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WFPP Performance initial operation data

Amsterdam's experience with the 4th-generation Waste-to-Energy

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Amsterdam Eco-port®





AEB Business Case

Design Concepts:

World's largest WtE facility; > 1,500,000 MTPA

- WFPP® most efficient facility; > 30% (850 kWh/MT MSW)
- Overall solids recycling rate > 98%
- Robust design, 94% availability, extended life cycle
- Amongst the world's cleanest; emissions < 20% EPA limits

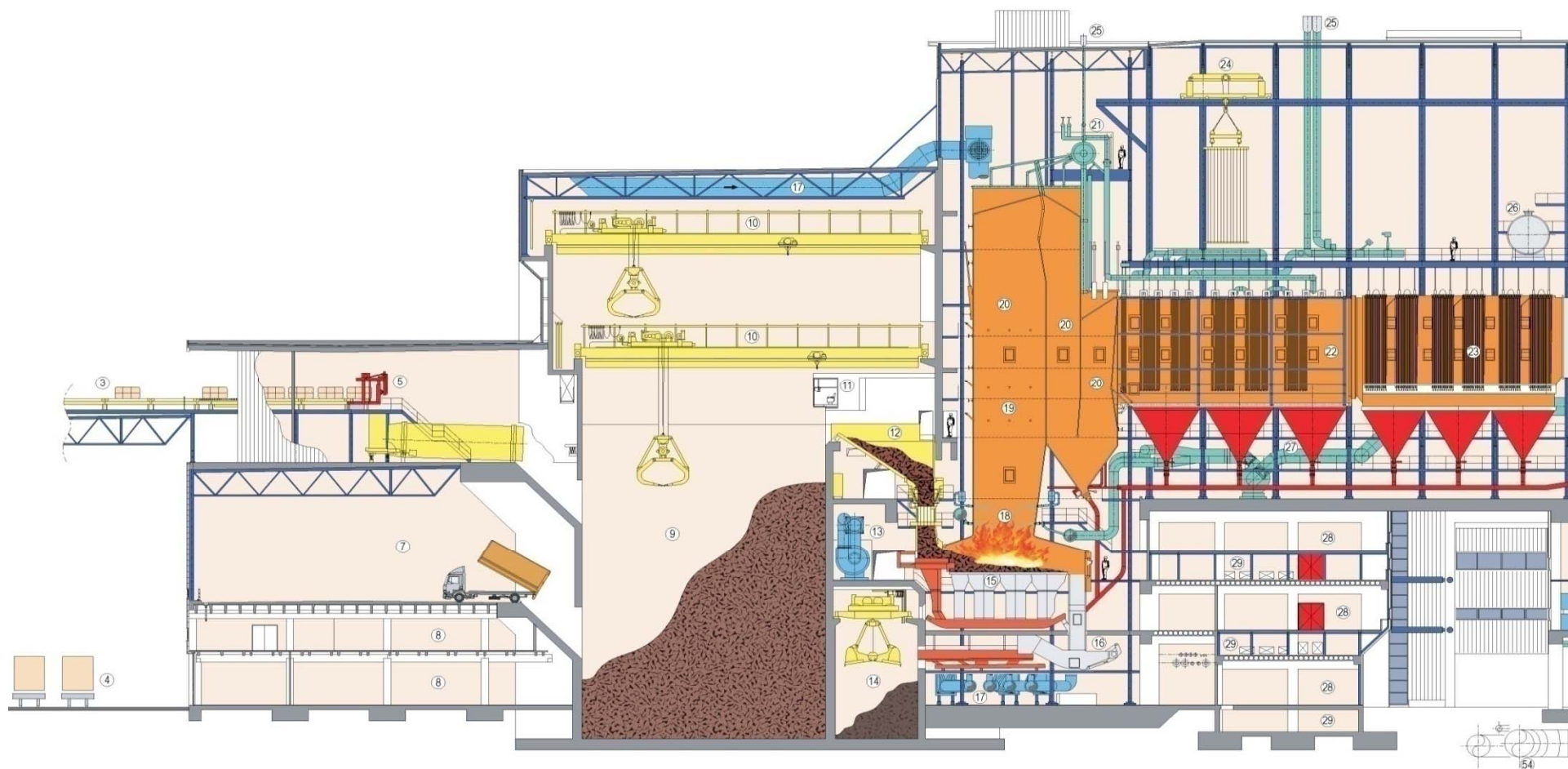
Design Benefits:

- Avoided CO₂; 600,000 MTPA (CFPP)
- Zero liquids discharge
- Lowest tipping fees in the Netherlands; €60/MT
- Low Nuisance Factor, Easy Permitting



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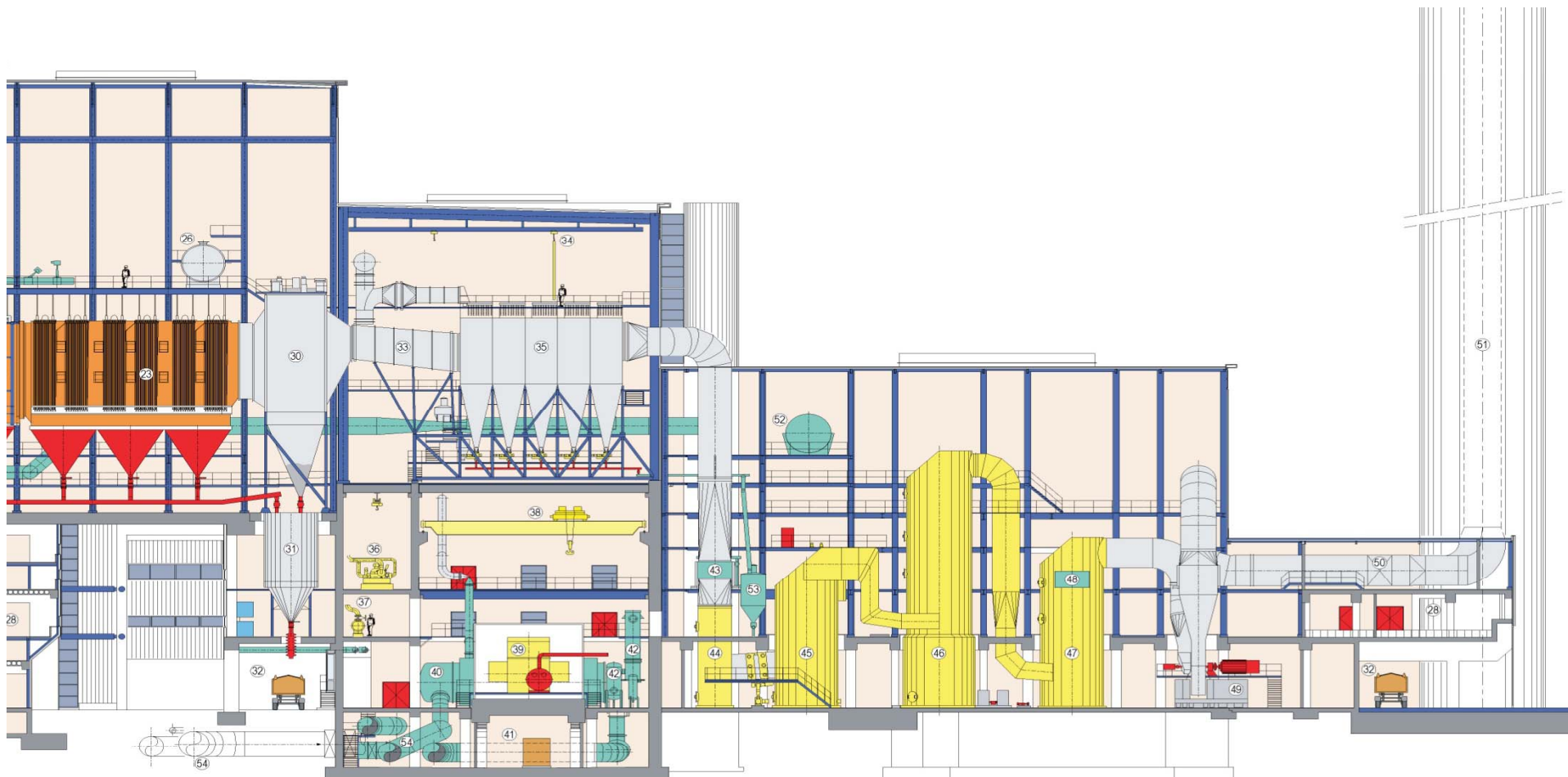
WFPP® MSW handling, Grate and Boiler





