Category		Title
NFR	5.C.2	Open burning of waste
SNAP	0907	Open burning of agricultural wastes (except 1003)
ISIC		
Version	Guidebook 2019	

Coordinator

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Contents

1 Overview

This chapter covers the volume reduction, by open burning, of small-scale (agricultural) waste. It does not include stubble burning (covered under NFR source category 4.F, Field burning of agricultural wastes) or forest fires (not covered by the Guidebook). The open burning of rubber tyres or waste oil on farms has also not been included.

Examples of agricultural wastes that might be burned are crop residues (e.g. cereal crops, peas, beans, soya, sugar beet, oil seed rape, etc.), wood, prunings, slash, leaves, plastics and other general wastes. Straw and wood are often used as the fuel for the open burning of agricultural wastes. Poultry and animal excreta are difficult to burn except under controlled conditions.

The open burning of agricultural waste is likely to be widespread, although it will rarely be a significant source of emissions except on a local scale for short-time periods.

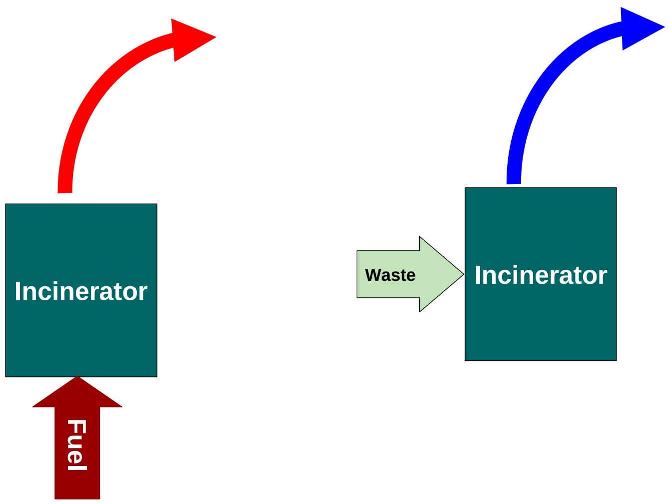
Incineration of animal carcasses is covered under Chapter 5.C.1.e, Cremation. Small-scale (open) burning of waste other than agricultural waste is not discussed in this chapter. Guidance on estimating these emissions can be found in US Environmental Protection Agency (US EPA) AP-42, Chapter 2, Section 5 (US EPA, 1992).

2 Description of sources

2.1 Process description

The emissions arising from open burning depend on a number of factors. The most important variables are the type of waste burned and the moisture content of the waste. The ambient temperature and wind conditions, and the density/compactness of the pile of waste also affect the combustion conditions and hence the emissions.

Figure 2-1 Process scheme for source category 5.C.2 Small-scale waste burning; the left panel shows the process when the energy from the burning is recovered (waste is used as a fuel); the right panel shows the situation when energy is not recovered.



It is good practice to report emissions accordingly:

- in the relevant combustion source category when energy recovery is applied (when the incinerated waste is used as a fuel for another combustion process);
- in this source category when no energy recovery is applied.

2.2 Techniques

The open burning of agricultural waste is carried out on the ground, in air curtain incinerators, in pits in the ground, or in open drums or wire mesh containers/baskets.

2.3 Emissions and controls

One of the main concerns regarding agricultural waste combustion is the emission of smoke/particulates (Ministry of Agriculture, Fisheries and Food (MAFF), 1992). Toxic organic micropollutants, such as polycyclic aromatic hydrocarbons (PAHs) and dioxins are likely to be present in the emissions. In many cases the combustion will be slow and inefficient, and therefore emissions of carbon monoxide (CO) and volatile organic compounds (VOCs) will be more significant than emissions of oxides of nitrogen (NO_x). The burning of plastics is likely to produce particularly toxic emissions, such as dioxins, other chlorinated organic compounds and cyanides.

The application of abatement equipment to open burning is impractical. However, changes in certain agricultural practices can reduce emissions. Waste minimisation and recycling and the use of other more environmentally acceptable disposal methods, such as composting, reduce the quantity of agricultural waste burned.

The recycling and reuse of plastics, or the use of disposal methods other than burning, is particularly important.

Methods to improve the oxygen supply to agricultural waste during combustion and the burning of dry waste only will improve combustion conditions and reduce emissions.

