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Discussion Paper on the Work of the North-East Asia Clean Air Partnership (NEACAP): Emissions Inventory[1]

[1] This discussion paper has been prepared by Professor Jung-Hun Woo in collaboration with the NEACAP Secretariat, but information and assessment in the paper are those of the author.

Executive Summary

The expected work of NEACAP requires a common information basis of air pollution emissions and related factors to support scientific assessment, policy dialogue, and technical cooperation. A key information basis is the Emission Inventory that provides decision-makers with the information of total air pollutants emitted each year by each activity sector (anthropogenic and natural) and allows monitoring emission reduction efforts and trends for a given sector and country.

In particular, an Emission Inventory could support (a) quantifying the major activity sectors or those that influence local and regional air pollution patterns, (b) following emission trends over time and assessing the impact of control strategies, (c) providing information for raising awareness of the general public, (d) checking compliance with ceiling objectives set by local and national policies, (e) comparing and assessing the impact of different emission reduction options, and (f) providing inputs to chemistry-transport models.

In North-East Asia, there exist multiple regional emission inventories, notably, the Comprehensive Regional Emissions inventory for Atmospheric Transport Experiments (CREATE), Regional Emission inventory in Asia (REAS) 2.1 and MIX. Inter-comparison of multiple emission inventories by year for NEACAP countries shows relatively high differences among the inventories. This is due to different objective, framework and data source. The assessments and consultations towards NEACAP indicated the need for developing and improving a subregional inventory that provides accurate, complete, and up-to-date data with a common methodology for comparability between national data. Furthermore, supporting policy-oriented studies requires a more comprehensive set of data that includes not only the emission data of each pollutant, but also socio-economic parameters including indicators of economy, technology, energy, etc. The review of the advanced regional emission inventory and technical supporting frameworks under CLRTAP shows how its Center on Emission Inventories carries out the data collection, QA/QC and technical support for its Parties, and provides data for modeling work and assessment.

In this regard, the paper proposes to the direction of NEACAP Emission Inventory as follows: a) developing the emission inventory with activity-based data and information submitted by member Countries, (b) supporting Integrated Assessment Modeling, and (c) supporting the Scientific Assessment Report and other frameworks such as EANET, LTP, GEMS, etc. The paper also presents the need and role of a coordination body, the NEACAP Working Group for Emissions Inventory (WGEI), and a dedicated center, Emission Inventory Technical Center (EITC).

I. Existing Emission Inventories in Northeast Asia

In North-East Asia, multiple regional emission inventories, notably, the Comprehensive Regional Emissions inventory for Atmospheric Transport Experiments (CREATE), Regional Emission inventory in Asia (REAS) 2.1 and MIX, cover the geographical domain of NEACAP members (Table 1). MIX combines REAS and the best available national inventories of MEIC (Mainland China), JEI-DB (Japan), and CAPSS (ROK) (Figure 1) and includes other countries in Asia. CREATE serves as the emission inventory for the source-receptor relationship modelling under Long-Range Transboundary Air Pollutants in North-East Asia (Li et al, 2017).

1.1 Description of notable emission inventories in Asia

MIX: The MIX inventory is developed for the years 2008 and 2010 to support the Model Inter-Comparison Study for Asia (MICS-Asia) and the Task Force on Hemispheric Transport of Air Pollution (TF HTAP) by a mosaic of up-to-date regional emission inventories. Emissions are estimated for all major anthropogenic sources in 29 countries and regions in Asia. Five emission inventories are collected and incorporated into the mosaic inventory, as listed in the following: REAS inventory version 2.1 for the whole of Asia (Kurokawa et al., 2013), the Multiresolution Emission Inventory for China (MEIC) developed by Tsinghua University (http://www.meicmodel.org), a high resolution NH3 emission inventory by Peking University (PKU-NH3 inventory; Huang et al., 2012), an Indian emission inventory developed by Argonne National Laboratory (referred to as ANL-India hereafter; Lu et al., 2011; Lu and Streets, 2012), and the official Korean emission inventory from the Clean Air Policy Support System (CAPSS; Lee et al., 2011).

The different emission datasets for various species for each country were selected by the following hierarchy. REAS2 was used as the default where local emission data are absent. Emission inventories compiled by the official agencies or developed with more local information are selected to override REAS2, which include MEIC for mainland China, ANL-India for India, and CAPSS for the Republic of Korea (Li et al, 2017).

REAS: The Regional Emission inventory in ASia (REAS) version 2.1 updated the REAS version 1.1 for both activity data and emission factors by each country and region using global and regional statistics and recent regional specific studies on emissions factors. Improved from its previous version, power plant emissions in REAS2 were estimated by combining information on generation capacity, fuel type, running years, and CO2 emissions from the Carbon Monitoring for Action database (CARMA; Wheeler and Ummel, 2008) and the World Electric Power Plants database (WEPP; Platts, 2009). REAS2 extended the domain to include emissions of Central Asia and the Asian part of Russia (referred to as Russia Asia). Readers can refer to Kurokawa et al. (2013) for detailed data sources of activity rates and emission factors assignments for each country and source type. REAS2 is available for the period of 2000–2008. REAS2 also incorporated a few regional inventories developed by local agencies with detailed activity data and emission factors, including the JEI-DB inventory (Japan Auto-Oil Program (JATOP) Emission Inventory-Data Base; JPEC, 2012a, b, c) for all anthropogenic sources in Japan excluding shipping, OPRF (Ocean Policy Research Foundation; OPRF, 2012) for shipping emissions in Japan, CAPSS emission inventory for ROK (Lee et al., 2011), and official emission data from the Environmental Protection Administration of Taiwan for Taiwan (Kurokawa et al., 2013). All these regional datasets were then harmonized to the same spatial and temporal resolution in REAS2. Emissions are estimated for each country and region using updated activity data and parameters. Monthly gridded data with a $0.25^{\circ} \times 0.25^{\circ}$ resolution are also provided (Li et al., 2017; Kurokawa et al., 2013).

CREATE: The NIER/KU-CREATE (Comprehensive Regional Emissions inventory for Atmospheric Transport Experiment) was developed in support of the various aircraft filed campaigns and air quality modeling researches. For anthropogenic emissions, it has 54 fuel classes, 201 sub-sectors and 13 pollutants, including CO_2, CH_4, N_2O, SO_2, NO_x, CO, NMVOC, NH_3, OC, BC, PM_{10}, $PM_{2.5}$, and mercury. Since the CREATE emissions framework was developed using the Integrated climate and air quality Assessment Modeling (IAM) framework (i.e. GAINS) and is fully connected with the comprehensive emission processing/modeling systems (i.e. SMOKE, KU-EPS, and MEGAN), it can be effectively used in support of various climate and air quality integrated modeling analysis and field experiments. For the field campaigns, we are providing modeling emissions inventory to participating air quality models, such as CMAQ, WRF-Chen, CAMx, GEOS-Chem, MOZART, for forecasting and post-analysis modes (Woo et al., 2013; Woo et al., 2018).

KORUS-AQ: The year 2015 KORUS-AQ emission inventory, which was developed at Konkuk University, was developed in support of NIER/NASA KORUS-AQ aircraft field campaign. Emissions are estimated for all major anthropogenic sources and biogenic sources in Asia. Five emission inventories are combined to develop a mosaic inventory, as listed in the following: CREATE for the entire Asia, CAPSS for ROK, MEIC for China, REAS for Japan, ANL-India for India. The KORUSv5 EI geographically covers all of Asia and uses the Sparse Matrix Operator Kernel Emissions (SMOKE-Asia) emissions processing (Woo et al., 2012) and SAPRC-99 chemical mechanism (W. Carter, 1999). The inventory reports CO, NH_3, NO_x, $PM_{2.5}$, PM_{10}, SO_2 and VOCs on a 3 km grid resolution for the Republic of Korea and does not include biogenic VOC sources.

LTP: LTP inventory is the Northeast Asia regional emission inventory based on the submission of national emission from Korea, China, Japan and Asian emissions inventory - CREATE. LTP is the name of the Joint Research Project for Long–range Transboundary Air Pollutants in Northeast Asia, which was established in 1996 to promote common understanding of mechanism of transboundary movement of pollutants, among the ministry of environment of Korea, China, and Japan. The objectives of the LTP project are to study the state of air quality, the influence of neighboring countries, and the policy making of each country to improve the air quality. As KORUS-AQ EI, LTP inventory also uses SMOKE-Asia emissions processing system to generate modeling emissions inventory. The list of inventory pollutants is CO, NH_3, NO_x, $PM_{2.5}$, PM_{10}, SO_2 and VOCs (LTP webpage, https:// eng.me.go.kr /).

MEIC: Multi-resolution Emission Inventory (MEIC) is a technology-based bottom-up air pollutant and greenhouse gases inventories from anthropogenic sources, which is developed and maintained on the basis of the cloud computing platform by Tsinghua University. MEIC is a comprehensive model for emission inventory development, including source categorization, emission factor database, technology-based method and high-resolution emission processing system on the cloud computing platform. The MEIC model is developed under six anthropogenic emission categories, including stationary combustion, industrial processes, mobile sources, solvent utilization, agricultural sources, and waste disposal. For each source category, the emissions can be further divided by different sectors, fuel types/products, combustion/production technology, and end-of-pipe control devices. The latest version of MEIC covers more than 700 anthropogenic emission sources (MEIC webpage: http://www.meicmodel.org/).

CAPSS: To accurately and realistically estimate administrative district level air pollutant emissions of the Republic of Korea, we developed a Korean Emissions Inventory System named the Clean Air Policy Support System (CAPSS). In CAPSS, emissions sources are classified into four levels. Emission factors for each classification category is collected from various domestic and international research reports, and the CAPSS utilizes various national, regional and local level statistical data, compiled by approximately 150 Korean organizations. Both direct and indirect methods were used for point sources depending on the available real-time emissions data (CEMS database). For the estimation of emissions from area sources, we used an indirect method utilizing various data from organizations in ROK. Total emissions from on-road mobiles sources per vehicle type were estimated by summing emissions from three subcategories, hot engine operation, cold start and fuel evaporation. Total emissions from non-road mobiles sources were estimated by summing emissions from the five sources of railways, ships, aircrafts, agricultural machinery and construction machinery(Lee et al., 2011; NIER, 2017; AIREMISS webpage: http://airemiss.nier.go.kr/).

JEI-DB: Japan emissions inventory named as the Japan Auto Oil Program (JATOP) Emission Inventory Data Base (JEI DB) were developed by JPEC (2012a, 2012b, 2012c). JEI DB includes vehicle emissions in 2000, 2005, and 2010 and non-vehicle emissions in 2000 and 2005 for SO_2, NO_x, CO, NMVOC, PM_{10}, and NH_3, with monthly variations and spatial resolution of 1km.

GLOBAL INVENTORY

- EDGAR (Emission Database for Global Atmospheric Research) – HTAP (Hemispheric Transport of Air Pollution) Emission Inventory: MIX, GAINS, EMEP, UNFCCC

REGIONAL INVENTORY in East Asia

- Greenhouse Gas-Air Pollution Interactions and Synergies (GAINS) Asia
- MIX Inventory: REAS, MEIC, CAPSS, ANL-India, PKU-NH_3
- KORUS-AQ Inventory: CREATE, MEIC, CAPSS, JEI-DB, SEAC4RS
- LTP Inventory: CAPSS, CRAES, JEI-DB, CREATE
- Regional Emission Inventory in Asia (REAS)
- Comprehensive Regional Emissions inventory for Atmospheric Transport Experiments (CREATE)
- Intercontinental Chemical Transport Experiment-Phase B (INTEX-B)

NATIONAL INVENTORY

- China Multi-resolution Emission Inventory (MEIC)
- Japan Auto-Oil Program Emission Inventory-Data Base (JEI-DB)
- ROK Clean Air Policy Support System (CAPSS)
- Annual overview of air emissions from major settlements and federal subject of the Russian Federation (by SRI Atmosphere)
- Annual compilation of air pollutants (by Mongolia National Agency for Meteorology and Environmental Monitoring)

Figure 1. Overview of emission inventories

They are also gridded emission inventories that describe the geographical distribution of emissions, present maps of emissions, facilitate communication with the public, and feed chemistry-transport models. However, there are significant challenges in the timely update as shown in Table 1, as well as uncertainty originating from inaccurate activity data, emission factors depending on location or emission sources, and temporal/spatial allocation of total emissions. This uncertainty needs to be well addressed to enable more accurate scientific assessment and policy development.

