# Impact of Co-Combustion of Wood Pellets at Avedøre Power Plant Fired with Heavy Fuel Oil and Natural Gas


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# Content

- Biomass data
- Avedøre 2
- Rebuilding to combustion of wood pellets
- Experience
- Conlusion

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# Biomass data

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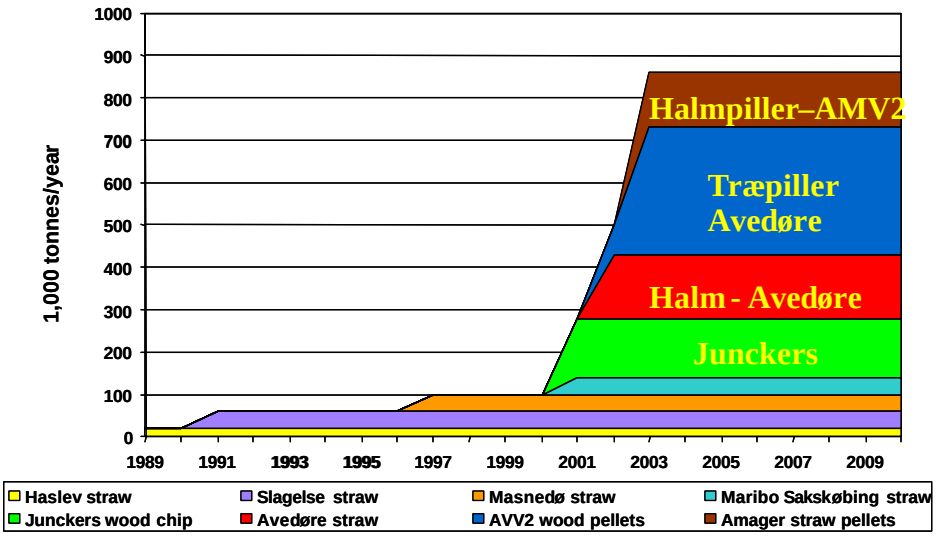
# Energi E2's expected use of biomass

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## Data of biomass fuels to be used at AVV2 and AMV2

| Biomass | LHV | Density | Ash | Price |
|---|---|---|---|---|
| | MJ/kg | kg/m$^3$ | % d.m. | EURO/GJ |
| Straw | 14,5 | 130 | 5 | 5,0 |
| | | | | |
| Straw pellets | 15,0 | 600 | 5 | 7,5 |
| | | | | |
| Wood chips | 10,5 | 250 | 0,5 | 4,0 |
| | | | | |
| Wood pellets | 17,5 | 650 | 0,5 | 6,0 |

