Category		Title
NFR	2.A.5.b	Construction and demolition
SNAP	040624	Public works and building sites
ISIC	4510	Site preparation
	4520	Building of complete constructions or parts thereof; civil engineering
	4530	Building installation
	4540	Building completion
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Contents

1 Overview

The present chapter discusses emissions from the construction sector (NFR “2.A.5.b: Construction and demolition”, changed from 2.A.7.b used before 2015).

It has long been recognized that the construction of infrastructure and buildings constitutes an important source of fugitive particulate matter (PM) emissions. Frequently, elevated ambient PM10 concentrations are observed at and around construction works. A significant proportion of construction activities takes place in urban and other densely populated areas. Consequently, a large number of people may be exposed to PM emitted from construction activities.

Besides being a source of fugitive PM emission, construction activities may emit other pollutants as well. This mostly concerns combustion products such as NO_x, soot and CO_2, and fugitive NMVOC emissions resulting from the use of products. In emission inventories however, all combustion and product use emissions are estimated elsewhere, either as a component of emissions from mobile machinery, or as a component of solvent/product use emissions. This chapter only considers fugitive PM emission.

2 Description of sources

2.1 Economic definition of the construction industry

The construction sector is a diverse and highly variable sector. For commercial and professional purposes, the NACE code-based Eurostat economic statistics provide an overview of which economic activities are associated with the construction industry. The Eurostat Structural Business Statistics divide the construction sector in the following branches for reporting (regional) economic activities:

NACE code	Description
F41	Construction of buildings:
F411	Development of building projects
F412	Construction of residential and non-residential buildings
F42	Civil engineering:
F421	Construction of roads and railways
F422	Construction of utility projects
F429	Construction of other civil engineering projects
F43	Specialised construction activities:
F431	Demolition and site preparation
F432	Electrical, plumbing and other construction installation activities
F433	Building completion and finishing
F439	Other specialised construction activities

From an emission point of view, a different classification is usually needed and reported economic activity is only of limited use. For emissions, activities are classified either based on the type of building constructed, or by considering the emission mechanism of the type of machinery used.

2.2 Emission sources, techniques and controls

In construction there are many possible activities that result in air emissions. For instance, the following activities, typical in construction, are relevant sources of fugitive PM:

- Land clearing and demolition
- Earth moving and cut and fill operations
- Equipment movements
- Mobile debris crushing equipment
- Vehicular transport (loading, unloading and hauling of materials, track out of dirt on paved roads and subsequent dust resuspension)
- Further site preparation activities
- Specific building activities such as concrete, mortar and plaster mixing, drilling, milling, cutting, grinding, sanding, welding and sandblasting activities
- Various finishing activities
- Windblown dust from temporary unpaved roads and bare construction sites

Fugitive PM emissions are largely of mineral composition and mechanical origin, with soil dust typically comprising a significant part. The resuspension of soil dust by hauling traffic is important contributor according to the literature, but since resuspension by road transport as a whole may also be estimated elsewhere, there is a danger of double counting of emissions. However, the published literature suggests that resuspension on construction sites is, by unit of activity and under the same meteorological conditions, usually several times higher than ‘normal’ traffic-induced resuspension. Vehicular resuspension from construction should therefore be estimated separately from resuspension by road transport. The tier 1 emission estimation method presented and discussed in this chapter includes vehicular resuspension by construction traffic.

For many activities that result in fugitive dust emissions, the dust emission is strongly dependent on the material or soil moisture content because moisture tends to promote particles to clog together, preventing particles becoming airborne. Therefore surface watering is an effective measure to control soil dust emission, e.g. by vehicular resuspension. Similarly, a water curtain may be used in demolition activities. Watering is a simple and effective emission control measure that is widely used in construction for many sources of fugitive dust.

Besides watering there are many more emission reducing measures and best practices to prevent emissions which are available for specific activities in the construction sector. A comprehensive overview of these can for instance be found in CSI, (2005). This chapter of the Guidebook addresses only watering as an emission control measure because of its wide application.

