BAT AND BEP IMPLEMENTATION TO REDUCE PCDD/PCDFs EMISSIONS IN ESEA COUNTRIES: TECHNOLOGY SELECTION AND MONITORING RESULTS

Centeno C[1], Sbrilli A[2], Gobbi M[3],

[1]Stockholm Convention Division, Environment Department, United Nations Industrial Development Organization (UNIDO), Wagramerstrasse 5, A-1400 Vienna, Austria
[2]UNIDO consultant, Italy;
[3]UNIDO consultant, Italy

Introduction

The ESEA (East-South East Asia) Forum is a programmatic regional initiative set up by UNIDO which was launched in 2007 and aims to introduce Best Available Techniques and Best Environmental Practices (BAT/BEP) on priority sectors defined by participating countries, according to the classification in Annex C, Article 5 of the Stockholm Convention on Persistent Organic Pollutants (POPs). The regional project, "Demonstration of BAT & BEP in fossil fuel-fired utilities and industrial boilers in response to the Stockholm Convention POPs" was the first sectoral project of the ESEA BAT/BEP Forum and was carried out in Cambodia, Indonesia, Lao PDR, Mongolia, Philippines and Thailand.

The baseline inventories of PCDD/PCDF for the specific heat and power sector in the participating countries were estimated on the basis of the emission factors provided by the UNEP Toolkit, recently updated in 2013[1], and rarely on real measurements, due lack of national standards, adequate monitoring capacities and related high costs. However, the emission factors in the Toolkit are mainly based on few measurements on large power plants and in industrialized countries, and do not take into consideration the presence of air pollution devices or of the age of the plants, so these are limiting factors when used for small and old boilers. Particularly, in the case of industrial boilers, literature reports a very wide range of emission factors (from sub-units to thousands μg TEQ/TJ), depending on type of fuel and age of the installation and especially for biomass fuelled facilities[2,3,4]. The outcomes from the inventories outlined the relevance of small and medium boilers in the ESEA industrial sector (66% of boilers are under 5 t/h steam and more than 80% are under 10 tons/hour steam production).

The paper discussed the implementation of BAT/BEP in some pilot selected facilities (both power plants and industrial boilers with different fuels and configuration) with combustion optimization and efficiency improvement, in order to reduce U-POPs releases, along with other main contaminants, and at the same time to gather new data to be used for the UNEP Toolkit update.

Materials and methods

Boilers selection

After preliminary inventories of boiler population in the six countries aimed to identify the most representative plants, eight facilities were selected. The more suitable technologies to produce a simultaneous reduction of PCDD/PCDF, Mercury and CO_2 were identified. The BAT/BEP intervention carried out are described in table 1.

Sampling and Monitoring

Sampling, monitoring and analytical activities were contracted to internationally certified laboratories. USEPA methods (EPA23A, EPA1613B and EPA 8290) and European methods (EN1948-1,2,3) were used by the laboratories for the sampling operations of PCDD/PCDF (samples of flue gases, of bottom ashes, fly ashes at dust filters boiler slags, slurry) and analysis of samples (filters, resins, solid and residues, etc.). Besides PCDD/PCDFs, ancillary parameters (particulate matter, SOx, NOx, mercury, chlorine content in fuels, etc) were monitored as well, whereas CO_2 releases were estimated.

Table 1: Description of facilities and interventions

Country	Sector	Type of boiler selected and capacity	Type of intervention
Cambodia	Garment Industry	Old Firetube –wood logs 4 t/h steam capacity	Replacement with wood chips firetubes+bag filter- - 3 t/h steam capacity
Indonesia	Power generation	Power boiler-coal - 600 MW	Combustion optimization and efficiency improvement
Indonesia	Tires Industry	Firetube boier-coal 10t/h steam capacity	Addition of economizer-inverters on fan system
Lao PdR	Food industry	Firetubes- heavy oil - 4 t/h	Replacement with Firetubes – coal. Cyclone+bag filter - 5 t/h
Mongolia	Power generation	Power+district heating boiler-coal 400 t/h steam-	Combustion optimization and efficiency improvement
Philippines	Power generation	Power Boiler-coal - 300 MW	Combustion optimization and efficiency improvement
Thailand	Beverage industry	Firetubes - heavy oil - 10 t/h	Retrofit with Micro-emulsion technology Oil+ water and oil+ alcohol
	Food Industry	Firetubes -coal – 16 t/h steam capacity	Combustion optimization and efficiency improvement

Results and discussion:

While sampling was carried out in all the selected facilities before BAT/BEP implementation, it was possible to repeat them only in some facilities after the intervention, due to some technical issues. Therefore, it was not possible to fully evaluate and compare the implemented measures based on real data and alternative assessment was carried out. New values for emission factors (expressed as µgTEQ/TJ), based on literature data and taking into account the effect of advanced technologies on PCDD/PCDF releases, were tentatively used as reference, to address the gaps of the UNEP Toolkit. The energy inputs needed by each facility according to the specific fuel used were calculated (as TJ/year) before and after BAT/BEP implementation and efficiency improvement, and were used for the calculation of the relevant PCDD/PCDF annual releases using the emission factors based on literatures. These estimated results were compared with the real data coming from monitoring campaigns where possible. . Estimated results and data coming from real monitoring campaigns for air emissions are shown in table

2 and 3, respectively. Estimates used highlighted that the improvement of burning condition and gain in efficiency result and the potential decrease of annual PCDD/PCDF releases especially for industrial boilers, while the decrease is much less evident for power boilers. Following the same method, CO_2 potential reduction in all the facilities was estimated as 172,184 Tons/year.