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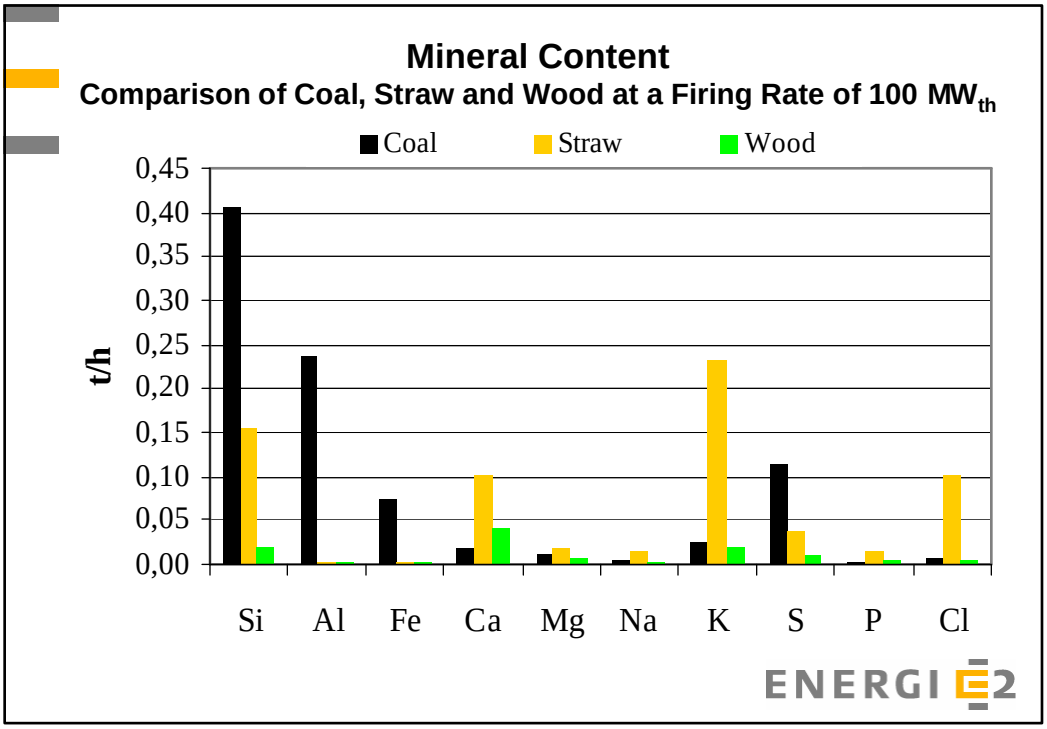
Mineral Content
Comparison of Coal, Straw and Wood at a Firing Rate of 100 MWth
Coal
Straw
Wood
t/h
0,45
0,40
0,35
0,30
0,25
0,20
0,15
0,10
0,05
0,00
Si
Al
Fe
Ca
Mg
Na
K
S
P
Cl
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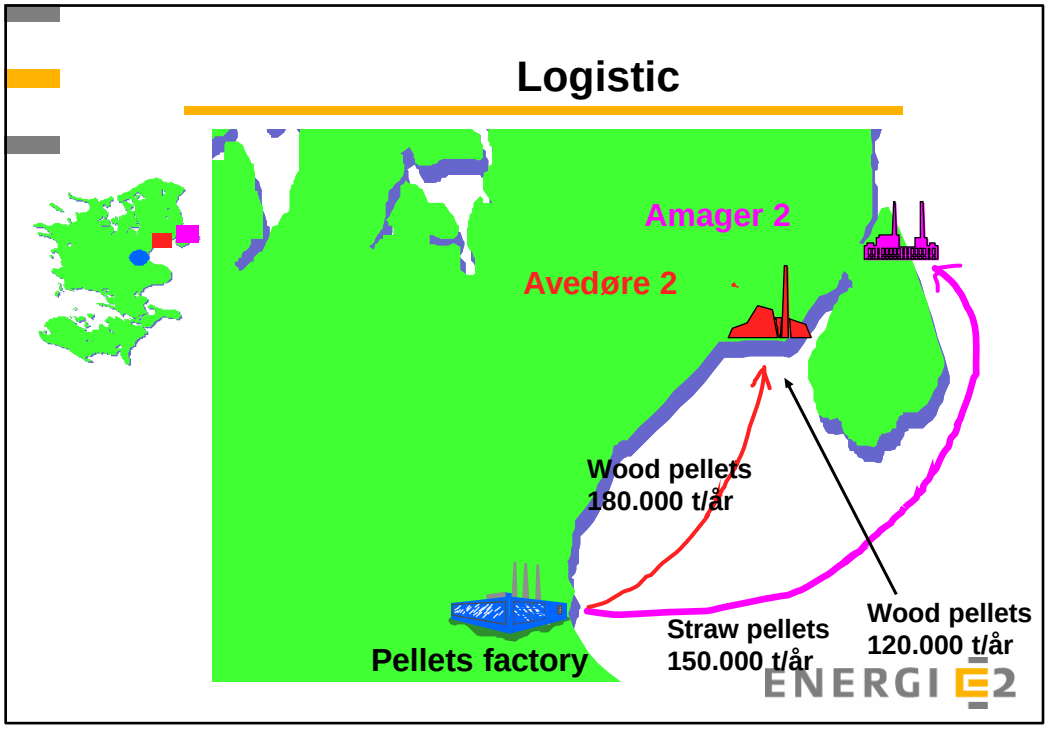
Logistic
Amager 2
Avedøre 2
Wood pellets
180.000 t/år
Straw pellets
150.000 t/år
Wood pellets
120.000 t/år
Pellets factory
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# Avedøre blok 2

