Biomass combustion and co-firing in The Netherlands

by

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KEMA

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Technical description and operational experiences

- Stand-alone biomass combustion projects
- Co-firing in pulverized coal-fired plants

Stand-alone biomass combustion

- Grate-fired wood combustion Schijndel
- Bubbling fluidized bed combustion Cuyk
- Torbed wood combustion Dronten

Timber industry Schijndel B.V.

Combustion plant (1 MWe)

- clean waste wood mostly from their own wood processing, and partly delivered by third parties
- E-production (green electricity)
- internal usage of heat
  (drying processes and residential heating)
- in operation since April 1997

Timber industry Schijndel B.V.

Wood storage in 4 silo's

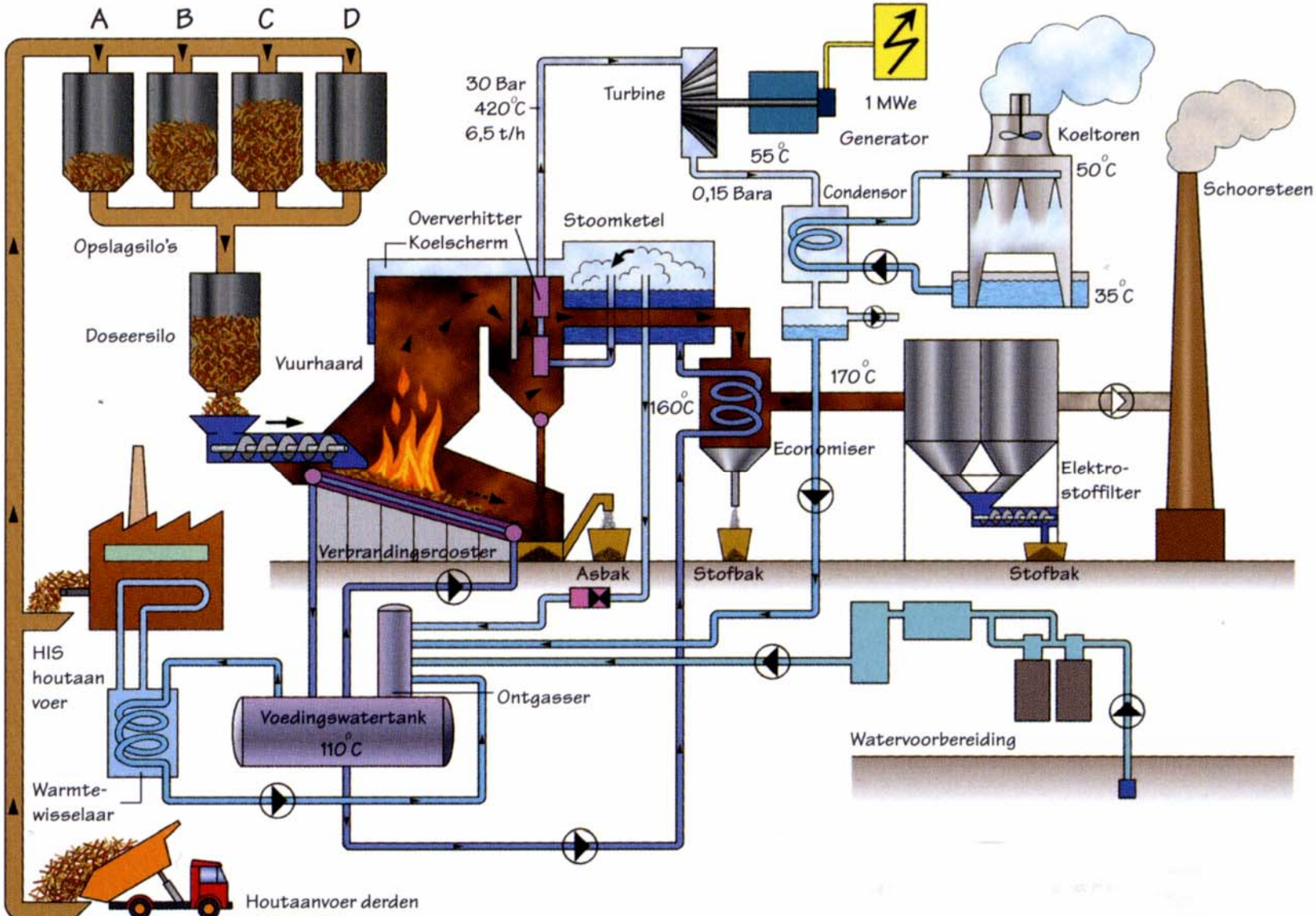
Dosing silo

Combustion on a travelling grate (water cooled)

Automatic ash removal

Steam production (28 bar , 420 ºC)

Bag house filter


A
B
C
D
Opslagsilo's
Doseersilo
Vuurhaard
Verbrandingsrooster
Oververhitter
Koelscherm
Stoomketel
30 Bar
420°C
6,5 t/h
Turbine
1 MWe
Generator
55°C
