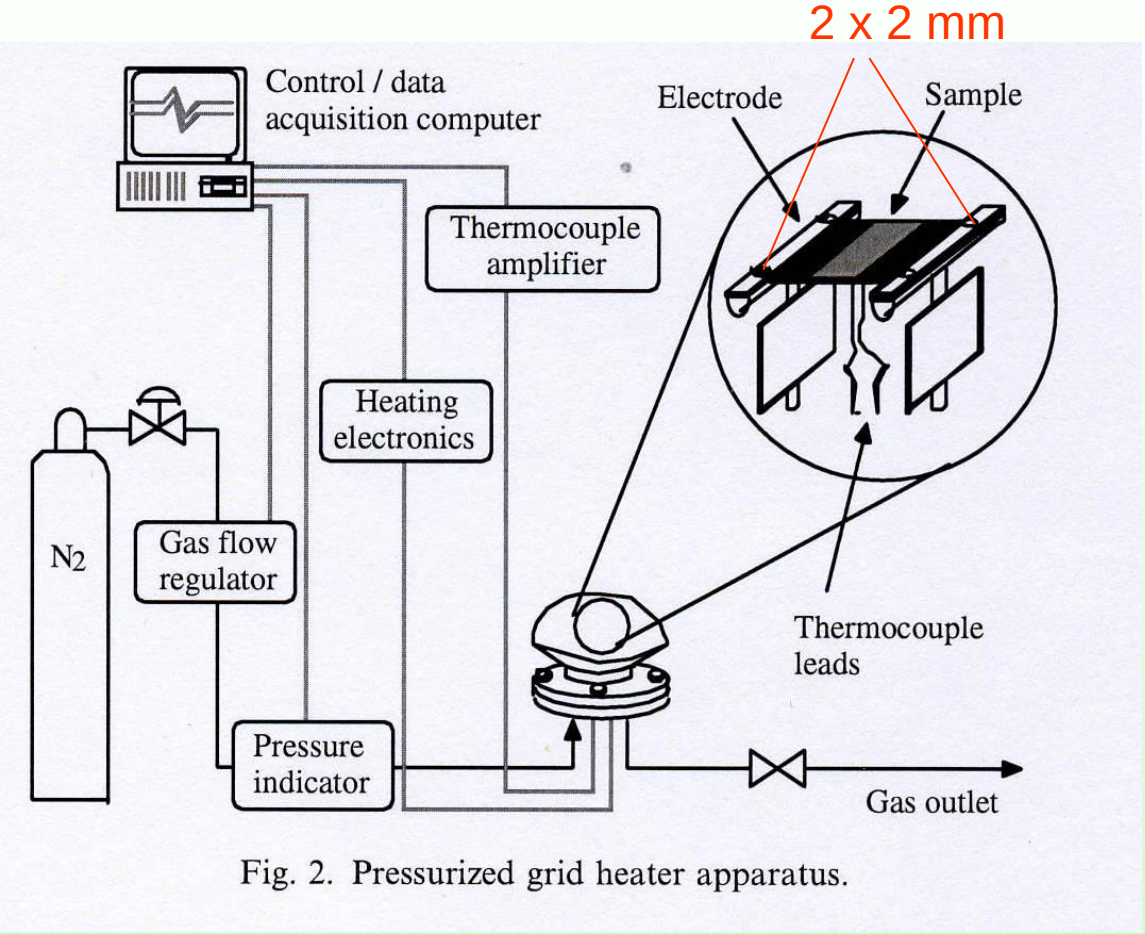


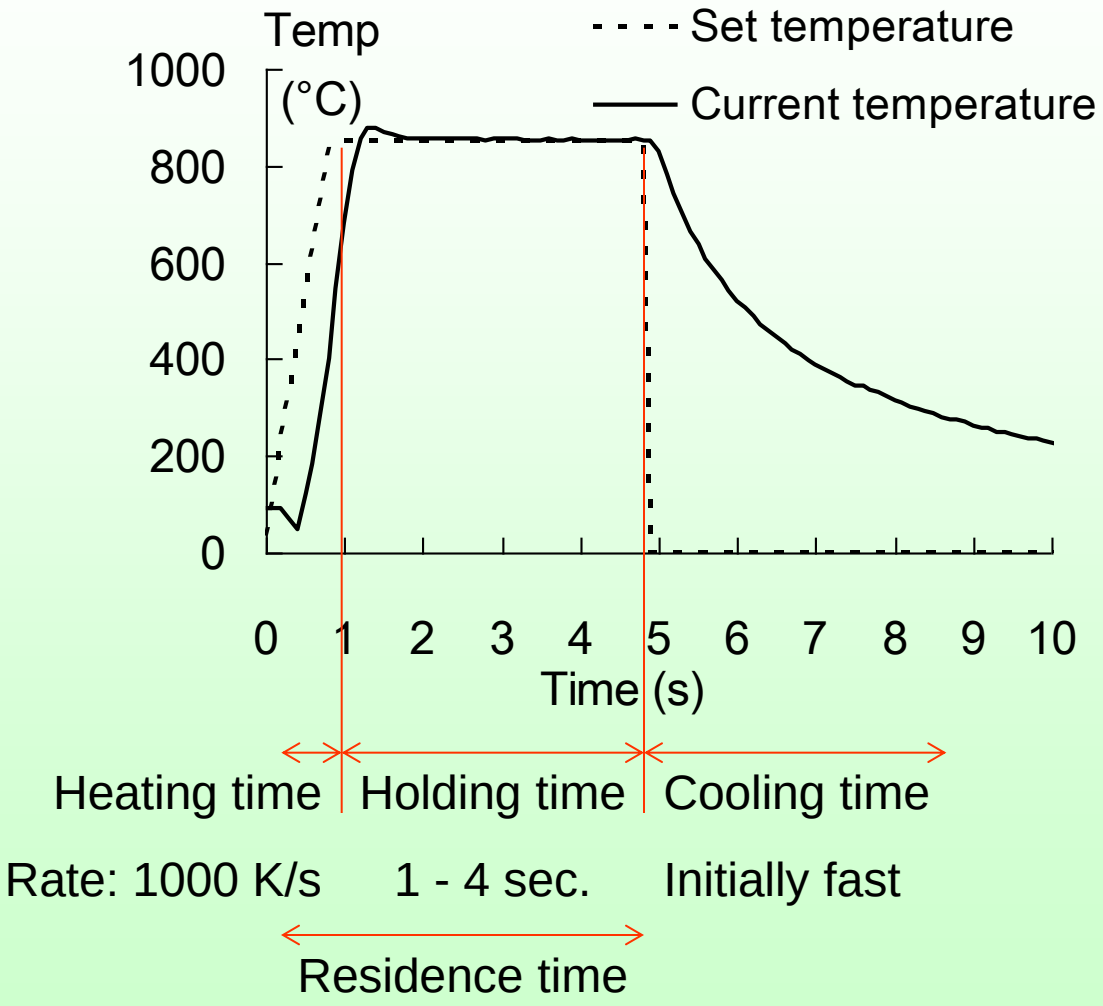
Fig. 2. Pressurized grid heater apparatus.

J Werkelin, M Hupa, Retention of ash-forming matter after fast pyrolysis of small biomass Samples, in "Impacts of Fuel Quality on Power Production & Environment", Saariselkä, Finland (2010)

New reactor design 2010

- Double wire mesh
  → improved heat transfer
- N_2 through the mesh
  → remove pyrolysis gases
- Smaller sample sizes
  – 50 mg → 10 mg