The partial results from real monitoring campaign show that the investigated coal-fired power plants had very low emission values. The relevant emission factors were calculated on the highest values for a conservative approach and are at least one order of magnitude lower than those provided by the UNEP Toolkit. Before BAT/BEP implementation, the wood-fired boiler in Cambodia, with no APCD, showed the highest emission factor, whereas the coal industrial boiler and the two heavy fuel boilers generally showed comparable emission factors. After the implementation of BAT/BEP, the emission to air (and in solid residues, data not shown) was reduced in a great extent in the Philippine power plant and in a quantitatively lower extent in the Thailand industrial boiler (that adopted the oil/alcohol/water micro-emulsion technology). On the other hand, the shifting from oil to coal in the Lao boiler resulted in a very limited increase of releases, but with a calculated emission factor well below that proposed by the UNEP Toolkit for coal. The aimed efficiency gain in the Thailand coal boiler did not give the expected results, instead showed an increase of PCDD/PCDF releases. The project put a special emphasis to the potential for replicability. The selected interventions showed interesting environmental improvements and fuel savings.

Table 2: Calculations based on UNEP Toolkit +literature EF and efficiency gain/change of energy input

PCDD/PCDF to air	Baseline Energy input (1)	After BAT/BEP Energy input (1)	Baseline Emission factor (UNEP Toolkit)	After BAT/BEP Emission Factor (from literature)	Baseline Releases (as found boiler)	Releases After BAT/BEP interventions	Achieved emission reductions
	TJ/year	TJ/year	EF µg/TJ	EF µg/TJ	mg/year	mg/year	mg/year
Cambodia Wood Industrial Boiler	78	39	500	50	38.98	1.95	-37.03
Indonesia Power Plant	45.342	44.571	10	10	453.42	445.71	-7.71
Indonesia Industrial Boiler	408	340	100	10	40.81	3.40	-37.41
Lao Oil-coal Industrial Boiler	107	87	10	1	1.07	0.09	-0.98
Mongolia Power Plant	7.032	7.007	10	10	70.32	70.07	-0.24
Philippines Power Plant	22.690	21.940	10	10	226.90	219.40	-7.49

Thailand Oil Industrial boiler	274	259	10	2.5	2.74	0.65	-2.10
Thailand Coal boiler	746	533	100	10	74.62	5.33	-69.29
Total					**908.84**	**746.59**	**-162.25**

(1) The difference in energy input for same steam production is the result from efficiency improvement interventions

Table 3: PCDD/PCDF and measured emission factors from monitoring campaigns

	BASELINE		**AFTER BAT/BEP**		**Balance**
PCDD/PCDF to air	**Measured Emission factor ug/TJ**	**Releases mg/year**	**Measured Emission factor ug/TJ**	**Releases mg/year**	**mg/year**
Cambodia Wood Industrial Boiler	98.78	3.54	Monitoring not conducted	Monitoring not conducted	
Indonesia Power Plant	1.50	73.51	Monitoring not conducted	Monitoring not conducted	
Lao Oil-coal Industrial Boiler	0.92	0.03	1.89	0.07	0.04
Mongolia Power Plant	1.22	8.58	Monitoring not conducted	Monitoring not conducted	
Philippines Power Plant	6.12	121.90	0.45	8.98	- 112.92
Thailand Oil+water Industrial boiler	1.72	0.22	0.86	0.08	- 0.14
Thailand Oil+alcohol Industrial boiler	1.72	0.22	0.48	0.05	- 0.18
Thailand Coal boiler	2.90	0.95	10.53	3.22	2.28
Total		**208.94** (total) **123.42** (partial, only if comparison is possible)		**12.33**	**-110.93** (partial)

Conclusion:

The BAT/BEP measures implemented resulted to a significant decrease in fuel consumption, decreasing dioxin and CO_2 releases. Improvement in sampling and analysis of industrial emission of dioxins in the region is recommended.

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References:
1. *UNEP Standardized Toolkit for identification and quantification of Dioxins and Furans Releases* (2013)
2. Grochowalski A. (2006). Some information about power generation system in Poland and potential for energy production from renewable sources - particularly biomass. Dioxins and PCBs emission preliminary data. *Presentation at UNEP Chemicals*, Geneva
3. A. V. Kucherenko et al (2001). *Organohalogen Compounds* **50** 459-463 and **53** 275-278
4. Schleicher O. (2008) "Dioxin emissions from domestic sources in Denmark and dioxin formation in wood stoves and boilers". *Workshop on Dioxin Emissions from Domestic Sources.* Brussels