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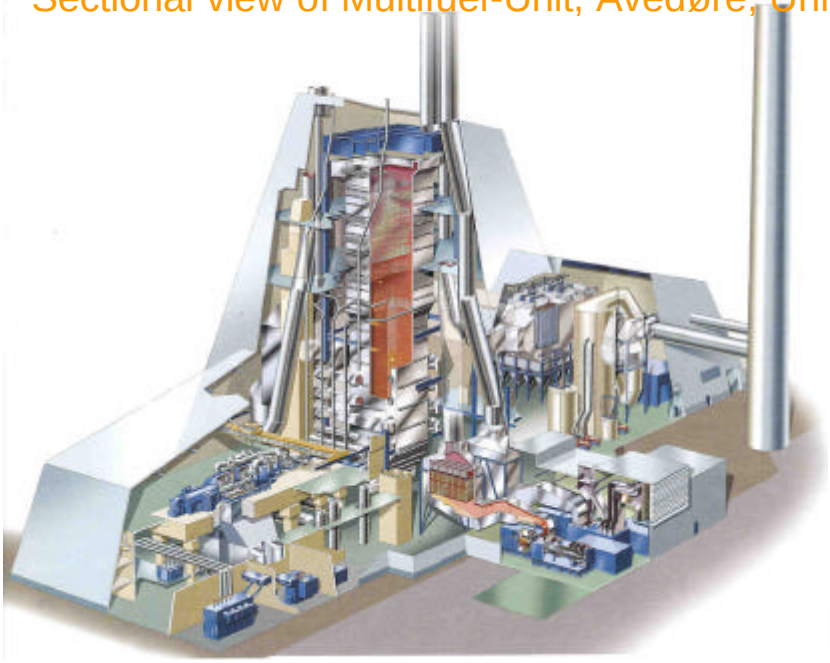
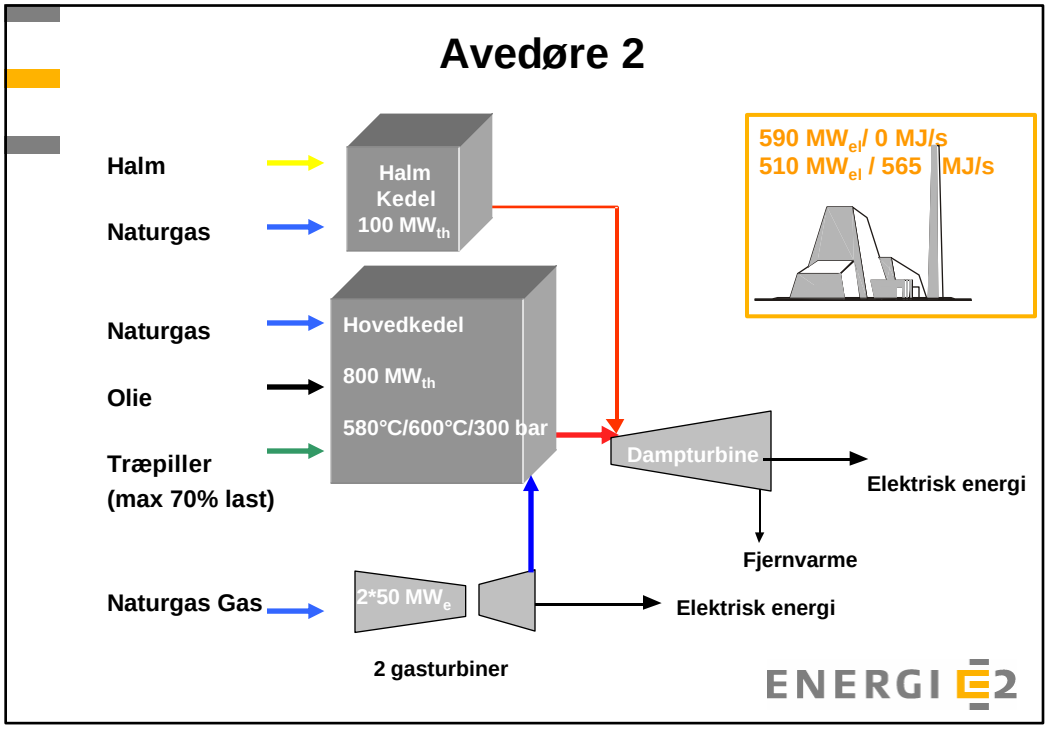
# Sectional view of Multifuel-Unit, Avedøre, Unit 2



# Avedøre 2


Halm
Naturgas
Halm Kedel 100 MWth
590 MWel/ 0 MJ/s
510 MWel / 565 MJ/s
Naturgas
Olie
Træpiller (max 70% last)
Hovedkedel
800 MWth
580°C/600°C/300 bar
Dampturbine
Elektrisk energi
Fjernvarme
Naturgas Gas
2*50 MWe
Elektrisk energi
2 gasturbiner
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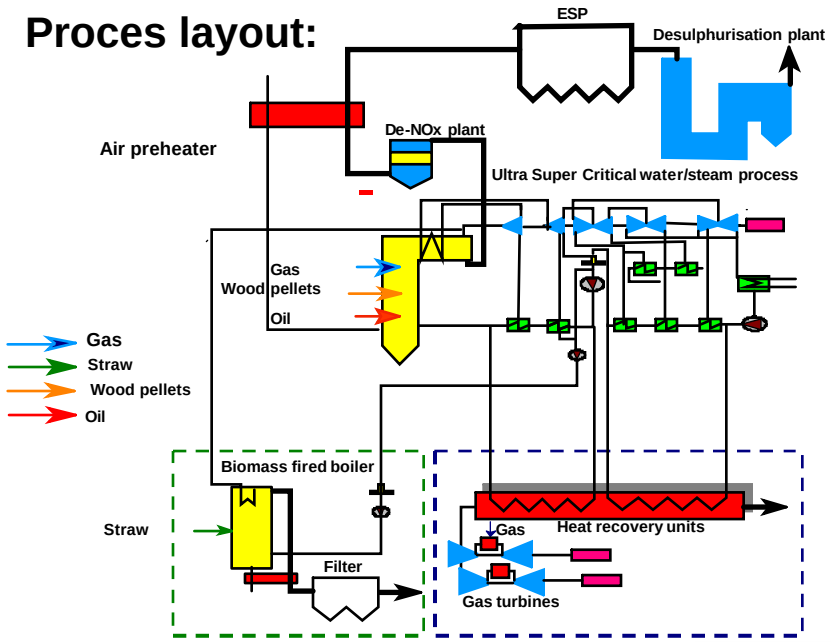
# Proces layout:

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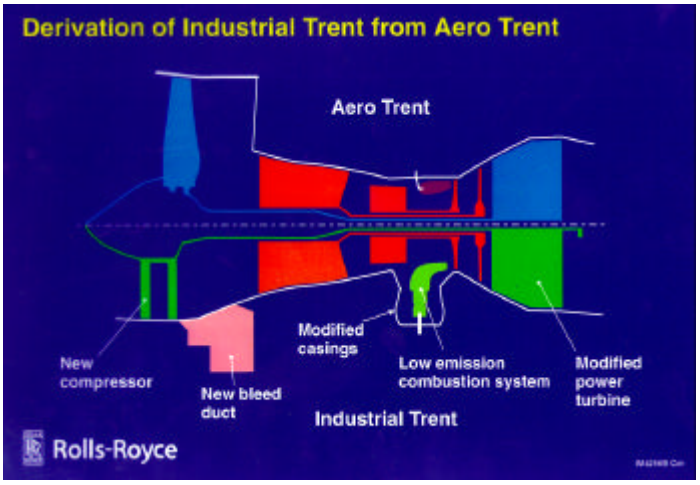
# RR Trent Aero and Industry

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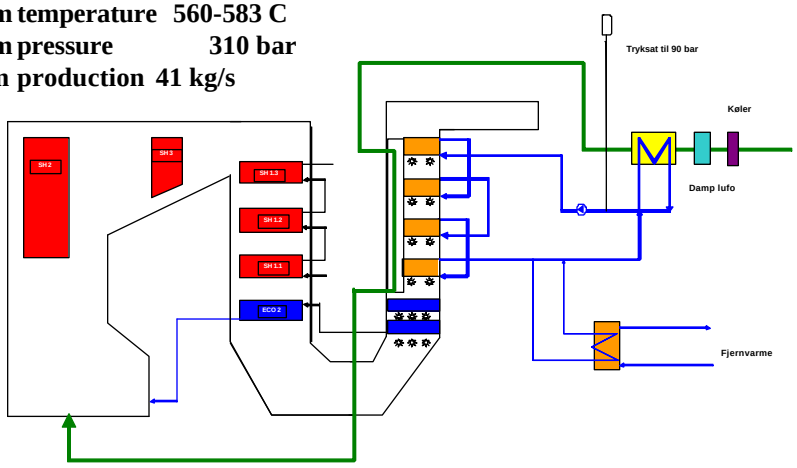
# Biomass boiler

**Steam temperature 560-583 C**
**Steam pressure 310 bar**
**Stram production 41 kg/s**

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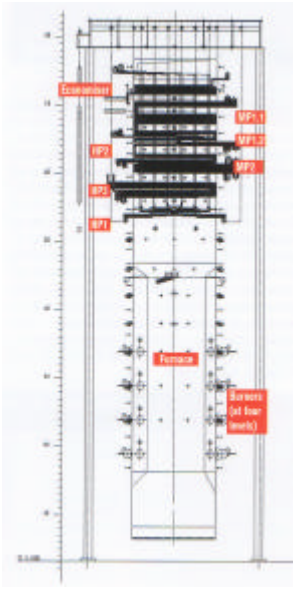
# AVV2 Main Boiler




**HT steam temperature 560-583 C**
**Stram pressure 310 bar**
**Stram production 297 kg/s**
**IP steam temperature 560-600 C**

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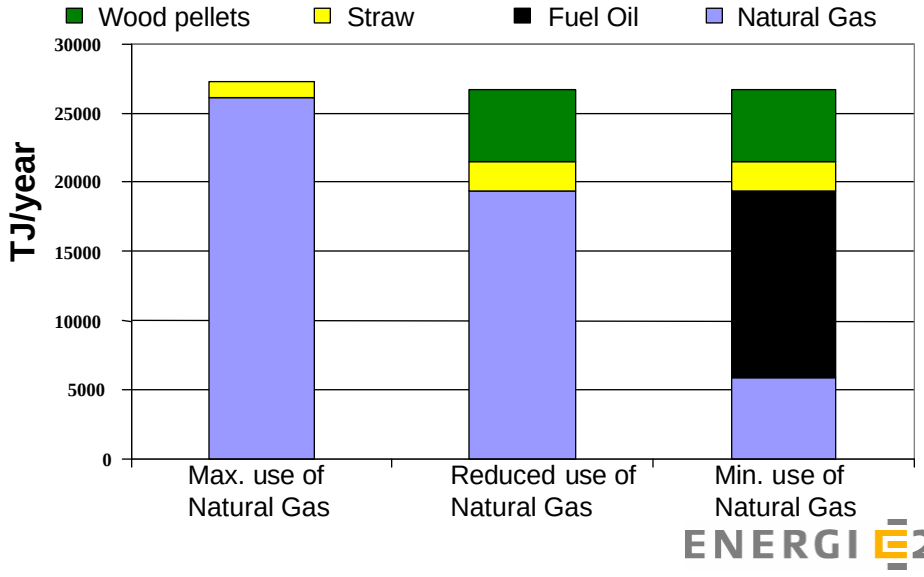
# Different Fuel Distributions