Temperature History of the Wire Mesh

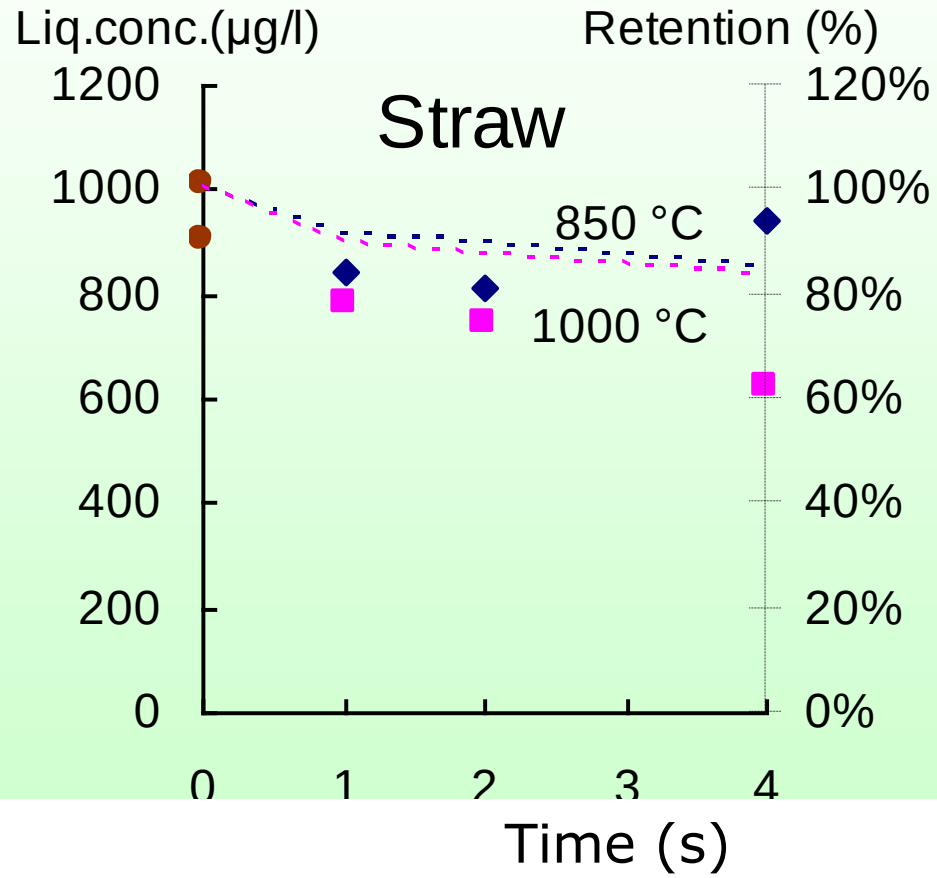


Potassium Retention in Mesh Pyrolysis - Raw Data

	TS (mg)	Pyr?	T (°C)	Tid (s)	Char (mg)	K (ppb)
Miscanthus	10,0	1	1000	4	1,0	259
Miscanthus	11,4	1	1000	2	1,0	214
Miscanthus	11,0	1	1000	1	1,5	351
Miscanthus	9,4	1	850	4	1,0	316
Miscanthus	11,7	1	850	2	1,2	408
Miscanthus	9,9	1	850	1	1,1	325
Miscanthus	11,3	0	0	0	0	530
Miscanthus	11,3	0	0	0	0	522

J Werkelin, M Hupa, Retention of ash-forming matter after fast pyrolysis of small biomass Samples, in “Impacts of Fuel Quality on Power Production & Environment”, Saariselkä, Finland (2010)

Retention of Biomass Potassium in Pyrolysis - Wire Mesh Tests (1000 K/s)



