



bioenergy2020+

Who's on first, What's on second.

Understanding European certification values and what they mean for a changing New Source Performance Standard

Results of the BIOENERGY 2020+ report for residential boilers

HeatNE, April 27th 2010, Manchester, NH

COMET

Competence Centers for
Excellent Technologies

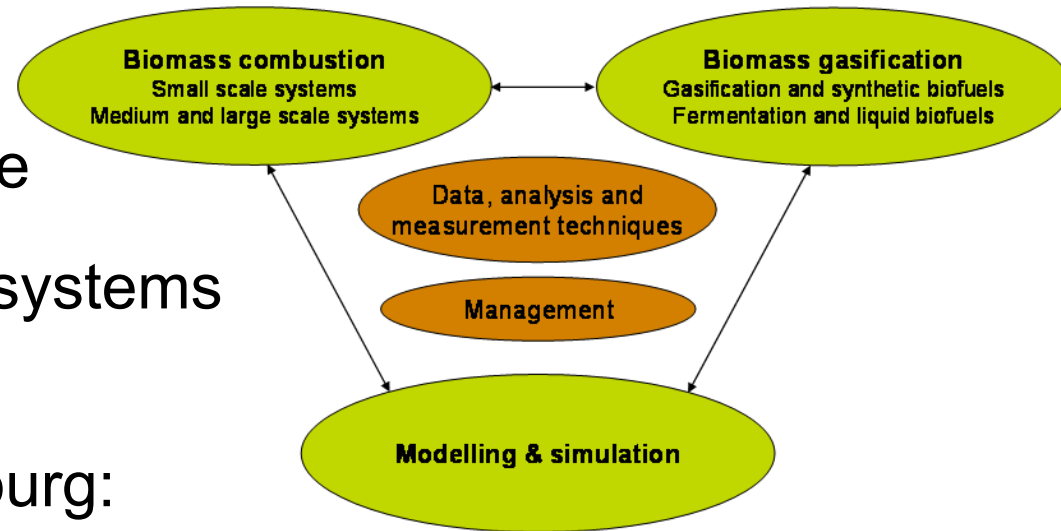


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- Bioenergy 2020+
- Why look at European biomass technology?
 - Performance developments over last 30 years
 - Biomass combustion technology
- EN 303-5 – the European standard for solid fuel boilers
 - General
 - Performance requirements
 - Testing procedure
- TOP 25% performing European biomass appliances
 - Selection criteria
 - Results
- Summary

Bioenergy 2020+

- National Biomass K1 Centre of Competence
- Small scale biomass systems located in Wieselburg
- R&D focus in Wieselburg:
 - Standardized solid bio-fuels
 - Small scale combustion systems
 - Small and micro scale CHP (and cooling)



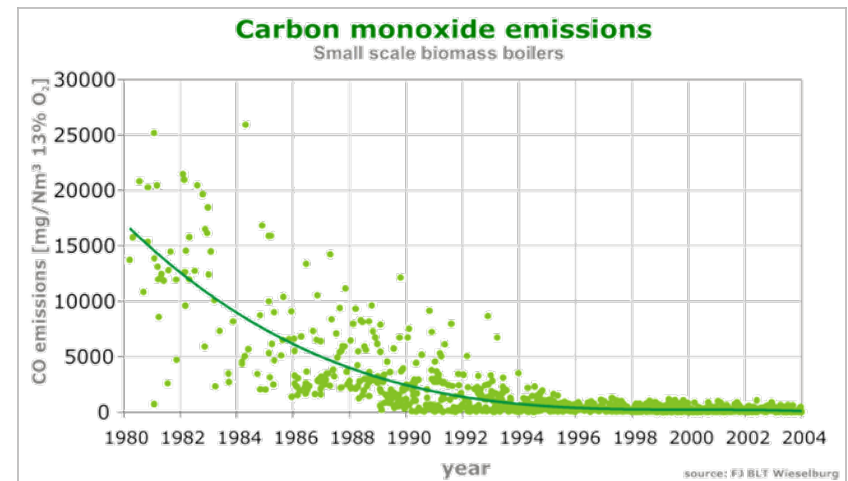
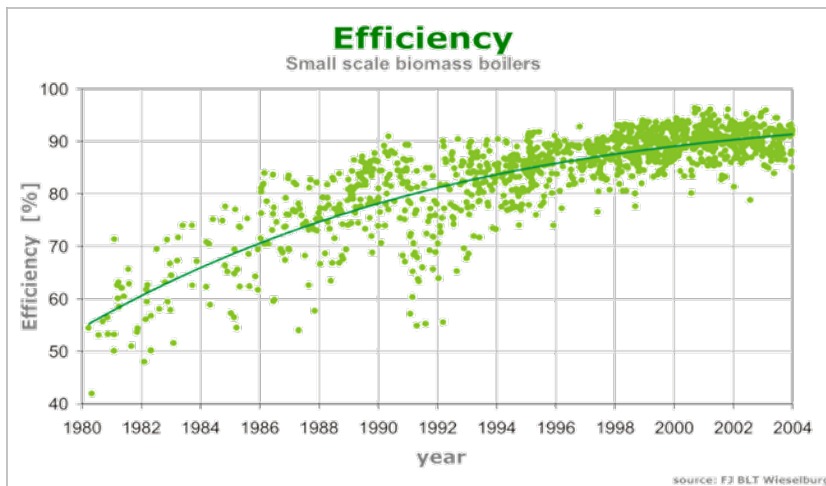
Our business: Energy from biomass

Why look at European biomass technology?

