



# **From BAT/BEP for Unintentional POP Reduction to Integrated Pollution Prevention and Control of Pollutants to Tackle the Triple Planetary Crisis**

*Prof. Harald Schönberger<sup>1</sup> and Dr. Roland Weber<sup>2</sup>*

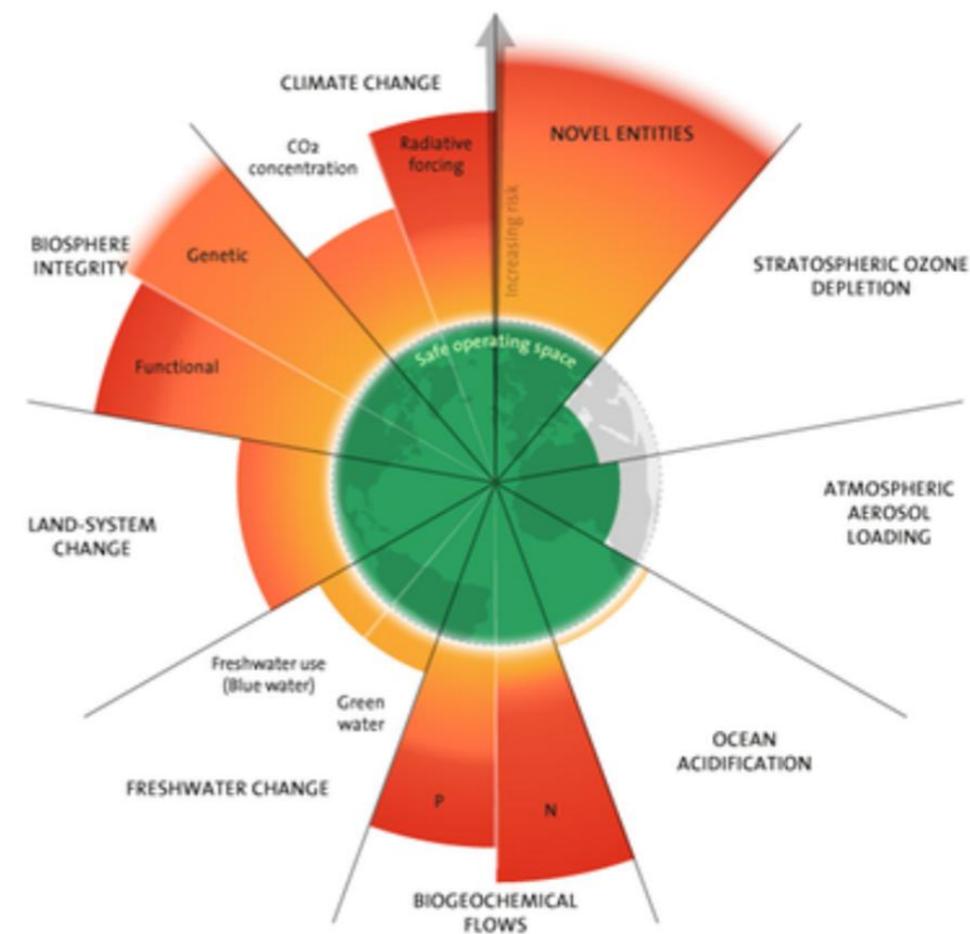
*<sup>1</sup>Stuttgart University; 70569 Stuttgart Bandtäle, Germany*

*<sup>2</sup>POPs Environmental Consulting, 73525 Schwäbisch Gmünd, Germany*

# Outline

- **The Requirements of the Stockholm Convention**
- **The BAT/BEP guidelines**
- **General principles applied to BAT/BEP**
- **Relevant industrial sectors**
  - **Integrated steel works**
  - **Electric steelworks**
  - **Metal smelters**
  - **Cement plants**
  - **Electro plating installations**
- **IPPC permits in the EU**
- **The implementation of the Stockholm Convention in the EU**

## Triple Planetary Crisis



# Unintentionally Produced POPs

**Compounds included in Annex C:**

**PCDD, PCDF, PCB (incl. 12 dioxin-like PCB; WHO-TEFs), HCB, PeCB and HCBD**

## Article 5

**Each Party shall at a minimum take the following measures to reduce the total releases ... of each of the chemicals listed in Annex C, with the goal of their continuing minimization and, where feasible, ultimate elimination.**

# Article 5 & Annex C:

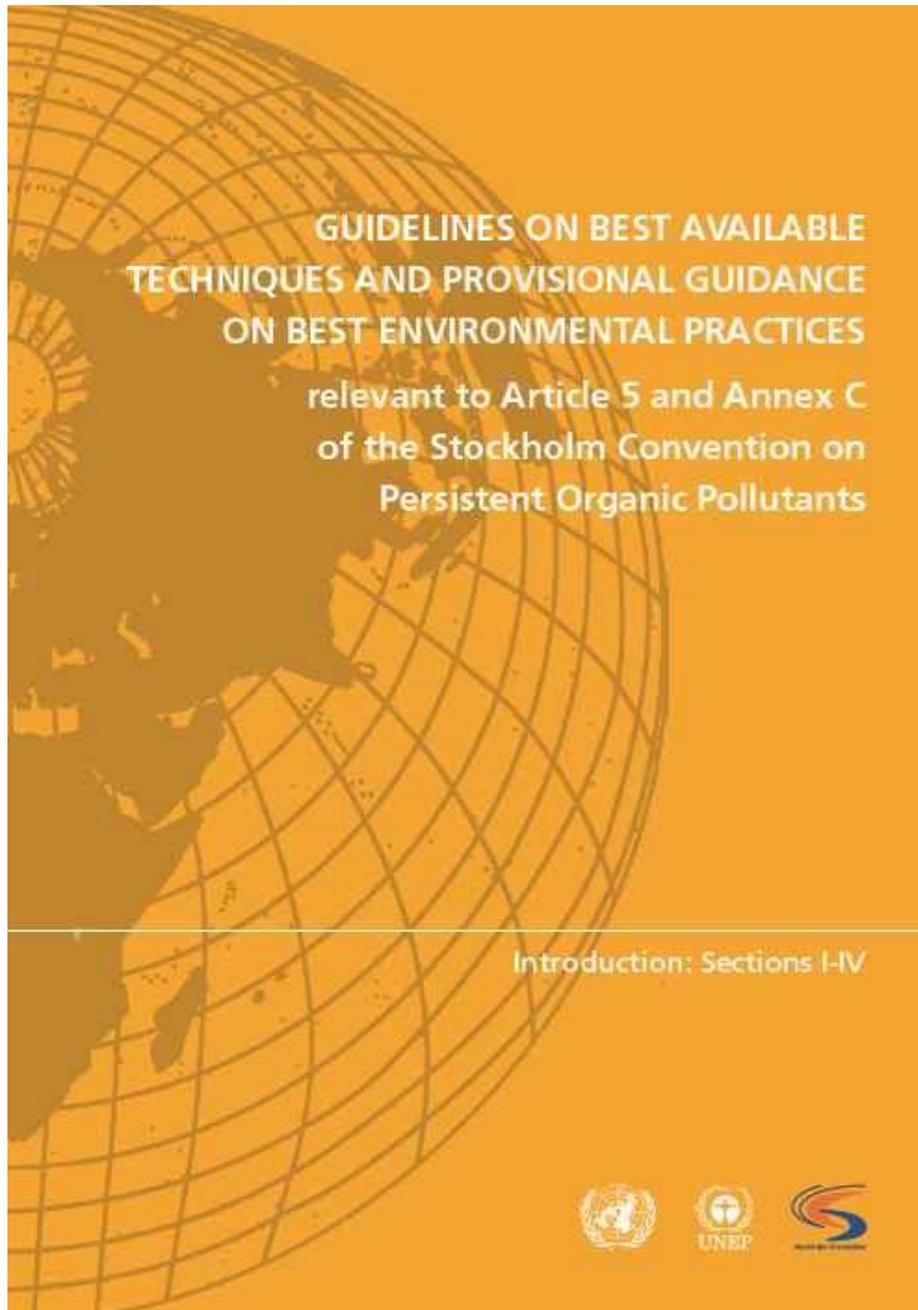
## Measures to reduce or eliminate releases from unintentional production

- *Develop* action plans within NIP (2 years after enter into force)
- *Promote*
  - available, feasible and practical measures to achieve realistic and meaningful levels of release reduction or source elimination
  - substitute products and processes
  - the use of **BAT/BEP**

# Article 5 & Annex C: Measures to reduce or eliminate releases from unintentional production

- in accordance with the implementation schedule of its action plan, require the use of **best available techniques** for new sources within source categories which a Party has identified as warranting such action in its action plan, with a particular initial focus on source categories identified in Part II of Annex C. (4 years after enter into force)