0,15 Bara
Condensor
Koeltoren
50°C
35°C
Schoorsteen
170°C
160°C
Economiser
Elektro-
stoffilter
Asbak
Stofbak
Stofbak
HIS
houtaan
voer
Ontgasser
Voedingswatertank
110°C
Warmte-
wisselaar
Watervoorbereiding
Houtaanvoer derden

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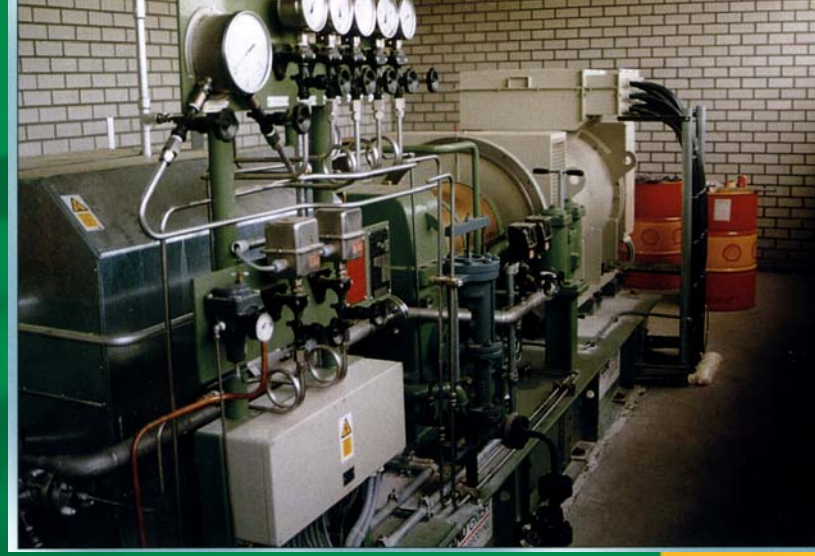
Specifications



Turbine + generator

Investment cost	3	MEuro
Operating hours hours/year	7000	
Payback time	7 - 10	year
E-power	1	MW_e
Internal power consumption	180	kW_e
Steam conditions °C	24 bar, 420	
Steam production ton/hour	6,5	
	5	MW_{th}
Fuel input	1400	kg/h

KEMA POWER GENERATION & SUSTAINABLES

Emissions

	Permit	Measured	
• CO mg/Nm^3	250	< 100	
• NO_x mg/Nm^3	400	~ 250	
• C_xH_y	50	< 2	mg/Nm^3
• Dust	25	< 10	mg/Nm^3

Technical evaluation

- Availability reasonable (70%, output increasing)
- Complex operation compared with large-scale
- Various technical problems, solved in part:
  - replacement superheater
  - defect generator
  - leakage/adaptions of the grate
  - major maintenance
  - regular slagging/fouling
  - fluctuating combustion conditions due to variations in fuel composition