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WFPP® Flue-gas cleaning





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Amsterdam Facility

- SNCR and Low excess air ratio
- High steam pressure and temperature: 125 bar / 440°C
- Intermediate superheating: 14 bar / 320°C
- Reduced condensation pressure: 30 mbar/ 30°C



22 %

Net electrical efficiency of > 30 %
Gross electrical efficiency of >34 %



Main Operating Parameters WFPP®

- Waste: $2 \times 33,6 \text{ t/h}_{@10\text{MJ/kg}} = 1600 \text{ t/d} = 530.000\text{t/y}$
- Thermal capacity: $2 \times 93,4 \text{ MW}_{\text{th}}$
- Live steam: $125 \text{ bar} / 440^{\circ}\text{C}$ (option 480°C)
- Steam-Steam reheating: $14 \text{ bar} / 330^{\circ}\text{C}$
- Sea water cooling: $0,03 \text{ bar}$ condenser
- Flue gas recirculation: 25% of total air
- Excess air ratio λ : $1,39 = 6\% \text{ O}_{2\text{-dry}}$
- Electric efficiency: $30,6\%_{\text{net}}$ at acceptance test
- Flue gas cleaning: Dry + wet



WFPP status report: Milestones

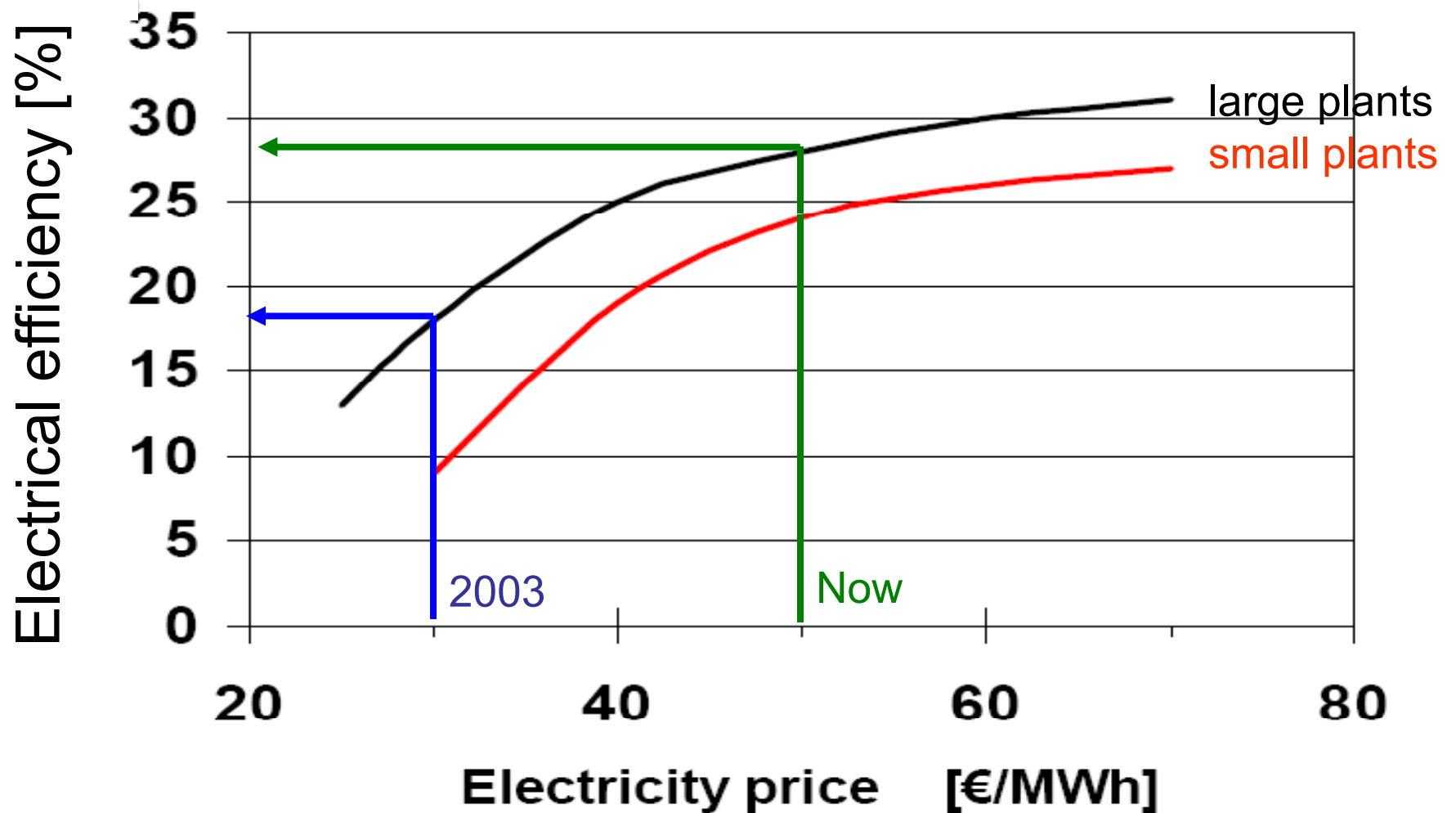
- Start of construction Jan 2004
- Hot commissioning 19 March, 2007
- 100% Load 2 boilers mid April, 2007
- Turbine online mid June, 2007
- Handover 1st August 2007