# Stockholm Convention BAT/BEP Guidance



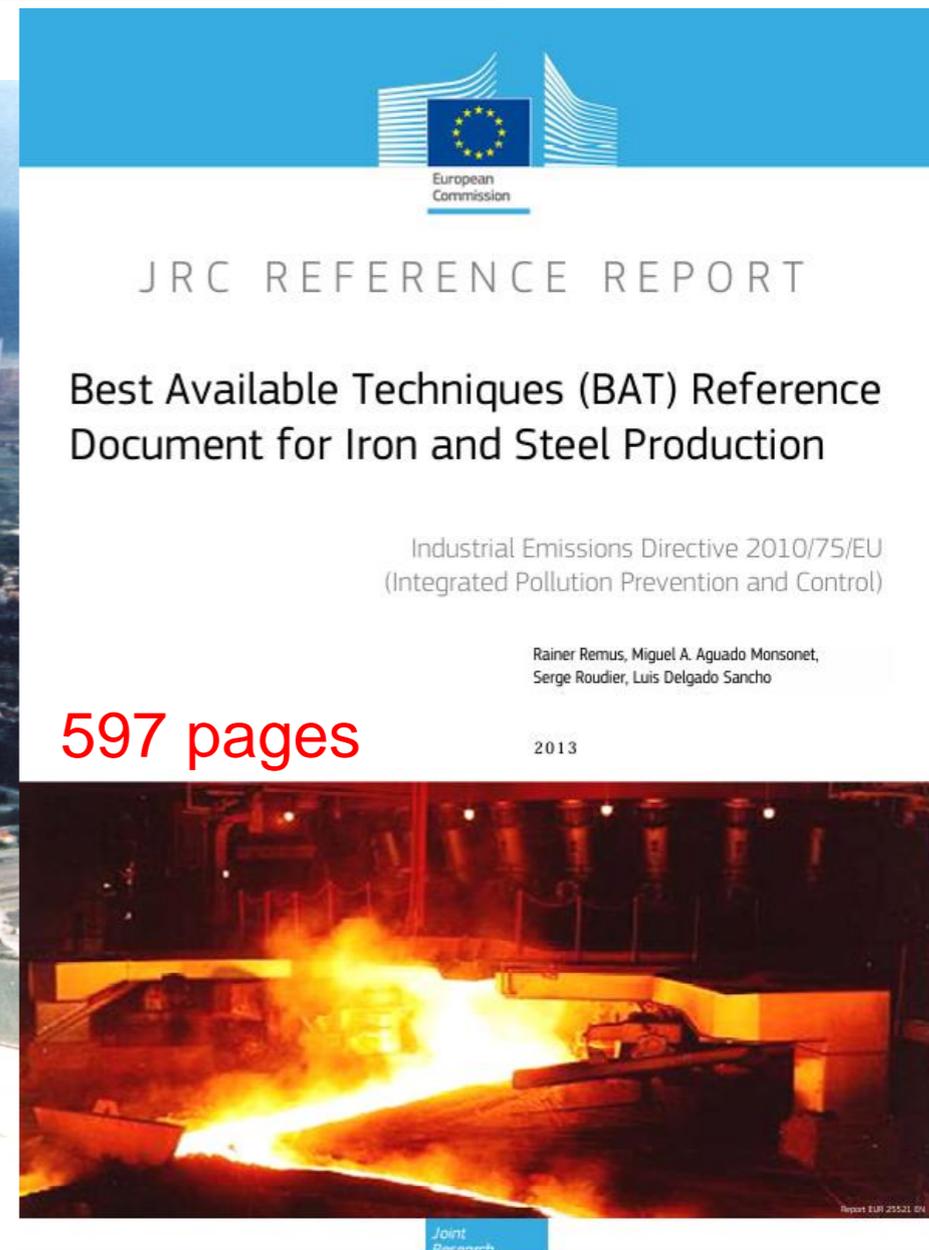
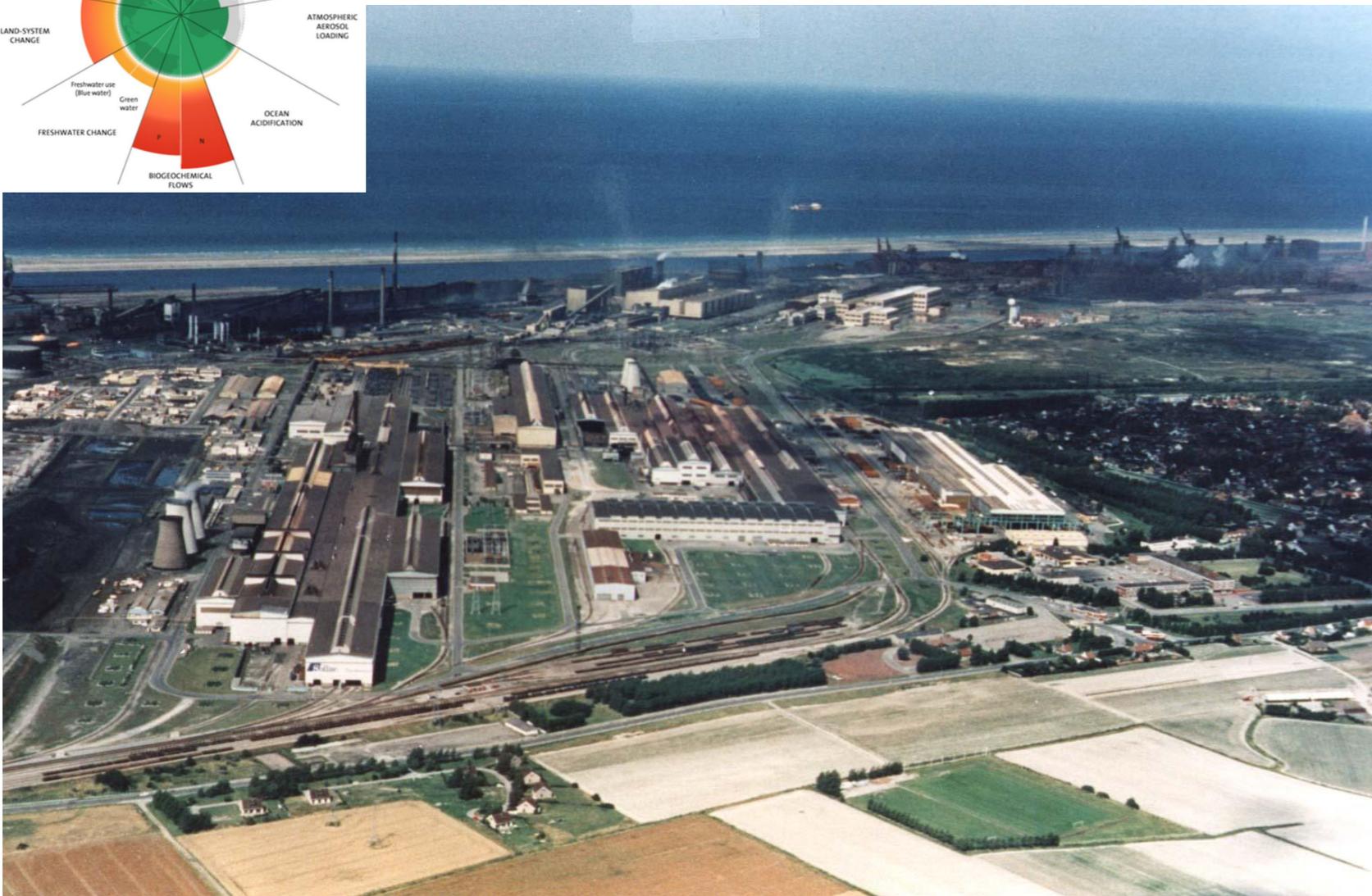
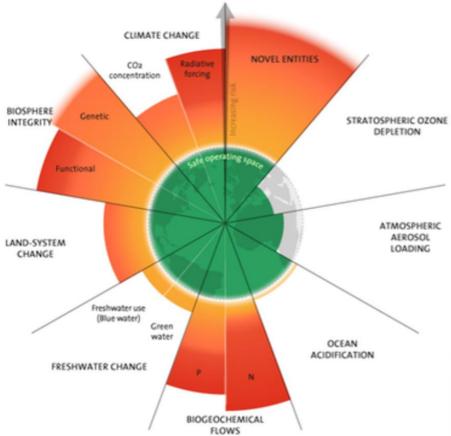
The Stockholm Convention **BAT/BEP Guideline** stresses in the “guidance principles and cross-cutting considerations” (Section III.B):

- **Cleaner Production**
- **Integrated Pollution Prevention and Control**
- **Waste hierarchy**
- **Internalizing environmental costs and polluter pays.**
- **Sustainable Development Sustainable Consumption and Production**
- **Precautionary Approach.**

# IED - Industrial Emissions Directive (integrated pollution prevention and control) – 2010 and 2024

- A framework directive aiming at a high level of protection for the environment from emissions of large scale industries (all environmental media)
- Not direct acting but a Framework Directive requiring Member States to introduce implementing law.
- Operating permits for industry with emissions limit values (ELVs) and other conditions to be based on “best available techniques” (BAT)
- Provides for an **exchange of information on BAT**

# Emissions from integrated steelworks



Source: [https://bureau-industrial-transformation.jrc.ec.europa.eu/sites/default/files/2019-11/IS\\_Adopted\\_03\\_2012.pdf](https://bureau-industrial-transformation.jrc.ec.europa.eu/sites/default/files/2019-11/IS_Adopted_03_2012.pdf)

# Emissions to air of an integrated steelworks (non-BAT; EU E-PRTR data) (10-12 Mio t steel/yr)



	Release to air/year)
<b>PCDD/PCDF</b>	<b>99.6 g TEQ</b>
<b>PCB</b>	<b>0.13 tonnes</b>
<b>Benzene</b>	<b>237 tonnes</b>
<b>PAH</b>	<b>33.6 tonnes</b>
<b>Lead &amp; compounds</b>	<b>79.2 tonnes</b>
<b>Chromium</b>	<b>3.87 tonnes</b>
<b>Mercury</b>	<b>1.5 tonnes</b>
<b>Cadmium &amp; compounds</b>	<b>0.4 tonnes</b>
<b>Nickel</b>	<b>0.6 tonnes</b>
<b>PM10</b>	<b>5380 tonnes</b>
<b>HCN</b>	<b>3.94 tonnes</b>
<b>SOx</b>	<b>40,800 tonnes</b>
<b>NOx</b>	<b>28,100 tonnes</b>
<b>HF</b>	<b>568 tonnes</b>
<b>Carbon dioxide</b>	<b>11,300,000 tonnes</b>
<b>Carbon monoxide</b>	<b>569,000 tonnes</b>
<b>Ammonia</b>	<b>33.5 tonnes</b>

This emissions of the plant were reduced in the last decade. However recent publications and documentary still reported on the increased death rates and cancer rates in this area also in children.