→ Performance improvement

■ Test results from small scale biomass boilers

- Pellet boilers starting in 1998
- Data from Austrian test house (FJ-BLT)

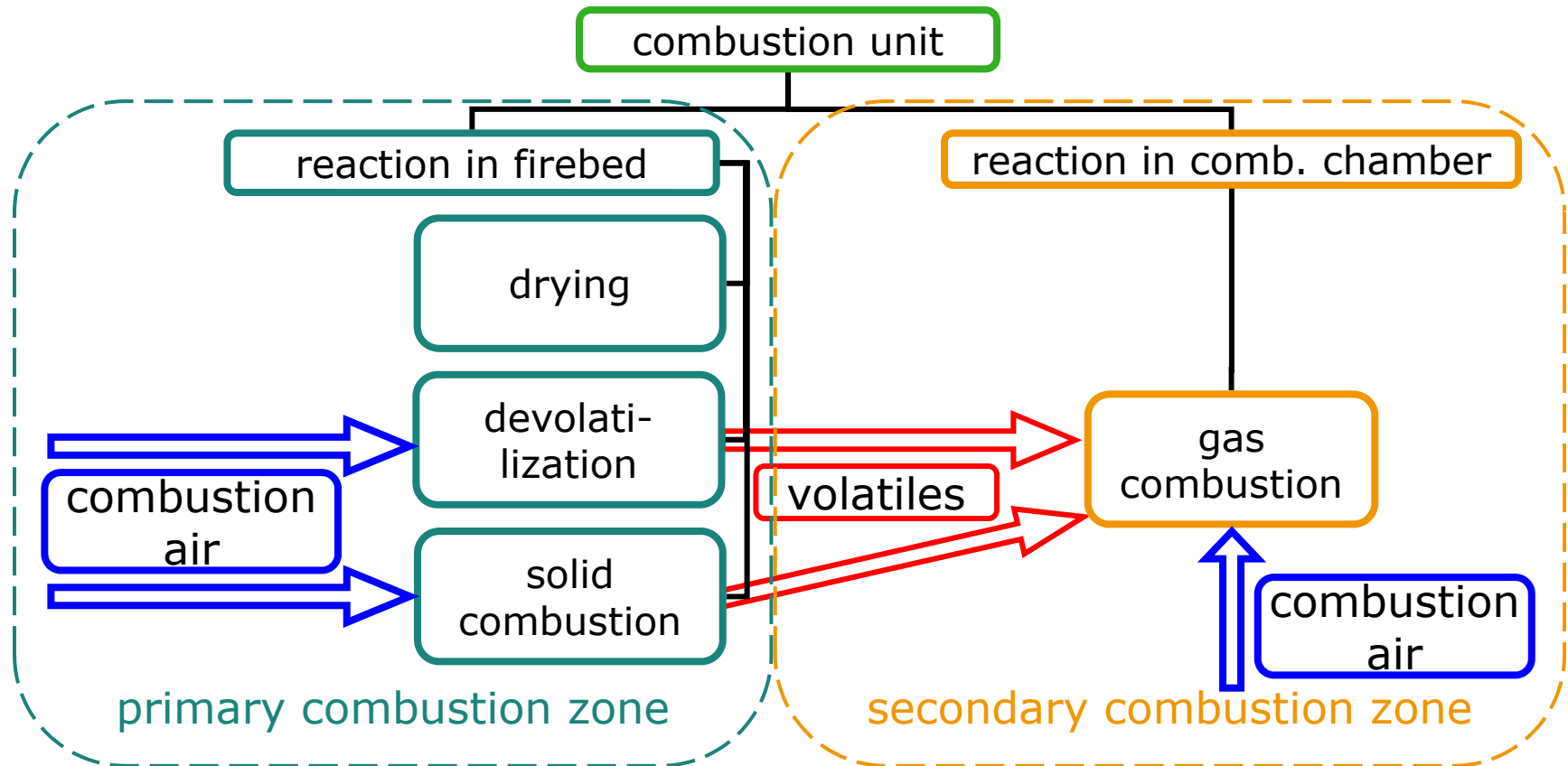


- Efficiency (based on NCV):
55 → > 90 %
- CO-Emissions:
15,000 → < 50 mg/m³

Why look at European biomass technology?