Economical evaluation

Economical feasibility depends strongly on:

- investment cost
- fuel price
- price paid for electricity to the grid and heat
- plant availability

- avoid purchasing wood from third parties
- minimal price 7.5 ct/kWh
- investment subsidies necessary

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75 years

Bio-energy CHP plant Cuyk

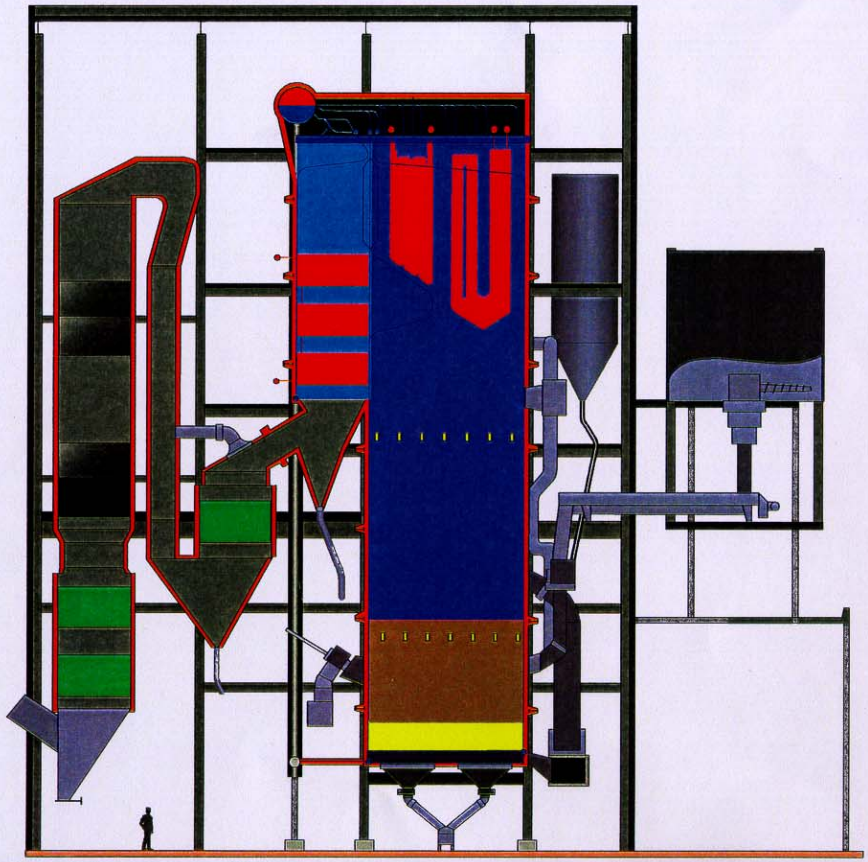
KEMA POWER GENERATION & SUSTAINABLES

Fuel	clean wood
Fuel	270.000 ton/yr at 50% moisture (36 ton/hr)
Storage capacity	2 x 5000 m^3
type boiler	bubbling fluidized bed
manufacturer	Kvaerner Finland
process	steam cycle with air cooled condensor (45 °C; 0.1 bar)
Investment	EUR 50,000,000
Thermal capacity	84 MW
gross electric output	27,5 MW
net electric output	25 MW
net electric efficiency	29.8 %
annual production: electricity heat/steam	 190 GWh delivery is prepared

Flue gas cleaning	
DeNOx	SCR/SNCR (high dust)
Dust filter	ESP
emission-limits (6% O_2,dry) mg/Nm3	
dust	20
SO_2	250
NO_x	100
CO	100
HCl	15
HF	1,5
sum heavy metals	1,5
Cd	0,075
Hg	0,075
PCDD + PCDF	0,15 ng I-TEQ/m3
C_xH_y	15
NH_3	5