Table 1. Overview of regional emission inventories

Inventory	Geographical Scope /Type	Spatial (deg)	Temporal	Years	Sector / Pollutants
EDGARv4.2	Global/Activity	0.1x0.1	Annual	1970~2008	Anthropogenic / Biom. burning / Int. shipping / Aviation CO_2, CH_4, N_2O, F-gas, CO, NOx, SO_2, NH_3, VOCs, PM_{10}
RCPs EI	Global/Activity	0.5x0.5	Monthly (bydecade)	2000 – 2100	Anthropogenic / Biom. burning / Int. shipping / Aviation CO_2, CH_4, N_2O, F-gas, BC, OC, CO, NOx, SO2, NH_3, VOC
ECLIPSE	Global/Activity	0.1x0.1	Annual /Monthly	1990-2050	Anthropogenic (All GHGs, APs) CO_2, CH_4, N_2O, CO, NOx, NMVOC, NH_3, PM10, PM2.5, SO_2
TRACE-P	Asia/Activity	0.5x0.5	Annual	2000	Anthropogenic/Biomass burning/International shipping SO_2, NOx, CO, NMVOC, NH_3, OC, BC, CO_2, CH_4
INTEX	Asia/Activity(Mosaic)	0.5x0.5	Annual	2006	Anthropogenic: SO_2, NOx, CO, NMVOC, OC, BC, PM_{10}, $PM_{2.5}$
REAS	Asia + Russia /Activity(Mosaic)	0.25x0.25	Monthly	2000-2008	Anthropogenic: SO_2, NOx, CO, NMVOC, PM10, PM2.5, BC, OC, NH_3, CH_4, N_2O, and CO_2 Soil NOx and others
CREATE	Asia + Russia /Activity	0.1x0.1	Annual	2010,2015	Anthropogenic/BiomBurning/Biogenic CO_2, CH_4, N_2O, CO, NOx, NMVOC, NH_3, PM10, PM2.5, SO_2
MICS-Asia (MIX)	Asia + Russia /Mosaic	0.25x0.25	Monthly	2008, 2010	Anthropogenic: SO_2, NOx, CO, NMVOC, NH_3, CO_2, PM2.5, PMC, BC, OC
KORUS-AQ	Asia+Russia /Mosaic	0.1x0.1	Monthly	2015	Anthropogenic/Biogenic: SO_2, NOx, CO, NMVOC, NH_3, CO_2, PM2.5, PM10, BC, OC
LTP	Korea, China, Japan, and Northeast Asia	0.1x0.1	Monthly	2017(China) ,2015(Korea , Japan)	Anthropogenic/Biogenic: SO_2, NOx, CO, NMVOC, NH_3, PM2.5, PM10
MEIC	China/Activity	0.25x0.25	Monthly	2012-2015	Anthropogenic: SO2, NOx, CO, NMVOC, NH3, CO2, PM2.5, PM10, BC, OC
JEI-DB	Japan/Activity	1kmx1km	Monthly	2000, 2005,2010	Anthropogenic: CO, NOx, NMVOC, NH_3, PM10, PM2.5, SO_2
CAPSS	ROK /Activity	1kmx1km	Annual	1999-2016	Anthropogenic: CO, NOx, NMVOC, NH_3, TSP, PM10, PM2.5, SO_2

1.2 Characteristics of existing emission inventories in Northeast Asia

Figure 2 shows the inter-comparison results of multiple bottom-up emission inventories for each NEACAP member countries. Even though emissions amounts are different by inventory, most pollutant emissions show a decreasing trend from 2008 to 2015, except for NMVOCs and NH_3. The

MEIC 2015 is considered the most reliable bottom-up emissions inventory in China and shows similar estimates to CREATE Ver. 3.0 other than SO_2, NMVOCs, and NH_3. This is due to faster implementation of emission reduction policies (for SO2) and larger growth of volatile material use, such as paint and gasoline (for VOCs). Other East Asian countries—such as DPRK, Mongolia, and Russia—also contribute to transboundary air quality impacts in ROK even though their contribution would be relatively smaller (J.-H. Woo, 2019).

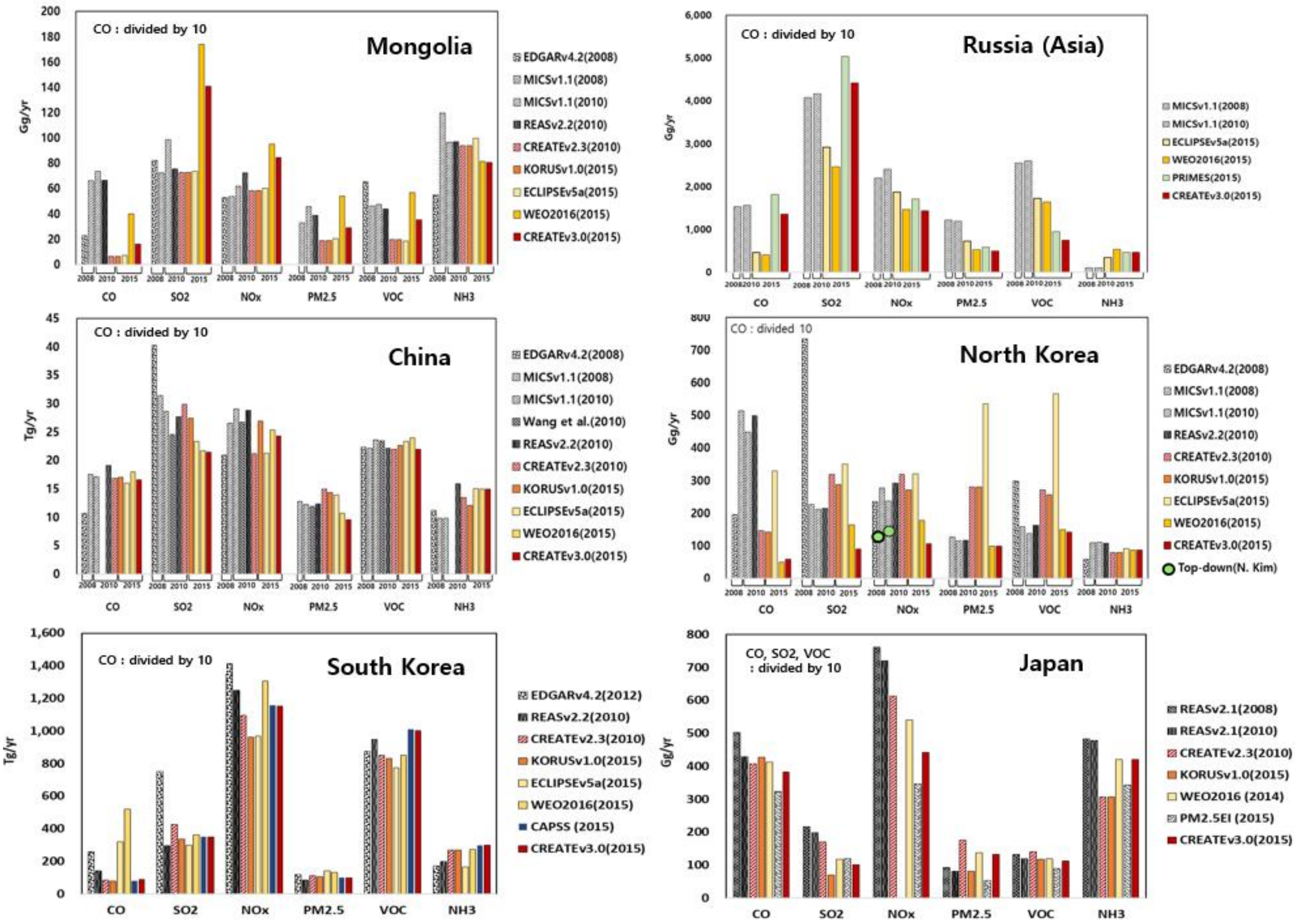


Figure 2. Inter-comparison of multiple bottom-up emission inventories for NEACAP countries

Inter-comparison of multiple emission inventories by year for NEACAP countries shown in the Figure 2 has relatively high differences among the inventories. We therefore inter-compare bottom - up emissions against top-down estimates from the ESA GlobeEmissions to enhance our understanding (Figure 3). For China, the CREATE 2015 NOx emissions show 19% and 14% higher estimates than OMI-based and GOME-based top-down emissions, respectively, from GlobeEmissions-DECSO. NO_x Emissions in DPRK show only 12% difference compare to OMI-based top-down emissions in year 2015, which is much better agreement than year 2010 estimates. For ROK, NO_x emission from the bottom-up and top-down emissions show good agreement over the country. Because the energy activity information for DPRK would be highly uncertain, the uncertainty of emission estimation is also expected to be high. China emissions show higher differences in the scenario emissions but fairly well matched with top-down estimates in the other emission scenario. Recent emission reduction by very aggressive air quality policy penetration in China would explain such differences in agreements by scenario and by period. Performances of air quality modeling based on multiple KORUS-AQ participating models are shown in the Figure 4. Not only emissions inventory but spatio-temporally and chemically resolved modeling emissions are very important parameter to support and understand successful air quality modeling. Feedback between emissions inventory and air quality modeling/monitoring communities was a key to improve the quality of emissions information.

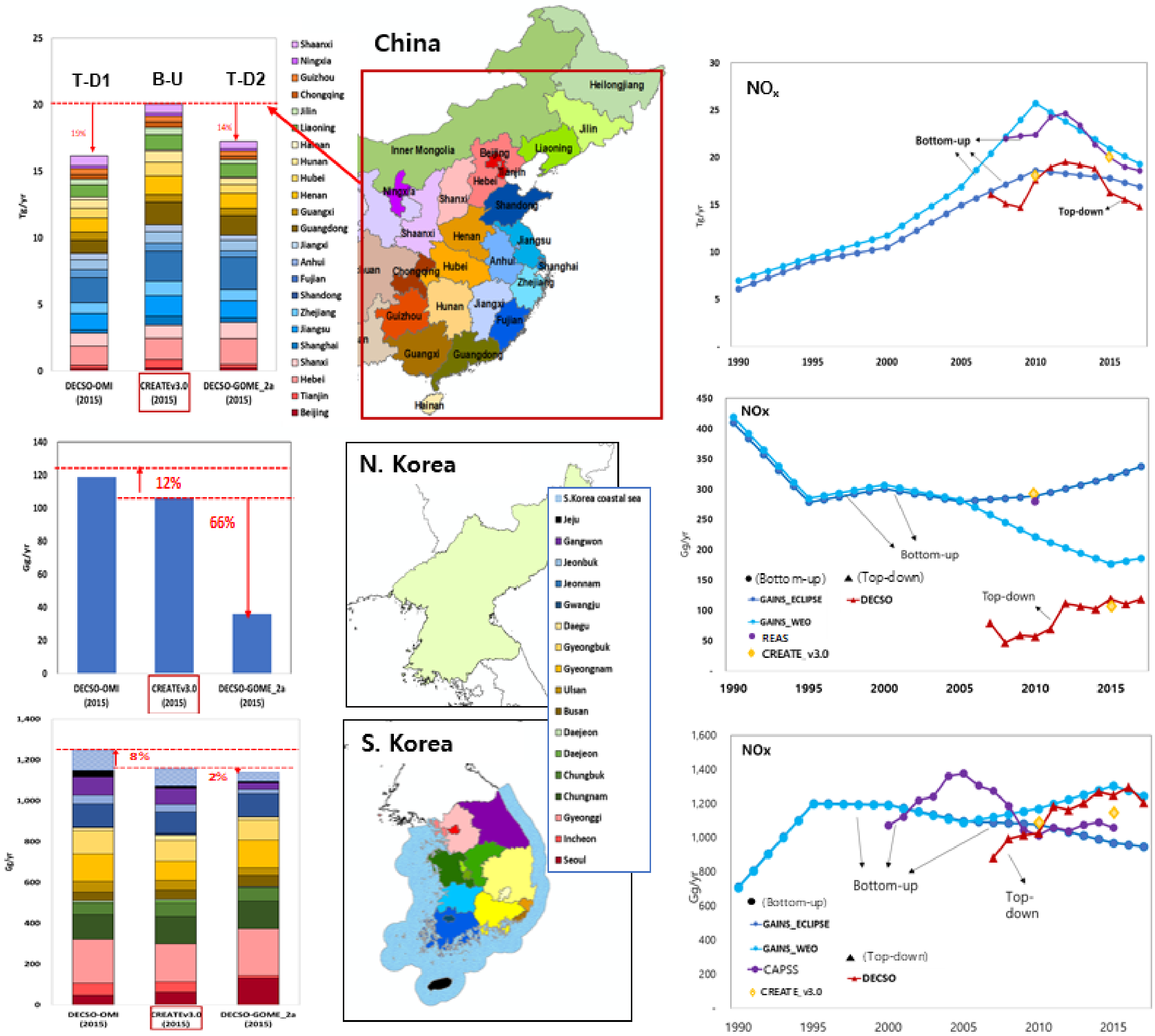


Figure 3. Inter-comparison of bottom-up and top-down emission inventories for China, DPRK, and ROK.

