Preparatory Work on SLCFs during IPCC AR6 cycle

IPCC Scoping Meeting

Methodology Report on Short-lived Climate Forcers (SLCFs): 2027 Supplement to the 2006 IPCC Guidelines

Brisbane, Australia, 26-28 February 2024

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IPCC TFI TSU

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INTERGOVERNMENTAL PANEL ON climate change

WMO UNEP

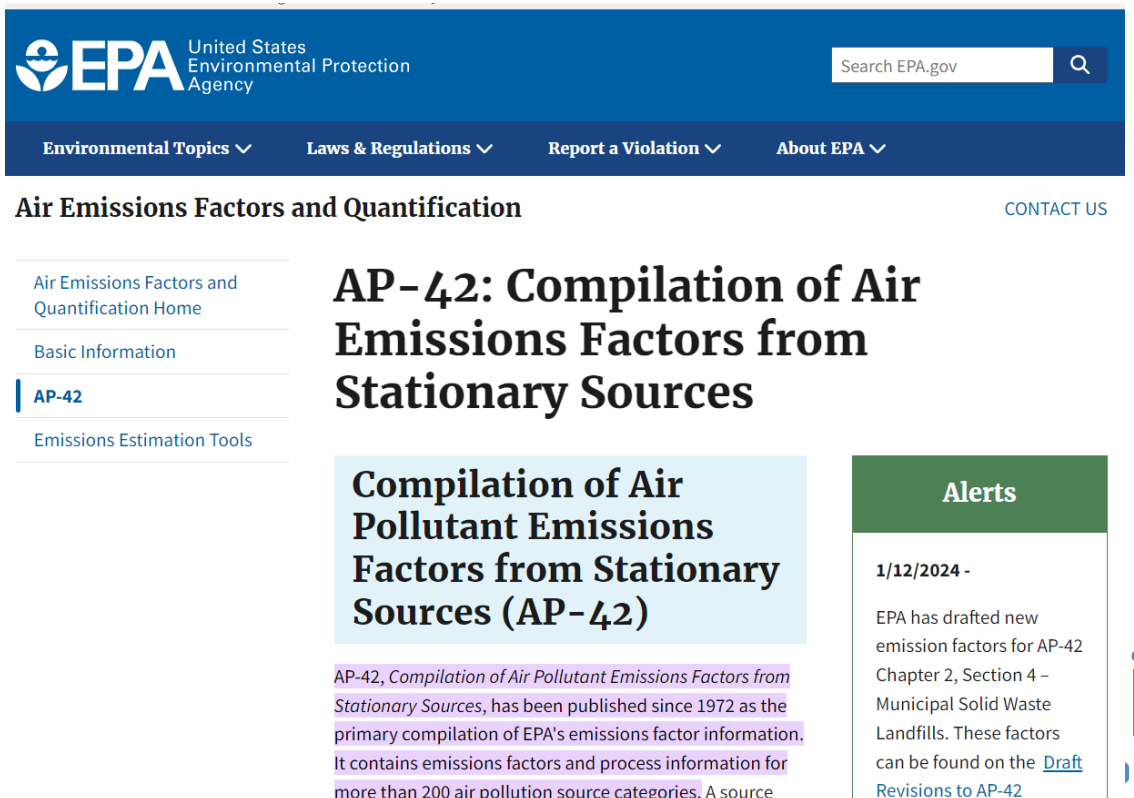
Mandate for Preparatory Work

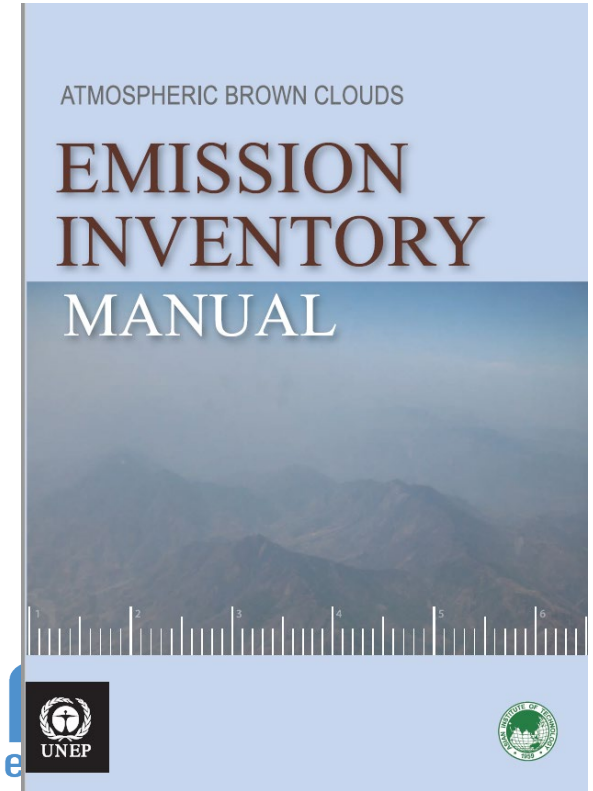
IPCC49 (May 2019, Kyoto, Japan) decided that IPCC TFI should develop a new Methodology Report on SLCFs during AR7 cycle with a preparatory work during AR6 cycle (Decision IPCC-XLIX-7):

- Approach
  - **The preparatory work for the Methodology Report (including supporting materials and scoping) is completed as soon as possible, starting in the AR6 cycle**. Followed by further methodological development in the AR7 cycle
- Output and Timeline
  - **Expert meetings will produce a series of supporting materials to be published**
  - **These supporting materials will be used to inform the scoping of methodological work on SLCF**
  - The scoping meeting will take into consideration the work on SLCF underway in the AR6 reports of WGI and WGIII
  - The outline will be presented for approval to the Panel soon after the scoping meeting
- Required Activities
  - **Technical analysis work by TFI TSU with other experts**
  - **3-4 Expert meetings**
  - Scoping Meeting
  - Approval of outline by the Panel

Technical Analysis

- IPCC TFI TSU conducted extensive technical analysis of the main methodological frameworks on SLCFs source categories and associated emissions:
  - EMEP/EEA Air Pollutant Emission Inventory Guidebook 2019
  - US EPA AP-42: Compilation of Air Pollutant Emissions Factors
  - UNEP Atmospheric Brown Clouds (ABC) Emission Inventory Manual
- This analysis was the basis for discussion at the Joint 1st and 2nd Expert Meeting.





- Part A: general guidance chapters
  - 2 Key category analysis and methodological choice 2019 [833.6 KB]
  - 3 Data collection 2019 [505.6 KB]
  - 4 Time series consistency 2019 [358.7 KB]
  - 5 Uncertainties 2019 [699.2 KB]
  - 6 Inventory management, improvement and QA QC 2019 [818.6 KB]
  - 7 Spatial mapping of emissions 2019 [996.0 KB]
  - 8 Projections 2019 [1.4 MB]
- Part B: sectoral guidance chapters
  - 1. Energy
    - 1.A Combustion
      - 1.A.1 Energy industries [2.5 MB]
      - 1.A.2 Combustion in manufacturing industries and construction [821.6 KI
      - 1.A.3.a Aviation 2019 [1.5 MB]
      - 1.A.3.a Aviation 2 LTO emissions calculator 2019 [3.3 MB]
      - 1.A.3.a Aviation 1 Master emissions calculator 2019 [6.3 MB]
      - 1.A.3.b.i-iv Road transport 2019 [2.9 MB]
      - 1.A.3.b.i-iv Road Transport Appendix 4 Emission Factors 2019 [7.1 MB]
      - 1.A.3.b.v Gasoline evaporation 2019 [1.6 MB]
      - 1.A.3.b.vi-vii Road tyre and brake wear 2019 [497.8 KB]
      - 1.A.3.c Railways 2019 [589.7 KB]
      - 1.A.3.d Navigation (shipping) 2019 [800.7 KB]
      - 1.A.3.e.i Pipeline transport 2019 [60.0 KB]
      - 1.A.4 Small combustion 2019 [3.7 MB]
      - 1.A.4 Non road mobile machinery 2019 [1.6 MB]
      - 1.A.4 Non road mobile machinery Annex [92.1 KB]
    - 1.B Fugitive emissions from fuels

...extensive work...

