Category		Title
NFR	3.F	Field burning of agricultural residues
SNAP	100301 100302 100303 100304 100305	Cereals Pulses Tuber and root Sugar cane Other
ISIC		
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Contents

1 Overview

This activity is a minor source of several pollutants. Burning crop residues is practiced as a means of clearing land rapidly and inexpensively and allowing tillage practices to proceed unimpeded by residual crop material. Burning may also improve disease and pest control in certain crops. Legislation within the EU has largely outlawed the practice of field burning agricultural wastes.

Note: this activity does not include the burning of crop products that are burnt after having been used on the farm, e.g. straw used to protect agricultural products during on-farm storage. Such burning should be reported under NFR code 5.C.2 Open burning of waste.

Burning of crop residues leads to the emission of a number of atmospheric pollutants: ammonia (NH_3), oxides of nitrogen (NO_x), non-methane volatile organic compounds (NMVOCs), sulphur dioxide (SO_2), carbon monoxide (CO) and particulate matter (PM) including black carbon (BC[1]). Burning these residues will also give rise to emissions of heavy metals (HM) and dioxin.

Table 1-1 Contributions of emissions of gases from the field burning of agricultural residues; 2005 estimates (Gg)

	NH_3	NO_x	NMVOC	SO_2	CO	$PM_{2.5}$	PM_{10}
Total	3 554	9 776	8 287	7 150	26 959	1 234	1 930
Burning	1.2	5.8	12.6	0.1	29.9	3.6	3.7
Burning %	0.04	0.06	0.15	<0.01	0.11	0.29	0.19

Source: http://webdab.emep.int for EU-27

2 Description of sources

2.1 Process description

The process is the open burning of crop residue on arable land after harvesting. Very little information exists on the nature and strength of this source of ammonia (NH_3) or other emissions from the burning of wastes. The principal source of the NH_3 and NO_x is from plant nitrogen, although some NH_3 is likely to originate from the soil underlying the crop wastes combusted.

2.2 Emissions

Emissions are influenced by factors that affect the combustion efficiency of the fire. These include the amount of available oxygen, combustion temperature, residue moisture content, residence time of ventilation air, prevalent meteorological conditions, rate of flame spread, fire management techniques and turbulence. Emissions are also affected by the stubble characteristics, including chemical makeup, residue mass per unit area (loading), residue orientation and extent of compaction in the field (Dhammapala et al., 2007, and references cited therein). The larger emissions tend to be produced by heading fires at higher moisture contents (15 to 20 % wet basis; Goss and Miller, 1973). Heading fires are those in which the flames are blown towards unburned material.

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(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.

Combustion in the field may also be affected by several additional variables, including local meteorology, terrain and cropping. Compacting of the residues before burning has been reported to increase dioxin emissions by a factor of 60 (United Nations Environment Programme (UNEP), 2008).

2.3 Controls

Control of this source is effectively to cease the activity, and it has been banned in many countries, albeit with some minor exceptions. The alternative adopted in many countries being that crop residues are ploughed in or used for production or heat and power.

3 Methods

3.1 Choice of method

Tier 1 is based on simple aggregated area estimates for cropland residues and the application of a default EF for each pollutant. Under a Tier 2 method, estimates have been developed for the major crop types. Tier 3 would be a country-specific method involving process modelling and/or detailed measurement. A Tier 2 methodology should be used if this is a key source.

3.2 Tier 1 default approach

3.2.1 Algorithm

The Tier 1 approach for emissions from field burning of agricultural residues uses the general equation:

$$E_{pollutant} = AR_{residue\_burnt} \cdot EF_{pollutant} \tag{1}$$

$E_{pollutant}$ = emission (E)of pollutant (kg),

$AR_{residue\_burnt}$ = activity rate (AR), mass of residue burnt (kg dry matter),

$EF_{pollutant}$ = emission factor (EF) for pollutant (kg kg^{-1} dry matter).

This equation is applied at the national level, using annual national total amount of residue burnt. Note that $AR_{residue\_burnt} = A \cdot M_b \cdot C_f$ using the IPCC (2006) terminology, where A is the area burnt in hectares, M_b is the mass of fuel available for combustion, in tonnes per hectare and C_f is a combustion factor (dimensionless). For default values please refer to the 2006 IPCC Guidelines, Vol. 4, Chapter 2, Table 2.6.

