



Energy research Centre of the Netherlands

Bioenergy use in stationary installations and air pollution Highlights BOLK Phase 2

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Objectives

- Provide:
 - Estimations on **populations/activities of biomass use** in stationary applications and medium-scale fossil-fired installations (now and 2020) in the Netherlands
 - Estimations **NEC emission factors (NO_x, SO_x, dust, NH₃, NMVOC)** medium-scale biomass/fossil-fired installations, small-scale wood stoves, biofuel production and biomass transshipment/storage activities in the Netherlands
 - Estimation of **costs/performance of flue gas cleaning** for medium- and small-scale biomass installations
 - Estimation of **total NEC emissions** of the combustion of biomass in stationary applications in the Netherlands

*All as input for the BOLK integration phase to reduce bandwidths/
uncertainties*

Approach

- Literature search (literature, internet, permits)
- Limited contacts with relevant companies/authorities
- ‘What-if’ scenario's used for estimation future populations
- No extensive market consultation/modelling/statistical research

Results

- A large amount of data has been gathered/generated in this study. Only a small part is presented here. Reference is made to the report for all results/details.

Results populations

- Based on 'What-if' scenarios (= not best guess!!!) and biomass fuel input LHV

	2007 (CBS)	Updated Reference Projections 2020 (2009)	Scenario Low 2020	Scenario High 2020
PJ_{LHVinput/a}				
Co-firing gas/coal fired power plants	15	0	89	89
Waste incineration (only biogenic part)	28	48	41	41
Small-scale biomass combustion/stoves	12	8	8	16
Medium-scale biomass combustion	7	11	49	51
Large-scale biomass combustiton	0	0	0	0
<i>Biogas engines from waste tips</i>	2	0		
<i>Biogas enginess from AWZI/RWZI</i>	2	8		
<i>Agricultural biogas plants</i>	2	2		
<i>Other biogas plants</i>	1.5	2		
Total anaerobic digestion	7	13	37	50
Bio-oil/fat-fired engines	0.5	0	6	6
Cement industry	-	0	0	0
Total	71	80	224	252

Results emission factors

- **Medium-scale biomass and natural gas fired installations**
(1-50 MW_{th})
 - Introduction of new legislation (*BEMS, also for existing installations*) in 2010 will have nivillating and reducing effect on emissions of NO_x, SO_x and dust
 - Estimates based on available literature, own estimations and legislation
 - Higher emission factors found for biomass compared to (clean) gas fired installations
 - NH₃ emissions originate from De-NO_x (ammonia slip). If NO_x is lowered by De-NO_x, NH₃ is expected to rise

Results emission factors

	Nox		Sox		dust		NMVOC		NH3	
	Now	2020	Now	2020	Now	2020	Now	2020	Now	2020
Medium-scale biomass										
Solid biomass-fired boilers	x	x	x	x	x	x	x	x	x	x
Biogas-fired gas engines	x	x	x	x	x	x	x	x	x	x
Bio-oil fired diesel engines	x	x	x	x	x	x	x	x	x	x
Woodstoves (small scale biomass)	x	x	x	x	x	x	x	x	x	x
Medium-scale fossil-fired CHP										
NG gas engine	x	x	x	x	x	x	x	x	x	x
NG gas turbine	x	x	x	x	x	x	x	x	x	x
NG gas boiler	x	x	x	x	x	x	x	x	x	x
Biomass transshipment and storage					x					
Biofuel production										
Biodiesel	x		x		x		x		x	
Bioethanol	x		x		x		x		x	
Fischer-Tropsch	x		x		x		x		x	
Biomethanol	x		x		x		x		x	

= To much to discuss in detail here...