AP-42, Compilation of Air Pollutant Emissions Factors from Stationary Sources

Chapter	Title
Table of Contents	AP-42 Table of Contents (pdf) (245.4 KB)
Introduction	AP-42 Introduction (pdf) (287.7 KB)
Chapter 1	External Combustion Sources
Chapter 2	Solid Waste Disposal
Chapter 3	Stationary Internal Combustion Sources
Chapter 4	Evaporation Loss Sources
Chapter 5	Petroleum Industry
Chapter 6	Organic Chemical Process Industry
Chapter 7	Liquid Storage Tanks
Chapter 8	Inorganic Chemical Industry
Chapter 9	Food and Agricultural Industries
Chapter 10	Wood Products Industry

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Technical analysis tables

IPCC code	Category	SLCFs	IPCC Method	Alternative methodology	Available EFs/ Parameters	Globally applicable?	Gaps (if any)	Comments
A	B	C	D	E	F	G	H	I
2B Chemical Industry								
2B1	Ammonia production	NOx, NH3, CO, NMVOC, SOx	Yes, with modification, the method is slightly different: fuel and carbon content (IPCC-CO2) per output of ammonia vs. EF of SLCF per output of ammonia		EMEP/EEA, UNEP, US AP-42, REAS, MEP China	Yes		D: In the 2006 IPCC Guidelines, in the case of ammonia production no distinction is made between fuel and feedstock emissions with all emissions accounted for in the IPPU Sector. The method for CO2 and SLCFs is slightly different: input of fuel and its carbon content (IPCC-CO2) by output of ammonia vs. EF of SLCF by output of ammonia (SLCF). F: EMEP/EEA – NOx, CO, NH3. NMVOC - Tier2, Tier 2 - technology specific UNEP – NOx, CO, NH3, SOx, NMVOC US AP-42 – NH3, SO2, CO, NMVOC REAS – NH3 MEP China – NMVOC
2B2	Nitric Acid production	NOx, NH3	Yes		EMEP/EEA, UNEP, US AP-42	**Yes**		F: EMEP/EEA – NOx. UNEP – NOx and NH3 US AP-42 – NOx
2B3	Adipic Acid production	NOx, CO, NMVOC	Yes		EMEP/EEA, UNEP, US AP-42	**Yes**		F: EMEP/EEA – NOx, CO UNEP and US AP-42 – NOx, CO, NMVOC

✓ ***Excerption from IPPU table***

Joint 1st and 2nd IPCC Expert Meeting on SLCFs

- The Joint 1st and 2nd Expert Meeting was held in October 2021 in online format

- Working on the technical documents, the expert meeting successfully achieved its goals:
  - A complete list of SLCF source categories and associated SLCF species for all sectors – ENERGY, IPPU, AFOLU and WASTE
  - List of knowledge gaps in all sectors

- All outcomes (the categories list, gaps list, BOGs discussion and conclusions, presentations and tables for each sector) are part of the meeting report published at the IPCC TFI website: https://www.ipcc-nggip.iges.or.jp/public/mtdocs/2110_SLCF.html

✓ ***The category list will form the future sectoral outline for Chapters/Volumes of the New Methodology Report on SLCFs***

