The Viking Gasifier

Outline

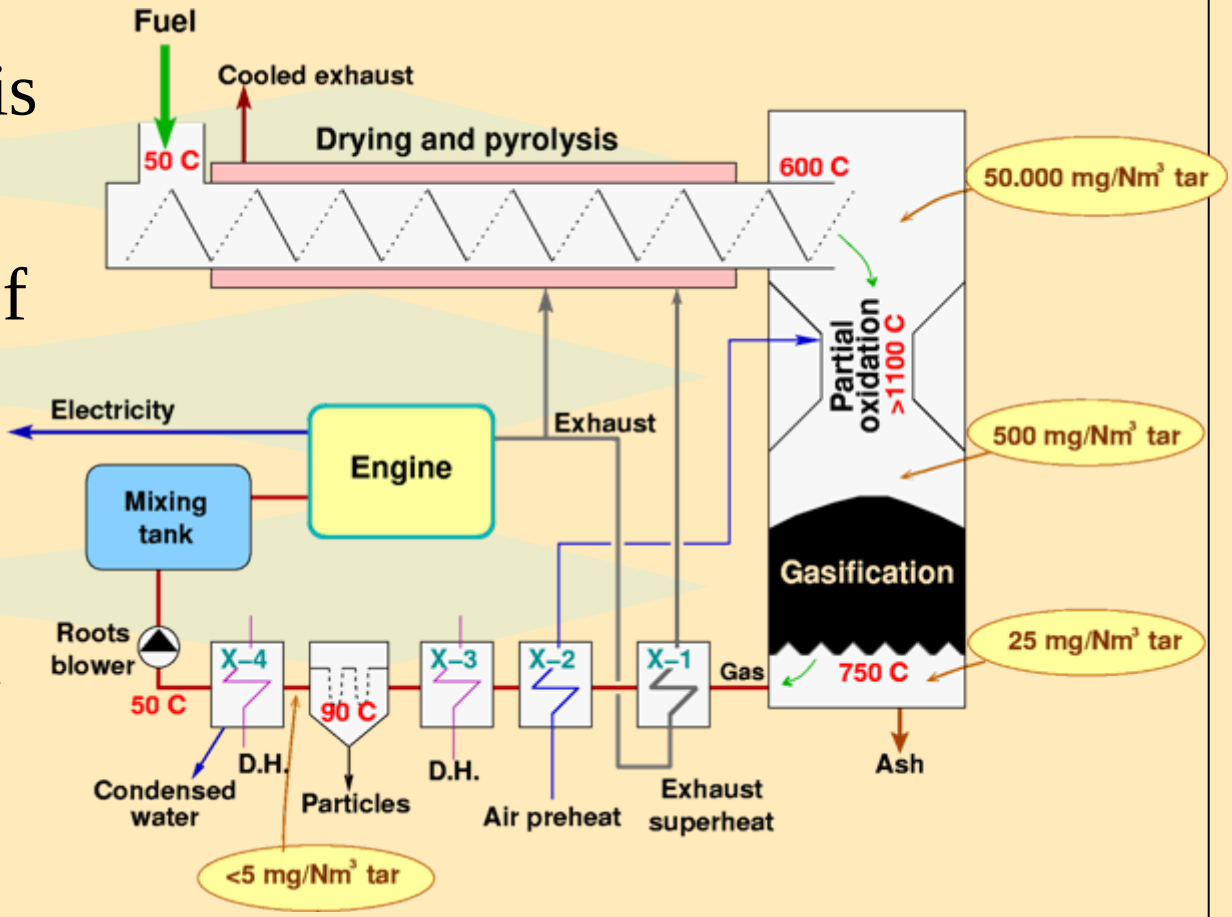
- Biomass Gasification Group at DTU
- Two stage gasification
- Viking gasifier
  - Technologies
  - Hurdles on the way
- Results from April 2003
- Conclusions

Biomass Gasification Group

- Thermal conversion of biomass
- 15 years of experience
- 12 Employees
- Externally financed

Two-stage gasification

- Separated pyrolysis and gasification
- Partial oxidation of pyrolysis gases
  - → No tar in gas **nor in waste**
  - → High efficiency