Article

**Taranto's Long Shadow? Cancer Mortality Is Higher for People Living Closer to One of the Most Polluted City of Italy**

Roberto Cazzolla Gatti <sup>1,\*</sup> and Alena Velichevskaya <sup>2</sup>

<https://doi.org/10.3390/su14052662>



Environment International

Volume 132, November 2019, 105030

Industrial air pollution and mortality in the Taranto area, Southern Italy: A difference-in-differences approach

<https://doi.org/10.1016/j.envint.2019.105030>

Simona Leogrande <sup>a</sup>, Ester Rita Alessandrini <sup>b</sup>, Massimo Stafoggia <sup>b</sup>

Review Article <http://dx.doi.org/10.1155/2013/753719>

**Environment and Health in Contaminated Sites: The Case of Taranto, Italy**

**Inside Italy's 'toxic town', where children grow up fearing cancer**

<https://www.itv.com/news/2026-01-06/inside-italys-toxic-town-where-children-grow-up-fearing-cancer>

WORLD | ITALY | CORBY | Tuesday 6 January 2026 at 10:25am



Amy Lewis  
ITV News Reporter



# Emissions to water of an integrated steelworks (non-BAI ; EU E-PRTR data)

	Release to water (per year)
PAH	3.32 tons
Phenols	12.8 tons
Arsenic	0.88 tons
Copper	14.9 tons
Lead and compounds	0.91 tons
<b>Chromium</b>	<b>10.9 tons</b>
Mercury	0.46 tons
Cadmium and compounds	0.37 tons
Nickel	8,32 tons
Zinc	33.8 tons
<b>Cyanides (as CN)</b>	<b>41.6 tons</b>
Phosphorous	16.1 tons
<b>TOC (as COD/3)</b>	<b>1250 tons</b>
Total nitrogen	2140 tons

**Capacity:  
10-12 Mio tons**

# Lead Poisoning of Children Around Chinese Metal Smelters

- Abnormal high levels of lead in 1,354 children in Hunan province, 851 children Shaanxi province, 200 in Yunnan province around metal smelters (affected up to 20 kilometers away from factories). (CNN 2009)
- Lead poisoning can cause severe developmental problems in children ranging from permanent brain damage, anemia and can cause lifelong consequences.
- Government offered free examinations for children & compensation for affected families.
- Eight factories were shut down (e.g. iron and manganese smelters) and only reopened after they meet standards.

Source: CNN 02/09/2009:

<http://edition.cnn.com/2009/WORLD/asiapcf/09/02/china.lead.poisoning.hunan/index.html>



# IPPC installations – electric steelworks (& other sec. metal)



  
European Commission

JRC REFERENCE REPORT

Best Available Techniques (BAT) Reference Document for Iron and Steel Production

Industrial Emissions Directive 2010/75/EU  
(Integrated Pollution Prevention and Control)

Rainer Remus, Miguel A. Aguado Monsonet,  
Serge Roudier, Luis Delgado Sancho

**597 pages**

2013

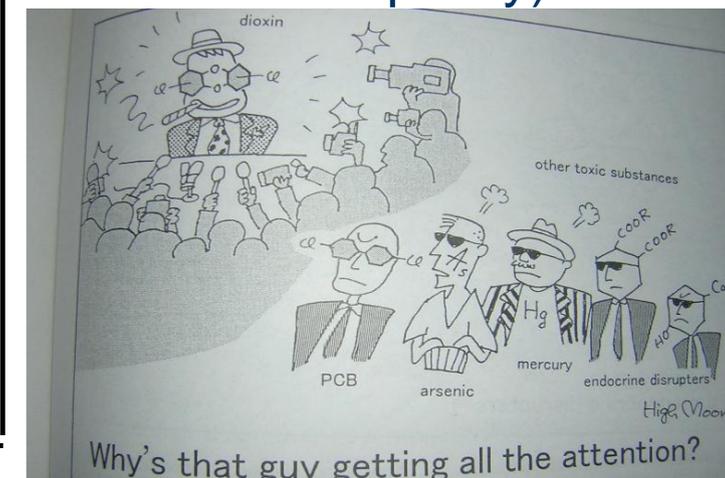


Source: [https://bureau-industrial-transformation.jrc.ec.europa.eu/sites/default/files/2019-11/IS\\_Adopted\\_03\\_2012.pdf](https://bureau-industrial-transformation.jrc.ec.europa.eu/sites/default/files/2019-11/IS_Adopted_03_2012.pdf)

# Air Emissions of a BAT Electric Arc Furnace (1,8 mio t steel/yr; 1,800,000 m<sup>3</sup>/h; 8,000 h/yr)

Parameter	Concentration	unit	Emission Factor	unit	Annual Load	unit
<b>Dust (PM)</b>	<b>0,6</b>	<b>mg/Nm<sup>3</sup></b>	4.8	g/t	8640	kg/a
Cadmium	0,0005	mg/Nm <sup>3</sup>	4.0	mg/t	7.2	kg/a
<b>Mercury</b>	<b>0,044</b>	<b>mg/Nm<sup>3</sup></b>	352	mg/t	<b>633.6</b>	<b>kg/a</b>
Thallium	< 0.0005	mg/Nm <sup>3</sup>	< 4.0	mg/t	< 7.2	kg/a
<b>Arsenic</b>	<b>0,0016</b>	<b>mg/Nm<sup>3</sup></b>	12.8	mg/t	23	kg/a
Cobalt	< 0.0005	mg/Nm <sup>3</sup>	< 4.0	mg/t	< 7.2	kg/a
Nickel	0,0005	mg/Nm <sup>3</sup>	4.0	mg/t	7.2	kg/a
<b>Lead</b>	<b>0,0095</b>	<b>mg/Nm<sup>3</sup></b>	76	mg/t	<b>136.8</b>	<b>kg/a</b>
Chromium	0,0037	mg/Nm <sup>3</sup>	29.6	mg/t	53.3	kg/a
Copper	0,0016	mg/Nm <sup>3</sup>	12.8	mg/t	23.0	kg/a
Tin	0,0011	mg/Nm <sup>3</sup>	8.8	mg/t	15.8	kg/a
HCl	1,21	mg/Nm <sup>3</sup>	9.7	g/t	17.5	t/a
HF	0,115	mg/Nm <sup>3</sup>	0.9	g/t	1.6	t/a
NO <sub>x</sub>	12	mg/Nm <sup>3</sup>	96	g/t	172.8	t/a
CO	284	mg/Nm <sup>3</sup>	2272	g/t	4089.6	t/a
Organic carbon	5,4	mg/Nm <sup>3</sup>	43.2	g/t	77.8	t/a
<b>Benzene</b>	<b>0,58</b>	<b>mg/Nm<sup>3</sup></b>	4640	mg/t	<b>8352</b>	<b>kg/a</b>
<b>Nickeltetracarbonyl</b>	<b>0,078</b>	<b>mg/Nm<sup>3</sup></b>	624	mg/t	<b>1123.2</b>	<b>kg/a</b>
Benzo(a)pyrene	< 0.00001	µg/Nm <sup>3</sup>	< 0.08	µg/t	< 0.14	g/a
Dibenz(a,h)anthracen	< 0.00001	µg/Nm <sup>3</sup>	< 0.08	µg/t	< 0.14	g/a
<b>PCDD/F</b>	<b>0,068</b>	<b>ng TEQ/Nm<sup>3</sup></b>	0.54	µg/t	<b>1.0</b>	<b>g/a</b>
<b>PCB (LAGA)</b>	<b>0,65</b>	<b>µg/Nm<sup>3</sup></b>	5.2	mg/t	<b>9360</b>	<b>g/a</b>
<b>HCB</b>	<b>0,078</b>	<b>µg/Nm<sup>3</sup></b>	0.6	mg/t	<b>1100</b>	<b>g/a</b>

- UPOPs are only one pollutant class from large thermal emission sources.
- Other categories like **heavy metals or PM** can be more relevant from health impacts.
- They also can be reduced by measures reducing UPOPs emissions (e.g. dust filters, catalysts, improvement of combustion quality).



# Synergies of addressing unintentional POPs and heavy metals

- **UNEP highlighted that the global exposure risks posed by toxic metals and metalloids – lead, cadmium, arsenic, and organotins – remain inadequately addressed.**
- Therefore **UNEP published** in the recent 7<sup>th</sup> session of the UN Environmental Assembly (12/2025) a “**Report on options to address lead, cadmium, arsenic, and organotins pollution**”.
- The smelting industries are significant contributors to environmental contamination, often releasing heavy metals and other pollutants into surrounding environment.
- Measures to reduce dioxins/UPOPs from **incinerators or metal industries** can at the same time reduce **these heavy metals, particulate matter (PM), PAHs, and black carbon (soot; SLCP).**

United Nations Environment Assembly  
of the United Nations Environment Programme  
Seventh session

Nairobi, 8–12 December 2025

Item 5 of the provisional agenda

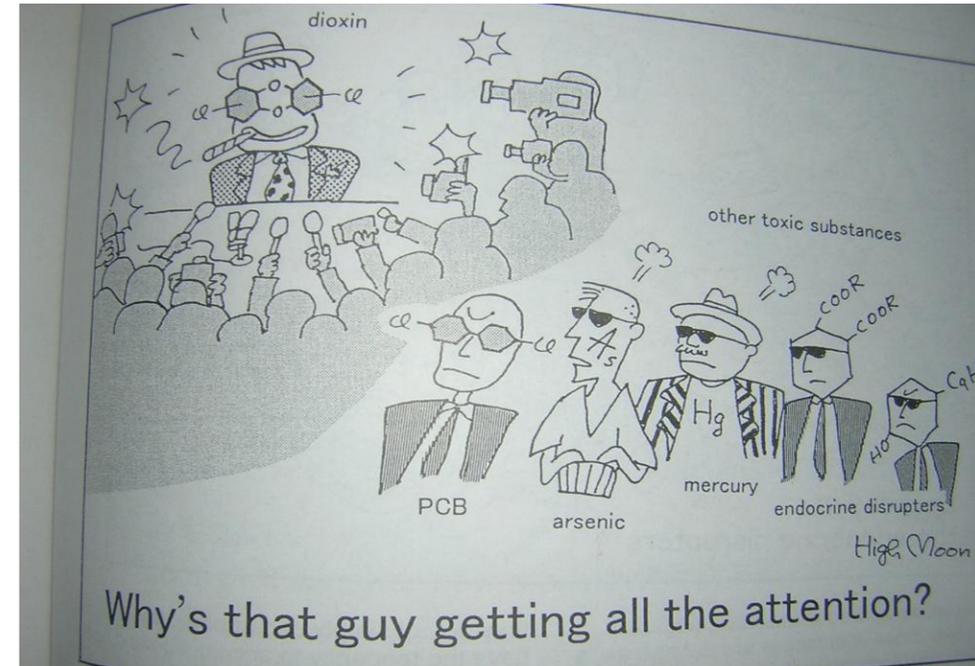
International environmental policy and governance issues