3 Methods

3.1 Choice of method

The vast majority of all available information on fugitive PM emission by construction activities originates from the United States. Work started there in the 1970s with the development of emission factors for specific construction-related fugitive dust sources, such as earth moving activities. The list of emission factors has been extended steadily since then, and nowadays forms the basis for EPA's more detailed bottom-up tier 3 methodology for estimating fugitive dust emissions from construction activities (included in EPA's AP-42 document, EPA, 2011). As a tier 3 method, it requires more detailed activity data, for instance on vehicular movements and earth moving activities. In addition, it needs basic climatic and soil data.

In the 1980s and 1990s dust measurements downwind of large construction sites took place in Las Vegas and California, and the results were used as the basis for EPA's current top-down tier 1 methodology for construction emissions (WRAP, 2006). This methodology was developed and refined in the late 1990s and has been adapted for use for other regions of the US by providing the option to correct for climatic and soil differences (Thesing and Huntley, 2001). It requires the total extent of the affected area for a number of major types of construction as activity data.

A rather different approach was followed by the HASKONING company in 2000 (Kimmel et al. 2000). It is based on inverse modelling of emission from occupational dust exposure data for dust sensitive professions in the construction industry. It also partially relied on general EPA emission factors for vehicular dust resuspension and a crude estimation of vehicular movements. This methodology was the basis for the previous Guidebook tier 1 emission factor. The method only requires basic activity data, such as total floor area constructed or number of active workers for major branches in construction.

An evaluation of both available tier 1 methods was made in UBA, (2015), which concluded that the soil dust contribution (the chief contribution according to the EPA tier 1 method) might have been underestimated by Kimmel et al. (2000). According to the latter method, the majority of the emissions are caused by specific, mostly indoor, building and finishing activities, and not soil dust. However, this method was never backed by any direct emission measurements and there is no documentation available in English.

The recommended tier 1 method is therefore that of the US EPA, although strictly speaking this method was never intended to be used outside of the United States. It gives in general considerably higher results that the method by Kimmel et al.

All emission literature dealing with construction activities states that the estimated emissions by the construction industry are only a first order quantification of the actual emissions and the uncertainty is high, much higher than for most other sources of primary PM.

The US EPA tier 1 method only considers new construction (including site preparation). Renovation or demolishing without any significant new construction is not covered and there are no other emission factors available for demolition activities only.

3.2 Tier 1 default approach

The US EPA tier 1 emission estimation method for construction emissions distinguishes four main types of construction:

- Residential housing, single- or two family
- Residential housing, apartments
- Non-residential housing
- Road construction

The method involves multiplication of a specific emission factor for each type of construction with the total area affected by that specific type of construction (e.g. the area of the bare construction site) and the average duration of the construction. Since the affected area is usually not directly available from statistical sources, a means of estimating affected area based on other statistical data is suggested. The method offers the further option to correct for the soil moisture content and the soil particle size distribution (which both affect dust sensitivity).

3.2.1 Algorithm

The US EPA Tier 1 approach to estimating total fugitive PM emissions uses the following equation:

$$EM_{PM_{10}} = EF_{PM_{10}} \cdot A_{affected} \cdot d \cdot (1 - CE) \cdot \left(\frac{24}{PE}\right) \cdot \left(\frac{s}{9\%}\right) \quad (1)$$

PM10 emission factor	Affected area	Construc-tion duration	1 - control efficiency	Correction for soil moisture	Correction for silt content

Where:

EM_{PM10}	=	PM_{10} emission (kg PM_{10})
EF_{PM10}	=	the emission factor for this pollutant emission (kg PM_{10}/[m^2 · year])
$A_{affected}$	=	area affected by construction activity (m^2)
d	=	duration of construction (year)
CE	=	efficiency of emission control measures (-)
PE	=	Thornthwaite precipitation-evaporation index (-)
s	=	soil silt content (%)

3.2.2 Default emission factors (EF_{PM10})

Default PM_{10} emission factors for uncontrolled fugitive particulate matter (PM) emissions from the four main types of construction activities are provided in Tables 3.1 to 3.4. The default emission factors are derived from the US EPA tier 1 PM_{10} emission estimation method.