Bubbling fluidized bed boiler

Pulp & Paper



Energy Systems BV
Cuijk
The Netherlands

Steam	78 MW_{th}
	27.4 kg/s
	100 bar
	525 °C
Fuels	Wood fuel
Start-up	1999

Kvaerner Pulping - Power Division

KVÆRNER

Operational experiences

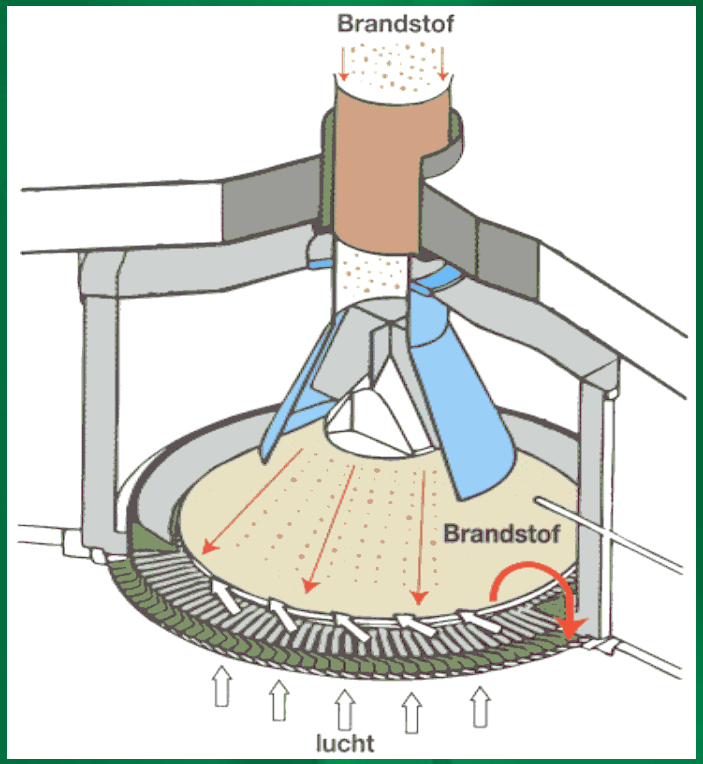
- Lack of experience with influence of fuel quality on conversion behaviour
- bed agglomeration / fouling
- wood fuel handling (bridge formation)

Torbed wood combustion Dronten

- 2 x 4 MW_{th} Torbed units
- shredded waste wood as fuel (< 5x1x1 cm)
- hot air for drying manure in a rotary kiln

- emission limits
  - NO_x 150 mg/Nm^3
  - CO 100 mg/Nm^3

Torbed vergassingstechnologie



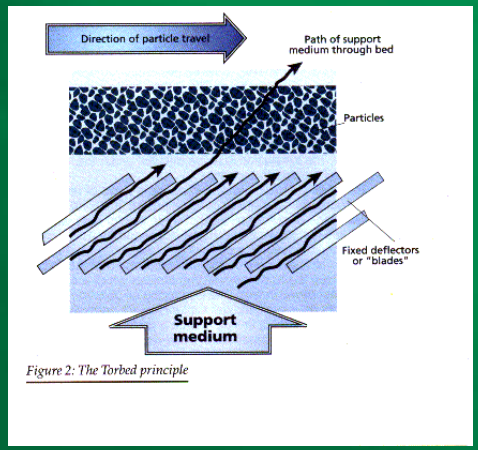


Figure 2: The Torbed principle

Blade ring detail

Operational experiences

- Operators not trained well with new technology
- Severe mechanical damage by temperature excursions
- Manure drying process more delicate than expected