→ Biomass combustion technology

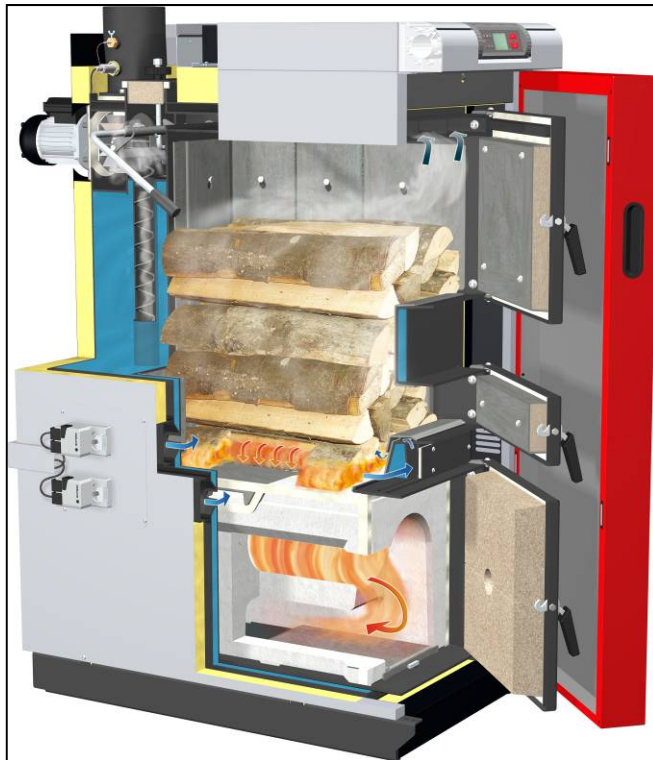
- Staged combustion



Why look at European biomass technology?

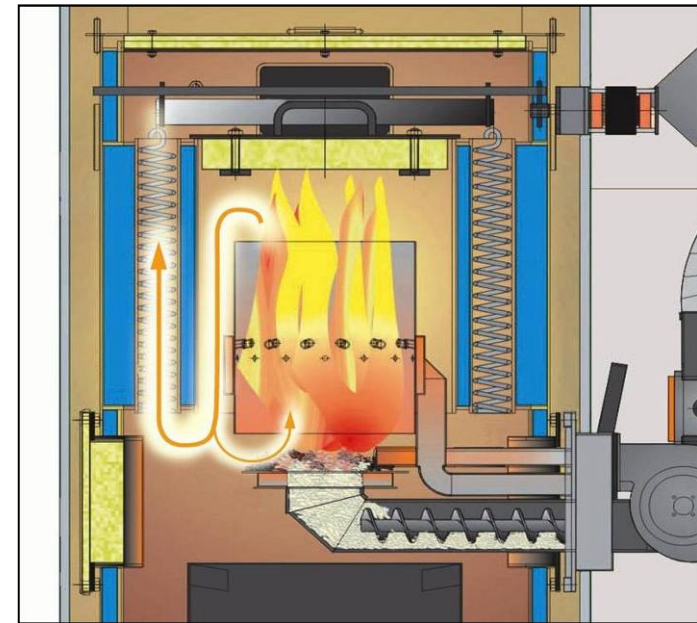
→ Biomass combustion technology

- Solid wood: under-burning principle



Froeling FHG Turbo

- Pellets: under-feed burner (also wood chip technology)

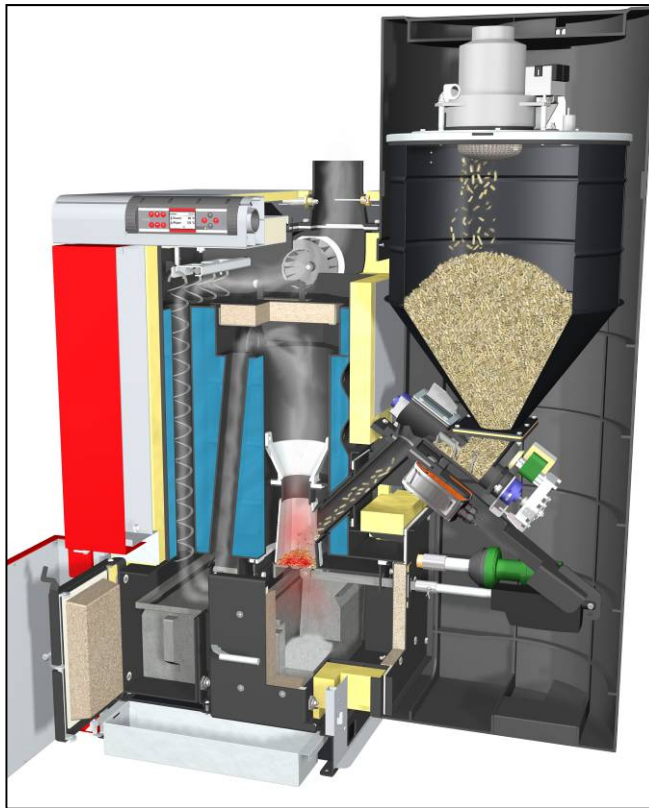


OekoFEN Pellematic

Why look at European biomass technology?