As is often the case for dust emissions of mechanical origin, geological dust suspended by construction activities has a relatively low content of $PM_{2.5}$ in PM_{10}. According to MRI (2006), the overall $PM_{2.5}$ fraction in PM_{10} of construction emissions varies between 5 and 15%, while Muleski et al. (2005) measured 1 – 10% (average 3%) for several specific sources. For construction as a whole, it is recommended that the average $PM_{2.5}$ content of PM_{10} should be assumed to be 10%. TSP emission is estimated to be roughly three times the PM_{10} emission, based on a reported content of PM_{10} in TSP of 30% (US EPA 1999).

Table 3.1 Tier 1 emission factors for uncontrolled fugitive emissions for source category 2.A.5.b Construction and demolition – Construction of houses

Tier 1 default emission factors		
	Code	Name
NFR Source Category	2.A.5.b	Construction and demolition – Construction of houses (detached single family, detached two family and single family terraced)
Fuel	NA	

Not applicable	NOx, CO, SOx, NH_3, NMVOC, BC, Pb, Cd, Hg, As, Cr, Cu, Ni, Se, Zn, HCH, PCBs, PCDD/F, Benzo(a)pyrene, Benzo(b)fluoranthene, Benzo(k)fluoranthene, Indeno(1,2,3-cd)pyrene, HCB				
Not estimated	NA				
Pollutant	**Value**	**Unit**	**95% confidence interval**		**Reference**
			Lower	**Upper**	
TSP	0.29	kg/[m^2· year]	0.03	0.9	WRAP 2006, MRI 2006
PM_{10}	0.086	kg/[m^2· year]	0.009	0.3	WRAP 2006, MRI 2006
$PM_{2.5}$	0.0086	kg/[m^2· year]	0.0009	0.03	WRAP 2006, MRI 2006

Table 3.2 Tier 1 emission factors for uncontrolled fugitive emissions for source category 2.A.5.b Construction and demolition – Construction of apartment buildings

Tier 1 default emission factors					
	Code	Name			
NFR Source Category	2.A.5.b	Construction and demolition – Construction of apartments (all types)			
Fuel	NA				
Not applicable	NOx, CO, SOx, NH_3, NMVOC, BC, Pb, Cd, Hg, As, Cr, Cu, Ni, Se, Zn, HCH, PCBs, PCDD/F, Benzo(a)pyrene, Benzo(b)fluoranthene, Benzo(k)fluoranthene, Indeno(1,2,3-cd)pyrene, HCB				
Not estimated	NA				
Pollutant	**Value**	**Unit**	**95% confidence interval**		**Reference**
			Lower	**Upper**	
TSP	1.0	kg/[m^2· year]	0.1	3	WRAP 2006, MRI 2006
PM_{10}	0.30	kg/[m^2· year]	0.03	0.9	WRAP 2006, MRI 2006
$PM_{2.5}$	0.030	kg/[m^2· year]	0.003	0.09	WRAP 2006, MRI 2006

Table 3.3 Tier 1 emission factors for uncontrolled fugitive emissions for source category 2.A.5.b Construction and demolition – Non-residential construction

Tier 1 default emission factors					
	Code	Name			
NFR Source Category	2.A.5.b	Construction and demolition – Non-residential construction (all construction except residential construction and road construction)			
Fuel	NA				
Not applicable	NOx, CO, SOx, NH_3, NMVOC, BC, Pb, Cd, Hg, As, Cr, Cu, Ni, Se, Zn, HCH, PCBs, PCDD/F, Benzo(a)pyrene, Benzo(b)fluoranthene, Benzo(k)fluoranthene, Indeno(1,2,3-cd)pyrene, HCB				
Not estimated	NA				
Pollutant	**Value**	**Unit**	**95% confidence interval**		**Reference**
			Lower	**Upper**	
TSP	3.3	kg/[m^2· year]	0.3	10	WRAP 2006, MRI 2006
PM_{10}	1.0	kg/[m^2· year]	0.1	3	WRAP 2006, MRI 2006
$PM_{2.5}$	0.1	kg/[m^2· year]	0.01	0.3	WRAP 2006, MRI 2006

Table 3.4 Tier 1 emission factors for uncontrolled fugitive emissions for source category 2.A.5.b Construction and demolition – Road construction

Tier 1 default emission factors		
	Code	Name
NFR Source Category	2.A.5.b	Construction and demolition – Road construction
Fuel	NA	