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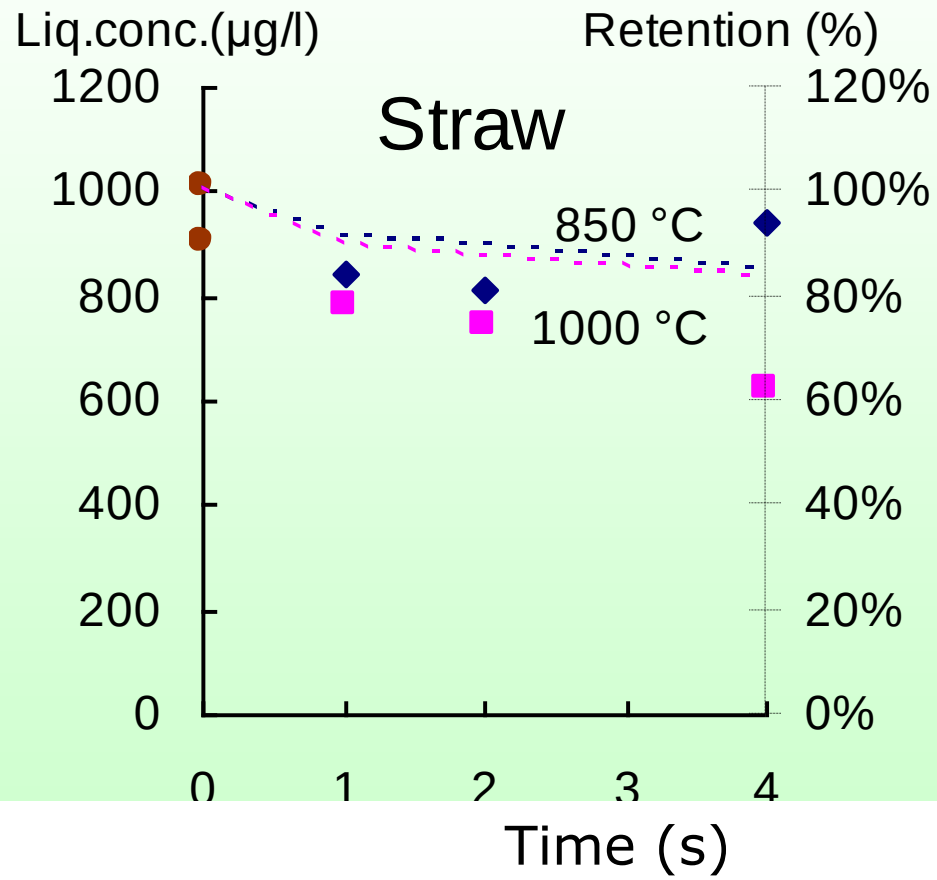