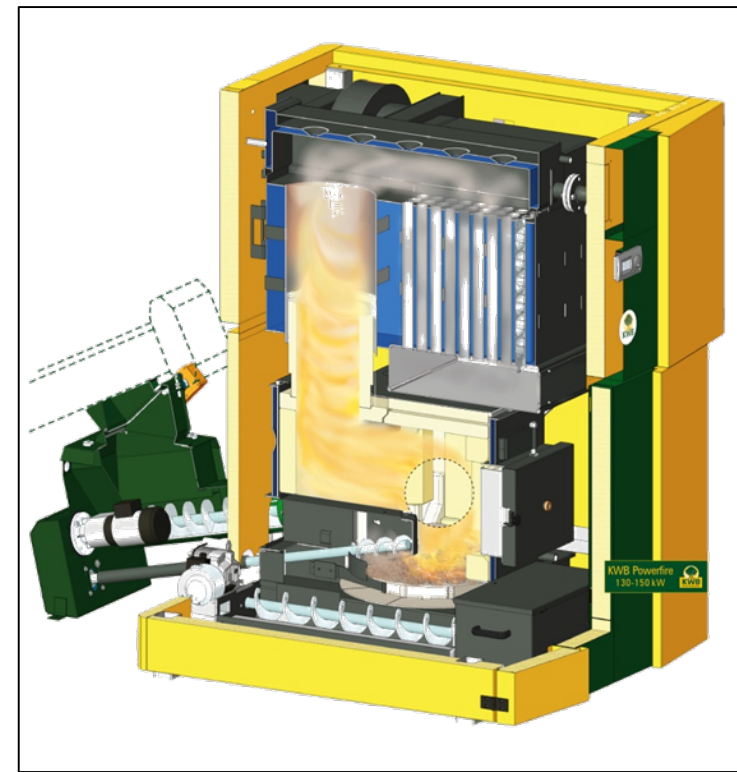
→ Biomass combustion technology

- Pellets: top-feed burner



Froeling P4 Pellet

- Pellets and wood chips: horizontal-feed burner



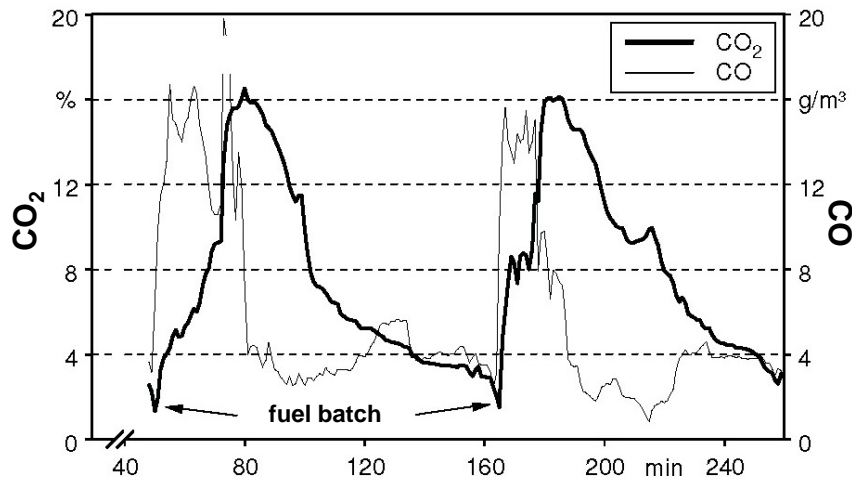
KWB Powerfire TDS

Why look at European biomass technology?

→ Biomass combustion technology

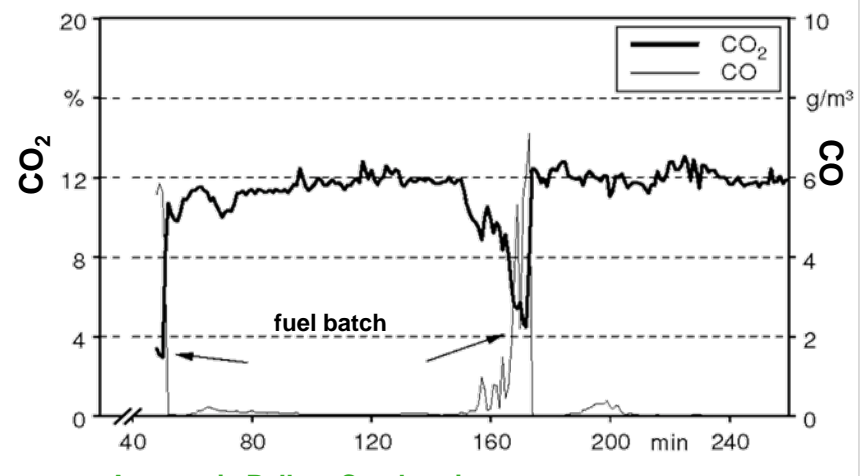
■ Advantages of novel combustion technology

Manually Stoked, Natural Draught Combustion

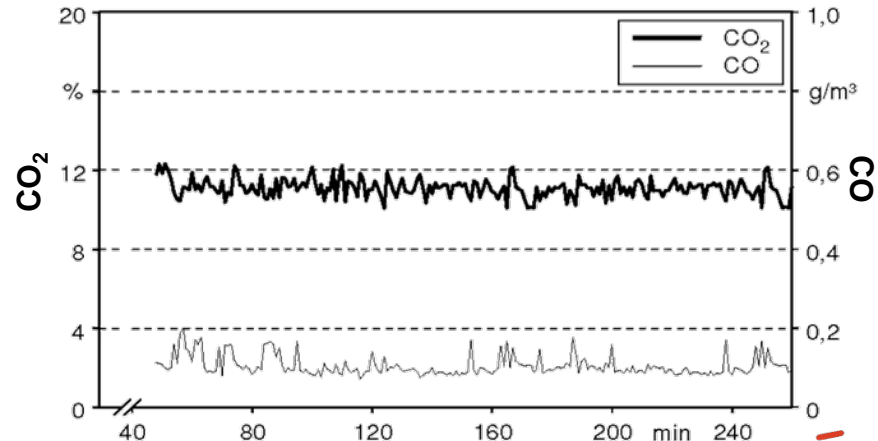


from Handbuch – Bioenergie Kleinanlagen (FNR)

Manually stoked, Under-Burning Combustion



Automatic Pellets Combustion



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EN 303-5 – European standard for boilers