Not applicable	NOx, CO, SOx, NH_3, NMVOC, BC, Pb, Cd, Hg, As, Cr, Cu, Ni, Se, Zn, HCH, PCBs, PCDD/F, Benzo(a)pyrene, Benzo(b)fluoranthene, Benzo(k)fluoranthene, Indeno(1,2,3-cd)pyrene, HCB				
Not estimated	NA				
Pollutant	Value	Unit	95% confidence interval		Reference
			Lower	Upper	
TSP	7.7	kg/[m^2· year]	0.8	20	WRAP 2006, MRI 2006
PM_{10}	2.3	kg/[m^2· year]	0.2	7	WRAP 2006, MRI 2006
$PM_{2.5}$	0.23	kg/[m^2· year]	0.02	0.7	WRAP 2006, MRI 2006

3.2.3 Estimation parameters (d, CE, PE and s)

In order to produce acceptable results, a number of calculation parameters have to be set in accordance with country-specific conditions. These parameters are: the duration of the construction (d); the control efficiency of any applied emission reduction measures (CE); the Thornthwaite precipitation-evaporation index (PE); and the soil silt content (s). All these parameters may vary considerably and have a profound influence on the outcome of the methodology. In this section, some guidance is given on how to set these parameters. In addition default values are suggested, in case information is lacking.

Duration of construction (d)

The duration d is the duration of the construction activity, as specified in the building permit for example. This parameter means the total duration of all activities from land clearing and/or demolition to the finishing of the structure. In general, a more complex structure requires a longer construction time. The following average values may be used as default when no country-specific information is available.

Type of construction	Estimated duration (year)
Construction of houses (detached single family, detached two family and single family terraced)	0.5 (6 months)
Construction of apartments (all types)	0.75 (9 months)
Non-residential construction (all construction except residential construction and road construction)	0.83 (10 months)
Road construction	1 (12 months)

Control efficiency of applied emission reduction measures (CE)

Watering of temporary unpaved roads is a simple and effective emission control measure that is widely used in construction in Europe, especially during very dry periods. The effect of watering is the highest directly after spraying and then decreases again as the road surface dries. WRAP, (2006) reports an overall efficiency of about 50% on average. It is assumed that in general watering routinely takes place in heavy construction activities during dry periods, resulting in an overall emission reduction of 50%. This translates to the following control efficiencies by type of construction, which may be used as default for Europe in cases where no country-specific information regarding building practices is available.

Type of construction	Fractional overall control efficiency (-)
Construction of houses (detached single family, detached two family and single family terraced)	0
Construction of apartments (all types)	0

Non-residential construction (all construction except residential construction and road construction)	0.5
Road construction	0.5

Thornthwaite precipitation-evaporation index (PE)

One of the parameters that has the strongest influence on soil dust sensitivity is the soil moisture content. The EPA tier 1 method provides an option for a rough correction for climatic conditions that influence the soil moisture content. As an indicator of the soil moisture content the Thornthwaite precipitation-evaporation (PE) index is used, which may be calculated based on the monthly precipitation P_i (in mm) and the mean temperature T_i (in °C) according to:

$$\text{PE index} = 3.16 \sum_{i=0}^{12} \left(\frac{P_i}{1.8\,T_i + 22}\right)^{\frac{10}{9}}$$

To derive a country or region-specific value for PE, the above formula may be used, or a value for PE can be taken from the table below:

Climate	PE Index
Wet	More than 128
Humid	64 - 127
Sub-humid	32 - 63
Semi-arid	16 - 31
Arid	Less than 16

This method of classifying climatic conditions was originally developed for the Eastern part of the US with only limited applicability for other regions in the world. However, it is widely used throughout the world. The PE index may underestimate the moisture content of the top soil layer for Europe because on average there tend to be longer and more frequent periods of lighter rain fall compared to the US. This fact is not accounted for when considering only the total monthly precipitation. However, in the latter case of longer periods of light rainfall, top soil dust sensitivity is lower. PE Index values for the Eastern part of the US vary from 90 to 180 with an average of about 120 (EPA, 1999). A value of 120 was also assumed for Germany (UBA, 2015).

For the regions where the construction dust measurements originally took place (Las Vegas and California), the PE index varied from 9 to 41 with an average of 24. Correction for a very different soil moisture often has a far-reaching influence on the result, and the applicability of the EPA emission factors may be stretched in such cases.

