Economic consequences of low cost additives in waste wood combustion systems

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Life cycle cost analysis

Objective: determination of the economic effects of using resource efficient additives in waste wood fuel mixes

A financial comparison between the baseline scenario and a scenario in which additives are used

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Life cycle costing: input data

Baseline scenario:

- Plant data of a regular and representative year of operation

Depreciation period	year
Total project cost	€
Nett Environmental Subsidy	€
Purchasing cost wet wood chips	€/ton
Revenue for heat delivered	€ct/kWh
Revenue from electricity feed	€ct/kWh
Exploitation and insurance costs	€/year
Max electricity production	kWe
Max heat production	kWth
Thermal supply of wood chips	kWth
Heating value of biomass	MJ/kg
Biomass use on a yearly basis	ton/year
Operational (full load) hours of boiler	hours
Nett heat production	MWh/yea r
Nett electricity production	MWh/yea r

Additives scenario:

- Baseline scenario
  + Additional costs and investments
  + Cost reductions

Costs of additive	€/year
Investment in gypsum dosing equipment	€
Additional cost for fluegas desulphurization	€/year
Additional (ash and gypsum) disposal costs	€/year
Cost reduction due to decreased downtime	€/year
Cost reduction due to increased lifetime heat exchanger/superheater	€/year
Increased boiler efficiency	

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LCC methodology (1)

Baseline scenario:

Depreciation period	years
Total project cost	€
Nett Environmental Subsidy	€
Purchasing cost wet wood chips	€/ton
Revenue for heat delivered	€ct/kWh
Revenue from electricity feed	€ct/kWh
Exploitation and insurance costs	€/year
Max electricity production	kWe
Max heat production	kWth
Thermal supply of wood chips	kWth
Heating value of biomass	MJ/kg
Biomass use on a yearly basis	ton/year
Operational (full load) hours of boiler	hours
Nett heat production	MWh/year
Nett electricity production	MWh/year

Exploitation costs breakdown:

Costs of additive	€/year
Investment in gypsum dosing equipment	€
Additional cost for fluegas desulphurization	€/year
Additional (ash and gypsum) disposal costs	€/year
Cost reduction due to decreased downtime	€/year
Cost reduction due to increased lifetime heat exchanger/superheater	€/year

Increased boiler efficiency → lower thermal supply of wood chips needed

Project result: Cost reduction (before interest and corporate tax) in € per year

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LCC methodology (2)

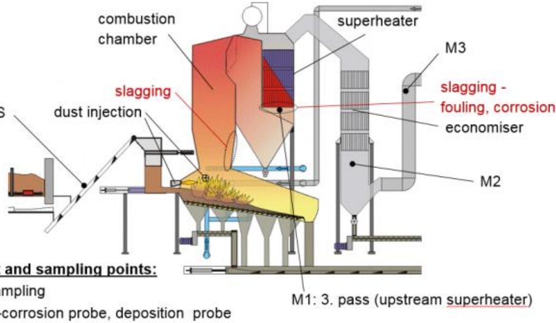
- Input data provided by REFAWOOD project partners and test reports

- Distinction made in high and low effect scenario

- Variation (High – Low) in:

➢ Downtime reduction
➢ Increased total plant efficiency
➢ Increased lifetime heat exchanger / superheater

Wood gratefired boiler Austria



Measurement and sampling points:
FS ... fuel sampling
M1 ... online-corrosion probe, deposition probe
M2 ... flue gas analysis,
M3 ... total dust and aerosols emissions

Baseline scenario:

Depreciation period	10	years
Total project cost	13.300.000	€
Nett Environmental Subsidy	0	€
Purchasing cost wet wood chips	75	€/ton
Revenue for heat delivered	3,00	€ct/kWh
Revenue from electricity feed	10,50	€ct/kWh
Exploitation and insurance costs	2.000.000	€/year
Max electricity production	8.800	kWe
Max heat production	4.000	kWth
Thermal supply of wood chips	40.000	kWth
Heating value of biomass	11,54	MJ/kg
Biomass use on a yearly basis	103.533	ton/year
Operational (full load) hours of boiler		Hours
	8.297	MWh/yea
Nett heat production	33.180	r
	73.014	MWh/yea
Nett electricity production		r

Additives scenarios:

- Gypsum: 1 wt-%
- Downtime reduction: 42-83 h/year
- Increased total plant efficiency: 0,5-1%
- Increased lifetime heat exchanger: 2,5-5 years

Costs of additive	38.500	€/year
Investment in gypsum dosing equipment	42.150	€
Additional cost for fluegas desulphurization	15.500	€/year
Additional (ash and gypsum) disposal costs	43.800	€/year
Cost reduction due to decreased downtime	90.968	€/year
Cost reduction due to increased lifetime heat exchanger	40.588	€/year

Project result: Cost reduction (before interest and corporate tax)	**19.000 - 128.000€/year**

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Demolition wood gratefired boiler, Sweden

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Baseline scenario:

Depreciation period	25	years
Total project cost	103.000.000	€
Nett Environmental Subsidy	0	€
Purchasing cost wet wood chips	13	€/ton
Revenue for heat delivered	1,90	€ct/kWh
Revenue from electricity feed	2,90	€ct/kWh
Exploitation and insurance costs	6.919.603	€/year
Max electricity production	22.000	kWe
Max heat production	45.000	kWth
Thermal supply of wood chips	71.000	kWth
Heating value of biomass	12,3	MJ/kg
Biomass use on a yearly basis	87.901	ton/year
Operational (full load) hours of boiler	4.230	hours
Nett heat production	190.350	MWh/year
Nett electricity production	49.280	MWh/year

Additives scenarios:

- Gypsum: 1 wt-% (421 ton/year ≈ 0,5%)
- Downtime reduction: 25-50 h/year
- Increased total plant efficiency: 0,25 -0,5%
- Increased lifetime superheater: 3-6 years

Costs of additive	8.420	€/year
Investment in gypsum dosing equipment	50.000	€
Additional cost for fluegas desulphurization	5.000	€/year
Additional (ash and gypsum) disposal costs	0	€/year
Cost reduction due to decreased downtime	150.000-300.000	€/year
Cost reduction due to increased lifetime superhea	8.330-16.667	€/year

Project result: Cost reduction (before interest and corporate tax) 114.000- 293.000 €/year

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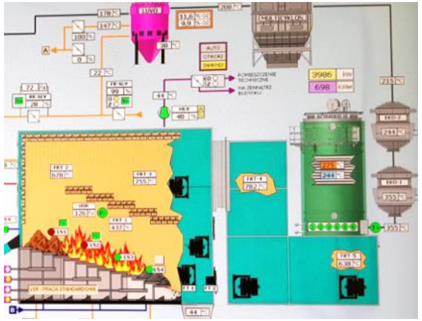
Fresh wood chips gratefired, Poland



Baseline scenario:

Depreciation period	8	years
Total project cost	7.530.000	€
Nett Environmental Subsidy	3.765.000	€
Purchasing cost wet wood chips	37	€/ton
Revenue for heat delivered	6,50	€ct/kWh
Revenue from electricity feed	2,40	€ct/kWh
Exploitation and insurance costs	851.765	€/year
Max electricity production	1.200	kWe
Max heat production	5.500	kWth
Thermal supply of wood chips	8.000	kWth
Heating value of biomass	8,3	MJ/kg
Biomass use on a yearly basis	23.075	ton/year
Operational (full load) hours of boiler		hours
	6.800	MWh/yea
Nett heat production	37.400	r
	7.980	MWh/yea
Nett electricity production		r

Additives scenarios:

- Gypsum: 1 wt-%
- Downtime reduction: 75-150 h/year
- Increased total plant efficiency: 0,5-1%
- Increased lifetime heat exchanger: 0,75-1,5 years

Costs of additive	116	€/year
Investment in gypsum dosing equipment	3.000	€
Additional cost for fluegas desulphurization	0	€/year
Additional (ash and gypsum) disposal costs	3.000	€/year
Cost reduction due to decreased downtime	20.900-41.700	€/year
Cost reduction due to increased lifetime heat exchanger	6.200-12.400	€/year

Project result: Cost reduction (before interest and corporate tax)	**28.000- 60.000**	**€/year**

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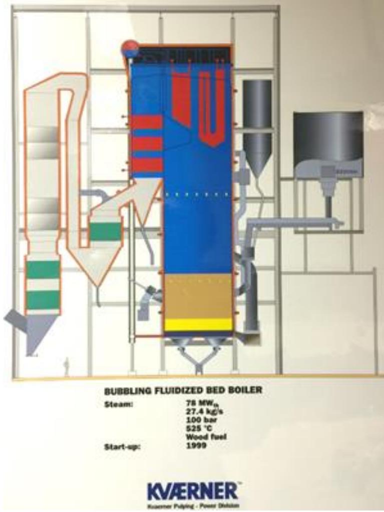
Wood fluidized bed boiler, Netherlands



Baseline scenario:

Depreciation period	12	years
Total project cost	55.000.000	€
Nett Environmental Subsidy	0	€
Purchasing cost wet wood chips	28	€/ton
Revenue for heat delivered	5,00	€ct/kWh
Revenue from electricity feed	3,20	€ct/kWh
Exploitation and insurance costs	4.150.000	€/year
Max electricity production	21.000	kWe
Max heat production	40.000	kWth
Thermal supply of wood chips	83.000	kWth
Heating value of biomass	8,83	MJ/kg
Biomass use on a yearly basis	250.140	ton/year
Operational (full load) hours of boiler		hours
	7.400	MWh/yea
Nett heat production	296.000	r
	155.400	MWh/yea
Nett electricity production		r

Additives scenarios:

- Gypsum: 1 wt-%
- Downtime reduction: 100-200 h/year
- Increased total plant efficiency: 0,5-1%
- Increased lifetime 3 superheaters: 4-8 years

Costs of additive	40.000	€/year
Investment in gypsum dosing equipment	30.000	€
Additional cost for fluegas desulphurization	-	€/year
Additional (ash and gypsum) disposal costs	30.000	€/year
Cost reduction due to decreased downtime	84.000-166.000	€/year
Cost reduction due to increased lifetime 3 superheaters	30.000-60.000	€/year