6,500 hours Full Load per Year, Gas Turbines Running

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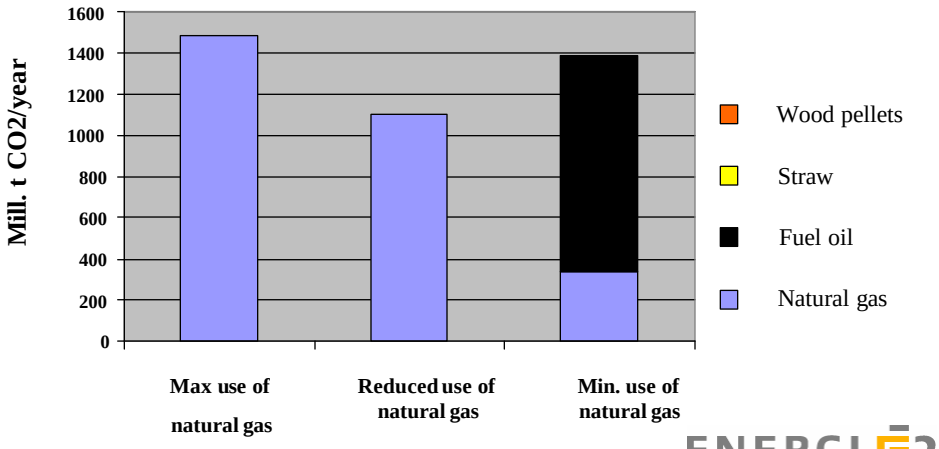
# CO2-emission of different fuel distributions

6,500 hours full load per year, gas turbines running

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## Rebuilding to combustion of wood pellets

- Modification of unloader in harbour
- Transport systems
- Storage facilities
- New mills (3 modified coal mills - )
- Explosion and fire protection system at AVV2
- Optimising of burners

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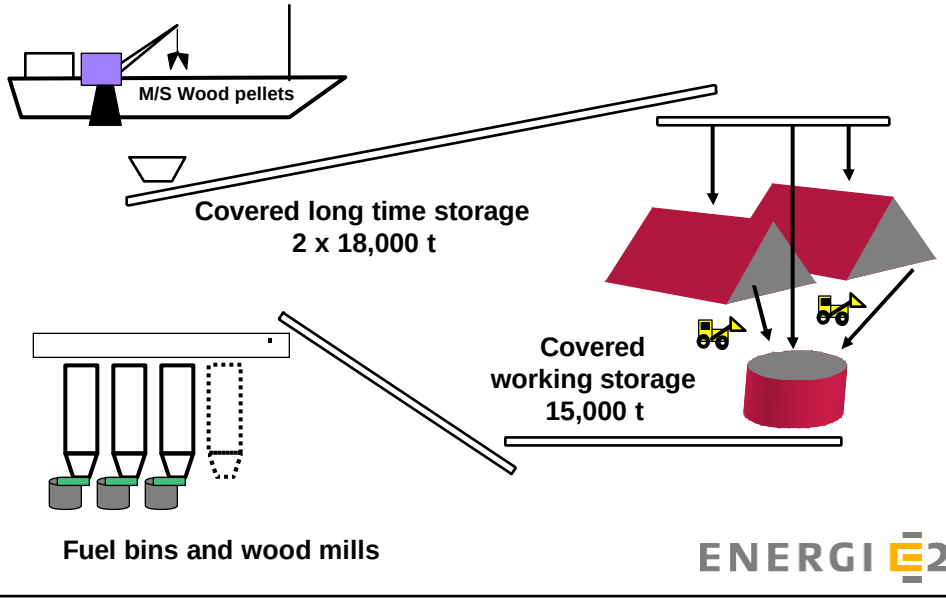
# Fuel Handling of Wood Pellets at AVV2

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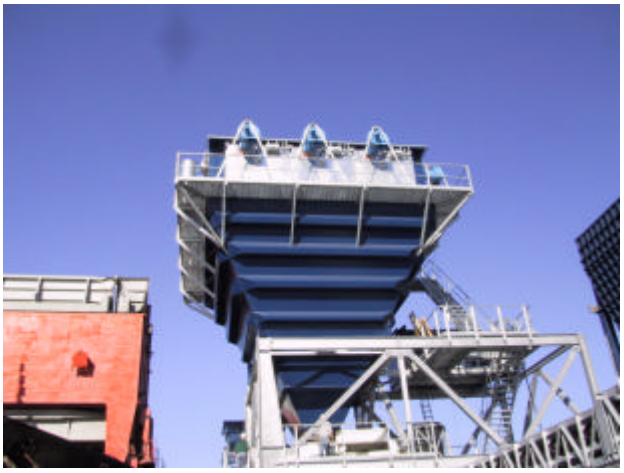
## Unloader bin for grab crane



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## Explosion protection system at AVV2

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## First year experience

- Capacity
- Fuel flexibility
- Corrosion
- Fowling
- DeNOx
- Gas/gas reheater
- Addition of fly ash