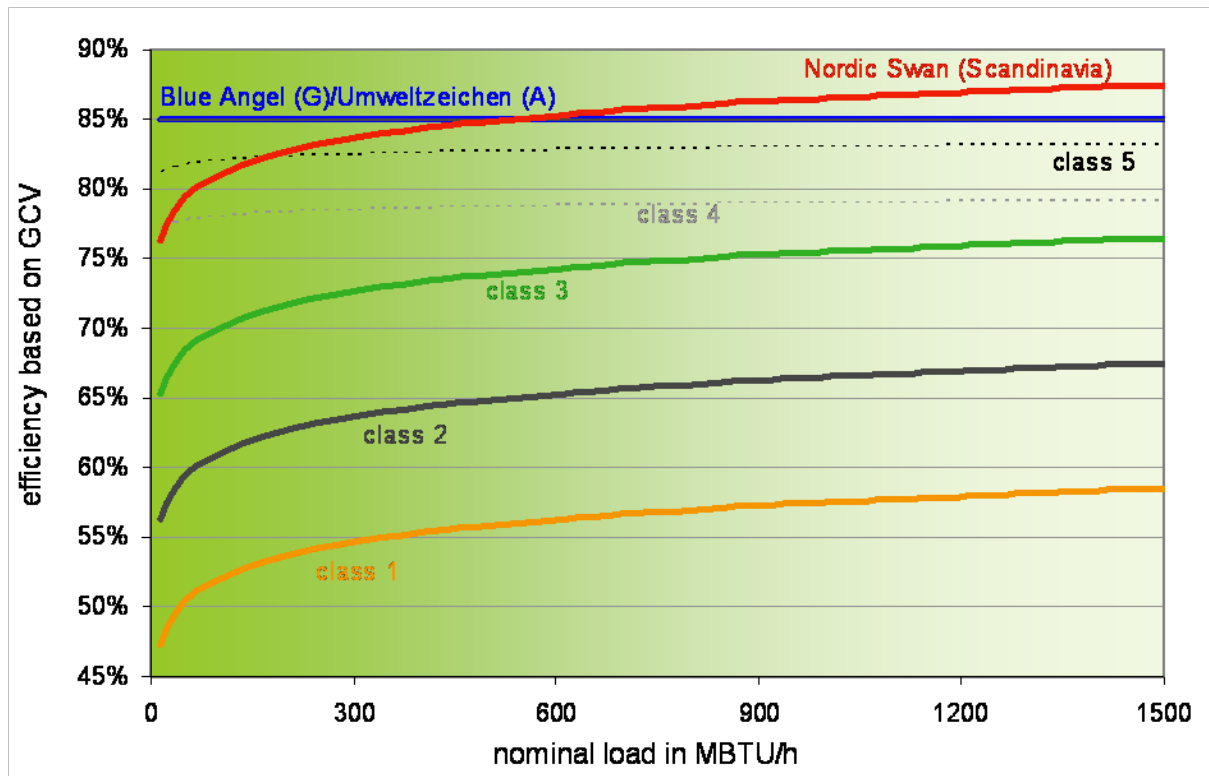
→ General

- Currently under revision
- Valid for
 - Solid fuel boilers (hydronic heating only)
 - Manual and automatic stoking
 - Up to 1025 MBtu/h (1700 MBtu/h under discussion)
- Regulates
 - Requirements
general, safety, construction, design, performance
 - Test methods
heat output, efficiency, emissions, test fuel, safety devices, surface temperatures; pressure test,
 - Test report, documentation, ...