- Equipment repaired
- Operator training

Dutch direct co-firing experiences

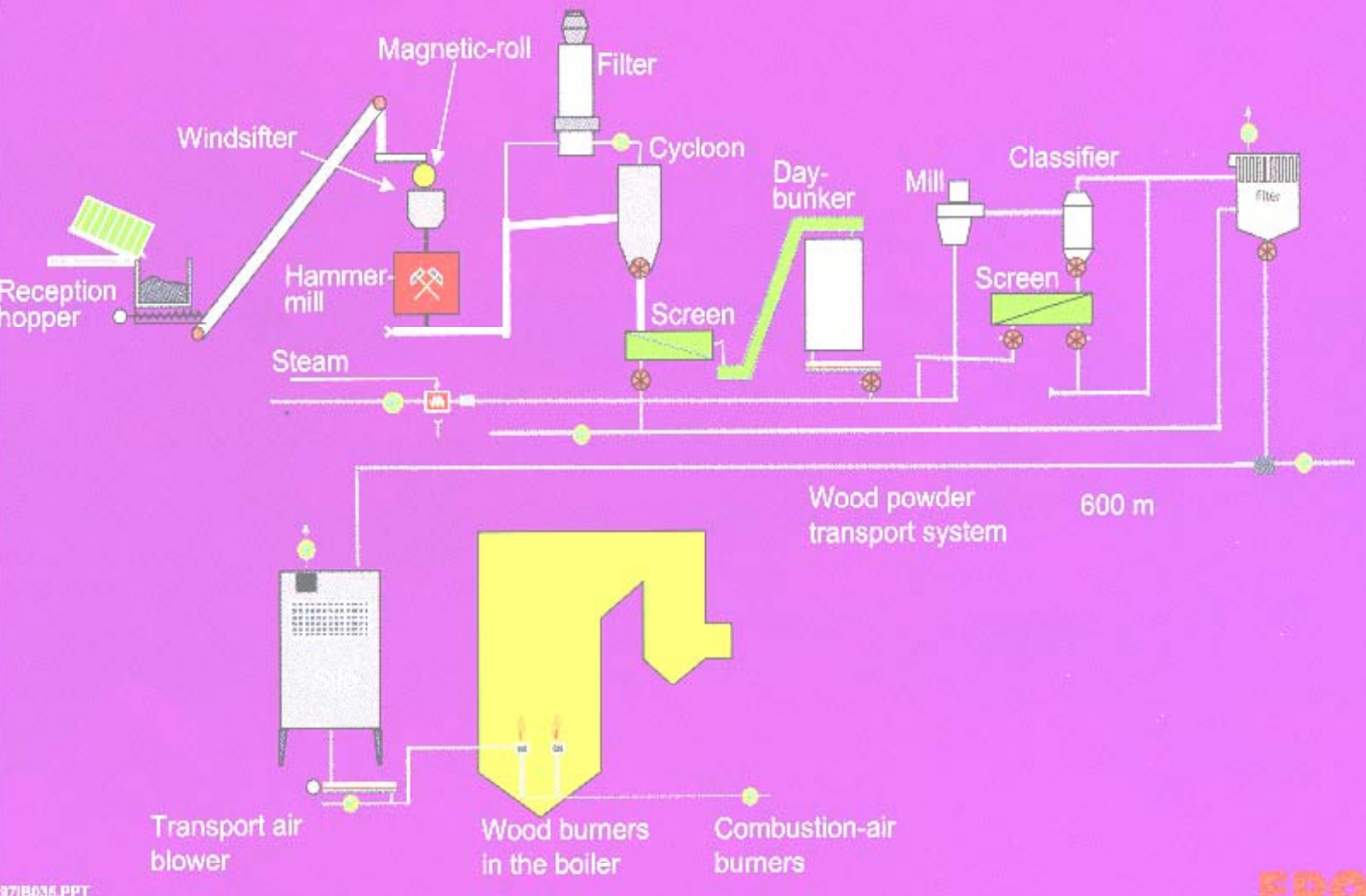
Power plant	Type of fuel	[kt/yr]	% cofiring (energy)	CO_2-em.red. [kt/yr]	Status
Gelderland-13	demolition wood	60	3	97	operational
Amer-8	paper sludge	75	0.3	11	operational
Amer 9	wood pellets				
Borssele-12	phosphor oven gas sewage sludge palm kernels	75	3	71	operational
Maasvlakte 1/2	Biomass pellets animal fat meat- and bone meal	150 40	3 3	77 82	operational tested
Buggenum-7	poultry litter	100	10	128	study
Hemweg-8	sewage sludge	75	3	92	tested