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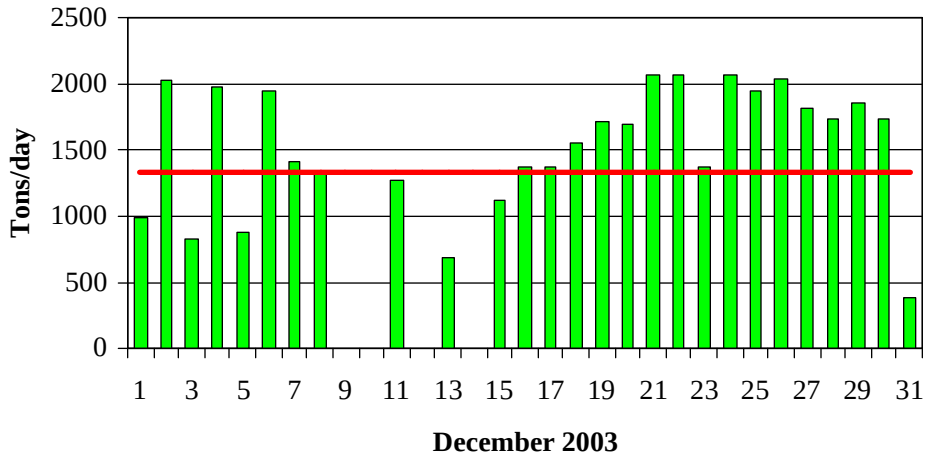
# Typical use of Wood Pellets

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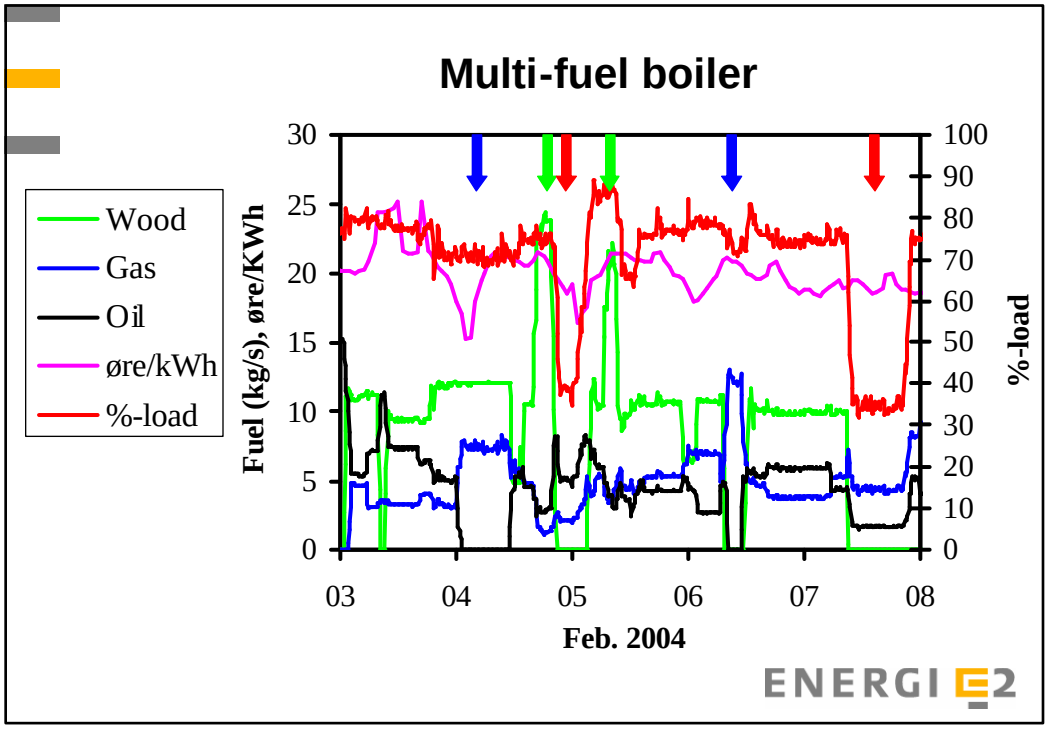
Multi-fuel boiler
Wood
Gas
Oil
øre/kWh
%-load
Fuel (kg/s), øre/KWh
%-load
0
5
10
15
20
25
30
0
10
20
30
40
50
60
70
80
90
100
03
04
05
06
07
08
Feb. 2004
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## Some important global additive reactions

KCl and Kaolin:

$$Al_2Si_2O_5(OH)_4 + 2\ KCl \Rightarrow 2\ KAlSiO_4 + H_2O + 2\ HCl$$
(kalsite)

$$Al_2Si_2O_5(OH)_4 + 2\ KCl + 2\ SiO_2 \Rightarrow 2\ KAlSi_2O_6 + H_2O + 2\ HCl$$
(Leucite)

KCl and $SiO_2$:

$$SiO_2 + 2\ KCl + H_2O \Rightarrow K_2O{\cdot}SiO_2 + 2\ HCl$$

KCl and $SO_2$:

$$SO_2 + 2KCl + H_2O + \tfrac{1}{2}\ O_2 \Rightarrow K_2SO_4 + 2HCl$$

Melting temperature

| KCl | $K_2SO_4$ | KCl+$K_2SO_4$ | $K_2O$+ $SiO_2$ | (kalsite) $KAlSiO_4$ | (Leucite) $KAlSi_2O_6$ | Leucite+$SiO_2$ |
|---|---|---|---|---|---|---|
| 750 C | 1076 C | 690 C | 750 C | 1686 C | 1150 C | 990 C |