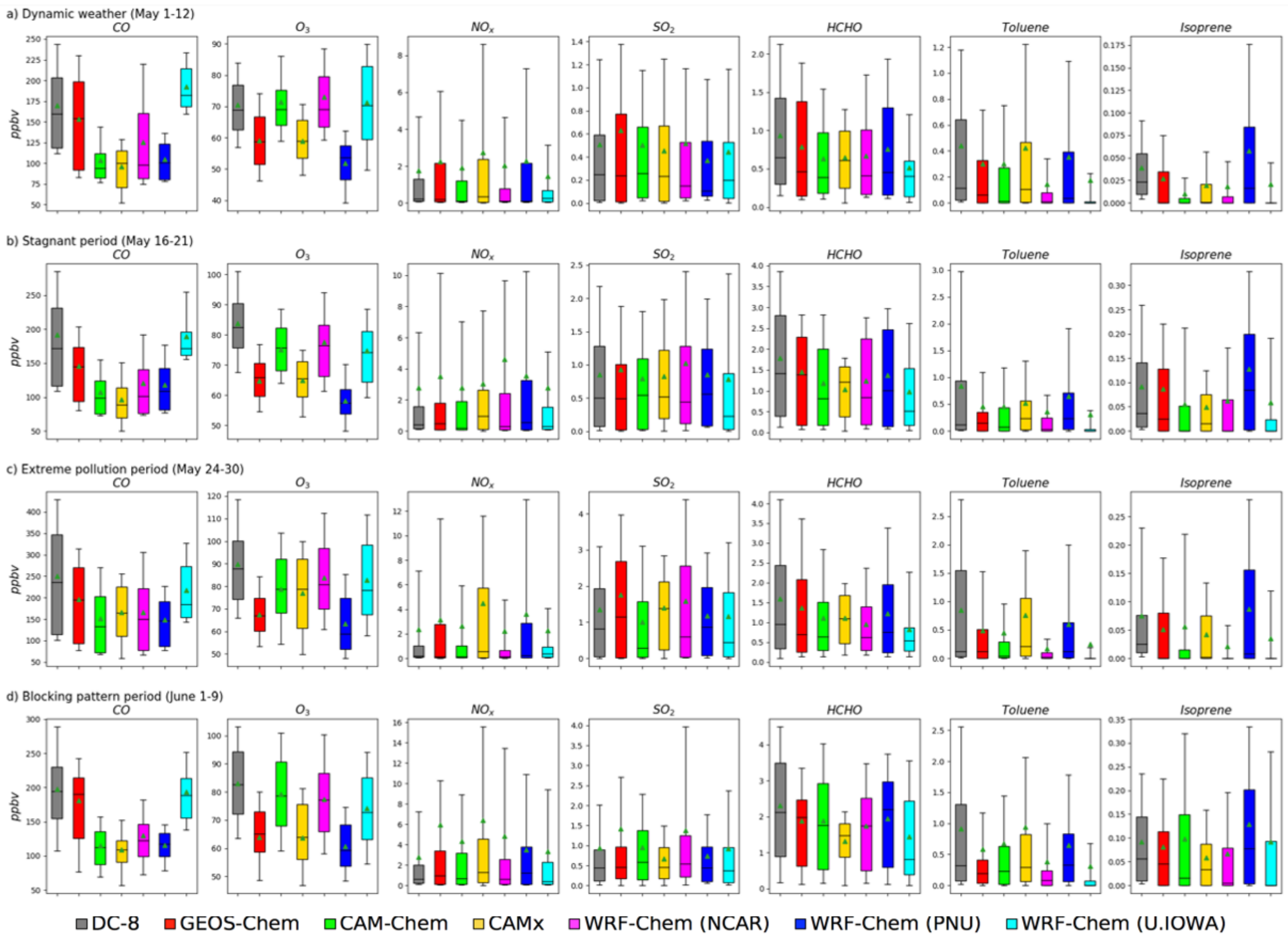


Figure 4. Multiple air quality model performance using DC-6 measurement and KORUS-AQ V5 emissions (Park et al., 2019)

II. Emission Inventories Requirements and Benchmark Frameworks

2.1 Description of notable emission inventories in Asia

The Chapter II illustrates the existence of multiple emission inventories which cover NEACAP regions. Their information, however, is not consistent because each of them has its own objective, framework, and data source. It is, therefore, always good to have independent ways to cross-check the accuracy of the data, such as top-down emissions, since no methodology is perfect.

Supporting policy-oriented studies requires a more comprehensive set of data that includes not only the emission data of each pollutant, but also socio-economic parameters including indicators of economy, technology, energy, etc (Figure 5). The assessments and consultations towards NEACAP also indicated the need for developing and improving a subregional inventory that provides accurate, complete, and up-to-date data with a common methodology for comparability between national data.

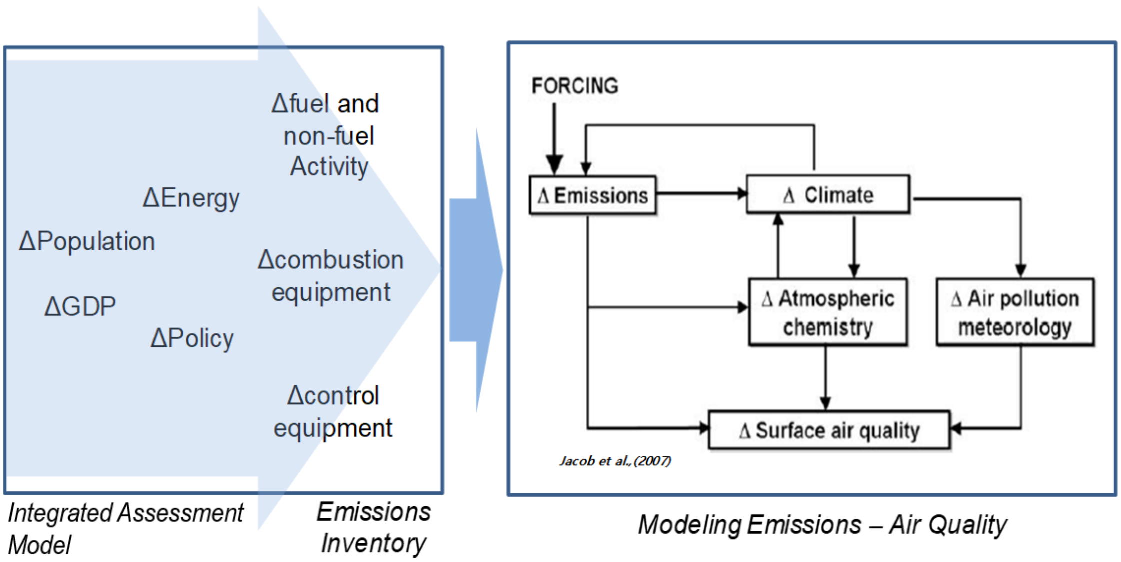


Figure 5. Role of emission inventory, scientific air pollution modeling, and integrated assessment in regional air quality improvement

Developing the NEACAP emission inventory would take into account the following basic properties (or criteria):

- **Comparability**: Inventories should be built up following the same methodological approach regarding the sectoral distribution, the variables used to describe the activity, and the emission factors.

- **Transparency:** Inventories should be correctly documented with data and assumptions chosen and are likely to be challenged by national or international experts.
- **Accuracy and Completeness:** Gaps in estimations should be avoided, all agreed targeted pollutants and sectors should be considered, and emissions provided with the best estimates.

In this regard, there is a benchmark example, the Centre on Emission Inventories and Projections (CEIP) of the Convention on Long-range Transboundary Air Pollution (CLRTAP; UNECE, 2015). Since the cooperative effort from all the member countries and the robust establishment of the supporting center(technical center) are essential keys to success, the role and process of the emission inventory center are also reviewed(EMAP webpage, www.emep.int).

2.2 Benchmark regional emission inventories and technical center : CEIP (CLRTAP/EMEP) [2]

(1) Overview

CEIP(the Center on Emission Inventories and Projections, CEIP) / EMEP(European Monitoring and Evaluation Programme, EMEP) is the technical center for emissions inventory and projection which was established in 2007(CEIP webpage : https://www.ceip.at/). EMEP scientifically supports CLRTAP with air quality monitoring and modeling, emissions inventory development and projection, and integrated assessment modeling. CLRTAP handles major regional environmental issues in 51 parties(countries) for UNECE (United Nations Economic Commission for Europe). Five centers and 4 task forces are operating as in the Figure 6.

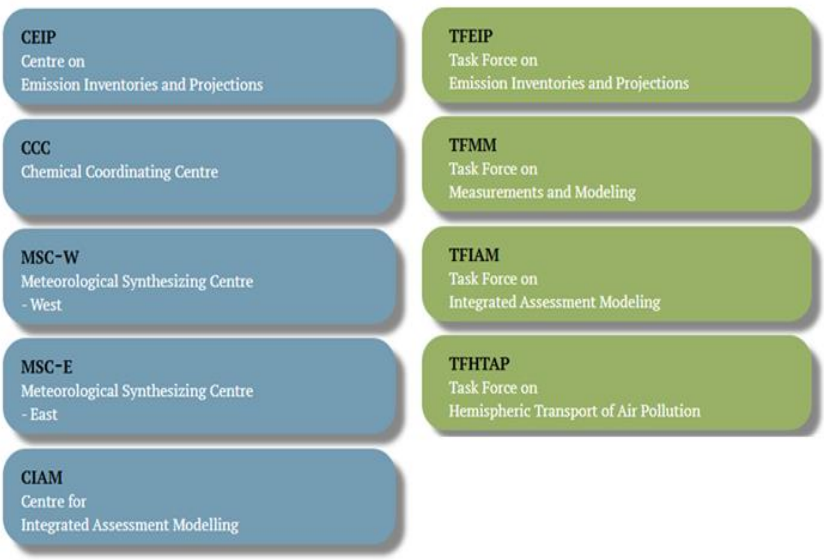


Figure 6. Structure of EMEP/CLRTAP and CEIP/TFEIP

2 References of this section are EMEP webpage : https://www.emep.int/ and CEIP webpage : https://www.ceip.at/

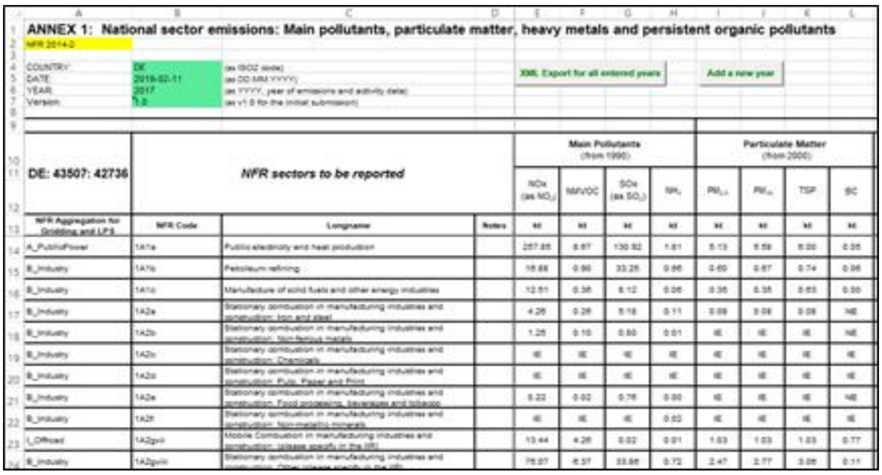
The role of CEIP is to receive emission inventory submission, QA/QC, technical support processes. CEIP also set up a standard procedure for submission, quality assurance, enhancement of compatibility, transparency, completeness, and accuracy. Submitted emissions from parties are integrated into EMEP/CEIP emission database system and supplied using CEIP website. CEIP also performs annual in-depth QA/QC process by evaluating consistency, completeness of the submitted dataset. The gridded emissions for EMEP air quality modeling is processed after then.

CEIP has been working with the international research institutes, such as International Institute for Applied System Analysis (IIASA) and United Nations Framework Convention on Climate Change (UNFCCC), for cross-checking emissions and evaluating their uncertainty. Capacity-building activities, such as workshop, training for underdeveloped parties is another mission of CEIP.

(2) Tasks of Inventory Center

Reporting Data for Parties: Emissions data reporting is required by sector and pollutant. The list of criteria pollutants is CO, NO_x, NMVOC, SO_x, NH_3(from year 1990 to 2 year before the present year) and $PM_{2.5}$, PM_{10}, TSP, BC (from year 2000 to 2 year before present year). The list of heavy metals are Pb, Cd, Hg(year 2000 ~ 2years before present) and POPs are PCDD/PCDF(dioxins/furans), PAHs(benzo(a) pyrene, benzo(b) fluoranthene, benzo(k) fluoranthene, indeno (1,2,3-cd) pyrene, Total 1-4), HCB, PCBs(year 2000 ~ 2years before present).

The reporting sectors have to follow the EMEP/EEA reporting guideline. Activity data have to be reported by fuel with unit. For example, fuel use could be classified as liquid, solid, gasoline, biomass, other and activities could be coal production, oil consumption, glass production, ammonia production, solvent use. Figure 7 is the 2017 data reported in 2019 by Germany.



ANNEX 1: National sector emissions: Main pollutants, particulate matter, heavy metals and persistent organic pollutants

NFR 2014-2

COUNTRY: DE (as ISO2 code)
DATE: 2019-02-11 (as DD.MM.YYYY)
YEAR: 2017 (as YYYY, year of emissions and activity data)
Version: 1.0 (as v1.0 for the initial submission)

XML Export for all entered years | Add a new year

DE: 43507: 42736	NFR sectors to be reported			Main Pollutants (from 1990)				Particulate Matter (from 2000)			
				NOx (as NO_2)	NMVOC	SOx (as SO_2)	NH_3	$PM_{2.5}$	PM_{10}	TSP	BC
NFR Aggregation for Gridding and LPS	NFR Code	Longname	Notes	kt	kt	kt	kt	kt	kt	kt	kt
A_PublicPower	1A1a	Public electricity and heat production		257.85	8.67	130.92	1.81	5.13	5.59	6.00	0.05
B_Industry	1A1b	Petroleum refining		15.88	0.90	33.25	0.66	0.60	0.67	0.74	0.06
B_Industry	1A1c	Manufacture of solid fuels and other energy industries		12.51	0.36	8.12	0.06	0.35	0.35	0.65	0.00
B_Industry	1A2a	Stationary combustion in manufacturing industries and construction: Iron and steel		4.26	0.26	5.18	0.11	0.08	0.08	0.08	NE
B_Industry	1A2b	Stationary combustion in manufacturing industries and construction: Non-ferrous metals		1.26	0.10	0.80	0.01	IE	IE	IE	NE
B_Industry	1A2c	Stationary combustion in manufacturing industries and construction: Chemicals		IE	IE	IE	IE	IE	IE	IE	IE
B_Industry	1A2d	Stationary combustion in manufacturing industries and construction: Pulp, Paper and Print		IE	IE	IE	IE	IE	IE	IE	IE
B_Industry	1A2e	Stationary combustion in manufacturing industries and construction: Food processing, beverages and tobacco		0.22	0.02	0.76	0.00	IE	IE	IE	NE
B_Industry	1A2f	Stationary combustion in manufacturing industries and construction: Non-metallic minerals		IE	IE	IE	0.02	IE	IE	IE	IE
I_Offroad	1A2gvii	Mobile Combustion in manufacturing industries and construction: (please specify in the IIR)		13.44	4.26	0.02	0.01	1.03	1.03	1.03	0.77
B_Industry	1A2gviii	Stationary combustion in manufacturing industries and construction: Other (please specify in the IIR)		76.07	6.37	33.66	0.72	2.47	2.77	3.06	0.11

Figure 7. Example of emission data submission (Germany)

Emission projection: For future emission projection, NO_x, NMVOC, SO_x, NH_3, BC have to be projected every year and target years are 2020, 2025, 2030 (mandatory), 2040, 2050(optional). On The Books (OTB) and On The Way (OTW) control scenarios have to be included in National Air Pollution Control Programme (NAPCP) based on National Emission Ceilings Directive (NECD). Figure 8 is an emission projection example by Germany.