EN 303-5 – European standard for boilers

→ Performance requirements

■ Efficiency

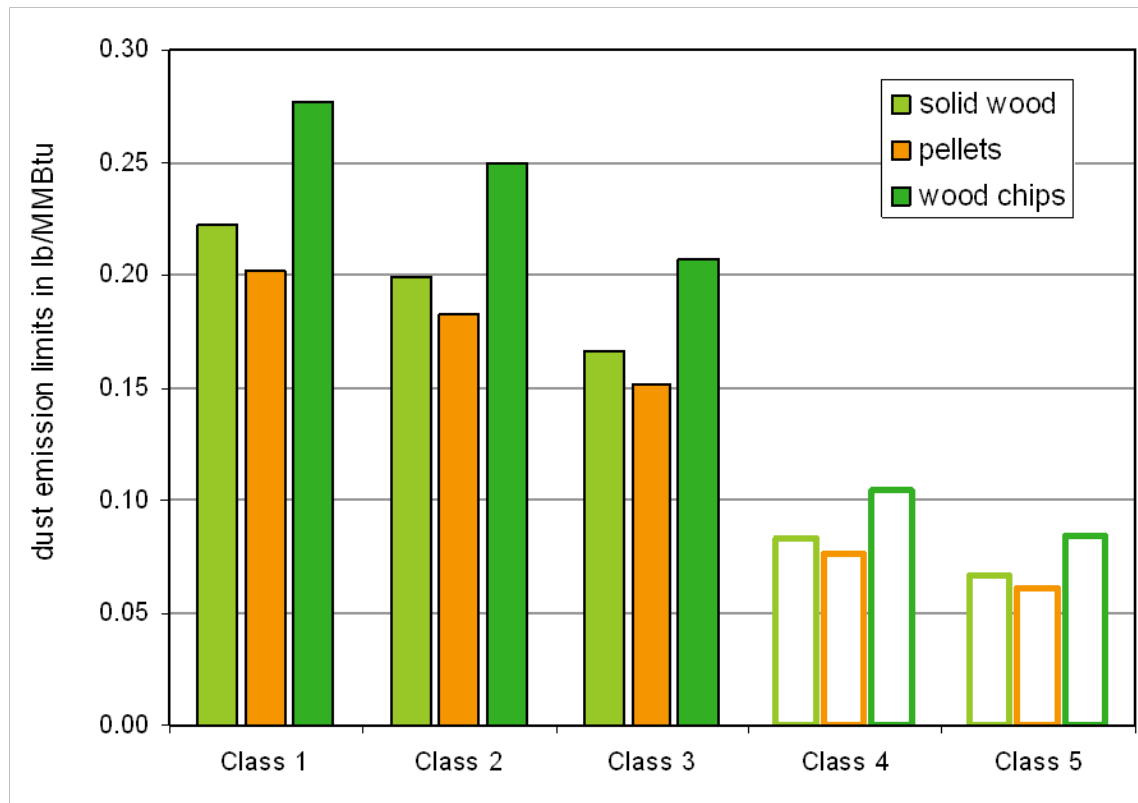


- Efficiencies were converted for pellets fuel
- Current version of EN 303-5: class 1 to class 3
- Future efficiency requirements: class 3 to class 5
- Class 4 and 5 under discussion!

EN 303-5 – European standard for boilers

→ Performance requirements

■ Emission limits



- Limits also given for CO and OGC emissions
- Class 4 and 5 under discussion!

EN 303-5 – European standard for boilers

→ Performance requirements

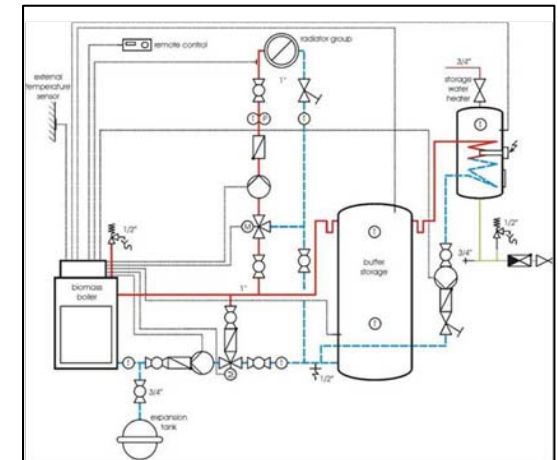
■ Minimum heat output

- Minimum heat output of 30% of nominal load required
- Minimum heat output for manual boilers may be higher

- Manufacturer has to specify how to dissipate produced heat
- Usually heat storage is recommended
- Design guideline for heat storage

$$V_{AT} = 4.5 \cdot T_B \cdot Q_N \cdot \left(1 - 0.3 \frac{Q_H}{Q_{min}} \right)$$

V_{AT}	Accumulator tank capacity	l
Q_N	Nominal heat output	MBtu/h
T_B	Burning period	h
Q_H	Heating load of the premises	MBtu/h
Q_{min}	Minimum heat output	MBtu/h



- No heat storage necessary if < 300 l/80 gal

EN 303-5 – European standard for boilers

→ Testing procedure

- Reach normal working conditions (stationary state) before testing
- Test cycles:
 - 2 tests at nominal load
 - 1 test at smallest load
- Duration:
 - 6 hours for automatic stoking
 - One fuel charge for manual stoking (minimum 2 hours for full load)
- Ranges for ambient air temperature and return/flow-temperature given
- Dust measurements taken twice during 30 period at full load





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TOP 25% performing appliances

→ Selection criteria

- Austrian, German, Swedish, Danish and Norwegian biomass appliances considered
- Vast data collection of test results
 - 954 boiler data sets
433 pellets, 279, solid wood, 213 wood chips
 - 130 room heater data sets
79 pellets, 51 solid wood
- Selection criteria for TOP 25%:
 - Appliances grouped in load ranges
 - Highest efficiencies at full load
 - CO-emissions at full load smaller than average CO-emissions in respective load range

TOP 25% performing appliances

→ Results

technology	fuel	load range (MBtu/h)	data at nominal load			
			$\eta_{GCV}^{(1)}$ (%)	CO (mg/m ³ _{12%O₂})	TSP ⁽¹⁾ (lb/MMBtu)	NOx (mg/m ³ _{12%O₂})
boiler	pellets	< 55	87	43	0.022	140
		55 - 100	86	39	0.024	136
		100 - 170	87	38	0.023	132
		170 - 340	86	24	0.036	154
		> 340	86	17	0.031	133
	solid wood	< 85	83	174	0.039	139
		85 - 120	83	220	0.044	126
		120 - 170	83	152	0.066	115
		> 170	82	97	0.033	119
	wood chips	< 100	76	60	0.046	157
		100 - 200	79	39	0.027	134
		200 - 340	78	30	0.038	138
340 - 680		80	22	0.042	125	
> 680		78	34	0.092	131	
combined boiler	pellets	50 - 150	82	34	0.027	145
	solid wood		79	252	0.027	120
stove with hot water	pellets	25 - 50	85	117	0.019	143
stove	pellets	< 30	88	164	0.045	88
		> 30	87	180	0.043	110
	solid wood	20 - 130	73	1069	0.050	126

¹⁾ related to the Gross Calorific Value (upper heating value)