UNEP/EA.7/INF/10



United Nations  
Environment  
Programme

**Information on the implementation of resolution 6/9 on sound management of chemicals and waste to address lead, cadmium, arsenic, and organotins\***



## **BAT for Waste gas dedusting (2000 and 2013):**

### **Abatement techniques:**

- Efficient collection of primary and secondary dust emissions**
- Well designed bag filter**

**BAT for dust collection efficiency: 98%**

**BAT-AEL for Dust: 5 mg/Nm<sup>3</sup> for new plants**

**15 mg/Nm<sup>3</sup> for existing plants**

**→ <5 mg/Nm<sup>3</sup>**

## BAT for the Reduction of PCDD/F (2000 and 2013)

### Abatement techniques:

- Post combustion with wet rapid quenching
- Injection of adsorbents (coal/lignite coke) and bag filter

BAT-AEL for PCDD/F: < 0.1 – 0.5 ng I-TEQ/Nm<sup>3</sup>

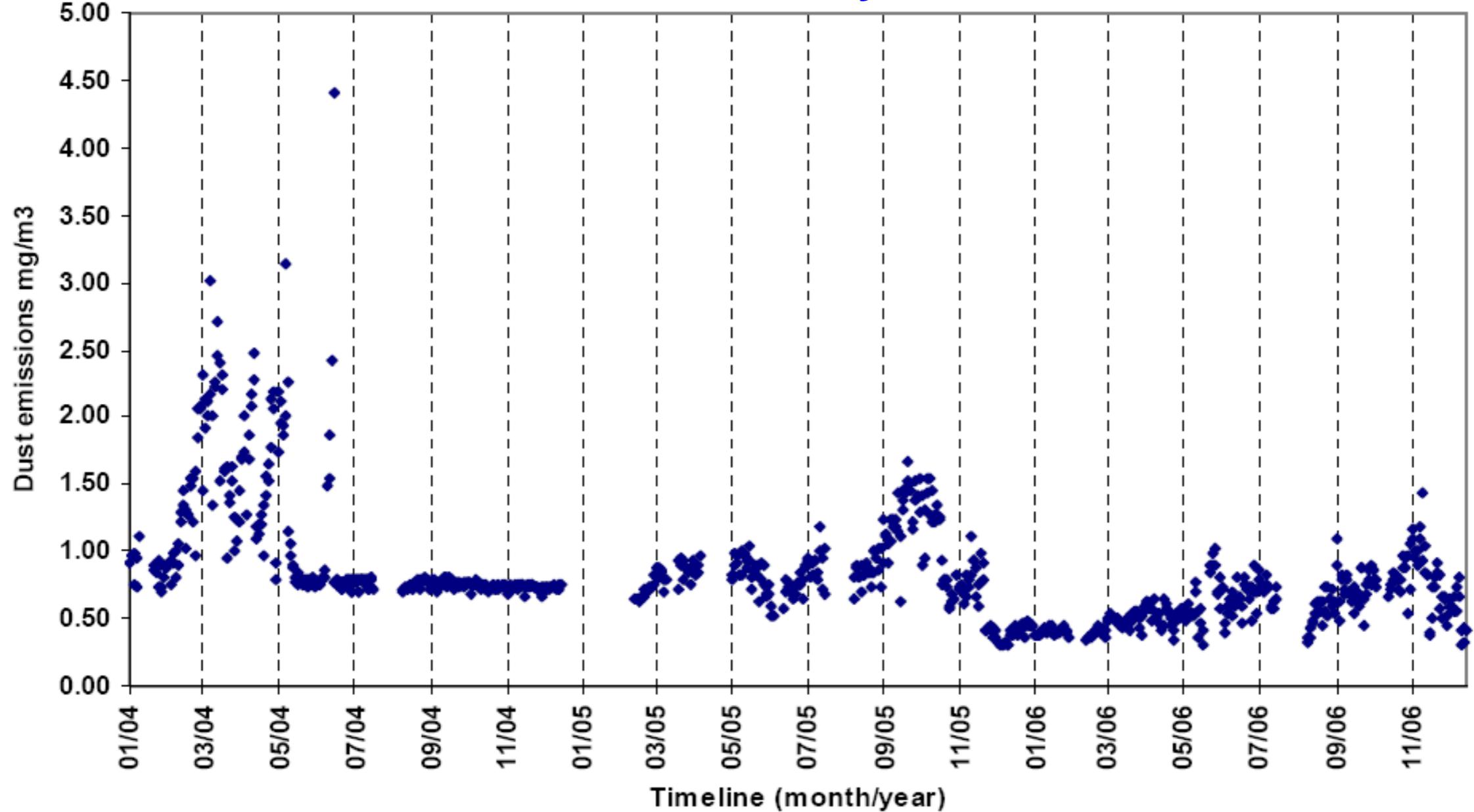
→ <0.1 ng I-TEQ/Nm<sup>3</sup>

# Continuous self-monitoring of emissions to air from an EAF

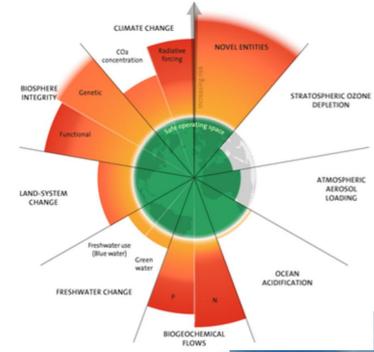
– dust, NOx, VOC, Hg



# Online dust self-monitoring - daily mean values for dust from an EAF over three years



# IPPC installations - cement plant



JRC REFERENCE REPORTS

## Best Available Techniques (BAT) Reference Document for the Production of Cement, Lime and Magnesium Oxide

Industrial Emissions Directive 2010/75/EU  
(Integrated Pollution Prevention and Control)

Frauke Schorch, Ioanna Kourti,  
Bianca Maria Scalet, Serge Roudier,  
Luis Delgado Sancho