3.2.2 Default emission factors

The following default EFs have been derived from research conducted by Jenkins et al. (1992, 1996a & 1996b) together with measurements of NH_3 emissions reported by Lee and Atkins (1994). EFs for HMs are scarce in the literature. Turn et al. (1997) and Li et al (2007) reported EFs for HMs. To insure the highest degree of consistency between PM EFs and HM EFs Turn et al. (1997) has been chosen, since the underlying data are from Jenkins (1996a). UNEP (2008) provide EFs for emissions of dioxins, which has been implemented at the Tier 1 level. The Tier 1 EFs have been taken as the EFs for wheat as this is assumed to be the most prevalent crop.

Table 3-1 Tier 1 emission factors for source category 3.F Field burning of agricultural residues

Tier 1 default emission factors					
	Code	Name			
NFR Source Category	3.F	Field burning of agricultural residues			
Fuel	NA				
Not applicable					
Not estimated	HCB, PCBs				
Pollutant	**Value**	**Unit**	**95% confidence interval**		**Reference**
			Lower	**Upper**	
NO_x	0.0023	kg kg-1 dry matter	0.0018	0.0029	Jenkins et al. (1996a)
CO	0.0667	kg kg-1 dry matter	0.0381	0.0953	Jenkins et al. (1996a)
NMVOC	0.0005	kg kg-1 dry matter	0.0002	0.0008	Jenkins et al. (1996a)
SO_x	0.0005	kg kg-1 dry matter	0.0003	0.0007	Jenkins et al. (1996a)
NH_3	0.0024	kg kg-1 dry matter	0.0012	0.0036	Lee & Atkins (1994)
TSP	0.0058	kg kg-1 dry matter	0.0045	0.0071	Jenkins et al. (1996a)
PM_{10}	0.0057	kg kg-1 dry matter	0.0044	0.0071	Jenkins et al. (1996a)
$PM_{2.5}$	0.0054	kg kg-1 dry matter	0.0042	0.0067	Jenkins et al. (1996a)
BC[2]	500	mg kg-1 dry matter	150	1000	Turn et al. (1997)
Pb	0.11	mg kg-1 dry matter	0.055	0.22	Turn et al. (1997)
Cd	0.88	mg kg-1 dry matter	0.44	1.76	Turn et al. (1997)
Hg	0.14	mg kg-1 dry matter	0.07	0.28	Turn et al. (1997)
As	0.0064	mg kg-1 dry matter	0.0032	0.0128	Turn et al. (1997)
Cr	0.08	mg kg-1 dry matter	0.04	0.16	Turn et al. (1997)
Cu	0.073	mg kg-1 dry matter	0.0365	0.146	Turn et al. (1997)
Ni	0.052	mg kg-1 dry matter	0.026	0.104	Turn et al. (1997)
Se	0.02	mg kg-1 dry matter	0.01	0.04	Turn et al. (1997)
Zn	0.56	mg kg-1 dry matter	0.28	1.12	Turn et al. (1997)
PCDD/F*	0.500	µg I-TEQ t^{-1}	NA	NA	UNEP (2008)
Benzo(a)pyrene	0.393	mg kg-1 dry matter	0.222	0.785	Jenkins et al. (1996b)
Benzo(b)fluoranthene	1.097	mg kg-1 dry matter	0.548	2.194	Jenkins et al. (1996b)
Benzo(k)fluoranthene	0.468	mg kg-1 dry matter	0.234	0.936	Jenkins et al. (1996b)
Indeno(1,2,3-cd)pyrene	0.336	mg kg-1 dry matter	0.168	0.672	Jenkins et al. (1996b)

Note:

*when the residue is compacted this value should be 30.0.