ANNEX IV A-WM: Emission projections reporting template - With Measures

NFR 2014-1

COUNTRY: DE (as ISO2 code)
DATE: 2019-11-16 (as DD.MM.YYYY)
Version: 1.0 (as v1.0 for the initial submission)

		Projected emissions (kt)						Projected emissions (kt)					
		NOx						NMVOC					
		Guidelines Reporting Years						Guidelines Reporting Years					
NFR Code	Longname	2016	2020	2025	2030	2040 where available	2050 where available	2016	2020	2025	2030	2040 where available	2050 where available
1A1	Energy industries (Combustion in power plants & Energy Production)	294.7	260.8	256.5	219.5	NR	NR	10.7	10.2	10.2	8.6	NR	NR
1A2	Manufacturing Industries and Construction (Combustion in industry including Mobile)	88.2	73.0	65.5	60.2	NR	NR	10.2	6.6	6.5	5.9	NR	NR
1A3b	Road Transport	431.2	302.6	179.2	117.6	NR	NR	94.3	72.5	61.1	51.3	NR	NR
1A3bi	R.T., Passenger cars	249.9	201.4	119.6	74.0	NR	NR	56.8	45.4	40.2	35.9	NR	NR
1A3bii	R.T., Light duty vehicles	34.6	25.1	15.5	10.7	NR	NR	1.4	0.9	0.7	0.6	NR	NR
1A3biii	R.T., Heavy duty vehicles	143.9	73.7	42.2	31.4	NR	NR	4.5	3.1	2.3	2.1	NR	NR
1A3biv	R.T., Mopeds & Motorcycles	2.8	2.4	1.9	1.5	NR	NR	19.2	15.2	11.0	6.5	NR	NR
1A3bv	R.T., Gasoline evaporation	NA	NA	NA	NA	NR	NR	12.4	7.8	7.0	6.3	NR	NR
1A3bvi	R.T., Automobile tyre and brake wear	NA	NA	NA	NA	NR	NR	NA	NA	NA	NA	NR	NR
1A3bvii	R.T., Automobile road abrasion	NA	NA	NA	NA	NR	NR	NA	NA	NA	NA	NR	NR
1A3a,c,d,e	Off-road transport	56.3	52.0	47.1	42.1	NR	NR	2.6	2.5	2.4	2.4	NR	NR
1A4	Other sectors (Commercial, institutional, residential, agriculture and fishing stationary and mobile	129.4	99.7	85.7	74.1	NR	NR	63.5	54.8	49.0	46.2	NR	NR
1A5	Other	4.6	4.5	4.0	3.7	NR	NR	1.8	2.1	1.8	1.6	NR	NR
1B	Fugitive emissions (Fugitive emissions from fuels)	1.0	1.1	1.1	1.1	NR	NR	72.6	73.3	73.3	73.3	NR	NR
2A,B,C,H,I,J,K,L	Industrial Processes	84.9	86.4	85.3	82.9	NR	NR	34.9	35.3	35.2	35.0	NR	NR

Figure 8. Example of emission projection report submission (Germany)

Large Point Sources (LPSs): Parties have to submit LPSs by sector annually. Stack parameters are not mandatory but recommended. CEIP evaluates LPSs information against European Pollutant Release and Transfer Register(E-PRTR) data. Stack information, however, could not be available to the center because of confidentiality issue. Another alternative could be some web-based information about facility level emissions as in Figure 9.

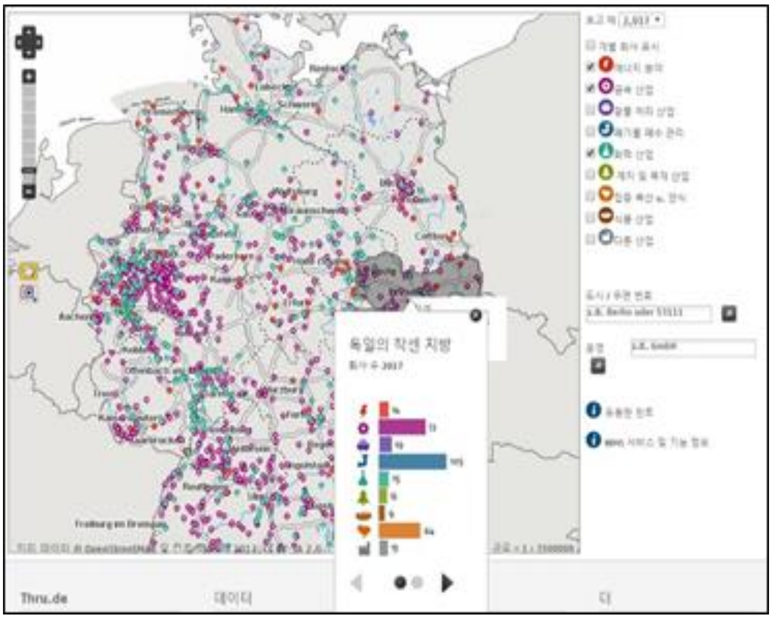


Figure 9. Example of facility level emissions (Germany)

Gridded data: For gridded data, parties have to submit in 0.1°x0.1° resolution. If it is not possible, 50kmx50km gridded data could be acceptable. Mandatory pollutants are NOx, CO, NH3, NMVOC, SOx, PM2.5, PM10 and have to be submitted by every 5years (e.g. year 1990, 1995, 2000, 2005, 2010, 2015).

Adjustments: Parties can request adjustments for reduction target or emission estimates. The center may review their relevance and give approval in the following conditions: change in source classification, emission factor, estimation methodology.

Informative Inventory Reports (IIR): Parties have to submit IIR with other submitted data above. The methodologies for emission estimation, references need to be included so that the center could review the inventory more accurately and transparently. Most of parties submit IIR in pdf or word format but Germany uses website for more effective communication as in Figure 10.

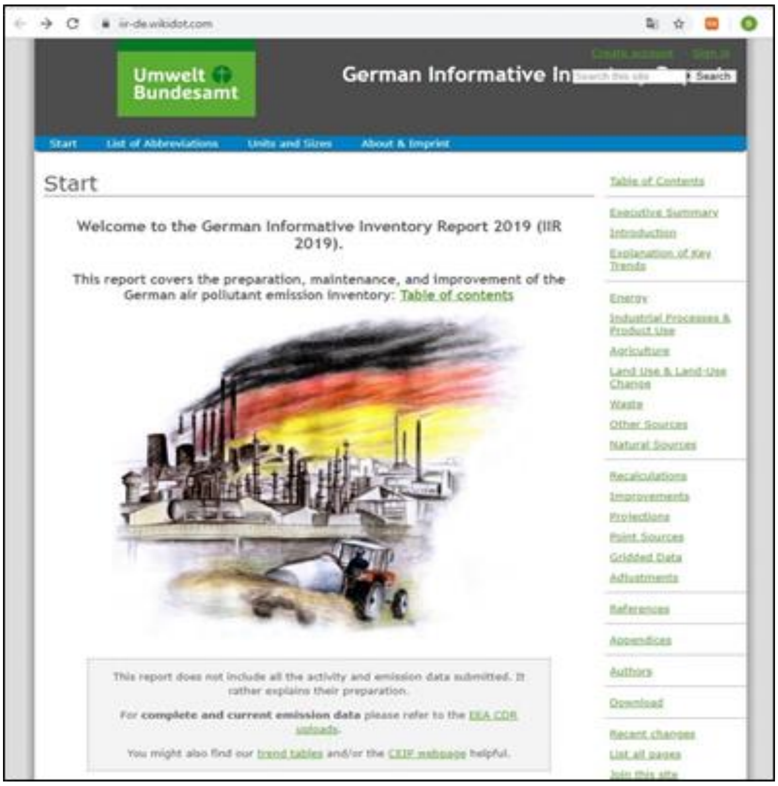


Figure 10. Example of IIR webpage (Germany)

(3) Emission Inventory Development Process

Process Overview: The year 2019 inventory compiling schedule of CEIP is shown in Figure 11. Submission from the parties need to be completed by Feb. 15 and the center reviews submission in terms of timeline, format, completeness, consistency by Mar. 15. In the meantime, parties have to submit projection and IIR by Mar. 15. The center's first stage review starts from then and review report for a country need to be finished by Apr. 15. During that process, parties prepare and submit gridded and LPSs data by May 1. The center's second stage review starts from Apr. 15 until Jun. 1. Country data review report and QA/QC questioner are posted on the password-protected website during May 1 ~Jun. 1 period. The 0.1°x0.1° gridded emissions are being prepared during May 1 ~ Jul. 1. After the 2nd stage review, parties post their opinion during Jun 1 ~ Jul. 1 whereas the center performs its 3rd stage review, updates WebDab, and prepares CEIP report. Also, the center review parties Adjustments and develop EMEP annual report during May 1 ~ Aug. 1. EMEP annual report needs to be submitted by Sep. 1 then the center prepares for the next year's submission.

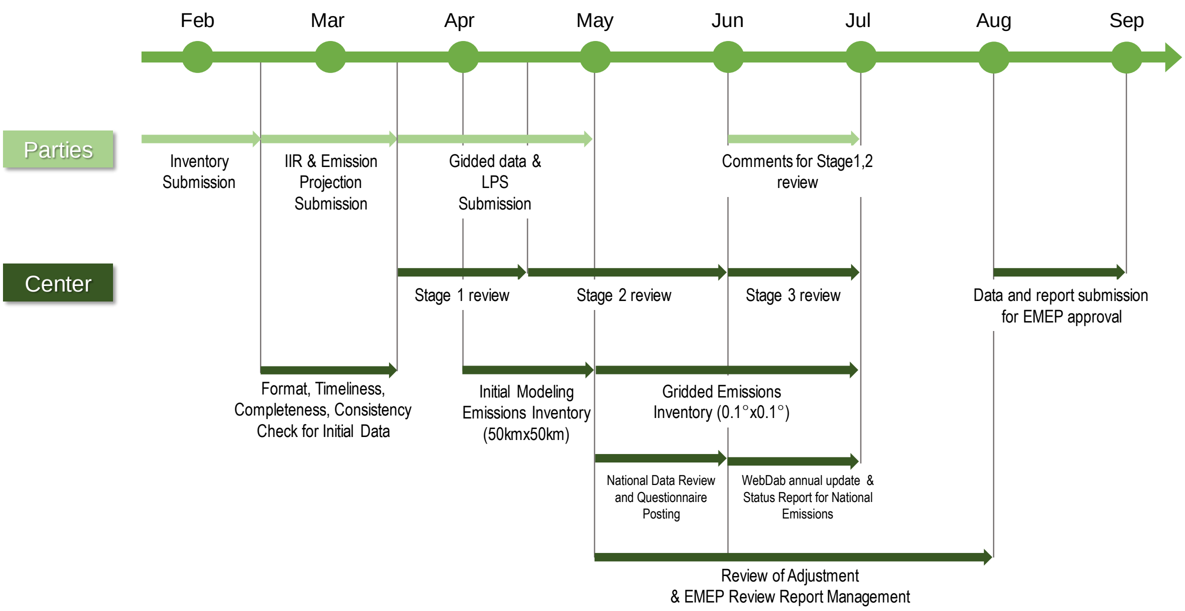


Figure 11. CEIP inventory development process (year 2019)

Review Stage: Stage 1 reviews include timeliness, completeness, data format, transparency and IIR. If the parties reporting inventory late, it cannot be merged in the regional inventory and modeling. In addition, completeness of pollutant list, consistency, and emission projection are reviewed. The format of the data should follow the submission guidelines in the Appendix for efficient data processing at the center.

Stage 2 reviews include recalculation, time series consistency, key category analysis, inventory comparisons, and emissions comparisons using the economic index. In the case of recalculation, the difference in total national emissions over the entire time series is evaluated to review the need for recalculation. The major causes of recalculation, such as activity updates, emission sector changes, and double counting are then reviewed. Time series consistency is checked by reviewing time series consistency from 1990 to two years before the present year. Since the main category contributes 80% of the total emissions, it is advantageous in identifying important air pollutants in the EMEP region and in individual countries. In the case of inventory comparisons, inventories are compared between countries to identify consistency and anomalies. In addition, the sector's share of each pollutant source is assessed, and the difference in emissions between CLRTAP and UNFCCC by year or pollutant is analyzed.

The stage 3 review is a process in which two review teams, with the support of the EEA, conduct a technical in-depth review of 10 countries each year to ensure consistency among the Parties. The review includes the completeness and consistency of the emission inventory, proper documentation and accuracy. The center design stage 3 review process so that parties would take a stage 3 review at least every five years.

(4) Inventory Reporting Guideline

RepDab: RepDab is a system that allows Parties to check the format, consistency and completeness of files before submitting inventory and data to CEIP (Figure 12). Entering email address and submission file (* .zip or * .xlsx), and a party can get the check results by email in 5 minutes.

Figure 12. RepDab webpage

Reporting Guidelines: Several forms of reporting guidelines are provided for efficient data processing by the Center and for accurate reporting of the Parties. The website provides a template of the data and guideline of data and methodology, such as pollutants, year, calculation method, and timing of submission. By providing assistance to Parties, the center can help parties developing their inventory relatively easy and accurate. In addition, as shown in Figure 13 and 14, EMEP and EEA publish annual emission inventory guidelines and a mapping table for accurate reporting when sector classifications changed, respectively. This mapping table enables Parties to effectively report inventory with different sector classifications.