Technical analysis tables

IPCC code	Category	SLCFs	IPCC Method	Alternative methodology	Available EFs/ Parameters	Globally applicable?	Gaps (if any)	Comments
A	B	C	D	E	F	G	H	I
2B Chemical Industry								
2B1	Ammonia production	NOx, NH3, CO, NMVOC, SOx	Yes, with modification, the method is slightly different: fuel and carbon content (IPCC-CO2) per output of ammonia vs. EF of SLCF per output of ammonia		EMEP/EEA, UNEP, US AP-42, REAS, MEP China	Yes		D: In the 2006 IPCC Guidelines, in the case of ammonia production no distinction is made between fuel and feedstock emissions with all emissions accounted for in the IPPU Sector. The method for CO2 and SLCFs is slightly different: input of fuel and its carbon content (IPCC-CO2) by output of ammonia vs. EF of SLCF by output of ammonia (SLCF). F: EMEP/EEA – NOx, CO, NH3. NMVOC - Tier2, Tier 2 - technology specific UNEP – NOx, CO, NH3, SOx, NMVOC US AP-42 – NH3, SO2, CO, NMVOC REAS – NH3 MEP China – NMVOC
2B2	Nitric Acid production	NOx, NH3	Yes		EMEP/EEA, UNEP, US AP-42	**Yes**		F: EMEP/EEA – NOx. UNEP – NOx and NH3 US AP-42 – NOx
2B3	Adipic Acid production	NOx, CO, NMVOC	Yes		EMEP/EEA, UNEP, US AP-42	**Yes**		F: EMEP/EEA – NOx, CO UNEP and US AP-42 – NOx, CO, NMVOC

Category List

IPCC code	Category	SLCFs	Comments
A	B	C	I
2B Chemical Industry			
2B1	Ammonia production	NOx, NH3, CO, NMVOC, SOx	In the 2006 IPCC Guidelines, in the case of ammonia production no distinction is made between fuel and feedstock emissions with all emissions accounted for in the IPPU Sector. The method for CO2 and SLCFs is slightly different: input of fuel and its carbon content (IPCC-CO2) by output of ammonia vs. EF of SLCF by output of ammonia (SLCF). EMEP/EEA – NOx, CO, NH3. NMVOC - Tier2, Tier 2 - technology specific UNEP – NOx, CO, NH3, SOx, NMVOC US AP-42 – NH3, SO2, CO, NMVOC REAS – NH3 MEP China – NMVOC
2B2	Nitric Acid production	NOx, NH3	EMEP/EEA – NOx. UNEP – NOx and NH3 US AP-42 – NOx
2B3	Adipic Acid production	NOx, CO, NMVOC	EMEP/EEA – NOx, CO UNEP and US AP-42 – NOx, CO, NMVOC

Knowledge Gaps – IPPU Example

General gaps:

- Lack of AD, additional or different AD can be needed for SLCFs than to GHGs
- Abatement techniques and efficiencies
- Availability of regional or country specific EFs for all SLCFs
- Definition of BC and OC emissions, measurements standards, availability of EFs for BC and OC, and documentation of EFs with indication of measurement standards
- Definition of VOC (NMVOC), speciation
- Allocation of energy and process emissions, in terms of disaggregation between different processes
- No agreed climate metrics for SLCFs

Categories gaps:

- 2A2 Lime production – Data collection by type of kiln, and abatement
- 2B8f Carbon black – BC and OC from diffuse emissions, NMVOCs from storage tanks
- 2C1 Iron and Steel – Fugitive PM emissions, SO2 from desulfurization, PM and SO2 from foundries, PM, OC, EC, CO and VOCs from scrap preparation. Rolling mills – SO2 from use of volatile halogenated organics (VHO)
- 2C5 Lead production and 2C6 Zinc production – Data collection of domestic industries (processes, abatement, raw material)
- 2C7 Other (Copper) – SO2 from acid mist
- 2D3 Solvent use (Domestic solvent use) – Guidance on how to collect AD and on how to estimate AD if there are no statistics (e.g. modelling from a similar country etc.)
- 2D3 Solvent use (Coating application and Degreasing) – AD
- 2D3 Solvent use (Printing) – Collection of AD (use of ink and/or applied abatement techniques, default efficiencies for abatement are provided in EMEP/EEA)
- 2D3 Solvent use (Other Solvent use) – AD capita or product/solvent use
- 2D4 Other (Asphalt Roofing) – SO2 emissions in roofing materials
- 2F Product Uses as Substitutes for Ozone Depleting Substances – NH3, NMVOC – Methods, AD, EFs
- 2H1 Pulp and Paper Industry – Updated EFs