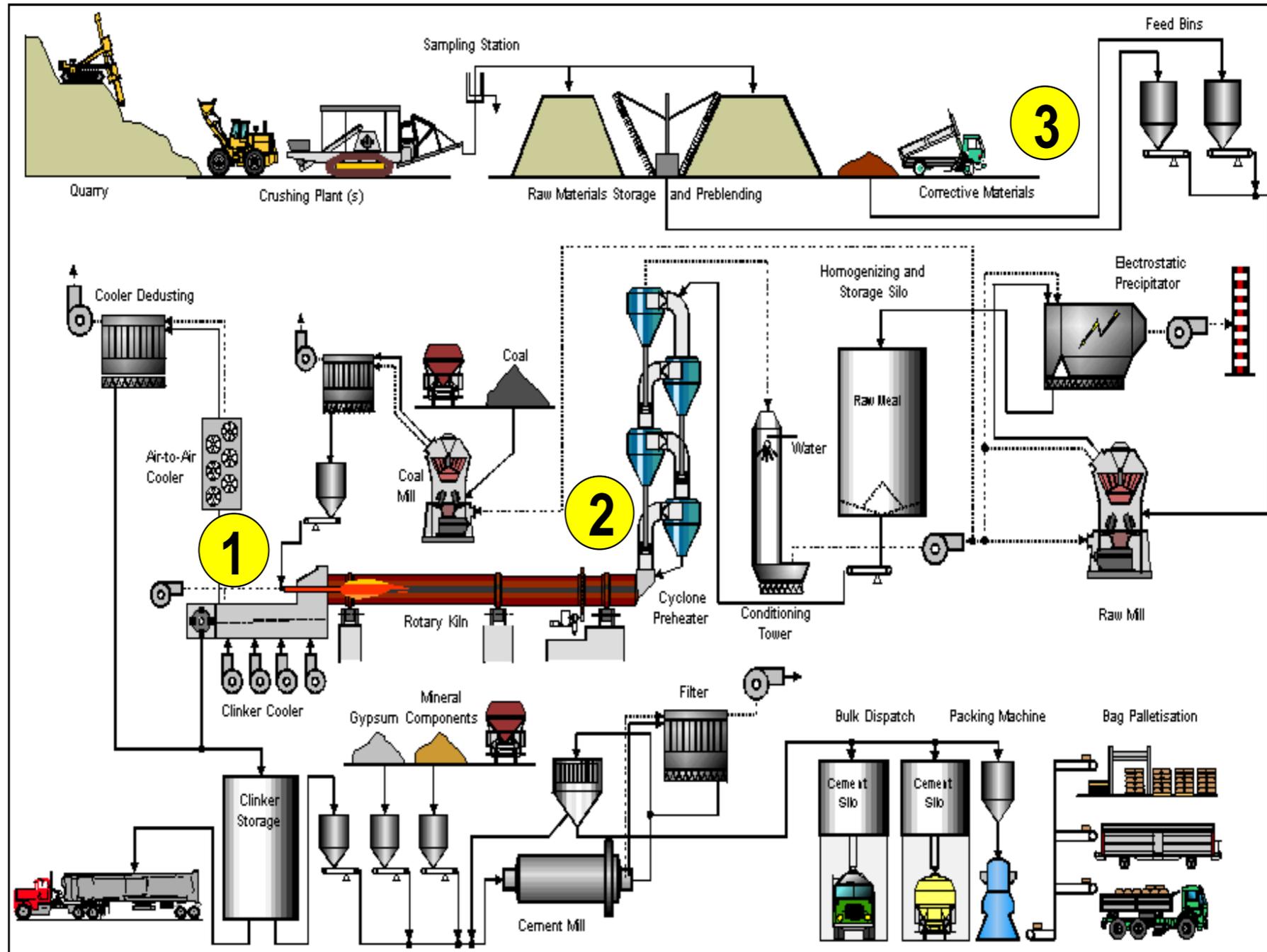
475 pages

2013

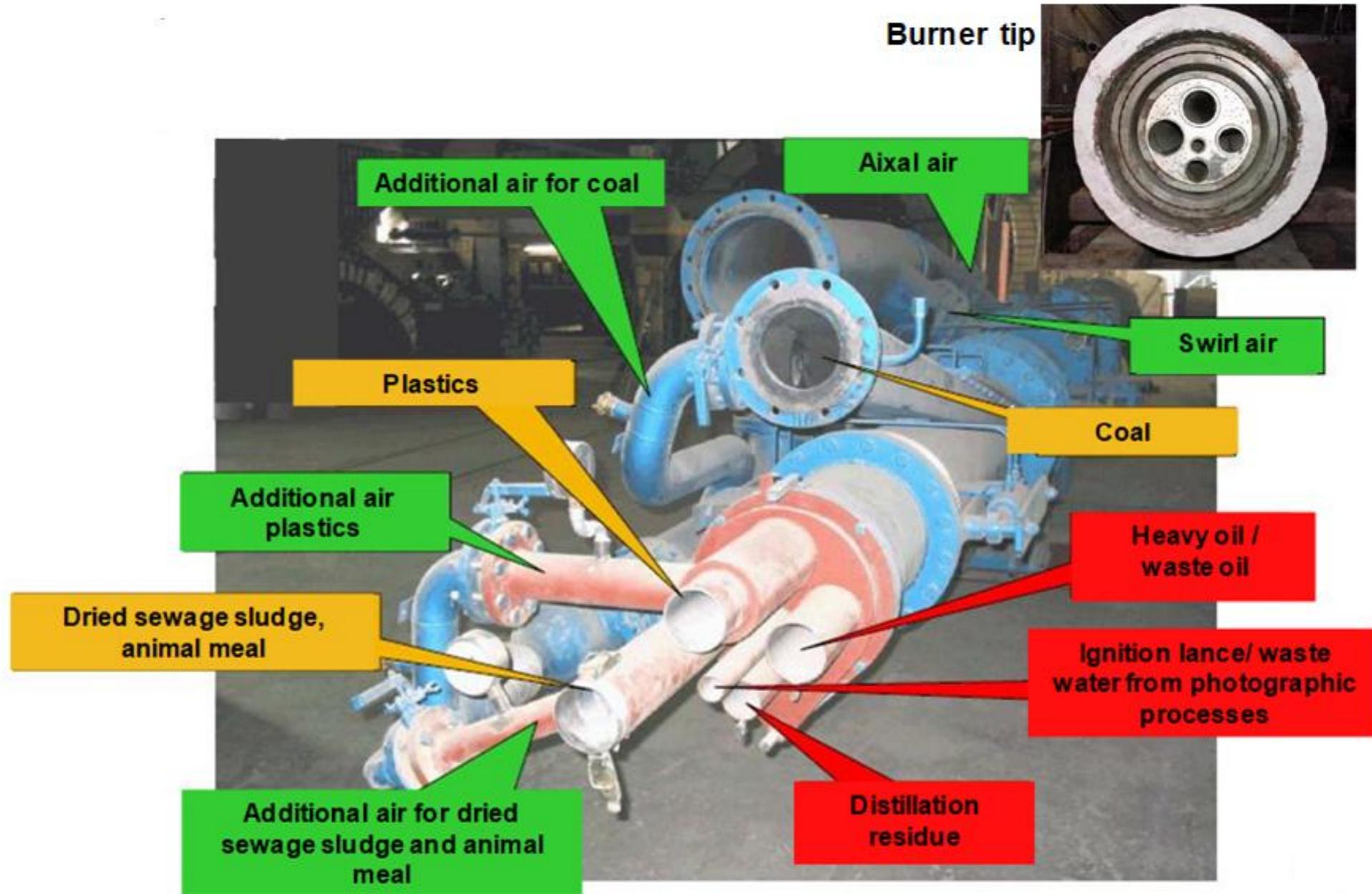


Source: [https://bureau-industrial-transformation.jrc.ec.europa.eu/sites/default/files/2019-11/CLM\\_Published\\_def\\_0.pdf](https://bureau-industrial-transformation.jrc.ec.europa.eu/sites/default/files/2019-11/CLM_Published_def_0.pdf)