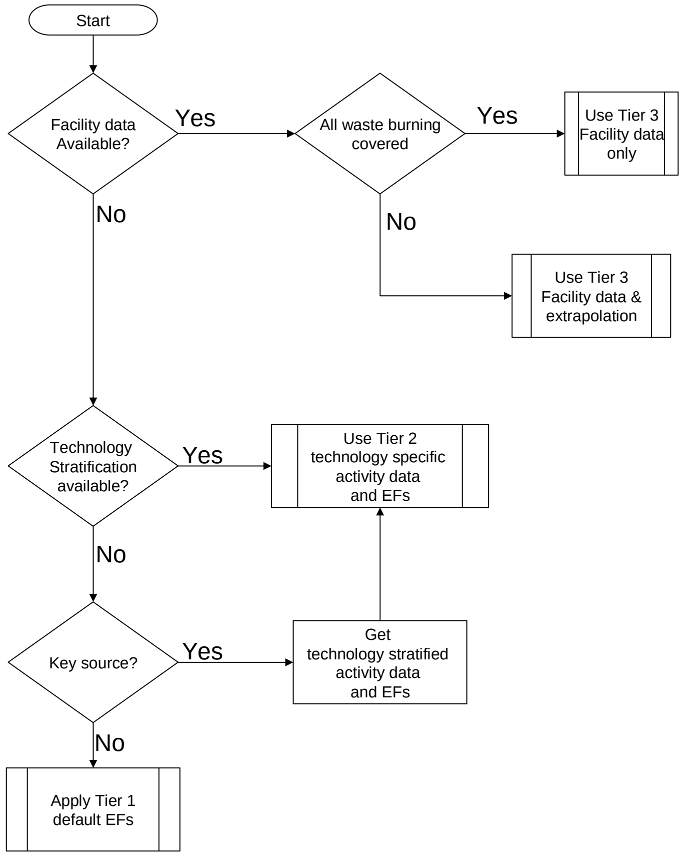
3 Methods

3.1 Choice of method

Figure 3-1 presents the procedure to select the methods for estimating emissions from the open burning of agricultural wastes. The basic concept is:

- if detailed information is available, use it;
- if the source category is a key category, a Tier 2 or better method must be applied and detailed input data must be collected. The decision tree directs the user in such cases to the Tier 2 method, since it is expected that it is more easy to obtain the necessary input data for this approach than to collect facility level data needed for a Tier 3 estimate;
- The alternative of applying a Tier 3 method, using detailed process modelling, is not explicitly included in this decision tree. However, detailed modelling will always be done at facility level and results of such modelling could be seen as ‘facility data’ in the decision tree.

Figure 3-1 Decision tree for source category 5.C.2 Small-scale waste burning



3.2 Tier 1 default approach

3.2.1 Algorithm

The simpler methodology involves the use of a single emission factor for each pollutant representing the emission per mass of waste burned, combined with activity statistics:

$$E_{pollutant} = AR_{production} \times EF_{pollutant} \quad (1)$$

This requires a prior knowledge of the weight of agricultural waste produced per hectare of forestry, orchard and farmland. It is assumed that open burning of agricultural waste (except stubble burning) is mainly practised in forestry, orchard and arable farming; emissions from open burning for other types of farming are likely to be less significant and are assumed to be negligible.

The dry weight of crop residue arising for an average hectare of cereal crops has been estimated to be 5 tonnes per hectare (Lee and Atkins 1994). Most of this crop residue is burned as stubble or ploughed into the ground. Using this figure as a guide, it is assumed that the average quantity of agricultural waste disposed of by open burning (except stubble burning) is equivalent to 0.5 % of dry crop residue arising in United Nations Economic Commission for Europe (UNECE) countries. The actual figure for each country will vary depending on farming practices and other available methods of disposal. The average amount of waste burned for arable farmland is therefore estimated to be 25 kg/hectare. For forest residues and orchard prunings, the amount of trimmings is highly dependent on the practices. It has therefore not been possible to provide a default value.

The Tier 1 emission factors assume an averaged or typical technology and abatement implementation in the country. In cases where specific abatement options are to be taken into account, a Tier 1 method is not applicable and a Tier 2 or Tier 3 approach must be used.