- Troubleshooting rest of 2007
- Operational optimisation 2008



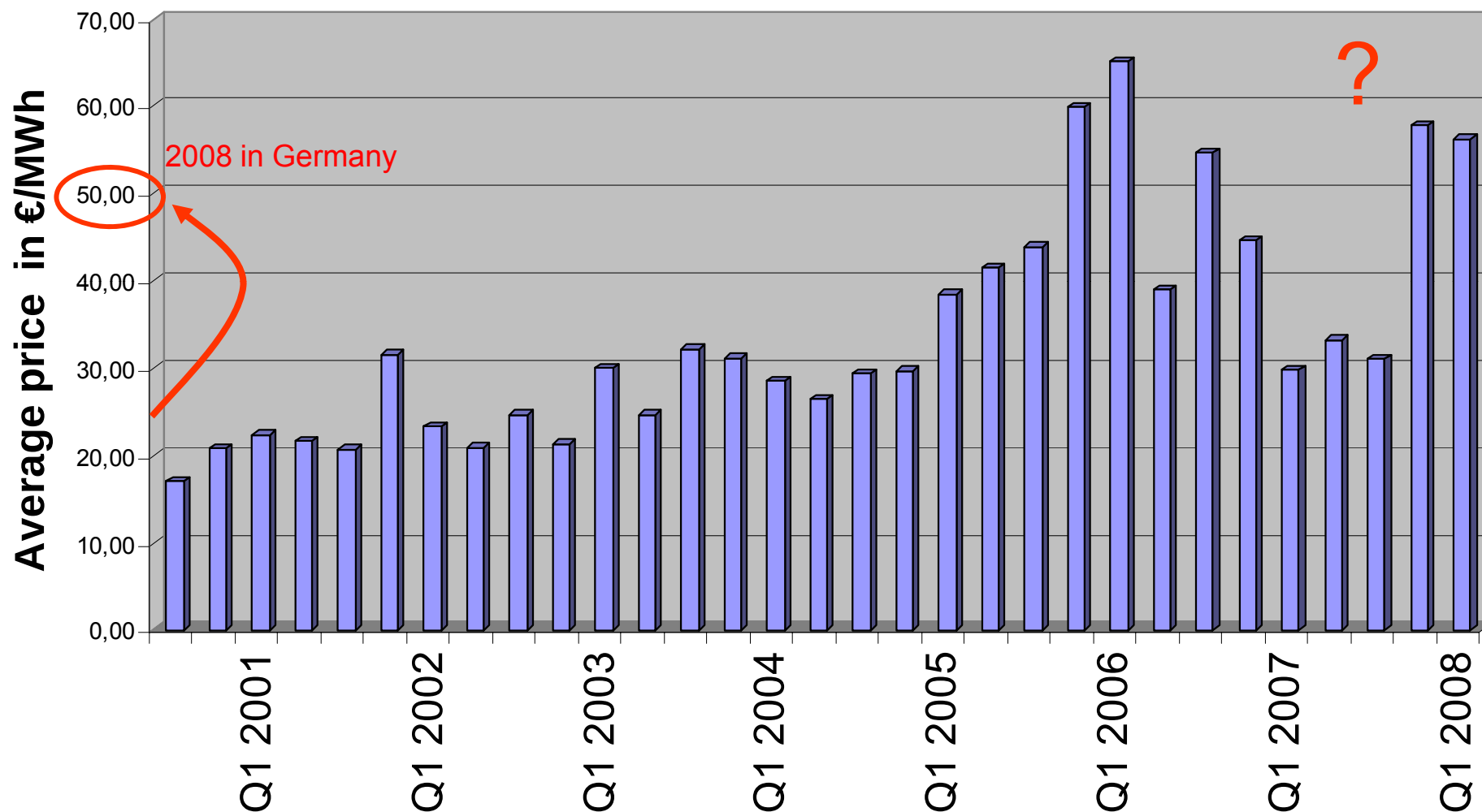
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Electricity price as driving force for efficiency increase