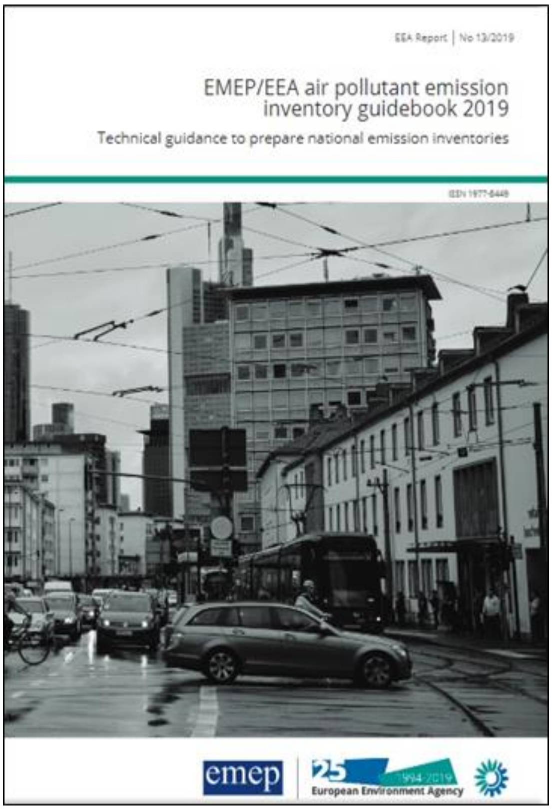


Figure 13. EMEP and EEA emission inventory guideline

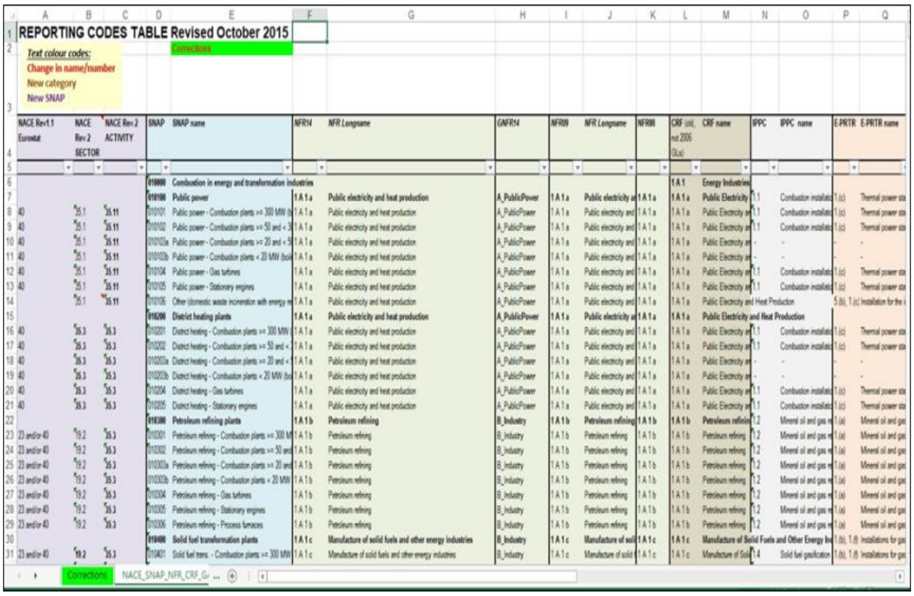
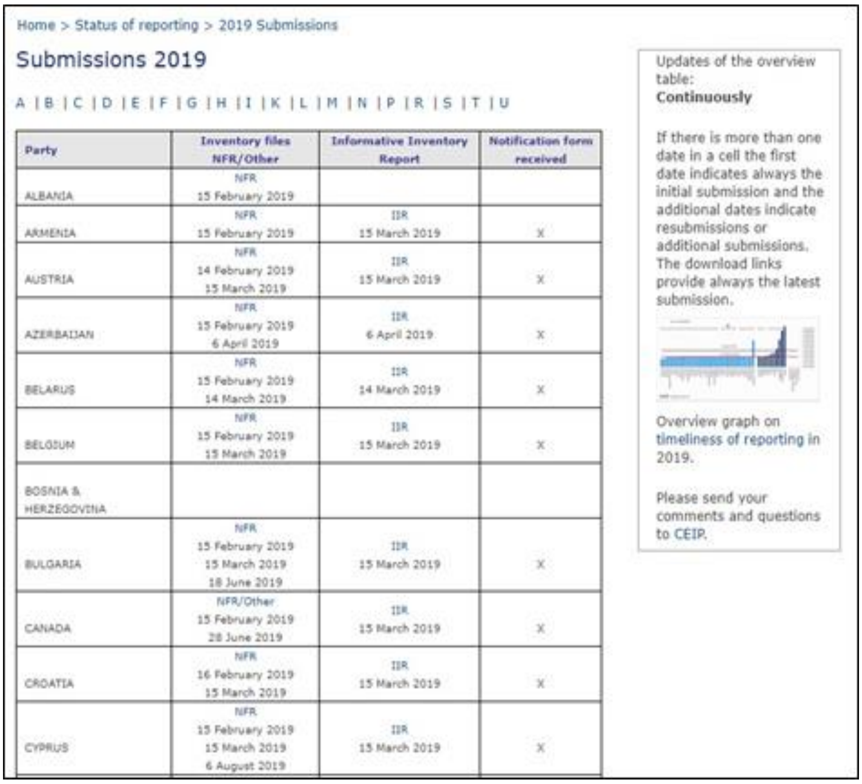


Figure 14. Emission sector mapping table

Other activities: Center provides modeling emissions to the air quality modelers and provides services, such as missing data analysis, trainings, workshops, to the collaborators in the parties. Help building an inventory for developing country. In addition, the center works with other centers and institutes within EMEP or with other agencies such as AMAP, IIASA, and EEA to improve inventory quality.

(5) Inventory Data Review and Distribution

Emission inventory and IIR: The emission inventory and IIR reported by the Party shall be posted on the homepage (Figure 15). Inventory can be downloaded in Excel format, and IIR can be downloaded in pdf or word format. In Germany, the exception is IIR, which is available on the website.



Home > Status of reporting > 2019 Submissions

Submissions 2019

A | B | C | D | E | F | G | H | I | K | L | M | N | P | R | S | T | U

Party	Inventory files NFR/Other	Informative Inventory Report	Notification form received
ALBANIA	NFR 15 February 2019		
ARMENIA	NFR 15 February 2019	IIR 15 March 2019	X
AUSTRIA	NFR 14 February 2019 15 March 2019	IIR 15 March 2019	X
AZERBAIJAN	NFR 15 February 2019 6 April 2019	IIR 6 April 2019	X
BELARUS	NFR 15 February 2019 14 March 2019	IIR 14 March 2019	X
BELGIUM	NFR 15 February 2019 15 March 2019	IIR 15 March 2019	X
BOSNIA & HERZEGOVINA			
BULGARIA	NFR 15 February 2019 15 March 2019 18 June 2019	IIR 15 March 2019	X
CANADA	NFR/Other 15 February 2019 28 June 2019	IIR 15 March 2019	X
CROATIA	NFR 16 February 2019 15 March 2019	IIR 15 March 2019	X
CYPRUS	NFR 15 February 2019 15 March 2019 6 August 2019	IIR 15 March 2019	X

Updates of the overview table:
Continuously

If there is more than one date in a cell the first date indicates always the initial submission and the additional dates indicate resubmissions or additional submissions. The download links provide always the latest submission.

Overview graph on timeliness of reporting in 2019.

Please send your comments and questions to CEIP.

Figure 15. Inventory and IIR reporting status

Review results report: After conducting both stages of the review, a report of the review results, including the accuracy and consistency of the data submitted by each Party, comparisons with other inventories, and recalculations, will be published as in Figure 16. In addition to the report, we publish data in Excel format comparing the values calculated by GAINS, the values reported by the Parties, and those calculated by the EMEP model.

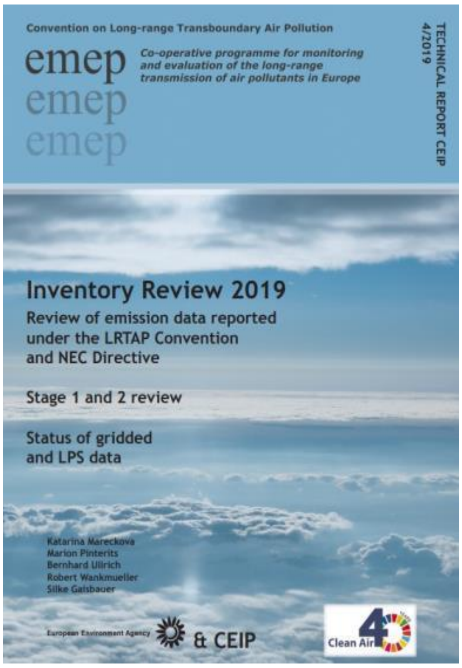


Figure 16. Inventory review report

WebDab (database): CEIP's emissions database, WebDab, provides access to 'Officially reported emissions data', 'Emissions data used in EMEP models', and 'Officially reported activity data'. It also provides a user guide for this. For officially reported emission data, user can retrieve and download emission data from 1980 to two years before present year with the selection of the country, year, pollutant, sector, unit, etc. The file format can also be downloaded as CSV or HTML. A trend graph from 1990 to two years before present year is also provided as in Figure 17.

WebDab search - Officially reported emission data

Display information and footnotes | Switch table rows and columns

Units in Gg
(Switch unit to g / kg / Mg)

Year: 1980
Sector: B_IndustrialComb

	Austria	Finland	France	Italy	Norway	Slovenia	United Kingdom
Aldrin	0	0	0	0	0		0
NOx (as NO2)	50.125	0	322.911	347.283	20.361	6.667	446.883
Ni	0	0	0	0	0	0	0.28
PM2.5	0	0	0	0	1.325	0	16.168

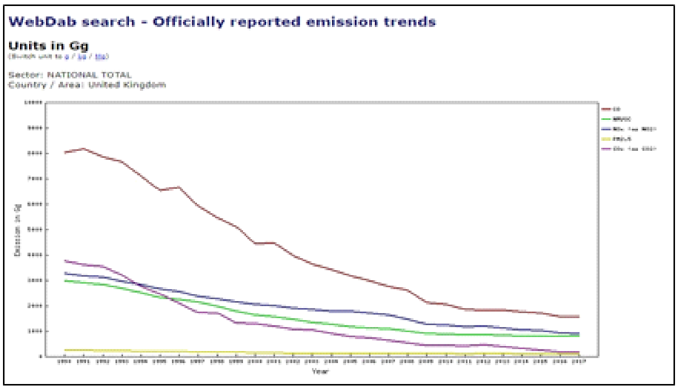


Figure 17. Officially reported emissions table (upper panel) and trend graph (lower panel)

'Emission data used in the EMEP model' includes the functionality provided by the 'Officially reported emission data', but retrieval and download of emission data is limited to data from 1990 to two years prior to present year. Trend graphs are also available from 1990 until two years before present year. In addition, the emission data used in the model provides additional 0.1 ° x 0.1 ° resolution grid data. Among the pollutants, SOx, NOx, NMVOC, NH3, CO, PM2.5, PM10, PM coarse provide data from 1990 to 2 years before present year, It supports downloading in CSV, NetCDF, and Shapefiles formats. As shown in Figure 18, you can compare and visualize grid data of 50kmx50km and 0.1 ° x 0.1 ° resolution through web page.

Figure 18. Emission data used in the EMEP model

For officially reported activity data, only emission data retrieval and download are provided. It provides data from 1980 to two years before present year, and allows the user to select a country, year, activity type, sector, etc. It can be downloaded as CSV or checked in HTML.

Interactive data viewers: The center provides an interactive data viewer so that users can intuitively check the data as in Figure 19. The officially reported emissions data can be selected as maps or graphs by selecting countries, years, pollutants and sectors and can be downloaded in formats such as PNG, CSV, PDF and PowerPoint.

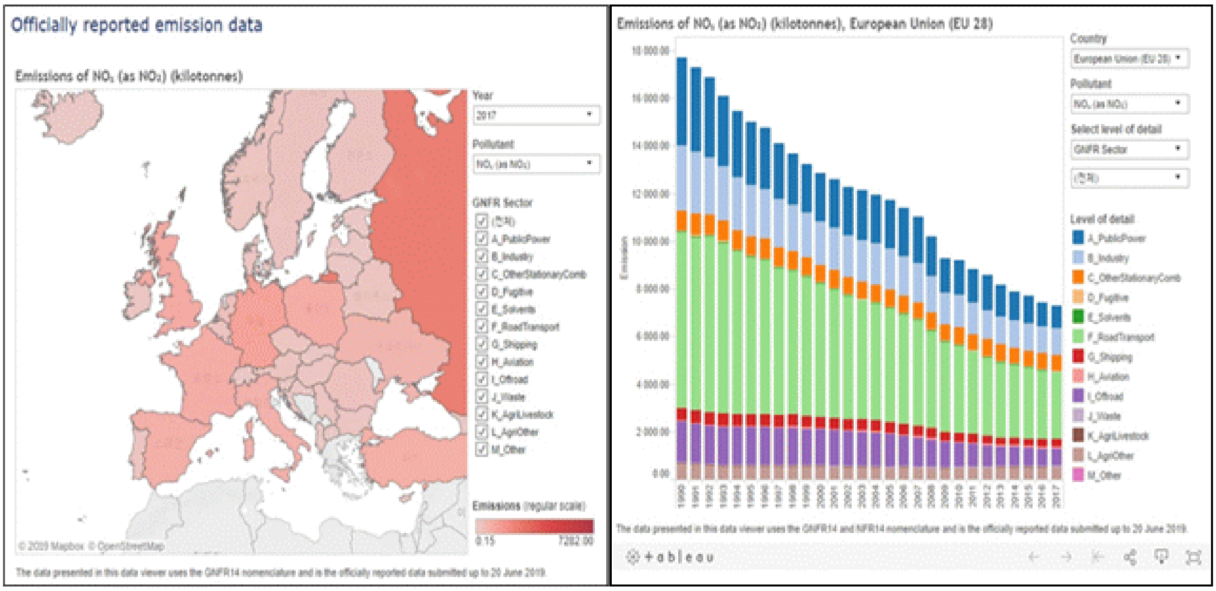


Figure 19. Interactive data viewer

III. Direction of NEACAP Emission Inventory[3]

3.1 Developing the emission inventory with activity-based data and information submitted by member Countries

Comprehensive understanding of air pollution relies not only knowledge from physical science field but also from the socio-economic analysis as shown in the figure 5. Fundamental socio-economic parameters, such as GDP and energy, are major elements of the Integrated Evaluation Model (IAM) together with energy related activity, policy, control technology, and other related parameters, which are essential components for the emissions inventory. In comparison, processing emissions in support of air quality modeling requires further processing of the estimated emissions into more spatio-temporally and chemically resolved form. The modeling emissions inventory is an essential information in support of Air Quality Modeling/Monitoring (AQM) and Scientific Assessment Report (SAR).