3.2.3 Activity data

Activity data should include estimates of land areas for each crop type, which are then used to estimate residues that are commonly burned, the fraction of residue burned and the dry matter content of residue. Expressed formally, the mass of crop residue burned can be calculated from the following equation;

$$AR_{residue\_burnt} = A \cdot Y \cdot s \cdot d \cdot p_b \cdot C_f \tag{2}$$

Where A (ha) is the area of land on which crops are grown whose residues are burned, Y (kg ha^{-1} fresh weight) is the average yield of those crops (e.g. grain), s is the ratio between the mass of crop residues and the crop yield, d is the dry matter content of that yield, p_b is proportion of those residues that are burned (as opposed to being incorporated in the soil, consumed by livestock on

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[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.

the field or removed from the field for use elsewhere) and C_f is the combustion factor (proportion of the fuel present at the time of the fire that is actually burned).

The most important data here are the actual amount of crops produced (by type) with residues that are commonly burned. Annual crop production statistics by country, for most of the crops from which residues are burned, are given in the Food and Agriculture Organization of the United Nations (FAO) Production Yearbook (FAO, 2006a, and 2006b). These statistics are equivalent to the terms $A \cdot Y$ in Equation 2. Users may also find the United Nations World Trade Yearbooks useful. Crop-specific data for each country, on ratios of residue to crop, fraction of residue burned and dry matter content of the residue, can be incorporated at any time to replace the default values. A potentially valuable data source is the study by Hall et al. (1996).

In the Intergovernmental Panel on Climate Change (IPCC) 2006 Guidelines (IPCC, 2006), chapter 5.2.4 (www.ipcc-nggip.iges.or.jp/public/2006gl/index.htm), recommends that the percentage of residues burned on-site must be based on a complete mass balance, accounting of the available residues, including the fractions removed before burning due to animal consumption, decay in the field and use in other sectors (e.g. biofuel, domestic livestock feed, building materials, etc.). It is also important to note that some agricultural residues may be removed from the fields and burned as a source of energy. Emissions from this type of burning are to be dealt with under biomass combustion (described in Chapter 1A1) and are not accounted for here.

It is assumed that country statistics giving the area of cropped land will always be available. In the absence of better data, the following values should be used. Default values of s can be obtained from Table 3–2. For consistency with IPCC (2006, chapter 2.4) and assuming d = 0.85 (Anon, 1997), for wheat: Y = 3.6, C_f = 0.9; for maize: Y = 11.8, C_f = 0.8; rice: Y = 4.6, C_f = 0.8. If p_b is not known, the value of 1 should be used. For crops other than wheat, maize and rice, the values for wheat should be used.

Table 3-2 Default data for estimating the amount of residues burned (from IPCC, 2000)

Crop	Ratio of residue mass to crop yield (s)
Wheat	1.3
Barley	1.2
Maize	1.0
Oats	1.3
Rye	1.6
Rice	1.4
Peas	1.5
Beans	2.1
Soya	2.1

Source: Strehler & Stützle, 1987

3.3 Tier 2 technology-specific approach

3.3.1 Algorithm

An improvement on the above can only be achieved by a prior knowledge of the dry weight per ha yield of a specific crop. This approach includes extending Tier 1 by matching more disaggregated area estimates (e.g. major crop types by climate zones) with country-specific residue accumulation rates. This can be accomplished through the use of more detailed annual or periodic surveys to estimate the areas of land in different crop classes. Areas are further classified into relevant categories such that all major combinations of crop types and climatic regions are represented, with area estimates for each. Countries should prioritize development of country-specific EFs by focusing on either the most common crops being burned or the systems with relatively large emissions per unit of land. Countries should document how specific crop area estimates have been developed and applied.

3.3.2 Technology-specific emission factors

This approach includes extending Tier 1 method by incorporating separate EFs for a number of major crops. The following default EFs have been derived from research conducted by Jenkins et al. (1996). 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.