Viking gasifier at DTU

Commisioned August 2002

Small scale (75 kW_{fuel})

Unattended operation

Engine woodgas operation for > 1100 hours

Waste: only ash, carbon dust and water

Key data April 2003

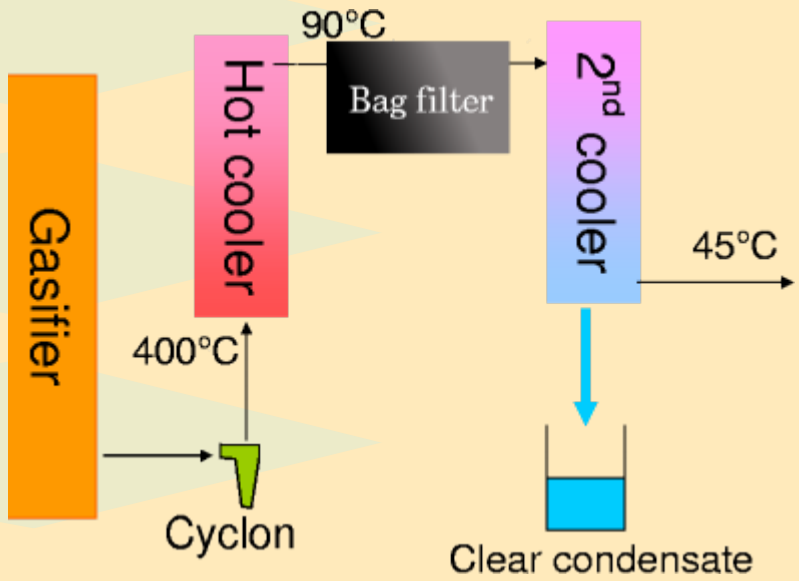
- Thermal input 68 kW
- Fuel: wood chips
- Moisture content 35-45 %
- Gasifier efficiency 93%
- Engine efficiency 32%
- Electric efficiency 27%
- Overall electric eff. 25%
- Tar level <5mg/Nm^3
- Dust level <5mg/Nm^3

Materials

- Partial oxidation zone: Brick lining
- Metal 700-1100C: MA-253 high temp. steel
- Metal <700C: Stainless steel
- Baghouse filter: Polyethylene

Bag house filter system

- Particle removal just above water dew point.
- Filter cleaning by N_2 back flush.
  - Bulk particles and condensate recovered separately.
  - Pressure drop <100 mmWG
  - Low energy consumption



Gas cleaning performance

- 1200 hours of reliable operation without permanent increase of the pressure drop
- Dust after filter <5 mg/Nm^3
- Residual tar condenses on particles, removed with these
  - → Tar level in gas drops from 25 to **"no tar"** (<5 mg/Nm^3)

Police filter after 1200 hours

Viking condensate quality

Amounts:	2-6 l/h
NH_3:	1 g/l
Naphtalene:	<20 µg/l
Other PAH:	<2 µg/l
Smell:	NH_3

⇒ OK for standard biological surridge plant!

Viking dust quality from bag house filter

Amounts: 100-600 mg/Nm^3
=5-30 g/h

Ash: Approx. 50%

Tar: <5% mass

→Low temperature reburning in boiler should be possible.

Ash from gasifier

- Unconverted carbon in ash from gasifier: ≈ 30 %
- Total unconverted carbon:
  - 0.1 wt.% of fuel
  - 0.3 % of energy in fuel

Intake manifold of the engine after 1100 hours on Wood Gas

Experiences

- No problems with brick lining
- Minor deposits of salts and carbonates in the hot gas system
- No corrosion of hot metal parts
- No deposits or corrosion in clean gas system and engine
- Shutdown corrosion in the system with cold uncleaned gas

Hurdles on the way

- Ash removal failed

Hurdles on the way

- Ash removal failed
  -> Totally new design

Hurdles on the way

- Ash removal failed
  -> Totally new design
- Condensation in ash
  -> Heat tracing

Hurdles on the way

- Ash removal failed
  -> Totally new design
- Condensation in ash
  -> Heat tracing
- Ceramics failed/smelted
  -> New reactor top using brick lining