Boilers

- > 75% efficiency based on GCV
- Dust emissions < 0.04 lb/MMBtu for pellets
- < 0.07 lb/MMBtu for solid wood and
- < 0.10 lb/MMBtu for wood chips

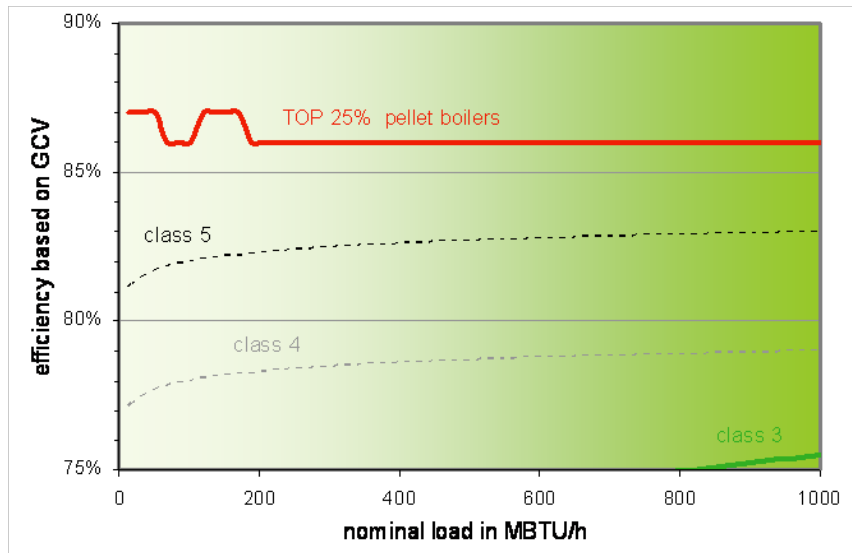
Stoves

- > 70% efficiency based on GCV
- Dust emissions < 0.05 lb/MMBtu

TOP 25% performing appliances

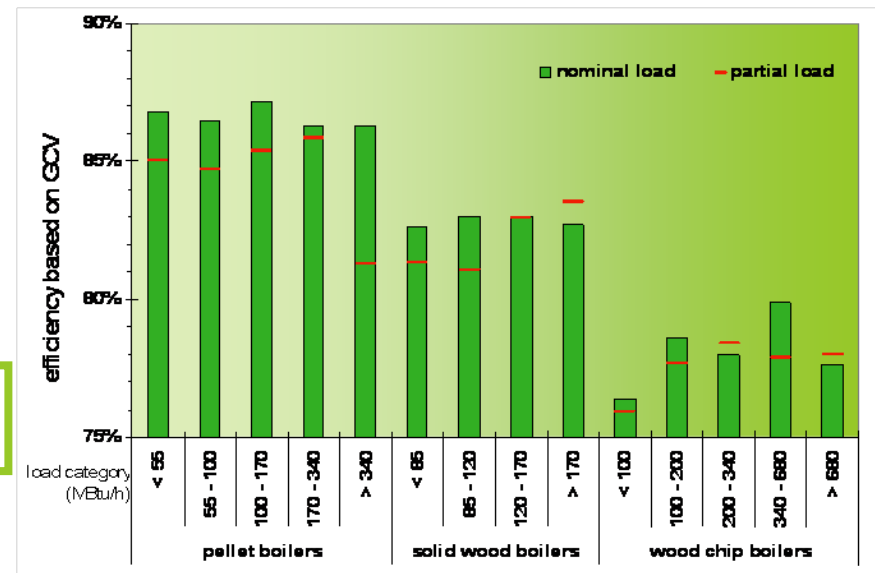
→ Results

■ Efficiencies



- TOP 25% pellet boilers reach higher efficiencies than future requirement of EN 303-5, class 5
- Also true for wood chip and solid wood boilers
- Class 4 and 5 under discussion!