3rd IPCC Expert Meeting on SLCFs

- The 3rd Expert Meeting further considered issues identified at the Joint 1st and 2nd Meeting and discussed cross-cutting issues in relation to the inventory of SLCFs emissions taking into account the assessments in the IPCC WGI and WGIII contributions to AR6

- It was held in April 2022 in online format

- The discussion was focused on three main topics:
  - Definitions of SLCF species and methods of their identification/quantification
  - General inventory issues (Data Collection, Key Category Analysis, Uncertainty Analysis, Verification, etc.)
  - Refined Category and Gaps' lists

✓ ***Possible issues for Volume 1 of the New Methodology Report on SLCFs – General Issues***

The meeting report was published on the IPCC TFI website:
https://www.ipcc-nggip.iges.or.jp/public/mtdocs/2204_SLCF_EM3.html

3rd IPCC Expert Meeting on SLCFs

- The 3rd Expert Meeting concluded, among others:
  - Most BC/OC emission estimates derive from $PM_{2.5}$, so $PM_{2.5}$ information is generally available
  - The priority for NMVOC reporting is to report the total mass of VOC *[not by species]*
  - Prioritization should be conducted by source category considering all "air pollutant SLCFs" (i.e. BC, OC, NO_X, SO_2, NH_3, NMVOCs, CO) *[all species are important]*
  - It is **not** recommended to use metrics to compare long-lived GHGs with SLCFs, thus those cannot be combined in a unique KCA
  - Given that sources of SLCF emissions are inherently variable and SLCF emissions are impacted by environmental conditions, consideration of spatial and temporal occurrence of emissions to relate those with climatic factors will be important in developing representative emission factors and methodologies. So, although SLCF information should be reported at minimum national and on an annual basis, finer regional disaggregation or full spatialization of emissions data along with their seasonality might therefore be needed to capture SLCF emissions accurately for some sources across all regions of the globe.

Outputs of the Joint 1st & 2nd and 3rd IPCC Expert Meetings on SLCFs

- The following materials were produced:
  - A complete list of inventory categories with respective SLCF species
  - Summary tables with relevant information on methods and EFs availability for each category from:
    - ✓ *EMEP/EEA Air Pollutant Emission Inventory Guidebook 2019*
    - ✓ *US EPA AP-42: Compilation of Air Pollutant Emissions Factors*
    - ✓ *UNEP Atmospheric Brown Clouds (ABC) Emission Inventory Manual*
  - A list of knowledge gaps
  - A list of allocation issues between different sectors
  - A note on SLCF species definition and relevance
  - A note on general inventory issues
  - A consolidated version of Volume 1 of the 2006 IPCC Guidelines and its 2019 Refinement
  - English Translation of SLCF methodologies used in China