Hurdles on the way

- Ash removal failed
  -> Totally new design
- Condensation in ash
  -> Heat tracing
- Ceramics failed/smelted
  -> New reactor using bricks

- Minor hurdles
  - Valves stuck during idle periods
  - Fuel feed blockages
  - Engine ignition system

Results during April 2003

Operation:

- Gasifier

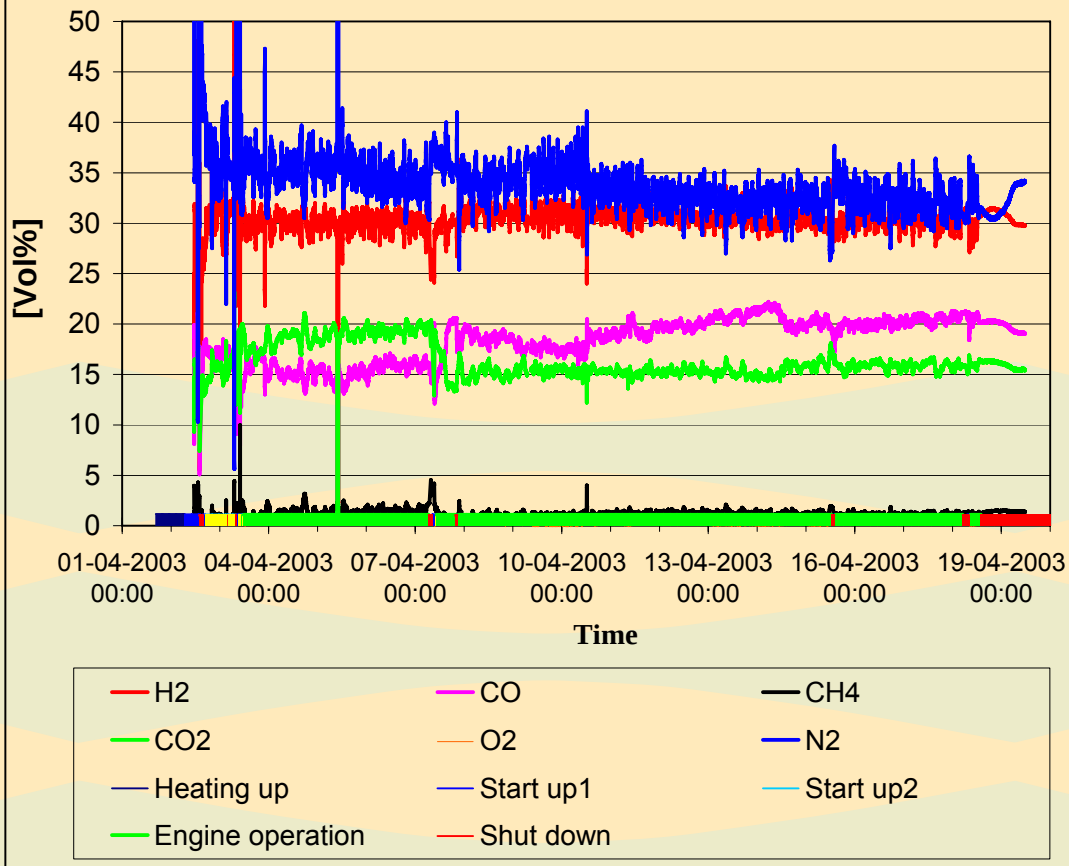
  380 hours April

  (>1300 hours total)