Table 3-3 Tier 2 emission factors for source category 3.F Burning wheat

Tier 2 emission factors					
	Code	Name			
NFR Source Category	3.F	Field burning of agricultural residues			
Fuel	NA				
SNAP (if applicable)	1003	On-field burning of stubble, straw,…			
Technologies/Practices	Burning Wheat				
Region or regional conditions	NA				
Abatement technologies	NA				
Not applicable					
Not estimated	PCDD/F, HCB, PCBs				
Pollutant	**Value**	**Unit**	**95% confidence interval**		**Reference**
			Lower	**Upper**	
NO_x	0.0023	kg kg-1 dry matter	0.0018	0.0029	Jenkins et al. (1996a)
CO	0.0667	kg kg-1 dry matter	0.0381	0.0953	Jenkins et al. (1996a)
NMVOC	0.0005	kg kg-1 dry matter	0.0002	0.0008	Jenkins et al. (1996a)
SO_x	0.0005	kg kg-1 dry matter	0.0003	0.0007	Jenkins et al. (1996a)
NH_3	0.0024	kg kg-1 dry matter	0.0012	0.0036	Lee & Atkins (1994)
TSP	0.0058	kg kg-1 dry matter	0.0045	0.0071	Jenkins et al. (1996a)
PM_{10}	0.0057	kg kg-1 dry matter	0.0044	0.0071	Jenkins et al. (1996a)
$PM_{2.5}$	0.0054	kg kg-1 dry matter	0.0042	0.0067	Jenkins et al. (1996a)
BC	500	mg kg-1 dry matter	150	1000	Turn et al. (1997)
Pb	0.11	mg kg-1 dry matter	0.055	0.22	Turn et al. (1997)
Cd	0.88	mg kg-1 dry matter	0.44	1.76	Turn et al. (1997)
Hg	0.14	mg kg-1 dry matter	0.07	0.28	Turn et al. (1997)
As	0.0064	mg kg-1 dry matter	0.0032	0.0128	Turn et al. (1997)
Cr	0.08	mg kg-1 dry matter	0.04	0.16	Turn et al. (1997)
Cu	0.073	mg kg-1 dry matter	0.0365	0.146	Turn et al. (1997)

Ni	0.052	mg kg-1 dry matter	0.026	0.104	Turn et al. (1997)
Se	0.02	mg kg-1 dry matter	0.01	0.04	Turn et al. (1997)
Zn	0.56	mg kg-1 dry matter	0.28	1.12	Turn et al. (1997)
Benzo(a)pyrene	0.393	mg kg-1 dry matter	0.222	0.785	Jenkins et al. (1996b)
Benzo(b)fluoranthene	1.097	mg kg-1 dry matter	0.548	2.194	Jenkins et al. (1996b)
Benzo(k)fluoranthene	0.468	mg kg-1 dry matter	0.234	0.936	Jenkins et al. (1996b)
Indeno(1,2,3-cd)pyrene	0.336	mg kg-1 dry matter	0.168	0.672	Jenkins et al. (1996b)

Table 3-4 Tier 2 emission factors for source category 3.F Burning barley

Tier 2 emission factors					
	Code	Name			
NFR Source Category	3.F	Field burning of agricultural residues			
Fuel	NA				
SNAP (if applicable)	1003	On-field burning of stubble, straw,...			
Technologies/Practices	Burning Barley				
Region or regional conditions	NA				
Abatement technologies	NA				
Not applicable					
Not estimated	As, PCDD/F, HCB, PCBs				
Pollutant	**Value**	**Unit**	**95% confidence interval**		**Reference**
			Lower	**Upper**	
NO_x	0.0027	kg kg-1 dry matter	0.0026	0.0029	Jenkins et al. (1996a)
CO	0.0987	kg kg-1 dry matter	0.0952	0.1022	Jenkins et al. (1996a)
NMVOC	0.0117	kg kg-1 dry matter	0.007	0.0163	Jenkins et al. (1996a)
SO_x	0.0001	kg kg-1 dry matter	0.0001	0.0001	Jenkins et al. (1996a)
NH_3	0.0024	kg kg-1 dry matter	0.0012	0.0036	Lee & Atkins (1994)
TSP	0.0078	kg kg-1 dry matter	0.0067	0.0088	Jenkins et al. (1996a)
PM_{10}	0.0077	kg kg-1 dry matter	0.0067	0.0087	Jenkins et al. (1996a)
$PM_{2.5}$	0.0074	kg kg-1 dry matter	0.0064	0.0085	Jenkins et al. (1996a)
BC	1200	mg kg-1 dry matter	400	2400	Turn et al. (1997)
Pb	0.0036	mg kg-1 dry matter	0.0018	0.0072	Turn et al. (1997)
Cd	0.24	mg kg-1 dry matter	0.12	0.48	Turn et al. (1997)
Hg	0.096	mg kg-1 dry matter	0.048	0.192	Turn et al. (1997)
Cr	0.14	mg kg-1 dry matter	0.07	0.28	Turn et al. (1997)
Cu	0.0036	mg kg-1 dry matter	0.0018	0.0072	Turn et al. (1997)
Ni	0.011	mg kg-1 dry matter	0.0055	0.022	Turn et al. (1997)
Se	0.039	mg kg-1 dry matter	0.0195	0.078	Turn et al. (1997)
Zn	0.49	mg kg-1 dry matter	0.245	0.98	Turn et al. (1997)
Benzo(a)pyrene	0.771	mg kg-1 dry matter	0.385	1.541	Jenkins et al. (1996b)
Benzo(b)fluoranthene	2.398	mg kg-1 dry matter	1.199	4.795	Jenkins et al. (1996b)
Benzo(k)fluoranthene	0.601	mg kg-1 dry matter	0.300	1.123	Jenkins et al. (1996b)
Indeno(1,2,3-cd)pyrene	0.298	mg kg-1 dry matter	0.149	0.780	Jenkins et al. (1996b)