Electricity price escalation



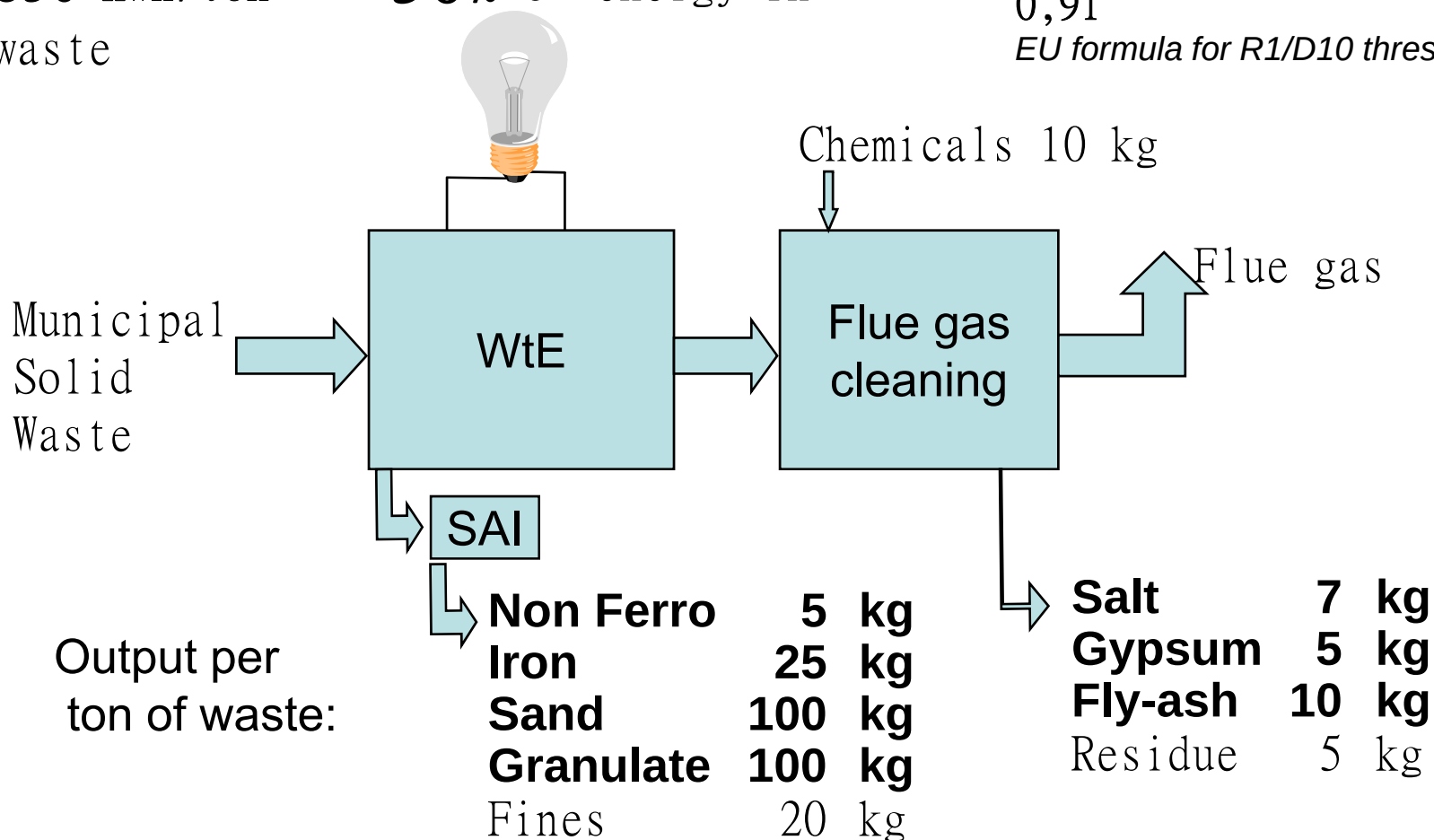


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CONCEPT for RECOVERY

850 kWh/ton = 30% of energy in
waste

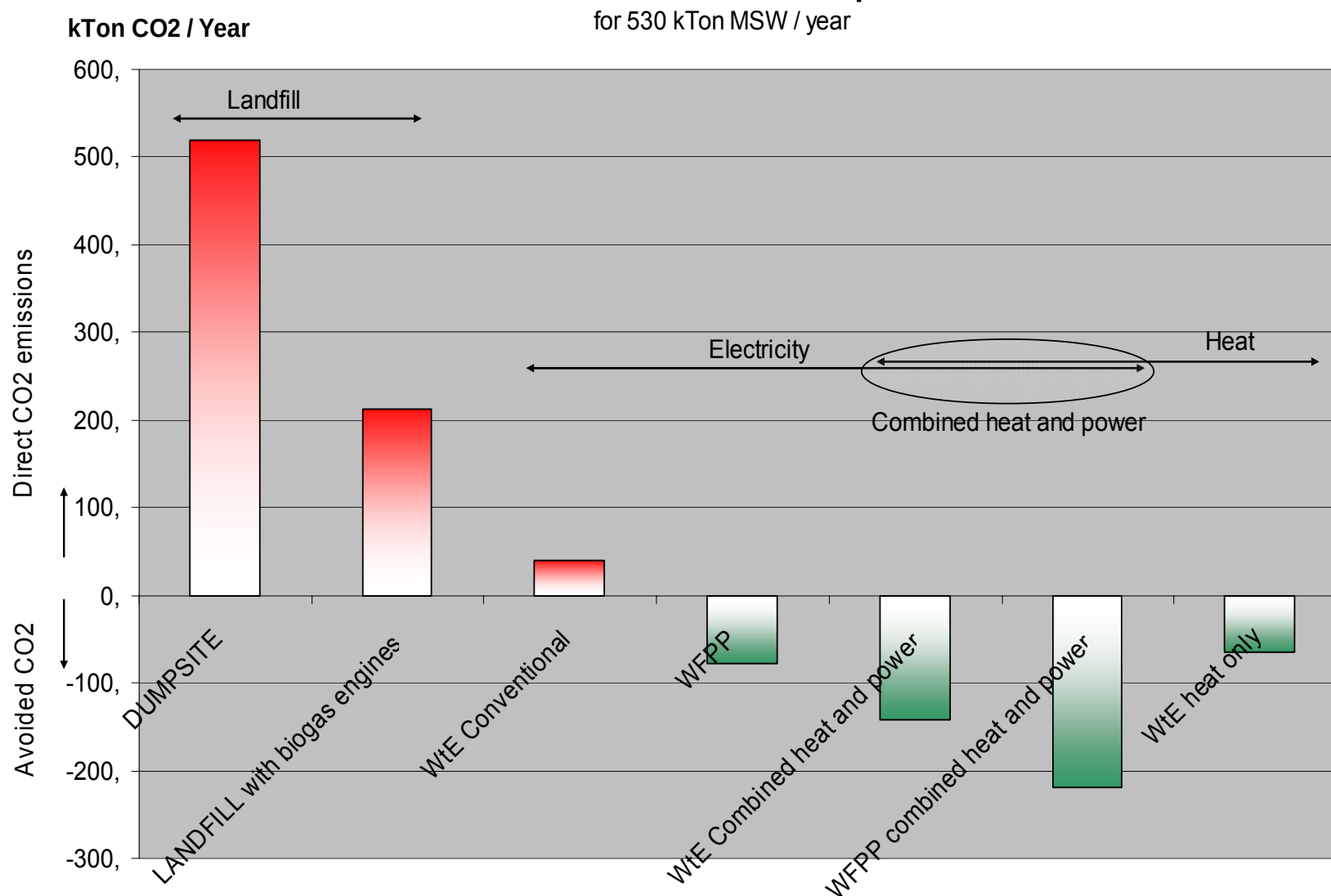
Energy utilisation rate =
0,91
EU formula for R1/D10 threshold





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Greenhouse effect; Dump, Landfill, W2E & WFPP