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[3] Some of the contents are taken from Woo, J-H., Suggestion to support Northeast Asia emission Inventory, National Council on Climate and Air quality (ROK), 2020.

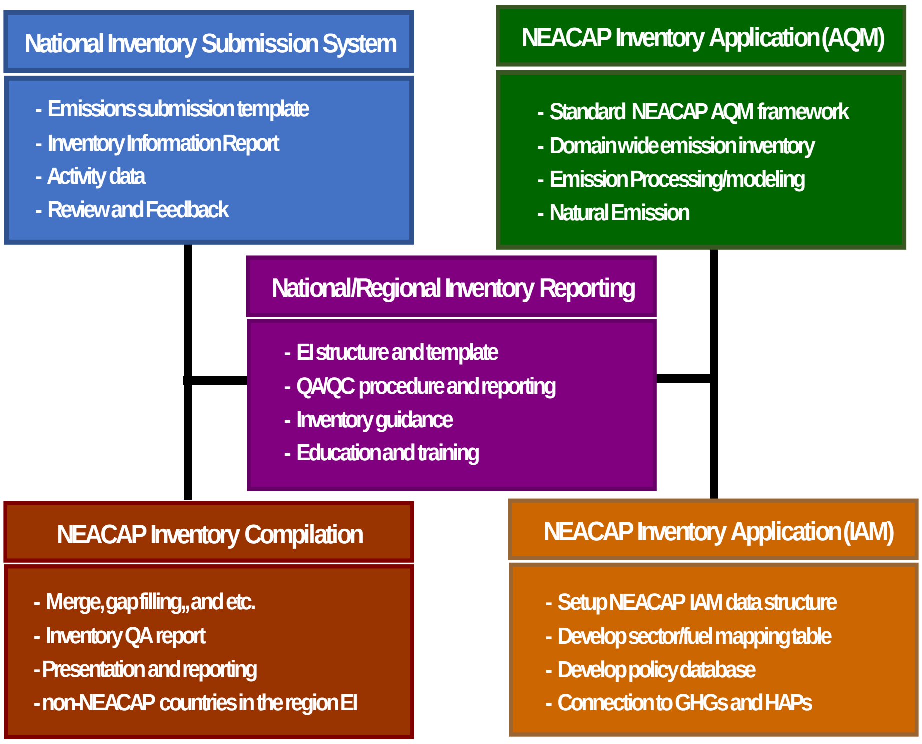


Figure 20. Components and functions of the NEACAP Emission Inventory system

Figure 20 illustrates the major functional components and specific tasks required for the NEACAP Emission Inventory system. There are a number of emission inventories for Asian countries, and regional-scale inventories are created in both activity-based and mosaic-based as needed. The emission inventory for NEACAP should be developed as activity-based to ensure effective connectivity to the IAM activity. Unlike existing emission inventories in the Table 1, which mostly developed by a center or by multiple emission mosaic, the Parties' submission of comprehensive national emission-related information would better be the fundamental source of NEACAP EI database. The pollutants list would start from Criteria Air Pollutants (CAPs) which are CO, SO_2, NO_x, NH_3, VOCs, PM_{10}, $PM_{2.5}$, then may extend to the GHGs and HAPs in the future. Inputs between activity-based data and emission inventories provided by each country should be entered and reviewed under a standard system of Emission Inventory Technical Center (EITC).

In addition to the collection of data, the work for EI involves QA checks and verification of accuracy. This process should design standard processes and data to ensure inventory integrity, connectivity, transparency and accuracy. Informative Inventory Report (IIR), which includes information such as methodologies and references used to create inventory, will be a very important source of transparency. Figure 11 shows the process of submitting and creating a comprehensive regional inventory between European EMEP Parties and the Technical Center (CEIP). This process requires close feedback processes with countries on data submission, review, evaluation. Submission of data through standardized data and systems and the provision of timely data inspection reports are essential for the creation of reliable inventories.

Standard data service systems are needed to support the wider user group, as well as the NEACAP member countries. Existing inventory centers provide data in the form of reports, actual data, GIS maps, etc., some of which allow users to query and process data directly through interactive web systems as in Figure 21. Thus, NEACAP needs EITC to supply and train the standard inventory methodology guidelines for countries and other (Figure 22).

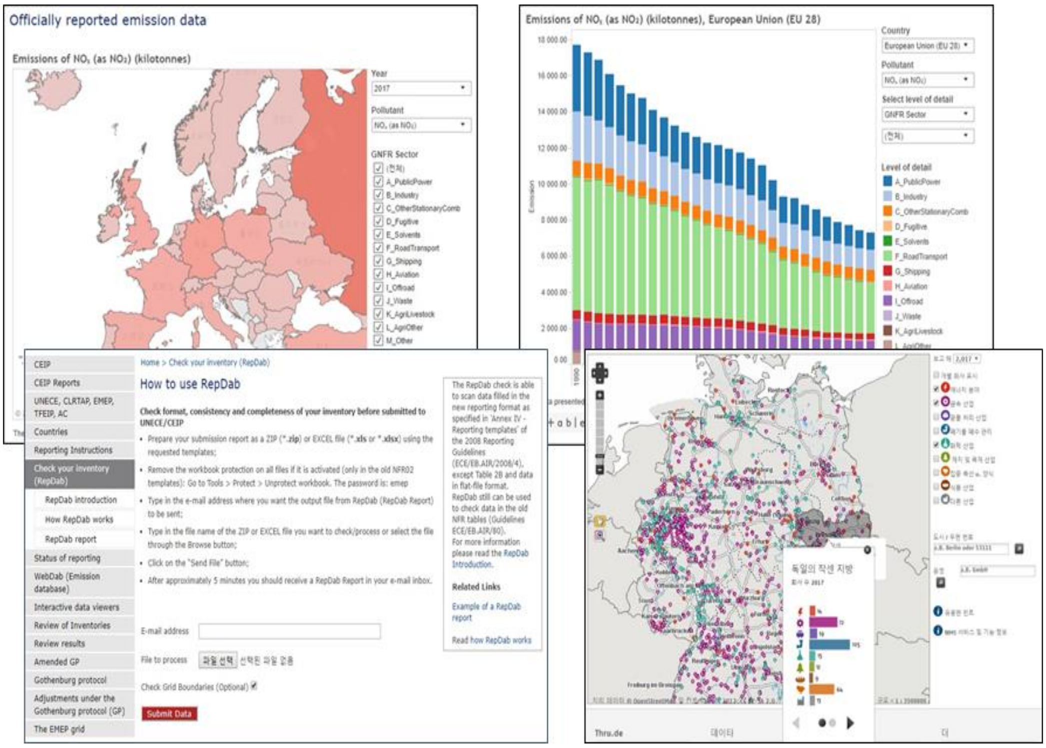


Figure 21. Example of emission data service system (CEIP)

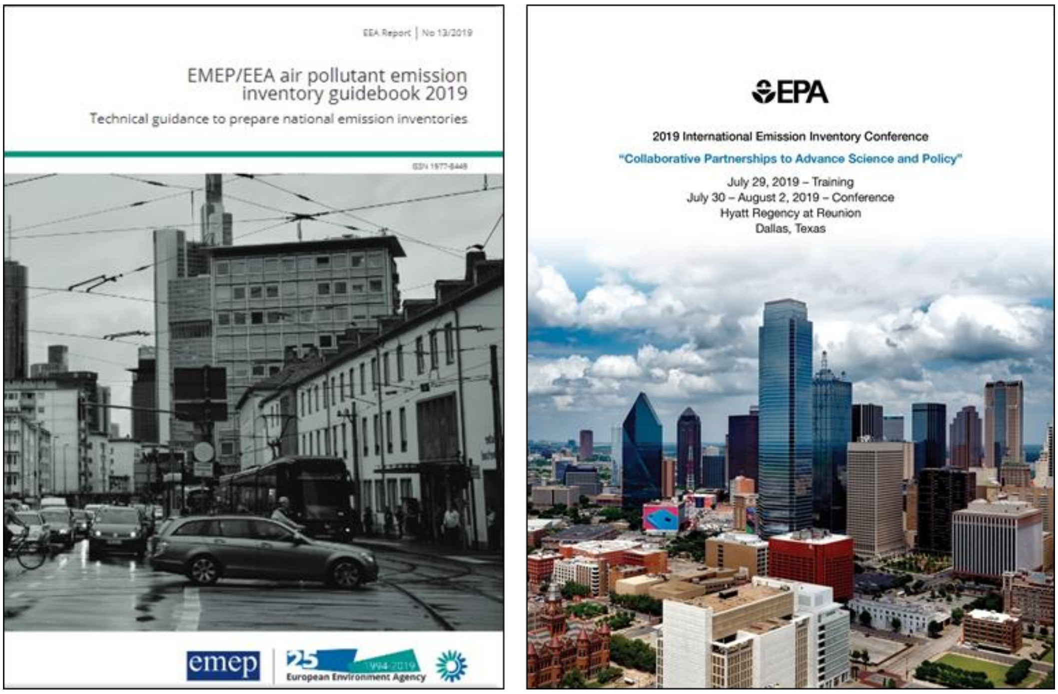
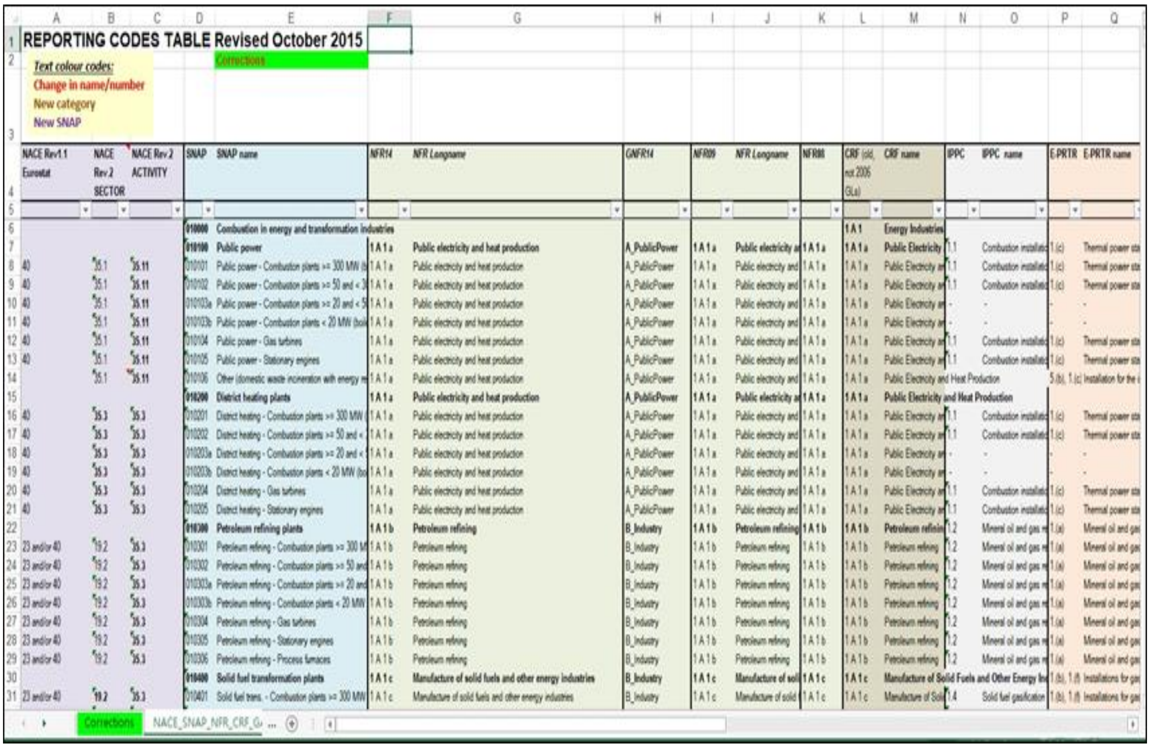


Figure 22. Example of emission inventory guideline (EMEP) and training (US EPA, www.epa.gov)

3.2 Supporting Integrated Assessment Modeling

One of the key roles of EI is to support IAM activity that covers each Party's energy outlook and environmental policy. In Europe, policy bodies and groups of specialists work together to maintain regular exchanges with the center and to operate policy support. In particular, as the GAINS Framework, an IAM used in EMEP, is used in the policy direction of each Party based on science and technology (Klimont and Amann, 2019). In order for the NEACAP emission inventory to be linked to Integrated Assessment Modeling (IAM), a standard template that includes activity, emission factors and abatement efficiencies should be provided. Standardization and integration of the NEACAP inventorying process will also require the development of standard mapping protocols between each country's activity and emissions frameworks and regional inventory frameworks as in Figure 23.