Table 3-5 Tier 2 emission factors for source category 3.F Burning maize

Tier 2 emission factors					
	Code	Name			
NFR Source Category	3.F	Field burning of agricultural residues			
Fuel	NA				
SNAP (if applicable)	1003	On-field burning of stubble, straw,...			
Technologies/Practices	Burning Maize				
Region or regional conditions	NA				
Abatement technologies	NA				
Not applicable					
Not estimated	PCDD/F, HCB, PCBs				
Pollutant	**Value**	**Unit**	**95% confidence interval**		**Reference**
			Lower	**Upper**	
NO_x	0.0018	kg kg-1 dry matter	0.0018	0.0019	Jenkins et al. (1996)
CO	0.0388	kg kg-1 dry matter	0.0374	0.0401	Jenkins et al. (1996)
NMVOC	0.0045	kg kg-1 dry matter	0.0044	0.0048	Jenkins et al. (1996)
SO_x	0.0002	kg kg-1 dry matter	0.0002	0.0002	Jenkins et al. (1996)
NH_3	0.0024	kg kg-1 dry matter	0.0012	0.0036	Lee & Atkins (1994)
TSP	0.0063	kg kg-1 dry matter	0.0048	0.0078	Jenkins et al. (1996)
PM_{10}	0.0062	kg kg-1 dry matter	0.0047	0.0077	Jenkins et al. (1996)
$PM_{2.5}$	0.0006	kg kg-1 dry matter	0.0045	0.0074	Jenkins et al. (1996)
BC	750	mg kg-1 dry matter	250	1500	Turn et al. (1997)
Pb	0.007	mg kg-1 dry matter	0.0035	0.014	Turn et al. (1997)
Cd	0.036	mg kg-1 dry matter	0.018	0.072	Turn et al. (1997)
Hg	0.028	mg kg-1 dry matter	0.014	0.56	Turn et al. (1997)
As	0.013	mg kg-1 dry matter	0.0065	0.026	Turn et al. (1997)
Cr	0.100	mg kg-1 dry matter	0.05	0.2	Turn et al. (1997)
Cu	0.054	mg kg-1 dry matter	0.027	0.108	Turn et al. (1997)
Ni	0.036	mg kg-1 dry matter	0.018	0.072	Turn et al. (1997)
Se	0.028	mg kg-1 dry matter	0.014	0.056	Turn et al. (1997)
Zn	0.840	mg kg-1 dry matter	0.42	1.68	Turn et al. (1997)
Benzo(a)pyrene	7.162	mg kg-1 dry matter	3.581	14.325	Jenkins et al. (1996b)
Benzo(b)fluoranthene	3.495	mg kg-1 dry matter	1.747	6.989	Jenkins et al. (1996b)
Benzo(k)fluoranthene	2.138	mg kg-1 dry matter	1.069	4.275	Jenkins et al. (1996b)
Indeno(1,2,3-cd)pyrene	2.415	mg kg-1 dry matter	1.208	4.831	Jenkins et al. (1996b)