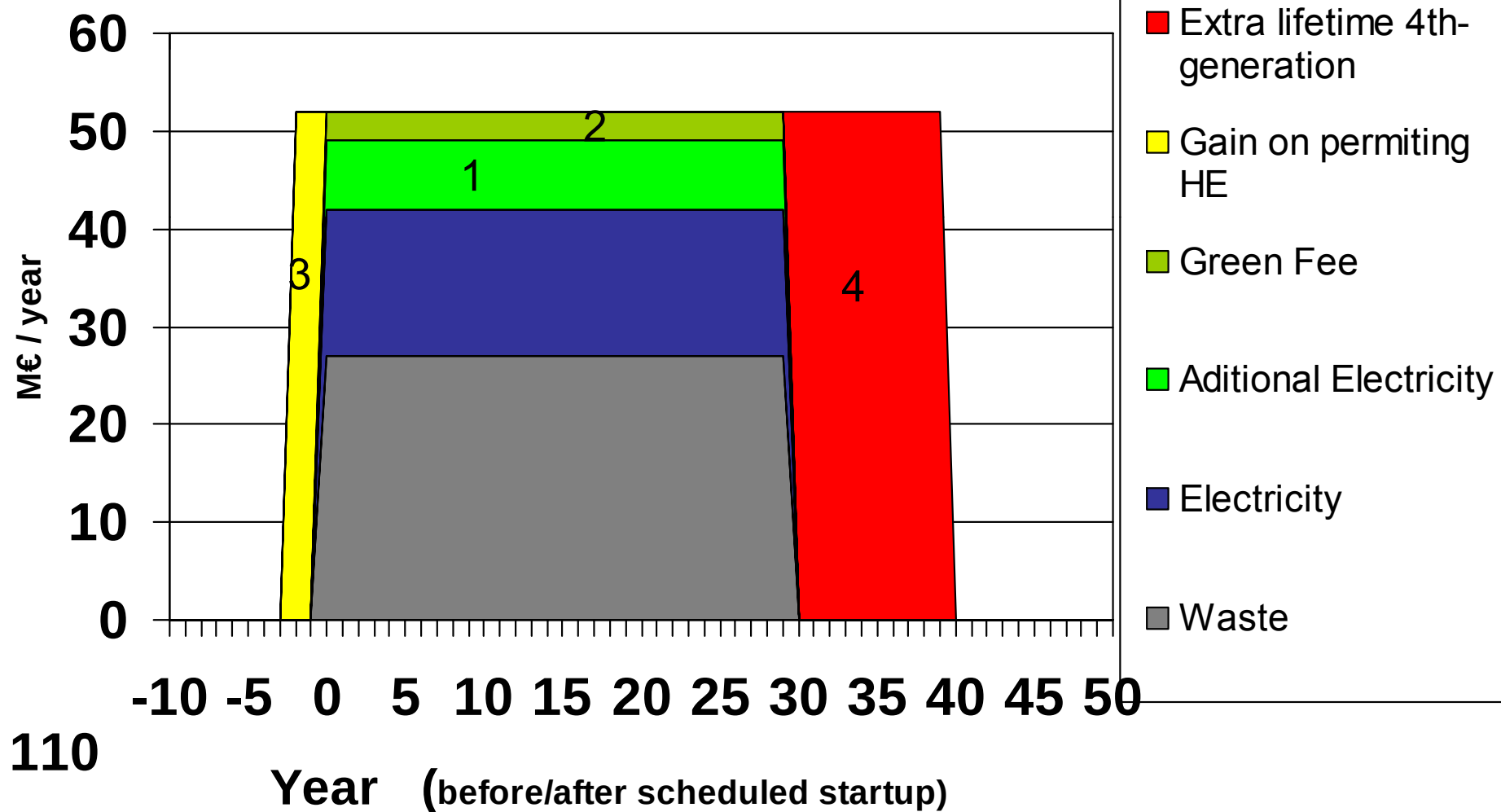




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Business case for 4th-generation

Income from waste and energy

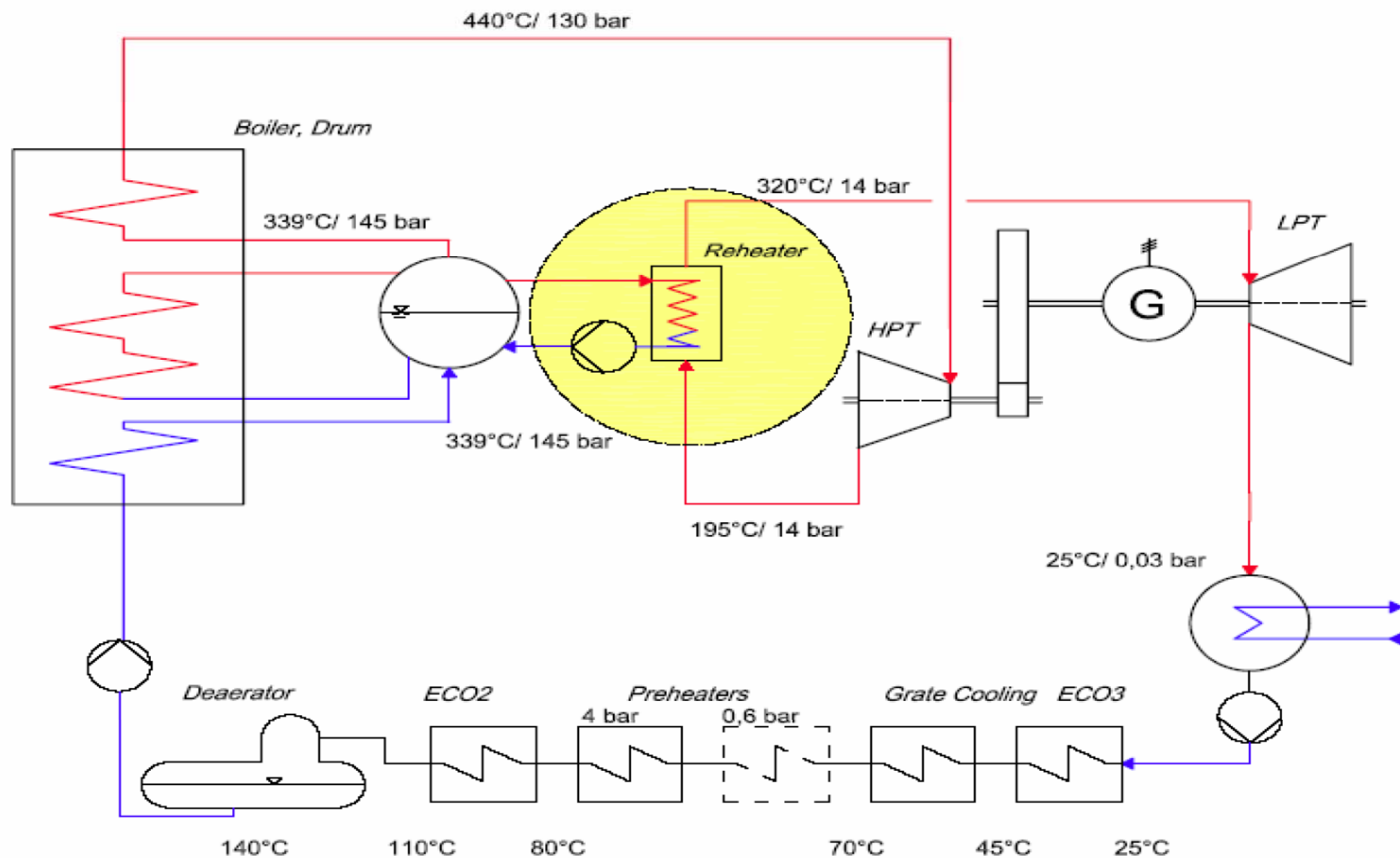


110



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Water / steam flow diagram





Heat transfer surfaces (relative size, boiler, turbine only)