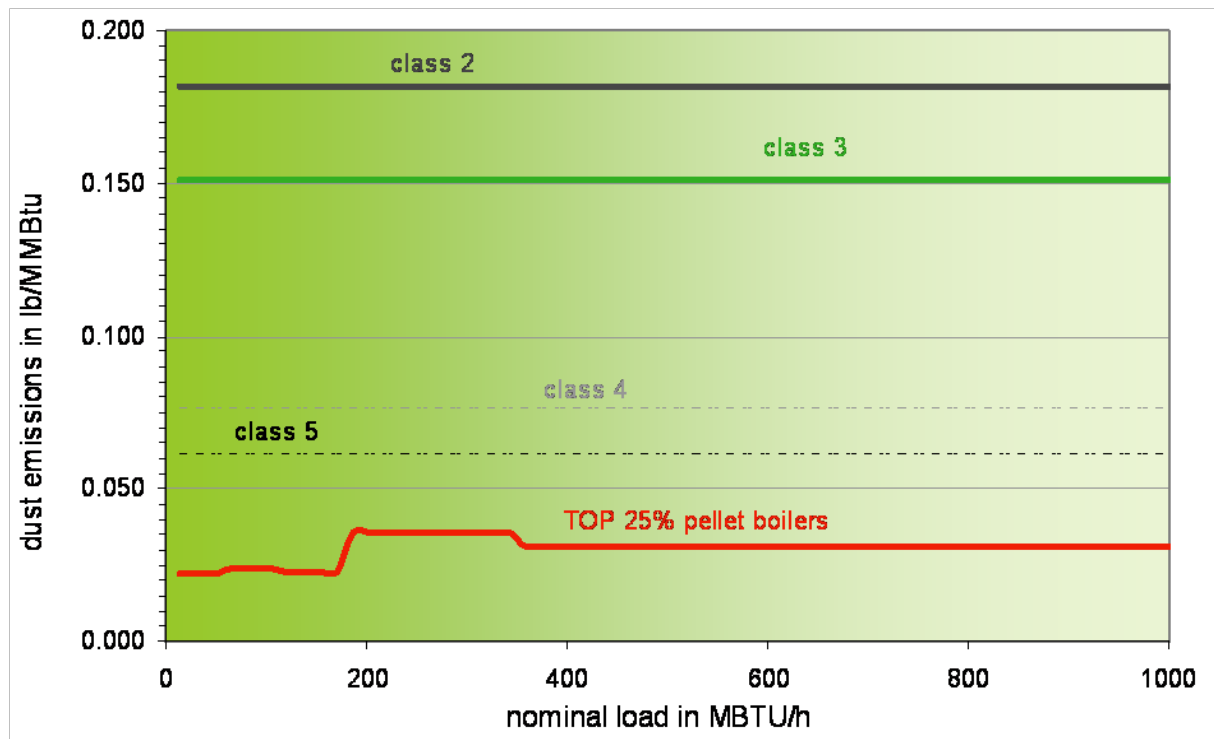
- Small variations between efficiencies at full and partial load
- Even higher efficiencies at partial load possible



TOP 25% performing appliances

→ Results

■ Dust emissions



- TOP 25% pellet boilers reach lower dust emissions than future requirement of EN 303-5, class 5
- Also true for wood chip and solid wood boilers
- Class 4 and 5 under discussion!



Summary

- Staged combustion is state-of-the-art in Europe
- Under-burning technology used for solid wood boilers
- European/national regulations and eco-labels are major driving forces for technological developments
- EN 303-5 (under revision)
 - Performance requirements
 - Different classes encompass all European technology levels
 - Heat storage required if partial load > 30%
 - Test methods described for heat load, efficiency, emissions, ...
- TOP 25% performing biomass appliances
 - Austrian, German and Scandinavian products were analyzed
 - Reach higher performances than required in future EN 303-5



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Results of the BIOENERGY 2020+ report for residential boilers

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HeatNE, April 27th 2010, Manchester, NH

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Emission limits

■ Current emission limits

Stoking	Nominal heat load in MBtu/h	Emission limits at 12% O ₂								
		CO in mg/m ³			OGC in mg/m ³			Dust ³⁾ in mg/m ³ (and lb/MMBtu)		
		class	class	class	class	class	class	class	class	class
		1	2	3	1	2	3	1	2	3
Manual ¹⁾	≤ 170	20455	6545	4090	1635	245	120	165 (0.22)	145 (0.20)	125 (0.17)
	170 - 510	10227	4090	2045	1230	165	80	165 (0.22)	145 (0.20)	125 (0.17)
	510 - 1025	10227	1635	980	1230	165	80	165 (0.22)	145 (0.20)	125 (0.17)
Automatic ²⁾	≤ 170	12270	4090	2455	1430	165	80	165 (0.20)	145 (0.18)	125 (0.15)
	170 - 510	10230	3680	2045	1020	120	65	165 (0.20)	145 (0.18)	125 (0.15)
	510 - 1025	10230	1635	980	1020	120	65	165 (0.20)	145 (0.18)	125 (0.15)

¹⁾ Based on the higher heat value (GCV) and the heat value for solid wood (dust values only)

²⁾ Based on the higher heat value (GCV) and the heat value for pellets (dust values only)

³⁾ Dust emission limits are identical for automatical and manual systems in EN 303-5, conversion from mg/m³ to lb/MMBtu results in higher emission limits for manually stoked appliances, though

Future (discussed) emission limits

Stoking	Nominal heat load in MBtu/h	Emission at 12% O ₂								
		CO limits in mg/m ³			OGC limits in mg/m ³			Dust ³⁾ in mg/m ³ (and lb/MMBtu)		
		class	class	class	class	class	class	class	class	class
		3	4	5	3	4	5	3	4	5
Manual ¹⁾	≤ 170	4090	820	410	125	60	40	125 (0.17)	60 (0.08)	50 (0.07)
	170 - 510	2045	615	245	80	40	25	125 (0.17)	60 (0.08)	50 (0.07)
	510 - 1025	980	410	205	80	10	10	125 (0.17)	60 (0.08)	50 (0.07)
	1025 - 1710	980	410	205	80	10	10	125 (0.17)	60 (0.08)	50 (0.07)
Automatic ²⁾	≤ 170	2455	820	410	80	60	40	125 (0.15)	60 (0.08)	50 (0.06)
	170 - 510	2045	615	245	65	60	40	125 (0.15)	60 (0.08)	50 (0.06)
	510 - 1025	980	410	205	65	40	20	125 (0.15)	60 (0.08)	50 (0.06)
	1025 - 1710	980	410	205	65	40	20	125 (0.15)	60 (0.08)	50 (0.06)

¹⁾ Based on the higher heat value (GCV) and the heat value for solid wood (dust values only)

²⁾ Based on the higher heat value (GCV) and the heat value for pellets (dust values only)

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