3.2.2 Default emission factors

Table 3-1 provides the Tier 1 default emission factors. With the exception of PCDD/F, these are calculated from the average of the two sets of Tier 2 emission factors, making it an average of Douglas fir slash, Ponderosa pine slash, almond pruning and walnut pruning. However, not all four datasets are complete with all compounds, e.g. the Tier 1 emission factor for Cr is only based on measurements on walnut tree pruning burning, as the other three slash and pruning measurements from Turn et al. (1997) were less than or equal to the measurement uncertainty.

Table 3-1 Tier 1 emission factors for source category 5.C.2 Small-scale waste burning

Tier 1 default emission factors					
	Code	Name			
NFR Source Category	5.C.2	Open burning of waste			
Fuel	NA				
Not applicable	PCBs				
Not estimated	NH_3, Hg, Ni, Indeno(1,2,3-cd)pyrene, HCB				
Pollutant	**Value**	**Unit**	**95% confidence interval**		**Reference**
			Lower	**Upper**	
CO	55.83	kg/Mg waste	18.61	167.50	Jenkins et al (1996a)
NO_x	3.18	kg/Mg waste	1.06	9.55	Jenkins et al (1996a)
SO_2	0.11	kg/Mg waste	0.04	0.32	Jenkins et al (1996a)
NMVOC	1.23	kg/Mg waste	0.41	3.70	Jenkins et al (1996a)
TSP	4.64	kg/Mg waste	1.55	13.93	Jenkins et al (1996a)
PM_{10}	4.51	kg/Mg waste	1.50	13.53	Jenkins et al (1996a)
$PM_{2.5}$	4.19	kg/Mg waste	1.40	12.56	Jenkins et al (1996a)
BC[1]	42.0	% of $PM_{2.5}$	20	70	Turn et al. (1997)
Cr	0.01	g/Mg waste	0.004	0.033	Turn et al. (1997)
Cu	0.20	g/Mg waste	0.07	0.59	Turn et al. (1997)
Zn	17.53	g/Mg waste	5.84	52.58	Turn et al. (1997)
As	0.41	g/Mg waste	0.14	1.24	Turn et al. (1997)
Se	0.07	g/Mg waste	0.02	0.20	Turn et al. (1997)
Pb	0.49	g/Mg waste	0.16	1.48	Turn et al. (1997)
Cd	0.10	g/Mg waste	0.03	0.30	Turn et al. (1997)
Benzo[b]fluoranthene	0.021	mg/kg dry matter	0,007	0,064	Jenkins et al. (1996b)
Benzo[k]fluoranthene	0.029	mg/kg dry matter	0,010	0,087	Jenkins et al. (1996b)
Benzo[a]pyrene	0.011	mg/kg dry matter	0,004	0,034	Jenkins et al. (1996b)
PCDD/F	10	µg I-TEQ/Mg waste	3,33	30	Bremmer (1994), Thomas and Spiro (1994)

3.2.3 Activity data

To use the Tier 1 emission factors, the national area of forestry and orchard is required. If a more detailed methodology is required, then the breakdown of the national area of farmland, forestry and orchard into different types of farming/plantation (including the breakdown of arable farming into areas of different crops) would be needed.

([1]) For the purposes of this guidance, BC emission factors are assumed to equal those for elemental carbon (EC). For further information please refer to Chapter 1.A.1 Energy Industries.

3.3 Tier 2 technology-specific approach

3.3.1 Algorithm

The Tier 2 approach is similar to the Tier 1 approach. To apply the Tier 2 approach, both the activity data and the emission factors need to be stratified according to the different techniques that may occur in the country.

The approach followed to apply a Tier 2 approach is as follows.

Stratify the waste burning in the country to model the different product and process types occurring in the national (small scale) waste burning into the inventory by:

- defining the production using each of the separate product and/or process types (together called 'technologies' in the formulae below) separately; and
- applying technology specific emission factors for each process type:

$$E_{pollutant} = \sum_{technologies} AR_{production,technology} \times EF_{technology,pollutant} \quad (2)$$

where:

$AR_{production,technology}$ = the production rate within the source category, using this specific technology,

$EF_{technology,pollutant}$ = the emission factor for this technology and this pollutant.

A country where only one technology is implemented will result in a penetration factor of 100 % and the algorithm reduces to:

$$E_{pollutant} = AR_{production} \times EF_{technology,pollutant} \quad (3)$$

where:

$E_{pollutant}$ = the emission of the specified pollutant,

$AR_{production}$ = the activity rate for open burning of waste,

$EF_{pollutant}$ = the emission factor for this pollutant.

The emission factors in this approach still will include all sub-processes within the waste burning (small scale).

