ABSTRACT

The centre for Best Available techniques (BAT) is founded by the Flemish government, and is hosted by VITO. The BAT centre collects, evaluates and distributes information on environmentally friendly techniques. Moreover, it advises the Flemish authorities on how to translate this information into its environmental policy. Central in this translation is the concept 'BAT' (Best Available Techniques). BAT corresponds to the techniques with the best environmental performance that can be introduced at a reasonable cost.

The objective of this study is to list all available information concerning the environmental impact of the combustion of renewable fuels. Next the environmentally friendly techniques that can prevent or reduce the environmental impact are evaluated. This report focuses mainly on the techniques to reduce dust, NOx and SO_2 emissions. This analysis is the basis for the selection of BAT for the combustion of renewable fuels and provides an insight into the achievable emission levels.

The term 'renewable' covers a broad range of fuels. In the widest sense of the word, renewable fuels include all biodegradable fractions of products, wastes and residues from agriculture, forestry and relevant sectors and also biodegradable fractions from industrial and domestic waste. This definitions includes both vegetable and animal products. Biomass and bio-waste are part of renewable fuels. As most new initiatives in the field of the combustion of renewable fuels concerns small and medium sized installations, these combustion installations and stationary engines will be the focus of this report.

The combustion of renewable fuels is still a sector under development. Renewable fuels show some similarity with fossil fuels, but also some differences.
Certain solid renewable fuels are characterized by high levels of N, S and ashes in comparison with coal. This results in higher emission levels for these renewable fuels. Because of their nature and physical characteristics a broader range of combustion techniques are used.
Liquid and gaseous renewable fuels bear more similarity to fossil fuels. These fuels are also combusted in similar combustion installations and engines. The difference with fossil fuels is that renewable fuels are characterized by a potential variable composition and a higher level of oxygen. This results in higher levels of NOx emissions. Furthermore the biogases contain trace elements and siloxanes which have a negative impact on the operation of the installed catalysts. These aspects are currently examined by the suppliers.
When evaluating BAT, the nature and composition of the fuels will be important factors to be considered.

The BAT selection is based on a literature survey, a limited set of measurement data, calculations of emissions and costs, plant visits and repeated discussions with industry experts and authorities. The formal consultation was organized by means of an advisory committee.

As this concerns a recent sector, the available measurement data and practical experiences with renewable fuels are limited. Because of the limited sets of available data, it was decided, in consultation with the advisory committee, to work with calculated emission levels for solid fuels, both for the raw and cleaned emissions. For liquid and gaseous fuels it is not possible to estimate the emission levels based on calculations. For these fuels the limited available data sets are used.

The evaluation of the technical feasibility and environmental aspects of the environmentally friendly techniques leads to a broad range of potential techniques. To be able to select BAT for this horizontal sector the cost-efficiency of the environmental techniques is used. The cost-efficiency (cost per ton emissions reduced) is determined based on an estimation of the investment and operational costs and reduction efficiencies. Indicative reference values for the assessment of the cost-efficiency are used. For NOx reduction techniques this value lies between <5 and. 7 euro per tonne NOx reduced. For SO_2 reduction measures the reference value lies between < 2,5 and. 3,5 euro per tonne SO_2 reduced.
The feasibility of the costs (cost related to the economic strength of the sector) is subject to the specific sector. Therefore this can not be determined in this horizontal study and needs to be considered on a case by case level.

To analyse the potential and effect of this approach, a sensitivity analysis was carried out. This analysis showed that the number of operating hours, the capacity and the investment costs of the environmental techniques are important factors in the evaluation of BAT. Since investment costs – and emission levels – for new and existing installations differ, a distinction between new and existing installations is made.

The BAT conclusions are based on the assumptions and conclusion as mentioned above. The BAT conclusions are summarized in the tables below. Here, a distinction is made between the composition of the fuel, the number of operating hours, the capacity and new or existing installations. For more details on the assumptions used to evaluate BAT and BAT associated emission levels, we refer to the full text in Dutch. For information you can contact the Flemish BAT centre.

- Solid renewable fuels
  - BAT for the reduction of dust[3]

Existing installations		
	< 4000 h	**> 4000 h**
< 1% ash	Multi-cyclone	Multi-cyclone
> 1% ash	Multi-cyclone	< 5 MW Multi-cyclone > 5 MW Fabric filter or ESP
New installations		
	< 4000 h	**> 4000 h**
< 1% ash	Multi-cyclone	< 5 MW Multi-cyclone > 5 MW Fabric filter or ESP
> 1% ash	< 5 MW Multi-cyclone > 5 MW Fabric filter or ESP	Fabric filter or ESP

  - BAT for the reduction of SO_2[1,4]

Existing installations		
	< 4000 h	**> 4000 h**
< 1% S	< 5 MW use of fuel with < 0,3 wt.% S > 5 MW Dry sorbent injection	Dry sorbent injection or use of fuel with < 0,3 wt.% S
> 1% S	Dry sorbent injection	Dry sorbent injection

[3] It is BAT to use the techniques given in the tables or any other technique with a similar environmental performance.

New installations		
	< 4000 h	**> 4000 h**
< 1% S	Dry sorbent injection or use of fuel with < 0,1 wt.% S	Dry sorbent injection or use of fuel with < 0,1 wt.% S > 20 MW Wet scrubber
> 1% S	Dry sorbent injection > 20 MW Wet scrubber	Dry sorbent injection > 20 MW Wet scrubber

– BAT for the reduction of NOx[1]

Existing installations		
	< 4000 h	**> 4000 h**
< 1% N	No end-of-pipe techniques	SNCR or use of fuels with < 0,4 wt.% N
> 1% N	SNCR	SCR
New installations		
	< 4000 h	**> 4000 h**
< 1% N	SNCR use of fuels with < 0,4 wt.% N	SCR
> 1% N	SCR	SCR

- Liquid renewable fuels
  – BAT for the reduction of NOx[1]

Combustion installations		
	< 4000 h	**> 4000 h**
Animal fat	SNCR	Primary measures + SNCR of SCR*
	< 6000 h	**> 6000 h**
Pure vegetable oils and recycled frying oils	Primary measures	Primary measures + SNCR of SCR*
Diesel engines		
Animal fat and pure vegetable oils	SCR	

* combination with SCR for new installations

- Gaseous renewable fuels
  – BAT for the reduction of NOx[1]

Existing	New
Combustion installations	
Primary measures: low NOx burner	Optimization of primary measures
Gas engines and turbines	
Primary measures: lean burn or dry low NOx	Optimization of primary measures

[4] In the evaluation of BAT the combination of in-situ desulphurisation in fluidised bed combustion systems with other desulphurisation techniques is not considered. In practice however, the combination of these techniques is technically feasible.

When translating these BAT conclusions into permit conditions a number of policy issues need to be considered, e.g. the European Directive on National Emissions Ceilings (NEC) and the promotion of co-generation and renewable fuels. As all of these aspects need to be taken into account, it is impossible to make recommendations for environmental permit conditions neither on a general nor sector level within this BAT study.

This report provides an insight into the important factors which determine the environmental impact of the combustion of renewable fuels. Furthermore it shows the techniques that are available (technically and cost-effective) to reduce this environmental impact.