Table 3-6 Tier 2 emission factors for source category 3.F Burning rice

Tier 2 emission factors					
	Code	Name			
NFR Source Category	3.F	Field burning of agricultural residues			
Fuel	NA				
SNAP (if applicable)	1003	On-field burning of stubble, straw,…			
Technologies/Practices	Burning Rice				
Region or regional conditions	NA				
Abatement technologies	NA				
Not applicable					
Not estimated	PCDD/F, HCB, PCBs				
Pollutant	**Value**	**Unit**	**95% confidence interval**		**Reference**
			Lower	**Upper**	
NO_x	0.0024	kg kg-1 dry matter	0.0018	0.0028	Jenkins et al. (1996)
CO	0.0589	kg kg-1 dry matter	0.0314	0.0987	Jenkins et al. (1996)
NMVOC	0.0063	kg kg-1 dry matter	0.0034	0.0117	Jenkins et al. (1996)
SO_x	0.0003	kg kg-1 dry matter	0.0001	0.0006	Jenkins et al. (1996)
NH_3	0.0024	kg kg-1 dry matter	0.0012	0.0036	Lee & Atkins (1994)
TSP	0.0058	kg kg-1 dry matter	0.0035	0.0078	Jenkins et al. (1996)
PM_{10}	0.0058	kg kg-1 dry matter	0.0035	0.0077	Jenkins et al. (1996)
$PM_{2.5}$	0.0055	kg kg-1 dry matter	0.0031	0.0074	Jenkins et al. (1996)
BC	500	mg kg-1 dry matter	150	1000	Turn et al. (1997)
Pb	0.072	mg kg-1 dry matter	0.036	0.144	Turn et al. (1997)
Cd	0.16	mg kg-1 dry matter	0.08	0.32	Turn et al. (1997)
Hg	0.033	mg kg-1 dry matter	0.0165	0.066	Turn et al. (1997)
As	0.091	mg kg-1 dry matter	0.00455	0.0182	Turn et al. (1997)
Cr	0.10	mg kg-1 dry matter	0.05	0.2	Turn et al. (1997)
Cu	0.088	mg kg-1 dry matter	0.044	0.176	Turn et al. (1997)
Ni	0.045	mg kg-1 dry matter	0.0225	0.09	Turn et al. (1997)
Se	0.048	mg kg-1 dry matter	0.024	0.096	Turn et al. (1997)
Zn	0.92	mg kg-1 dry matter	0.46	1.84	Turn et al. (1997)
Benzo(a)pyrene	0.072	mg kg-1 dry matter	0.026	0.144	Jenkins et al. (1996b)
Benzo(b)fluoranthene	0.120	mg kg-1 dry matter	0.060	0.239	Jenkins et al. (1996b)
Benzo(k)fluoranthene	0.088	mg kg-1 dry matter	0.044	0.176	Jenkins et al. (1996b)
Indeno(1,2,3-cd)pyrene	0.055	mg kg-1 dry matter	0.028	0.110	Jenkins et al. (1996b)

3.3.3 Abatement

The main abatement measure is to reduce the amount of residues burned, and this will be taken into account in the activity data calculations. Ensuring the crop residues are dry before burning should give lesser emissions, but there is insufficient data to produce a range of reliable emission factors according to residue dry matter.

3.3.4 Activity data

This approach includes extending Tier 1 by using more disaggregated area estimates (e.g. major crop types). This can be accomplished through the use of more detailed annual or periodic surveys to estimate the areas of land in different crop classes. If country-specific finer resolution data are only partially available, countries are encouraged to extrapolate to the entire land base of crops using sound assumptions from best available knowledge. Countries should prioritize development of country-specific EF by focusing on either the most common crops being burned or the systems with relatively high levels of emissions per unit of land. Countries should document how specific crop area estimates have been developed and applied.