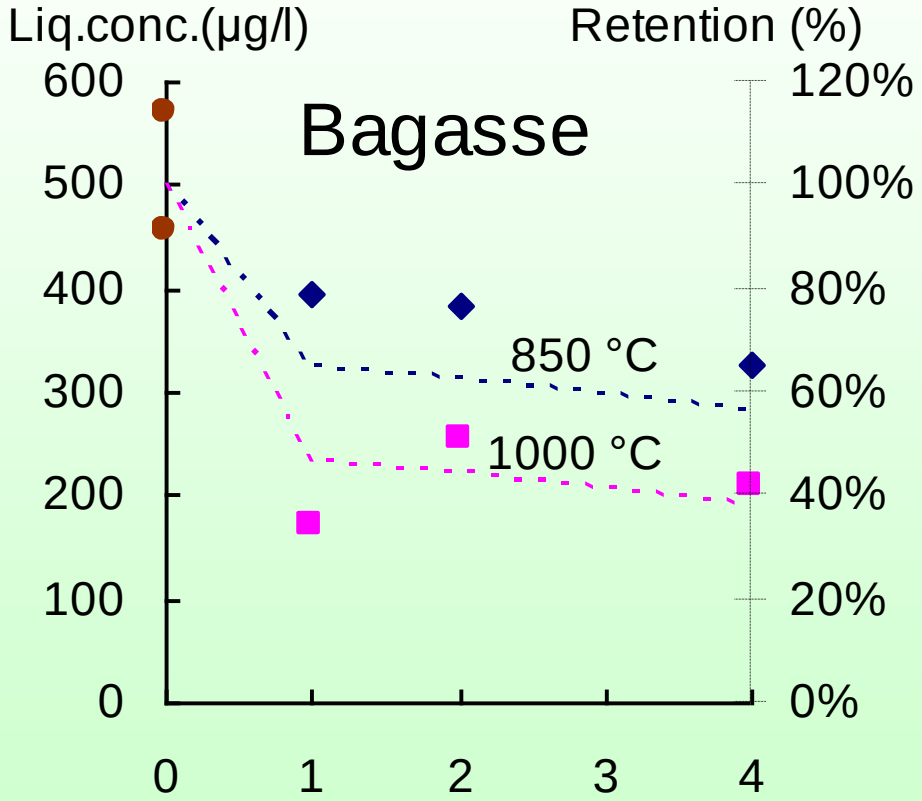
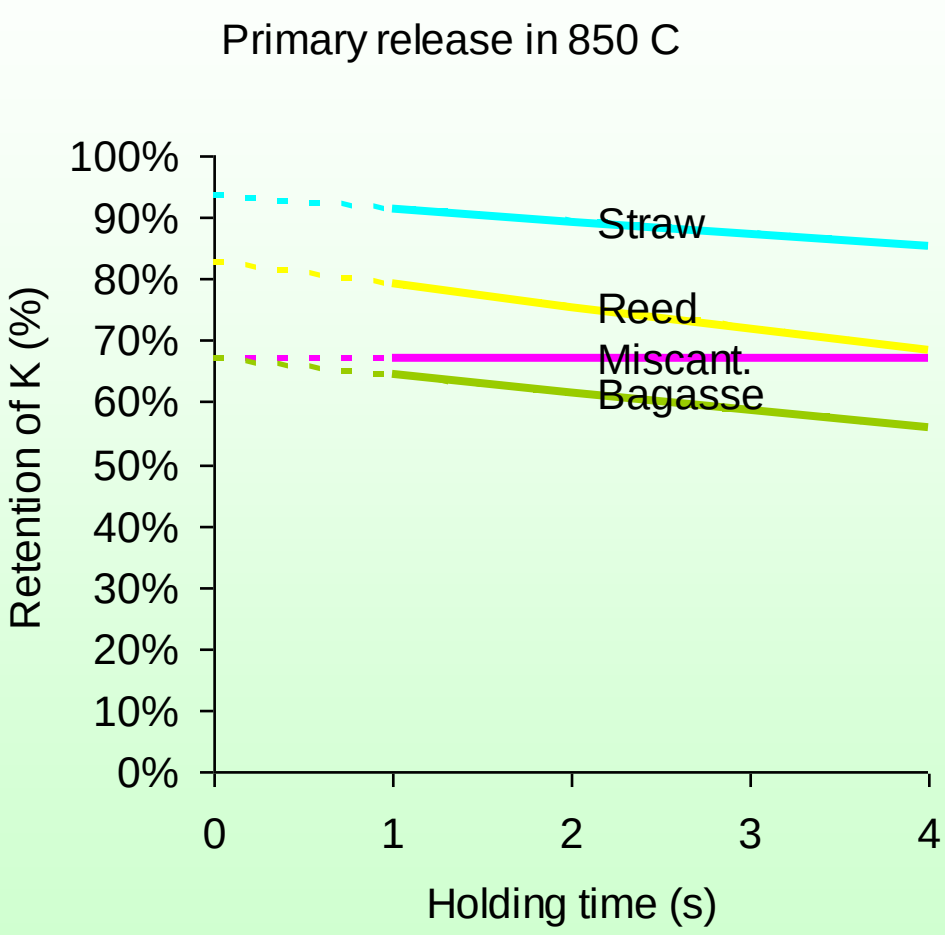
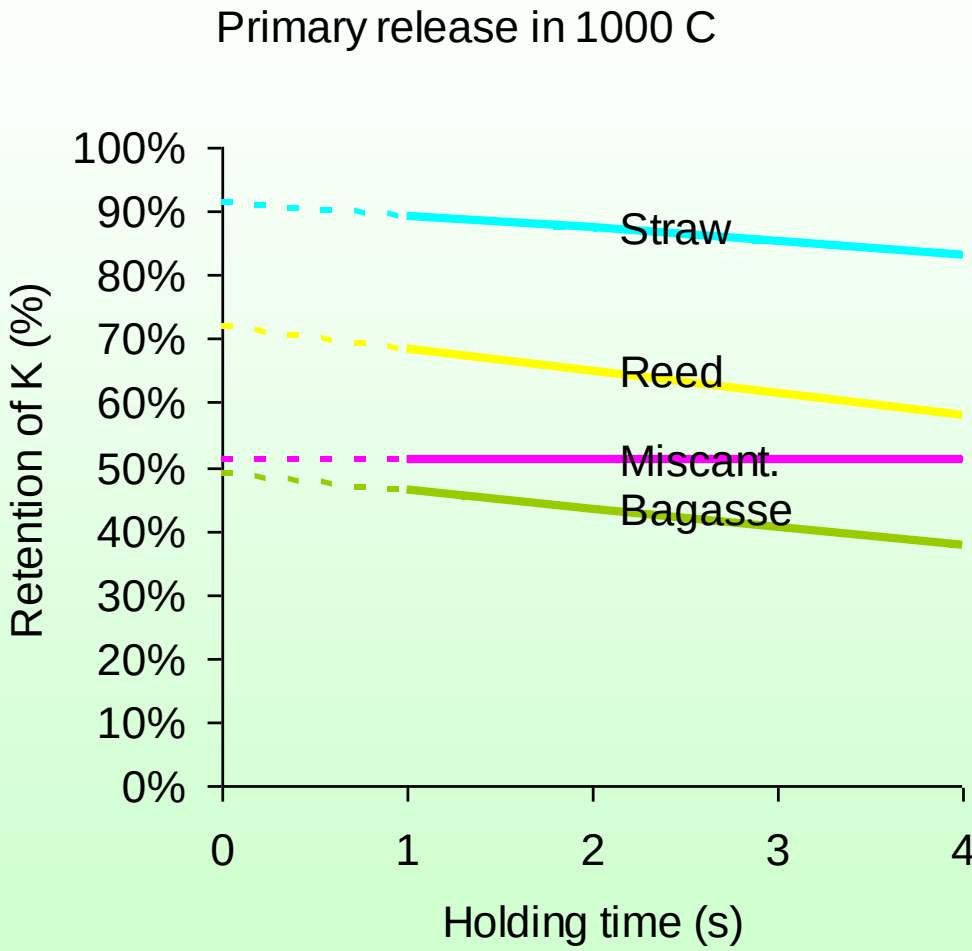