3.3.2 Technology-specific emission factors

This section presents default emission factors for burning of forest residues (Douglas fir slash & Ponderosa pine slash) and orchard crops (almond prunings & walnut prunings).

3.3.2.1 Forest residues

Table 3-2 Tier 2 emission factors for source category 5.C.2 Small-scale waste burning, forest residues

Tier 2 emission factors					
	Code	Name			
NFR Source Category	5.C.2	Open burning of waste			
Fuel	NA				
SNAP (if applicable)	090700	Open burning of agricultural wastes (except 10.03)			
Technologies/Practices	Forest residue				
Region or regional conditions					
Abatement technologies					
Not applicable	PCBs				
Not estimated	NH_3, Cr, Hg, Ni, Indeno(1,2,3-cd)pyrene, HCB, PCDD/F				
Pollutant	**Value**	**Unit**	**95% confidence interval**		**Reference**
			Lower	**Upper**	
CO	48.79	kg/Mg waste	16.26	146.36	Jenkins et al (1996a)
NO_x	1.38	kg/Mg waste	0.46	4.13	Jenkins et al (1996a)
SO_2	0.03	kg/Mg waste	0.01	0.08	Jenkins et al (1996a)
NMVOC	1.47	kg/Mg waste	0.49	4.41	Jenkins et al (1996a)
TSP	4.31	kg/Mg waste	1.44	12.92	Jenkins et al (1996a)
PM_{10}	4.13	kg/Mg waste	1.38	12.39	Jenkins et al (1996a)
$PM_{2.5}$	3.76	kg/Mg waste	1.25	11.28	Jenkins et al (1996a)
BC[2]	28.2	% of $PM_{2.5}$	20	40	Turn et al. (1997)
Cu	0.25	g/Mg waste	0.08	0.75	Turn et al. (1997)
Zn	17.00	g/Mg waste	5.67	51.00	Turn et al. (1997)
As	0.79	g/Mg waste	0.26	2.37	Turn et al. (1997)
Se	0.10	g/Mg waste	0.03	0.31	Turn et al. (1997)
Pb	0.32	g/Mg waste	0.11	0.95	Turn et al. (1997)
Cd	0.13	g/Mg waste	0.04	0.39	Turn et al. (1997)
Benzo[b]fluoranthene	0.027	mg/kg dry matter	0,009	0,082	Jenkins et al. (1996b)
Benzo[k]fluoranthene	0.024	mg/kg dry matter	0,008	0,073	Jenkins et al. (1996b)
Benzo[a]pyrene	0.014	mg/kg dry matter	0,005	0,043	Jenkins et al. (1996b)

No Tier 2 emission factors are available for PCDD/F for forest residues; the default Tier 1 emission factor from Table 3-1 might instead be used for this pollutant.

3.3.2.2 Orchard crops

Table 3-3 Tier 2 emission factors for source category 5.C.2 Small-scale waste burning, orchard crops

Tier 2 emission factors		
	Code	Name
NFR Source Category	5.C.2	Open burning of waste
Fuel	NA	
SNAP (if applicable)	090700	Open burning of agricultural wastes (except 10.03)
Technologies/Practices	Orchard crops	
Region or regional conditions		
Abatement technologies		
Not applicable	PCBs	
Not estimated	NH_3, Hg, Ni, Indeno(1,2,3-cd)pyrene, HCB, PCDD/F	

(2) For the purposes of this guidance, BC emission factors are assumed to equal those for elemental carbon (EC). For further information please refer to Chapter 1.A.1 Energy Industries.