REPORTING CODES TABLE Revised October 2015

Corrections

Text colour codes:
Change in name/number
New category
New SNAP

NACE Rev1.1 Eurostat	NACE Rev 2 SECTOR	NACE Rev 2 ACTIVITY	SNAP	SNAP name	NFR14	NFR Longname	GNFR14	NFR09	NFR Longname	NFR88	CRF (old, not 2006 GLs)	CRF name	IPPC	IPPC name	E-PRTR	E-PRTR name
			010000	Combustion in energy and transformation industries							1 A 1	Energy Industries				
			010100	Public power	1 A 1 a	Public electricity and heat production	A_PublicPower	1 A 1 a	Public electricity a	1 A 1 a	1 A 1 a	Public Electricity	1.1	Combustion installatio	1.(c)	Thermal power sta
40	35.1	35.11	010101	Public power - Combustion plants >= 300 MW (b	1 A 1 a	Public electricity and heat production	A_PublicPower	1 A 1 a	Public electricity and	1 A 1 a	1 A 1 a	Public Electricity ar	1.1	Combustion installatio	1.(c)	Thermal power sta
40	35.1	35.11	010102	Public power - Combustion plants >= 50 and < 3	1 A 1 a	Public electricity and heat production	A_PublicPower	1 A 1 a	Public electricity and	1 A 1 a	1 A 1 a	Public Electricity ar	1.1	Combustion installatio	1.(c)	Thermal power sta
40	35.1	35.11	010103a	Public power - Combustion plants >= 20 and < 5	1 A 1 a	Public electricity and heat production	A_PublicPower	1 A 1 a	Public electricity and	1 A 1 a	1 A 1 a	Public Electricity ar	-	-	-	-
40	35.1	35.11	010103b	Public power - Combustion plants < 20 MW (boi	1 A 1 a	Public electricity and heat production	A_PublicPower	1 A 1 a	Public electricity and	1 A 1 a	1 A 1 a	Public Electricity ar	-	-	-	-
40	35.1	35.11	010104	Public power - Gas turbines	1 A 1 a	Public electricity and heat production	A_PublicPower	1 A 1 a	Public electricity and	1 A 1 a	1 A 1 a	Public Electricity ar	1.1	Combustion installatio	1.(c)	Thermal power sta
40	35.1	35.11	010105	Public power - Stationary engines	1 A 1 a	Public electricity and heat production	A_PublicPower	1 A 1 a	Public electricity and	1 A 1 a	1 A 1 a	Public Electricity ar	1.1	Combustion installatio	1.(c)	Thermal power sta
	35.1	35.11	010106	Other (domestic waste incineration with energy re	1 A 1 a	Public electricity and heat production	A_PublicPower	1 A 1 a	Public electricity and	1 A 1 a	1 A 1 a	Public Electricity and Heat Production			5.(b), 1.(c)	Installation for the
			010200	District heating plants	1 A 1 a	Public electricity and heat production	A_PublicPower	1 A 1 a	Public electricity a	1 A 1 a	1 A 1 a	Public Electricity and Heat Production				
40	35.3	35.3	010201	District heating - Combustion plants >= 300 MW (	1 A 1 a	Public electricity and heat production	A_PublicPower	1 A 1 a	Public electricity and	1 A 1 a	1 A 1 a	Public Electricity ar	1.1	Combustion installatio	1.(c)	Thermal power sta
40	35.3	35.3	010202	District heating - Combustion plants >= 50 and <	1 A 1 a	Public electricity and heat production	A_PublicPower	1 A 1 a	Public electricity and	1 A 1 a	1 A 1 a	Public Electricity ar	1.1	Combustion installatio	1.(c)	Thermal power sta
40	35.3	35.3	010203a	District heating - Combustion plants >= 20 and <	1 A 1 a	Public electricity and heat production	A_PublicPower	1 A 1 a	Public electricity and	1 A 1 a	1 A 1 a	Public Electricity ar	-	-	-	-
40	35.3	35.3	010203b	District heating - Combustion plants < 20 MW (bo	1 A 1 a	Public electricity and heat production	A_PublicPower	1 A 1 a	Public electricity and	1 A 1 a	1 A 1 a	Public Electricity ar	-	-	-	-
40	35.3	35.3	010204	District heating - Gas turbines	1 A 1 a	Public electricity and heat production	A_PublicPower	1 A 1 a	Public electricity and	1 A 1 a	1 A 1 a	Public Electricity ar	1.1	Combustion installatio	1.(c)	Thermal power sta
40	35.3	35.3	010205	District heating - Stationary engines	1 A 1 a	Public electricity and heat production	A_PublicPower	1 A 1 a	Public electricity and	1 A 1 a	1 A 1 a	Public Electricity ar	1.1	Combustion installatio	1.(c)	Thermal power sta
			010300	Petroleum refining plants	1 A 1 b	Petroleum refining	B_Industry	1 A 1 b	Petroleum refining	1 A 1 b	1 A 1 b	Petroleum refinin	1.2	Mineral oil and gas re	1.(a)	Mineral oil and gas
23 and/or 40	19.2	35.3	010301	Petroleum refining - Combustion plants >= 300 M	1 A 1 b	Petroleum refining	B_Industry	1 A 1 b	Petroleum refining	1 A 1 b	1 A 1 b	Petroleum refining	1.2	Mineral oil and gas re	1.(a)	Mineral oil and gas
23 and/or 40	19.2	35.3	010302	Petroleum refining - Combustion plants >= 50 and	1 A 1 b	Petroleum refining	B_Industry	1 A 1 b	Petroleum refining	1 A 1 b	1 A 1 b	Petroleum refining	1.2	Mineral oil and gas re	1.(a)	Mineral oil and gas
23 and/or 40	19.2	35.3	010303a	Petroleum refining - Combustion plants >= 20 and	1 A 1 b	Petroleum refining	B_Industry	1 A 1 b	Petroleum refining	1 A 1 b	1 A 1 b	Petroleum refining	1.2	Mineral oil and gas re	1.(a)	Mineral oil and gas
23 and/or 40	19.2	35.3	010303b	Petroleum refining - Combustion plants < 20 MW	1 A 1 b	Petroleum refining	B_Industry	1 A 1 b	Petroleum refining	1 A 1 b	1 A 1 b	Petroleum refining	1.2	Mineral oil and gas re	1.(a)	Mineral oil and gas
23 and/or 40	19.2	35.3	010304	Petroleum refining - Gas turbines	1 A 1 b	Petroleum refining	B_Industry	1 A 1 b	Petroleum refining	1 A 1 b	1 A 1 b	Petroleum refining	1.2	Mineral oil and gas re	1.(a)	Mineral oil and gas
23 and/or 40	19.2	35.3	010305	Petroleum refining - Stationary engines	1 A 1 b	Petroleum refining	B_Industry	1 A 1 b	Petroleum refining	1 A 1 b	1 A 1 b	Petroleum refining	1.2	Mineral oil and gas re	1.(a)	Mineral oil and gas
23 and/or 40	19.2	35.3	010306	Petroleum refining - Process furnaces	1 A 1 b	Petroleum refining	B_Industry	1 A 1 b	Petroleum refining	1 A 1 b	1 A 1 b	Petroleum refining	1.2	Mineral oil and gas re	1.(a)	Mineral oil and gas
			010400	Solid fuel transformation plants	1 A 1 c	Manufacture of solid fuels and other energy industries	B_Industry	1 A 1 c	Manufacture of soli	1 A 1 c	1 A 1 c	Manufacture of Solid Fuels and Other Energy Ind			1.(b), 1.(f)	Installations for gas
23 and/or 40	19.2	35.3	010401	Solid fuel trans. - Combustion plants >= 300 MW	1 A 1 c	Manufacture of solid fuels and other energy industries	B_Industry	1 A 1 c	Manufacture of solid f	1 A 1 c	1 A 1 c	Manufacture of Soli	1.4	Solid fuel gasification	1.(b), 1.(f)	Installations for gas

Figure 23. Mapping table linking categories of different reporting formats (NACE, SNAP, NFR14, NFR09, CRF, E-PRTR, GAINS/RAINS)

In order to ensure continuity of data and consistency in policy evaluation, it is necessary to improve not only present but past data. Such cases happen when a new improvement made in emission methodologies or introduction of new emission factors. CEIP implements this through the emission adjustment process, and GAINS implements this by changing the variables themselves into the IAM methodology. These functions should be considered in NEACAP inventory as they are an indispensable factor in properly evaluating policy effectiveness. The GAINS-Korea as an example of emission inventory and IAM integration is illustrated in the Figure 24. Thus, along with IAM working group, the EITC should develop country-specific inventory directions and package of measures to support the IAM activity.

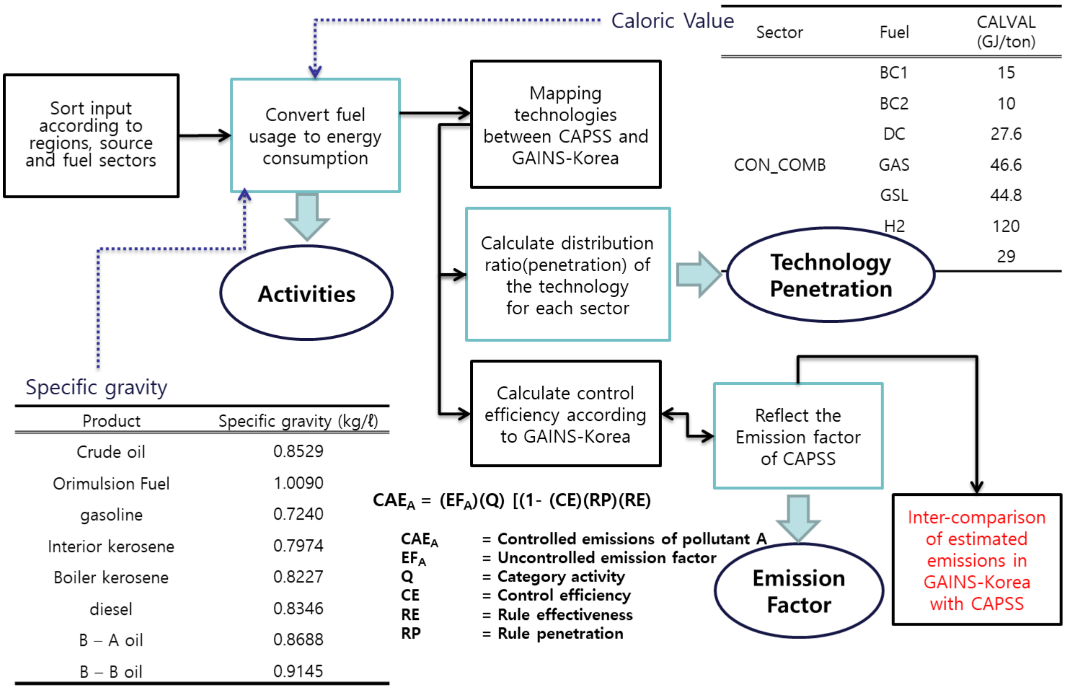


Figure 24. An example of emission inventory and IAM integration (GAINS-Korea)

3.3 Supporting Scientific Assessment Report and Other Frameworks

The inventory center should be able to develop a regional emissions inventory and regional/local Air Quality Modeling (AQM) emissions inventory. As shown in Figure 25, standard domains and grid systems to support NEACAP air pollution modeling should be defined and emission processing should be performed. At this time, member countries should submit information related to spatio-temporal allocation and chemical speciation. Using those information, AQM-Ready emissions data, which are used as input data for air quality modeling, should also be developed and provided by Center (J.-H. Woo et al., 2012).

This modeling support helps build trust through data access between Parties in policy evaluation and scientific assessment. Although the majority of Asian inventories now focus more on anthropogenic emissions, the center should also collect, prepare and provide emissions data from natural sources to support better air pollution modeling in NEACAP region as in Figure 26.