# Overview of a cement works – with the 3 feeding points



# Input facilities for various waste-derived fuels to be fed to the main burner

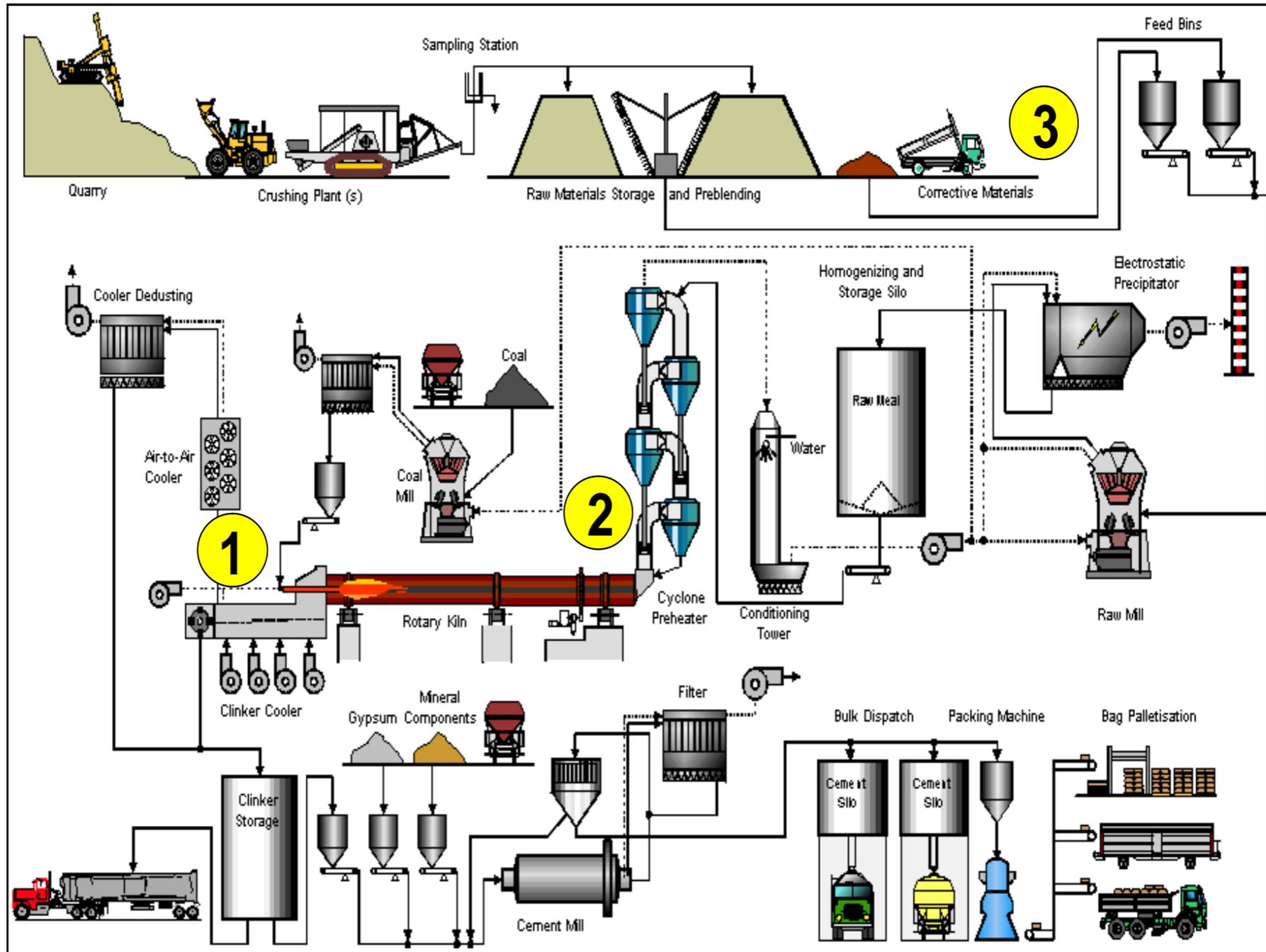


# Feeding pipes for different waste-derived fuels to the main burner

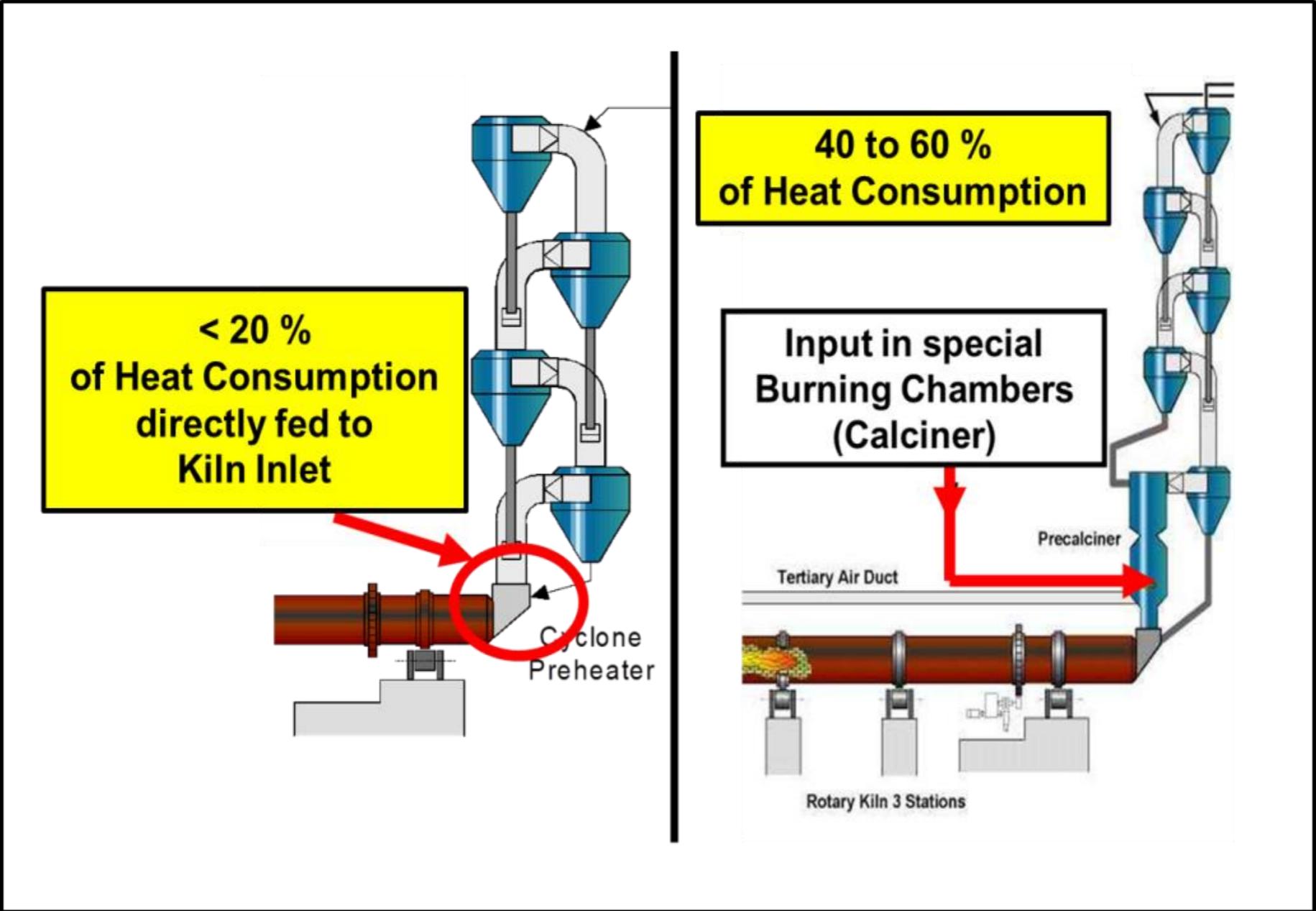


→ In Germany , there are several cement plants running 100 % on waste-derived fuels (less GHG emissions)

# Overview of a cement works – with feeding points



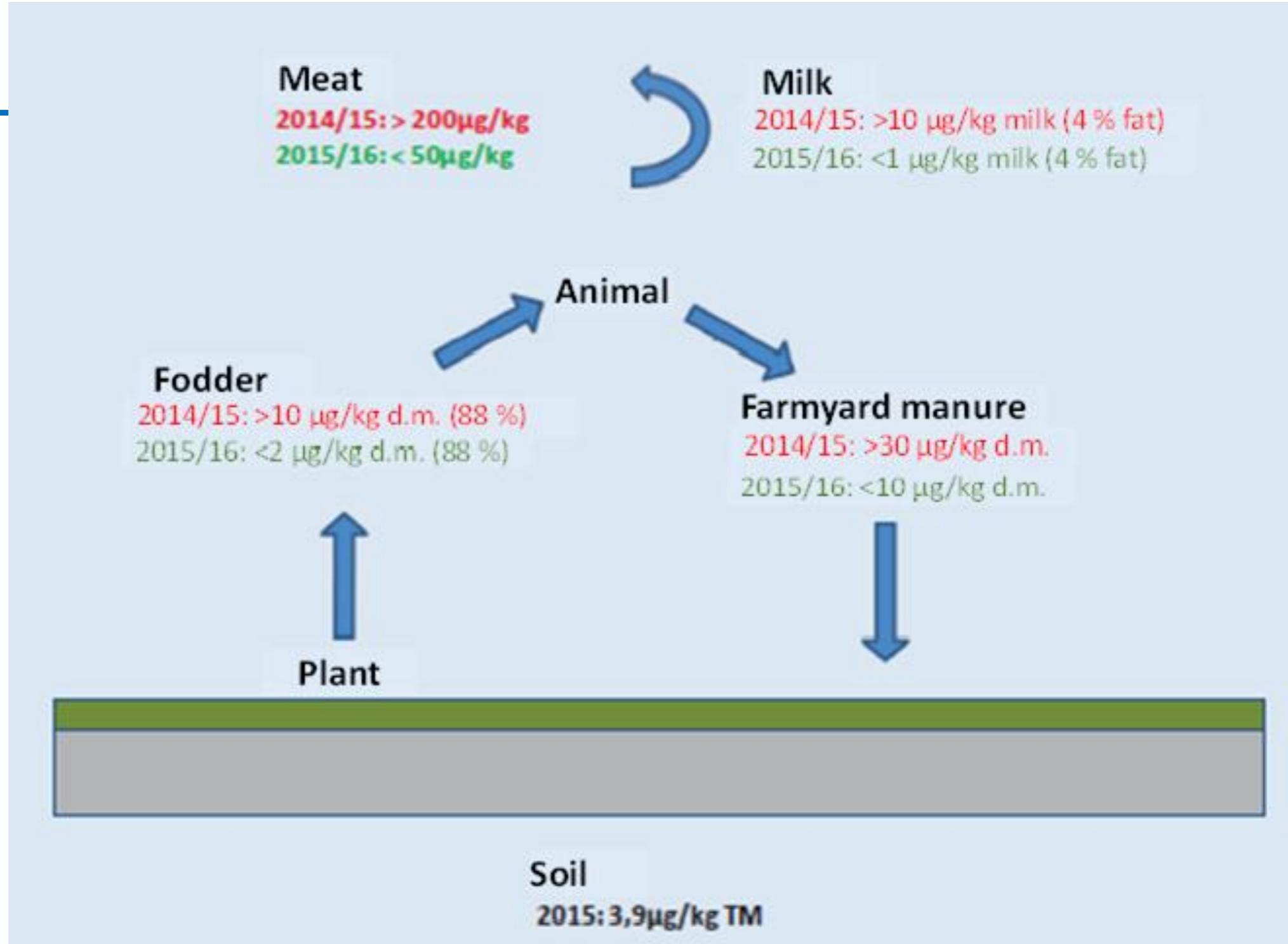
# Fuel Input in Secondary Firings



Cement works of w&p Zement GmbH in A-9373 Wietersdorf / Klein St. Paul in the valley Görtschitztal – **HCB contamination in 2014**



HCB in the cycle “soil-plant-fodder-animal-farmyard manure-product” in the valley Görttschitztal from 2014 to 2015





EUROPEAN COMMISSION

**under  
revision –  
D1 from  
2/2025**

Integrated Pollution Prevention and Control

Reference Document on Best Available  
Techniques for the

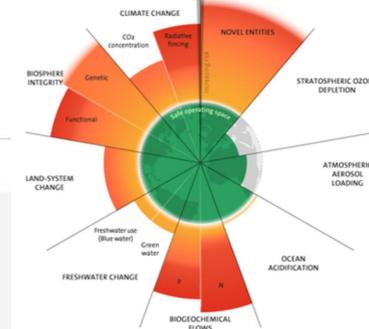
546 pages

# Surface Treatment of Metals and Plastics

August 2006

Source: [https://bureau-industrial-transformation.jrc.ec.europa.eu/sites/default/files/2019-11/stm\\_bref\\_0806.pdf](https://bureau-industrial-transformation.jrc.ec.europa.eu/sites/default/files/2019-11/stm_bref_0806.pdf)

Source: [https://bureau-industrial-transformation.jrc.ec.europa.eu/sites/default/files/2025-02/STM%20BREF\\_D1\\_%20BW-bref.pdf](https://bureau-industrial-transformation.jrc.ec.europa.eu/sites/default/files/2025-02/STM%20BREF_D1_%20BW-bref.pdf)



## Best Available Techniques (BAT) Reference Document for the Surface Treatment of Metals and Plastics

**Colour code:**  
Black: Deleted text from the original STM BREF (2007)  
Yellow highlights are messages to the TWG, not part of the BREF

Directive 2010/75/EU on  
Industrial and Livestock  
Rearing Emissions  
(Integrated Pollution  
Prevention and Control)

JOINT RESEARCH CENTRE  
Directorate B – Fair and  
Sustainable Economy  
Circular Economy and Sustainable  
Industry Unit  
European Bureau for Research on  
Industrial Transformation and  
Emissions (EU-BRITE)  
Draft 1 (February 2025)