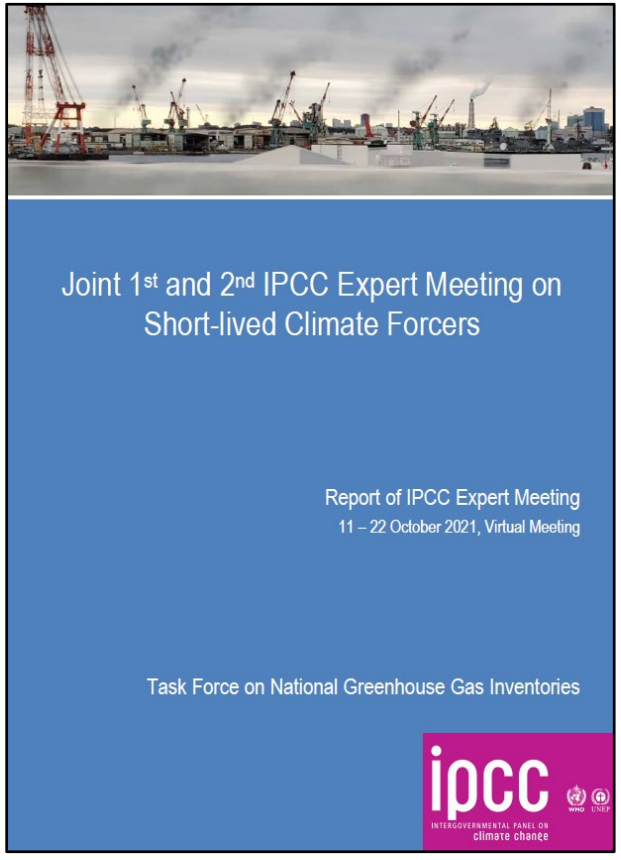
Category List: Energy

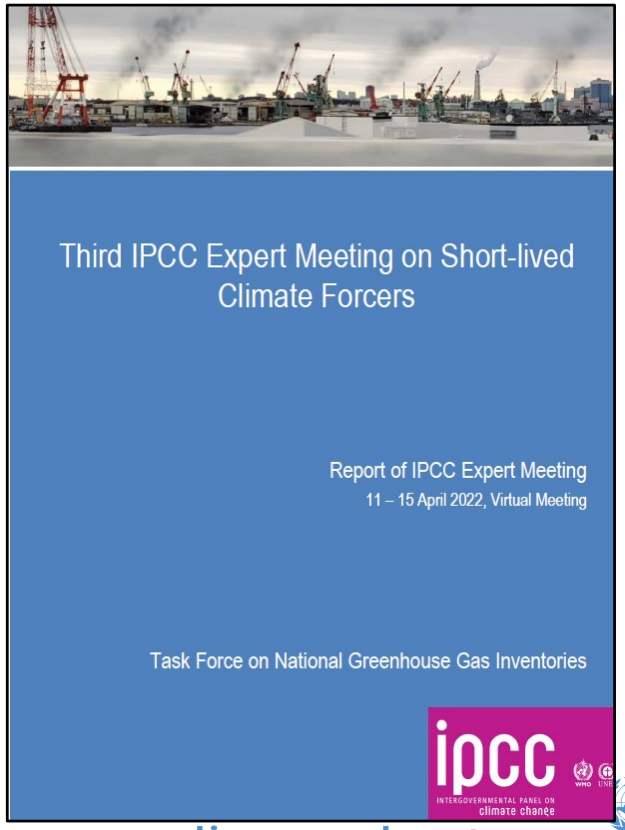
IPCC categorization	Category	SL			
		NO_x	NH_3	SO_2	CC
1	ENERGY				
1.A	Fuel combustion activities				
1.A.1	Energy Industries				
1.A.1.a.	Main activity electricity and heat production	X	X	X	X
1.A.1.b.	Petroleum refining	X	X	X	X
1.A.1.c.	Manufacture of solid fuels and other energy industries				
1.A.1.c.i.	Manufacture of solid fuels	X	X	X	X
1.A.1.c.ii.	Other energy industries	X	X	X	X
1.A.2	Manufacturing industries and construction				
1.A.2.a.	Iron and steel	X	X	X	X
1.A.2.b.	Non-ferrous metals	X	X	X	X
1.A.2.c.	Chemicals	X	X	X	X
1.A.2.d.	Pulp, paper and print	X	X	X	X
1.A.2.e.	Food processing, beverages and tobacco	X	X	X	X
1.A.2.f.	Non-metallic minerals	X	X	X	X
1.A.2.g.	Transport equipment	X	X	X	X
1.A.2.h.	Machinery	X	X	X	X
1.A.2.i.	Mining (excluding fuels) and quarrying	X	X	X	X
1.A.2.j.	Wood and wood products	X	X	X	X
1.A.2.k.	Construction	X	X	X	X
1.A.2.l.	Textile and leather	X	X	X	X
1.A.2.m.	Non-specified industry	X	X	X	X
1.A.3.	Transport				
1.A.3.a.	Civil aviation				
1.A.3.a.i.	international aviation (international bunkers)	X		X	X
1.A.3.a.ii.	Domestic aviation	X		X	X
1.A.3.b.	Road transportation				
1.A.3.b.i.	Cars	X	X	X	X
1.A.3.b.ii.	Light duty trucks	X	X	X	X
1.A.3.b.iii.	Heavy duty trucks and buses	X	X	X	X
1.A.3.b.iv.	Motorcycles	X	X	X	X
1.A.3.b.v	Evaporative emissions from vehicles				
1.A.3.b.vi	Urea-based catalysts	X	X	X	X
	Non-exhaust emissions				
	Use of lubricants	X	X	X	X
1.A.3.c.	Railways	X	X	X	X
1.A.3.d.	Waterborne navigation				
1.A.3.d.i.	international waterborne navigation (international bunkers)	X	X	X	X
1.A.3.d.ii.	Domestic waterborne navigation	X	X	X	X
1.A.3.e.	Other transportation				
1.A.3.e.i	Pipeline transport	X	X	X	X