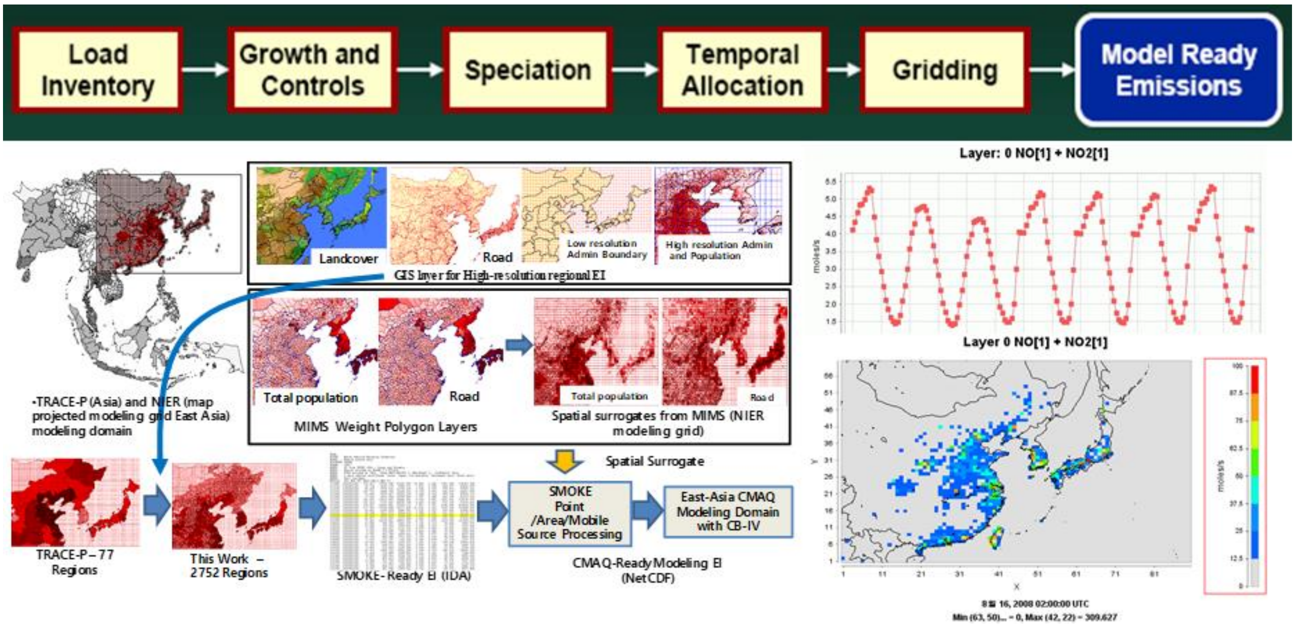


Figure 25. Emission processing system to develop modeling emissions inventory

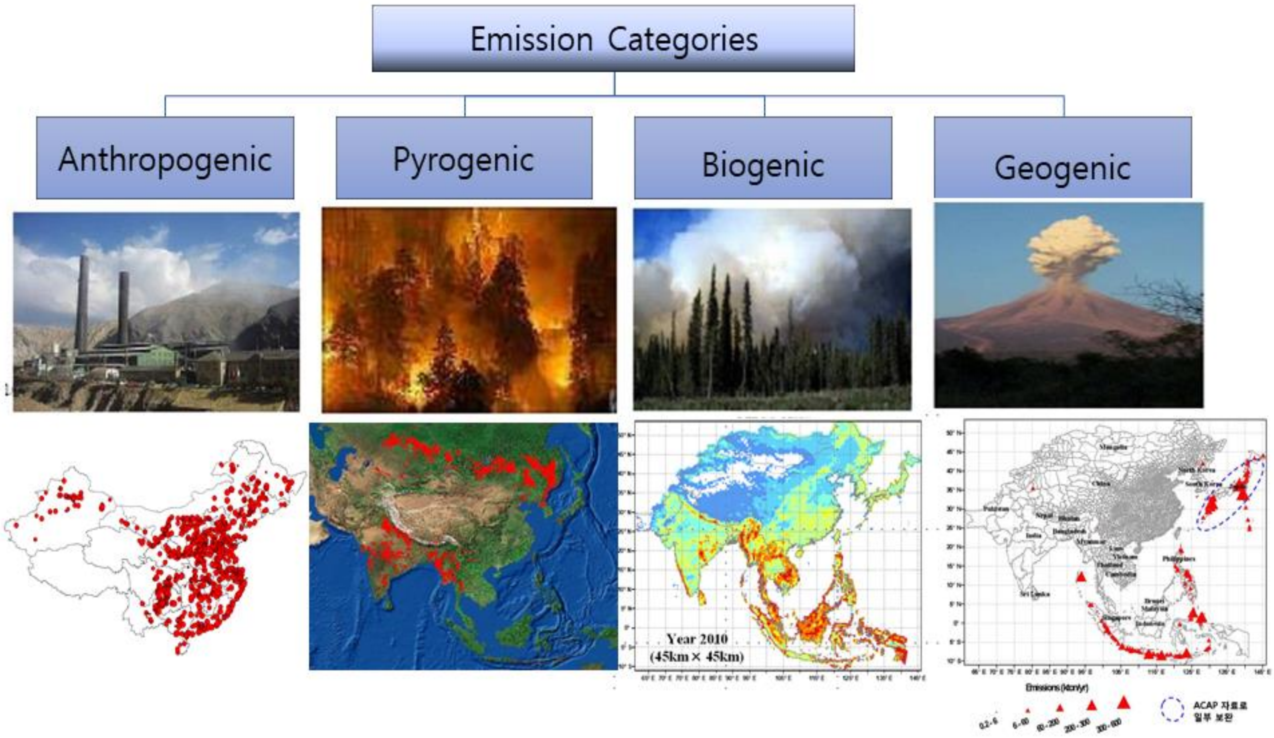


Figure 26. Anthropogenic and natural emissions for air quality modeling support

The NEACAP EI has to integrate and manage reliable regional emissions from the countries' submission to support not only IAM, SAR but other air quality monitoring and modeling activities, such as EANET, LTP and GEMS. EANET was established in 2001 as an intergovernmental initiative to create a common understanding on the state of acid deposition problems in East Asia, provide useful inputs for decision making at various levels, and promote cooperation among countries. 13

countries in East Asia are participating in EANET at present. UN Environment Programme is the Secretariat and the Asia Center for Air Pollution Research (ACAP) located in Japan is the Network Center for EANET(EANET webpage : https://www.eanet.asia/). Since 1996, the Joint Research Project for Long-range Transboundary Air Pollutants in Northeast Asia (LTP, hereafter), was established to promote common understanding of mechanism of transboundary movement of pollutants, among the ministry of environment of Korea, China, and Japan. The objectives of the LTP project are to study the state of air quality, the influence of neighboring countries, and the policy making of each country to improve the air quality. The LTP project has been executed in the four stages as below:

- 1st stage (2000–2004): Built the foundation for collaborative research of measurements and modeling
- 2nd stage (2005–2007): Collaborative measurement and modeling for S compounds among 3 countries
- 3rd stage (2008–2012): Collaborative measurement and modeling for N compounds among 3 countries
- 4th stage (2013–2017): Estimate S–R relationship of PM2.5 concentrations over China, Japan and ROK.

The Geostationary Environment Monitoring Spectrometer (GEMS) was launched in February 2020 to monitor air quality (AQ) at an unprecedented spatial and temporal resolution from a geostationary Earth orbit (GEO) for the first time. With the development of UV–visible spectrometers at sub-nm spectral resolution and sophisticated retrieval algorithms, estimates of the column amounts of atmospheric pollutants (O_3, NO_2, SO_2, HCHO, CHOCHO, and aerosols) can be obtained. To date, all the UV–visible satellite missions monitoring air quality have been in low Earth orbit (LEO), allowing one to two observations per day. With UV–visible instruments on GEO platforms, the diurnal variations of these pollutants can now be determined. The GEMS will provide synergistic science products to better understand air quality, the long-range transport of air pollutants, emission source distributions, and chemical processes. GEMS will be joined by NASA's Tropospheric Emissions: Monitoring of Pollution (TEMPO) and ESA's Sentinel-4 to form a GEO AQ satellite constellation in early 2020s, coordinated by the Committee on Earth Observation Satellites (CEOS; J. Kim., 2019; J. Kim et al., 2020)

3.4 Institutional arrangements and schedule

During the upcoming SPC meeting, major NEACAP activity areas need to be discussed and approved with the selection of Working Groups and Technical Centers. Collaborative working framework of suggested NECAP activities are illustrated in the Figure 27.

The collection, evaluation, compilation and utilization of emission information from member countries and the operation of regional emissions database require a coordination body and a dedicated center, the NEACAP Working Group for Emissions Inventory (WGEI) and Technical Center (EITC). EITC could develop emissions information not only for NEACAP's own purpose, but also for other regional/global frameworks. In the future, user groups of these information would include other formal activities/frameworks in the North-East Asia as well as all group of users interested in scientific and social issues related to the atmosphere of the North-East Asia.

Members of WGEI, who will be nominated and approved by SPC under the consent of their own government, need to set up a practical framework and schedule for NEACAP EI development. SPC also needs to nominate and approve EITC to support WGEI. When the NEACAP EITC is launched, the inventory is required to be developed in cooperation with member countries and participating Institutions (e.g. NIER, ACAP, SAI, etc.) and need to support NEACAP activities such as Integrated Assessment Model (IAM) and Scientific Assessment Report (SAR). In addition, WGEI and EITC need to collaborate with other existing regional and global frameworks, such as LTP, EANET, GEMS, HTAP, to improve Northeast Asia's overall understanding of air pollution and regional capacity to solve air pollution problems. Figure 27 shows the role of the NEACAP WGEI and EITC in this regard.

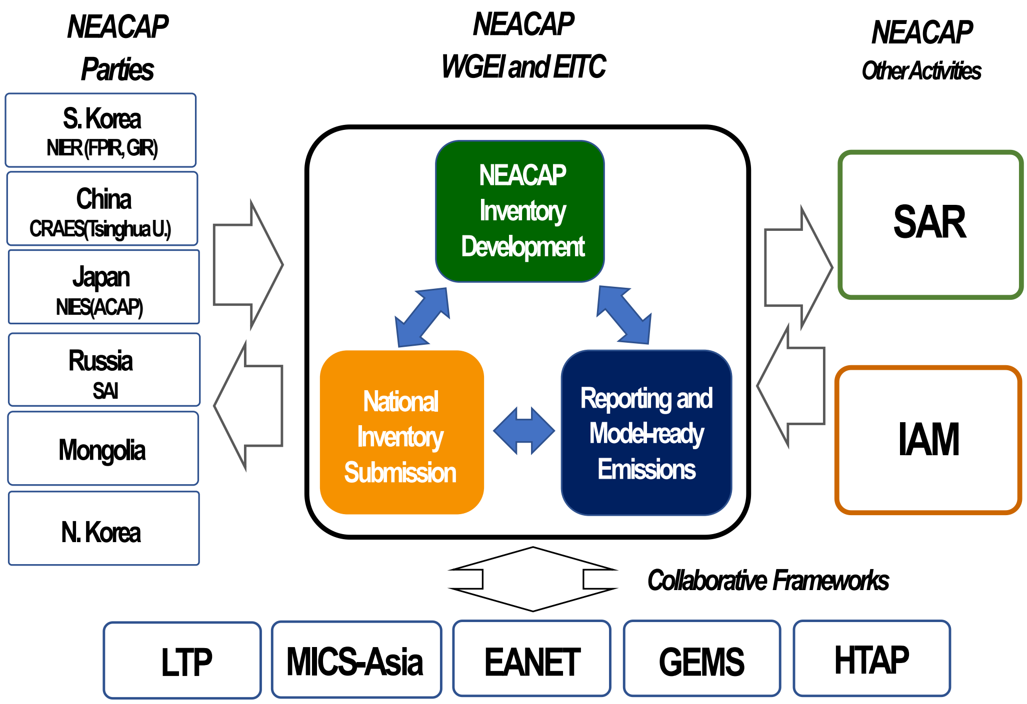


Figure 27. Overall Roles of NEACAP WGEI and EITC

(GEMS: Geostationary Environmental Monitoring Spectrometer, HTAP: Hemispheric Transport of Air Pollution)

As shown in the Figure 27, the fundamental task of WGEI and EITC is to develop NECAP emission inventory from countries' emission inventory submission. They work together to develop following components for NEACAP EI;

- Emission Inventory framework: Pollutants list, sectors-fuel classification, emission factors, etc.
- National inventory/activity data submission methodology and system

- Methodology to develop regional emissions inventory (merge, gap-filling, time series analysis, etc.)
- Develop QA/QC methodology and inventory data quality improvement plan
- Develop emission processing system for air quality modeling
- Develop emission inventory guidebook and training for inventory development/improvement
- Support other working groups and activities in NEACAP
- Collaborate with other regional frameworks

In addition to the decision on the establishment of the NEACAP Working Group for Emissions Inventory (WGEI), SPC also needs to nominate and approve EITC to support WGEI. During the following working group meeting, the direction and framework for NEACAP inventory development and role of technical center need to be decided. The schedule of these process is illustrated in the Figure 28.

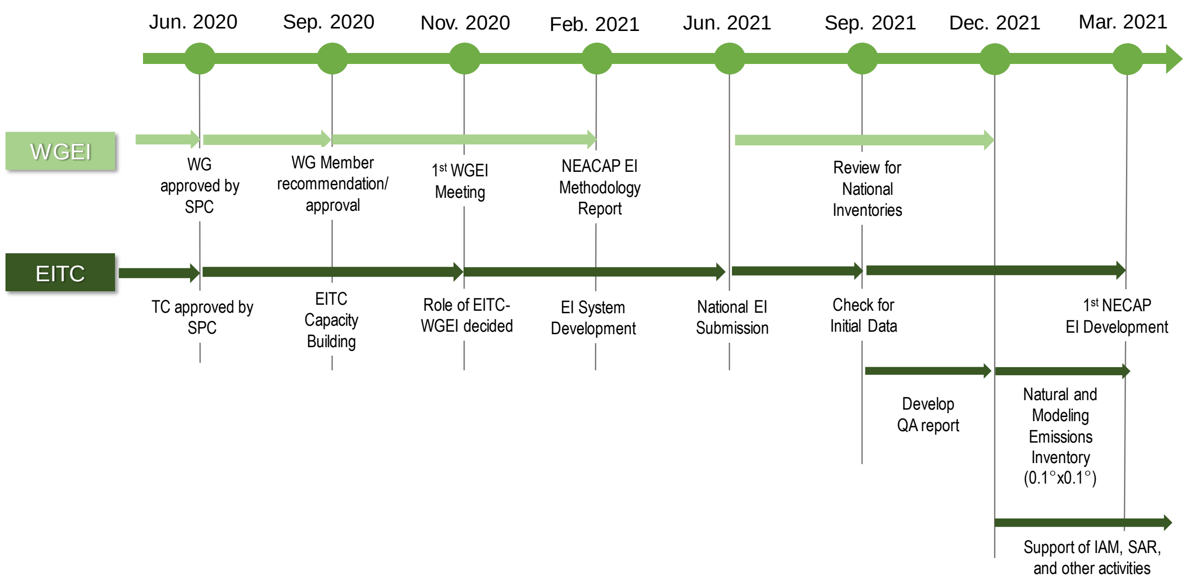


Figure 28. NECAP EI Development Process and Schedule

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US EPA webpage : https://www.epa.gov/air-emissions-inventories/