3.4 Tier 3 emission modelling and use of facility data

3.4.1 Tier 3 emission modelling and use of facility data

Tier 3 approach using models based on country-specific parameters should be well developed and provide estimates for CO, NO, NO_x, NMVOC and SO_2. These estimates should address the parameters in equation 3.18 in Chapter 3 of IPCC 2006 and should utilize national inventory data to assure that no burning of crop residues is being omitted. Countries should prioritize development of country-specific EFs and combustion efficiency parameters by focusing on the most common crop residues being burned, based on national inventories. Reported EFs may be modified based on additional data and expert opinion, provided clear rationale and documentation are included in the inventory report.

3.4.2 Activity data

Tier 3 requires fine-resolution activity data disaggregated at sub-national to fine grid scales. Similar to Tier 2, land area is classified into specific types of crops, but also by major climate and soil categories and other potentially important regional variables (e.g. regional patterns of management practices) to be used in models. If possible, spatially explicit area estimates may be used to facilitate complete coverage of the cropland and ensure that areas are not over or underestimated. Furthermore, spatially explicit area estimates can be related to locally relevant emission rates and management impacts, improving the accuracy of estimates.

4 Data quality

4.1 Completeness

The current IPCC method incorporates all the factors necessary to estimate emissions from burning agricultural residues. Several crops are still missing in IPCC Chapter 4 Table 4.1.5 (IPCC, 2006) and each country may add important crops to the table.

4.2 Avoiding double counting with other sectors

This activity does not include the burning of crop products that are burnt after having been used on the farm, even if these products are burnt in the field. Such burning should be reported under NFR code 6.C.e (Small scale waste burning).

4.3 Verification

There are no direct methods to evaluate total inventory estimates of emissions following the burning of crop residues, and verification is dependent on field studies of emissions from example situations. In particular, some reported studies have focused on laboratory measurements and there is a need to provide long-term field measurements to estimate emissions over a range of crop types in different climates. However, given the small, and declining, significance of this source, it is unlikely that many such studies will be carried out.

4.4 Developing a consistent time series and recalculation

There are good prospects for developing the trend of emissions from agricultural residue burning because the statistics of agricultural production are compiled with reasonable accuracy. The weakness in the computation is estimating the percentage of residue burned in the field. Each inventory agency has to collect activity data on the disposition of each crop residue, especially the percentage of residue burned on-site, after harvest.

4.5 Uncertainty assessment

4.5.1 Emission factor uncertainties

Emission factors for CO may be uncertain by ±17 %, those for PM 2.2 by ±25 % (Dhammapala et al., 2006). The uncertainties quoted for the EFs were derived from the results presented by Jenkins et al. (1996), Turn et al. (1997) and expert judgement.

4.5.2 Activity data uncertainties

Crop production data are reasonably accurate, although it is difficult to determine the uncertainty. The fraction of agricultural residue burned in the field is probably the variable with the largest degree of uncertainty. Statistical data have to be compiled to account for the use of agricultural residue after harvest. The following discussion provides guidance on approaches for assessing uncertainty associated with each Tier method.

The sources of uncertainty when using the Tier 1 approach include the degree of accuracy in land area estimates and in the default EF. A published compilation of research on EF was used to derive the default data provided in this section. While defaults were derived from multiple studies, their uncertainty ranges were not included in the publications.

4.6 Inventory quality assurance/quality control QA/QC

The quality of emission estimates from agricultural residue burning will vary considerably from country to country, depending largely on the quality of the information regarding the percentage of the residue burned in the field. The qualities of other activity data and EFs are reasonable and can be improved by collecting the data of the amount of residues burned during different seasons. Crop production data can be verified by using commodity trade statistics.

4.7 Gridding

The simplest approach to spatially disaggregate emissions from residue burning is to scale these by the distribution of different crop residues burned with the EFs provided in Table 3–1. This may be estimated from local country statistics on land-use.

4.8 Reporting and documentation

It is good practice to document and archive all information required to produce the national emissions inventory. Agricultural production data are easily accessible from each country or from the FAO Production Yearbook (FAO, 2006a, 2006b). Weather conditions and the amount of each crop burned in the field have to be reported. It is necessary to measure and report the dry matter fraction, the carbon fraction, and the N to C ratio for each crop residue. It is also important to conduct field experiments that estimate EFs under a range of meteorological conditions.

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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 Agriculture and Nature. Please refer to the TFEIP website (www.tfeip-secretariat.org/) for the contact details of the current expert panel leaders.