J Werkelin, M Hupa, in "Impacts of Fuel Quality on Power Production & Environment" (2010)

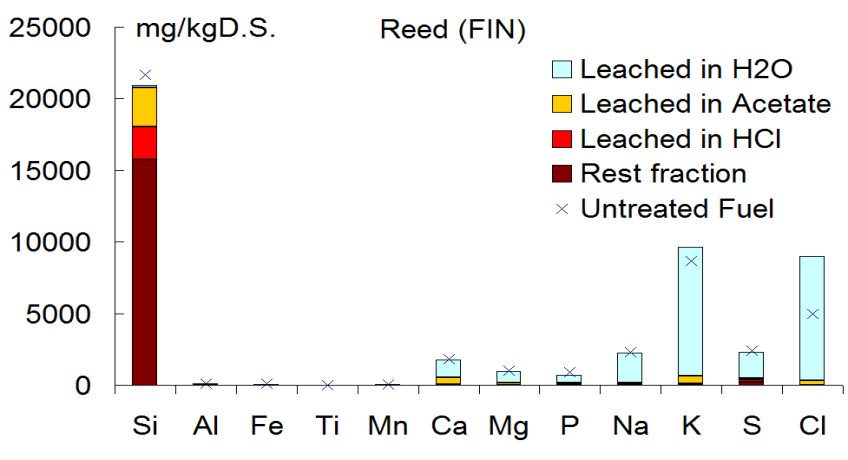
Retention of Potassium in Pyrolysis - Summary