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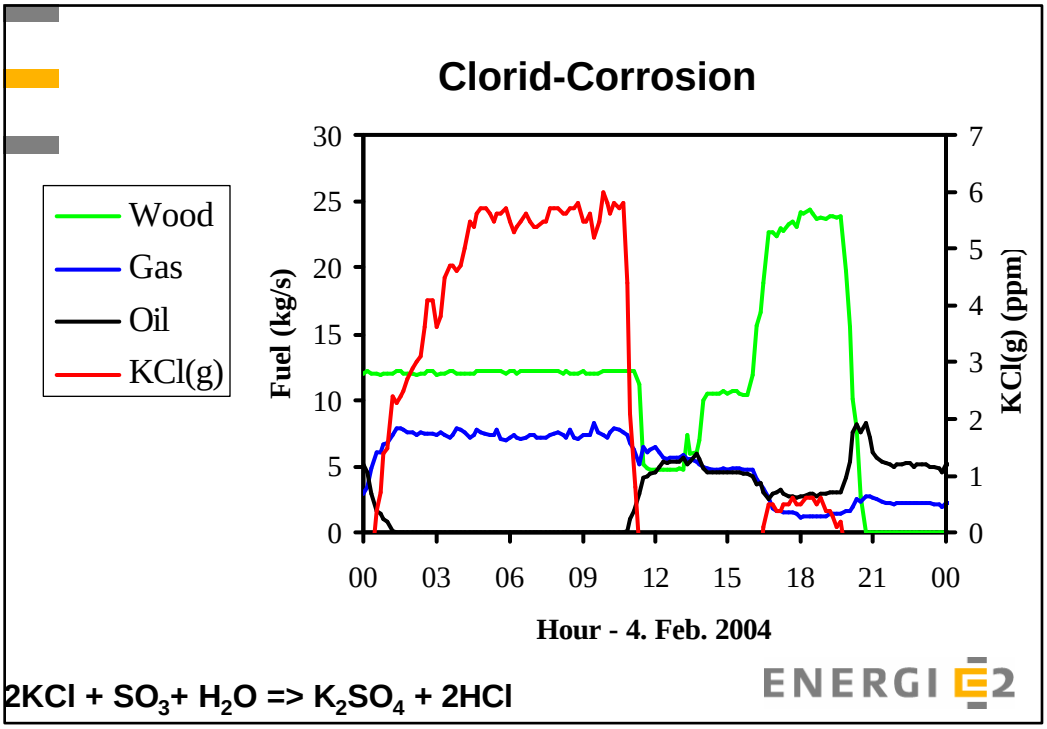


$2KCl + SO_3 + H_2O \Rightarrow K_2SO_4 + 2HCl$

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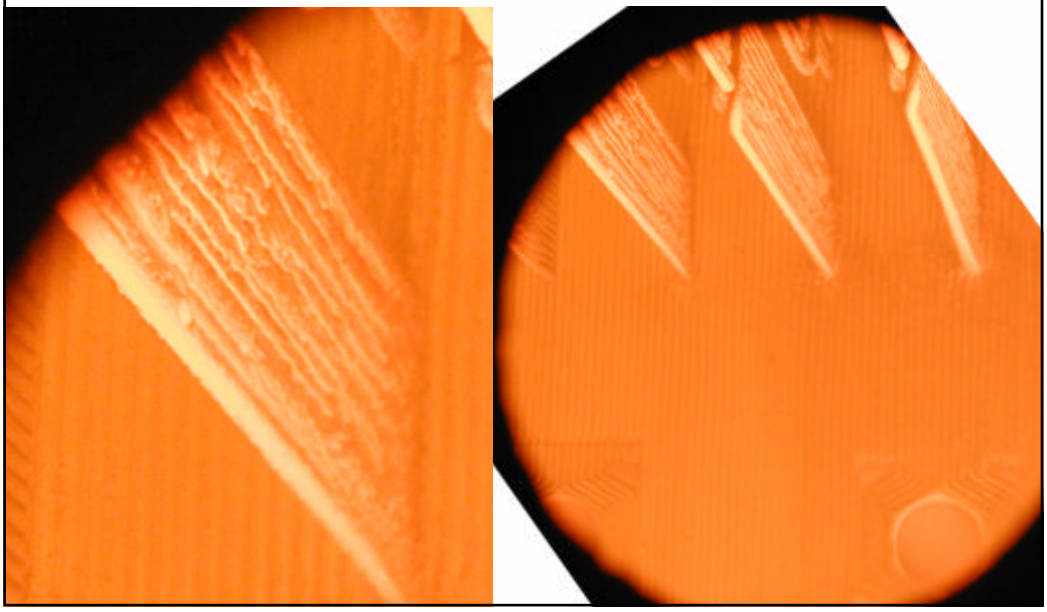
## Overhedere i AVV2's hovedkedel



# Content

- Damages on GGH
- Damages on lining
  - Mechanical
  - Corrosion due to $SO_3$
- Steps to minimize damages

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- Damages on GGH
- Damages on lining
  - Mechanical
  - Corrosion due to $SO_3$
- Steps to minimize damages