Demolition wood / sewage sludge: negative view from the public (heavy metals)

Biomass pellets: 60 w% paper/cardboard, 24 w% waste wood, 16 w% compost

Gelderland 13 power plant

- 602 MW_e, pulverised coal wall fired, dry bottom, bituminous coal (import blends)
- subcritical steam (540 °C ,190 bar; 540 °C reheat)
- Low-NO_x burners, SCR
- ESP + wet FGD


Magnetic-roll
Filter
Windsifter
Cycloon
Day-
bunker
Mill
Classifier
Reception
hopper
Hammer-
mill
Screen
Screen
Steam
Wood powder
transport system
600 m
Transport air
blower
Wood burners
in the boiler
Combustion-air
burners

97IB036.PPT

Wood logistics CG13

Experiences CG13

- Wood milling circuit capacity not sufficient
- High maintenance cost
- Unburned wood particles in bottom ash

- redesign of milling circuit
- injection wood powder in the coal feed pipes

Co-firing at Maasvlakte

- 2 units 518 MW_e, pulverised coal tangentially fired, dry bottom, bituminous coal (import blends)
- subcritical steam (540 °C ,180 bar; 540 °C reheat)
- Low-NO_x burners, overfire air
- ESP + wet FGD

Co-firing experience

- animal fat
- anode cokes
- biomass pellets
- citrus pellets
- meat and bone meal
- petroleum cokes
- poultry litter

Biomass plant Maasvlakte E.ON

Operational experiences

- Pet-cokes: burn-out, fly ash quality
- Biomass pellets: limited by drying capacity of the coal pulverisers
- animal fat: coal mill pattern essential for steam temperature setpoint
- meat and bone meal: bottom ash quality