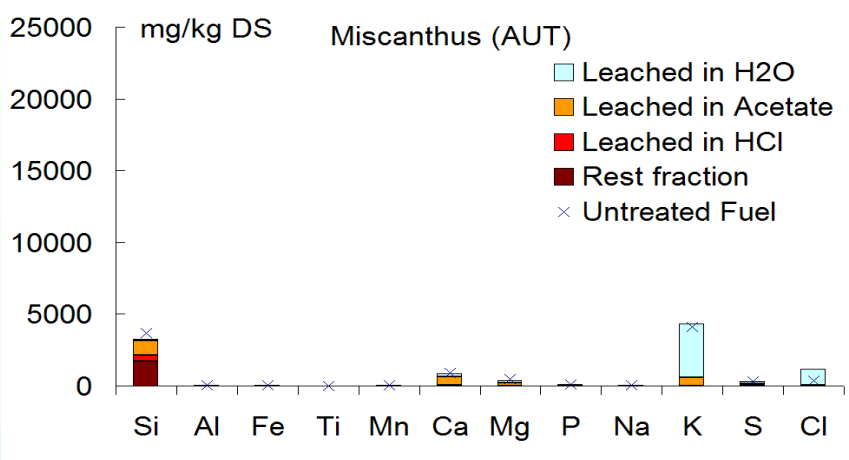


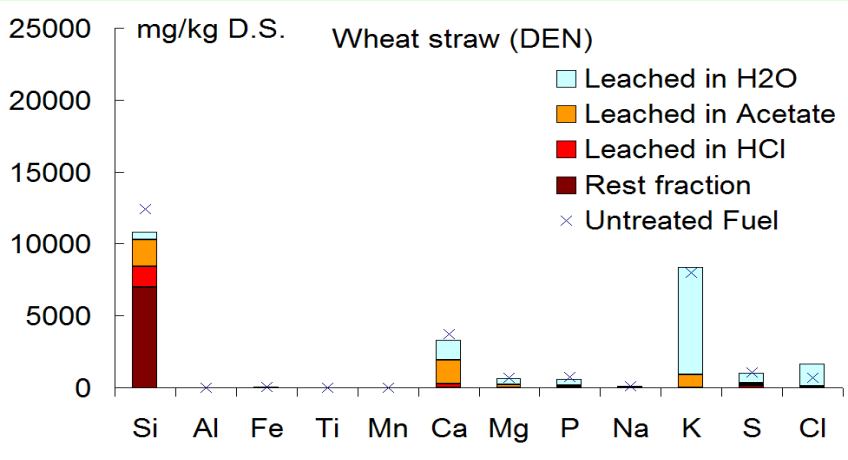


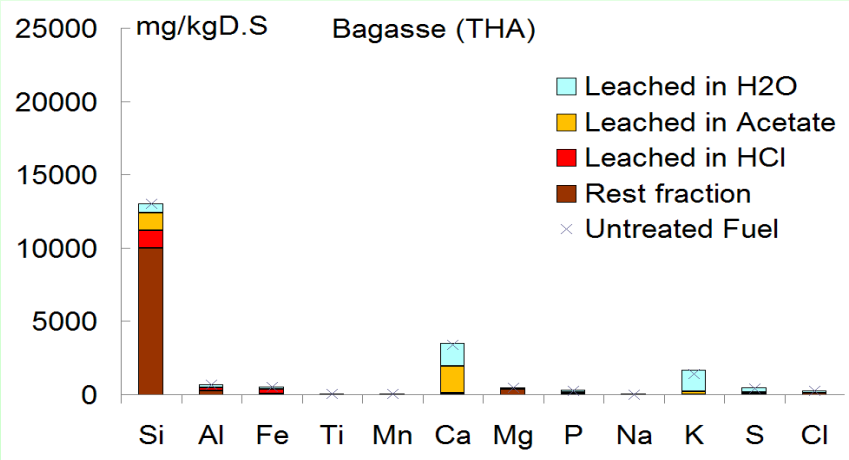
J Werkelin, M Hupa, in "Impacts of Fuel Quality on Power Production & Environment" (2010)