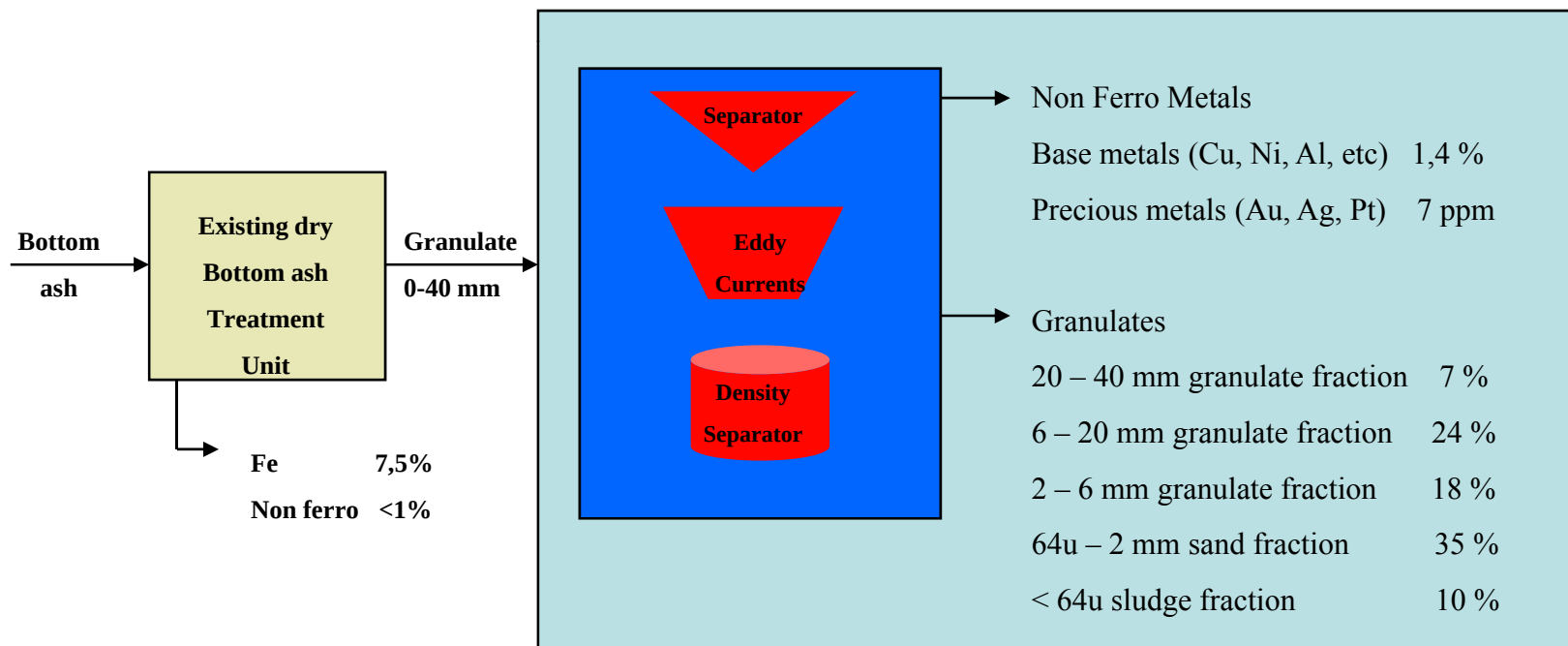


Estimated technical data		40 bar / 380 °C	130 bar / 440 °C	90 bar / 500 °C
Efficiency Eta, net	%	20,6	28,1	24,7
Economizer heat transfer surface	m ²	2812	3338	3280
Evaporator heat transfer surface	m ²	2322	1757	1940
Membrane wall	m ²	1612	-	-
Tube bundles	m ²	711	-	-
Superheater surface	m ²	1828	2665	2763
Platen	m ²	-	-	478
Bundles	m ²	1828	2665	2285
Heat exchanger surface intermediate reheat	m ²	-	105	-
Total of all heat transfer surfaces	m ²	6961	7865	7983
Inconel 625 for membrane walls	m ²	-	583 1 st +2 nd Pass	242 1 st Pass
Inconel 686 or Colmonoy 88 for platen superheater	m ²	-	-	478
Height of boiler house	%	100	125 (based on AEB new/old)	ca. 100 (?)
Length of boiler house	%	100	136 (based on AEB new/old)	ca. 100 (?)



How to capture the value? MINING

- Joint development with TU Delft
- Fully patented process





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Guarantee Measurements

	100% Load		110% Load		Unit
Date	24-7-2007		25-7-2007		
Timespan	16:00 - 22:00		8.00 - 14:00		
Duration	6		6		h
Net Goal	≥ 30		> 30		%
Mesuring company	Supplier	KEMA (Tüv)	Supplier	KEMA (Tüv)	
Boiler efficiency (Thermal)	85,2	$85,5 \pm 1$	85,8	$85,5 \pm 1$	%
Net electr. Efficiency	30,5 * Design	$30,6 \pm 1,6$ * Measured	30,8 * Design	$30,9 \pm 1,6$ * Measured	%



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Guarantee Measurements

	Guaranteed value	Guarantee measurement		Unit
		boiler 35	boiler 36	
Waste Throughput	33,6	34,89	34,94	Mg/h
Calorific value	10	9,94	10,26	MJ/kg
Steam production	28,4	28,46	28,52	kg/s
	= 102	102	103	Mg/h
Boiler outlet temperature	180°constant	177,35 - 183,75		°C
Boiler efficiency	85	85,2		%
850°C residence time	>2	5		s
Power from waste	93,3	96,9	97,07	MW
Thermal boiler load	102,7	103,63	102,93	MW
Own consumption	< 850	498		kW



Guarantee Measurements

	Guaranteed value	Guarantee measurement		Unit
		boiler 35	boiler 36	
Control range Steam flow	2	-0,72 / +1,18	-1,57 / 0,75	%
Control range Steam temp	4	3,87	1,92	±K
O2-concentration (boiler outlet)	6,5	6,0 - 6,73	ø<6,5	%
CO (boiler outlet)	≤30	6		mg/m3
NOx (boiler outlet)	70	66 - 68		mg/m3
NH3 (boiler outlet)	≤5	3		mg/m3
TOC in bottomash	≤1,5	0,1 - 0,66		%



WFPP status: Problem Areas

- | | | |
|--|--------------|-------------------------|
| ■ Emergency condenser: | Pipe rupture | design failure |
| ■ Steam valves: | Actuator | design failure |
| ■ Cranes: | Unreliable | Electrical drive change |
| ■ Flue gas cleaning -
Blow down treatment : | Size/process | Lot contractor |
| ■ Fabric filter | Bag problem | AC-dosing |
| ■ Condensate pump | Leakage | software change |
| ■ Fly ash | Loading | change |
| ■ Empty pass fly ash | Transport | change |
| ■ ID-fan El-drive | el-brake | change freq. conv |



WFPP status: Problem Areas

- Automation incomplete optimise
 - Feed water pump damage repair
 - Cooling water water hammer modify
-
- Turbine axis broken civil problem 6 months repair
now running part load @90%



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WFPP® status: Boiler Corrosion