1.A.3.e.ii.	Off-road	X	X	X	X
1.A.4.	Other Sectors				
1.A.4.a.	Commercial/institutional				
1.A.4.a.i.	Stationary combustion	X	X	X	X
1.A.4.a.ii.	Off-road vehicles and other machinery	X	X	X	X
1.A.4.b.	Residential				
1.A.4.b.i.	Stationary combustion	X	X	X	X
1.A.4.b.ii.	Off-road vehicles and other machinery	X	X	X	X
1.A.4.c.	Agriculture/forestry/fishing				
1.A.4.c.i.	Stationary	X	X	X	X
1.A.4.c.ii.	Off-road vehicles and other machinery	X	X	X	X
1.A.4.c.iii.	Fishing (mobile combustion)				
1.A.5	Other (Not specified elsewhere)				
1.A.5.b.ii.	Mobile (waterborne component)				
1.A.5.b.iii.	Mobile (other)				
1.B	Fugitive emissions from fuels				
1.B.1	Solid fuel				
1.B.1.a.	Coal mining and handling				
1.B.1.a.i	Underground mines				
1.B.1.a.i.1	Mining				
1.B.1.a.i.2	Post-mining seam gas emissions				
1.B.1.a.i.4	Flaring of drained CH4 or conversion of CH4 to CO2				
1.B.1.a.ii	Surface mines				
1.B.1.a.ii.1	Mining				
1.B.1.a.ii.2	Post-mining seam gas emissions				
1.B.1.c.	Fuel transformation				
1.B.1.c.i.	Charcoal and biochar production				
1.B.1.c.ii.	Coke production				
1.B.2	Oil and natural gas				
1.B.2.a	Oil				
1.B.2.a.i.	Exploration	X		X	X	X	X	X
1.B.2.a.ii.	Production and upgrading	X		X	X	X	X	X
1.B.2.a.iii.	Transport					X		
1.B.2.a.iv.	Refining	X	X	X	X	X	X	X
1.B.2.a.v.	Distribution of oil products					X		
1.B.2.a.vi	Other					X		
1.B.2.b	Natural gas							
1.B.2.b.i.	Gas exploration	X		X	X	X	X	X
1.B.2.b.ii.	Production and gathering	X		X	X	X	X	X
1.B.2.b.iii.	Processing	X	X	X	X	X	X	X
1.B.2.b.iv.	Transmission and storage					X		
1.B.2.b.v.	Gas distribution					X		
1.B.2.b.vi.	Gas post-meter					X		
1.B.3	Other emissions from energy production							
1.B.3.a.	Other							
	Geothermal energy extraction		X	X				