Technical and environmental constraints

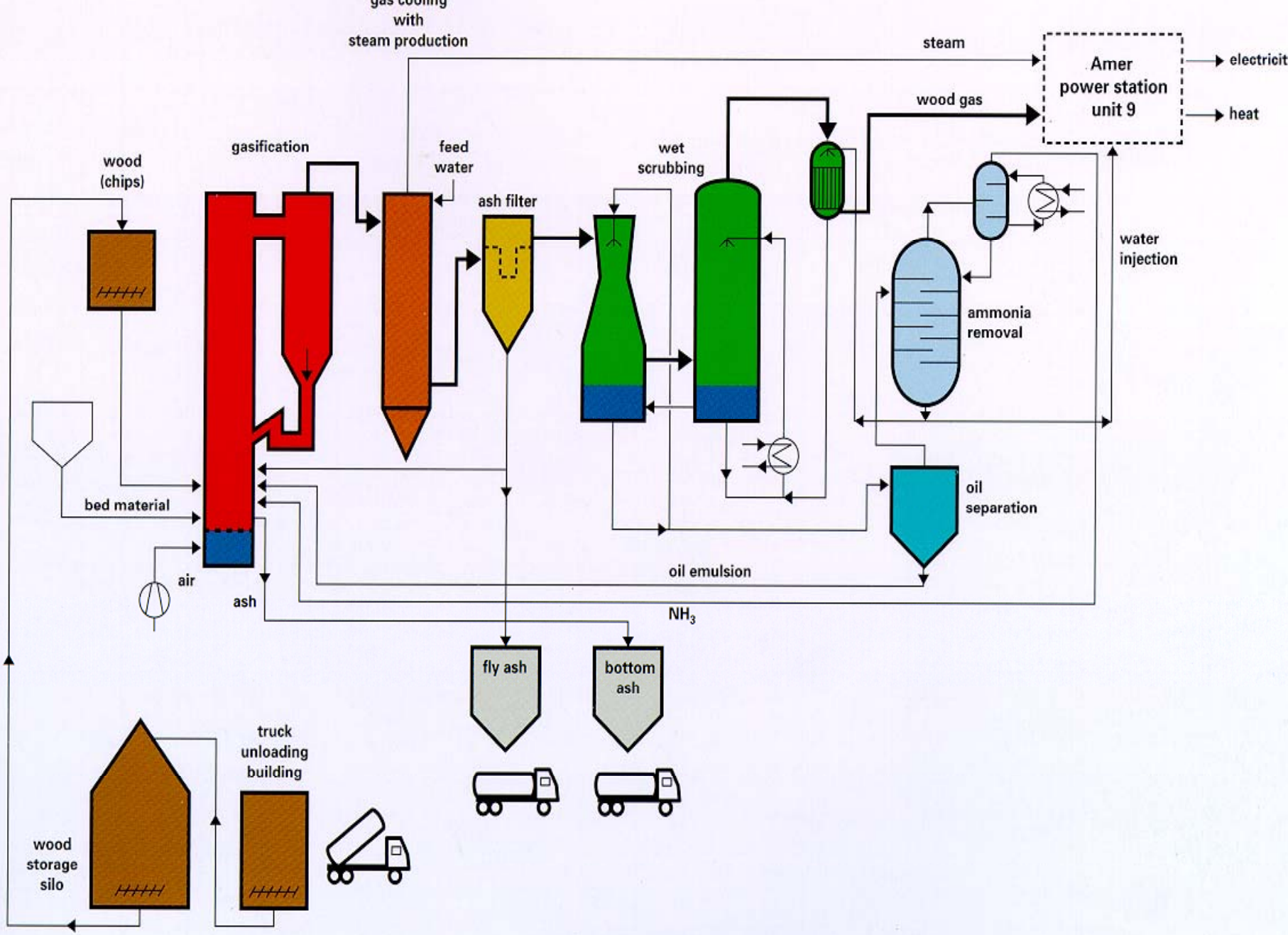
- fuel handling
  - storage / spontaneous combustion
- milling / drying
- combustion
  - reactivity ↔ particle size distribution
- fouling and slagging
  - alkali chlorides
- thermal behaviour of the boiler

Technical and environmental constraints

- corrosion / erosion
  - ratio S/Cl
- by-product quality
  - free CaO
  - soluble PO_4
- emissions to the atmosphere
  - < CO_2, < SO_2
  - SCR deactivation
- components capacity

Amer 9 power plant

- 600 MW_e, 350 MW_{th}, pulverised coal tangentially fired, dry bottom, bituminous coal (import blends)
- supercritical steam (535 °C , 230 bar; 568 °C reheat)
- Low-NO_x burners, overfire air
- ESP + wet FGD