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# Lameller

- 10-15 cm corroded

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## Steps to minimize corrosion

- Reduction of $SO_3$ , low $O_2$ in flue gas
  - Adding $Mg(OH)_2$ or Coal fly ash
  - Mechanical protection beneath GGH
    - Rubber in cold clean gas (60 °C)
    - Laminate in cold raw gas (100 °C)
  - Adding limestone to hot fluegas
- New coating in hot clean gas
  - Ceilcote 387 Hybricote

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## Of line washing of elements

Positive part:

- Easy to handle elements outside reactor

Negative part:

- All elements has to be removed from reactor
- Bad working condition when removing elements

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## Washing machine for in situ wash

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# Impact on SCR catalyst and cleaning by washing

- Why washing  SCR catalyst?
- In situ or of line wash of deNOx catalyst
- Experience of deactivating and results of wash
- Analyses of washing water
- Conclusions and future work

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## Results optained

Wood pellets and heavy fuel oil (AVV2)

- Activity is reestablished
- K and Cl are washed out
- Ash from heavy fuel is washed out
- Number of repeated washing procedures are unknown

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# Addition of coal fly ash

- **Possible effects**
  - **Corrosion (KCl ->$K_2O{\cdot}SiO_2$)**
  - **Fouling (Errosion from fly ash)**
  - **Lifetime of SCR catalyst ( Longer)**
  - **Handling ( Fly ash mix is easy to handle)**
  - **Reuse of fly ash ( Fly ash can be used at cement production)**
  - **Reduction of corrosion on GGH ( $SO_3$ content in fluegas are reduced)**
- **Technical solution**

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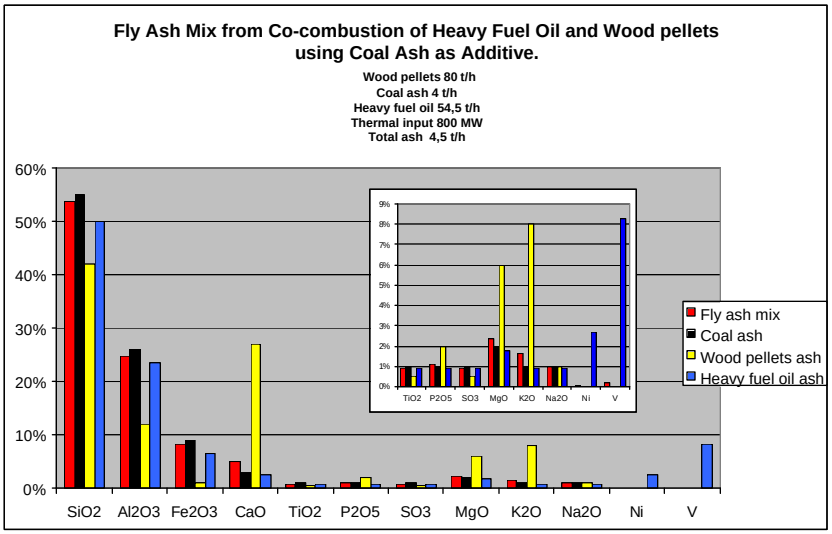
Fly Ash Mix from Co-combustion of Heavy Fuel Oil and Wood pellets using Coal Ash as Additive.
Wood pellets 80 t/h
Coal ash 4 t/h
Heavy fuel oil 54,5 t/h
Thermal input 800 MW
Total ash 4,5 t/h
60%
50%
40%
30%
20%
10%
0%
SiO2
Al2O3
Fe2O3
CaO
TiO2
P2O5
SO3
MgO
K2O
Na2O
Ni
V
Fly ash mix
Coal ash
Wood pellets ash
Heavy fuel oil ash

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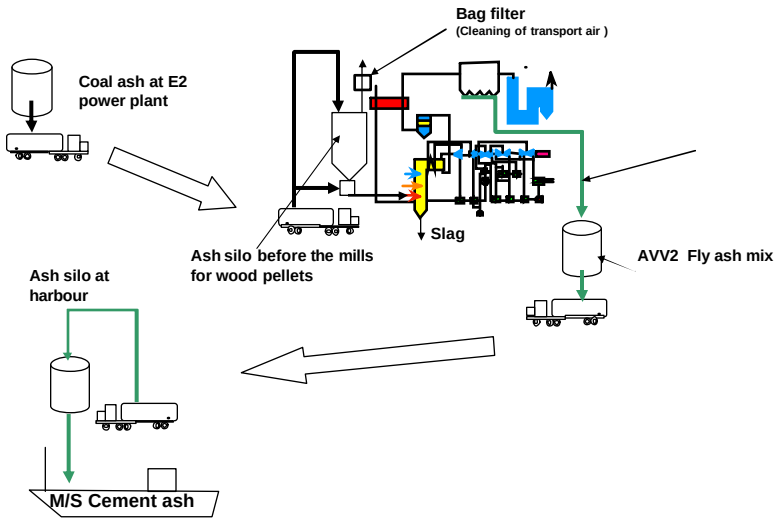
# Proces for adding coal fly ash

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