Project result: Cost reduction (before interest and corporate tax)	**106.000 - 268.000**	**€/year**

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Economic results for 4 power plants

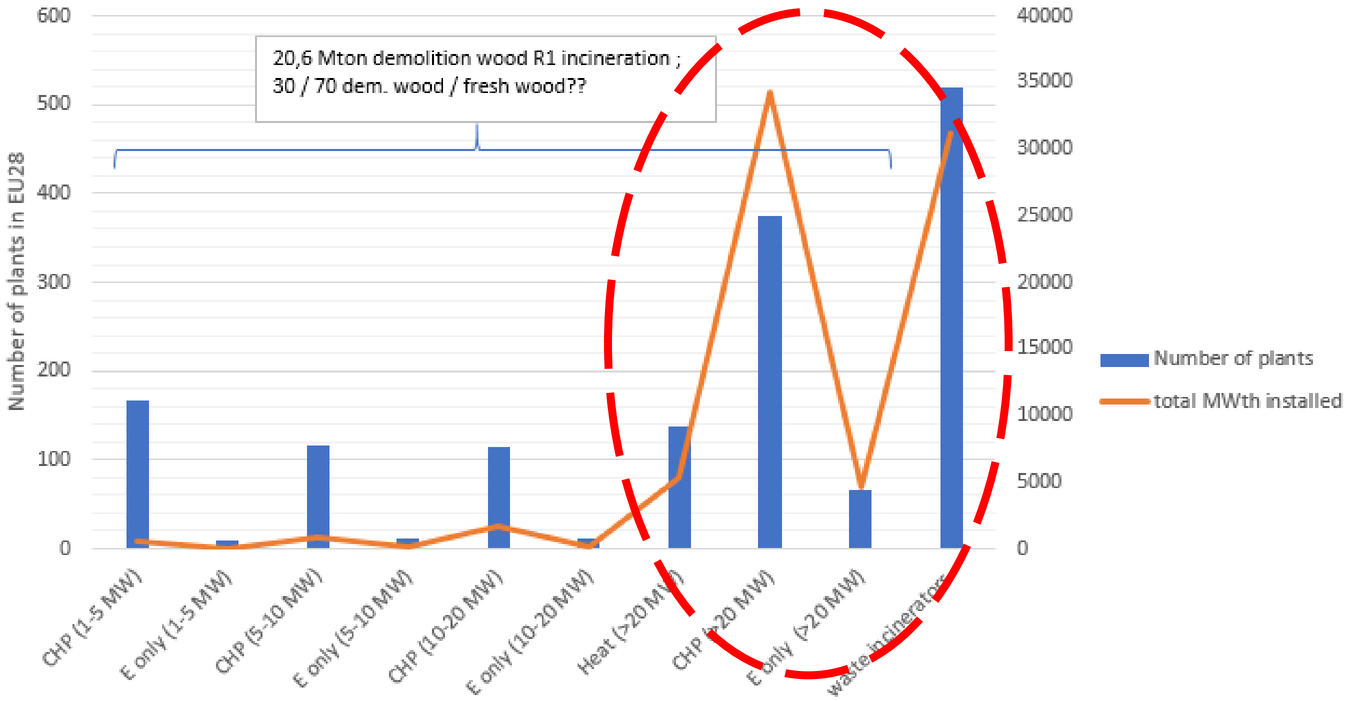
Case study	Cost reduction
Wood boiler Austria, gypsum scenario	19.000-128.000€/year
Demolition gratefired Sweden, gypsum scenario	114.000-293.000€/year
Fresh wood chips Poland, gypsum scenario	28.000-60.000€/year
Various biomass Netherlands, gypsum scenario	106.000-268.000€/year

Considerations when applying new additives

Possible considerations with regard to potential application of S-rich additives:

- High steam temperatures (> 400 °C) & low lifetime of superheaters (<15 yrs; existing corrosion!)
- Current slagging & fouling problems in the boiler
- High chlorine content in fuel (in g/GJ; e.g. waste wood or municipal waste)
- Combustion technology (e.g. grate or fluidized bed?)
- Existing flue gas desulphurization equipment with possibility to clean higher SO2 loadings (or bag filter which may be converted)

Quantative data on wood boilers and waste incinerators EU-28



Sources: wood chip plants AEBIOM Bioenergy outlook 2017 (BASIS project), CEWEP interactive map

Appr. 580 wood fired boilers >20 MW in EU28 (44.000 MW_{th})

Assumption:
->180 boilers using demolition wood >20 MW_{th}

>520 waste incineration plants (30.000 MW_{th})

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Conclusions and recommendations

Gypsum cofiring scenarios at 4 different wood-fired power stations have been set up.

The addition of gypsum may result in

- lower superheater corrosion rates
- lower boiler downtime
- higher boiler efficiency

For a 70 MW_{th} demolition wood-fired boiler this may lead to 114.000 – 293.000 euro in yearly savings.

There is a huge potential for using this technology in other European demolition wood boilers and especially waste incinerations plants.

Thank you for your attention

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