gas cooling
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removal
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oil
separation
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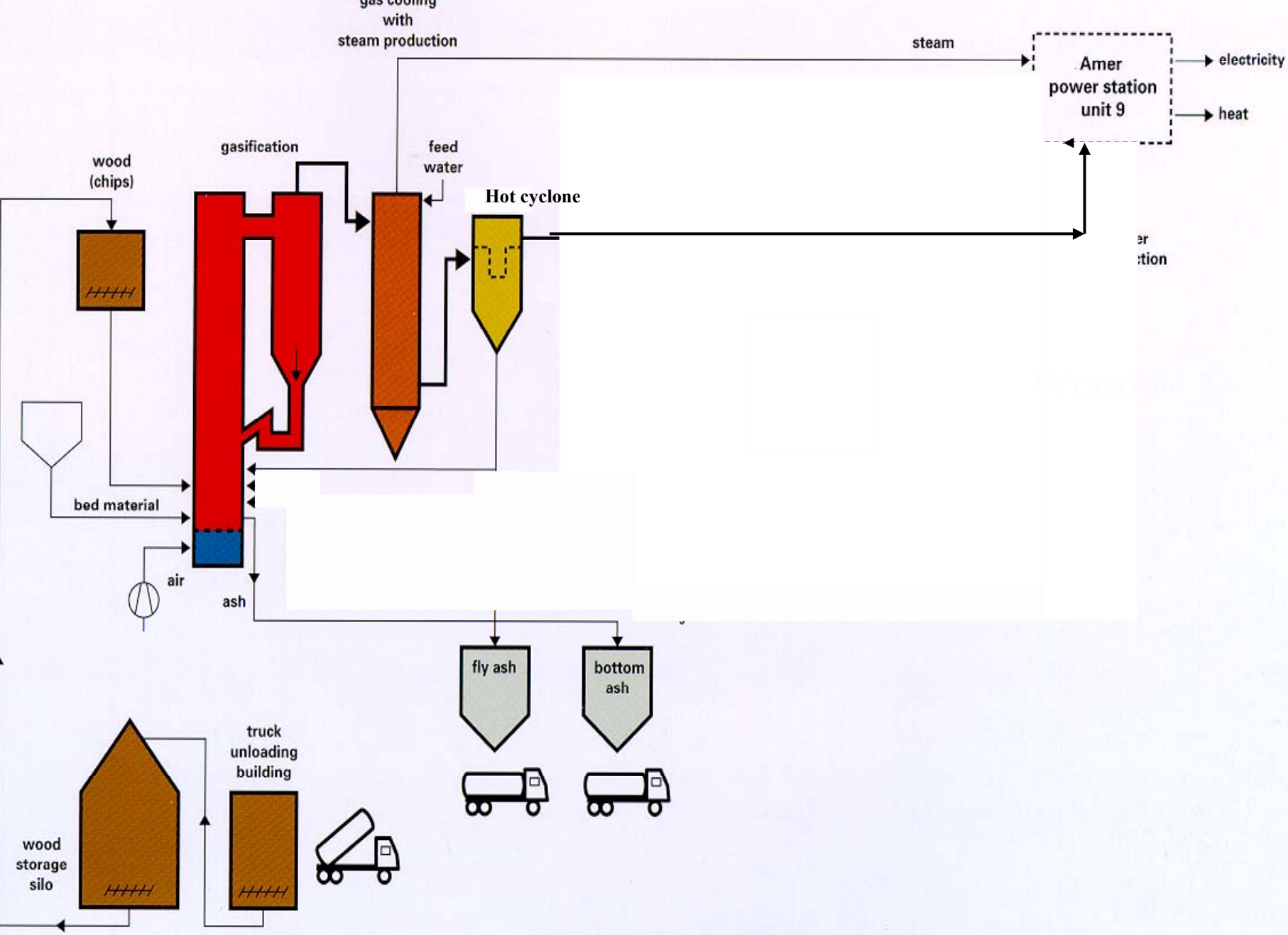
oil emulsion
ash
NH_3
fly ash
bottom
ash
truck
unloading
building
wood
storage
silo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water
Hot cyclone
bed material
air
ash
fly ash
bottom
ash
truck
unloading
building
wood
storage
silo

CONCLUSIONS

- DIRECT CO-COMBUSTION
  - cheapest way
  - high efficiency
  - proven with small percentages (< 10%)
  - strong incentive in the Netherlands to realize Kyoto agreement
  - emerging interest in other countries

CONCLUSIONS

- INDIRECT CO-COMBUSTION
  - more expensive but cheaper than stand-alone
  - increase to higher co-combustion percentage / dirtier fuels
  - most promising concepts:
    - upstream gasification without low-temperature fuel gas clean-up
    - biomass upgrading