- Engine

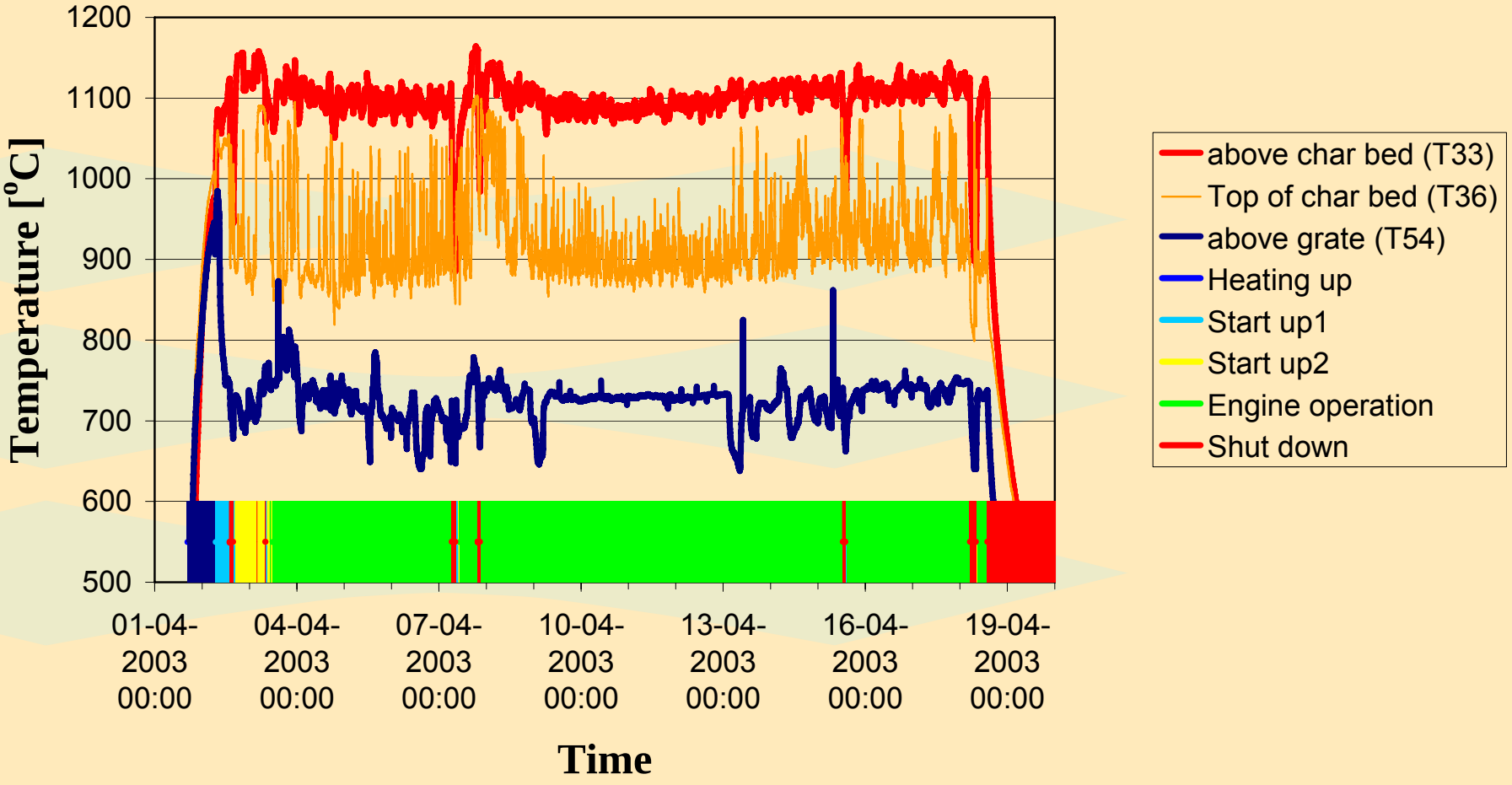
  346 hours

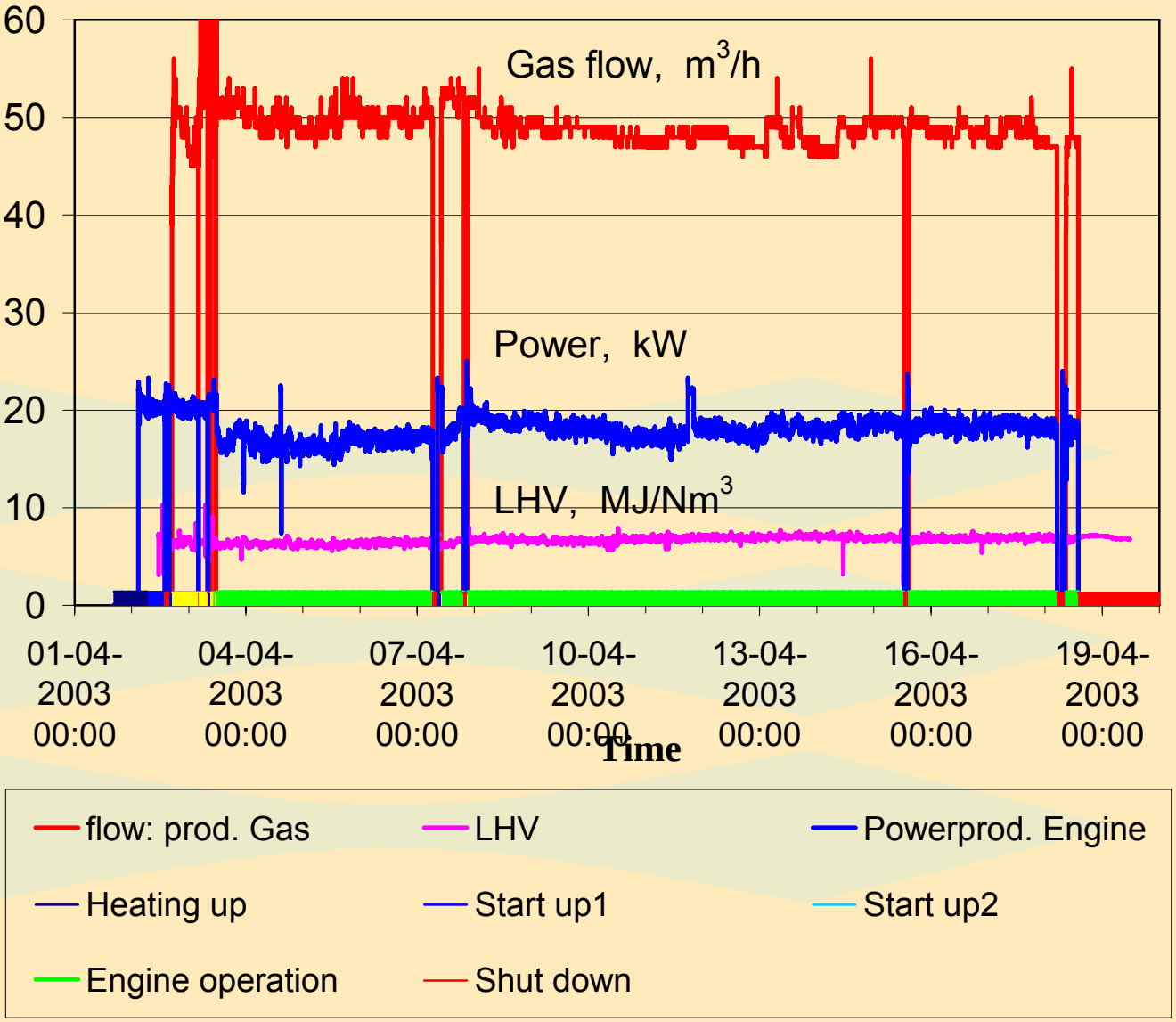
  (>1100 hours total)



Average dry gas composition		
H_2	30.5	%
CO	19.6	%
CH_4	1.2	%
CO_2	15.4	%
N_2	33.3	%
LHV	5.6	MJ/N m^3
HHV	6.2	MJ/N m^3
Gas flow (dry. 0°C)	37.1	m^3/h