Soil silt content (s)

Silt is soil with particles sized between 0.002 and 0.075 mm (or 0.063 mm according to the ISO definition) and the soil silt content is the weight fraction of these particles.

Silt is the fraction of the soil that is the most dust sensitive and therefore the estimated construction emissions must be corrected for the average silt content of the top soil of the affected area. Examples of silt content of various soil types are given below (EPA, 1999).

Soil type	Silt content (%)
Silt loam	52
Sandy load	33
Sand	12
Loamy sand	12
Clay	29
Clay loam	29
Loam	40

Silt content as available from soil maps usually refers to the silt content of the first 1.2 m of the undisturbed natural soil. This information is however often not directly applicable in EPA's tier 1 method. Soil types with typically high silt content such as loam or clay are usually too unstable to build directly upon. Therefore these soil layers are removed to a certain depth and replaced by sand in order to prepare the subsurface for construction and create a stable basis. Consequently, this typically takes place at an early stage in the construction project. In addition, in cities, the soil is usually anthropogenic to begin with, with most anthropogenic soils being sandy. Also areas that will eventually be paved in some way require a layer of sand as a basis. Sand has a silt content of only about 12% and some grades of construction sands have a silt content as low as 2%. The silt content as available from soil maps can therefore lead to a significant overestimation of emissions.

Those sections of the affected area that keep their natural soil layer on top but nevertheless remain bare throughout the duration of the construction project will probably only comprise a minor part of the affected area. An example may be the temporary unpaved roads used for hauling of materials that extent over areas with an undisturbed natural soil. But the majority of the affected area at a construction site will have a sand cover for the majority of the time. It seems therefore safe to assume that the average silt content of the affected area will lie somewhere between that of the natural undisturbed soil and that of sand, in fact closer to that of sand than that of the undisturbed soil, especially in urban areas.

For this reason an average silt content of 20% is assumed for Germany, whereas the weighted average silt content as derived from soil maps was almost double (38%) that. The average silt content for California/Las Vegas where EPA's measurements took place was relatively low, at 9%.

3.2.4 Activity data ($A_{affected}$)

The US EPA tier 1 methodology is based on the affected area as primary activity value. The term "affected area" means the total area of which the soil is disturbed by the construction activity, usually equal to the area of the construction site plus any accessory temporary unpaved roads. This activity parameter is however often not directly available from statistical sources. EPA therefore provides simple means to estimate the affected area based on basic construction activity data for the four types of construction for which different emission factors are available (single/two family and terraced houses, apartment buildings, non-residential buildings and road construction). Both statistical data from national statistics bureaus as well as statistics published directly by the industry itself may have to be consulted.

Houses

For houses, construction activity data may be available for the total number of houses built (whether single or two family, or terraced). The total affected area can be calculated by multiplying the number of houses by the affected area per house, which is given by a conversion factor multiplied by the footprint area per house. The term “footprint area” means the two dimensional projection of the building on the ground.

A representative average for both the conversion factor and the footprint area per type of house can be estimated based on country-specific information, or one or more values can be selected from the following defaults (German data, UBA, 2015).

Type of house	Footprint area (m^2/house)	Conversion factor (-)	Affected area (m^2/house)
Detached single family	150	2	300
Detached two family (i.e. semi-detached)	125	1.5	188
Terraced	80	1.5	120

The US EPA also suggests default values for footprint area and conversion factor which are representative of the US, and both much higher than the values in the above table. These values are however not recommended for use in Europe as European construction sites have a more compact layout and footprint areas are on average significantly smaller.

As an alternative to the above method for estimating affected area (using a footprint area and a conversion factor) any other way of estimating the total affected area for house construction would be acceptable for application to the relevant emission factor.

Apartment buildings

The number of constructed apartment buildings is a parameter that may be available from national statistical sources. Alternatively the number of constructed apartment units may be available. The affected area for apartment construction may then be calculated in a way similar to houses, by multiplication of the average footprint area of the apartment building or apartment unit by a conversion factor. The average footprint area and conversion factor should preferably be estimated on the basis of country-specific information. If this is not possible the following default values may be considered (German data, UBA 2015).