**Inconel 625:
Lifetime 5-10 years**



**0,1-0,3 mm/yr corrosion
add sacrificing layer**

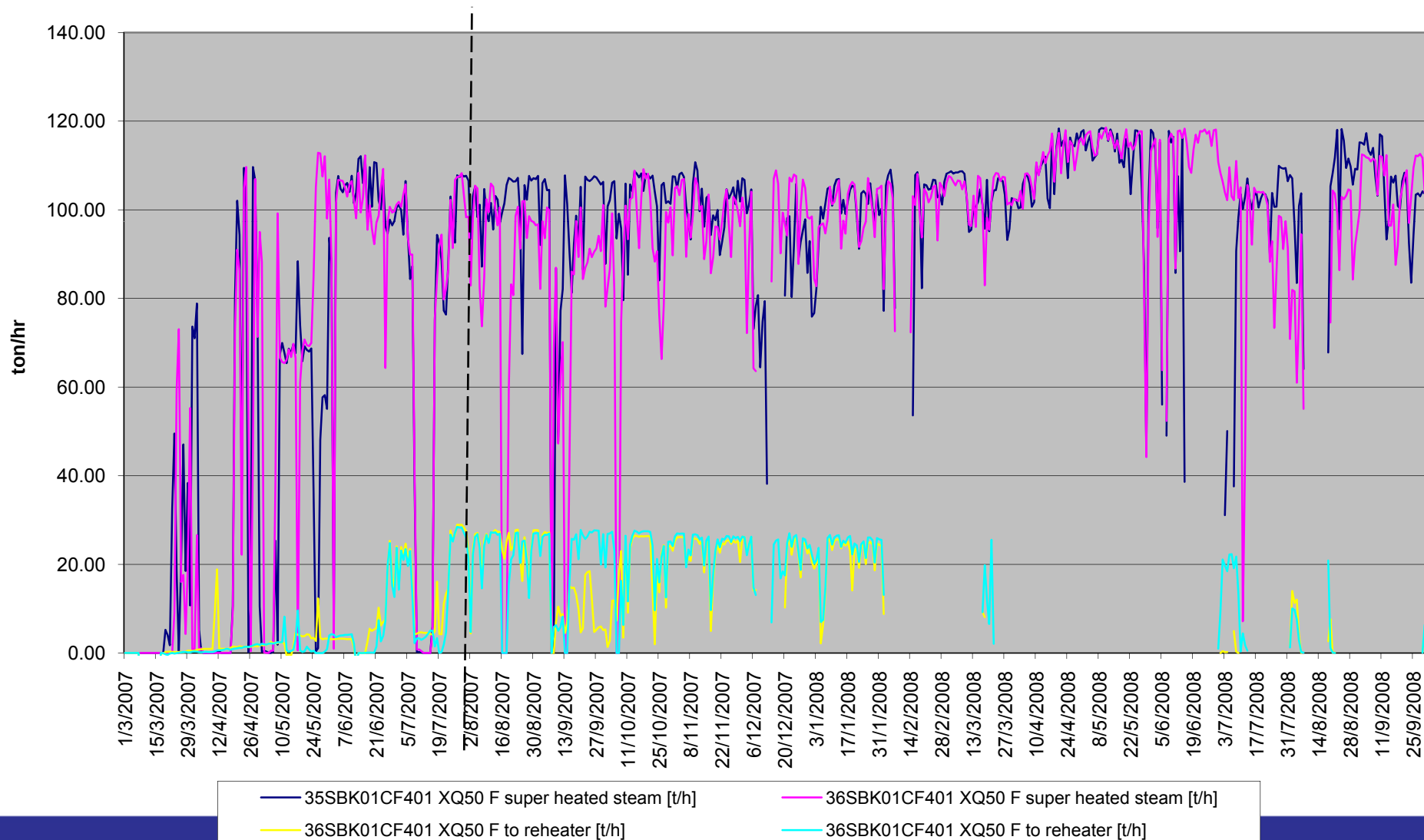


Pictures after
>8000hrs of operation
at full load.



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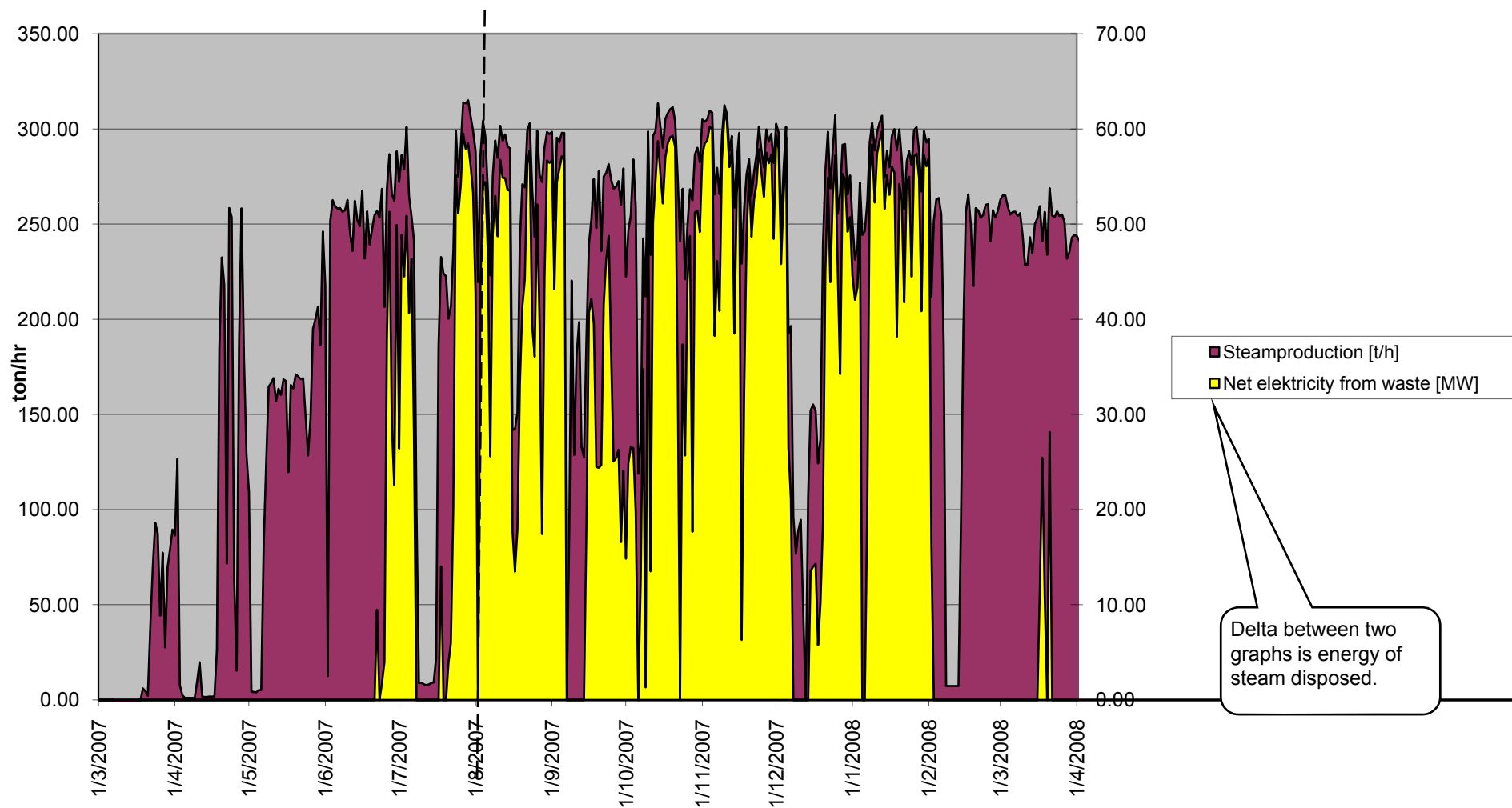
Steam production, 2007 and 2008





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Net Electricity delivered to grid in 2007