Gas temperatures in char bed



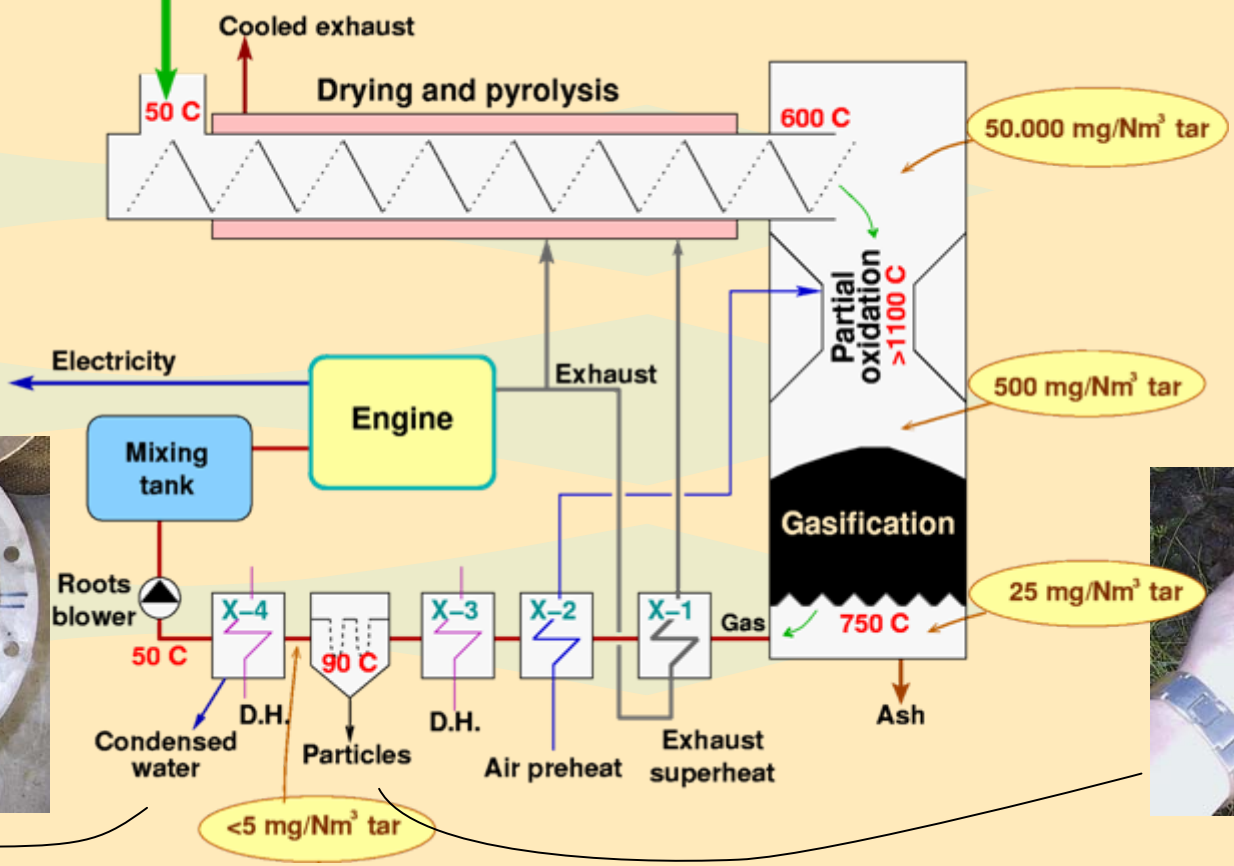

60
50
40
30
20
10
0
Gas flow, m3/h
Power, kW
LHV, MJ/Nm3
01-04-2003 00:00
04-04-2003 00:00
07-04-2003 00:00
10-04-2003 00:00
13-04-2003 00:00
16-04-2003 00:00
19-04-2003 00:00
Time
flow: prod. Gas
LHV
Powerprod. Engine
Heating up
Start up1
Start up2
Engine operation
Shut down

Conclusions

- Fully automatic unattended operation
- 1300 hours of operation
- 25 % efficiency from biomass to electricity to the grid.
- No tar in the gas
- Good engine performance - no deposits in engine
- Condensate not a waste problem
- Dust can be treated separately
- Absence of tars $\Rightarrow$ simple, cheap gas cleaning system.

Questions?


Fuel


Cooled exhaust
50 C
Drying and pyrolysis
600 C
50.000 mg/Nm³ tar
Partial oxidation
>1100 C
Electricity
Engine
Exhaust
Mixing tank
500 mg/Nm³ tar
Gasification
Roots blower
X–4
X–3
X–2
X–1
Gas
25 mg/Nm³ tar
50 C
90 C
750 C
D.H.
D.H.
Condensed water
Particles
Air preheat
Exhaust superheat
Ash
<5 mg/Nm³ tar