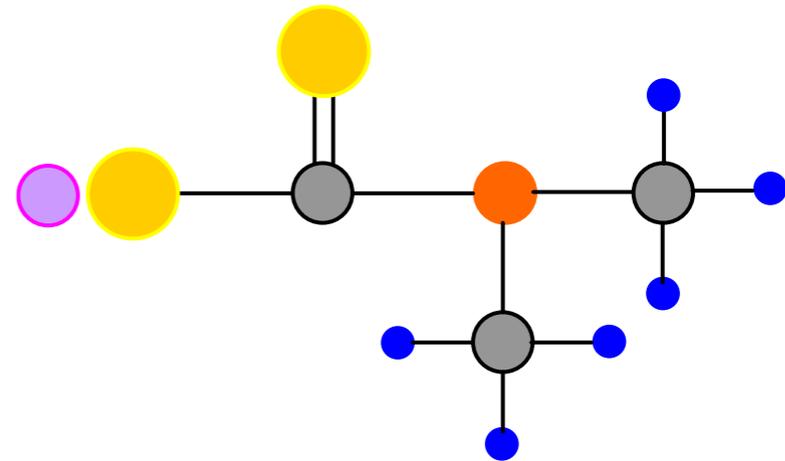
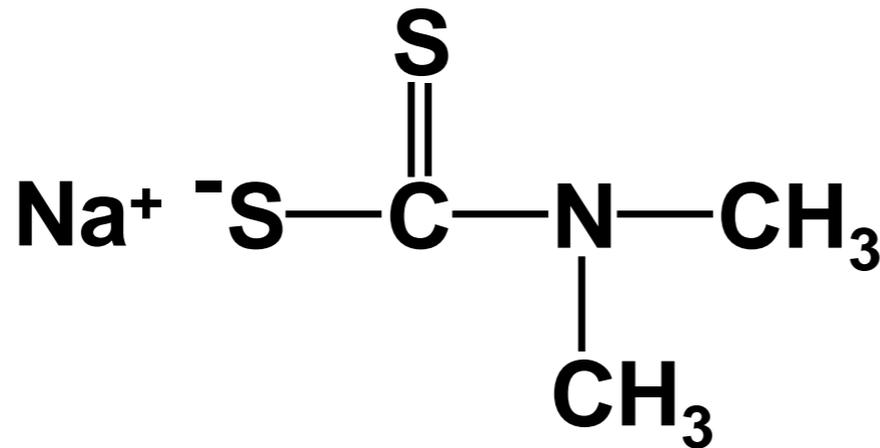
930 pages

*This draft has not been adopted or endorsed by the European Commission. Any views expressed are the preliminary views of the Commission services and may not in any circumstances be regarded as stating an official position of the Commission. The information transmitted is intended only for the Member State or entity to which it is addressed for discussions and may contain confidential and/or privileged material.*



## Precipitation of heavy metals with organic sulphides

→ Organosulfide, esp. Dimethyldithiocarbamate (DMDTC)



**Effect: heavy metal precipitation**

**but also cytotoxic → broad band biocide**

**→ toxic to bacteria (nitrification), algae and fish**

## Toxicity of sodium dimethyldithiocarbamate (DMDTC)

- **Algae toxicity = 0.25 mg/l (EC50)**
- **Fish toxicity = 0.76 mg/l (LC50)**
- **Bacteria toxicity = 3.65 mg/l (EC50, 3 h)**
- **Biodegradability: inconsistent information**

Commercial products: [Plexon](#) , [Antiplex](#), [Diplexin](#), [Preventol Z](#),  
[Simafloc](#) etc.

## Fish kill in River Neckar (Upper Neckar) in 2014



# Complete inhibition of nitrification on a municipal wastewater treatment plant (AZV Oberer Neckar)

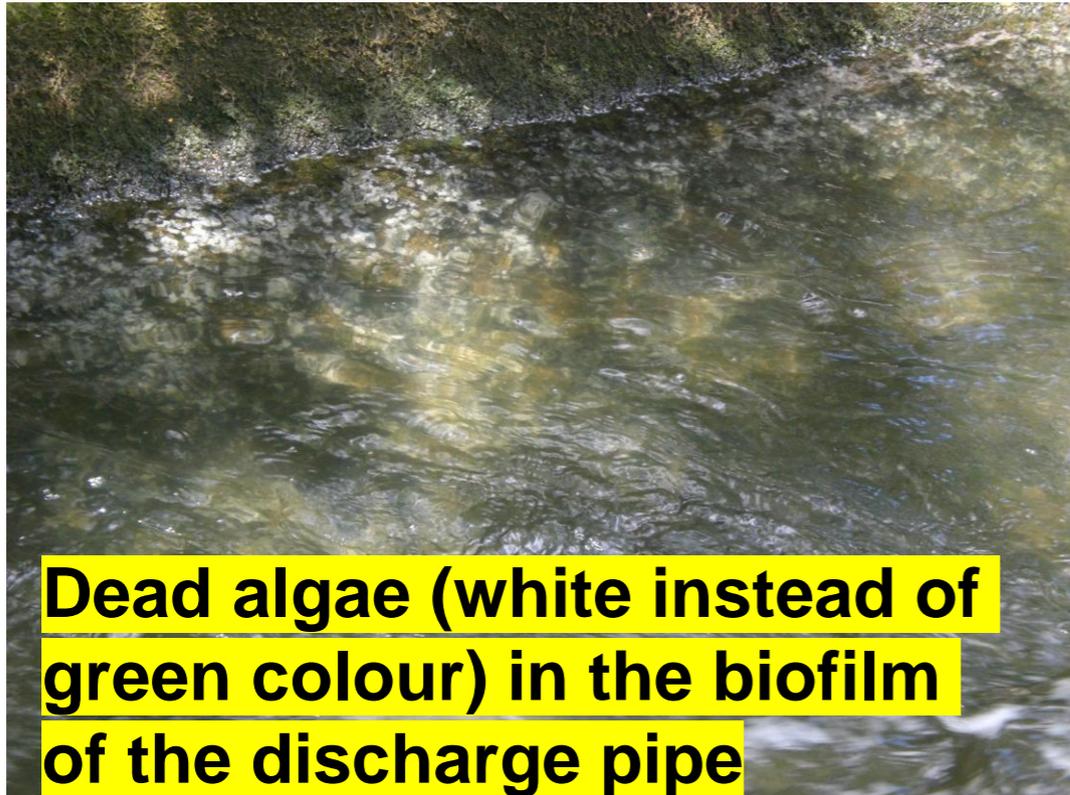
The identification of the source required significant efforts

- **Analysis of DMDTC** (only University of Stuttgart could do it) – 12.5 kg/d – 31 L of a 40 % solution
- Sampling of **sewer biofilm**
- Hint on an electroplating company



## Fish kill in River Neckar (Upper Neckar) in 2014

**Discharge point of  
the municipal WWTP  
- Foam and dead fish**



Permit taking into account:

- All aspects and pollutants
- IED Directive,
- Other EU-Direct.
- Stockholm Conv.
- UNECE Protocol on long range transport (CLRTAP)