Pollutant	Value	Unit	95% confidence interval		Reference
			Lower	Upper	
CO	62.88	kg/Mg waste	20.96	188.63	Jenkins et al (1996a)
NO_x	4.99	kg/Mg waste	1.66	14.98	Jenkins et al (1996a)
SO_2	0.19	kg/Mg waste	0.06	0.57	Jenkins et al (1996a)
NMVOC	1.00	kg/Mg waste	0.33	3.00	Jenkins et al (1996a)
TSP	4.98	kg/Mg waste	1.66	14.94	Jenkins et al (1996a)
PM_{10}	4.89	kg/Mg waste	1.63	14.67	Jenkins et al (1996a)
$PM_{2.5}$	4.61	kg/Mg waste	1.54	13.83	Jenkins et al (1996a)
BC[3]	55.9	% of $PM_{2.5}$	40	70	Turn et al. (1997)
Cr	0.01	g/Mg waste	0.00	0.03	Turn et al. (1997)
Cu	0.14	g/Mg waste	0.05	0.43	Turn et al. (1997)
Zn	18.05	g/Mg waste	6.02	54.15	Turn et al. (1997)
As	0.04	g/Mg waste	0.01	0.11	Turn et al. (1997)
Se	0.03	g/Mg waste	0.01	0.10	Turn et al. (1997)
Pb	0.67	g/Mg waste	0.22	2.00	Turn et al. (1997)
Cd	0.07	g/Mg waste	0.02	0.21	Turn et al. (1997)
Benzo[b]fluoranthene	0.015	mg/kg dry matter	0,005	0,046	Jenkins et al. (1996b)
Benzo[k]fluoranthene	0.034	mg/kg dry matter	0,005	0,102	Jenkins et al. (1996b)
Benzo[a]pyrene	0.008	mg/kg dry matter	0,003	0,025	Jenkins et al. (1996b)

No Tier 2 emission factors are available for PCDD/F for forest residues; the default Tier 1 emission factor from Table 3-1 might instead be used for this pollutant.

3.3.3 Abatement

For this source category, no abatement efficiencies are available.

3.3.4 Activity data

To use the Tier 2 emission factors, the national annual quantity of agricultural waste incinerated is required for different crops. These data might be calculated from the national area of forestry, orchard land and farmland divided into different types of farming (including a breakdown of different types of arable farming into areas of different crops).

For small scale waste incineration, the national annual quantity of agricultural waste incinerated is required.

3.4 Tier 3 emission modelling and use of facility data

An improvement of the Tier 1 and Tier 2 methodology can be achieved by estimating the weight of waste produced per hectare for different types of farming, and, in the case of arable farming, for different types of crop. This would require a more detailed review of farming practices.

More general information regarding open burning (not limited to agricultural waste) is available in US EPA AP42, Chapter 2, Section 5 (US EPA, 1998).

([3]) For the purposes of this guidance, BC emission factors are assumed to equal those for elemental carbon (EC). For further information please refer to Chapter 1.A.1 Energy Industries.

4 Data quality

4.1 Completeness

The dioxin profile for individual isomers is only reported in a few of the relevant reports. It is dominated by the tetra and octachlorinated dioxins and furans.

4.2 Avoiding double counting with other sectors

Care should be taken not to double count emissions from waste incineration. It is good practice to report the emissions in this source category only if no heat recovery is used. If heat recovery is used, it is good practice to report the emissions in the relevant 1.A combustion chapter.

4.3 Verification

4.3.1 Best Available Technique emission factors

No specific document is available describing the Best Available Techniques for open burning of waste. However, the IPPC Reference Document on Best Available Techniques on Waste Incineration (European Commission, 2006) may be used for reference.

4.4 Developing a consistent time series and recalculation

No specific issues.

4.5 Uncertainty assessment

There are little data on emissions from the open burning of agricultural waste (not including stubble burning). However, stubble burning is likely to involve similar combustion conditions to the open burning of agricultural waste, and therefore similar emission factors can be applied. As for many reports on emissions of PAHs and dioxins, significant uncertainty is caused by the fact that 'total' PAHs or 'total' dioxins in emissions from stubble burning are generally reported, whereas it is likely that only a limited number of compounds were measured.

Although information on the area of farmland is likely to be reliable, the estimation of the weight of waste arising per hectare of farmland is very uncertain.

4.5.1 Emission factor uncertainties

No specific issues.

4.5.2 Activity data uncertainties

No specific issues.

4.6 Inventory quality assurance/quality control QA/QC

No specific issues.

4.7 Gridding

Spatial disaggregation requires knowledge about the location of the farms that will carry out a significant amount of open burning of agricultural waste (other than stubble burning). These are likely to be arable farms as opposed to farms with mainly livestock. Spatial disaggregation might be possible if a Tier 3 methodology would be developed as this would involve the estimation of emissions from different types of farm.

4.8 Reporting and documentation

No specific issues.

5 References

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6 Point of enquiry

Enquiries concerning this chapter should be directed to the relevant leader(s) of the Task Force on Emission Inventories and Projection's expert panel on combustion and industry. Please refer to the TFEIP website (www.tfeip-secretariat.org/) for the contact details of the current expert panel leaders.