All apartment types	Footprint area (m^2)	Conversion factor (-)	Total affected area
Apartment, building basis	450	1.3	585 m^2/building
Apartment, unit basis	50	1.3	65 m^2/apartment

The default values for footprint area and conversion factor supplied by the US EPA for use in the US are not recommended for use in Europe due the much more compact methods of construction which are used in Europe.

Any other equivalent method for estimating the affected area for apartment construction may be used for application to the relevant emission factor.

Non-residential construction

Non-residential construction includes building construction (commercial, industrial, institutional, governmental) and also public works. In the US EPA tier 1 method, any other type of construction besides residential or road construction falls under non-residential construction. As a result, this type of construction is very broad with activities ranging from the construction of utility buildings such as schools and hospitals to civil engineering projects, to the construction of office or factory complexes, to very large projects involving the construction of an airport or a stadium. The bulk of non-residential construction in Germany comprises mid-sized commercial buildings.

Compared to residential construction, non-residential construction is often less well represented in statistical data on construction activity. There is a reasonable chance though that the total number of non-residential buildings constructed or total constructed utility floor area is available from national or industry statistics.

If only the number of non-residential buildings is available, an average footprint area of 800 m^2/building may be assumed, again based on German data. From German construction data on total utility floor area and the total number of non-residential buildings, an average utility floor area per building of approximately 1 000 m^2 is calculated. Analysis of a large number of non-residential buildings in Germany suggests that the footprint area is on average somewhat lower than the total utility floor area (UBA, 2015). If only the total constructed utility floor area is available, the affected area may be estimated using 0.8 m^2 footprint area per m^2 utility floor area. For large non-residential buildings, often constructed in densely populated urban areas, it may further be assumed that the affected area is approximately equal to the footprint area of the building.

In the absence of any of the above discussed activity data, estimating total affected area can be a real challenge. One possibility may be to estimate the affected area based on financial data for commercial non-residential construction. An estimate of 1 m^2 affected area per thousand Euro industry revenue may be used as a default when no other data is available.

Road construction

Road construction emissions are largely determined by the amount of earthmoving that occurs at a site. Almost all roadway construction involves extensive earthmoving and heavy construction vehicle travel, causing emissions to be higher than found for other construction activities. The US EPA tier 1 method only considers new road or lane construction, and does not address road renovation activities.

The affected area for road construction may be estimated from the total length of new road constructed, which is available from national statistical sources. The length of the affected area is the road section length while the width is estimated from the roadway width, lane and shoulder number. A value of 36 m is derived in UBA (2015) as an average width of the affected area for the German road network. If no other data besides the total length of newly constructed road is available an affected area of 36 000 m^2 per km may be used.

3.3 Tier 2 technology-specific approach

Not available for this source.

3.4 Tier 3 emission modelling and use of facility data

3.4.1 Methodology

A more detailed methodology for analysis of emissions from construction and demolition is provided by US EPA (2011): “AP-42, Compilation of Air Pollutant Emission Factors”. A survey of the compilation of formulas relevant for construction and demolition is presented in Table 3.5.

Table 3.5 Methodologies for estimation of emissions from construction and demolition provided in AP-42, chapter 13.2.3 “Heavy construction operations” (US EPA, 2011).

I. Demolition and debris removal	1. Demolition of buildings or other (natural) obstacles such as trees, boulders etc. a. Mechanical dismemberment (“headache ball”) of existing structures b. Implosion of existing structures c. Drilling and blasting of soils (general) d. General land clearing	na na AP-42; 11.9/na AP-42; 11.9
	2. Loading of debris into trucks	AP-42; 13.2.4
	3. Truck transport of debris	AP-42; 13.2.1 AP-42; 13.2.2
	4. Truck unloading of debris	AP-42; 13.2.4
II. Site preparation (earth removal)	1. Bulldozing	AP-42; 11.9
	2. Scrapers unloading topsoil	AP-42; 11.9
	3. Scrapers in travel	AP-42; 11.9
	4. Scrapers removing topsoil	AP-42; 13.2.3
	5. Loading of excavated material into trucks	AP-42; 13.2.4
	6. Truck dumping of fill material, road base, or other materials	AP-42; 13.2.4
	7. Compacting	AP-42; 11.9
	8. Motor grading	AP-42; 11.9
III. General construction	1. Vehicular traffic	AP-42; 13.2.1 AP-42, 13.2.2
	2. Portable plants a. Crushing b. Screening c. Material transfers	AP-42; 11.19.2 AP-42;