Estimated stationary biomass emission factors 2007 and 2020 (executive summary)

- Also available: SO_x and dust EF

Unit: g/GJ _{LHV, input}	NO _x		PM		NMVOC	
	2007	2020	2007	2020	2007	2020
Co-firing in coal-fired power plants	40	40	0.9	0.9	2	2
Waste Incineration (only biogenic)	35	35	0.5	0.5	1	1
Small-scale biomass combustion /stoves	111	129	180	137	750	620
Medium-scale biomass combustion	130	40	5	1.7	10	10
Biogas from AWZI/RWZI	195	30	0.5	0.5	14	14
Biogas from waste tips	195	30	0.5	0.5	14	14
Agricultural biogas plants	195	30	0.5	0.5	14	14
Other biogas plants	195	30	0.5	0.5	14	14
Bio-oil/fat fired engines	130	130	17	17	31	31

Results emission factors 2020

Category/NEC component	NO _x		SO _x		NH ₃		Dust		NMVOC	
	Phase 1	Phase 2	Phase 1	Phase 2	Phase 1	Phase 2	Phase 1	Phase 2	Phase 1	Phase 2
Co-firing	40	40	11	11	5	5	0.9	0.9	0	2 ^{a)}
Waste Incineration (only biogenic)	35	35	1.3	1.3	1.3	1.3	0.5	0.5	1.3	1.3
Small-scale biomass combustion/stoves	150	130	30	13	9.0	0	108	136/137^{b)}	43	588/620^{b)}
Medium-scale biomass combustion	1020	40	0	10	0	1.7	29	1.7	4	10
Large-scale biomass combustion	1020	n.d.	0	n.d.	-	n.d.	29	n.d.	4	n.d.
Biogas from waste tips	250	30	27	2	0.0	0.15	1.2	0.5	0	14
Biogas from AWZI/RWZI	35	30	2	2	2.5	0.15	1.4	0.5	0	14
Agricultural biogas plants	250	30	108	2	5.0	0.15	10	0.5	0	14
Other biogas plants	-	30	-	2	-	0.15	-	0.5	-	14
Bio-oil/fat-fired engines	1020	130	0	9	0	4.4	29	17	4	31

- Woodstoves: CBS/Emission Registration are updating their data in 2010

Results emission factors

- **Biofuel (bio-EtOH, bio-MeOH, bio-FT, bio-diesel)**
production process emissions:
 - Estimated from permits
 - Very location specific: depends on feedstock, process layout, integration with other plants, etc. Number of plants in the Netherlands is currently very limited.
 - NO_x and SO_x emissions arise from CHP, range:
 - SO_x : 0.2-1.9 g/GJ fuel
 - NO_x : 0.5-2.3 g/GJ fuel
 - NMVOC: 0.3-1.4 g/GJ fuel
 - Dust emissions are negligible, no NH_3 limits mentioned and are expected negligible
 - No data found available on bio-Fischer Tropsch



Results emission factors

- **Biomass transshipment and storage:**

- Dutch Emission Guidelines (NeR) dusting classes:



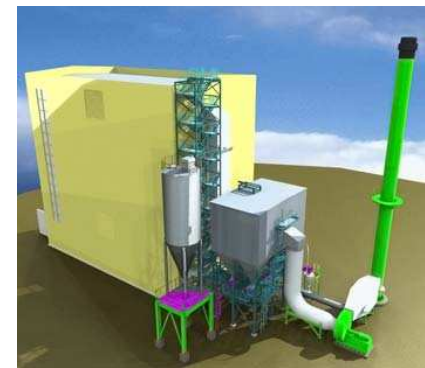
Class		
Not drift sensitive	S5	
	Not wettable ¹⁾	Wettable
Highly drift sensitive	S1	S2
Moderately drift sensitive	S3	S4

¹⁾ Class S1 and S3 may only be stored in closed spaces

- Lack of reliable data
- Wood pellets: dusty but have often closed transportation systems
 - Emission factor: 0.05 g/GJ
- Wood chips: range: 0.04-1.6 g/GJ
- 2020: estimated emission wood pellets approx. 0.02 tonne/a with 20 Mtonne/a = 2% of total emissions of Dutch bulk activities in 2008
- Dust is biodegradable!