**Owner or operator of an IPPC installation**

**Support of consultants**

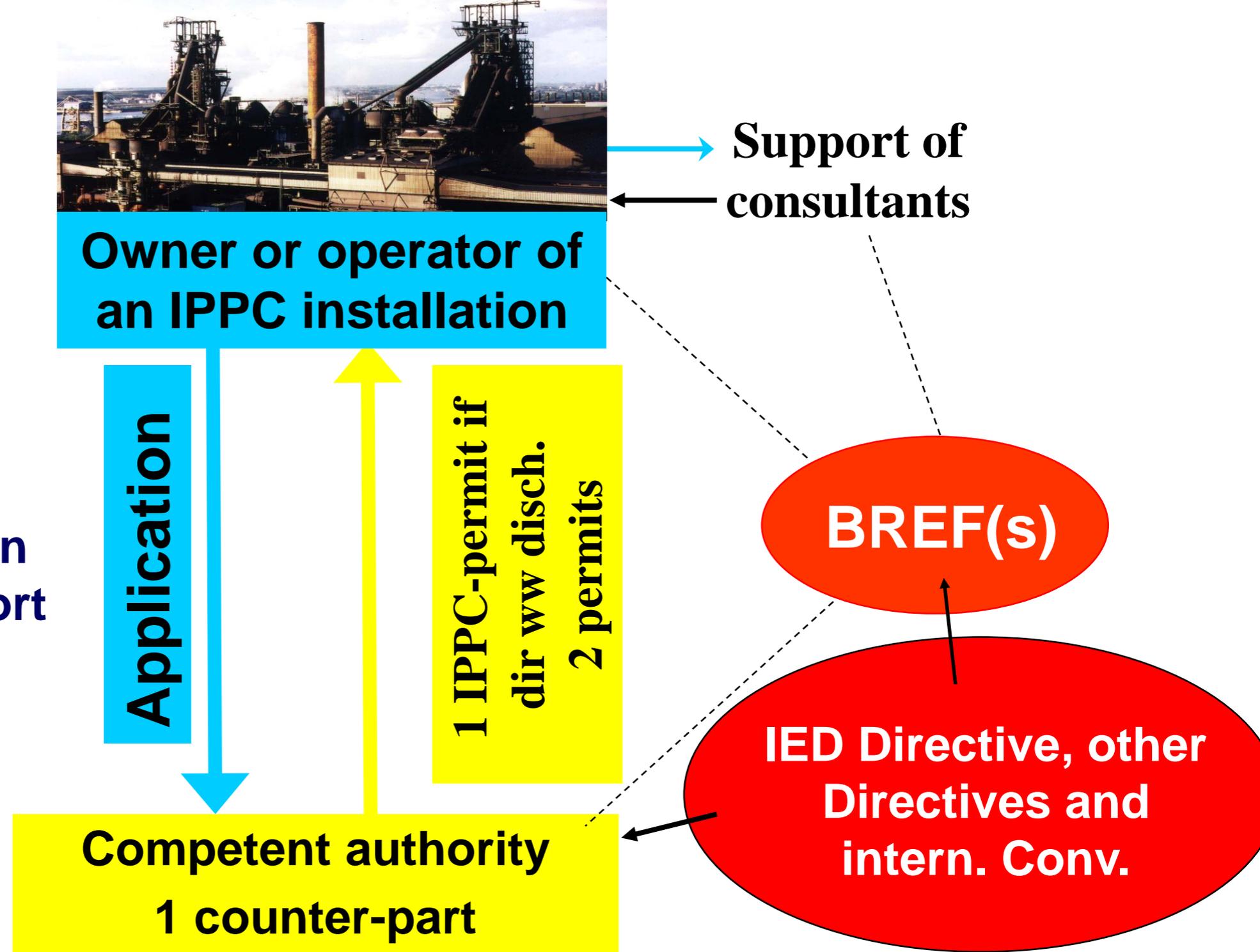
**Application**

**1 IPPC-permit if dir ww disch.  
2 permits**

**Competent authority  
1 counter-part**

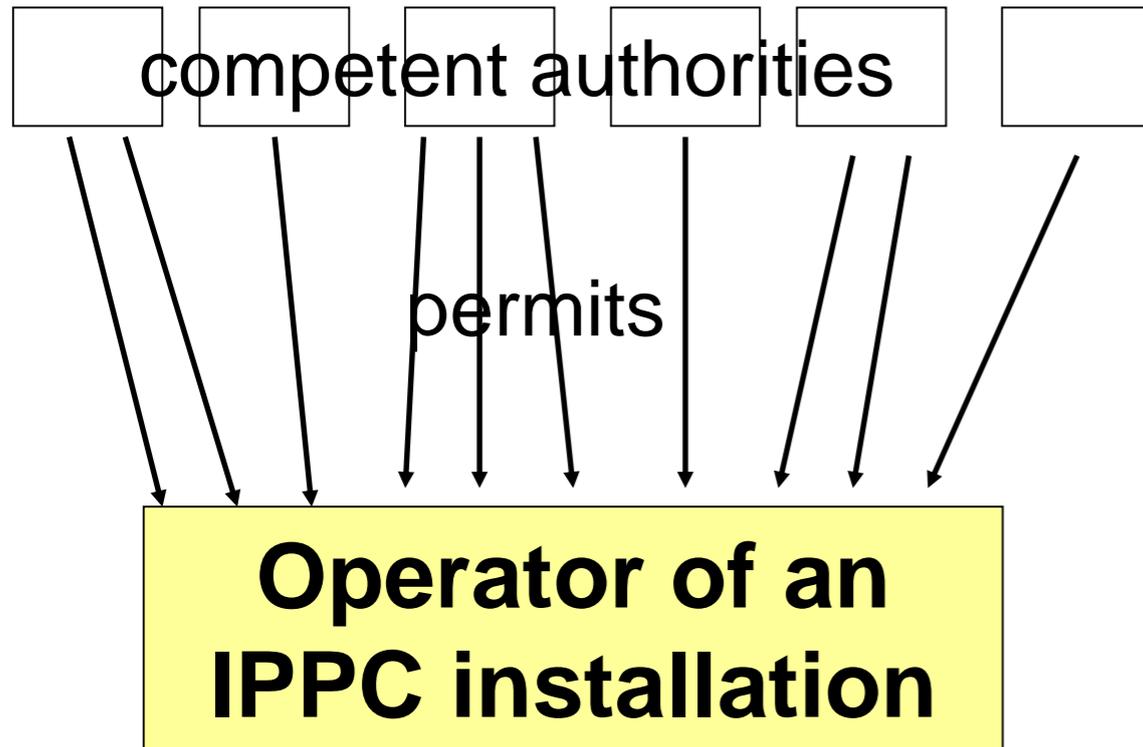
**BREF(s)**

**IED Directive, other Directives and intern. Conv.**

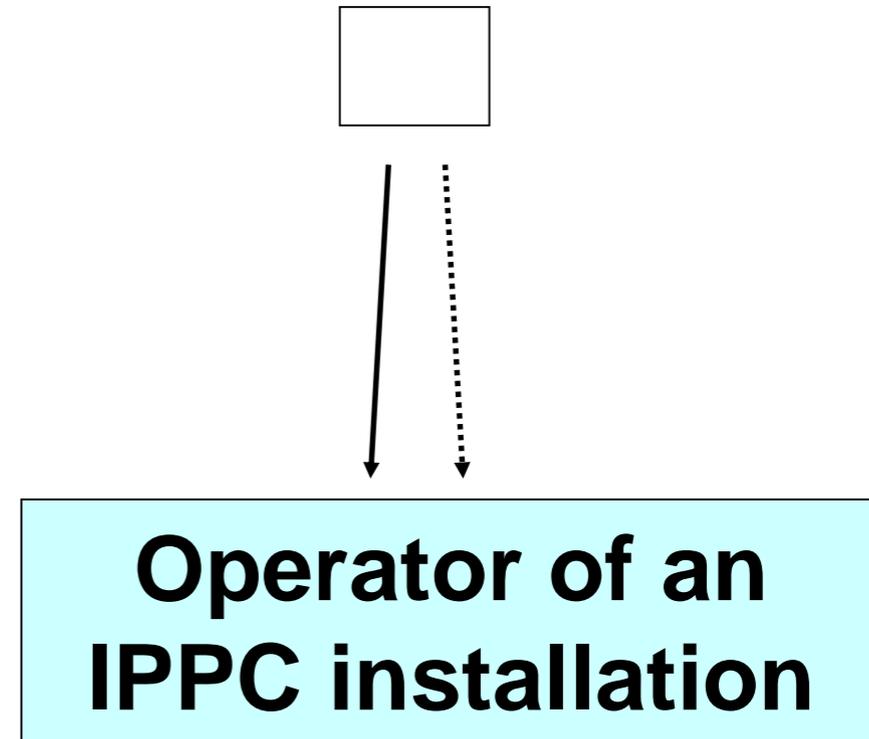


# Permitting of industrial installations: “yesterday” and today

**Formerly: several competent authorities and many permits**



**Today: one competent authority issues 1 permit (or 2)**



# IED Directive – directly directs the competent authorities

- The operation of an IPPC installation requires a permit  
➔ operator must apply for it
- The permit shall include emission limit values (ELVs) and appropriate requirements and conditions based on BAT

## Article 15(2) of the IED Directive (2010/2024)

Without prejudice to Article 18 (Environmental Quality Standards), the emission limit values and the equivalent parameters and technical measures referred to in Article 14(1) and (2) **shall be based on the best available techniques**, without prescribing the use of any technique or specific technology.

## BAT under Article 3(10) - definition

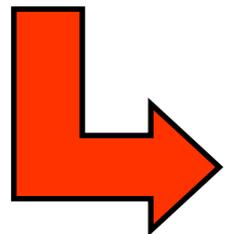
- ‘Best’** most effective in achieving **a high general level of protection of the environment as a whole**
- ‘Techniques’** includes **both** the technology used and the way in which the installation is designed, built, maintained, operated and decommissioned
- ‘Available’** developed on a scale which allows implementation in the relevant industrial sector, under **economically and technically viable conditions, considering the costs and advantages ...**

*Note: in determining BAT, special consideration should be given to the items listed in Annex III bearing in mind the likely costs and benefits*

## BAT under Article 2(11)

- **Article 13(1) of the IED Directive (IED 2010/2024) – Exchange of information:**

*The European Commission shall organise an exchange of information between Member States, the industries concerned, non-governmental organisations promoting environmental protection, and the Commission.*



**Result: Best Available Techniques REference Documents (BREFs)**

# Actors in the information exchange and for development of BREFs

**Information exchange Forum (IEF)**

Member States,  
industries, NGOs

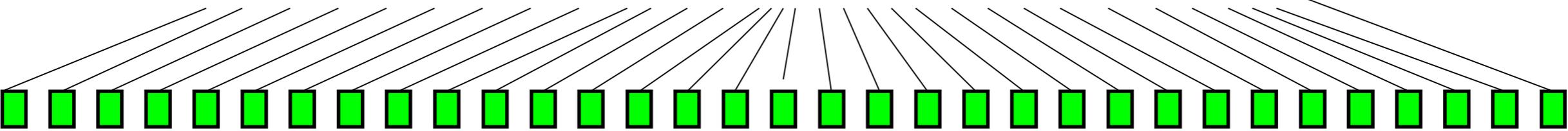
management, planning,  
co-ordination, oversight



progress reports,  
draft BREFs



**Europ. Bureau for Research on Ind. Transf.+ Emis. (EU BRITE)**



**38 Technical Working Groups for all the sectors**



# 5 Horizontal BREFs



ICS MON EFS ECM ENE

33 Vertical BREFS

Energy: 2 sectors



Metal: 5 sectors



Mineral: 4 sectors



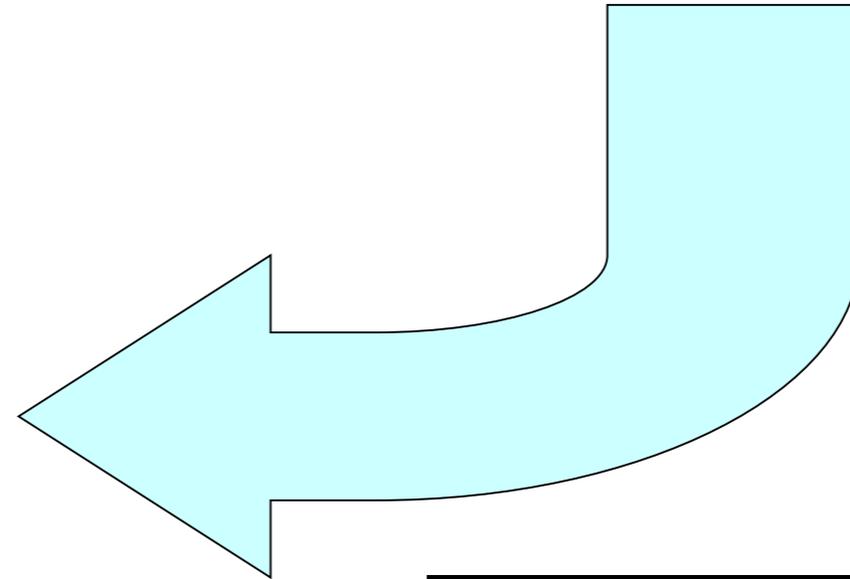
Chemical: 9 sectors



Waste: 2 sectors



Others: 11 sectors



38 BREFs  
completed

→ <http://eippcb.irc.es/reference/>

# Thank you for your attention

**Prof. Dr.-Ing. habil. Harald SCHOENBERGER**  
**University Stuttgart, Germany**

[harald.schoenberger@iswa.uni-stuttgart.de](mailto:harald.schoenberger@iswa.uni-stuttgart.de)

**Dr. Roland Weber**  
**POPs Environmental Consulting**  
**Schwäbisch Gmünd, Germany**

[Roland.weber10@web.de](mailto:Roland.weber10@web.de)