		11.19.2 AP-42; 13.2.4
	3. Other operations	AP-42; 11

3.4.2 Activity data

The methodologies provided by US EPA with AP-42 require very detailed local data e.g. material silt content, road surface silt content, material moisture content, medium wind speed, mean vehicle weight, mean vehicle speed, vehicle kilometre travelled (VKT) etc. Collection of such data is likely to be possible only for individual large point sources.

4 Data quality

The construction industry involves a large variety of different activities and the conditions under which these occur are in addition highly variable. Estimating fugitive dust emissions is difficult in general and the high variability makes it even more challenging for the construction industry.

The US EPA does not provide a quality rating of its tier 1 methodology for construction, but all supporting documentation states that the results may only be regarded as a first order estimate. Even under the same conditions as those under which the supporting measurements took place (averagely sized construction projects, semi-arid conditions, moderate silt content), the estimated emission is highly uncertain. The option to correct for a different soil moisture and/or silt content may make this methodology in theory applicable to other regions, but this correction method is very simple and as the correction gets larger, the results will likely become even more uncertain. In addition, the methodology was developed for the US where building practices may be structurally different to those in Europe.

The above considerations are reflected in the estimated 95% confidence intervals of the emission factors in Tables 3.1 to 3.4, which are very wide. Based on the available information only a rather subjective estimate of the uncertainty in the emission factors is possible. As a lower limit about 10% (a factor of 0.1) of the emission factor is assumed and as an upper limit approximately 300% (a factor of 3).

Besides the uncertainty of the emission factors there is also considerable uncertainty in the main activity parameter, the total affected area. The uncertainty of the total affected area is the result of uncertainties of various estimation components, the average building footprint and the multiplier to go to from footprint area to affected area being major sources of uncertainty. The lower limit of uncertainty in the affected area is therefore estimated at 50% (i.e. a factor of 0.5) and the upper limit at 300% (i.e. a factor of 3). This uncertainty range may seem high but there is considerable uncertainty in the degree to which the average footprint area for non-residential buildings in particular is representative of the actual situation, which is extremely diverse.

Finally, the various calculation parameters (average duration of the construction; control efficiency of any applied emission reduction measures; the Thornthwaite precipitation-evaporation index and the soil silt content) each have an uncertainty. Collectively these parameters are estimated to result in an additional uncertainty of at least a factor of 2 (up and down).

It is difficult to calculate how these uncertainties propagate in the overall uncertainty of the whole methodology. There may yet be additional methodological uncertainties as well that are currently overlooked. There is a possibility that certain contributions such as by building completion and finishing may be underestimated, or the soil dust contribution might be severely overestimated under wet circumstances (although there are no direct indications for this). Also for the overall uncertainty only a subjective estimate can be made, based on all factors contributing to the overall uncertainty and the fact that uncertainties in individual components tend to average out in the final result, provided that individual uncertainties are independent of each other. The overall lower and upper limits of the whole methodology are estimated at respectively 5 – 10% and 300 – 500% of the best estimate (a very wide range).

In some cases information on the overall contribution of geological dust can be assessed from tracer concentrations in background ambient PM_{10}, such as Si and Al. As fugitive construction emissions are largely geological dust, the overall (background) soil dust contribution to ambient PM_{10} puts an upper limit on the contribution from construction emissions. The fact that there are also other significant sources of soil dust, such as wind-blown dust, agriculture and resuspension by traffic should be taken into account. Since the uncertainty of the contribution from construction activities is so high, calculation of the total soil dust contribution and estimating a soil dust emission strength based on this contribution may provide a welcome means of validation and reduction of the upper uncertainty range.

5 Glossary

EM_{PM10}	PM_{10} emission
EF_{PM10}	the emission factor for this pollutant emission
$A_{affected}$	area affected by construction activity
d	duration of construction
CE	efficiency of emission control measures
PE	Thornthwaite precipitation-evaporation index
s	soil silt content

6 References

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7 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.