Fuel analysis

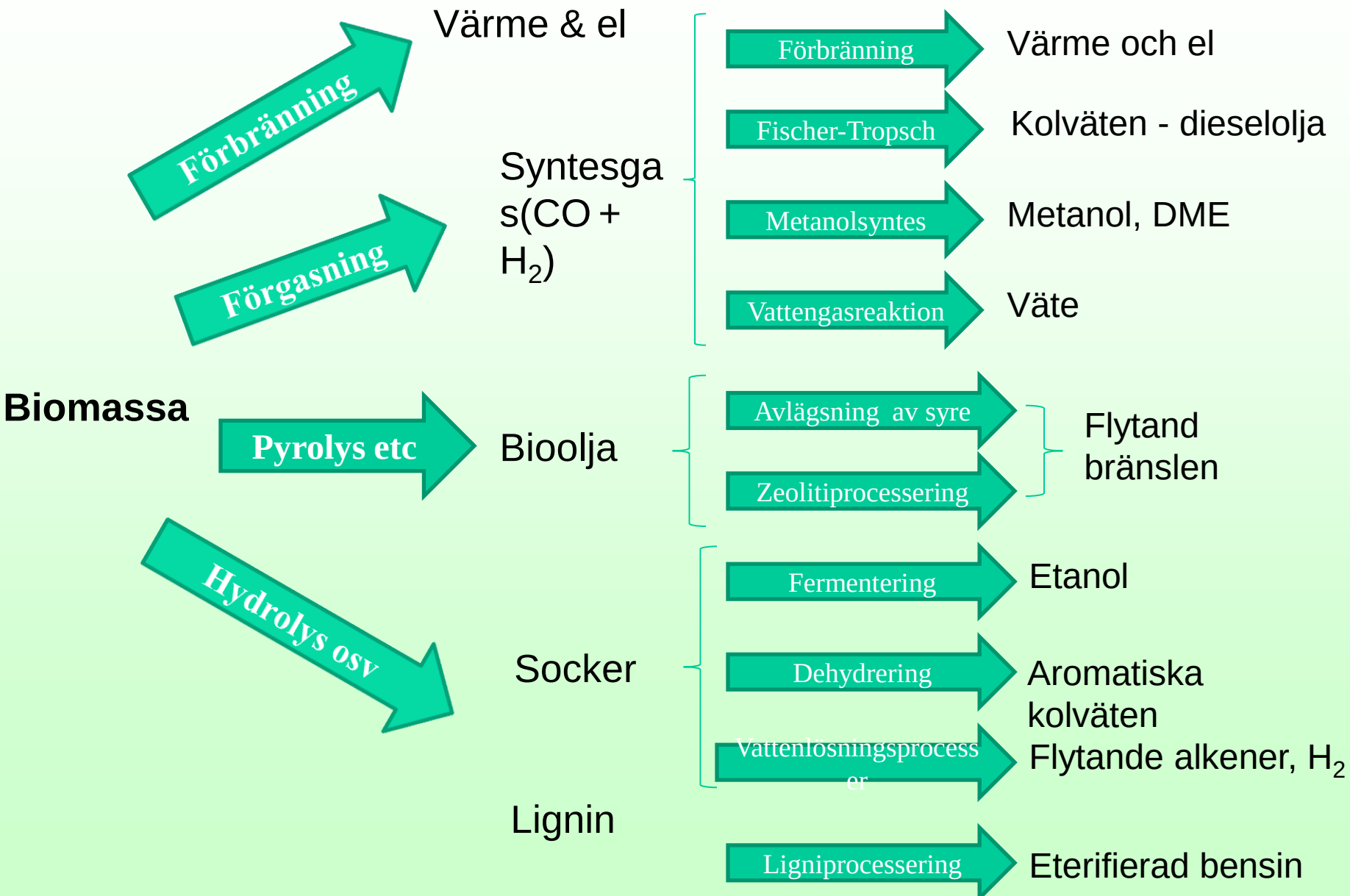








Bioenergialternativ



Bioenergy

- Olika biomassor – olika egenskaper – olika potentiella processer
- Stort antal alternativa tekniker
- De flesta under utveckling – få kommerciellt tillgängliga

The Devil will be in the (chemical) details!