Results costs and performance

- **Flue gas cleaning medium-scale biomass installations:**
 - For all NEC pollutants cleaning measures are available
 - Very wide cost ranges are found = function (numerous parameters) and often made to measure. Costs can therefore be **very case specific**.
 - Typical NO_x removal costs for low NO_x burners (4000-6000 hrs/a):
 - Coal fired power plant: 2-4 Euro/kg
 - Wood in medium-scale CHP: 5-10 Euro/ton
 - Gas engine on biogas: 10-15 Euro/ton
 - NMVOC removal: oxycat research for biomass applications needed



Source: Cofely GDF Suez

Results costs and performance

- **Flue gas cleaning (dust removal) for woodstoves:**
 - Cost effectiveness replacing unapproved by approved stoves: 30-50 Euro/kg dust
 - Cost effectiveness using ESP: >210 Euro/kg dust



Results impact analysis 2020

Scenario	Biomass use [PJ _{LHV,input} /a]	NO _x [kton/a]	SO _x [kton/a]	NH ₃ [kton/a]	Dust [kton/a]	NMVOC [kton/a]
<i>Estimated emission level for 2007</i>	71	5.3	0.5	0.1	2.2	9
BOLK Phase 1 Reference Projections (2007)	215	18	1.7	0.7	1.2	0.5
BOLK Phase 2 Updated Reference Projections (2009)	80	3.5	0.3	0.1	1.2	5.4
Scenario 'Low'	224	10	1.8	0.6	1.4	6.3
Scenario 'High'	252	11	1.9	0.6	2.5	11

- The degree of co-firing can have significant impact on NO_x and SO_x emissions
- NO_x emissions are significantly lower compared to previous estimate due to lower estimate EF medium-scale installations
- NMVOC is higher due to significant higher estimate EF medium- and small-scale installations
- Small-scale installations contribute more than proportional for the components NMVOC and dust
- Substitution effect (coal, oil, gas) should be taken into consideration for 'net' effect!

Results impact analysis 2020

- **Net effects biomass use: ↑ NO_x, NH₃, PM, NMVOC ↓ SO_x**

Table 4 Change in air polluting emissions due to the substitution of fossil-based power and heat generation with bio-energy generation for the two scenarios for 2020 (minus is a decrease, plus is an increase)

Scenario	Additional biomass use in 2020 [PJ/a]	NO _x [kton/a]	SO _x [kton/a]	NH ₃ [kton/a]	PM ₁₀ [kton/a]	NMVOC [kton/a]
'Low'	142	+0.2	-1.7	+0.5	+0.5	+3.0
'High'	172	+1.6	-1.6	+0.5	+1.2	+8.5

- **Net effects natural gas medium scale CHP: ↑ NMVOC ↓ NO_x, SO_x**

Scenario	Natural CHP in 2020 [PJe/a]/[PJh/a] ¹	NO _x [kton/a]	SO _x [kton/a]	PM ₁₀ [kton/a]	NMVOC [kton/a]	NH ₃ [kton/a]
'Low'	7 (e) / 10 (h)	-0.3	-0.4	0	0.6	0
'High'	16 (e) / 23 (h)	-0.6	-0.8	0	1.4	0
Ref URGE National total		198.5	48	35	165	129
Industry and Energy		80	47	12	69	3

Conclusions

- Effects on air quality in ‘*what if*’ scenario’s compared to reference:
 - Use of biomass: \uparrow NO_x , NH_3 , PM, NMVOC \downarrow SO_x
 - Use of medium scale natural gas CHP: \uparrow NMVOC \downarrow NO_x , SO_x
- Future populations are highly uncertain as they are:
- often (currently) **not economic feasible** and therefore realisation is strongly dependent **of subsidies/obligations**
- strongly dependent on **future technological and market developments**
- Actual emission factors can be very site specific. Often a bandwidth can be expected.
- **Results of this study should therefore be used with care** due to the high uncertainties, but can give a **first indication** of expected effects



Recommendations

- Still large uncertainties present (although they are reduced...)
- Further improvement of (current) emission data will require substantial effort to obtain (and maintain!) them. Improve:



- **population characteristics and emission** data and coupling thereof
- the **data on NMVOC** by measuring at specific representative installations
- the **data on biofuel production** by extending the studied permits and/or obtain actual emission data
- the **data on gas cleaning costs** by performing an extensive market survey
- the **data on biomass transshipment and storage** (measurements)

Any questions?