Note on SLCF species – Example for Black Carbon

Black Carbon	
Black carbon (BC) is the most strongly light-absorbing component of particulate matter, and is formed by the incomplete combustion of fossil fuels, biofuels and biomass[10]. Properties are: absorbing visible light at all wavelength and with a mass absorption coefficient (MAC) of *5–15 m 2 g−1 at 550 nm; insoluble in water -and common organic solvents, acids and bases-, refractory to thermal decomposition at 4000 K, aggregate morphology (carbon spherules). Many analytical protocols exist for determining BC content by thermal, chemical, molecular marker or optical methods. The choice of method depends on the nature of the matrix being analysed and on the equipment available in the laboratory. Further, matrix-specific methods are needed for soils or sediments (to access historical deposition and reconstruct past emissions)[11] Many common measurement methods do not quantify this material specifically, instead reporting a proxy like light absorption or refractory component, with names like "effective black carbon" (eBC) or "elemental carbon" (EC). EPA's National Emissions Inventory and SPECIATE particulate matter composition database use EC to represent BC. Analytical differences create uncertainty in emission factors and predicted light absorption[12]	
1. Definition:	A solid form of mostly pure carbon that absorbs solar radiation at all wavelengths and is produced by incomplete combustion (Black Carbon Report to Congress, 2012).
2. Measurement methods:	Different methods applied to measure BC provides for different BC types: ✓ *Based on light absorption (equivalent black carbon[13] - eBC[14]): Aethalometers, Light absorption/reflectance (MAAP), CLAP, PSAP, denuder/light absorption (COSMOS[15] or BCM); Photo-acoustic (PASS)* ✓ *Based on r refractory[16] properties (refractory black carbon - rBC): Laser induced incandescence, SP2;* ✓ *Based on combustion properties: (elemental carbon - EC): Thermo-optical (TOT);* Or as a fraction of $PM_{2.5}$
Reference/Source:	Caria et al. 2011 http://dx.doi.org/10.1111/j.1475-2743.2011.00349.x Bond et al. 2006 https://www.tandfonline.com/doi/full/10.1080/02786820500421521 Chow et al. 2004 https://pubs.acs.org/doi/10.1021/es034936u Chow et al. 2007 https://www.tandfonline.com/doi/pdf/10.3155/1047-3289.57.9.1014 Gysel et al. 2011 https://amt.copernicus.org/articles/4/2851/2011/ Kondo et al. 2011 https://www.tandfonline.com/doi/full/10.1080/02786826.2010.533215 Petzold et al. 2013 https://acp.copernicus.org/articles/13/8365/2013/acp-13-8365-2013.html; https://acp.copernicus.org/preprints/13/9485/2013/acpd-13-9485-2013.pdf Pileci et al. 2021 https://amt.copernicus.org/articles/14/1379/2021/

Meeting Reports





https://www.ipcc-nggip.iges.or.jp/public/mtdocs/1805_Geneva.html
https://www.ipcc-nggip.iges.or.jp/public/mtdocs/2110_SLCF.html
https://www.ipcc-nggip.iges.or.jp/public/mtdocs/2204_SLCF_EM3.html

Conclusion

- The participants are able to benefit from the preparatory work in the AR6 cycle:
  - Technical analysis work
  - Expert meetings with supporting materials

- Based on the results of the preparatory work, IPCC TFB drafted the documents for the Scoping meeting. The most important of them is the Table of Contents (general and sectoral outline) of the Methodology report on SLCFs.
  - ✓ *see the next presentation*

Thank you

https://www.ipcc-nggip.iges.or.jp/index.html

https://www.ipcc-nggip.iges.or.jp/meeting/meeting.html

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