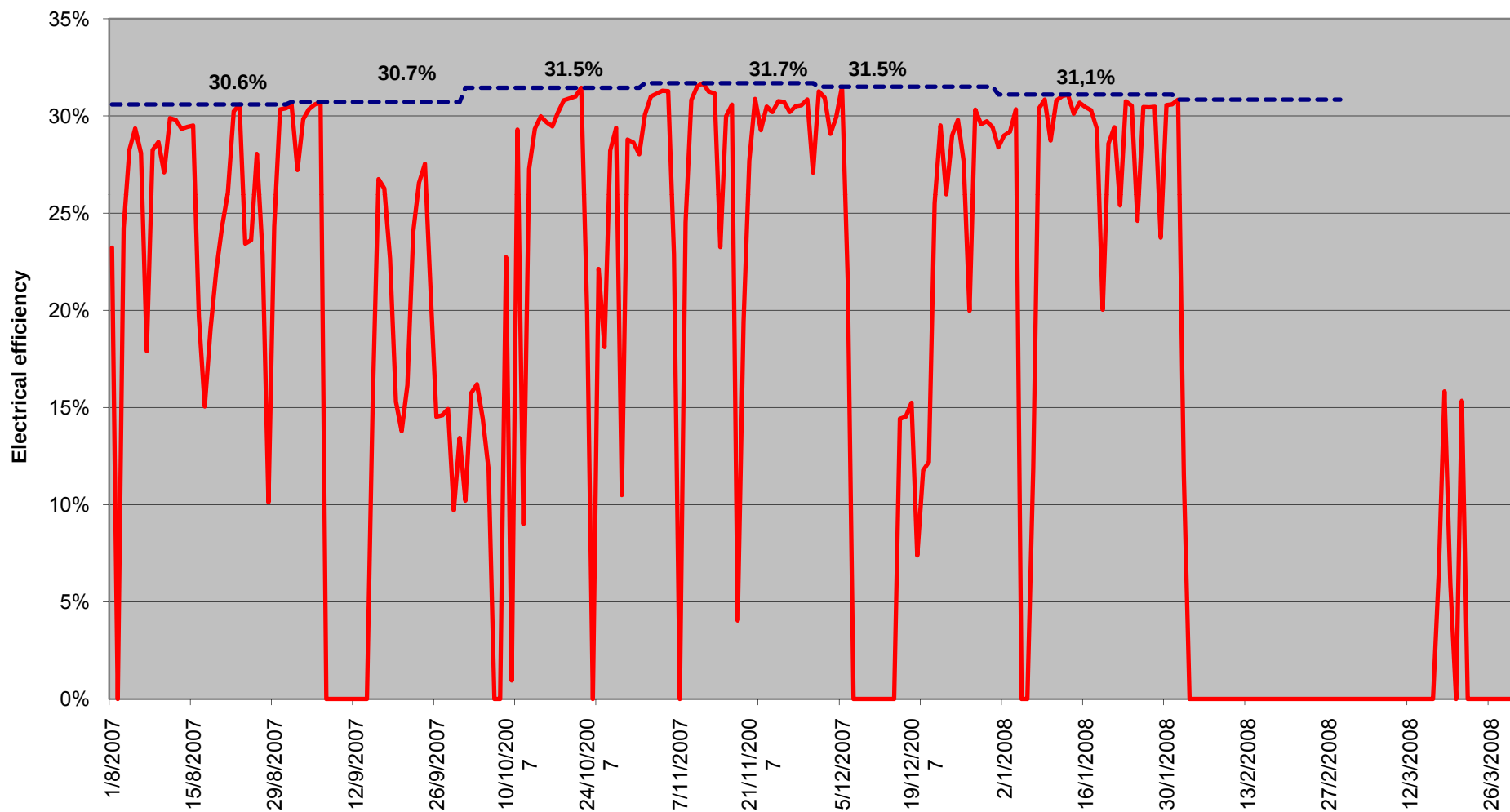


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Net electrical efficiency, 2007

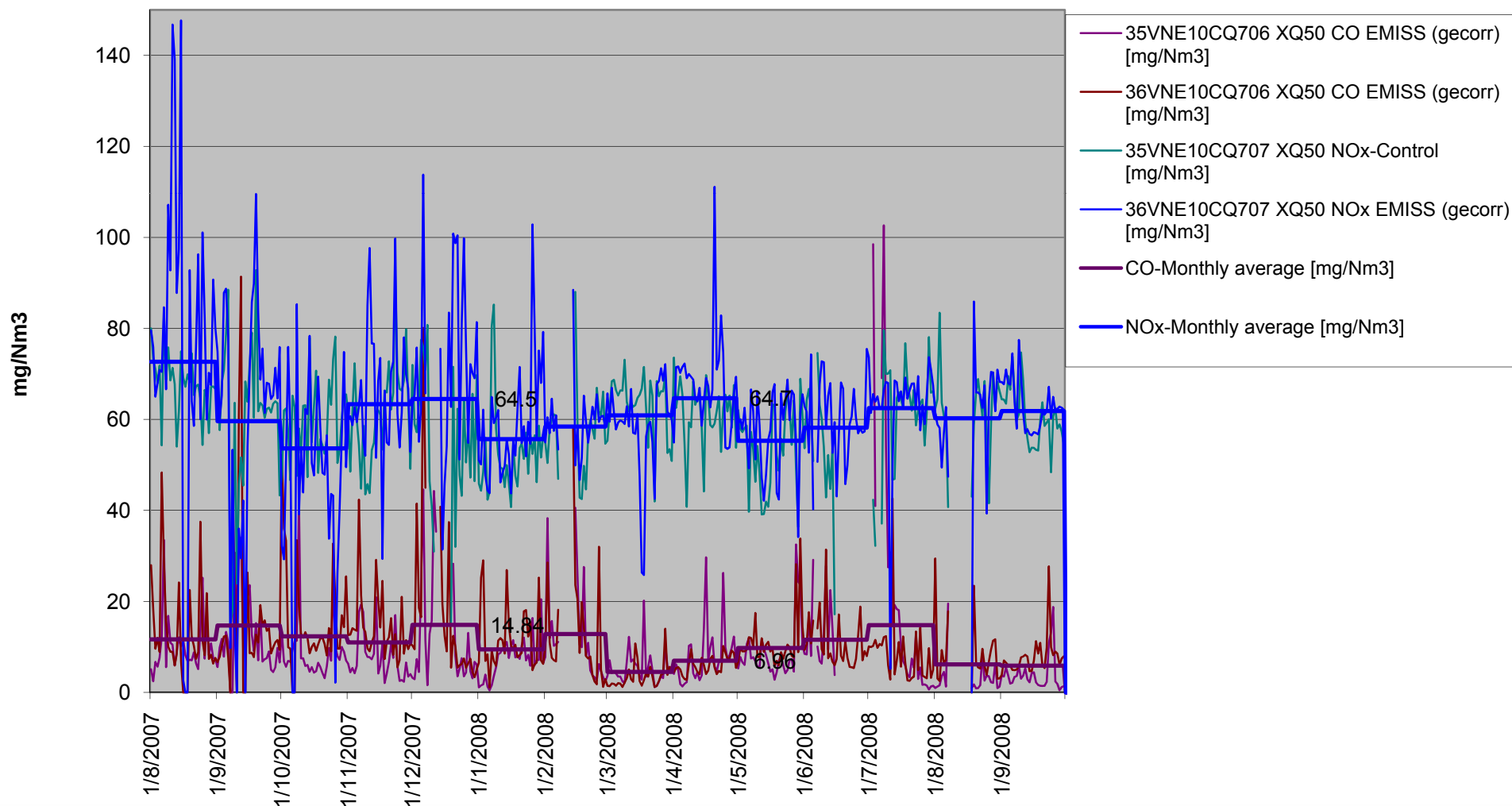
Monthly averages + Moving average + Best day





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CO and Nox Emissions, 2007, 2008





- Plant size matters
- High electric efficiency more than pays for itself with increasing energy cost
- Metal recovery pays for the bottom ash treatment and virtually eliminates landfill cost
- High efficiency energy production and bottom ash recycling significantly reduces CO₂ emissions.
- Robust design means high availability and long life cycle



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The Plant is doing well, Thank You

Come and visit us in Amsterdam

